## 1. A calculation method of nitrogen column length for controlling annular overpressure in underground gas storage (UGS) wells with intensive production and injection

**Accession number:** 20213010677943
**Title of translation:**
**Authors:** Zhang, Zhi (1); Cai, Nan (1); Zhao, Yuanjin (1); Zhang, Huali (2); Li, Yufei (2); Zhang, Lin (2)
**Author affiliation:** (1) State Key Laboratory of Oil & Gas Reservoir Geology and Exploitation, Southwest Petroleum University, Chengdu; 610500, China; (2) Engineering Technology Research Institute, PetroChina Southwest Oil & Gasfield Company, Guanghan; 618300, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
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**Pages:** 83-88
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Number of references:** 19
**Main heading:** Thermal expansion
**Controlled terms:** Corrosion protection - High pressure effects - Injection (oil wells) - Nitrogen - Oil field equipment - Strain - Tubing - Underground gas storage
**Uncontrolled terms:** Annulus pressures - Ballooning effects - Column lengths - Intensive injection/production well - Nitrogen column chart - Nitrogen column length - Production wells - Storage wells - Sustained casing pressure - Temperature effect
**Classification code:** 511.1 Oil Field Production Operations - 511.2 Oil Field Equipment - 522 Gas Fuels - 539.2 Corrosion Protection - 619.1 Pipe, Piping and Pipelines - 641.1 Thermodynamics - 694.4 Storage - 804 Chemical Products Generally - 951 Materials Science
**Numerical data indexing:** Percentage 2.00E+00% to 4.00E+00%
**DOI:** 10.3787/j.issn.1000-0976.2021.06.009
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 2. A V-cutter PDC bit suitable for ultra-HTHP plastic mudstones

**Accession number:** 20212010376047
**Title of translation:** VPDC
**Authors:** Luo, Ming (1, 2); Zhu, Haiyan (3); Liu, Qingyou (3); Wang, Zhaowei (4); Li, Yanjun (2); Han, Cheng (2); Zhang, Chao (2)
**Author affiliation:** (1) State Key Laboratory of Petroleum Resources and Prospecting, China University of Petroleum, Beijing; 102249, China; (2) CNOOC China Limited Zhanjiang Company, Zhanjiang; Guangdong; 524057, China; (3) State Key Laboratory of Oil & Gas Reservoir Geology and Exploitation, Chengdu University of Technology, Chengdu; Sichuan; 610059, China; (4) Sinopec KingDream Petroleum Machinery Co., Ltd., Wuhan; Hubei; 430223, China
**Corresponding author:** Zhu, Haiyan(zhuhaiyan040129@163.com)
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
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**Issue date:** April 25, 2021
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**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency

**Abstract:** Due to the pressure holding effect generated near the wellbore by hydrostatic column pressure and deep confining pressure of high-density drilling fluid, the mechanical characteristics of strong plasticity appear in the mudstone near the bottom hole, which makes it difficult for the bit to penetrate in the strata and slows down the rate of penetration (ROP). Moreover, it may induce other downhole troubles so as to increase the drilling and completion costs. In order to provide theoretical and technical support for the research and development of an individualized PDC bit suitable for deep plastic strata, this paper takes the massive mudstone of ultra high temperature and high pressure (HTHP) in the Yingqiong Basin of western South China Sea as an example to select the D-P criterion and determine the mechanical parameters of constitutive model based on the rock mechanical experiment of plastic mudstone. Then, the cutter group of PDC bit cutting mudstone was numerically simulated. And the following research results were obtained. First, it is shown by comparing the mechanical mechanism of V-shaped, ridge and plane cutter groups to break mudstone that the V-shaped cutter group is more aggressive to the plastic mudstone and has a higher breaking efficiency than the ridge cutter group and the plane cutter group. Second, on the premise of ensuring bit's anti-wear performance, the application of smaller back rake angle and larger cutter group spacing can provide higher rock breaking efficiencies in HTHP plastic mudstone. Third, when the newly developed V-cutter individualized PDC bit is applied on site, the average ROP is up to 20.99 m/h, about 2.52 times that of the conventional PDC bit in the adjacent well. Obviously, the ROP in this interval is improved greatly. When the bit is pulled out of the hole, its matrix is complete, and the inner and outer cone parts are not seriously damaged, so it could still be used. In conclusion, the research results can provide theoretical and technical support for the efficient drilling in the deep plastic mudstone of the Yingqiong Basin. © 2021, Natural Gas Industry Journal Agency. All right reserved.
**Number of references:** 19
**Main heading:** Sedimentary rocks
**Controlled terms:** Bits - Diamond drills - Drilling fluids - Efficiency - Infill drilling - Tribology
**Uncontrolled terms:** Breaking mechanism - Breakings - Deep area of yingqiong basin - High pressure - Individualized PDC bit - PDC bit - Plastic mudstone - Rate of penetration - Ultra high temperature and ultra high pressure - Ultra-high - Ultrahigh temperature - V-shaped cutter - Western south china seas
**Classification code:** 482.2 Minerals - 511.1 Oil Field Production Operations - 603.2 Machine Tool Accessories - 913.1 Production Engineering - 931 Classical Physics; Quantum Theory; Relativity
**Numerical data indexing:** Size 2.099E+01m
**DOI:** 10.3787/j.issn.1000-0976.2021.04.011
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 3. Research progresses on pipeline transportation of hydrogen-blended natural gas

**Accession number:** 20212010375690
**Title of translation:**
**Authors:** Li, Jingfa (1); Su, Yue (2); Zhang, Heng (1); Yu, Bo (1)
**Author affiliation:** (1) School of Mechanical Engineering, Beijing Institute of Petrochemical Technology, Beijing; 102617, China; (2) College of Mechanical and Transportation Engineering, China University of Petroleum, Beijing; 102249, China
**Corresponding author:** Yu, Bo(yubobox@vip.163.com)
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
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**Publication year:** 2021
**Pages:** 137-152
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Number of references:** 104
**Main heading:** Natural gas
**Controlled terms:** Accidents - Blending - Explosions - Gases - Hydrogen production - Natural gas pipelines - Natural gas transportation - Risk assessment - Waste incineration

**Uncontrolled terms:** Blending ratio - Gas interchangeability - Hydrogen blending ratio - Hydrogen-blended natural gas - Integrity management - Material compatibility - Pipe-line transportations - Renewable energies - Safety accidents - Standard and norm
**Classification code:** 452.4 Industrial Wastes Treatment and Disposal - 522 Gas Fuels - 619.1 Pipe, Piping and Pipelines - 802.3 Chemical Operations - 914.1 Accidents and Accident Prevention
**DOI:** 10.3787/j.issn.1000-0976.2021.04.015
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 4. Technical ideas of value and efficiency increase for salt-cavern underground gas storage industry chain

**Accession number:** 20211710247371
**Title of translation:**
**Authors:** Wang, Wenquan (1)
**Author affiliation:** (1) Jiangsu Gas Storage Branch, PetroChina Huabei Petroleum Administration Co. Ltd., Zhenjiang; 212004, China
**Corresponding author:** Wang, Wenquan(wangwenquan@petrochina.com.cn)
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
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**Issue date:** March 25, 2021
**Publication year:** 2021
**Pages:** 127-132
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Number of references:** 23
**Main heading:** Extraction
**Controlled terms:** Caves - Chains - Compressed air - Compressed air energy storage - Electric energy storage - Energy resources - Salt deposits - Underground gas storage
**Uncontrolled terms:** Brine treatment - Cushion gas - Efficiency increase - Gas electricities - Gas liquids - Gas-electricity linkage peak shaving - Gas-liquid reciprocating replacement - Industry chain - Peak-shaving - Salt caverns - Salt-cavern underground gas storage - Technical ideas - Utilization of cushion gas - Value and efficiency increase
**Classification code:** 481.1 Geology - 505.1 Nonmetallic Mines - 522 Gas Fuels - 525.1 Energy Resources and Renewable Energy Issues - 525.7 Energy Storage - 602.1 Mechanical Drives - 694.4 Storage - 802.3 Chemical Operations
**DOI:** 10.3787/j.issn.1000-0976.2021.03.015
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 5. Wellbore stability mechanism and drilling fluid safety density window of horizontal well in lacustrine shale: A case study on the Jurassic Da'anzhai Member in the Sichuan Basin

**Accession number:** 20214311047407
**Title of translation:** --
**Authors:** Ma, Tianshou (1); Xiang, Guofu (1); Lin, Zhaoyong (2); Yang, Bozhong (3); Chen, Yingjie (4)
**Author affiliation:** (1) State Key Laboratory of Oil and Gas Reservoir Geology and Exploitation, Southwest Petroleum University, Chengdu; 610500, China; (2) Professional Training Department, Training Center, CNPC Chuanqing Drilling Engineering Company Limited, Chengdu; 610015, China; (3) Drilling & Production Technology Research Institute, CNPC Chuanqing Drilling Engineering Company Limited, Guanghan; 638100, China; (4) Exploration Division, PetroChina Southwest Oil &Gasfield Company, Chengdu; 610041, China

**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 9
**Issue date:** September 25, 2021
**Publication year:** 2021
**Pages:** 114-124
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** Recently, Sinopec and PetroChina have successively achieved oil and gas exploration breakthroughs in the Jurassic lacustrine shale in the Sichuan Basin, and Well Taiye 1, Ping'an 1 and Long'an 1 produce industrial oil and gas flow from shale reservoirs, which further reveals the oil and gas exploration and development potential of lacustrine shale. The lacustrine shale in the Sichuan Basin is an important target of shale oil and gas exploration in China, but the horizontal wells in shale have a higher risk of wellbore instability and tend to suffer wellbore collapse, pipe sticking and pipe burying accidents, which seriously restricts the drilling speed and efficiency improvement and drilling safety and horizontal wells. In order to clarify the wellbore stability mechanism of lacustrine shale, this paper systematically tests and analyzes the mineral composition, microstructure, physical and chemical properties and rock mechanics of shale by taking the lacustrine shale of Jurassic Da'anzhai Member in the Sichuan Basin as the research object. Then, the evaluation model of drilling fluid safety density window is established and the wellbore stability of Da'anzhai Member shale is analyzed. Finally, the accuracy of wellbore stability mechanism and drilling fluid safety density window evaluation results is verified in Well N2H. And the following research results are obtained. First, the wellbore instability mechanism of Da'anzhai shale is mainly the mechanical instability caused by high stress concentration, strength anisotropy and penetration of drilling fluid into the planes of weakness, so it is necessary to pay attention to the physical plugging performance of drilling fluid. Second, the wellbore stability of vertical well and small-angle directional well is the best, and the collapse pressure increases sharply when the well inclination exceeds 45°. Third, the horizontal well along the maximum horizontal in-situ stress has low collapse pressure, high fracture pressure and good wellbore stability, but it isn't conducive to fracturing. Fourth, the horizontal well along the minimum horizontal in-situ stress has high collapse pressure, low fracture pressure and poor wellbore stability, but it is conducive to fracturing. In conclusion, the lower and upper limits of safety density window in Well N2H are 1.91-1.98g/cm3 (mean value of 1.94g/cm3) and 2.37-2.55g/cm3 (mean value of 2.45g/cm3), respectively, the recommended density of oil-based drilling fluid ranges from 2.05 to 2.30g/cm3, and the prediction results are in line with the actual drilling situation. The research results can provide effective guidance for wellbore instability control, design and construction of horizontal well in Da'anzhai Member lacustrine shale. 
**Number of references:** 37
**Main heading:** Anisotropy
**Controlled terms:** Boreholes - Chemical stability - Drilling fluids - Flow of gases - Gases - Horizontal wells - Infill drilling - Minerals - Oil field equipment - Oil wells - Petroleum prospecting - Petroleum reservoir engineering - Rock mechanics - Shale - Shale gas
**Uncontrolled terms:** Drilling fluid safety density window - Jurassic - Jurassic da'anzhai member - Lacustrine shale - Oil and gas - Sichuan Basin - Stability mechanisms - Wellbore instability - Wellbore stability - Wellbore stability mechanism
**Classification code:** 482.2 Minerals - 483.1 Soils and Soil Mechanics - 511.1 Oil Field Production Operations - 511.2 Oil Field Equipment - 512.1.1 Oil Fields - 512.1.2 Petroleum Deposits : Development Operations - 512.2 Natural Gas Deposits - 522 Gas Fuels - 631.1.2 Gas Dynamics - 801 Chemistry - 931.2 Physical Properties of Gases, Liquids and Solids
**Numerical data indexing:** Linear density 1.91E-01kg/m to 1.98E-01kg/m, Linear density 1.94E-01kg/m, Linear density 2.05E-01kg/m to 2.30E-01kg/m, Linear density 2.37E-01kg/m to 2.55E-01kg/m, Linear density 2.45E-01kg/m
**DOI:** 10.3787/j.issn.1000-0976.2021.09.012
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 6. Progress and prospect of CNOOC's oil and gas well drilling and completion technologies

**Accession number:** 20213910945240
**Title of translation:**
**Authors:** Li, Zhong (1, 2); Xie, Renjun (1, 2); Wu, Yi (1, 2); Yuan, Junliang (1, 2)

**Author affiliation:** (1) CNOOC Research Institute Co., Ltd., Beijing; 100028, China; (2) State Key Laboratory of Offshore Oil Exploitation, Beijing; 100028, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
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**Issue date:** August 25, 2021
**Publication year:** 2021
**Pages:** 178-185
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** Offshore oil and gas production has become an important growth pole to ensure national energy security. However, China's offshore oil and gas production is lack of key core technologies and weak in tool and equipment foundation and can hardly support the optimized fast development of important fields. To solve these technological difficulties, China National Offshore Oil Corporation (CNOOC) insisted on independent technological innovation and overcame a series of key core technologies through theoretical research and key technology research and test during the 13th Five-Year Plan. And the following research results are obtained. First, several key technologies are broken through, including efficient drilling and completion in the middle and deep layers of the Bohai Sea, offshore large-scale heavy oil thermal recovery, deep-water oil and gas field development, and high temperature and high pressure well drilling and completion in the South China Sea, unconventional oil and gas stimulation, and offshore emergency rescue. Domestic first independently operated ultra deep water giant gas field, namely "Deepsea 1" is successfully put into production, so that the leap from 300 m to 1 500 m of water depth and from exploration to development is realized. Second, key tools and equipment are developed, such as logging while drilling and rotary steering drilling system, deep-water drilling surface conductor, underwater emergency killing device, and underwater wellhead Christmas tree, which promote the high-quality development of China's offshore oil industry. Finally, some suggestions are proposed as follows. In the future, CNOOC shall strengthen independent technological innovation, quicken the pace to deepsea oil and gas, and continue to research key core technologies for oil and gas reserves and production increase (e.g. continuous localization of drilling and completion technologies, equipment and materials in complex fields), commingled gas production and test and green energy transformation (e.g. geothermal energy), so as to make greater contributions to ensure national energy security and build a maritime power. 
**Number of references:** 22
**Main heading:** Offshore oil well production
**Controlled terms:** Christmas trees (wellheads) - Crude oil - Drilling equipment - Energy security - Gas industry - Gases - Heavy oil production - Infill drilling - Natural gas well completion - Offshore drilling - Offshore gas fields - Offshore gas wells - Offshore oil fields - Offshore oil wells - Offshore technology - Oil field development - Oil well drilling - Petroleum reservoir evaluation - Petroleum reservoirs - Proven reserves - Well equipment
**Uncontrolled terms:** "deepsea 1" giant gas field - 13th five-year plan - China national offshore oil corporations - Deep-water oil and gas field development - Deep-water oil and gas well drilling - Deepwater - Equipment and tool - Five-year plans - Gas field development - Giant gas fields - High temperatures and high pressures - Oil and gas fields - Oil and gas well drilling
**Classification code:** 511.1 Oil Field Production Operations - 511.2 Oil Field Equipment - 512.1 Petroleum Deposits - 512.1.1 Oil Fields - 512.1.2 Petroleum Deposits : Development Operations - 512.2.1 Natural Gas Fields - 512.2.2 Natural Gas Deposits: Development Operations - 522 Gas Fuels - 525.6 Energy Policy - 674.2 Marine Drilling Rigs and Platforms - 675 Marine Engineering
**Numerical data indexing:** Size 3.00E+02m to 1.00E00m, Size 5.00E+02m
**DOI:** 10.3787/j.issn.1000-0976.2021.08.016
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 7. Research progress and prospect of the integrated supercritical CO2 enhanced shale gas recovery and geological sequestration

**Accession number:** 20213010678052
**Title of translation:** CO2

**Authors:** Lu, Yiyu (1, 2); Zhou, Junping (1, 2); Xian, Xuefu (1, 2); Tang, Jiren (1, 2); Zhou, Lei (1, 2); Jiang, Yong-Dong (1, 2); Xia, Binwei (1, 2); Wang, Xiangzeng (3); Kang, Yong (4)
**Author affiliation:** (1) State Key Laboratory of Coal Mine Disaster Dynamics and Control, Chongqing University, Chongqing; 400044, China; (2) School of Resources and Safety Engineering, Chongqing University, Chongqing; 400044, China; (3) Shaanxi Yanchang Petroleum Co., Ltd., Xi'an; 710052, China; (4) Key Laboratory of Hubei Province for Water Jet Theory & New Technology, Wuhan University, Wuhan; 430072, China
**Corresponding author:** Zhou, Junping(zhoujp1982@sina.com)
**Source title:** Natural Gas Industry
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**Publication year:** 2021
**Pages:** 60-73
**Language:** Chinese
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**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Number of references:** 90
**Main heading:** Carbon dioxide
**Controlled terms:** Adsorption - Carbon - Fracturing fluids - Gases - Geology - Petroleum reservoirs - Recovery - Shale - Shale gas
**Uncontrolled terms:** Carbon neutralities - Carbon peaks - CH 4 - CO2 enhanced shale gas recovery - CO2 geological sequestration - Competitive adsorption - Gas recovery - Geological sequestration - Supercritical CO 2 - Supercritical CO2 fracturing
**Classification code:** 481.1 Geology - 512.1.1 Oil Fields - 512.2 Natural Gas Deposits - 522 Gas Fuels - 802.3 Chemical Operations - 804 Chemical Products Generally - 804.2 Inorganic Compounds
**DOI:** 10.3787/j.issn.1000-0976.2021.06.007
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 8. Geological characteristics and resource prospect of deep marine shale gas in the southern Sichuan Basin

**Accession number:** 20214311047280
**Title of translation:**
**Authors:** Zhang, Surong (1, 2, 3); Dong, Dazhong (1, 2, 3); Liao, Qunshan (4); Sun, Shasha (1, 2, 3); Huang, Shengsong (5); Guan, Quanzhong (6); Zhang, Chenchen (7); Guo, Wen (1); Jiang, Shan (8); Shi, Pengyu (9)
**Author affiliation:** (1) PetroChina Research Institute of Petroleum Exploration & Development, Beijing; 100083, China; (2) CNPC Key Laboratory of Unconventional Oil & Gas, Langfang; 065007, China; (3) National Energy Shale Gas R&D (Experiment) Center, Langfang; 065007, China; (4) China Petroleum Consulting Center, Beijing; 100724, China; (5) Engineering Technology Department, CNPC Great Wall Drilling Engineering Limited Company, Beijing; 100101, China; (6) Chengdu University of Technology, Chengdu; 610059, China; (7) China Railway Liuyuan Group Co., Ltd., Tianjin; 300308, China; (8) Sinopec Economics & Development Research Institute, Beijing; 100029, China; (9) China University of Petroleum , Beijing; 102249, China
**Corresponding authors:** Dong, Dazhong(ddz@petrochina.com.cn); Dong, Dazhong(ddz@petrochina.com.cn); Dong, Dazhong(ddz@petrochina.com.cn)
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
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**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3

**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** There are abundant deep shale gas resources in the Upper Ordovician Wufeng Formation-Lower Silurian Longmaxi Formation of southern Sichuan Basin, which is a replacement area for increasing gas reserves and production in the Sichuan Basin. So far, however, the geological characteristics of deep shale gas reservoirs in this area have not been understood comprehensively. In order to evaluate the resource potential of deep shale gas in the southern Sichuan Basin, determine the favorable exploration areas and provide reference for the three-dimensional development of shale gas in this area, this paper systematically analyzes the sedimentary environment, organic geochemistry, reservoir physical properties, rock brittleness, gas-bearing characteristics and other geological characteristics of deep marine shale. Then, the volume of deep shale gas resources is calculated by dividing evaluation units and selecting shale gas resource evaluation methods and calculation parameters. Finally, favorable exploration areas of deep shale gas are determined. And the following research results are obtained. First, the deep shale of Wufeng Formation-Longmaxi Formation in the southern Sichuan Basin is deposited in the environment of deep-water shelf facies, its average effective thickness is 61 m, its distribution area accounts for 83% of the whole area, and its resource base is great. The total organic carbon is 3.1%. The organic matter is of sapropel type and is in the stage of high-over-mature dry gas generation of crude oil cracking, with better gas generation potential. Second, organic pores, inorganic pores and microfractures are developed in the deep shale of this area. The porosity is in the range of 2.3%-8.1%. The reservoir physical properties are good. The mineral compositions are mainly quartz and clay minerals, and the content of brittle minerals is 63%, so it has better fracability. Third, the gas content of deep shale gas reservoir is high and free gas accounts for 60%. The pressure coefficient is high. And the gas preservation conditions are good. Fourth, the geological resources of deep shale gas are 25.62×1012 m3, the recoverable resources are 6.14×1012 m3, and the resource abundance is 6.67×108 m3/km2, indicating great resource potential. In conclusion, the favorable exploration areas of deep shale gas in the Wufeng Formation-lower Long 1 submember of Longmaxi Formation in the southern Sichuan Basin are Zigong-Fushun, Luxian-Luzhou and Neijiang-Yongchuan whose burial depth is less than 4500 m. © 2021, Natural Gas Industry Journal Agency. All right reserved.
**Number of references:** 36
**Main heading:** Organic carbon
**Controlled terms:** Clay minerals - Cracks - Energy resources - Fracture mechanics - Gas generators - Gases - Geochemistry - Organic minerals - Petroleum reservoirs - Proven reserves - Sedimentary rocks - Shale gas
**Uncontrolled terms:** Deep shale gas - Favorable exploration area - Geological characteristics - Luxian-luzhou - Resource evaluation - Resource potentials - Sichuan Basin - Southern sichuan basin - Yongchuan - Zigong-fushun
**Classification code:** 481.2 Geochemistry - 482.2 Minerals - 512.1.1 Oil Fields - 512.1.2 Petroleum Deposits : Development Operations - 512.2 Natural Gas Deposits - 522 Gas Fuels - 525.1 Energy Resources and Renewable Energy Issues - 804.1 Organic Compounds - 931.1 Mechanics
**Numerical data indexing:** Percentage 2.30E+00% to 8.10E+00%, Percentage 3.10E+00%, Percentage 6.00E+01%, Percentage 6.30E+01%, Percentage 8.30E+01%, Size 4.50E+03m, Size 6.10E+01m
**DOI:** 10.3787/j.issn.1000-0976.2021.09.004
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 9. Study on the production laws of shale gas in different occurrence states in the use of NMR online detection technology

**Accession number:** 20212510530436
**Title of translation:**
**Authors:** Duan, Xianggang (1, 2); Hu, Zhiming (1, 2); Gu, Zhaobin (1); Chang, Jin (1, 2); Shen, Rui (1); Sun, Wei (1); Mu, Ying (3); Zhou, Guangzhao (3)
**Author affiliation:** (1) PetroChina Research Institute of Petroleum Exploration & Development, Langfang; 065007, China; (2) National Energy Shale Gas R & D Center, Langfang; 065007, China; (3) Department of Porous Flow & Fluid Mechanics, University of Chinese Academy of Sciences, Beijing; 100049, China
**Corresponding author:** Gu, Zhaobin(guzhaob69@petrochina.com.cn)
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
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**Issue date:** May 25, 2021
**Publication year:** 2021

**Pages:** 76-83
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** The premise and basis to establish a reasonable shale gas well production system and then optimize shale gas field development technology policies is to understand the production laws of shale gas in different occurrence states. For the purpose of avoiding the uncertainty of indirect testing, a NMR (nuclear magnetic resonance) online detection system suitable for high temperature and high pressure conditions is developed. The cores of Long 11 layer (the first submember of the first Member of Longmaxi Formation, Lower Silurian)taken through Well N203 in the Changning area of the Sichuan Basin were selected, and methane gas was used as the experimental fluid to measure the production changes of free and adsorbed methane in the process of shale gas exploitation. And combined with physical simulation experiment of shale-gas depletion development, the production characteristics and production change laws of shale gas in different occurrence states were studied. And the following research results were obtained. First, the NMR T2 spectrum of the methane saturated shale has obvious characteristics of two peaks. The adsorbed methane mainly occurs on the surface of shale nanopores and the relaxation time is shorter (0.1-1.0 ms), while the free methane occurs in the larger pores and the relaxation time is longer (1-100 ms). Second, the total methane content and adsorbed/free methane content measured by NMR are closer to the results obtained by the indirect method. Third, the physical simulation experiment of shale gas development shows that in the early stage of the development, the produced gas is dominated by free methane and the stage contribution rate of adsorbed methane is less than 5%. As the production continues, the stage contribution rate of adsorbed methane gradually increases. And especially when the pressure is lower than 15 MPa, the stage contribution rate of adsorbed methane rises rapidly. In the late stage of the development, the stage contribution rate of adsorbed methane exceeds 50% and its cumulative contribution rate reaches 30%. Fourth, it is indicated by converting the experimental results into the field production dynamic data of a gas well that the contribution rate of adsorbed methane to cumulative gas production of a gas well is less than 5% in the first 5 years of the production and reaches 25% at the end of the production. In conclusion, NMR online monitoring technology can quantitatively characterize the production laws of methane gas in different occurrence states, and provide a new method for studying shale gas-water two-phase imbibition and CO2/CH4 adsorption replacement in the following stage. 
**Number of references:** 32
**Main heading:** Gas industry
**Controlled terms:** Gases - Methanation - Methane - Natural gas well production - Natural gas wells - Nuclear magnetic resonance - Relaxation time - Shale gas
**Uncontrolled terms:** Cumulative gas productions - Experimental fluids - Gas field development - High temperature and high pressure - On-line detection system - Physical simulation experiment - Production characteristics - Production dynamic data
**Classification code:** 512.2.1 Natural Gas Fields - 522 Gas Fuels - 802.2 Chemical Reactions - 804.1 Organic Compounds - 931 Classical Physics; Quantum Theory; Relativity
**Numerical data indexing:** Age 5.00e+00yr, Percentage 2.50e+01%, Percentage 3.00e+01%, Percentage 5.00e+00%, Percentage 5.00e+01%, Pressure 1.50e+07Pa, Time 1.00e-03s to 1.00e-01s, Time 1.00e-04s to 1.00e-03s
**DOI:** 10.3787/j.issn.1000-0976.2021.05.008
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 10. Role of paleouplift in the scale formation of intra-platform carbonate mound-bank body reservoirs in the Sichuan Basin

**Accession number:** 20212010375768
**Title of translation:**
**Authors:** Yang, Wei (1); Wei, Guoqi (1); Xie, Wuren (1); Liu, Mancang (1); Su, Nan (1); Jin, Hui (1); Wu, Saijun (1); Shen, Juehong (1); Hao, Cuiguo (1); Wang, Xiaodan (1)
**Author affiliation:** (1) PetroChina Research Institute of Petroleum Exploration & Development, Beijing; 100083, China
**Source title:** Natural Gas Industry
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**Pages:** 1-12
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** Intra-platform carbonate mound-bank body reservoirs is an important type of oil and gas reservoirs in the Sichuan Basin, and paleouplift plays an important role in the scale formation process of scale intra-platform mound-bank body reservoir. So far, however, the control action of paleouplift on the formation and distribution of intra-platform mound-bank body reservoirs has not been understood clearly enough, which restricts the oil and gas exploration progress of this type of reservoirs. In order to provide the basis for oil and gas exploration deployment, this paper analyzes the formation and evolution of four paleouplifts developed in the cratonic stage of the Sichuan Basin. On this basis, the genetic mechanisms and characteristics of scale intra-platform mound-bank body reservoirs are studied, and the characteristics and distribution of large-scale intra-platform reservoirs in the main series of strata are analyzed. And the following research results were obtained. First, the four paleouplifts developed in the Sichuan Basin plays an important constructive role in the formation of scale intra-platform mound-bank body reservoirs. Their control actions mainly include sedimentation and diagenesis. Along with the sea level change, they control the sedimentation scale and distribution range of intra-platform mound-bank body. They control the interlayer karstification and quasi-syngenetic dolomitization of intra-platform mound-bank body. And together with the late tectonic movement, they control the weathering crust karstification and fracturing of intra-platform mound-bank body. Second, Gaoshiti-Moxi paleouplift mainly controls the formation of the large-scale intra-platform mound-bank body reservoirs in the Sinian Dengying Formation and the Cambrian Longwangmiao Formation, Leshan-Longnüsi paleouplift mainly controls the formation of the scale intra-platform mound-bank body reservoir in the Cambrian Xixiangchi Formation and the Carboniferous Huanglong Formation, while Luzhou and Kaijiang paleouplifts mainly control the formation of the scale intra-platform mound-bank body reservoirs in the Triassic Jialingjiang Formation and Leikoupo Formation. Third, six sets of scale intra-platform reservoirs are developed in the Sichuan Basin. The intra-platform mound-bank body reservoirs of Dengying Formation and Longwangmiao Formation are mainly distributed in the core of paleouplift, and the other four sets are mainly distributed in the slope of paleouplift. In conclusion, these research results provide the geological basis for the prediction of scale intra-platform mound-bank body reservoirs in the Sichuan Basin and they are of important theoretical and practical significance. © 2021, Natural Gas Industry Journal Agency. All right reserved.
**Number of references:** 32
**Main heading:** Petroleum reservoir engineering
**Controlled terms:** Geological surveys - Offshore gas fields - Petroleum prospecting - Petroleum reservoirs - Scale (deposits) - Sea level
**Uncontrolled terms:** Dengying formation - Formation and evolutions - Genetic mechanism - Jialingjiang formation - Oil and gas exploration - Oil and gas reservoir - Research results - Tectonic movements
**Classification code:** 471.1 Oceanography, General - 481.1 Geology - 512 Petroleum and Related Deposits
**DOI:** 10.3787/j.issn.1000-0976.2021.04.001
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 11. Burial dolomitization of marginal platform bank facies and its petroleum geological implications: The genesis of Middle Permian Qixia Formation dolostones in the northwestern Sichuan Basin

**Accession number:** 20212010375725
**Title of translation:** -
**Authors:** Pei, Senqi (1, 2); Wang, Xingzhi (1); Li, Rongrong (2); Yang, Xun (2); Long, Hongyu (2); Hu, Xin (2); Wang, Xiaoxing (3)
**Author affiliation:** (1) Southwest Petroleum University, Chengdu; Sichuan; 610500, China; (2) Northwest Sichuan Division, PetroChina Southwest Oil & Gasfield Company, Jiangyou; Sichuan; 621700, China; (3) Exploration Department, PetroChina Southwest Oil & Gasfield Company, Chengdu; Sichuan; 610051, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
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**Publication year:** 2021
**Pages:** 22-29
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** The Middle Permian Qixia Formation dolostones are important reservoir strata of marine carbonate gas reservoirs in the northwestern Sichuan Basin. And as for its origin, there are many opinions and no agreement has been reached yet. In order to provide the basis for the reservoir prediction in the northwestern Sichuan Basin, this paper comprehensively analyzes the petrological and geochemical characteristics of the outcrop and drilling core samples of Qixia Formation dolostones in this area by means of thin section analysis, cathodoluminescence, scanning electron microscope, energy spectrum, X-ray diffraction and carbon/oxygen isotope test. On this basis, the formation mechanisms of the burial dolostone of marginal platform bank facies are studies, and its petroleum geological implications to the formation of reservoirs are discussed. And the following research results were obtained. First, medium-coarse crystalline allotriomorphic mosaic-like dolomite develops in the Qixia Formation dolostones of this area. Crystalline is mainly automorphous and semi-automorphous, the degree of crystallization is high, and the degree of order is moderate to high. It is dolomitized completely and the original rock structure disappears thoroughly. It presents the petrographical characteristics of late dolomitization. Second, the Qixia Formation dolomitization keeps higher burial temperature, and the growth of dolomite lasts to Middle and Late Triassic. Third, Qixia Formation dolostones and its contemporaneous sea water have similar carbon/oxygen/strontium isotopic characteristics, which is the result of burial dolomitization caused by the increase of salinity and Mg/Ca ratio of original sedimentary pore water in the stage of shallow and middle burial depth. In conclusion, the original rock structure of Qixia Formation dolostones in the northwestern Sichuan Basin disappears, it is dolomitized completely and a large number of intercrystalline pores are formed, so as to improve the reservoir physical properties and promote the formation of late dissolution pores, which is of great reservoir significance to natural gas accumulation in this area. 
**Number of references:** 29
**Main heading:** Gasoline
**Controlled terms:** Carbon - Exploratory geochemistry - Isotopes - Offshore gas fields - Petroleum geology - Petroleum reservoirs - Scanning electron microscopy - Seawater
**Uncontrolled terms:** Degree of crystallization - Formation mechanism - Geochemical characteristic - Intercrystalline pores - Isotopic characteristics - Natural-gas accumulation - Reservoir physical property - Reservoir prediction
**Classification code:** 471.4 Seawater, Tides and Waves - 481.1 Geology - 481.2 Geochemistry - 512 Petroleum and Related Deposits - 523 Liquid Fuels - 804 Chemical Products Generally
**DOI:** 10.3787/j.issn.1000-0976.2021.04.003
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 12. Design and test of a cuttings bed remover for horizontal wells

**Accession number:** 20211210117070
**Title of translation:**
**Authors:** Ji, Guodong (1, 2); Wang, Haige (1); Huang, Hongchun (1); Meng, Zhao (1); Cui, Liu (1); Guo, Weihong (1)
**Author affiliation:** (1) CNPC Engineering Technology R& D Co., Ltd., Beijing; 102206, China; (2) PetroChina Research Institute of Petroleum Exploration & Development, Beijing; 100083, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
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**Publication year:** 2021
**Pages:** 125-131
**Language:** Chinese
**ISSN:** 10000976
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**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency

**Abstract:** Cuttings accumulation in horizontal drilling of a shale gas well is one of the main reasons for high drilling torque and drag and serious backing pressure and consequently influencing the rate of penetration (ROP), so inhibiting the generation of a cuttings bed and keeping the hole clean is an important prerequisite to ensure the smooth and safe drilling of horizontal section. In order to improve the hole cleaning efficiency of horizontal sections, this paper studied the decay laws of helical flow induced by helix angles and rotation speed of a newly developed cuttings bed remover with V-shaped blades for horizontal wells and their influences on the resuspension distribution of cuttings particles by virtue of the CFD numerical simulation method and Euler-Euler binary-fluid model, combined with the theory of particle dynamics. Then, the parameters such as blade rotation speed and blade helix angle were optimized. And the following research results were obtained. First, with the increase of the rotation speed, cuttings deposit at the bottom of the annulus deflects to a certain degree. And the higher the rotation speed, the more obvious the deflection. Second, annulus pressure drop loss increases with the increase of the helix angle. And this phenomenon is more obvious when the helix angle is larger. Third, the field test results in Well Changning H25-7 of the southern Sichuan Basin show that after the application of the newly developed cuttings bed remover for horizontal wells, the drilling friction is decreased by 33%, the tripping is smooth without sticking. And in the process of its application, no complex downhole accident happened. Obviously, it provides good hole cleaning to ensure the safe and smooth implementation of the later casing running operation. In conclusion, this newly developed cuttings bed remover can satisfy the demand of cutting bed cleaning and drilling cost reduction and efficiency improvement of horizontal wells, so it is worth popularizing and applying. What's more, it provides guidance and reference for the design of similar cuttings bed removers. 
**Number of references:** 26
**Main heading:** Horizontal drilling
**Controlled terms:** Cleaning - Computational fluid dynamics - Cost reduction - Efficiency - Horizontal wells - Infill drilling - Numerical methods - Rotation
**Uncontrolled terms:** Annulus pressures - CFD numerical simulations - Drilling torques - Horizontal section - Particle dynamics - Rate of penetration - Research results - Running operation
**Classification code:** 511.1 Oil Field Production Operations - 512.1.1 Oil Fields - 802.3 Chemical Operations - 913.1 Production Engineering - 921.6 Numerical Methods - 931.1 Mechanics
**Numerical data indexing:** Percentage 3.30e+01%
**DOI:** 10.3787/j.issn.1000-0976.2021.02.015
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 13. Stage division of shale gas accumulation process: An example from the Wufeng Formation-Longmaxi Formation shale gas reservoir in the Ningxi area of the Sichuan Basin

**Accession number:** 20210609883995
**Title of translation:** --
**Authors:** Wu, Jianfa (1); Wu, Juan (2); Liu, Wenping (1); Zhou, Zheng (2); Luo, Chao (1); Wu, Wei (1); Li, Xiaojia (2); Deng, Bin (2)
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**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 1
**Issue date:** January 25, 2021
**Publication year:** 2021
**Pages:** 83-92
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** The Sichuan Basin and its periphery have generally experienced a multi-cycle tectonic evolution process. At present, the correlation between the multi-stage activity and enrichment and accumulation laws of shale gas in the target strata of this area and the regional great burial depth-strong uplifting and denudation process is less researched. Taking the typical well in the western part of Changning Shale Gas Block (hereinafter referred to as Ningxi area)in

the southern Sichuan Basin as the research object, this paper studied the coupling characteristics between the Cenozoic uplift and the shale gas enrichment and destruction in the Wufeng Formation-Longmaxi Formation of this area with the hydrocarbon generation dynamics of Upper Ordovician Wufeng Formation-Lower Silurian Longmaxi Formation and the change characteristics of its pressure system as the carrier, based on comprehensive studies, such as low-temperature thermochronology, fluid inclusion and basin thermal history simulation. And the following research results were obtained. First, apatite fission track ages (AFT) and (U-Th)/He ages are about 20-40 Ma and 10-20 Ma, respectively, indicating the Cenozoic surface denudation is 2000 m. Second, the burial depth and subsidence thermal history of Wufeng Formation-Longmaxi Formation can be divided into three thermal evolution stages, namely low-moderate maturity in the Early Silurian-Late Triassic, high maturity in the Early-Middle Jurassic, and over maturity in the Late Jurassic-Cretaceous. Third, the fluid homogenization temperature of calcite inclusion in the Wufeng Formation-Longmaxi Formation presents the characteristics of double peaks in the range of 120-140 and 160-180, respectively. The fluid salinity varies substantially in the late stage, indicating the preservation conditions are destroyed due to the hybridization of deep and near-surface fluids. Fourth, the Wufeng Formation-Longmaxi Formation shale presents the characteristics of overpressure for a long time in the period hydrocarbon generation, and the gas generation rate reaches the peak to form abnormal pressure due to the continuous great burial depth in the Late Jurassic-Cretaceous. In the Cenozoic, however, the overpressure system is destroyed by fast uplifting and denudation, and it is currently a normal pressure system. In conclusion, shale gas accumulation process in the Wufeng Formation-Longmaxi Formation of Ningxi area has obvious multi-stage characteristics, i.e., high-pressure enrichment in the early stage, great burial depth and ultrahigh pressure maintenance, and structure uplifting adjustment/destruction in the later stage. 
**Number of references:** 26
**Main heading:** Shale gas
**Controlled terms:** Calcite - Erosion - Fission reactions - Gases - Hydrocarbons - Petroleum reservoirs - Phosphate minerals - Temperature
**Uncontrolled terms:** Apatite fission track ages - Coupling characteristic - Enrichment and accumulations - Homogenization temperatures - Hydrocarbon generation - Overpressure systems - Preservation condition - Thermal history simulation
**Classification code:** 482.2 Minerals - 512.1.1 Oil Fields - 522 Gas Fuels - 641.1 Thermodynamics - 804.1 Organic Compounds - 932.2.1 Fission and Fusion Reactions
**Numerical data indexing:** Age 1.00e+07yr to 2.00e+07yr, Age 2.00e+07yr to 4.00e+07yr, Size 2.00e+03m
**DOI:** 10.3787/j.issn.1000-0976.2021.01.007
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 14. Exploration challenges, countermeasures and prospect of mountain shallow shale gas: A cased study on the Zhaotong National Shale Gas Demonstration Area

**Accession number:** 20211210117010
**Title of translation:** , -
**Authors:** Liang, Xing (1); Zhang, Zhao (1); Shan, Chang'an (2); Zhang, Jiehui (1); Wang, Weixu (1); Xu, Zhengyu (3); Li, Zhaofeng (1); Mei, Jue (1); Zhang, Lei (1); Xu, Jinbin (1); Wang, Gaocheng (1); Xu, Yunjun (3); Jiang, Liwei (1)
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**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
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**Publication year:** 2021
**Pages:** 27-36
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** Intraplate deformation superimposed by multi-stage tectonic movement results in the particular mountain characteristics of peripheral Sichuan Basin and great difficulty in the gas exploration of the Zhaotong National Shale

Gas Demonstration Area. In order to resolve the exploration difficulty of mountain shale gas in the complex tectonic area, this paper comprehensively analyzes the connotation and geological characteristics of mountain shale gas. Based on this, the enrichment and high yield laws of shallow shale gas in Taiyang anticlinal structure of Zhaotong exploration area are summarized, and the corresponding exploration ideas and technical countermeasures are put forward. Finally, its exploration prospect is predicted. And the following research results were obtained. First, mountain shale gas has complex surface landform and inner geological characteristics, such as strong structural deformation, old strata and over mature thermal evolution, so the overall sealing and preservation condition of shale gas is the key to hydrocarbon accumulation. Second, the shale gas reservoirs in this area is of strong heterogeneity, the high shear stress is complex and faults, fracture zones and surface karst caves are developed, so drilling engineering is of high implementation risk and high cost. Third, shallow shale gas in this area is better sealed and preserved vertically and laterally. Under the joint action of roof, floor and sealing faults, a good three-dimensional sealed reservoir space system is formed. Fourth, to cope with the challenges of mountain shale gas and the restrictions of oilfield mining right, the exploration ideas of "stepping out of the stable area of the basin to develop the mountain zone" and "stepping out of the Wufeng Formation and Longmaxi Formation to achieve breakthroughs in other shale strata" are put forward. Fifth, based on the practice of geology-engineering integration, the evaluation concept of "building a transparent manmade-fracture shale gas reservoir in the whole chain" and the working concept of integrated precise control in the whole process are put forward definitely. In conclusion, shallow shale gas resources are abundant in the Zhaotong Shale Gas Demonstration Area and the residual structural depression area of the peripheral Sichuan Basin, and the drilling situations in many zones are good, which indicates a better exploration prospect of shallow shale gas. 
**Number of references:** 43
**Main heading:** Petroleum prospecting
**Controlled terms:** Cost engineering - Deformation - Demonstrations - Energy resources - Faulting - Gases - Infill drilling - Landforms - Petroleum reservoir evaluation - Petroleum reservoirs - Shale gas - Shear stress
**Uncontrolled terms:** Drilling engineering - Exploration prospects - Geological characteristics - Hydrocarbon accumulation - Preservation condition - Strong heterogeneities - Structural deformation - Technical countermeasures
**Classification code:** 481.1 Geology - 484.1 Earthquake Measurements and Analysis - 511.1 Oil Field Production Operations - 512.1.1 Oil Fields - 512.1.2 Petroleum Deposits : Development Operations - 522 Gas Fuels - 525.1 Energy Resources and Renewable Energy Issues - 911 Cost and Value Engineering; Industrial Economics
**DOI:** 10.3787/j.issn.1000-0976.2021.02.004
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 15. A new technology for the multi-diameter combination operation of coiled tubing in ultra-deep gas wells

**Accession number:** 20211710247355
**Title of translation:**
**Authors:** Pang, Dexin (1); Aibaibu, Abulimiti (1); Jiao, Wenfu (1); Chen, Bo (1); Guo, Xinwei (1); Wang, Yiquan (1); Bai, Huaming (1)
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**Corresponding author:** Aibaibu, Abulimiti(aibaibu@petrochina.com.cn)
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
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**Issue date:** March 25, 2021
**Publication year:** 2021
**Pages:** 112-118
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** As the exploration and development of deep and ultra deep oil and gas is increased, there are more and more "three-ultra wells" (reservoir temperature, reservoir pressure and well depth exceed 177 , 105 MPa and 6 000 m, respectively), the completion well structure is more complex, and especially the inner diameter of production string

is variable and the production string and production interval are blocked, which brings adverse impact on gas well production and even results in well shut down. To deal with this situation, it is necessary for the operation of coiled tubing in ultra deep gas wells to meet new requirements. In order to ensure the commissioning, stable production and production increase of "three-ultra wells", this paper researches and developes a technology for the multi-diameter combination operation of coiled tubing based on the advantages of casing tubing (including different dimensions, flexible movement of modularized equipment, high automation degree and snubbing), combined with the actual characteristics of "three-ultra wells" (such as geological conditions, borehole structure and fluid medium change). In addition, a support multi-diameter coiled tubing connection device was developed. And they have been successfully applied in Well XX 11 of PetroChina Tarim Oilfield Company. And the following research and practice results were obtained. First, by virtue of the multi-diameter combination operation of coiled tubing, the safety load factor of the string is increased effectively by 0.12. Second, the friction along the string is reduced effectively, with a friction reduction rate of 41.7%. Third, under the same pressure, the end effect is increased by 33% by increasing the construction displacement. Fourth, the cuttings return capacity is enhanced. In conclusion, this technology meets the requirements of the variable-diameter wellbore operation in ultra deep gas wells and provides a new safe, efficient and low-cost solution for the operation of coiled tubing in ultra deep gas wells. 
**Number of references:** 32
**Main heading:** Coiled tubing
**Controlled terms:** Boreholes - Friction - Gas industry - Gases - Natural gas well completion - Natural gas well production - Natural gas wells - Oil field development - Oil well completion - Oil well production - Oil wells - Petroleum prospecting - Safety factor - Well equipment
**Uncontrolled terms:** Combination operation - Exploration and development - Friction reduction - Geological conditions - Production increase - Reservoir pressures - Reservoir temperatures - Tubing connections
**Classification code:** 511.1 Oil Field Production Operations - 512 Petroleum and Related Deposits - 522 Gas Fuels - 619.1 Pipe, Piping and Pipelines - 914.1 Accidents and Accident Prevention
**Numerical data indexing:** Percentage 3.30e+01%, Percentage 4.17e+01%, Pressure 1.05e+08Pa, Size 6.00e+03m
**DOI:** 10.3787/j.issn.1000-0976.2021.03.013
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 16. A calculation model of adsorbed shale gas contents considering pore size distribution

**Accession number:** 20211210117185
**Title of translation:**
**Authors:** Zhao, Jun (1); Deng, Jiajie (1); Yang, Lin (2); Liu, Kai (1); Huang, Ke (2); He, Yufei (2)
**Author affiliation:** (1) School of Geosciences and Technology, Southwest Petroleum University, Chengdu; 610500, China; (2) Oil and Gas Evaluation Center, CNPC Logging Co., Ltd., Xi'an; 710077, China
**Source title:** Natural Gas Industry
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**Publication year:** 2021
**Pages:** 75-82
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** Shale absorption gas content is an important indicator to evaluate resource potential and development value of shale gas. Pore size distribution in shale gas reservoirs is highly heterogeneous and micropores and mesopores are relatively developed, so the influence of pore space size on gas adsorption capacity is usually taken into consideration when shale absorption gas content is calculated. As a result, the calculation results are more different and even larger deviation generates. In order to solve these problems, this paper constructs an interlaminar structure of organic matter using graphene. Then, the adsorption phase density values under five groups of temperatures, nine groups of pressures and seven groups of pore sizes were simulated based on molecular dynamics. Finally, based on the simulation results, the calculation formula of adsorption phase density for three pore sizes classified based on pore diameter was established, and the isothermal adsorption model was modified on the basis of adsorption phase density. The calculation result comparison between the conventional isothermal adsorption model and the modified model

shows that with the increase of pressure, the difference of the adsorption capacity calculated by both models is more than twice. The actual data processing result shows that the modified model is more consistent with the actual test data because it takes into consideration the influence of pore size on adsorption phase density. In conclusion, if shale absorption gas content is calculated directly by using the isothermal adsorption model without considering the influence of the change of pore size in shale on the adsorption phase density, the evaluation on the adsorption capacity of a shale gas reservoir will be greatly deviated. In the modified model, the calculation deviation is reduced, the calculation accuracy is increased and the calculation result is more consistent with the test result. 
**Number of references:** 29
**Main heading:** Pore size
**Controlled terms:** Data handling - Gas absorption - Gas adsorption - Gases - Isotherms - Molecular dynamics - Petroleum reservoir evaluation - Petroleum reservoirs - Shale gas - Size distribution
**Uncontrolled terms:** Adsorption capacities - Calculation accuracy - Calculation formula - Calculation results - Gas adsorption capacity - Isothermal adsorption - Resource potentials - Shale gas reservoirs
**Classification code:** 512.1.1 Oil Fields - 512.1.2 Petroleum Deposits : Development Operations - 522 Gas Fuels - 723.2 Data Processing and Image Processing - 801.4 Physical Chemistry - 802.3 Chemical Operations - 922.2 Mathematical Statistics - 951 Materials Science
**DOI:** 10.3787/j.issn.1000-0976.2021.02.009
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 17. Fine description of ramp-type small bioherms and the breakthrough of "two bioherms in one well" in high-yield gas wells: A case study of the Changxing Formation small bioherm group in the eastern Sichuan Basin

**Accession number:** 20211210116981
**Title of translation:** ""-
**Authors:** Ran, Qi (1); Tao, Xiayan (1); Xu, Changhai (1); Zhang, Lianjin (1); Huang, Tianjun (1); Liu, Shumin (1); Ding, Kongyun (1); Pu, Baiyu (1)
**Author affiliation:** (1) Exploration and Development Research Institute, PetroChina Southwest Oil & Gasfield Company, Chengdu; 610041, China
**Corresponding author:** Tao, Xiayan(taoxiayan@petrochina.com.cn)
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**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** Ramp-type bioherm is geologically characterized by lateral migration, small size and discrete distribution. The fine bioherm description is of high difficulty and the benefit development of bioherm gas reservoirs can be hardly realized. To solve these difficulties, this paper put forward a new bioherm identification method based on well-seismic combination after cognizing the geological characteristics of ramp-type bioherms deeply. And this new method plays a successful role in guiding the drilling of Well Y012-X16 in the mode of "two bioherms in one well" in the Damaoping Block of eastern Sichuan Basin. High-yield industrial gas flow of 113.65×104 m3/d is obtained during the test and great new progress is achieved in the exploration of bioherm gas reservoirs. And the following research results were obtained. First, the degree of slope at the marginal platform slope of ramp-type bioherm is only 2 °-4 °. The migration and evolution laws of bioherms are mainly controlled by the change of paleogeomorphology and sea level. As a result, small bioherms of multiple rows and multiple periods are formed and the gas-water contact of ramp-type bioherm gas reservoir is not united, presenting the characteristics of "one bioherm, one reservoir". The gas bearing property is good at the top of the bioherm. The overall gas bearing property is poorer in the early bioherm of the second Member of Upper Permian Changxing Formation and better in the late bioherm of the third Member of Changxing Formation. Second, a new bioherm identification method with "double-high" integrated seismic processing technology, data driven

"box-shaped volume" perspective technology, remaining thickness method based sedimentary paleogeomorphology restoration technology and three-dimensional visualization technology as the core is developed innovatively, which provides the fine description of ramp-type small bioherms in the three dimensional space. Third, based on the application of the new bioherm identification method, the distribution detail of the bioherms in the Damaoping Block is clarified, the development mode of "two bioherms in one well" for long horizontal sections is established and a PetroChina's new record of bioherm reservoir drilling length is set up in Well Y012-X16, which launches a new means to the benefit development of small bioherm group. Fourth, it is predicted that a number of bioherm development areas can be newly increased in the Damaoping Block, which can provide the supplement productivity of 100×104 m3/d for the development of gas reservoirs, so their natural gas exploration and development potential is huge. In conclusion, the fine description technologies for ramp-type small bioherms are conducive to the identification of ramp-type small bioherm group and the efficient exploration and development of bioherm gas reservoirs in the Sichuan Basin. 
**Number of references:** 26
**Main heading:** Reefs
**Controlled terms:** Data handling - Data visualization - Flow of gases - Gas bearings - Gases - Horizontal wells - Infill drilling - Offshore gas fields - Offshore gas wells - Oil bearing formations - Petroleum prospecting - Petroleum reservoirs - Sea level - Seismology - Three dimensional computer graphics
**Uncontrolled terms:** Discrete distribution - Exploration and development - Gas-water contacts - Geological characteristics - Identification method - Natural gas exploration - Three dimensional space - Three dimensional visualization
**Classification code:** 471.1 Oceanography, General - 481.1 Geology - 484.1 Earthquake Measurements and Analysis - 511.1 Oil Field Production Operations - 512 Petroleum and Related Deposits - 601.2 Machine Components - 631.1.2 Gas Dynamics - 723.2 Data Processing and Image Processing
**DOI:** 10.3787/j.issn.1000-0976.2021.02.002
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 18. Early-stage development evaluation technology for complex fault group gas reservoirs below 7 000 m: A case study of Qixia Formation gas reservoir in Shuangyushi structure of northwestern Sichuan Basin

**Accession number:** 20213210735488
**Title of translation:** 7 000 m-
**Authors:** Ren, Liming (1); Zhang, Lianjin (2, 3); Wang, Junjie (2, 3); Lan, Xuemei (2); Tang, Qingsong (4); Wen, Menghan (1); Wen, Wen (2)
**Author affiliation:** (1) Technical Advisory Center, PetroChina Southwest Oil & Gasfield Company, Chengdu; 610051, China; (2) Research Institute of Exploration and Development, PetroChina Southwest Oil & Gasfield Company, Chengdu; 610213, China; (3) CNPC Key Laboratory of Carbonate Reservoirs, Chengdu; 610213, China; (4) Gas Field Development and Management Department, PetroChina Southwest Oil & Gasfield Company, Chengdu; 610051, China
**Corresponding author:** Wang, Junjie(wangjunjie.kyy@petrochina.com.cn)
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**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** Gas reservoir of Middle Permian Qixia Formation in the Shuangyushi structure of northwestern Sichuan Basin has great potential of natural gas exploration and development, and it is still in the early stage of development. The geological conditions in this area is special and there is lack of dynamic and static data, so this reservoir has not been understood sufficiently and its overall large-scale benefit development has not been realized. In order to effectively predict the development prospect of the complex gas reservoir in the early stage of development and support its subsequent overall benefit development, this paper systematically evaluates the geological and gas

reservoir engineering characteristics of Qixia Formation gas reservoir in the Shuangyushi structure by using digital core, grey correlation method and big data analysis, based on new drilling and testing data. In addition, the influential factors controlling the high yield of gas wells are summarized and the development prospect of the gas reservoir is evaluated. And the following research results are obtained. First, the Qixia Formation gas reservoir in the Shuangyushi structure of northwestern Sichuan Basin has the obvious characteristics of "stratification and zonation". Fourteen local traps are developed in 6 structural high belts from west to east, with a total trap area of 246.4 km2. On the whole, it is a platform-marginal platform deposit. Breccia dolomite and saccharoidal dolomite are favorable reservoir lithofacies. Second, the reservoir is of ultra low-low porosity and low porosity and its reservoir and percolation space is mainly fracture-vug type and fracture-pore type. Third, this gas reservoir has a unified pressure system and natural gas properties, a large structural-lithologic trap is overall developed, and it is an ultra deep complex fault group gas reservoir. Fourth, the geological reserves of this gas reservoir estimated by the volumetric method exceed 1 000×108 m3, and the total dynamic reserves of production test wells are 150×108 m3. Gas well productivity is more different, and the production rate of horizontal well (highly deviated well) is improved significantly. It is confirmed based on the grey correlation method that the main geological factor controlling high-yield wells is sedimentary facies. Fifth, it is predicted by virtue of big data analysis technology that the gas recovery rate of Qixia Formation gas reservoir in the Shuangyushi structure is 2.61%, the stable production time is 11.34 years and the recovery factor is 60.5%. 
**Number of references:** 24
**Main heading:** Petroleum reservoirs
**Controlled terms:** Big data - Correlation methods - Data handling - Faulting - Gas engineering - Gases - Horizontal wells - Information analysis - Natural gas - Natural gas well production - Natural gas wells - Petroleum reservoir evaluation - Porosity - Proven reserves - Solvents
**Uncontrolled terms:** Development prospects - Gas reservoir engineering - Gas well productivities - Geological conditions - Grey correlation methods - Highly deviated wells - Influential factors - Natural gas exploration
**Classification code:** 484.1 Earthquake Measurements and Analysis - 512 Petroleum and Related Deposits - 522 Gas Fuels - 723.2 Data Processing and Image Processing - 803 Chemical Agents and Basic Industrial Chemicals - 903.1 Information Sources and Analysis - 922.2 Mathematical Statistics - 931.2 Physical Properties of Gases, Liquids and Solids
**Numerical data indexing:** Age 1.13e+01yr, Area 2.46e+08m2, Percentage 2.61e+00%, Percentage 6.05e+01%
**DOI:** 10.3787/j.issn.1000-0976.2021.07.008
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 19. Geochemical characteristics of Sinian-Cambrian natural gas in central Sichuan paleo-uplift and exploration potential of Taihe gas area

**Accession number:** 20213210735544
**Title of translation:** -
**Authors:** Xie, Zengye (1, 2); Li, Jian (1, 2); Yang, Chunlong (1, 2); Tian, Xingwang (3); Zhang, Lu (1, 2); Li, Jin (1, 2); Li, Zhisheng (1, 2); Guo, Jianying (1, 2); Xie, Wuren (1); Guo, Zeqing (1); Qi, Xuening (1, 2); Hao, Aisheng (1, 2)
**Author affiliation:** (1) Research Institute of Petroleum Exploration and Development, Beijing; 100083, China; (2) CNPC Key Laboratory of Gas Reservoir Formation and Development, Langfang; 065007, China; (3) Research Institute of Exploration and Development, PetroChina Southwest Oil & Gasfield Company, Chengdu; 610041, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 7
**Issue date:** July 25, 2021
**Publication year:** 2021
**Pages:** 1-14
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** In 2020, Well PT1 and Well JT1 in the north slope of central Sichuan paleo-uplift of the Sichuan Basin successively obtained high-yield industrial gas flow from the second Member of the Upper Sinian Dengying Formation and the Lower Cambrian Canglangpu Formation, respectively. Analysis results show that their geochemical

characteristics of natural gas are different, and they are also different from those in the Anyue Gas Field. In order to further understand the natural gas origins in the north slope of central Sichuan paleo-uplift, this paper systematically studies the natural gas origins in this area based on the analysis of experimental data of natural gas composition, natural gas carbon isotope and hydrogen isotope in abundant exploration wells, appraisal wells and development wells. And combined with current exploration understandings, the next key natural gas block of one trillion cubic meters is ascertained, i.e., the Taihe gas area. And the following research results are obtained. First, Sinian-Cambrian natural gas in Taihe gas area and that in Anyue gas area are similar in compositions and the humidity coefficient is less than 0.2%. It is shown in the natural gas origin type identification chart that they both are oil cracking gas. Second, compared with Canglangpu Formation natural gas, Dengying Formation natural gas in the Taihe gas area has lower C2H6 content, heavier #13C2 and lighter #2HCH4. The difference of C2H6 content and #13C2 is mainly related to the thermal evolution degree, and #2HCH4 is mainly affected by the salinity of water medium of original parent material deposits. Third, oil cracking gas of different evolution stages accumulates in Taihe and Anyue gas areas. In the Taihe gas area, the early-late oil cracking gas of the paleo oil reservoir accumulates. The higher the proportion of the early cracking gas is, the lighter the #13C is. In the Anyue gas area, the late oil cracking gas mainly accumulates. The higher the proportion of the late cracking gas is, the heavier the #13C is. In conclusion, in the Taihe gas area, the sealing conditions to preserve the early-late oil cracking gas are satisfactory and large-scale quality beach facies reservoirs with multiple overlays are developed, so the areas with good reservoir-caprock assemblages within or adjacent to the paleo oil reservoirs are the favorable areas for further natural gas exploration. 
**Number of references:** 62
**Main heading:** Natural gas wells
**Controlled terms:** Exploratory geochemistry - Flow of gases - Gases - Isotopes - Natural gas - Petroleum prospecting - Petroleum reservoir engineering - Petroleum reservoirs
**Uncontrolled terms:** Different evolutions - Exploration potential - Geochemical characteristic - Natural gas composition - Natural gas exploration - Natural gas origin - Reservoir-caprock assemblage - Sealing conditions
**Classification code:** 481.2 Geochemistry - 512 Petroleum and Related Deposits - 522 Gas Fuels - 631.1.2 Gas Dynamics
**Numerical data indexing:** Percentage 2.00e-01%
**DOI:** 10.3787/j.issn.1000-0976.2021.07.001
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 20. Review on the development of China's natural gas industry in the background of "carbon neutrality"

**Accession number:** 20213910945323
**Title of translation:** ""
**Authors:** Wang, Zhen (1); Kong, Yinghao (1); Li, Wei (1)
**Author affiliation:** (1) CNOOC Energy Economics Institute, Beijing; 100013, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 8
**Issue date:** August 25, 2021
**Publication year:** 2021
**Pages:** 194-202
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Number of references:** 48
**Main heading:** Natural gas
**Controlled terms:** Carbon - Economics - Gas industry - Gases - Natural gas pipelines
**Uncontrolled terms:** Carbon neutralities - China natural gas industry - Development prospects - Gas pipeline system reform - Gas-fired - Natural gas fired power generation - Natural Gas Industry - Pipeline systems - Power- generations - Supply and demand relation - System reform

**Classification code:** 522 Gas Fuels - 619.1 Pipe, Piping and Pipelines - 804 Chemical Products Generally - 971 Social Sciences
**DOI:** 10.3787/j.issn.1000-0976.2021.08.018
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 21. Evolution laws and new trends of global LNG pricing and their implications

**Accession number:** 20212510530587
**Title of translation:** LNG
**Authors:** Chen, Rui (1); Qi, Pengfei (2); Zhang, Xiaoyu (1); Li, Chunxia (1)
**Author affiliation:** (1) CNPC Economic & Technology Research Institute, Beijing; 100724, China; (2) China National Offshore Oil Corporation, Beijing; 100010, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 5
**Issue date:** May 25, 2021
**Publication year:** 2021
**Pages:** 144-152
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Number of references:** 24
**Main heading:** Gases
**Controlled terms:** Commerce - Contracts - Costs - Energy security - Financial markets - Liquefied natural gas
**Uncontrolled terms:** Asian premium - Gas-gas competition - Global LNG trade - LNG trade - Long-term agreement - Long-term contracts - Longer-term contracts - Oil price linked - Oil Prices - Pricing mechanism - Spot
**Classification code:** 523 Liquid Fuels - 525.6 Energy Policy - 902.3 Legal Aspects - 911 Cost and Value Engineering; Industrial Economics
**DOI:** 10.3787/j.issn.1000-0976.2021.05.016
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 22. Multi-scenario conception on the development of natural gas industry under the goal of carbon neutrality

**Accession number:** 20211210117133
**Title of translation:**
**Authors:** Li, Nu (1); Wang, Jianliang (1, 2); Liu, Rui (1); Tang, Xu (1, 2)
**Author affiliation:** (1) School of Economics and Management, China University of Petroleum, Beijing; 102249, China; (2) Research Center for China's Oil and Gas Industry Development, Beijing; 102249, China
**Corresponding author:** Wang, Jianliang(wangjianliang@cup.edu.cn)
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 2
**Issue date:** February 25, 2021
**Publication year:** 2021
**Pages:** 183-192
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)

**Publisher:** Natural Gas Industry Journal Agency
**Number of references:** 20
**Main heading:** Natural gas
**Controlled terms:** Carbon - Gas industry - Gases
**Uncontrolled terms:** Carbon emissions - Carbon neutralities - Carbon peaks - Carbon sink - Carbon source - Energy structures - Energy transformation - Fossil energy - Natural Gas Industry - Peak demand
**Classification code:** 522 Gas Fuels - 804 Chemical Products Generally
**DOI:** 10.3787/j.issn.1000-0976.2021.02.021
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 23. Development path of China's gas power industry under the background of low-carbon transformation

**Accession number:** 20213010677929
**Title of translation:**
**Authors:** Liu, Zhitan (1); Li, Yugang (1); Yang, Guangjun (1); Wang, Wenfei (1)
**Author affiliation:** (1) State Power Environmental Protection Research Institute Co., Ltd., Nanjing; 210031, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 6
**Issue date:** June 25, 2021
**Publication year:** 2021
**Pages:** 152-161
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Number of references:** 20
**Main heading:** Emission control
**Controlled terms:** Carbon - Coal deposits - Energy utilization - Gas emissions - Gas turbines - Natural gas - Natural gas deposits - Renewable energy resources - Sustainable development
**Uncontrolled terms:** Carbon emission intensities - Carbon neutralities - Carbon peaks - Collaborative emission reduction - Collaborative emission reduction benefit - Development path - Emission reduction - Gas power industry - Integrated development - Power industry
**Classification code:** 451.2 Air Pollution Control - 503 Mines and Mining, Coal - 512.2 Natural Gas Deposits - 522 Gas Fuels - 525.1 Energy Resources and Renewable Energy Issues - 525.3 Energy Utilization - 612.3 Gas Turbines and Engines - 804 Chemical Products Generally
**DOI:** 10.3787/j.issn.1000-0976.2021.06.018
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 24. Digital twin based intelligent risk decision-making system of compressor station equipment

**Accession number:** 20213210735560
**Title of translation:**
**Authors:** Wang, Jinjiang (1); Wang, Shuhui (1); Zhang, Laibin (1); Zhang, Zhe (2)
**Author affiliation:** (1) College of Safety and Ocean Engineering, China University of Petroleum, Beijing; 102249, China; (2) Hutubi Gas Storage Operation Area, PetroChina Xinjiang Oilfield Company, Karamay; 831100, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 7

**Issue date:** July 25, 2021
**Publication year:** 2021
**Pages:** 115-123
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Number of references:** 28
**Main heading:** Risk analysis
**Controlled terms:** Decision making - Digital storage - Gas compressors - Information management - Inspection - Maintenance - Reliability analysis - Risk assessment - Risk management
**Uncontrolled terms:** Compressor stations - Digital modeling - Dynamic equipment - Reliability-centred maintenance - Risk decision making - Risk-based - Risk-based inspection - Static equipment - Station equipment - Visual systems
**Classification code:** 618.1 Compressors - 722.1 Data Storage, Equipment and Techniques - 912.2 Management - 913.5 Maintenance - 914.1 Accidents and Accident Prevention - 922 Statistical Methods
**DOI:** 10.3787/j.issn.1000-0976.2021.07.013
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 25. Research progress in key mechanical theories of deep shale network fracturing

**Accession number:** 20210609884089
**Title of translation:**
**Authors:** Guo, Jianchun (1); Zhao, Zhihong (1); Lu, Qianli (1); Yin, Congbin (2); Chen, Chaogang (3)
**Author affiliation:** (1) State Key Laboratory of Oil and Gas Reservoir Geology and Exploitation, Southwest Petroleum University, Chengdu; 610500, China; (2) Downhole Service Company, CNPC Chuanqing Drilling Engineering Company Limited, Chengdu; 610052, China; (3) Chongqing Shale Gas Exploration and Development Co. LTD., Chongqing; 401121, China
**Corresponding author:** Zhao, Zhihong(swpuzzh@163.com)
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 1
**Issue date:** January 25, 2021
**Publication year:** 2021
**Pages:** 102-117
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** With the increase of burial depth, structural complexity and formation temperature and pressure increase, and mechanical parameters also increase to different degrees, including formation closure pressure, in-situ stress difference, Young's modulus and compressive strength. As a result, the staged multi-cluster fracturing technology of horizontal well is faced with great challenges when it is applied to the exploration and development of deep shale gas. And the following problems needs solving urgently: (1) Brittleness and fracability evaluation on deep shale under high stress; (2) Initiation and propagation of multi-cluster fractures under the condition of high stress, working fluid disturbance and anistrophy; (3) Proppant transport and laying in fracture networks; (4) Long-term support of fracture networks under high-stress hydration; (5) Mechanical mechanism of shale multi-component microstructure. In order to provide theoretical support for the formation of the effective stimulated volume of deep shale gas reservoirs, this paper systematically analyzes and illustrates the research progress and development trend of related theories based on the key mechanical theories of deep shale fracturing, including shale brittleness and fracability evaluation, competitive initiation and propagation of multi-fracture networks, proppant transport in fracture networks, support of fracture networks under high stress, and mechanism of water-rock interaction. Then, the development direction of key mechanical theories on the fracturing of deep shale gas reservoirs are pointed out as follows: (1) Fluid-solid coupled shale brittleness model and fracability evaluation model under high temperature and high stress; (2) The constitutive model of shale under water-rock interaction of high temperature and high stress and the prediction model of anisotropic

shale fracture pressure; (3) Three-dimensional fracture network propagation simulation with proppant transport; (4) Proppant diversion and transport mechanism in fracture networks and simulation of proppant transport in curved rough fracture networks; (5) Comprehensive flow conductivity optimization of fractures at all levels infracture networks; (6) Shale softening mechanism and hydration microfracture initiation and propagation mechanism. In conclusion, the research results provide guidance and reference for promoting the development of the related fracturing theories of deep shale reservoirs and the progress of fracturing technologies. 
**Number of references:** 145
**Main heading:** Fracture
**Controlled terms:** Brittleness - Compressive strength - Elastic moduli - Fracture mechanics - Horizontal wells - Hydration - Mechanisms - Petroleum prospecting - Petroleum reservoir evaluation - Petroleum reservoirs - Plasticity - Predictive analytics - Proppants - Shale gas - Stresses - Transport properties
**Uncontrolled terms:** Development directions - Exploration and development - Formation temperature - Initiation and propagation - Mechanical mechanisms - Propagation simulation - Three dimensional fracture network - Water rock interactions
**Classification code:** 511.1 Oil Field Production Operations - 512.1.1 Oil Fields - 512.1.2 Petroleum Deposits : Development Operations - 522 Gas Fuels - 601.3 Mechanisms - 931.1 Mechanics - 931.2 Physical Properties of Gases, Liquids and Solids - 951 Materials Science
**DOI:** 10.3787/j.issn.1000-0976.2021.01.009
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 26. Technological innovation and achievements in the exploration and development of shale gas in complex mountainous areas: A case study of the Zhaotong National Shale Gas Demonstration Area

**Accession number:** 20212010376125
**Title of translation:** -
**Authors:** Du, Jianping (1); Ye, Xi (1); Shi, Shuyou (1); Wu, Chen (1)
**Author affiliation:** (1) PetroChina Zhejiang Oilfield Company, Hangzhou; Zhejiang; 310023, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 4
**Issue date:** April 25, 2021
**Publication year:** 2021
**Pages:** 41-50
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** Marine shale gas in China is mainly distributed in the Yangtze Block, including the Sichuan Basin, the Yangtze River Basin and the surrounding areas, which is one of the most realistic areas of shale gas exploration and development at home. The Zhaotong National Shale Gas Demonstration Area is located in the central-western area of Weixin sag, Dianqianbei depression, i.e., the southern margin zone of the low-steep fold felt in the southern Sichuan Basin, and it is a typical mountainous block of South China. Under the influence of complex topography, strong tectonic event, fault development and high thermal evolution degree, shale gas exploration and development in this area is difficult to some extent. In order to realize the scale benefit development of shale gas in complex mountainous areas, PetroChina Zhejiang Oilfield Company has been continuously carrying out practical shale gas exploration and development in the complex zone of Dianqianbei structure in recent years. Based on the productivity construction in the Zhaotong National Shale Gas Demonstration Area, innovation and breakthroughs are made in the basic geological theory study and low-cost engineering technology research of complex mountainous shale gas, and the "three-factor control reservoir" accumulation and occurrence theory, shale reservoir classification and evaluation standard and target evaluation system of complex mountainous shale gas are established. The seismic anisotropy processing and sweet spot prediction technology and the seismic-geology-engineering integrated evaluation technology are formed. The environmentally-friendly high-performance water-based drilling fluid for horizontal wells is developed, and the rate of penetration improvement technology for shale gas horizontal wells is optimized. In addition, the complex net

fracturing technology of "long section diversion + multi-cluster close cutting + quartz sand" for shale with high complex stress is established. In this way, the technologies and strategies for the exploration and development of complex mountainous shale gas are preliminarily formed, and multiple exploration breakthroughs and efficient development of complex mountainous shale gas are realized. In conclusion, the Zhaotong National Shale Gas Demonstration Area has submitted the proved shale gas reserves of over 1 000×108 m3 and has constructed the shale gas benefit development scale of 18×108 m3/a, presenting a promising prospect of mountainous shale gas exploration and development. 
**Number of references:** 22
**Main heading:** Shale gas
**Controlled terms:** Cost engineering - Demonstrations - Drilling fluids - Engineering research - Gases - Geological surveys - Geology - Horizontal wells - Oil field development - Petroleum reservoir evaluation - Proven reserves - Seismology - Topography
**Uncontrolled terms:** Classification and evaluations - Complex mountainous areas - Complex topographies - Exploration and development - Integrated evaluation - Prediction technologies - Technological innovation - Water based drilling fluids
**Classification code:** 481.1 Geology - 484.1 Earthquake Measurements and Analysis - 512.1.1 Oil Fields - 512.1.2 Petroleum Deposits : Development Operations - 522 Gas Fuels - 901.3 Engineering Research - 911 Cost and Value Engineering; Industrial Economics - 951 Materials Science
**DOI:** 10.3787/j.issn.1000-0976.2021.04.005
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 27. Sedimentary evolution characteristics and large-scale natural gas accumulation pattern of microbial carbonate in the slope area of major paleouplift, the Sichuan Basin

**Accession number:** 20211710247377
**Title of translation:**
**Authors:** Yang, Yueming (1); Wang, Wenzhi (2); Wen, Long (3); Luo, Bing (4); Zhang, Xuan (2); Chen, Xi (2); Jia, Min (2); Long, Hongyu (2)
**Author affiliation:** (1) PetroChina Southwest Oil & Gasfield Company, Chengdu; 610051, China; (2) Exploration and Development Research Institute, PetroChina Southwest Oil & Gasfield Company, Chengdu; 610051, China; (3) Northwest Sichuan Division, PetroChina Southwest Oil & Gasfield Company, Jiangyou; 621709, China; (4) Chongqing Division, PetroChina Southwest Oil & Gasfield Company, Chongqing; 402160, China
**Corresponding author:** Wang, Wenzhi(wangwenzhi@petrochina.com.cn)
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 3
**Issue date:** March 25, 2021
**Publication year:** 2021
**Pages:** 38-47
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** After Well Gaoshi 1 realized great breakthrough of natural gas exploration in the Upper Sinian Dengying Formation of Gaoshiti-Moxi area in the core part of central Sichuan paleouplift, the Sichuan Basin in 2011, Well Jiaotan 1 achieved significant new discovery of natural gas exploration in the slope area of central Sichuan paleouplift recently. In order to further determine the oil and gas exploration target and direction of Dengying Formation, this paper analyzed the sedimentary evolution process, reservoir characteristics and hydrocarbon accumulation pattern of Dengying Formation and discussed the key factors related to the hydrocarbon accumulation of the thick microbial carbonate reservoir in this slope area. And the following research results were obtained. First, the differential sedimentation of Dengying Formation is strong in the slope area, and regional tectonic movement lays the foundation for the sedimentary paleogeomorphology which is high in the south and low in the north in this area. The sedimentary environment from the central Sichuan Basin to the northern Sichuan Basin is transformed from the restricted to the open. Compared with Gaoshiti-Moxi area, the sedimentary hydrodynamic condition in this area is stronger. Moreover, the micro-paleogeomorphology in this area is controlled by abundant contemporaneous faults developed in the

tensional setting, and step-like sedimentary paleogeomorphology is formed in the setting of the slope, which intensifies the differential sedimentation further in this area. Second, the reservoir spans largely in the vertical direction and is under the control of paleogeomorphology and contemporaneous faults. The photoaxis of Cyanobacteria increases the sedimentation rate of the carbonate rocks at the micro-paleogeomorphological high, so the mound-bank body at the paleogeomorphological high is thicker and the sediments in the low-lying area are dominated by low-energy fine grained carbonates. What's more, the cyclic temporary decline of sea level in the period of sedimentation provides the favorable conditions for the early dissolution of mound-bank body. Third, in the late stage, the platform was exposed extensively, and a catchment zone was formed in the low-lying area. As a result, the reservoir at the top of the low-lying area was eroded and the tight layer was left, which provides the good barrier condition for the mound-bank facies reservoir at the low-lying area, so as to form a lithologic trap. Fourth, during hydrocarbon generation peak, the slope area was located at the paleostructural high and had developed fault systems, so it is the accumulation direction area of paleo-oil reservoirs. In conclusion, stronger differential sedimentation in the slope area is the main control factor of the development of lithologic trap. And the slope area of central Sichuan paleouplift was located at the paleostructural high during the hydrocarbon generation peak, which is the key to large-scale natural gas accumulation. 
**Number of references:** 27
**Main heading:** Discovery wells
**Controlled terms:** Carbonates - Carbonation - Catchments - Gases - Geological surveys - Hydrocarbons - Natural gas - Natural gas wells - Offshore gas fields - Petroleum prospecting - Petroleum reservoir engineering - Petroleum reservoirs - Sea level - Sedimentation - Sedimentology
**Uncontrolled terms:** Fine-grained carbonates - Hydrocarbon accumulation - Hydrodynamic conditions - Natural gas exploration - Natural-gas accumulation - Oil and gas exploration - Reservoir characteristic - Sedimentary environment
**Classification code:** 471.1 Oceanography, General - 481.1 Geology - 512 Petroleum and Related Deposits - 522 Gas Fuels - 802.2 Chemical Reactions - 802.3 Chemical Operations - 804.1 Organic Compounds - 804.2 Inorganic Compounds
**DOI:** 10.3787/j.issn.1000-0976.2021.03.005
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 28. Distribution pattern and formation mechanism of the strike-slip fault system in the central Tarim Basin

**Accession number:** 20211710247367
**Title of translation:**
**Authors:** Li, Guohui (1); Li, Shiyin (1); Li, Huiyuan (1); Sun, Chong (1); Xie, Zhou (1); Li, Fei (1)
**Author affiliation:** (1) PetroChina Tarim Oilfield Company, Korla; 841000, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 3
**Issue date:** March 25, 2021
**Publication year:** 2021
**Pages:** 30-37
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** Strike-slip faults are developed in the Ordovician carbonate rocks of central Tarim Basin (hereinafter referred to as "platform basin area") and they have an obvious control effect on reservoirs and hydrocarbon accumulation. However, the formation mechanism of strike-slip faults is not figured out clearly, which hampers the oil and gas exploration and development progress in this area. Based on 3D seismic interpretation results, combined with previous research achievements and understandings, this paper describes the overall distribution pattern of strike-slip faults in the platform basin area, and analyzes their geometric characteristics and formation periods. Then, based on the pre-existing tectonic background and regional tectonic stress field, the formation mechanisms of strike-slip faults were discussed and the distribution laws of potential strike-slip faults were predicted. And the following research results were obtained. First, the strike-slip faults in the platform basin area are controlled by pre-existing structures and a

united large strike-slip fault system was formed under the action of compression stress from southwest, southeast and north at the end of Middle Ordovician. Second, F5 fault in the overall pattern of strike-slip faults in the platform basin area is the most important, which adjusts the movement difference between the east and the west blocks, which is the boundary between the east and the west strike-slip fault systems in the platform basin area. The transition faults such as F10 and F17 faults decompose the reduction of north-south strata, which form the boundary of the fault system and control the development range of strike-slip faults in the fault system. Third, the strike-slip fault system in the platform basin area can be divided into four systems, namely pure shear fault system in Tabei uplift, left-lateral fault system in Tazhong uplift, right-lateral fault system in Bachu uplift, and transform fault system in Aman transition zone. In conclusion, fault F5, F10 and F17 are of high fault activity strength and they have a strong effect on reservoir reworking and oil and gas migration, so it is currently the most favorable oil and gas exploration target in fault controlled areas. What's more, it is predicted that a transform fault symmetrical to fault F10 may be developed in the Aman transition zone to the west of fault F5 and a NE trending strike-slip fault may be developed in the west of Tazhong uplift and Bachu uplift, which is a worthy object for the next oil and gas exploration. 
**Number of references:** 30
**Main heading:** Fault slips
**Controlled terms:** Geological surveys - Petroleum prospecting - Petroleum reservoir engineering - Seismology - Strike-slip faults - Structural geology - Transform faults
**Uncontrolled terms:** Central Tarim Basin - Distribution patterns - Geometric characteristics - Hydrocarbon accumulation - Oil and gas exploration - Oil and gas migration - Research achievements - Strike-slip fault systems
**Classification code:** 481.1 Geology - 484.1 Earthquake Measurements and Analysis - 512.1.2 Petroleum Deposits : Development Operations
**DOI:** 10.3787/j.issn.1000-0976.2021.03.004
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 29. Main factors controlling the formation of giant marine carbonate gas fields in the Sichuan Basin and exploration ideas

**Accession number:** 20213010678071
**Title of translation:**
**Authors:** Li, Jianzhong (1); Gu, Zhidong (1); Lu, Weihua (1); Jiang, Hua (1); Zhai, Xiufen (1); Liu, Guixia (1); Zhao, Rongrong (2)
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**Corresponding author:** Gu, Zhidong(guzhidong@petrochina.com.cn)
**Source title:** Natural Gas Industry
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**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** So far, 12 giant marine carbonate gas fields have been discovered in the Sinian-Middle Triassic of the Sichuan Basin and marine carbonate gas reservoirs have become an important natural gas exploration domain and direction in the Sichuan Basin. In order to further expand the exploration domain of marine carbonate gas reservoirs in the Sichuan Basin, this paper firstly analyzes the basic characteristics of the discovered giant marine carbonate gas fields. Based on this, the main factors controlling the formation of giant marine carbonate gas fields were summarized systematically and the corresponding exploration ideas and evaluation methods were put forward. And the following research results are obtained. First, the giant marine carbonate gas fields in the Sichuan Basin have high quality source-reservoir-cap assemblages of lower source rock and upper reservoir with the Lower Cambrian, the Lower Silurian and the Upper Permian as the major source rocks, the mound-shoal complex of the Upper Sinian Dengying Formation, the grain shoal of the Lower Cambrian Longwangmiao Formation, the Carboniferous dolomite, the reef-

shoal complex of the Upper Permian Changxing Formation-Lower Triassic Feixianguan Formation and the grain shoal of the Lower Triassic Jialingjiang Formation-Middle Triassic Leikoupo Formation as the main reservoirs, and the Triassic evaporite, the Lower Cambrian shale and the Middle Permian mudstone as the regional cap rocks. Second, the formation of giant marine carbonate gas fields in the Sichuan Basin is mainly controlled by the following three factors: Palaeotectonic environment and tectonic evolution control the formation and distribution of "uplift-depression pattern" in the basin, and thus control the formation and distribution of major hydrocarbon source rocks and large-scale reservoirs; Palaeogeomorphic high belts of palaeo-uplifts and palaeo-slopes control the distribution of high-energy depositional facies belts (such as reefs and shoals), large-area karst reservoirs and ancient oil/gas reservoirs; Regional and direct cap rocks control the spatial distribution and enrichment of giant gas fields. In conclusion, the exploration ideas for the giant marine carbonate gas field in the Sichuan Basin are proposed as: determining favorable exploration plays according to the "uplift-depression pattern", searching for high-energy depositional facies belts in the palaeogeomorphic high belts, searching for reservoirs based on seismic prediction, and determining targets based on ancient and modern trap conditions. In addition, the evaluation methods are to determine the lithofacies and palaeogeographic pattern of the basin by virtue of well-seismic-outcrop comprehensive analysis, precisely characterize high-energy depositional facies belts of reef (mound)-shoal complex by means of impression method, residual thickness method and seismic facies, and comprehensively evaluate favorable exploration plays and targets based on the conditions of source rocks, reservoirs and cap rocks. 
**Number of references:** 51
**Main heading:** Natural gas fields
**Controlled terms:** Carbonation - Deposition - Gases - Petroleum prospecting - Petroleum reservoir evaluation - Petroleum reservoirs - Reefs - Rocks - Seismology
**Uncontrolled terms:** Basic characteristics - Comprehensive analysis - Feixianguan formation - High quality source - Hydrocarbon source rocks - Jialingjiang formation - Natural gas exploration - Seismic predictions
**Classification code:** 481.1 Geology - 484.1 Earthquake Measurements and Analysis - 512 Petroleum and Related Deposits - 802.2 Chemical Reactions - 802.3 Chemical Operations
**DOI:** 10.3787/j.issn.1000-0976.2021.06.002
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 30. Occurrence morphology of bitumen in Dengying Formation deep and ultra-deep carbonate reservoirs of the Sichuan Basin and its indicating significance to oil and gas reservoirs

**Accession number:** 20213910945251
**Title of translation:**
**Authors:** Liu, Shugen (1, 2); Li, Zeqi (1); Deng, Bin (1); Sun, Wei (1); Li, Zhiwu (1); Ding, Yi (1); Song, Jinming (1); Wu, Juan (1)
**Author affiliation:** (1) State Key Laboratory of Oil & Gas Reservoir Geology and Exploitation, Chengdu University of Technology, Chengdu; 610059, China; (2) Xihua University, Chengdu; 610039, China
**Corresponding author:** Li, Zeqi(lzqlizard@126.com)
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
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**Pages:** 102-112
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** Abundant bitumen can be discovered in the wells of Upper Sinian Dengying Formation in the Sichuan Basin and their peripheral outcrop sections. As the cracking product of a paleo-oil reservoir, the occurrence morphologies and distribution characteristics of bitumen in carbonate reservoirs can indicate the preservation, migration and other key information of (paleo-) oil and gas reservoirs. In order to provide reference and basis for the deep and ultra-deep oil and gas exploration in the Sichuan Basin and the basins in western China, this paper systematically studies the

occurrence morphological characteristics of bitumen in deep and ultra-deep carbonate reservoirs in the wells Gaoshi 1 of the Sichuan Basin by carrying out thin section observation, scanning electron microscope-energy spectrum analysis and fluid inclusion organic geochemical analysis on the cores of the fourth Member of Dengying Formation (Deng 4 Member). In addition, the coupling relationship between the occurrence morphology of bitumen and the key event of hydrocarbon accumulation is revealed. And the following research results are obtained. First, the solid bitumen in the Deng 4 Member deep and ultra-deep reservoir has two types of occurrence morphology. The first type of bitumen adheres to pore walls in the shape of a rim or exits in pores in the form of sticky branch (e.g. Wells Chuanshen 1 and Gaoshi 1). There are more obvious contraction joints and residual pores generated by in-situ thermal cracking in this type of bitumen. And combined with fluid inclusion and burial thermal history, it can effectively indicate that a paleo-gas reservoir has been preserved so far since the paleo-oil reservoir was thermally cracked into carbonaceous bitumen. The second type of bitumen is distributed at intra- and inter-neogenic mineral crystals in pores disorderly in the shape of grain and band (e.g. Wells Mashen 1 and Wutan 1) and it has obvious breaking edges. It reveals that after a paleo-oil reservoir was thermally cracked into carbonaceous bitumen, the paleo-gas reservoir suffered blowdown and gas escape and neogenic fluid minerals moved into reservoirs to fill in pores. In conclusion, the occurrence morphologies and distribution characteristics of bitumen in deep and ultra-deep carbonate reservoirs can effective indicate the hydrocarbon accumulation and evolution process of paleo-oil and gas reservoirs. 
**Number of references:** 27
**Main heading:** Morphology
**Controlled terms:** Analytical geochemistry - Bituminous materials - Carbonation - Gases - Geological surveys - Mineralogy - Petroleum geology - Petroleum prospecting - Petroleum reservoir engineering - Petroleum reservoirs - Scanning electron microscopy - Spectrum analysis
**Uncontrolled terms:** Bitumen morphology - Carbonate rock - Deep and ultra deep oil and gas exploration - Dengying formation - Indicating significance to (paleo-) oil and gas reservoir - Oil and gas exploration - Oil and gas reservoir - Sichuan Basin - Ultra deeps - Upper sinian dengying formation
**Classification code:** 411 Bituminous Materials - 481.1 Geology - 481.2 Geochemistry - 482 Mineralogy - 512.1 Petroleum Deposits - 512.1.1 Oil Fields - 512.1.2 Petroleum Deposits : Development Operations - 801 Chemistry - 802.2 Chemical Reactions - 931.2 Physical Properties of Gases, Liquids and Solids - 951 Materials Science
**DOI:** 10.3787/j.issn.1000-0976.2021.08.010
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 31. Evolution laws of fracture permeability of deep shale in the process of shear slip

**Accession number:** 20210609884086
**Title of translation:**
**Authors:** Lu, Zhaohui (1, 2); Jia, Yunzhong (1, 2, 3); Tang, Jiren (3); Cheng, Yugang (1, 2); He, Pei (1, 2); Ouyang, Liming (1, 2)
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**Corresponding author:** Jia, Yunzhong(yunzhong.jia@geo.uu.se)
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
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**Issue date:** January 25, 2021
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**Pages:** 146-153
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** To investigate the evolution laws of fracture permeability of deep shale in the process of shear slip, this paper selected the Lower Silurian Longmaxi Formation shale samples from the Puling area of the Sichuan Basin and the Marcellus shale outcrop samples from Pennsylvania of the USA as the research objects to perform fracture

shear slip experiments under different normal stresses and slip rates. Then, the variation data of fracture permeability was collected using the pulse-decay method. Finally, the influential laws of normal stress, shale mineralogy and slip rate on the long-term flow conductivity of fractures in deep shale were analyzed. And the following research results were obtained. First, the shale fracture permeability in the process of shear slip is influenced comprehensively by two factors, i.e., shear failure of fracture surface asperity and shear dilation. Second, the shear failure of fracture surface asperity results in the decrease of porosity, effective hydraulic aperture and permeability. And the variation of permeability is mainly under the comprehensive effect of shale mineralogy, normal stress and slip rate. Third, under high normal stress and high slip rate, the surface asperity of the shale fracture with a high phyllosilicate content is damaged by the shear action, and its permeability reduction amplitude is larger than that of the shale fracture with a high tectosilicate content. Fourth, shear dilation of slip fractures leads to the increase of fracture permeability and effective hydraulic aperture. And the variation of permeability is mainly influenced by slip distance, dilation angle, shale mineralogy and normal stress. Fifth, under low normal stress and low slip rate, the permeability of the shale fracture with a high tectosilicate content is increased slightly due to shear dilation. Sixth, it is recommended to adopt large displacement and high injection pressure in the early stage of hydraulic fracturing to form large-scale complex fracture networks and apply lower fluid injection rate and injection pressure in the later stage to drive the slip of hydraulic fractures and natural fractures to a certain degree, so as to improve fracture permeability and overall reservoir permeability effectively. 
**Number of references:** 23
**Main heading:** Shale
**Controlled terms:** Digital storage - Fracture - Hydraulic fracturing - Mechanical permeability - Minerals - Petroleum reservoir engineering
**Uncontrolled terms:** Comprehensive effect - Fracture permeability - High injection pressures - Injection pressures - Large displacements - Permeability reduction - Reservoir permeability - Surface asperities
**Classification code:** 482.2 Minerals - 512.1.2 Petroleum Deposits : Development Operations - 722.1 Data Storage, Equipment and Techniques - 951 Materials Science
**DOI:** 10.3787/j.issn.1000-0976.2021.01.013
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 32. Practice of high-intensity volume fracturing in the Shaximiao Formation tight sandstone gas reservoirs of the Qiulin Block, Central Sichuan Basin

**Accession number:** 20211210117020
**Title of translation:**
**Authors:** Zheng, Youcheng (1); Han, Xu (2, 3); Zeng, Ji (2); Zhou, Changlin (2); Zhou, Lang (1); Chen, Weihua (2)
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**Corresponding author:** Zeng, Ji(zeng_ji@petrochina.com.cn)
**Source title:** Natural Gas Industry
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**Issue date:** February 25, 2021
**Publication year:** 2021
**Pages:** 92-99
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** In order to solve the difficulties in the volume fracturing stimulation of Middle Jurassic Shaximiao Formation tight sandstone reservoirs in the Qiulin Block of Central Sichuan Basin and explore the adaptability of high-intensity volume fracturing technology, we selected the outcrop samples of Shaximiao Formation tight sandstone in the Qiulin Block to carry out the physical simulation experiment of true triaxial hydraulic fracturing. On this basis, horizontal well cluster perforation was optimally designed by using the production prediction model of staged multi-cluster fracturing horizontal wells. Then, based on the liquid control and proppant increase mode, three rounds of pilot tests were carried out on the tight sandstone reservoirs in this area. And the following research results were obtained. First, natural

fractures in the Shaximiao Formation tight sandstone reservoir of the Qiulin Block are undeveloped, and hydraulic fractures are morphologically dominated by symmetric double-wing fractures, so complex fracture networks can be hardly formed. In addition, the reservoir is of medium to strong water sensitivity, so conventional volume fracturing is not adaptive to the reservoir stimulation in this block. Second, the connotation of high-intensity volume fracturing technology is to carry out multi-cluster perforation in each section to form multiple independent double-wing fractures and to implement the proppant injection mode of liquid control and proppant increase to reduce the inflow fluid while ensuring the high-intensity proppant injection, so as to reduce the damage of inflow fluid to the formation. Third, there are 10 fracturing sections in Well Qiulin 207-5-H2, with 7-12 clusters in each section, and the displacement is in the range of 16-18 m3/min. According to the fluid control and proppant increase mode, 12 146 m3 slick water and 4 170 t proppant are injected in total. The tested production rate and absolute open flow of natural gas after the fracturing are up to 83.88×104 m3/d and 214.05×104 m3/d, respectively. Fourth, with the decrease of cluster spacing, the cumulative gas production increases gradually, but when the cluster spacing is less than 15 m, the increase amplitude of cumulative gas production decreases. Fifth, when the proppant injection intensity is lower than 6 t/m, the tested gas production per kilometer of stimulated section in a horizontal well overall presents an increasing trend with the increase of proppant injection intensity. When the proppant injection intensity is higher than 6 t/m, however, the tested gas production per kilometer of stimulated section does not increase significantly with the increase of proppant injection intensity. Sixth, as the included angle between the borehole trajectory and the direction of maximum horizontal principal stress increases, the tested gas production per kilometer of stimulated section overall presents an increasing trend. When the hydraulic fracture is nearly perpendicular to the borehole, the effective discharge area is the largest and the tested gas production per kilometer of stimulated section is also the highest. In conclusion, the fracturing mode of high production well has a borehole trajectory of large included angle, perforation cluster spacing of 10 m or so, proppant injection intensity of 5 t/m and large-displacement slick water + continuous injection of combined particle size proppant. 
**Number of references:** 21
**Main heading:** Injection (oil wells)
**Controlled terms:** Boreholes - Fracture - Gas industry - Gases - Horizontal wells - Particle size - Petroleum reservoirs - Predictive analytics - Proppants - Sandstone - Tight gas - Well perforation
**Uncontrolled terms:** Borehole trajectories - Central Sichuan Basin - Continuous injections - Cumulative gas productions - Maximum horizontal principal stress - Physical simulation experiment - Reservoir stimulations - Tight sandstone reservoirs
**Classification code:** 482.2 Minerals - 511.1 Oil Field Production Operations - 512.1.1 Oil Fields - 522 Gas Fuels - 951 Materials Science
**Numerical data indexing:** Size 1.00e+01m, Size 1.50e+01m, Volume 1.21e+04m3
**DOI:** 10.3787/j.issn.1000-0976.2021.02.011
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 33. Development of natural gas industry in China: Review and prospect

**Accession number:** 20213910945153
**Title of translation:**
**Authors:** Li, Luguang (1)
**Author affiliation:** (1) PetroChina Company Limited, Beijing; 100007, China
**Corresponding author:** Li, Luguang(liluguang@petrochina.com.cn)
**Source title:** Natural Gas Industry
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**Pages:** 1-11
**Language:** Chinese
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**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Number of references:** 31
**Main heading:** Natural gas

**Controlled terms:** Carbon - Energy policy - Energy security - Environmental protection - Gas industry - Gases - Natural gas deposits - Petroleum deposits - Proven reserves - Sustainable development
**Uncontrolled terms:** China - Development course - Development prospects - Energy - Energy environment policy - Environment policies - Exploration and development - Exploration prospects - Natural Gas Industry - Natural gas reserves - New proved natural gas reserve
**Classification code:** 454.2 Environmental Impact and Protection - 512.1 Petroleum Deposits - 512.1.2 Petroleum Deposits : Development Operations - 512.2 Natural Gas Deposits - 522 Gas Fuels - 525.6 Energy Policy - 804 Chemical Products Generally
**Numerical data indexing:** Percentage 1.40E+01%
**DOI:** 10.3787/j.issn.1000-0976.2021.08.001
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 34. Heat transfer behaviors and operation optimization of LNG submerged combustion vaporizers

**Accession number:** 20213010677915
**Title of translation:** LNG
**Authors:** Wang, Yujuan (1, 2); Li, Shuyi (2); Chen, Wenjie (2); Tang, Jianfeng (1); Li, Xuetao (1, 3); Wang, Dongxu (1); Yu, Xiao (1)
**Author affiliation:** (1) College of Pipeline and Civil Engineering, China University of Petroleum-East China, Qingdao; 266000, China; (2) Sinopec Qingdao Liquefied Natural Gas Co., Ltd., Qingdao; 266000, China; (3) Qingdao Hisense Hitachi Air-Conditioning Systems Co., Ltd., Qingdao; 266000, China
**Source title:** Natural Gas Industry
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**Publication year:** 2021
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**Language:** Chinese
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**CODEN:** TIGOE3
**Document type:** Journal article (JA)
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**Number of references:** 21
**Main heading:** Oil terminals
**Controlled terms:** Boundary layers - Combustion - Cost reduction - Gasification - Heat transfer - Thermodynamic properties
**Uncontrolled terms:** Core technology - Heat transfer behavior - Inlet pressures - Inlet speed - LNG terminal - Operational optimization - Operations optimization - Submerged combustion vaporizer - Submerged combustion vaporizers - Water bath temperatures
**Classification code:** 407.1 Maritime Structures - 641.1 Thermodynamics - 641.2 Heat Transfer - 802.3 Chemical Operations
**Numerical data indexing:** Pressure 7.20E+06Pa to 8.00E+06Pa
**DOI:** 10.3787/j.issn.1000-0976.2021.06.016
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 35. Influence of horizontal well section length on the depressurization development effect of natural gas hydrate reservoirs

**Accession number:** 20212510530502
**Title of translation:**
**Authors:** Zhuo, Lubin (1); Yu, Jing (1); Zhang, Hongyuan (1); Zhou, Cuiping (1)
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**Language:** Chinese
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**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Number of references:** 22
**Main heading:** Horizontal wells
**Controlled terms:** Computer software - Dissociation - Gas hydrates - Gases - Heat transfer - Horizontal drilling - Hydration - Natural gas - Numerical models - Oil well drilling
**Uncontrolled terms:** Depressurization development - Depressurizations - Development effect - Gas productions - Gas saturations - Hydrate saturation - Natural gas hydrates - Natural gas-hydrates - Physical experiments - Productivity changes
**Classification code:** 511.1 Oil Field Production Operations - 512.1.1 Oil Fields - 512.1.2 Petroleum Deposits : Development Operations - 512.2 Natural Gas Deposits - 522 Gas Fuels - 641.2 Heat Transfer - 723 Computer Software, Data Handling and Applications - 802.2 Chemical Reactions - 921 Mathematics
**DOI:** 10.3787/j.issn.1000-0976.2021.05.017
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 36. Construction of natural gas energy-metering system in China: A discussion

**Accession number:** 20213910945173
**Title of translation:**
**Authors:** Huang, Weihe (1, 2); Duan, Jiqin (3, 4, 5); Chang, Honggang (2, 3, 4); Luo, Qin (2, 3, 4); Zhou, Li (3, 4); Sun, Qi (1, 2)
**Author affiliation:** (1) PetroChina Company Limited, Beijing; 100007, China; (2) China National Natural Gas Standardization Technology Committee, Beijing; 100007, China; (3) Natural Gas Research Institute, PetroChina Southwest Oil & Gasfield Company, Chengdu; 610041, China; (4) CNPC Key Laboratory of Natural Gas Quality Control and Energy Measurement, Chengdu; 610041, China; (5) Chengdu Verification Branch, National Oil and Gas Large Flowrate Measurement Station, Chengdu; 610041, China
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**Pages:** 186-193
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Number of references:** 35
**Main heading:** Methane
**Controlled terms:** Abrasive cutting - Big data - Coal deposits - Coal industry - Construction equipment - Gas industry - Gases
**Uncontrolled terms:** Energy - Energy measurement system - Gas pipeline networks - Gas sources - Measurement standards - Measurement technologies - Metering systems - Mixed transportation - Natural gas energy - Value traceability
**Classification code:** 405.1 Construction Equipment - 503 Mines and Mining, Coal - 522 Gas Fuels - 524 Solid Fuels - 604.1 Metal Cutting - 606.1 Abrasive Materials - 723.2 Data Processing and Image Processing - 804.1 Organic Compounds

**Numerical data indexing:** Age 1.9992E+00yr, Energy 3.40E+07J, Energy 4.30E+07J, Percentage 2.00E+01%
**DOI:** 10.3787/j.issn.1000-0976.2021.08.017
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 37. Shale gas enrichment model and exploration implications in the mountainous complex structural area along the southwestern margin of the Sichuan Basin: A new shale gas area

**Accession number:** 20212510530417
**Title of translation:** :
**Authors:** Yang, Ping (1, 2); Yu, Qian (1, 2); Mou, Chuanlong (1, 2); Wang, Zhengjiang (1, 2); Liu, Wei (1, 2); Zhao, Zhan (1, 2); Liu, Jiahong (1, 2); Xiong, Guoqing (1, 2); Deng, Qi (1, 2)
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**Source title:** Natural Gas Industry
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**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** Marine shale gas in the southern Sichuan Basin is the most successful area of shale gas exploration and development in China. In order to open up new shale gas fields and search for new shale gas reserves and production replacement blocks, it is necessary to continuously establish and complete the standards on shale gas reservoir evaluation and area selection under different structural settings. The early exploration practice shows that shale in the mountainous complex structural area along the southwestern margin of the Sichuan Basin varies greatly in the gas bearing property, so systematical analysis and study on the shale gas enrichment mechanisms in this area is of great significance to searching for new shale gas exploration areas. Based on drilling data of 5 wells in the mountainous complex structural area along the southwestern margin of the Sichuan Basin, the main factors controlling the shale gas bearing property and the shale gas enrichment model were discussed based on the systematical experiments and analysis of the outcrops, cores and cuttings of Longmaxi Formation shale from the aspects of organic geochemistry, physical property, gas content, hydrocarbon generation history and pore evolution history, so as to lay a solid geological basis for the birth of a new shale gas area. And the following research results were obtained. First, the shale of the first submember of first Member of Longmaxi Formation (S1l11) in the mountainous complex structural area along the southwestern margin of the Sichuan Basin has an average TOC of 3.02%-4.97% and Ro of 2.38%-3.37%, and the average total gas content in local enrichment zones is up to 4.62 m3/t, so it is classified as quality shale. Second, the detailed studies on hydrocarbon generation history indicate that the shale has the characteristics of "low thermal evolution rate and low maturity". It is characterized by late hydrocarbon generation, low thermal evolution rate, low current maturity and short late diffusion time, which are favorable for shale gas enrichment. Third, the pore evolution history reveals that shale pore evolution can be divided into six stages, i.e., sharp pore reduction, pore reduction, organic pore formation, pore preservation, organic pore dissipation and karstification, and organic pore and TOC are the most direct control factors of shale gas content. Fourth, favorable shelf facies belt is conducive to the formation of large-scale reservoir space and effective pores, and diversities of preservation conditions under different structural styles and at different structural positions control different pore evolution stages. The shale gas in the mountainous complex structural area is characterized by horizontal zoning and differential enrichment. "Low thermal evolution rate and low maturity" and "slow structural uplifting" are beneficial to the long-term enrichment and preservation of shale gas. In conclusion, the mountainous complex structural area along the southwestern margin of the Sichuan Basin has a shale gas enrichment model of "sedimentation controlling source rocks, diagenesis controlling reservoirs and structure controlling preservation". This research result provides idea and reference for searching for new shale gas areas and fields. © 2021, Natural Gas Industry Journal Agency. All right reserved.
**Number of references:** 36
**Main heading:** Oil bearing formations

**Controlled terms:** Gas bearings - Gas industry - Gases - Geochemistry - Geological surveys - Hydrocarbons - Petroleum reservoir evaluation - Petroleum reservoirs - Proven reserves - Shale gas
**Uncontrolled terms:** Bearing properties - Exploration practices - Hydrocarbon generation - Hydrocarbon-generation history - Organic geochemistry - Preservation condition - Structural setting - Systematical analysis
**Classification code:** 481.1 Geology - 481.2 Geochemistry - 512.1.1 Oil Fields - 512.1.2 Petroleum Deposits : Development Operations - 522 Gas Fuels - 601.2 Machine Components - 804.1 Organic Compounds
**Numerical data indexing:** Percentage 2.38e+00% to 3.37e+00%, Percentage 3.02e+00% to 4.97e+00%
**DOI:** 10.3787/j.issn.1000-0976.2021.05.005
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 38. Co-production process of light hydrocarbon recovery and helium extraction from natural gas

**Accession number:** 20212510530467
**Title of translation:**
**Authors:** Rong, Yangjia (1, 2); Wang, Chengxiong (1); Zhao, Yunkun (1); Hu, Chengxing (3); Rao, Dong (2, 4); Zhu, Lin (2)
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**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Number of references:** 24
**Main heading:** Extraction
**Controlled terms:** Computer software - Energy utilization - Helium - Hydrocarbons - Recovery - Refrigeration
**Uncontrolled terms:** Co-production process - Cooling Capacity - Cryogen refrigeration - Expansion refrigeration - Extraction process - Helium extraction - HYSYS software - Light hydrocarbon recovery - Parameter analysis - Process simulations
**Classification code:** 525.3 Energy Utilization - 644.1 Refrigeration Methods - 723 Computer Software, Data Handling and Applications - 802.3 Chemical Operations - 804 Chemical Products Generally - 804.1 Organic Compounds
**Numerical data indexing:** Percentage 1.727E+01%, Percentage 2.22E+01%, Percentage 3.83E+01%, Percentage 9.339E+01%, Percentage 9.911E+01%
**DOI:** 10.3787/j.issn.1000-0976.2021.05.014
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 39. A new natural gas demand forecasting model and its application in the Sichuan-Chongqing area

**Accession number:** 20212010376183
**Title of translation:** -
**Authors:** Li, Hongbing (1); Zhang, Jijun (1)

**Author affiliation:** (1) School of Economics and Management, Southwest Petroleum University, Chengdu; Sichuan; 610500, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 4
**Issue date:** April 25, 2021
**Publication year:** 2021
**Pages:** 167-175
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Number of references:** 23
**Main heading:** Forecasting
**Controlled terms:** Functions - Gases - Industrial research - Natural gas - Regression analysis - Uncertainty analysis
**Uncontrolled terms:** Chongqing - Demand forecast - Demand function - Double logarithmic demand function - Grey correlation degrees - Influential factors - Sichuan - Sichuan-chongqing area - Stepwise regression analysis - Urbanization rate
**Classification code:** 522 Gas Fuels - 901.3 Engineering Research - 912.1 Industrial Engineering - 921 Mathematics - 922.1 Probability Theory - 922.2 Mathematical Statistics
**DOI:** 10.3787/j.issn.1000-0976.2021.04.018
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 40. Genetic classification and large-scale reservoir development law of burial dolomite: Cognition based on LA-ICP-MS trace elemental mapping and U-Pb dating

**Accession number:** 20214311047220
**Title of translation:** --U-Pb
**Authors:** Qiao, Zhanfeng (1, 2); Shao, Guanming (1, 2); Luo, Xianying (1, 2); Cao, Peng (1, 2); Sun, Xiaowei (1, 2); Shen, Anjiang (1, 2)
**Author affiliation:** (1) PetroChina Hangzhou Research Institute of Petroleum Geology, Hangzhou; 310023, China; (2) CNPC Key Laboratory of Carbonate Reservoir, Hangzhou; 310023, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
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**Publication year:** 2021
**Pages:** 46-56
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** Burial crystalline dolomite with huge natural gas exploration potential is extensively developed in the Tarim, Sichuan and Ordos Marine Basins and it is an important exploration field and target of deep natural gas, but its reservoir development law has not been understood sufficiently yet. In order to clarify the reservoir formation potential of burial dolomite of different geneses, this paper takes the Penglaiba Formation of Lower Ordovician in Yong'anba section of the Tarim Basin as the research object to discuss the genetic classification and reservoir formation mechanism of burial dolomite by analyzing its petrographic and geochemical characteristics, combined with the analysis results of LA-ICP-MS trace elemental mapping and laser ablation U-Pb dating. And the following research results are obtained. First, burial dolomite is divided into two types. Type I burial dolomite is formed from penecontemporaneous dolomite after recrystallization in the burial stage and type II burial dolomite is formed from limestone after replacement in the shallow burial stage. The former is initially formed in the penecontemporaneous

stage and then recrystallized in the shallow burial stage. The latter is initially formed in the shallow burial stage and extends to medium-deep burial, which is in the form of crystalline dolomite. Second, even though two types of burial dolomite are obviously different in petrographic and geochemical characteristics, they both are derived from marine-sourced dolomitized fluids. Type I is formed under the condition of high water/rock ratio and its geochemical characteristics represent the characteristics of dolomitized fluids, whereas type II is formed under the condition of low water/rock ratio and its geochemical characteristics represent the characteristics of surrounding rock. In conclusion, type I burial dolomite is superior in reservoir formation potential and its related reservoir development is of facies control, which lays a foundation for the large-scale stratified development of burial dolomite reservoir. These research results are of important theoretical guiding significance to optimize the exploration direction of deep oil and gas. 
**Number of references:** 32
**Main heading:** Laser ablation
**Controlled terms:** Binary alloys - Geochronology - Geological surveys - Inductively coupled plasma mass spectrometry - Inert gases - Mapping - Mass spectrometers - Metamorphic rocks - Natural gas - Petroleum prospecting - Recrystallization (metallurgy)
**Uncontrolled terms:** Burial dolomite - Dolomite reservoirs - Elemental mapping - LA-ICP-MS trace elemental mapping - Laser-ablation U-pb dating - Lasers ablations - Lower ordovician - Penglaibum formation of low ordovician - Tarim Basin - U-Pb dating
**Classification code:** 405.3 Surveying - 481.1 Geology - 481.3 Geophysics - 512.1.2 Petroleum Deposits : Development Operations - 522 Gas Fuels - 531.1 Metallurgy - 641.2 Heat Transfer - 744.8 Laser Beam Interactions - 801 Chemistry - 804.2 Inorganic Compounds
**DOI:** 10.3787/j.issn.1000-0976.2021.09.005
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 41. Determination of zero water potential surface and division of formation pressure system: A case study of Yan'an Gas Field in the Ordos Basin

**Accession number:** 20213210735510
**Title of translation:** -
**Authors:** Han, Xiaojie (1, 2, 3); Fan, Changyu (1, 2, 3); Gao, Chao (3, 4); Zhang, Lixia (3, 4); Yin, Jintao (3, 4); Wang, Chengda (3, 4); Wang, Ning (3, 4)
**Author affiliation:** (1) State Key Laboratory of Continental Dynamics, Xi'an; 710069, China; (2) Department of Geology, Northwest University, Xi'an; 710069, China; (3) Shaanxi Key Laboratory of Lacustrine Shale Gas Accumulation and Exploitation (Preparation), Xi'an; 710069, China; (4) Research Institute of Shanxi Yanchang Petroleum (Group) Co., Ltd., Xi'an; 710065, China
**Corresponding authors:** Fan, Changyu(330413771@qq.com); Gao, Chao(ycgaochao@qq.com)
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 7
**Issue date:** July 25, 2021
**Publication year:** 2021
**Pages:** 33-40
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** Calculation of formation hydrostatic pressure and division of formation pressure system are commonly performed with the earth surface as the zero point. However, this method is not suitable for the areas where the earth surface relief is great and the pressure-bearing surface is lower than the earth surface. What's more, water level monitoring used on site also faces more problems. In order to accurately understand the pressure system of the continental shale gas reservoir in the Yan'an Gas Field of the Ordos Basin, this paper obtains the altitude of the zero water potential surface by using the pressure measured in the open system and the zero water potential surface altitude calculation formula, based on the stratigraphic opening and closing system identification model and the principle of fluid mechanics. Then, the magnitude and value of the formation pressure anomaly are calculated, and the distribution characteristics of the water potential surface and formation pressure system in the Yan'an Gas Field

are analyzed. And the following research results are obtained. First, there is a hydrostatic pressure system in the strata above the 7th Member of the Upper Triassic Yanchang Formation in the Yan'an Gas Field. Second, in the Yan'an Gas Field, the zero water potential surface does not coincide with the earth surface and is mostly distributed below the earth surface. It is a curved surface instead of a straight line or a plane as traditionally recognized. Third, the lower Permian Shanxi Formation calculated from the zero water potential surface is mostly characterized by subpressure except small-amplitude overpressure in the northwest of the study area. Fourth, the error of the abnormal pressure calculated from the earth surface is between 0.07 MPa and 3.57 MPa. And below the burial depth of 2 600 m, the pressure error calculated from the earth surface begins to increase with the increase of the burial depth. Fifth, when the burial depth is above2 300 m, the abnormal pressure calculated from the zero water potential surface develops subpressure and increases with the increase of burial depth. A slight overpressure develops in the burial depth of 2 300-2 600 m. And below the burial depth of 2 600 m, subpressure develops and decreases with the increase of burial depth. In conclusion, the denudation thickness is better correlated with the abnormal pressure calculated from the zero water potential surface, so the abnormal pressure calculated from the zero water potential surface can reflect the geological reality more accurately. 
**Number of references:** 29
**Main heading:** Gases
**Controlled terms:** Hydraulics - Hydrostatic pressure - Metamorphic rocks - Petroleum reservoirs - Stratigraphy - Water levels
**Uncontrolled terms:** Calculation formula - Denudation thickness - Distribution characteristics - Formation pressure - Shale gas reservoirs - System identification models - Water level monitoring - Yanchang Formation
**Classification code:** 481.1 Geology - 512.1.1 Oil Fields - 631.1.1 Liquid Dynamics - 632.1 Hydraulics
**Numerical data indexing:** Pressure 3.57e+06Pa, Pressure 7.00e+04Pa, Size 2.30e+03m to 2.60e+03m, Size 2.60e+03m
**DOI:** 10.3787/j.issn.1000-0976.2021.07.004
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 42. Specified staged acid fracturing of horizontal well for strong-heterogeneity carbonate gas reservoirs: A case study on the gas reservoir of the fourth Member of Upper Sinian Dengying Formation in Gaoshiti-Moxi area of the central Sichuan Basin

**Accession number:** 20212010375648
**Title of translation:** --
**Authors:** Yue, Hong (1); Liu, Fei (2, 3); Zhang, Huali (2, 3); Zhou, Changlin (2, 3); Chen, Weihua (2, 3); Xiao, Zhenhua (4)
**Author affiliation:** (1) PetroChina Southwest Oil & Gasfield Company, Chengdu; Sichuan; 610051, China; (2) Engineering Technology Research Institute, PetroChina Southwest Oil & Gasfield Company, Chengdu; Sichuan; 610017, China; (3) National Energy R&D Center of High-sulfur Gas Reservoir Exploitation, Chengdu; Sichuan; 610017, China; (4) Exploration Department, PetroChina Southwest Oil & Gasfield Company, Chengdu; Sichuan; 610051, China
**Corresponding author:** Liu, Fei(liufei2015@petrochina.com.cn)
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 4
**Issue date:** April 25, 2021
**Publication year:** 2021
**Pages:** 51-60
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** The reservoir of the carbonate gas reservoir of the fourth Member of Upper Sinian Dengying Formation (hereinafter referred as "Deng 4 Member") in the Gaoshiti-Moxi area of the central Sichuan Basin is characterized by great burial depth, high reservoir temperature, low porosity, low permeability and strong heterogeneity. In order to effectively produce the reserves of this gas reservoir and improve its development benefits, this paper defines the reservoir stimulation factor by comprehensively considering the drilling, mud logging, logging interpretation and well type characteristic parameters, to carry out quantitative reservoir evaluation. Then, the refined segmentation method

was developed by fully considering the reservoir stimulation factor, in-situ stress and borehole condition. In addition, the differential acid fracturing technology was prepared for different types of reservoirs. On this basis, the specified staged acid fracturing technology of horizontal well for strong-heterogeneity carbonate reservoirs was developed and then applied in the field. And the following research results were obtained. First, the reservoir stimulation factor (y) can be used to accurately evaluate the reservoir characteristics. The high quality reservoir has $y \geq 1.0$, the moderate reservoir has $0.5 \leq$ y 4 m3/d, which is 46.5% higher than that in the early stage of gas reservoir development. In conclusion, the research results provide remarkable stimulation effects, increase the single well gas production greatly and effectively support the efficient development of Deng 4 Member gas reservoir in the Gaoshiti-Moxi area. 
**Number of references:** 29
**Main heading:** Low permeability reservoirs
**Controlled terms:** Boreholes - Carbonation - Fracturing (fossil fuel deposits) - Gas industry - Gases - Gelation - Horizontal wells - Mud logging - Natural gas - Natural gas deposits - Petroleum reservoir evaluation - Proven reserves - Stresses - Well stimulation
**Uncontrolled terms:** Different types of reservoirs - Gas reservoir development - High quality reservoir - Logging interpretation - Reservoir characteristic - Reservoir stimulations - Reservoir temperatures - Strong heterogeneities
**Classification code:** 511.1 Oil Field Production Operations - 512 Petroleum and Related Deposits - 522 Gas Fuels - 802.2 Chemical Reactions - 802.3 Chemical Operations
**Numerical data indexing:** Percentage 4.65e+01%
**DOI:** 10.3787/j.issn.1000-0976.2021.04.006
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 43. Numerical simulation on the mechanism for rigid particle plugging of leakage in fracture formations

**Accession number:** 20213210735498
**Title of translation:**
**Authors:** Feng, Yongcun (1, 2); Ma, Chengyun (1, 2); Chu, Mingming (1, 2); Zhong, Yi (1, 2); Deng, Jingen (1, 2)
**Author affiliation:** (1) State Key Laboratory of Petroleum Resource & Prospecting, China University of Petroleum (Beijing), Beijing; 102249, China; (2) College of Petroleum Engineering, China University of Petroleum (Beijing), Beijing; 102249, China
**Corresponding author:** Ma, Chengyun(mcy0000@163.com)
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
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**Issue date:** July 25, 2021
**Publication year:** 2021
**Pages:** 93-100
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** So far, the plugging mechanism of leakage fractures has not been fully understood, so the plugging of leakage fractures has always been a difficulty in the circle of drilling engineering. In order to improve the plugging efficiency of leakage fracture, this paper establishes a leakage fracture plugging model by using the Fluent-EDEM software based on the CFD-DEM numerical theory. Then, the influence laws of plugging particle size, concentration and size distribution and fracture morphology on the plugging efficiency of leakage fractures are studied and the plugging mechanisms of leakage fractures are revealed. And the following research results are obtained. First, "bridging" efficiency is the fundamental factor to determine the plugging efficiency of leakage fractures. The proper use of the friction coefficient, size and size distribution of plugging particles is conducive to improving the plugging efficiency of leakage fractures. The higher the friction coefficient is, the easier it is for particles to form bridging in leakage fractures. The bending angle in fractures can increase the probability of particle bridging in leakage fractures. Second, to a certain extent, the curvature of leakage fractures can impact the migration characteristics and "bridging efficiency" of plugging materials in leakage fractures. Third, the concentration of the leakage fracture plugging particles has a "bridging window". Below the lower limit of the "bridging window", the plugging particles cannot form effective

bridging in fractures; and above the upper limit, the plugging particles have little effect on bridging efficiency. In conclusion, besides particle concentration and particle size distribution, the characteristic parameters of fractures and plugging materials are the influence factors that shall not be neglected in the building process of efficient bridging from particles in leakage fractures. 
**Number of references:** 40
**Main heading:** Fracture
**Controlled terms:** Efficiency - Friction - Particle size - Particle size analysis - Size distribution
**Uncontrolled terms:** Drilling engineering - Fracture morphology - Friction coefficients - Particle bridgings - Particle concentrations - Plugging materials - Research results - Size and size distributions
**Classification code:** 913.1 Production Engineering - 922.2 Mathematical Statistics - 951 Materials Science
**DOI:** 10.3787/j.issn.1000-0976.2021.07.010
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 44. Efficient development technology slope-type strongly heterogeneous shale gas reservoirs: A case study on the Longmaxi Formation shale gas reservoir in the Weiyuan area of the southern Sichuan Basin

**Accession number:** 20212010375777
**Title of translation:** -
**Authors:** Wang, Zhiping (1); Zhang, Qing (2); Liu, Ziping (2); Li, Yanchao (2); Li, Yizhen (2); He, Feng (2); Zhao, Han (2)
**Author affiliation:** (1) CNPC Chuanqing Drilling Engineering Co., Ltd., Chengdu; Sichuan; 610051, China; (2) Shale Gas Exploration and Development Department, CNPC Chuanqing Drilling Engineering Co., Ltd., Chengdu; Sichuan; 610051, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
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**Issue:** 4
**Issue date:** April 25, 2021
**Publication year:** 2021
**Pages:** 72-81
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** The efficient development of the slope-type strongly heterogeneous shale gas reservoir of Lower Silurian Longmaxi Formation in the Weiyuan area of the southern Sichuan Basin faces several difficulties, such as long drilling cycle, difficult formation of complex fracture network, and low single well production. In view of this, one theory and four key technologies are developed after years of technological innovation, technological research and production practice, which provide effective support for the efficient construction of the Weiyuan National Shale Gas Demonstration Area. And the following research results were obtained. First, the differential enrichment theory of slope-type shale gas reservoir in the setting of paleouplift is put forward, namely "sedimentation area selection, tectonic zonation and preservation controlling reservoir". The multi-stage structure superimposed marine shale gas zone evaluation and sweet spot selection technology is developed. The organic-rich siliceous shale in the middle and lower parts of S1l1 layer is determined to be the optimal target in the vertical direction. The core productivity construction area covers 165 km2, where the deployed wells have an average daily gas production of 27×104 m3 during the testing and the EUR is more than 1.1×108 m3. Second, the efficient navigational drilling technology with geology-engineering integration guided technology and efficient long horizontal section drilling technology as the core for the horizontal well with a narrow target is developed, and the rate of penetration (ROP) improvement model of shale gas well is established. The drilling cycle is shortened by 33.1%, the drilling rate of quality shale reservoir is increased to 97.2%, and the extension capacity of horizontal section exceeds 3 000 m. Third, based on the dynamic propagation model of hydraulic fracture network, the volume fracturing optimization technology for strongly heterogeneous shale reservoir is developed, and the key evaluation indexes can be predicted quantitatively, including net fracturing stimulation area dimension, stimulated reservoir volume, effective stimulation volume and propped fracture area. The sanding intensity is increased from 1.3 t/m to 2.7 t/m, and the stimulation effect is improved. Fourth, the main factors controlling the productivity of shale gas wells in the Weiyuan area include Long111 reservoir thickness, pressure coefficient, total gas content,

perforation cluster quantity, sanding intensity and fracturing horizontal section length. Thanks to the application of the shale gas well production performance prediction method based on general regression neural network and modified embedded discrete fracture model, the coincidence rate of shale gas well production performance prediction result is close to and even higher than 95%. 
**Number of references:** 21
**Main heading:** Petroleum reservoir evaluation
**Controlled terms:** Backpropagation - Crack propagation - Fracture - Gas industry - Gases - Horizontal wells - Hydraulic fracturing - Infill drilling - Natural gas well production - Natural gas wells - Petroleum reservoirs - Productivity - Quality control - Shale gas - Well perforation - Well testing
**Uncontrolled terms:** Development technology - Discrete-fracture models - Efficient construction - General regression neural network - Optimization technology - Stimulated reservoir volumes - Technological innovation - Technological researches
**Classification code:** 511.1 Oil Field Production Operations - 512 Petroleum and Related Deposits - 522 Gas Fuels - 723.4 Artificial Intelligence - 913.3 Quality Assurance and Control - 951 Materials Science
**Numerical data indexing:** Area 1.65e+08m2, Percentage 3.31e+01%, Percentage 9.50e+01%, Percentage 9.72e+01%, Size 3.00e+03m
**DOI:** 10.3787/j.issn.1000-0976.2021.04.008
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 45. Establishment of igneous rock mechanical parameters model based on electric logging data inversion and its engineering application

**Accession number:** 20212510530384
**Title of translation:**
**Authors:** Yang, Hu (1); Xue, Xiaojun (2); Chen, Xianghui (2); Li, Xiubin (2); Zhou, Penggao (3)
**Author affiliation:** (1) Karamay Campus, China University of Petroleum (Beijing), Karamay; 834000, China; (2) Geological Research Institute, CNPC Xibu Drilling Engineering Company Limited, Karamay; 834000, China; (3) Karamay Vocational & Technical College, Karamay; 834000, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
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**Issue date:** May 25, 2021
**Publication year:** 2021
**Pages:** 101-109
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** So far, studies on igneous rock gas reservoir in Kelameili Gas Field of the Junggar Basin have mainly focused on rock physical properties and lithological identification, but rarely on rock mechanical characteristics. In order to provide guidance for the optimization design of drilling parameters of the igneous rock gas reservoirs in this area, we tested the mechanical properties of cores from 8 wells in the laboratory by taking the Carboniferous in Kelameili Piedmont as an example. By means of mathematical statistics, the dynamic and static values of core elastic parameters were converted, the in-situ log inversion model of igneous rock mechanical parameters was multiple regressed. In addition, the rock mechanical parameters and formation pressure profiles of some typical wells were plotted, and the optimal drilling pressure control mode and drilling fluid density range were designed to avoid wellbore complexity. And the following research results were obtained. First, compared with sedimentary rocks, igneous rocks have the characteristics of high compression and shear strength, high Young's modulus and low Poisson's ratio. Moreover, the mechanical strength of igneous rocks varies greatly with the lithology, and the risks of wellbore instability and leakage depend on the lithology of igneous rocks and the development degree of fractures. Second, the calculation errors of the mechanical parameter logging model for igneous rocks are less than 11%, and the formation collapse, leakage and fracturing pressure of typical wells in Kelameili piedmont can be accurately calculated. Third, analysis of the variation laws of the collapse pressure and leakage pressure of igneous rocks in Kelameili piedmont with the well trajectory indicates that the directional hole section along the minimum horizontal principal stress can improve the fracture connectivity probability, but the drilling risk is greater and the safety density window of drilling fluid

is narrower. In conclusion, the establishment method of this model is of great popularization value. 
**Number of references:** 26
**Main heading:** Igneous rocks
**Controlled terms:** Boreholes - Drilling fluids - Elastic moduli - Electric logging - Fracture - Horizontal wells - Infill drilling - Landforms - Lithology - Oil field equipment - Petroleum reservoirs - Risk assessment - Sedimentary rocks - Statistics
**Uncontrolled terms:** Drilling fluid density - Engineering applications - Fracture connectivity - Mechanical characteristics - Mechanical parameters - Rock mechanical parameters - Rock physical properties - Wellbore instability
**Classification code:** 481.1 Geology - 482.2 Minerals - 511.1 Oil Field Production Operations - 511.2 Oil Field Equipment - 512.1.1 Oil Fields - 512.1.2 Petroleum Deposits : Development Operations - 914.1 Accidents and Accident Prevention - 922.2 Mathematical Statistics - 951 Materials Science
**Numerical data indexing:** Percentage 1.10e+01%
**DOI:** 10.3787/j.issn.1000-0976.2021.05.011
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 46. A method for predicting the fault induced lag degree of seal formation time of mudstone cap rocks and its application

**Accession number:** 20213010677973
**Title of translation:**
**Authors:** Cao, Sijia (1); Xu, Fengming (2); Sun, Xianyi (2); Zhang, Yunfeng (1); Jiang, Meiling (1)
**Author affiliation:** (1) Northeast Petroleum University, Daqing; 163318, China; (2) Exploration Division, PetroChina Daqing Oilfield Company, Daqing; 163453, China
**Corresponding author:** Xu, Fengming(xufengming@petrochina.com.cn)
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
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**Issue:** 6
**Issue date:** June 25, 2021
**Publication year:** 2021
**Pages:** 37-43
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** It is very important to accurately predict the fault induced lag degree of seal formation time of mudstone cap rocks for correctly understanding the oil and gas distribution laws near faults, but there are few relevant researches and lack of theoretical basis. In order to correctly understand the oil and gas distribution laws near faults, this paper studies the fault induced lag degree of seal formation time of mudstone cap rocks and its influential factors. Based on this, the seal formation time of mudstone cap rocks and fault rocks was determined. In addition, a set of methods for evaluating the fault induced lag degree of seal formation time of mudstone cap rocks was put forward and verified based on case study. And the following research results are obtained. First, the fault induced lag degree of seal formation time of mudstone cap rocks is mainly affected by the relative relationship between the seal formation time of mudstone cap rocks and that of fault rocks. The later the seal formation time of fault rocks is than that of mudstone cap rocks, the greater the fault induced lag degree of seal formation time of mudstone cap rocks is, and vice versa. Second, the new method overcomes the shortcomings of the previous methods, which are difficult to accurately calculate the compaction diagenetic depth of fault rocks and take 1 MPa as the lower limit of the seal formation time of cap rocks and fault rocks. Third, the prediction results of the new method show that the seal formation time of the fault rocks of F4 fault of Nanpu No. 2 structure in the Bohai Bay Basin within the mudstone cap rocks of the second Member of Paleogene Dongying Formation (Dong 2 Member) is 1.1 Ma, and that of the Dong 2 Member mudstone cap rocks is 25.8 Ma. The lag degree of the seal formation time of Dong 2 Member mudstone cap rocks caused by F4 fault is 0.96. F4 fault is unfavorable to the accumulation and preservation of the oil and gas sourced from the first and third Member of Paleogene Shahejie Formation in the Dong 2 Member sandstone reservoir. In conclusion, the prediction results of F4 fault by the new method are consistent with the current oil and gas exploration practice, so this method can be used

to predict the fault induced lag degree of seal formation time of mudstone cap rocks. 
**Number of references:** 23
**Main heading:** Seals
**Controlled terms:** Forecasting - Gases - Petroleum prospecting - Sealing (finishing) - Sedimentary rocks
**Uncontrolled terms:** Dongying Formation - Influential factors - ITS applications - Oil and gas distribution law - Oil and gas exploration - Research results - Sandstone reservoirs - Shahejie formation
**Classification code:** 482.2 Minerals - 512.1.2 Petroleum Deposits : Development Operations - 619.1.1 Pipe Accessories
**Numerical data indexing:** Age 1.10e+06yr, Age 2.58e+07yr, Pressure 1.00e+06Pa
**DOI:** 10.3787/j.issn.1000-0976.2021.06.004
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 47. A classification method for shale gas reservoir types with free gas as the core parameter: A case study of Lower Silurian Longmaxi Formation marine shale gas reservoirs in the southern Sichuan Basin

**Accession number:** 20211210117176
**Title of translation:** -
**Authors:** Shi, Qiang (1); Jiang, Chunbi (2); Chen, Peng (1); Chen, Yuntian (2); Wang, Xiuqin (1); Liu, Fengxin (1)
**Author affiliation:** (1) PetroChina Research Institute of Petroleum Exploration & Development, Langfang; 065007, China; (2) Peng Cheng Laboratory, Shenzhen; 518000, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
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**Issue date:** February 25, 2021
**Publication year:** 2021
**Pages:** 37-46
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** There is a set of organic rich shale (TOC> 2%) of 30-50 m in thickness in the Lower Silurian Longmaxi Formation of the southern Sichuan Basin, but during its development, the shale gas production rate varies greatly in different layers. There is a big contradiction between the classification result according to the original evaluation standard and the actual productivity. To this end, this paper discusses the reasons for the contradiction between the original evaluation standard and the evaluation result based on the comparison of shale gas reservoir evaluation indicators, by analyzing a large number of experimental data. Then, combined with the production performance data, the shale gas reservoir classification method was studied, and a new shale gas reservoir classification method and standard with free gas as the core parameter was established. Finally, the new method was verified based on the practical shale gas development in the Weiyuan Block of southern Sichuan Basin. And the following research results were obtained. First, the reason for the above mentioned contradiction is that the control effect of shale gas occurrence mode on the gas production rate is not fully considered. Second, the new standard is mainly composed of TOC, adsorbed gas volume, brittle mineral content, porosity and free gas saturation. The main difference between the new standard and the old standard is that adsorbed gas content and free gas content are distinguished and the free gas content is replaced with the easily obtained gas saturation in the new standard. Third, the shale gas reservoir in the study area can be classified into three types, namely free type, adsorption type and transition type (mixed type). The free-type siliceous shale gas reservoir is the main high-yield interval of Longmaxi Formation shale in this area, and the transition-type shale gas reservoir is the potential favorable target interval. Fourth, the practice has proved that the new classification standard is of good applicability. In conclusion, the new classification method can distinguish different types of shale gas reservoirs more effectively and define the high-yield shale gas intervals accurately. © 2021, Natural Gas Industry Journal Agency. All right reserved.
**Number of references:** 20
**Main heading:** Gas industry
**Controlled terms:** Gases - Petroleum reservoir evaluation - Petroleum reservoirs - Shale gas

**Uncontrolled terms:** Classification methods - Classification results - Classification standard - Evaluation indicators - Evaluation standard - Organic-rich shales - Production performance - Shale gas reservoirs
**Classification code:** 512.1.1 Oil Fields - 512.1.2 Petroleum Deposits : Development Operations - 522 Gas Fuels
**Numerical data indexing:** Percentage 2.00e+00%, Size 3.00e+01m to 5.00e+01m
**DOI:** 10.3787/j.issn.1000-0976.2021.02.005
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 48. Main factors controlling the enrichment of Upper Carboniferous Benxi Formation tight gas in the Ordos Basin

**Accession number:** 20212010375655
**Title of translation:**
**Authors:** Li, Jian (1, 2); Zhang, Chunlin (1, 2); Jiang, Fujie (3, 4); Pei, Yu (3, 4); Wang, Jingyi (3, 4); Wang, Xirong (3, 4); Zhang, Jiaqi (3, 4)
**Author affiliation:** (1) PetroChina Research Institute of Petroleum Exploration & Development, Langfang; Hebei; 065007, China; (2) CNPC Key Laboratory of Gas Reservoir Formation and Development, Langfang; Hebei; 065007, China; (3) State Key Laboratory of Petroleum Resources and Prospecting, Beijing; 102249, China; (4) College of Geosciences, China University of Petroleum, Beijing; 102249, China
**Corresponding author:** Jiang, Fujie(jfjhtb@163.com)
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 4
**Issue date:** April 25, 2021
**Publication year:** 2021
**Pages:** 30-40
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** The exploration achievement of Upper Paleozoic tight sandstone gas in the Ordos Basin is remarkable, and compared with the Lower Permian Shanxi Formation and the eighth Member of Lower Shihezi Formation of Middle Permian, the Benxi Formation of Upper Carboniferous is greater in tight gas exploration potential, but its hydrocarbon accumulation mechanisms are not understood sufficiently and the main controlling factors of tight gas enrichment are not determined clearly, which brings about difficulty to oil and gas exploration evaluation and area selection. In order to provide basis and reference for the exploration of Benxi Formation tight sandstone gas in the Ordos Basin, this paper carries out statistical analysis on the test results of 165 wells in Benxi Formation and summarizes gas and water distribution characteristics and gas well productivity variation characteristics. On this basis, the main controlling factors of tight sandstone gas enrichment are studied by combining geological analysis, physical simulation and numerical simulation. Finally, the tight sandstone gas accumulation mechanisms in Benxi Formation are discussed, and the favorable areas for tight sandstone gas enrichment are predicted. And the following research results were obtained. First, in plane, the Benxi Formation tight sandstone gas reservoir is mainly distributed in the delta front branch channel facies belt and tidal flat sand bar facies belt, and the burial depth is about 2 800 m. Second, gas well productivity is in a certain positive correlation with coal bed thickness, sand body thickness and permeability, but the correlation is not strong. Third, there is a coupling relationship between the hydrocarbon expulsion intensity of source rocks and the reservoir porosity. Reservoir energy storage coefficient and overpressure distribution are the main geological factors controlling the distribution of gas reservoirs. Among them, the coupling relationship between hydrocarbon expulsion intensity of source rocks and reservoir porosity controls the distribution range of tight gas, energy storage coefficient controls the enrichment horizon of tight gas and overpressure distribution controls the enrichment degree of tight gas. In conclusion, the favorable areas for the enrichment of Benxi Formation tight gas in the Ordos Basin are mainly located in the transition zone between the tidal delta and the shallow sea and the neritic sand bar area with a gas generation intensity greater than 3×108 m3/km2. © 2021, Natural Gas Industry Journal Agency. All right reserved.
**Number of references:** 20
**Main heading:** Petroleum prospecting
**Controlled terms:** Coal deposits - Coal industry - Energy storage - Gases - Geological surveys - Geology - Hydrocarbons - Metamorphic rocks - Natural gas well production - Offshore gas fields - Offshore gas wells - Oil

field development - Petroleum reservoir engineering - Petroleum reservoirs - Porosity - Productivity - Sandstone - Tight gas - Water supply systems
**Uncontrolled terms:** Coupling relationships - Gas well productivities - Hydrocarbon accumulation - Hydrocarbon expulsion intensities - Main controlling factors - Oil and gas exploration - Positive correlations - Variation characteristics
**Classification code:** 446.1 Water Supply Systems - 481.1 Geology - 482.2 Minerals - 503 Mines and Mining, Coal - 512 Petroleum and Related Deposits - 522 Gas Fuels - 525.7 Energy Storage - 804.1 Organic Compounds - 931.2 Physical Properties of Gases, Liquids and Solids
**Numerical data indexing:** Size 2.80e+03m
**DOI:** 10.3787/j.issn.1000-0976.2021.04.004
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 49. Material balance method and classification of non-uniform water invasion mode for gas reservoirs with water considering the effect of water sealed gas

**Accession number:** 20211710247359
**Title of translation:**
**Authors:** Tan, Xiaohua (1); Peng, Gangzhen (1); Li, Xiaoping (1); Chen, Yingli (2); Xu, Xiaoling (3); Kui, Mingqing (3); Li, Qian (2); Yang, Guojun (3); Xiao, Heng (1)
**Author affiliation:** (1) Southwest Petroleum University, Chengdu; 610500, China; (2) PetroChina Southwest Oil & Gasfield Company, Chengdu; 610051, China; (3) PetroChina Qinghai Oilfield Company, Dunhuang; 736202, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 3
**Issue date:** March 25, 2021
**Publication year:** 2021
**Pages:** 97-103
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** In order to clarify the characteristics of non-uniform water invasion in water-bearing gas reservoirs, it is necessary to introduce the non-uniformity coefficient (A) and water invasion constant (B) to characterize the non-uniformity degree of reservoir physical properties and the activity degree of peripheral water, respectively, based on the dual mechanism of water invasion to recharge the formation energy and seal off the gas in the reservoir. Then, the material balance method considering the phenomenon of water sealed gas was established. On this basis, the water invasion characteristic curve chart of water-bearing gas reservoirs was plotted, and the non-uniform water invasion mode was classified based on the example gas reservoir. And the following research results were obtained. First, in the water invasion characteristic curve chart of water-bearing gas reservoirs which is plotted based on the material balance method considering the influence of water sealed gas, the upper right area and the lower left area are defined as recharge area and seal area, respectively. By taking A=0 and B=2 as the boundary, the recharge area is divided into strong recharge area and weak recharge area. By taking A=2 and B=2 as the boundary, the seal area is divided into strong seal area and weak seal area. And correspondingly there are four water invasion modes, i.e., strong recharge, weak recharge, weak seal and strong seal. Second, for fractured gas reservoirs, the non-uniformity degree of reservoir physical properties is high, and water sealed gas can be formed easily after water invasion. The dimensionless relative pseudo-pressure data of this type of gas reservoir is located in the seal area of the water invasion characteristic curve chart. Third, for the gas reservoirs whose reservoir physical properties are relatively uniform, the dimensionless relative pseudo-pressure data is located in the recharge area of the water invasion characteristic curve chart, and the recharge effect of water invasion on formation energy is greater than the weakening effect of water sealed gas on formation energy. Fourth, with the increase of A, the non-uniformity degree of reservoir physical properties increases, the water invasion characteristic curve shifts from the upper right to the lower left, and the recovery factor of gas reservoir decreases continuously. With the increase of B, the recharge effect of water invasion on formation energy and the weakening effect of water sealed gas on formation energy are both weakened, the distribution range of water invasion characteristic curve narrows to the recharge/seal boundary, and the

corresponding range of gas reservoir recovery factor also narrows. 
**Number of references:** 27
**Main heading:** Oil bearing formations
**Controlled terms:** Aquifers - Gases - Petroleum reservoirs - Physical properties - Seals
**Uncontrolled terms:** Characteristic curve - Formation energies - Fractured gas reservoirs - Influence of water - Material balance method - Recovery factors - Reservoir physical property - Water- bearing gas reservoirs
**Classification code:** 444.2 Groundwater - 512.1.1 Oil Fields - 619.1.1 Pipe Accessories - 931.2 Physical Properties of Gases, Liquids and Solids
**DOI:** 10.3787/j.issn.1000-0976.2021.03.011
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 50. A new log interpretation method for identifying water and gas layers in fractured carbonate reservoirs: A case study of Middle Permian in Jiulongshan area of northwestern Sichuan Basin

**Accession number:** 20213210735506
**Title of translation:** -
**Authors:** Yang, Hua (1); Zhang, Benjian (2); Chen, Mingjiang (3); Sun, Zhiyun (1); Tian, Yunying (1); Yang, Xun (1); Wang, Yufeng (1); Tang, Xingyu (1); Hu, Xin (1)
**Author affiliation:** (1) Northwest Sichuan Division, PetroChina Southwest Oil & Gasfield Company, Jiangyou; 621700, China; (2) Exploration and Development Research Institute, PetroChina Southwest Oil & Gasfield Company, Chengdu; 610041, China; (3) Geological Exploration & Development Research Institute, CNPC Chuanqing Drilling Engineering Company Limited, Chengdu; 610051, China
**Corresponding author:** Chen, Mingjiang(19092249@qq.com)
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 7
**Issue date:** July 25, 2021
**Publication year:** 2021
**Pages:** 56-62
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** A number of wells in the Jiulongshan area of northwestern Sichuan Basin have obtained high-yield gas flow (106 m3/d) from the Maokou Formation and Qixia Formation of Middle Permian, which indicates great potential of natural gas exploration and development in this area. However, complex fracture occurrences and widely developed non-uniform rock structures obscure the response of log information to fluid. In order to establish an effective gas/water layer identification method based on well log for this area, this paper firstly compares conventional and imaging logs data with core observation and well test results, develops the non-correlation analysis technology of log information for identifying fractures and non-uniform rock structures, and establishes non-correlation characteristic modes for different types of reservoirs. Then, Gaussian filtering is applied to resistivity curve to reduce the influence of fractures on the resistivity, and the resistivity information reflecting matrix blocks is acquired. Finally, a porosity-Gaussian filtering resistivity crossplot which can effectively identify gas and water layers is prepared according to the relationship between reservoir types and pore structure indexes (m). And the following research results are obtained. First, as reservoir types vary, resistivity boundaries between gas and water layers of Middle Permian vary between 80 #•M and 300 #•M and present a trend of rising gradually from fractured reservoirs to fractured-vuggy reservoirs and vuggy reservoirs. Second, gas and water layers in Well L004-3 of this study area are identified by using this newly established crossplot, and its identification result coincides with the actual test result. In conclusion, the research results provide guidance for understanding the gas/water distribution in the Lower Permian of Jiulongshan area of northwestern Sichuan Basin, as well as a new idea for identifying gas and water layers in fractured reservoirs in other blocks. © 2021, Natural Gas Industry Journal Agency. All right reserved.
**Number of references:** 20
**Main heading:** Natural gas wells

**Controlled terms:** Flow of gases - Fracture - Gases - Information filtering - Petroleum prospecting - Petroleum reservoirs - Pore structure - Pulse shaping circuits - Well logging - Well testing
**Uncontrolled terms:** Correlation analysis - Correlation characteristics - Different types of reservoirs - Fractured carbonate reservoirs - Fractured reservoir - Fractured-vuggy reservoirs - Identification method - Natural gas exploration
**Classification code:** 512 Petroleum and Related Deposits - 631.1.2 Gas Dynamics - 713.4 Pulse Circuits - 903.1 Information Sources and Analysis - 931.2 Physical Properties of Gases, Liquids and Solids - 951 Materials Science
**DOI:** 10.3787/j.issn.1000-0976.2021.07.006
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 51. Technological parameter optimization for improving the complexity of hydraulic fractures in deep shale reservoirs

**Accession number:** 20210609883997
**Title of translation:**
**Authors:** Zhang, Fengshou (1, 2); Wu, Jianfa (3); Huang, Haoyong (3); Wang, Xiaohua (1, 2); Luo, Haoran (3); Yue, Wenhan (3); Hou, Bing (4, 5)
**Author affiliation:** (1) Key Laboratory of Geotechnical & Underground Engineering of Ministry of Education, Tongji University, Shanghai; 200092, China; (2) Department of Geotechnical Engineering, College of Civil Engineering, Tongji University, Shanghai; 200092, China; (3) Shale Gas Research Institute, PetroChina Southwest Oil & Gasfield Company, Chengdu; 610051, China; (4) State Key Laboratory of Petroleum Resources and Prospecting, China University of Petroleum, Beijing; 102249, China; (5) Key Laboratory of Petroleum Engineering Education Ministry, China University of Petroleum, Beijing; 102249, China
**Corresponding author:** Wang, Xiaohua(wangxh199206@163.com)
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
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**Issue date:** January 25, 2021
**Publication year:** 2021
**Pages:** 125-135
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** Deep shale reservoirs below 3 500 m are characterized by high horizontal principal stress difference, developed bedding fracture and low brittleness index, so it is difficult to form complex fractures during hydraulic fracturing. In order to better understand the propagation laws of hydraulic fractures in deep shale reservoirs, this paper applies the 3D discrete lattice method to carry out discrete element numerical simulation and analysis on the true triaxial fracturing physical simulation experiment results of Lower Silurian Longmaxi Formation deep bedding shale in the Sichuan Basin under the horizontal principal stress difference of 12 MPa. And the numerical simulation results are consistent with fracture propagation laws clarified in the laboratory fracturing physical simulation of shale outcrop with single bedding. Then, the propagation laws of the fractures in deep shale reservoirs with multiple beddings under the influence of displacement, fracturing fluid viscosity, bedding strength and alternative fracturing fluid injection were numerically simulated. And the following research results were obtained. First, high-displacement injection and increasing fracturing fluid viscosity can enhance the deep-penetration stimulation capacity of deep shale reservoirs. Hydraulic fractures can continuously pass through four beddings and penetrate the entire sample when the displacement reaches 90 mL/min or the fracturing fluid viscosity is increased to 60 mPa•s. Second, under high horizontal principal stress difference, low-viscosity fracturing fluid tends to activate horizontal bedding while high-viscosity fracturing fluid tends to pass through the bedding directly to form vertical main fractures. In conclusion, the fracturing technology based on the alternative injection with high-viscosity fracturing fluid in the early stage and low-viscosity fracturing fluid in the later stage can maximize the complexity of hydraulic fractures in deep shale reservoirs. In addition, when there is weak bedding near the wellbore, it is necessary to adjust fracturing technologies and parameters (such as to increase the construction displacement as much as possible and to adopt guar fracturing fluid), so that hydraulic fractures can break through the inhibition of the weak bedding near the wellbore and achieve deep-penetration stimulation. © 2021, Natural Gas Industry Journal Agency. All right reserved.

**Number of references:** 37
**Main heading:** Shale
**Controlled terms:** Boreholes - Fracture mechanics - Fracturing fluids - Hydraulic fracturing - Numerical methods - Numerical models - Oil field equipment - Viscosity
**Uncontrolled terms:** Alternative injection - Brittleness index - Discrete lattices - Fracture propagation - Physical simulation - Physical simulation experiment - Simulation and analysis - Technological parameter optimization
**Classification code:** 511.2 Oil Field Equipment - 512.1.2 Petroleum Deposits : Development Operations - 921 Mathematics - 921.6 Numerical Methods - 931.1 Mechanics - 931.2 Physical Properties of Gases, Liquids and Solids
**Numerical data indexing:** Pressure 1.20e+07Pa, Size 3.50e+03m
**DOI:** 10.3787/j.issn.1000-0976.2021.01.011
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 52. An optimization design of self-excited hydraulic oscillators

**Accession number:** 20211210117169
**Title of translation:**
**Authors:** Zhao, Chuanwei (1)
**Author affiliation:** (1) Drilling Technology Research Institute, Sinopec Shengli Oilfield Service Corporation, Dongying; 257017, China
**Corresponding author:** Zhao, Chuanwei(zcw860204@163.com)
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 2
**Issue date:** February 25, 2021
**Publication year:** 2021
**Pages:** 132-139
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** The self-excited hydraulic oscillator which was developed in the early stage generates periodic vibration by means of special flow channel and drilling fluid circulation, without moving parts and rubber parts. It is advantageous with high temperature resistance, corrosion resistance, high reliability and low cost, and it can effectively solve the problem of back pressure during the sliding drilling in the long horizontal section of a shale gas well. However, it has larger pressure drop and overload of mud pump, which restricts its application in shale-gas horizontal wells. To this end, this paper puts forward a method to optimize the above mentioned self-excited hydraulic oscillators. The significant factors influencing the average pressure drop and pressure drop amplitude of this tool were screened out using the Plackett-Burman design method. Based on the Taguchi method, an orthogonal experimental table was established to optimize the significant influence factors. And the optimal parameter combination was gradually determined by the virtue of means analysis and variance analysis. Finally, the performance of the tool before and after optimization was comparatively evaluated based on numerical simulation and laboratory experiments. And the following research results were obtained. First, under the condition of numerical simulation, the average pressure drop of the optimized tool decreases from 3.6 MPa to 2.9 MPa and the pressure drop amplitude decreases from 4.0 MPa to 3.5 MPa when the displacement is 30 L/s. Second, under the condition of laboratory experiment, the average pressure drop of the optimized tool decreases from 3.7 MPa to 3.0 MPa and the impact force decreases from 44.5 kN to 41.3 kN, reaching the optimization goal. In conclusion, optimizing the channel structure parameters of the self-excited hydraulic oscillator by combining Plackett-Burman design with the Taguchi method can ensure a greater impact force while reducing the pressure drop of the tool. © 2021, Natural Gas Industry Journal Agency. All right reserved.
**Number of references:** 26
**Main heading:** Design
**Controlled terms:** Channel flow - Corrosion resistance - Drilling fluids - Drops - High temperature corrosion - Horizontal wells - Infill drilling - Numerical models - Pressure drop - Shale gas - Taguchi methods
**Uncontrolled terms:** Drilling fluid circulation - High temperature resistance - Horizontal section - Hydraulic oscillator - Laboratory experiments - Optimal parameter combinations - Optimization design - Plackett-Burman designs

**Classification code:** 511.1 Oil Field Production Operations - 512.1.1 Oil Fields - 522 Gas Fuels - 539.1 Metals Corrosion - 631.1 Fluid Flow, General - 913.3 Quality Assurance and Control - 921 Mathematics
**Numerical data indexing:** Force 4.45e+04N to 4.13e+04N, Pressure 3.60e+06Pa to 2.90e+06Pa, Pressure 3.70e +06Pa to 3.00e+06Pa, Pressure 4.00e+06Pa to 3.50e+06Pa
**DOI:** 10.3787/j.issn.1000-0976.2021.02.016
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 53. Status quo and discussion on the standardization of analysis methods for the impurity components in hydrogen of vehicle fuel: A case study on the proton exchange membrane fuel cell vehicle

**Accession number:** 20212010375704
**Title of translation:** -
**Authors:** Pan, Yi (1, 2); Deng, Fanfeng (1); Wang, Weikang (1); Yang, Jiawei (1); Zhang, Ting (1); Lin, Junjie (1); Long, Zhou (2); Yao, Weimin (3); Fang, Zheng (1)
**Author affiliation:** (1) National Institute of Measurement and Testing Technology, Chengdu; Sichuan; 610021, China; (2) Analysis and Testing Center, Sichuan University, Chengdu; Sichuan; 610065, China; (3) Shimadzu Enterprise Management China Limited, Shanghai; 200233, China
**Corresponding author:** Fang, Zheng(fz_nimtt@126.com)
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 4
**Issue date:** April 25, 2021
**Publication year:** 2021
**Pages:** 115-123
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Number of references:** 47
**Main heading:** Fourier transform infrared spectroscopy
**Controlled terms:** Absorption spectroscopy - Ammonia - Catalysts - Gas chromatography - Gases - Hydrocarbons - Ionization of gases - Light measurement - Moisture - Proton exchange membrane fuel cells (PEMFC) - Spectrometers - Spectroscopic analysis - Temperature - Thermal conductivity of gases
**Uncontrolled terms:** 'current - Adaptability - Analysis method - Analytical instrument - Fuel cell vehicles - Hydrogen fuel cells - Impurities contents - Impurity components - Proton exchange membranes - Proton-exchange membranes fuel cells
**Classification code:** 641.1 Thermodynamics - 702.2 Fuel Cells - 741.3 Optical Devices and Systems - 801 Chemistry - 802.2 Chemical Reactions - 802.3 Chemical Operations - 803 Chemical Agents and Basic Industrial Chemicals - 804 Chemical Products Generally - 804.1 Organic Compounds - 804.2 Inorganic Compounds - 941.4 Optical Variables Measurements
**DOI:** 10.3787/j.issn.1000-0976.2021.04.013
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 54. An experimental study on the heat exchange performance of printed circuit heat exchangers in an FSRU

**Accession number:** 20213010678008
**Title of translation:** FSRU
**Authors:** Chen, Yongdong (1); Yu, Gaige (1); Yan, Yongchao (1); Han, Bingchuan (1); Ni, Ligang (1)
**Author affiliation:** (1) Hefei General Machinery Research Institute Co., Ltd., Hefei; 230032, China
**Source title:** Natural Gas Industry

**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 6
**Issue date:** June 25, 2021
**Publication year:** 2021
**Pages:** 120-126
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Number of references:** 17
**Main heading:** Cryogenics
**Controlled terms:** Gasification - Heat exchangers - Heat transfer coefficients - Liquefied natural gas - Printed circuits - Propane - Timing circuits
**Uncontrolled terms:** Apparent total heat transfer coefficient - Experimental study - Floating storage and regasification unit - Floating storage and regasification units - Marine natural gas - Printed circuit heat exchanger - Printed circuit heat exchangers - Re-gasification - Supercritical - Total heat transfer coefficient
**Classification code:** 523 Liquid Fuels - 616.1 Heat Exchange Equipment and Components - 641.2 Heat Transfer - 644.4 Cryogenics - 713.4 Pulse Circuits - 802.3 Chemical Operations
**DOI:** 10.3787/j.issn.1000-0976.2021.06.014
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 55. Evaluation on the dynamic sealing capacity of underground gas storages rebuilt from gas reservoirs: A case study of Xinjiang H underground gas storage

**Accession number:** 20211710247373
**Title of translation:** --H
**Authors:** Liao, Wei (1); Liu, Guoliang (1); Chen, Ruhe (2); Sun, Junchang (3, 4); Zhang, Shijie (1); Wang, Yu (5); Liu, Xianshan (3, 4)
**Author affiliation:** (1) Operation District of Hutubi Gas Storage, PetroChina Xinjiang Oilfield Company, Karamay; 834000, China; (2) No.1 Gas Product Plant, PetroChina Xinjiang Oilfield Company, Karamay; 834000, China; (3) PetroChina Research Institute of Petroleum Exploration & Development, Langfang; 065007, China; (4) CNPC Key Laboratory of Oil & Gas Underground Gas Storage Engineering, Langfang; 065007, China; (5) Development Department, PetroChina Xinjiang Oilfield Company, Karamay; 834000, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 3
**Issue date:** March 25, 2021
**Publication year:** 2021
**Pages:** 133-141
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Number of references:** 20
**Main heading:** Geomechanics
**Controlled terms:** Faulting - Geologic models - Injection (oil wells) - Petroleum reservoirs - Rocks - Speed - Underground gas storage - Water injection
**Uncontrolled terms:** Alternating stress - Bottom water - Cap rock - Edge and bottom water - Gas storage - Geomechanical model - Integrity of cap rock - Multi cycle - Multi-cycle injection and production - Sealing capacity of fault
**Classification code:** 481 Geology and Geophysics - 481.1 Geology - 484.1 Earthquake Measurements and Analysis - 511.1 Oil Field Production Operations - 512.1.1 Oil Fields - 522 Gas Fuels - 612.1 Internal Combustion Engines, General - 694.4 Storage - 931.1 Mechanics

**Numerical data indexing:** Age 1.40E+01yr, Size 5.00E-02m
**DOI:** 10.3787/j.issn.1000-0976.2021.03.016
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 56. Treatment of dehydrated oily sludge by hydrothermal coupled low temperature drying

**Accession number:** 20212010375742
**Title of translation:**
**Authors:** Tong, Kun (1, 2); Xie, Jiacai (1, 2); Nie, Fan (1, 2); Li, Huimin (3); Zhang, Mingdong (1, 2)
**Author affiliation:** (1) State Key Laboratory of Petroleum Pollution Control, Beijing; 102206, China; (2) CNPC Research Institute of Safety & Environmental Technology Co., Ltd., Beijing; 102206, China; (3) Research Institute of Engineering & Technology, PetroChina Xinjiang Oilfield Company, Karamay; Xinjiang; 843008, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
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**Publication year:** 2021
**Pages:** 153-159
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Number of references:** 20
**Main heading:** Energy conservation
**Controlled terms:** Asphaltenes - Distillation - Drying - Energy utilization - Particle size - Recovery - Temperature - Wastewater treatment
**Uncontrolled terms:** Asphaltene removal rate - Conditioning and destabilization - Dehydrated oily sludge - Drying rates - Energy savings - Energy-savings - High quality - High temperature simulated distillations - Hydrothermal methods - Low-temperature drying - Oily sludges - Recovery of high quality oil - Removal rate
**Classification code:** 452.4 Industrial Wastes Treatment and Disposal - 513 Petroleum Refining - 525.2 Energy Conservation - 525.3 Energy Utilization - 641.1 Thermodynamics - 802.3 Chemical Operations
**Numerical data indexing:** Angular velocity 2.505E+00rad/s, Time 1.80E+03s
**DOI:** 10.3787/j.issn.1000-0976.2021.04.016
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 57. Ten years of gas shale fracturing in China: Review and prospect

**Accession number:** 20213910945417
**Title of translation:** :
**Authors:** Zhao, Jinzhou (1); Ren, Lan (1); Jiang, Tingxue (2); Hu, Dongfeng (3); Wu, Leize (4); Wu, Jianfa (5); Yin, Congbin (6); Li, Yongming (1); Hu, Yongquan (1); Lin, Ran (1); Li, Xiaogang (1); Peng, Yu (1); Shen, Cheng (5); Chen, Xiyu (1); Yin, Qing (1); Jia, Changgui (2); Song, Yi (5); Wang, Haitao (2); Li, Yuanzhao (7); Wu, Jianjun (8); Zeng, Bin (9); Du, Linlin (10)
**Author affiliation:** (1) State Key Laboratory of Oil & Gas Reservoir Geology and Exploitation, Southwest Petroleum University, Chengdu; 610500, China; (2) Sinopec Research Institute of Petroleum Engineering, Beijing; 100101, China; (3) Sinopec Exploration Company, Chengdu; 610041, China; (4) Sinopec Jianghan Oilfield Company, Wuhan; 430000, China; (5) Shale Gas Research Institute, PetroChina Southwest Oil & Gasfield Company, Chengdu; 610051, China; (6) CNPC Chuanqing Drilling Engineering Co., Ltd., Chengdu; 610051, China; (7) Sinopec Chongqing Fuling Shale Gas Exploration and Development Co., Ltd., Chongqing; 408014, China; (8) PetroChina Coalbed Methane Co., Ltd., Beijing; 100028, China; (9) Gepetto Oil Technology Co. Ltd., Beijing; 100102, China; (10) Orient Baolin Technology Development Co., Ltd., Beijing; 100083, China
**Corresponding author:** Ren, Lan(renlanswpu@163.com)
**Source title:** Natural Gas Industry

**Abbreviated source title:** Natur. Gas Ind.
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**Issue date:** August 25, 2021
**Publication year:** 2021
**Pages:** 121-142
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Number of references:** 217
**Main heading:** Shale gas
**Controlled terms:** Design - Fracturing fluids - Gases - Hydraulic fracturing - Petroleum reservoir evaluation - Shale
**Uncontrolled terms:** China - Deep-marine - Deep/ultra-deep marine shale gas - Fluid and tool - Fracturing technology - Fundamental theory - Marine shales - Network fracturing - Terrestrial/marine-terrestrial transitional shale gas - Ultra deeps
**Classification code:** 512.1.2 Petroleum Deposits : Development Operations - 512.2 Natural Gas Deposits - 522 Gas Fuels
**Numerical data indexing:** Age 1.00E+01yr
**DOI:** 10.3787/j.issn.1000-0976.2021.08.012
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 58. Mechanical property and main control mechanism of ultra-deep fractured carbonate rocks

**Accession number:** 20213210735489
**Title of translation:**
**Authors:** Yang, Bin (1, 2); Zhang, Hao (1); Liu, Qiming (3); Ou, Biao (3); Hu, Yongzhang (3); She, Jiping (1); Pan, Guanchang (1, 2)
**Author affiliation:** (1) State Key Laboratory of Oil and Gas Reservoir Geology and Exploitation, Chengdu University of Technology, Chengdu; 610500, China; (2) Engineering Research Center of Development and Management for Low and Extra Low Permeability Oil Reservoirs in Western China, Ministry of Education, Xi'an Shiyou University, Xi'an; 710065, China; (3) Petroleum Engineering Technology Research Institute, Sinopec Southwest Oil & Gas Company, Deyang; 618000, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
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**Pages:** 107-114
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** Natural fractures developed in ultra-deep marine carbonate reservoirs can aggravate the risks of wellbore instability and circulation loss in the process of drilling and completion. What's more, the influence mechanisms of development degree and microscopic characteristics of natural fractures on the mechanical property of ultra-deep carbonate rocks need further studying. In order to provide experimental basis for improving the anti-collapse and anti-leak and acid fracturing technologies of ultra-deep marine carbonate reservoir, this paper carries out triaxial mechanical experiments by taking the carbonate reservoir of Middle Triassic Leikoupo Formation in the West Sichuan Depression of the Sichuan Basin as an example. Then, based on the results of CT scanning reconstruction, fracture filling analysis, fracture plane scanning image and friction coefficient test, its mechanical properties are studied from the aspects of fracture occurrence, fillings and friction characteristics. And the following research results are obtained.

First, natural fractures in the Leikoupo Formation ultra-deep carbonate reservoir of the West Sichuan Depression are mostly filled with high-purity calcite, and the rocks have the characteristics of low Poisson's ratio, low mechanical strength and strong discretion. Second, the rock samples of Leikoupo Formation generally suffer shear failure from high-angle natural fractures, and the dip angle of failure surfaces is in the range of 46°-80°. The contour of natural fractures is flat, the micro asperities on the fracture surfaces are underdeveloped with low slope, and calcite fillings are of low hardness and weak cementation. Third, fracture occurrence, fillings and friction characteristics weaken the shear failure resistance of rocks and reduces the compression strength overall, and the low friction coefficient of fracture surface is the key cause of weak shear failure resistance. Fourth, the good wettability of water-based drilling fluid to calcite filling layers leads to the further reduction of rock strength, and fractures' control characteristics are more obvious. In conclusion, the research results provide basic guidance more specifically for wellbore instability control and acid fracturing design optimization of ultra-deep fractured carbonate reservoirs. 
**Number of references:** 27
**Main heading:** Fracture
**Controlled terms:** Boreholes - Calcite - Carbonation - Computerized tomography - Drilling fluids - Filling - Flight control systems - Friction - Infill drilling - Mechanical properties - Mechanisms - Oil field equipment - Petroleum reservoirs - Sedimentary rocks
**Uncontrolled terms:** Control characteristics - Drilling and completion - Fractured carbonate reservoirs - Friction characteristics - Low friction coefficients - Microscopic characteristics - Water based drilling fluids - West Sichuan depression
**Classification code:** 482.2 Minerals - 511.1 Oil Field Production Operations - 511.2 Oil Field Equipment - 512.1.1 Oil Fields - 601.3 Mechanisms - 652.3 Aircraft Instruments and Equipment - 691.2 Materials Handling Methods - 723.5 Computer Applications - 802.2 Chemical Reactions - 951 Materials Science
**DOI:** 10.3787/j.issn.1000-0976.2021.07.012
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 59. Enrichment conditions and exploration potential of shale gas in continental lake basins in Qikou Sag, Bohai Bay Basin

**Accession number:** 20212510530410
**Title of translation:**
**Authors:** Zhou, Lihong (1); Chen, Changwei (1); Han, Guomeng (1); Yang, Fei (1); Shi, Qianru (1); Fu, Dongli (1); Dong, Yueqi (1); Zhao, Yue (1); Sun, Lili (1); Liang, Chen (1)
**Author affiliation:** (1) PetroChina Dagang Oilfield Company, Tianjin; 300280, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 5
**Issue date:** May 25, 2021
**Publication year:** 2021
**Pages:** 1-10
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** To further evaluate the shale gas enrichment conditions and exploration potentials of the continental lake basin in Qikou Sag of the Bohai Bay Basin, this paper studies the Es3(the third Member of Paleogene Shahejie Formation) shale in this area comprehensively from the aspects of sedimentary environment, lithology and its combination characteristics, hydrocarbon generation conditions, reservoir space, rock brittleness and gas bearing property by using seismic, wireline logging, mud logging and core analysis data. In addition, the shale gas accumulation pattern in this area is established and shale gas exploration potential is evaluated. And the following research results were obtained. First, the Es3 shale in this area is of great cumulative thickness and large distribution area, and in the middle-low slope area of Qikou Sag it has entered the stage of a large amount of gas generation, so it has the hydrocarbon generation conditions for scale shale gas reservoirs. Second, speaking of the shale in this area, the content of felsic minerals is dominant, and matrix pores and micro fractures are more developed to provide some reservoir spaces. Moreover, the content of brittle minerals is high, and the total content of illite and illite/montmorillonite

interlayer in clay minerals is 94%. The shale of low expansion and brittle can be fractured easily. Third, fluid expansion generated in the process of continuous hydrocarbon generation is the main cause of overpressure in Es3. The shale interval with pressure coefficient higher than 1.2 presents an obvious anomaly in while-drilling gas logging and has the conditions for shale gas accumulation. Fourth, when the burial depth of Es3in Qikou Sag is 3 100-4 400 m, shale gas and shale oil are associated mainly in the form of dissolved gas; when it is 4 400-4 850 m, wet gas is dominant; and when it is greater than 4 850 m, dry gas is dominant. In conclusion, the middle-low slope area in Qikou Sag is a favorable target area for shale gas exploration, whose favorable exploration area is about 1 476 km2 and shale gas resource is more than 1×1012 m3, indicating greater shale gas exploration potential. 
**Number of references:** 29
**Main heading:** Oil bearing formations
**Controlled terms:** Energy resources - Expansion - Fracture mechanics - Gases - Geological surveys - Hydrocarbons - Lakes - Lithology - Logging while drilling - Minerals - Mud logging - Oil well logging - Petroleum prospecting - Petroleum reservoirs - Sedimentary rocks - Shale gas
**Uncontrolled terms:** Bearing properties - Distribution area - Exploration potential - Hydrocarbon generation - Pressure coefficients - Sedimentary environment - Shahejie formation - Shale gas reservoirs
**Classification code:** 481.1 Geology - 482.2 Minerals - 512.1.1 Oil Fields - 512.1.2 Petroleum Deposits : Development Operations - 522 Gas Fuels - 525.1 Energy Resources and Renewable Energy Issues - 804.1 Organic Compounds - 931.1 Mechanics - 951 Materials Science
**Numerical data indexing:** Area 1.48e+09m2, Percentage 9.40e+01%, Size 3.10e+03m to 4.40e+03m, Size 4.40e+03m to 4.85e+03m, Size 4.85e+03m
**DOI:** 10.3787/j.issn.1000-0976.2021.05.001
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 60. A simulation experiment method for HTHP gas well productivity

**Accession number:** 20213210735486
**Title of translation:**
**Authors:** Zhou, Keming (1, 2); Li, Nong (1, 3); Liu, Tingzhi (1); He, Jiahuan (1); Yu, Huajie (1); Zou, Mengwen (1)
**Author affiliation:** (1) Research Institute of Exploration and Development, PetroChina Southwest Oil & Gasfield Company, Chengdu; 610213, China; (2) CNPC Key Laboratory of Carbonate Reservoirs, Chengdu; 610213, China; (3) State Key Laboratory of Oil and Gas Reservoir Geology and Exploitation, Southwest Petroleum University, Chengdu; 610500, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 7
**Issue date:** July 25, 2021
**Publication year:** 2021
**Pages:** 63-72
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** In recent years, a series of major natural gas exploration discoveries and breakthroughs have been achieved in deep and ultra deep carbonate gas reservoirs in the Sichuan Basin, and all discovered gas reservoirs are characterized by great burial depth, complex pore structures and high formation temperature and pore pressure. In order to accurately predict the single well gas production of high temperature and high pressure (HTHP) gas reservoirs and clarify the gas flow characteristics under formation conditions, this paper establishes a productivity simulation experimental device and method based on the formation temperature and pore pressure of carbonate gas reservoirs in the Middle Permian Qixia Formation of northwestern Sichuan Basin and the Upper Sinian Dengying Formation of central Sichuan Basin. Then, the cores of above mentioned gas reservoirs are selected to carry out the productivity simulation experiment under HTHP. Finally, the gas flow characteristics are studied. And the following research results are obtained. First, the newly established productivity simulation experimental device and method suitable for the conditions of 160 formation temperature and 100 MPa pore pressure is used to predict the natural gas AOF (absolute open flow) of Well S-1 in the Qixia Formation gas reservoir of northwestern Sichuan Basin. And the prediction result is better accordant with the calculation result of theoretical model, with are lative error of only 2.12%. Second, based

on the surface Klinkenberg permeability, the single well gas production calculated from the productivity simulation experiment is better accordant with the gas production of field completion testing; while based on the formation Klinkenberg permeability, the single well gas production calculated from the productivity simulation experiment is better accordant with the AOF. Third, the change of formation temperature and pore pressure has a significant influence on rock permeability, and the permeability is more sensitive to stress than to temperature. Fourth, to carry out the reservoir stress sensitivity experiment and the productivity simulation experiment, it is required that core samples be recovered to the formation conditions for aging, or the experimental results may have characteristics of strong stress sensitivity and cannot be used for reservoir engineering evaluation directly. In conclusion, the production rate and AOF of HTHP gas wells can be predicted accurately by means of productivity simulation experiment, based on drilling core samples. In addition, the formation Klinkenberg permeability can be evaluated by using the relational expression between surface or formation Klinkenberg permeability and single well gas production, combined with gas well testing data. 
**Number of references:** 28
**Main heading:** Natural gas wells
**Controlled terms:** Core samples - Flow of gases - Forecasting - Gas industry - Gas permeability - Gases - Natural gas - Natural gas well completion - Natural gas well production - Petroleum prospecting - Petroleum reservoir evaluation - Petroleum reservoirs - Pore pressure - Pore structure - Productivity - Surface testing - Well testing
**Uncontrolled terms:** Central Sichuan Basin - Flow charac-teristics - Formation temperature - High temperature and high pressures (HTHP) - Natural gas exploration - Productivity simulation - Reservoir engineering - Theoretical modeling
**Classification code:** 483.1 Soils and Soil Mechanics - 512 Petroleum and Related Deposits - 522 Gas Fuels - 631.1.2 Gas Dynamics - 931.2 Physical Properties of Gases, Liquids and Solids
**Numerical data indexing:** Percentage 2.12e+00%, Pressure 1.00e+08Pa
**DOI:** 10.3787/j.issn.1000-0976.2021.07.007
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 61. Status, potential and prospect of shale gas exploration and development in the Sichuan Basin and its periphery

**Accession number:** 20210609883890
**Title of translation:** ,
**Authors:** Yang, Yueming (1); Chen, Yulong (2); Liu, Shenyang (2); Deng, Bin (3); Xu, Hao (3); Chen, Liqing (2); Li, Dingyuan (2); Yin, Yingzi (2); Li, Yi (2)
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**Corresponding author:** Chen, Yulong(chenyulong08@petrochina.com.cn)
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 1
**Issue date:** January 25, 2021
**Publication year:** 2021
**Pages:** 42-58
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** After over ten years of exploration and development, southern China has completely stepped into the stage of scale benefit development of middle-shallow marine shale gas. And a comprehensive evaluation on the shale gas exploration and development potential and development prospect in the Sichuan Basin and its periphery is the key to the construction of "Natural Gas Daqing" in the Sichuan Basin. In order to provide theoretical support for the next shale gas exploration and development, this paper analyzes the status and potential of shale gas exploration and development and forecasts the future development prospect in southern China by systematically summarizing the theories and achievements of shale gas exploration and development in the Upper Ordovician Wufeng Formation-

Lower Silurian Longmaxi Formation of the Sichuan Basin. And following research results were obtained. First, shale gas resources in the Wufeng Formation-Longmaxi Formation marine shale above 4 500 m in southern Sichuan is 3.7×1012 m3, among which the recoverable reserves exceed 2×1012 m3. It has the development potential of constructing a yearly shale gas production scale of 1 000×108 m3 and stablizing production for more than 10 years. So far, PetroChina has submitted 1.061×1012 m3 proved geological reserves of shale gas in total and constructed the major shale gas province with a yearly production of tens of billions of cubic meters. Second, the Wufeng Formation-Longmaxi Formation marine shale in the northeastern Chongqing-western Hubei area and the southwestern Sichuan-northeastern Yunnan complex structural area have better shale gas resource potential and promising exploration and development prospect. Third, there are three backup series of shale gas strata in the Sichuan Basin and its periphery, i.e., Lower Cambrian Qiongzhusi Formation marine shale, Upper Permian Longtan Formation transitional facies shale and Lower Jurassic Ziliujing Formation continental shale. Among them, the Qiongzhusi Formation marine shale in Mianyang-Changning intracratonic sag is characterized by thicker quality shale, higher pressure and relatively developed pores, and it is the focus for the next shale gas exploration and development. And the Ziliujing Formation Daanzhi Member continental shale in the central-northeastern Sichuan Basin also has a certain potential of shale oil & gas exploration and development. 
**Number of references:** 45
**Main heading:** Gas industry
**Controlled terms:** Energy resources - Gases - Geological surveys - Petroleum deposits - Proven reserves - Shale gas
**Uncontrolled terms:** Comprehensive evaluation - Development potential - Development prospects - Exploration and development - Geological reserves - Longtan Formation - Northeastern Sichuan - Recoverable reserves
**Classification code:** 481.1 Geology - 512.1 Petroleum Deposits - 512.1.2 Petroleum Deposits : Development Operations - 522 Gas Fuels - 525.1 Energy Resources and Renewable Energy Issues
**Numerical data indexing:** Age 1.00e+01yr, Size 4.50e+03m
**DOI:** 10.3787/j.issn.1000-0976.2021.01.004
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 62. Control effect of strike-slip faults on carbonate reservoirs and hydrocarbon accumulation: A case study of the northern depression in the Tarim Basin

**Accession number:** 20211710247360
**Title of translation:** --
**Authors:** Wang, Rujun (1); Wang, Xuan (1); Deng, Xingliang (1); Zhang, Yintao (1); Yuan, Jingyi (1); Xie, Zhou (1); Li, Ting (1); Luo, Xiao (1); Ma, Xiaoping (1)
**Author affiliation:** (1) PetroChina Tarim Oilfield Company, Korla; 841000, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
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**Issue:** 3
**Issue date:** March 25, 2021
**Publication year:** 2021
**Pages:** 10-20
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** In the early exploration stage of Ordovician oil and gas in the Tarim Basin, carbonate karst reservoirs in Tabei uplift, Tazhong uplift and the slope of Tazhong uplift are dominant and a great number of carbonate oil and gas reservoirs are discovered. In the northern depression between the Tabei uplift and the Tazhong uplift, however, no oil and gas has been discovered and oil and gas exploration progress is restricted because its reservoir development mechanisms and hydrocarbon accumulation patterns are not understood sufficiently. After identifying the strike-slip faults by researching the interpretation on the strike-slip faults in the northern depression of the Tarim Basin, this paper studies the faults by layers and segments and then clarifies the control effect of strike-slip faults on reservoirs and hydrocarbon accumulation. And the following research results were obtained. First, the strike-slip fault activity in the northern depression is weaker. The accuracy of strike-slip fault identification can be greatly improved by extracting the attribute of amplitude change rate based on double filtering, and 34 strike-slip faults are identified in the northern

depression. Second, strike-slip faults have the characteristics of vertical stratification, and there are three sets of fault combinations that are dominated by high-angle linear strike-slip in Cambrian to Ordovician, linear semi-flower-like structure in Silurian to Permian, and en-echelon structure in Triassic to Paleogene. Third, strike-slip faults present the characteristics of three segments on plane, i.e., the compression and torsion segment of positive flower shape at the structural high, the tension and torsion segment of negative flower shape with obvious graben characteristics, and the translation segment with the weakest fault activity intensity. Fourth, the reservoirs and hydrocarbon accumulation are controlled by strike-slip faults obviously. The oil and gas reservoirs are mainly distributed along the fault belt on plane and oil and gas are distributed in multiple sections along faults in the vertical direction. Thus, there are 9 hydrocarbon accumulation patterns. In conclusion, the fine interpretation of weak strike-slip faults can be realized by virtue of the comprehensive description technology of strike-slip faults based on the interpretive processing of post-stack seismic data. What's more, these 9 reservoir accumulation patterns effectively guide the exploration deployment in the northern depression of the Tarim Basin and realize the efficient oil and gas development in this area. 
**Number of references:** 29
**Main heading:** Fault slips
**Controlled terms:** Carbonation - Gases - Hydrocarbon refining - Hydrocarbons - Petroleum prospecting - Petroleum reservoir engineering - Petroleum reservoirs - Seismology - Strike-slip faults - Structural geology - Torsional stress
**Uncontrolled terms:** Carbonate reservoir - Fault identifications - Flower-like structures - Hydrocarbon accumulation - Oil and gas exploration - Oil and gas reservoir - Reservoir development - Vertical stratification
**Classification code:** 481.1 Geology - 484.1 Earthquake Measurements and Analysis - 512.1.1 Oil Fields - 512.1.2 Petroleum Deposits : Development Operations - 802.2 Chemical Reactions - 802.3 Chemical Operations - 804.1 Organic Compounds
**DOI:** 10.3787/j.issn.1000-0976.2021.03.002
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 63. Economic and effective development of shale gas in mountainous areas outside the Sichuan Basin

**Accession number:** 20212010375709
**Title of translation:**
**Authors:** He, Yong (1); Li, Lin (1); Liu, Cheng (1); Wang, Jianjun (1); Rui, Yun (1)
**Author affiliation:** (1) PetroChina Zhejiang Oilfield Company, Hangzhou; Zhejiang; 310023, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
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**Issue date:** April 25, 2021
**Publication year:** 2021
**Pages:** 82-90
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** So far, there has been no successful precedent in developing shallow shale gas reservoirs with a depth less than 2 000 m, especially less than 1 000 m in China. In order to provide ideas for the development of domestic first mountainous shallow shale gas reservoir, i.e. the mountainous shallow shale gas reservoir of Taiyang Block (hereinafter referred to as "Taiyang gas reservoir"), this paper analyzes the hydrocarbon accumulation characteristics of mountainous shallow shale gas in this area based on previous research achievements, combined with existing seismic, geological, drilling, mud logging, well logging, testing, assay and production performance data of Taiyang anticlinal area in the Zhaotong National Shale Gas Demonstration Area in the periphery of the Sichuan Basin. Then, the technological countermeasures for economic and effective development of mountainous shallow shale gas in this area are explored. And the following research results were obtained. First, Taiyang gas reservoir is a composite anticlinal shale gas reservoir, which is featured by a trough-like structure with overall small burial depth, larger area, wide and gentle anticline and narrow syncline. It is monoblock, continuous and large and has greater resource potential for the large-scale productivity construction and stable production of shale gas. Second, different from middle and

deep shale gas reservoirs, Taiyang gas reservoir is influenced by Yanshanian and Himalayan tectonic uplift, so its preservation conditions are poor at the top and good at the flanks and the shale gas reservoir has developed natural fractures and smaller horizontal stress difference. The pressure coefficient is low, so it is a normal pressure-slight overpressure gas reservoir. Third, the anticlinal top in the same sublayer is associated with the characteristics of conventional gas accumulation and dispersion, i.e., higher free gas content, porosity and gas saturation. Fourth, shallow shale gas has the production performance characteristics of low initial pressure, initial productivity and production decline rate. Therefore, by taking the concept of the benefit development of mountainous shallow shale gas as the core, the design ideas for three types of wells (A, B and C) were defined based on burial depth, and the economically and technologically effective development countermeasures were put forward from the aspects of reservoir engineering, drilling and production engineering and investment cost control. 
**Number of references:** 21
**Main heading:** Gas industry
**Controlled terms:** Composite structures - Cost engineering - Economic and social effects - Gases - Infill drilling - Mud logging - Petroleum reservoirs - Productivity - Shale gas - Well testing
**Uncontrolled terms:** Development countermeasures - Hydrocarbon accumulation characteristics - Preservation condition - Pressure coefficients - Production decline rates - Production performance - Research achievements - Reservoir engineering
**Classification code:** 408.2 Structural Members and Shapes - 511.1 Oil Field Production Operations - 512.1.1 Oil Fields - 512.1.2 Petroleum Deposits : Development Operations - 522 Gas Fuels - 911 Cost and Value Engineering; Industrial Economics - 971 Social Sciences
**Numerical data indexing:** Size 1.00e+03m, Size 2.00e+03m
**DOI:** 10.3787/j.issn.1000-0976.2021.04.009
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 64. Key technologies for complex surface seismic acquisition in the Sichuan Basin and their application effect

**Accession number:** 20213210735551
**Title of translation:**
**Authors:** Wang, Xiaoyang (1, 2); Zhang, Xiaobin (2); Zhao, Xiaohong (3); Hu, Feng (2); Ren, Cong (3); Wang, Guangyin (4); Li, Shuqin (2); Sun, Siyi (3); Wang, Shuyan (3); Luo, Wen (2)
**Author affiliation:** (1) College of Geophysics, Chengdu University of Technology, Chengdu; 610059, China; (2) Southwest Geophysical Branch, BGP Inc., CNPC, Chengdu; 610213, China; (3) Exploration Department, PetroChina Southwest Oil & Gasfield Company, Chengdu; 610051, China; (4) Research & Development Center, BGP Inc., CNPC, Chengdu; 610213, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
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**Issue date:** July 25, 2021
**Publication year:** 2021
**Pages:** 15-23
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** The earth surface in the Sichuan Basin and its periphery is geologically complex, which causes low signal-to-noise ratio of seismic data, poor imaging quality of seismic profiles and great difficulty in acquisition construction. In order to ensure high-quality operation of the seismic exploration project in the complex surface of the Sichuan Basin, researchers have been working continuously to solve the bottleneck problems in the seismic acquisition technology for complex surface in recent years. In addition, the upgrading of acquisition technology and construction operation capacity is promoted effectively by means of technical innovation, and a series of key technologies for seismic acquisition are developed. And the following application results of this series of technologies are obtained. First, the optimization design technology of the observation system based on wave equation forward modeling and actual data, combined with prestack migration imaging can show the influence of different acquisition schemes on the prestack

imaging effect of complex targets more directly, which makes the seismic acquisition scheme more economic and effective. Second, by extracting landform risks and surface obstacle information intelligently, combined with field fine reconnaissance, landform risk identification and hierarchical evaluation and indoors intelligent optimization of well-shot physical point deployment are conducted, and thus the GIS+ intelligent deployment technology of shot point in complex surface is formed, which effectively reduces the risks of construction operation. Third, the cavity excitation technology which reduces the initial pressure of explosive pulse and extends the explosive action time of explosives can increase the conversion rate of rock excitation energy into effective elastic wave energy and the reflected energy and improve the quality of seismic single shot data. Fourth, combination of the automatic evaluation technology for field seismic data acquired in mountainous regions and the KL-GMLiveQC1.0 software can improve the evaluation efficiency, reduce the evaluation cost and ensure the high-quality acquisition of seismic data in complex surface. In conclusion, this series of key seismic acquisition technologies greatly improve the signal-to-noise ratio and resolution of seismic data, lay a foundation for fine reservoir prediction, and ensure the continuous important breakthrough of three-dimensional natural gas exploration and development in the gas fields of marine carbonate rock, shale gas, volcanic rock and shallow tight sandstone gas in the Sichuan Basin. 
**Number of references:** 22
**Main heading:** Economic and social effects
**Controlled terms:** Construction - Explosives - Intelligent well technology - Landforms - Natural gas fields - Natural gasoline plants - Petroleum prospecting - Petroleum reservoir evaluation - Quality control - Seismic design - Seismic prospecting - Seismic response - Seismic waves - Signal to noise ratio - Technology transfer - Wave energy conversion
**Uncontrolled terms:** Construction operations - Hierarchical evaluation - Intelligent optimization - Low signal-to-noise ratio - Marine carbonate rock - Natural gas exploration - Reservoir prediction - Technical innovation
**Classification code:** 405 Construction Equipment and Methods; Surveying - 408 Structural Design - 481.1 Geology - 481.4 Geophysical Prospecting - 484 Seismology - 512.1.2 Petroleum Deposits : Development Operations - 512.2.1 Natural Gas Fields - 513.2 Petroleum Refineries - 615.6 Wave Energy - 716.1 Information Theory and Signal Processing - 913.3 Quality Assurance and Control - 971 Social Sciences
**DOI:** 10.3787/j.issn.1000-0976.2021.07.002
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 65. Breakthrough of natural gas exploration in the beach facies porous dolomite reservoir of Middle Permian Maokou Formation in the Sichuan Basin and its enlightenment: A case study of the tridimensional exploration of Well JT1 in the central-northern Sichuan Basin

**Accession number:** 20211210116958
**Title of translation:** -JT1
**Authors:** Yang, Yu (1); Xie, Jirong (2); Zhao, Luzi (1); Huang, Pinghui (3); Zhang, Xihua (2); Chen, Cong (2); Zhang, Benjiang (2); Wen, Long (4); Wang, Hua (2); Gao, Zhaolong (2); Shan, Shujiao (2)
**Author affiliation:** (1) PetroChina Southwest Oil & Gasfield Company, Chengdu; 610051, China; (2) Exploration and Development Research Institute, PetroChina Southwest Oil & Gasfield Company, Chengdu; 610041, China; (3) Exploration Department, PetroChina Southwest Oil & Gasfield Company, Chengdu; 610051, China; (4) Northwest Sichuan Division, PetroChina Southwest Oil & Gasfield Company, Jiangyou; 621741, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
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**Issue date:** February 25, 2021
**Publication year:** 2021
**Pages:** 1-9
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** The neritic carbonate reservoir of Middle Permian Maokou Formation in the Sichuan Basin has been always treated as a fractured and fractured-vuggy reservoir. After realizing the breakthrough of natural gas exploration in the Lower Cambrian Canglangpu Formation in the Taihe gas bearing area of central-northern Sichuan Basin, Well JT1, a wildcat well, recently discovers a beach facies porous dolomite reservoir in the Maokou Formation above the

Canglangpu Formation, and the high-yield industrial gas flow of 112.8×104 m3/d is obtained during the test. And thus, Well JT1 achieves the breakthrough of tridimensional natural gas exploration in multiple gas bearing series of strata in the vertical direction and realizes the new discovery of reservoir type in the Maokou Formation. In order to further clarify the characteristics and control factors of the beach facies porous dolomite reservoir of Maokou Formation in the Taihe gas bearing area, this paper studied its sedimentary evolution, high-energy beach facies characteristics, reservoir characteristics and following natural gas exploration direction. And the following research results were obtained. First, along the syneclise margin of central-northern Sichuan Basin develops a beach facies porous reservoir of the second Member of Maokou Formation, whose lithology is dominated by residual dolarenite and calcsparite calcarenite and reservoir space is mainly acted by intergranular pores and intercrystalline pores, with the average porosity of 4.9%. Second, in the middle and late stage of Maokou period, Guangyuan-Bazhong paleo faulted depression was developed in the northern Sichuan Basin and intraplatform low was developed in the central-northern Sichuan Basin. In the central and the northern Sichuan Basin, the high-energy beach of Maokou Formation is distributed around the faulted depression and the syneclise margin in a large scale, and the paleogeographic pattern of "one-margin and three-high belt" is presented. Third, under the control of high-energy beach facies, the Maokou Formation porous reservoir in the central-northern Sichuan Basin is distributed along the "one-margin and three-high belt" in a large scale. The high-energy beach facies of "one-margin and three-high belt" covers the area of 6 500 km2. In this area, multiple sets of source rocks (Cambrian, Silurian and Permian) are developed vertically, hydrocarbon source fault is developed and carrier system is good, which is favorable for the large-scale hydrocarbon enrichment and accumulation. In conclusion, there are geological conditions for the development of facies controlled porous reservoir in the Maokou Formation of the Sichuan Basin, and the "one-margin and three-high belt" is the favorable area for the exploration of beach facies porous dolomite reservoir. The research results point out the new exploration field and direction for the large-scale increase of natural gas reserves in the Sichuan Basin. 
**Number of references:** 21
**Main heading:** Oil bearing formations
**Controlled terms:** Beaches - Calcite - Discovery wells - Flow of gases - Gas bearings - Gases - Geological surveys - Hydrocarbons - Lithology - Natural gas - Natural gas wells - Proven reserves - Textures - Wildcat wells
**Uncontrolled terms:** Enrichment and accumulations - Fractured-vuggy reservoirs - Geological conditions - Intercrystalline pores - Natural gas exploration - Natural gas reserves - Reservoir characteristic - Sedimentary evolution
**Classification code:** 407.3 Coastal Engineering - 481.1 Geology - 512 Petroleum and Related Deposits - 522 Gas Fuels - 601.2 Machine Components - 631.1.2 Gas Dynamics - 804.1 Organic Compounds - 804.2 Inorganic Compounds
**Numerical data indexing:** Area 6.50e+09m2, Percentage 4.90e+00%
**DOI:** 10.3787/j.issn.1000-0976.2021.02.001
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 66. Research progress and direction of geology-engineering integrated drilling technology: A case study on the deep shale gas reservoirs in the Sichuan Basin

**Accession number:** 20210609883960
**Title of translation:** -
**Authors:** Liu, Qingyou (1); Zhu, Haiyan (1); Chen, Pengju (1)
**Author affiliation:** (1) State Key Laboratory of Oil and Gas Reservoir Geology and Exploitation, Chengdu University of Technology, Chengdu; 610059, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 1
**Issue date:** January 25, 2021
**Publication year:** 2021
**Pages:** 178-188
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)

**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** In order to develop domestic deep shale gas resources safely and efficiently, it is in urgent need to study the geology-engineering integrated drilling technology. In this paper, the latest progress in the research field of geology-engineering integrated drilling is summarized systematically after the concepts and research ideas of geology-engineering integrated drilling are illustrated. Then, based on the characteristics of deep shale gas reservoirs in the Sichuan Basin, the research direction in the following stage is pointed out. And the following research results were obtained. First, geology-engineering integrated drilling is based on geologic study to adjust and optimize the drilling scheme specifically, so as to realize safe and efficient drilling. In the meantime, it makes use of actual drilling data to modify the geologic model, so as to finally provide a safe and efficient geology-engineering integrated drilling scheme. Second, the existing geologic modeling technologies can hardly precisely describe the spatial distribution characteristics of deep shale gas reservoirs in the Sichuan Basin. Third, the reservoirs are of strong heterogeneity, so it is recommended to establish a dynamic model of drilling string system considering the anisotropic characteristics of shale reservoir. Fourth, improving the lubricity of drilling fluid and controlling the borehole trajectory precisely is the key to reducing the friction and drag of drill string in the horizontal section. Fifth, in order to meet the demand of efficient rock breaking, it is necessary to carry out a systematic study on the rock breaking mechanisms of non-plane teeth. Sixth, downhole robot can control weight on bit (WOB) and rate of penetration (ROP) intelligently and it may be a new method of intelligent drilling. Seventh, the studies on the mechanical-chemical damage to circumferential rock and the friction behaviors on the plane of micro fracture will the main content to research the borehole instability mechanisms in deep shale. Eighth, the research and development of artificial intelligence aided geosteering technology and novel measurement while drilling tool is the main research direction. In conclusion, an important progress has been made in researching the geology-engineering integrated drilling technology at home. As for the deep shale gas reservoirs in the Sichuan Basin, however, it is necessary to strengthen the studies on high precision geologic modeling, efficient personalized bit, intelligent drilling control, high-accuracy steering and environmental drilling fluid of friction reduction and collapse prevention, so that the safe and efficient geology-engineering-ecology integrated drilling technology suitable for deep shale gas reservoirs can be developed ultimately. 
**Number of references:** 85
**Main heading:** Infill drilling
**Controlled terms:** Artificial intelligence - Boreholes - Drill strings - Drilling fluids - Drilling machines (machine tools) - Energy resources - Environmental technology - Friction - Gases - Geologic models - Petroleum reservoirs - Precision engineering - Shale gas - Silicon compounds
**Uncontrolled terms:** Borehole trajectories - Distribution characteristics - Environmental drilling - Measurement-while-drilling tools - Research and development - Rock breaking mechanism - Shale gas reservoirs - Strong heterogeneities
**Classification code:** 454 Environmental Engineering - 481.1 Geology - 511.1 Oil Field Production Operations - 511.2 Oil Field Equipment - 512.1.1 Oil Fields - 522 Gas Fuels - 525.1 Energy Resources and Renewable Energy Issues - 603.1 Machine Tools, General - 723.4 Artificial Intelligence
**DOI:** 10.3787/j.issn.1000-0976.2021.01.016
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 67. Prevention and punishment of natural gas theft offence

**Accession number:** 20212010375685
**Title of translation:**
**Authors:** Chen, Ziqiang (1); Tong, Xinya (1)
**Author affiliation:** (1) School of Arts and Laws, Southwest Petroleum University, Chengdu; Sichuan; 610500, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 4
**Issue date:** April 25, 2021
**Publication year:** 2021
**Pages:** 160-166
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency

**Abstract:** The illegal and criminal activities of stealing gas and oil for personal purposes may pose a great threat to enterprises' property security and public security, and even impact the normal production and operation order of related oil and gas enterprises. In recent years, the incidence of oil and gas theft in China has been decreasing year by year, but it is still necessary to further control and reduce domestic incidence and crime rates of oil and gas theft. In order to prevent and punish the natural gas theft offence, this paper carries out a statistical analysis on the annual and geographic distribution, criminal act and oil and gas theft classification, criminal result and conviction classification, and penalty application classification of domestic oil and gas theft offences, as well as the application situations of relevant judicial explanation in domestic judicial trail of oil and gas theft offence by means of judicial adjudicative document retrieval and data analysis, based on the Big Data. Then, prevention and punishment suggestions were proposed specifically from the enterprise and society level and the law and judicial level, respectively. In conclusion, only by constantly improving the realization degree of the criminal law function in oil and gas theft offence and by paying close attention to the self-improvement of criminal laws in the prevention and punishment of oil and gas theft offence can this type of offence be prevented and controlled effectively and practically and the security of domestic oil and gas resources and the normal production and operation order of oil and gas enterprises be ensured. 
**Number of references:** 17
**Main heading:** Crime
**Controlled terms:** Energy resources - Gases - Geographical distribution - Information retrieval systems - Natural gas - Natural gas wells - Petroleum deposits
**Uncontrolled terms:** Application classifications - Criminal activities - Criminal laws - Document Retrieval - Domestic oil - Oil and gas - Public security
**Classification code:** 405.3 Surveying - 512.1 Petroleum Deposits - 512.2.1 Natural Gas Fields - 522 Gas Fuels - 525.1 Energy Resources and Renewable Energy Issues - 903.3 Information Retrieval and Use - 971 Social Sciences
**DOI:** 10.3787/j.issn.1000-0976.2021.04.017
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 68. Multi-scale finite volume method for the flow and heat transfer process in hot dry rocks

**Accession number:** 20211710247376
**Title of translation:**
**Authors:** Yu, Bo (1); Li, Tingyu (2); Han, Dongxu (1); Sun, Dongliang (1); Yang, Fusheng (2); Wei, Jinjia (2)
**Author affiliation:** (1) School of Mechanical Engineering, Beijing Institute of Petrochemical Technology, Beijing; 102617, China; (2) School of Chemical Engineering and Technology, Xi'an Jiaotong University, Xi'an; 710049, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 3
**Issue date:** March 25, 2021
**Publication year:** 2021
**Pages:** 168-178
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** Efficient and reliable numerical simulation technology is crucial to deeply understanding the flow and heat transfer process in hot dry rock reservoirs and formulate reasonable development plans. However, the traditional high-fidelity finite volume method is time-consuming when it is used to solve complex flow and heat transfer of fractured reservoirs. To this end, this paper puts forward an integrated thermal-hydraulic multi-scale finite volume solution method based on the embedded discrete fracture model. And its solution process is mainly as follows. First, obtain the pressure and temperature basis functions in the coarse grid support area of matrix and fractures through Jacobian iteration. These basis functions can not only reflect the heterogeneity of matrix in the fine-scale area, but also can represent fracture distribution characteristics. Second, construct a transient coarse grid discrete system by using pressure and temperature basis functions and pre-defined coarse scale operators. And third, adopt the strategy of two-step iterative multi-scale solution to successively dissipate the surplus multi-scale error in the coarse and fine scales, so as to achieve the required solution accuracy. Then, the calculation accuracy and efficiency of the multi-scale finite volume method were verified based on two examples of fractured geothermal reservoir exploitation. And the following research results were obtained. First, the solution accuracy of pressure and temperature fields by the multi-scale finite

volume method decreases slightly with the increase of simulation time. The calculation accuracy can be increased by increasing the number of multi-scale cycles, but if the number of cycles is too large, the multi-scale acceleration effect will be spoiled. Second, when the number of multi-scale cycles is in the range of 50-100, the relative deviation of two norms between the multi-scale solution and the fine-scale solution is 10-3-10-4. In conclusion, compared with the traditional finite volume method, the multi-scale finite volume method can increase the calculation efficiency by 4-5 times while ensuring the calculation accuracy. 
**Number of references:** 31
**Main heading:** Iterative methods
**Controlled terms:** Efficiency - Finite volume method - Fracture - Functions - Geothermal fields - Geothermal wells - Heat transfer coefficients - Jacobian matrices
**Uncontrolled terms:** Calculation accuracy and efficiencies - Calculation efficiency - Discrete-fracture models - Finite volume solution - Fracture distributions - Hot dry rock reservoirs - Pressure and temperature - Simulation technologies
**Classification code:** 481.3.1 Geothermal Phenomena - 641.2 Heat Transfer - 913.1 Production Engineering - 921 Mathematics - 951 Materials Science
**DOI:** 10.3787/j.issn.1000-0976.2021.03.020
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 69. Strategies for promoting LNG high-quality development in the transportation sector: A case of the Chengdu-Chongqing economic circle

**Accession number:** 20213010678023
**Title of translation:** LNG--
**Authors:** Qian, Zhijia (1); Zhu, Liyang (2); Xiong, Bo (2); Wang, Li (3); Zhang, Jianping (3)
**Author affiliation:** (1) PetroChina Natural Gas Marketing Company, Kunlun Energy Co., Ltd., Beijing; 100000, China; (2) PetroChina Southwest Oil & Gasfield Company, Chengdu; 610015, China; (3) Natural Gas Economic Research Institute, PetroChina Southwest Oil & Gasfield Company, Chengdu; 610015, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 6
**Issue date:** June 25, 2021
**Publication year:** 2021
**Pages:** 104-110
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Number of references:** 23
**Main heading:** Gases
**Controlled terms:** Carbon - Chains - Commerce - Ecology - Gas industry - Natural gas - Resource allocation
**Uncontrolled terms:** Chengdu - Chengdu-chongqing economic circle - Chongqing - Commercial ecosystem - Ecological chains - Economic circles - Gas ecological chain - High quality - High-quality development demonstration area of natural gas industry - Market cultivation - Natural Gas Industry - Natural gas vehicle
**Classification code:** 454.3 Ecology and Ecosystems - 522 Gas Fuels - 602.1 Mechanical Drives - 804 Chemical Products Generally - 912.2 Management
**DOI:** 10.3787/j.issn.1000-0976.2021.06.012
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 70. Development of China's natural gas industry during the 14th Five-Year Plan in the background of carbon neutrality

**Accession number:** 20211210117277

**Title of translation:** ""
**Authors:** Zhou, Shuhui (1); Wang, Jun (1); Liang, Yan (1)
**Author affiliation:** (1) PetroChina Planning and Engineering Institute, Beijing; 100083, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 2
**Issue date:** February 25, 2021
**Publication year:** 2021
**Pages:** 171-182
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Number of references:** 27
**Main heading:** Commerce
**Controlled terms:** Carbon - Energy resources - Gas industry - Greenhouse gases - Natural gas - Natural gas deposits - Natural gas transportation - Petroleum deposits - Pipelines
**Uncontrolled terms:** 14th five-year plan - Carbon neutralities - China - Five-year plans - Industry development - Infrastructure - Market - Natural Gas Industry - Natural gas industry development - Resource supply - Suggestion
**Classification code:** 451.1 Air Pollution Sources - 512.1 Petroleum Deposits - 512.2 Natural Gas Deposits - 522 Gas Fuels - 525.1 Energy Resources and Renewable Energy Issues - 619.1 Pipe, Piping and Pipelines - 804 Chemical Products Generally
**Numerical data indexing:** Age 1.50E+01yr, Age 5.00E+00yr to 1.00E+01yr, Percentage 4.50E+01%
**DOI:** 10.3787/j.issn.1000-0976.2021.02.020
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 71. Prediction of medium- and long-term change trend and spatial distribution of natural gas demand based on the SD-GIS method: A case study of Beijing

**Accession number:** 20212010375696
**Title of translation:** SD-GIS-
**Authors:** Ding, Yu (1); Fu, Jiaxin (2, 3); Tang, Xu (1, 4); Wang, Jianliang (1, 4)
**Author affiliation:** (1) School of Economics and Management, China University of Petroleum, Beijing; 102249, China; (2) School of Economics and Management, Beijing Jiaotong University, Beijing; 100044, China; (3) Beijing Gas Group Co., Ltd., Beijing; 100044, China; (4) China Petroleum Industry Development Research Center, Beijing; 102249, China
**Corresponding author:** Tang, Xu(tangxu2001@163.com)
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 4
**Issue date:** April 25, 2021
**Publication year:** 2021
**Pages:** 176-185
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Number of references:** 31
**Main heading:** Natural gas
**Controlled terms:** Carbon - Decision making - Emission control - Forecasting - Gas emissions - Gas industry - Geographic information systems - Spatial distribution - Spatial variables measurement - System theory
**Uncontrolled terms:** Beijing - Carbon emissions - Change trends - Demand - Distribution characteristics - Five-year plans - Forecasting models - Long-term changes - Natural gas demand - System methods

**Classification code:** 405.3 Surveying - 451.2 Air Pollution Control - 522 Gas Fuels - 804 Chemical Products Generally - 902.1 Engineering Graphics - 903.3 Information Retrieval and Use - 912.2 Management - 921 Mathematics - 943.2 Mechanical Variables Measurements - 961 Systems Science
**Numerical data indexing:** Percentage 5.25E+01%
**DOI:** 10.3787/j.issn.1000-0976.2021.04.019
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 72. Natural gas development prospect in Changqing gas province of the Ordos Basin

**Accession number:** 20213910945325
**Title of translation:**
**Authors:** He, Jiangchuan (1, 2); Yu, Haojie (1, 2); He, Guanghuai (2, 3, 4); Zhang, Ji (2, 3); Li, Ya (3, 4)
**Author affiliation:** (1) PetroChina Changqing Oilfield Company, Xi'an; 710018, China; (2) National Engineering Laboratory of Low-Permeability Oil & Gas Exploration and Development, Xi'an; 710018, China; (3) Consulting Center, PetroChina Changqing Oilfield Company, Xi'an; 710018, China; (4) Exploration and Development Research Institute, PetroChina Changqing Oilfield Company, Xi'an; 710018, China
**Corresponding authors:** Zhang, Ji(zhangji_cq@petrochina.com.cn); Zhang, Ji(zhangji_cq@petrochina.com.cn)
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 8
**Issue date:** August 25, 2021
**Publication year:** 2021
**Pages:** 23-33
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** At present, natural gas accounts for a low proportion in China's primary energy consumption structure and is highly dependent on foreign sources. Changqing gas province of the Ordos Basin where the PetroChina Changqing Oilfield Company (referred to as Changqing Oilfield) is located is one of China's four major natural gas production bases. It bears the important responsibility for ensuring people's livelihood and promoting the healthy development of social economy. In recent years, Changqing Oilfield actively implements national instructive spirit on vigorously promoting domestic oil and gas exploration and development strength and formulates the secondary acceleration development strategies. Its annual natural gas production in 2020 reaches 448.5×108 m3 and oil and gas equivalent exceeds 6 000×104 t, tamping its important position of "Western Daqing" in this industry. In order to further promote the continuous stable production and realize the goal of quality and efficiency improvement in Changqing gas province, this paper analyzes the situations and challenges of natural gas development in this gas province, prepares the development technological countermeasures and forecasts the natural gas development prospect. And the following research results are obtained. First, the natural gas exploration and development in Changqing gas province is divided into four stages and the main technologies for the development of low-permeability carbonate gas reservoirs, low-permeability sandstone gas reservoirs and tight sandstone gas reservoirs are formed. Second, the natural gas development in Changqing gas province faces six challenges, such as low reserve production degree, sharp decline of production rates and complex distribution of remaining undeveloped reserves of developed gas fields. And twenty-six development technological countermeasures are put forward correspondingly, such as well pattern thickening, extension and reserve increase, secondary production layer potential tapping and fine gas well management. Third, the development direction and goal of natural gas development in Changqing gas province is to pay equal attention to the stable production of old gas fields and the production increase of new areas and carry out conventional gas and unconventional gas research simultaneously. In conclusion, the annual natural gas production of Changqing gas province will maintain a sound momentum of steady growth and will exceed 500×108 m3 at the end of the 14th Five-Year Plan and maintain at a stable level for a long term, which is conducive to the optimization of domestic energy consumption structure and realization of "carbon peak and carbon neutrality". © 2021, Natural Gas Industry Journal Agency. All right reserved.
**Number of references:** 31
**Main heading:** Metamorphic rocks

**Controlled terms:** Energy utilization - Gas industry - Gas permeability - Gases - Low permeability reservoirs - Natural gas - Natural gas fields - Natural gas well production - Petroleum reservoir engineering - Proven reserves - Sandstone - Tight gas
**Uncontrolled terms:** Changqing gas province of the ordo basin - Changqing oilfield companies - Development potential - Development prospects - Natural gas development - PetroChina - Petrochina changqing oilfield company - Situation and challenge - Technological countermeasure
**Classification code:** 482.2 Minerals - 512.1 Petroleum Deposits - 512.1.2 Petroleum Deposits : Development Operations - 512.2 Natural Gas Deposits - 512.2.1 Natural Gas Fields - 522 Gas Fuels - 525.3 Energy Utilization - 931.2 Physical Properties of Gases, Liquids and Solids
**DOI:** 10.3787/j.issn.1000-0976.2021.08.003
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 73. Enrichment control factors and exploration potential of lacustrine shale oil and gas: A case study of Jurassic in the Fuling area of the Sichuan Basin

**Accession number:** 20213910945563
**Title of translation:** --
**Authors:** Hu, Dongfeng (1); Wei, Zhihong (1); Liu, Ruobing (1); Wei, Xiangfeng (1); Chen, Feiran (1); Liu, Zhujiang (1)
**Author affiliation:** (1) Sinopec Exploration Company, Chengdu; 610041, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 8
**Issue date:** August 25, 2021
**Publication year:** 2021
**Pages:** 113-120
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** The Well Taiye 1 in the Fuling area of the eastern Sichuan Basin has obtained a high-yield industrial gas flow (7.5×104 m3/d gas and 9.8 m3/d oil) from the Middle Jurassic Lianggaoshan Formation, presenting a good test production effect, which means the realization of a major breakthrough in the exploration of Jurassic lacustrine shale oil and gas in the Sichuan Basin. In order to further determine the exploration potential of lacustrine shale oil and gas in this area and realize the large-scale efficient development and utilization of lacustrine shale oil and gas, this paper analyzes the geological conditions for the accumulation of lacustrine shale oil and gas in this area by using the drilling data of 10 key wells, such as wells Taiye 1 and Fuye 10. Then, the main factors controlling the enrichment of lacustrine shale oil and gas are discussed, and the exploration potential and favorable target zones of Jurassic lacustrine shale oil and gas in the Fuling area are defined. And the following research results are obtained. First, the quality Jurassic semi-deep lacustrine shale in the Fuling area is characterized by high organic matter abundance, high porosity and high gas content, and it is the geological base of shale oil and gas enrichment. Second, the developed large wide and gentle syncline, good preservation condition and higher pressure coefficient (generally >1.2) are the key to the enrichment and high yield of shale oil and gas. Third, the developed microfractures in lacustrine shale are conducive to the enrichment and later fracturing of shale oil and gas. In conclusion, the Lianggaoshan Formation lacustrine shale in the Fuling area is widely distributed with moderate burial depth, developed microfractures and moderate thermal evolution, and its shale gas resource extent and shale oil resource extent are 1 922×108 m3 and 2 800×104 t, respectively, indicating greater potential of shale oil and gas exploration, so shale oil and gas is the important field of oil and gas reserves and production increase in this area in the following stage. 
**Number of references:** 32
**Main heading:** Gases
**Controlled terms:** Energy resources - Flow of gases - Geology - Petroleum deposits - Petroleum prospecting - Shale gas
**Uncontrolled terms:** Enrichment and high yield - Exploration potential - Fuling area - Higher yield - Middle Jurassic - Middle jurassic lianggaoshan formation - Oil and gas - Resource extent - Sichuan Basin - Well taiye 1

**Classification code:** 481.1 Geology - 512.1 Petroleum Deposits - 512.1.2 Petroleum Deposits : Development Operations - 512.2 Natural Gas Deposits - 522 Gas Fuels - 525.1 Energy Resources and Renewable Energy Issues - 631.1.2 Gas Dynamics
**Numerical data indexing:** Size 2.54E-02m, Size 9.80E+00m
**DOI:** 10.3787/j.issn.1000-0976.2021.08.011
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 74. Quantitative model construction of oil & gas exploration and development technological element profit sharing

**Accession number:** 20211710247375
**Title of translation:**
**Authors:** Jiang, Zi'ang (1); Liu-Shen, Aoyi (2); Gu, Sui (1); Wang, Jing (1); Ren, Limei (3); Liu, Weidong (4); Peng, Bin (5)
**Author affiliation:** (1) Natural Gas Economic Research Institute, PetroChina Southwest Oil & Gasfield Company, Chengdu; 610051, China; (2) PetroChina Research Institute of Petroleum Exploration & Development, Beijing; 100083, China; (3) Tight Oil & Gas Exploration and Development Project Division, PetroChina Southwest Oil & Gasfield Company, Chengdu; 610051, China; (4) Communications and Information Technology Center, PetroChina Southwest Oil & Gasfield Company, Chengdu; 610051, China; (5) CNPC Chuanqing Drilling Engineering Co., Ltd., Chengdu; 610051, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 3
**Issue date:** March 25, 2021
**Publication year:** 2021
**Pages:** 147-154
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** Oil & gas industry is a typical resource-intensive and technology-intensive industry. Its scientific and technological activities are carried out closely around the production demand, so the technological achievements and production achievements are integrated and difficult to be separated. The contribution may be different when a technology is applied in different oil & gasfield. Meanwhile, the profit can be gained, because there's always a lot of synergy between technological achievements and other production elements. No matter using "with or without contrast method" or "incremental benefit method", it is impossible to calculate technological element directly contribution for an enterprise, and it cannot quantify value of specific technological achievements. Thus, based on the theories of elements distribution and technological value sharing, it analyzes influence mechanism of oil & gas all production elements working in reserve and production profit, constructs quantitative model of oil & gas exploration and development technological element profit sharing. It suggests that: Firstly, using all elements sharing residual value method, oil & gas reserves evaluation criterion, oil & gasfield core characteristic index, it can define the non-technological elements profit sharing rate. Secondly, using technological innovation indicators to calculate specific technological innovation intensity coefficient, it can define the net profit sharing of technological innovation achievements, so as to quantify specific technological value and realize profit sharing from the whole technological elements to a single technological element. It provides a scientific basis for oil & gas technology to share profit with its value and contribution, as an important production elment. And it innovates and develops scientific and technological assessment theory under regulation conditions. © 2021, Natural Gas Industry Journal Agency. All right reserved.
**Number of references:** 20
**Main heading:** Proven reserves
**Controlled terms:** Gas industry - Gases - Geological surveys - Profitability - Reserves to production ratio - Wages
**Uncontrolled terms:** Characteristic indices - Elements distribution - Influence mechanism - Production demand - Quantitative modeling - Scientific basis - Technological activity - Technological innovation
**Classification code:** 481.1 Geology - 512.1 Petroleum Deposits - 512.1.2 Petroleum Deposits : Development Operations - 522 Gas Fuels - 911.2 Industrial Economics - 912.4 Personnel

**DOI:** 10.3787/j.issn.1000-0976.2021.03.018
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 75. Action mechanism on the influence of impact load on micropore structure of anthracite

**Accession number:** 20214311047331
**Title of translation:**
**Authors:** Wang, Yixian (1); Liang, Weimin (2)
**Author affiliation:** (1) Henan Technical College of Construction, Zhengzhou; 450064, China; (2) School of Civil Engineering, Henan Polytechnic University, Jiaozuo; 454000, China
**Corresponding author:** Liang, Weimin(liangwm@hpu.edu.cn)
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 9
**Issue date:** September 25, 2021
**Publication year:** 2021
**Pages:** 87-97
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** In order to study the action mechanism of impact load on the micropores of anthracite and improve the development effect of coalbed methane (CBM), this paper takes the anthracite of Chengzhuang Mine of Qinshui Coal Field as the research object to carry out impact loading simulation experiment on the coal samples in vertical, parallel and 45° oblique bedding direction by using Hopkinson impact system. Then, the action laws and characteristics of impact load on the micropores of anthracite are analyzed based on the measured data of mercury intrusion, low-temperature liquid nitrogen and scanning electron microscope(SEM) before and after the impact. Finally, the action mechanisms of impact load on the micropores of anthracite are explored further. And the following research results are obtained. First, impact load can increase pore diameter and pore volume, improve pore structure and pore connectivity, and enhance gas diffusion, seepage and migration velocity. There is an optimal improvement effect of impact load, and the impact load corresponding to the optimal improvement effect in different directions is different. Second, the impact load before the optimal improvement effect improves pore structures and permeability performance, and that after the optimal improvement effect increases micropores, blocks mesopores and macropores, and overall deteriorates porosity and permeability performance of pores. Third, there are two coal failure modes under impact load. One failure mode starts from microcrystalline structure and is based on dislocation pile-up effect; and the other starts from macropore and is based on coal matrix crushing. In conclusion, the research results are of important theoretical significance to further understand the mechanisms, characteristics and control factors of CBM production, and of practical significance and promotion value for economic and efficient CBM exploitation. © 2021, Natural Gas Industry Journal Agency. All right reserved.
**Number of references:** 36
**Main heading:** Methane
**Controlled terms:** Anthracite - Coal deposits - Coal mines - Deformation - Failure modes - Liquefied gases - Microporosity - Piles - Pore structure - Scanning electron microscopy - Temperature
**Uncontrolled terms:** Action mechanisms - Coal fields - Coalbeds - Dislocation pileup - Impact loads - Micropores - Performance - Pores structure - Qinshui coal field - Research results
**Classification code:** 408.2 Structural Members and Shapes - 503 Mines and Mining, Coal - 503.1 Coal Mines - 524 Solid Fuels - 641.1 Thermodynamics - 804.1 Organic Compounds - 931.2 Physical Properties of Gases, Liquids and Solids
**DOI:** 10.3787/j.issn.1000-0976.2021.09.009
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 76. Key technological challenges and research directions of deep shale gas development

**Accession number:** 20210609884025
**Title of translation:**
**Authors:** He, Xiao (1); Li, Wuguang (1); Dang, Lurui (1); Huang, Shan (2); Wang, Xudong (2); Zhang, Chenglin (2); Zhang, Nanqiao (2); Chen, Yue (2)
**Author affiliation:** (1) PetroChina Southwest Oil & Gasfield Company, Chengdu; 610051, China; (2) Research Institute of Shale Gas, PetroChina Southwest Oil & Gasfield Company, Chengdu; 610051, China
**Corresponding author:** Li, Wuguang(liwuguang@petrochina.com.cn)
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**Abbreviated source title:** Natur. Gas Ind.
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**Pages:** 118-124
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** In order to realize scale beneficial development of deep shale gas, this paper analyzed the challenges in the efficient development of deep shale gas by comparing geological and engineering characteristics between the deep shale reservoirs of Upper Ordovician Wufeng Formation-Long11 Submember of Lower Silurian Longmaxi Formation and the medium-shallow shale reservoirs in the southern Sichuan Basin. It is shown that compared with the medium-shallow shale reservoirs, the engineering characteristic parameters of deep shale reservoirs in China are characterized by "five highs", i.e., high Poisson's ratio and elastic modulus, high reservoir temperature, high horizontal stress difference, high fracturing pressure and high closure pressure. Recently, strategic breakthroughs have been achieved in deep shale gas, but its key development technologies are still limited in the following aspects. First, commercial production of high-temperature rotary steering tool has not been realized at home, reservoir prediction accuracy by geosteering technology is low, "one-trip" technology has not been formed, and drilling fluid to satisfy the need of anti-collapse and anti-leak is not mature. Second, after the fracturing of deep shale gas wells, complex fracture networks can be hardly formed, and fracture initiation and propagation is difficult. What's more, proppant injection is of high difficulty. Therefore, it is difficult to obtain fractures of high flow conductivity. Third, the phase state of CH4 in the pores of deep shale reservoirs are still unknown, so multi-scale flow laws of deep shale gas and its development technologies and countermeasures cannot be determined. For these reasons, it is necessary to carry out technological researches in terms of drilling engineering, fracturing engineering and development technology and countermeasure. First, develop the 3D geosteering technology based on multi-source information fusion, apply the enhanced hole cleaning technology of "high rotation speed, large displacement and long circulation", and strengthen the research and development of efficient micrometer and nanometer plugging materials and special lost circulation materials used for oil-based drilling fluid, so as to drill horizontal wells better, longer and faster. Second, establish the stress-strain constitutive relationship of deep shale, the toughness model of type , and fracture, the fluid-solid-heat multi-field coupling based hydraulic fracture propagation model considering the mechanical property of weak plane, and the mechanical model and evaluation method of proppant embedment considering the shale creep, so as to ensure sufficient reservoir fracturing. Third, research the microscopic flow capacity and production mechanism of gas in shale reservoirs, optimize the key parameters of horizontal wells, formulate a reasonable flowback system and production system and then optimize the tridimensional development mode, so as to achieve the scale efficient development of deep shale gas. 
**Number of references:** 20
**Main heading:** Oil field equipment
**Controlled terms:** Drilling fluids - Fracture - Gas industry - Gases - High pressure engineering - High temperature engineering - Horizontal wells - Infill drilling - Low temperature production - Oil field development - Oil well drilling - Petroleum reservoir evaluation - Proppants - Shale gas - Stress-strain curves
**Uncontrolled terms:** Engineering characteristics - Hydraulic fracture propagation - Lost circulation materials - Multi-source information fusion - Oil-based drilling fluid - Research and development - Stress-strain constitutive relationships - Technological researches
**Classification code:** 511.1 Oil Field Production Operations - 511.2 Oil Field Equipment - 512.1.1 Oil Fields - 512.1.2 Petroleum Deposits : Development Operations - 522 Gas Fuels - 951 Materials Science
**DOI:** 10.3787/j.issn.1000-0976.2021.01.010
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village

## 77. Pore pressure prediction methods for new blocks and undrilled deep strata: A case study of the high pressure gas wells along the southern margin of the Junggar Basin

**Accession number:** 20211710247361
**Title of translation:** --
**Authors:** Huo, Jin (1); Shi, Jiangang (1); Shen, Xinpu (2); Li, Yuan (1); Shen, Guoxiao (2)
**Author affiliation:** (1) PetroChina Xinjiang Oilfield Company, Karamay; 834000, China; (2) China University of Petroleum , Qingdao; 266580, China
**Corresponding author:** Shen, Xinpu(20180011@upc.edu.cn)
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
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**Issue:** 3
**Issue date:** March 25, 2021
**Publication year:** 2021
**Pages:** 104-111
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** Prediction of formation pore pressure is usually calculated based on the data of acoustic logging and resistivity logging, and it cannot be carried out unless there is a well in the study area or there is a well near the target well. For new blocks or deep strata without wells, the data are limited and no formation pressure is tested for reference, which brings risks to the proper and safe design of drilling fluid density and casing program. To this end, 3D geostress and horizon velocity are introduced into the Eaton method to calculate formation pore pressure. Firstly, the interval transit time, rock density, maximum geostress and minimum geostress of the strata without wells are calculated based on the seismic horizon velocity. Then, the seismic horizon velocity is introduced using the Gardner empirical formation method to calculate the rock density under the overburden rock pressure. Afterwards, finite element modeling and calculation are carried out on the 3D fine geostress field of the target block. On this basis, the 3D numerical solution of fine geostress field of the target block is obtained, and vertical geostress (maximum principal stress), minimum horizontal principal stress and final formation pore pressure are determined. Finally, the key parameters obtained by the Eaton method are verified by using the existing logging density, acoustic, formation fracturing pressure and formation pressure of the upper strata with wells. According to the above mentioned method, Well Tian'an 1 along the southern margin of the Junggar Basin is designed to drill to the hole section 4 131-5 650 m of Cretaceous Lianmuqin Formation at the fourth spudding, where gas shows are obtained, indicating the pore pressure of this hole section is close to the drilling fluid density. In conclusion, the proposed formation pore pressure prediction method based on horizon velocity and 3D geostress for new blocks or deep strata without wells is feasible, and it provides guidance and reference for the drilling design in the similar areas. © 2021, Natural Gas Industry Journal Agency. All right reserved.
**Number of references:** 18
**Main heading:** Acoustic logging
**Controlled terms:** Drilling fluids - Electric logging - Forecasting - Infill drilling - Landforms - Pore pressure - Seismology - Software testing - Velocity
**Uncontrolled terms:** Drilling fluid density - Formation pore pressure - Fracturing pressure - High pressure gas wells - Interval transit time - Maximum principal stress - Pore pressure prediction - Resistivity logging
**Classification code:** 481.1 Geology - 483.1 Soils and Soil Mechanics - 484.1 Earthquake Measurements and Analysis - 511.1 Oil Field Production Operations - 512.1.2 Petroleum Deposits : Development Operations - 723.5 Computer Applications - 751.2 Acoustic Properties of Materials
**Numerical data indexing:** Size 4.13e+03m to 5.65e+03m
**DOI:** 10.3787/j.issn.1000-0976.2021.03.012
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 78. Gel-breaking free drill-in fluid technology for deepwater high-porosity and high-permeability reservoirs

**Accession number:** 20212010376095
**Title of translation:**
**Authors:** Zhao, Xin (1, 2); Geng, Qi (1, 2); Qiu, Zhengsong (1, 2); Geng, Tie (3); Zhou, Guowei (1); Xing, Xijin (4)
**Author affiliation:** (1) Shandong Key Laboratory of Oilfield Chemistry, China University of Petroleum - East China, Qingdao; Shandong; 266580, China; (2) School of Petroleum Engineering, China University of Petroleum - East China, Qingdao; Shandong; 266580, China; (3) China Oilfield Services Limited, Sanhe; Hebei; 065200, China; (4) CNOOC Research Institute Co., Ltd., Beijing; 100028, China
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**Abbreviated source title:** Natur. Gas Ind.
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**Issue date:** April 25, 2021
**Publication year:** 2021
**Pages:** 107-114
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** Deepwater drilling and completion engineering has high cost and great risk, and severe reservoir damage can cause substantial losses. In this paper, the reservoir damage mechanisms in the deepwater gas fields of the South China Sea were analyzed by means of X-ray diffraction, mercury intrusion, scanning electron microscope, hydration swelling and dispersion experiment, and reservoir sensitivity flow experiment. Then, technical countermeasures for reservoir protection were proposed and the drill-in fluid with the ability of reservoir protection was optimized. And the following research results were obtained. First, this reservoir is a sandstone reservoir of high porosity and high permeability and its average clay content is 12.38%. It has a strong velocity sensitivity and moderate water sensitivity. Second, the reservoir damage mechanisms mainly include the solid invasion of drilling and completion working fluid and the incompatibility between working fluid and reservoir rock. Third, the effective temporary plugging of the large-sized pore throats using the ideal packing bridging method is the key technical measure to protect reservoirs. Fourth, the optimized water based drill-in fluid has stable rheological properties under 2-75, the temperature of deepwater wellbore. The recovery ratio of core permeability is in the range of 74.5-92.24% after direct plugging removal by flowback. In addition, the recovery ratio of core permeability is higher than 86% after the core is successively contaminated by the drill-in fluid and chelating acid completion fluid. The field applications in four deepwater wells show that no downhole troubles happen, and plugging removal by flowback is carried out directly after the operation, so the completion operation time is saved. In conclusion, the optimized drill-in fluid can meet the drilling technical requirements of deepwater high-porosity and high-permeability reservoirs. What's more, it is gel-breaking free and its reservoir protection effect is good. 
**Number of references:** 27
**Main heading:** Petroleum reservoir engineering
**Controlled terms:** Core samples - Cost engineering - Deepwater drilling - Drills - Infill drilling - Offshore gas fields - Porosity - Scanning electron microscopy - Well completion - Working fluids
**Uncontrolled terms:** Completion operations - Drilling and completion - High permeability reservoirs - Reservoir damage mechanism - Reservoir sensitivity - Sandstone reservoirs - Technical countermeasures - Technical requirement
**Classification code:** 511.1 Oil Field Production Operations - 512.1.2 Petroleum Deposits : Development Operations - 512.2.1 Natural Gas Fields - 603.2 Machine Tool Accessories - 911 Cost and Value Engineering; Industrial Economics - 931.2 Physical Properties of Gases, Liquids and Solids
**Numerical data indexing:** Percentage 1.24e+01%, Percentage 7.45e+01% to 9.22e+01%, Percentage 8.60e+01%
**DOI:** 10.3787/j.issn.1000-0976.2021.04.012
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 79. Optimization of key parameters for porosity measurement of shale gas reservoirs

**Accession number:** 20212510530540
**Title of translation:**
**Authors:** Zhou, Shangwen (1, 2); Dong, Dazhong (1, 2); Zhang, Jiehui (3); Zou, Chen (3); Tian, Chong (4); Rui, Yun (3); Liu, Dexun (1, 2); Jiao, Pengfei (1, 2)

**Author affiliation:** (1) PetroChina Research Institute of Petroleum Exploration & Development, Beijing; 100083, China; (2) CNPC Key Laboratory of Unconventional Oil & Gas, Langfang; 065007, China; (3) PetroChina Zhejiang Oilfield Company, Hangzhou; 311100, China; (4) Shale Gas Institute, PetroChina Southwest Oil & Gasfield Company, Chengdu; 610051, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
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**Publication year:** 2021
**Pages:** 20-29
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** Porosity is a key parameter in shale gas reservoir evaluation and reserve calculation and its accurate test is the basis for calculating geological reserves of shale gas and determining development plans. In order to clarify the differences between different porosity test methods and their influences on the calculation results of shale gas reserves, we collected 65 shale samples of Lower Silurian Longmaxi Formation from six shale gas wells in the Zhaotong National Shale Gas Demonstration Area of the southern Sichuan Basin for comparative experiments using three porosity test method, including gas injection porosimetry (GIP) method, water immersion porosimetry (WIP) method and nuclear magnetic resonance (NMR) method. Then, these three methods were comparatively analyzed based on the test results. Finally, it was proposed to optimize the key parameters of these three shale porosity test methods. And the following research results were obtained. First, in terms of the GIP method, the particle size of shale sample shall be in the range of 20-60 mesh and the helium saturation equilibrium time shall be over 1 800 s. Second, in terms of the WIP method, the sample shall be dried for at least 48 hours under 110 and saturated for 24 h under the confining pressure of 15 MPa. Third, in terms of the NMR method, NMR porosity calculation shall not be conducted until the NMR signal of the dried sample is deducted, on the basis of echo time and waiting time optimization. Fourth, porosity average and median value obtained by these three shale porosity test methods follow the relationship of WIP porosity > NMR porosity > particle GIP porosity > plunger GIP porosity. Fifth, different shale porosity test methods have greater influences on the calculation results of shale gas geological reserves, whose difference can reach 20%. In conclusion, during the application of NMR method and WIP method, fluid is introduced for saturation, which may damage the shale pores. However, the particle GIP porosity can reflect the entire space of shale more comprehensively and is not influenced by the properties of the applied fluid. Therefore, it is suggested to adopt the particle GIP method to calculate shale gas geological reserves. © 2021, Natural Gas Industry Journal Agency. All right reserved.
**Number of references:** 39
**Main heading:** Porosity
**Controlled terms:** Gases - Geology - Injection (oil wells) - Nuclear magnetic resonance - Nuclear magnetic resonance spectroscopy - Parameter estimation - Particle size - Petroleum reservoir evaluation - Petroleum reservoirs - Proven reserves - Shale gas - Testing
**Uncontrolled terms:** Calculation results - Comparative experiments - Confining pressures - Nuclear magnetic resonance(NMR) - Porosity calculations - Porosity measurement - Saturation equilibrium - Shale gas reservoirs
**Classification code:** 481.1 Geology - 511.1 Oil Field Production Operations - 512.1.1 Oil Fields - 512.1.2 Petroleum Deposits : Development Operations - 522 Gas Fuels - 931.2 Physical Properties of Gases, Liquids and Solids
**Numerical data indexing:** Percentage 2.00e+01%, Pressure 1.50e+07Pa, Time 1.73e+05s, Time 1.80e+03s, Time 8.64e+04s
**DOI:** 10.3787/j.issn.1000-0976.2021.05.003
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 80. Calculation of natural gas compressibility factor and hydrocarbon dew point by the GERG-2008 equation

**Accession number:** 20213210735509
**Title of translation:** GERG-2008
**Authors:** Zhang, Pu (1, 2); Zhou, Li (1, 2); Lu, Chun (1, 2); He, Li (3); Wang, Xiaoli (4); Zhao, Hong (4)

**Author affiliation:** (1) Research Institute of Natural Gas Technology, PetroChina Southwest Oil & Gasfield Company, Chengdu; 610213, China; (2) CNPC Key Laboratory of Natural Gas Quality and Energy Measurement, Chengdu; 610213, China; (3) PipeChina Guangdong Pipeline Network Co., Ltd., Guangzhou; 510530, China; (4) Sichuan Huayou Group Corporation Limited, PetroChina Southwest Oil & Gasfield Company, Chengdu; 610041, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
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**Pages:** 134-143
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** The GERG-2008 equation is recommended in international standard ISO 20765-2 to calculate the thermodynamic properties of natural gas. Comprehensively evaluating the accuracy of GERG-2008 equation in calculating the compressibility factor, density and dew point of natural gas with different compositions and phase states is of great significance to select the calculation method of natural gas thermodynamic properties appropriately and to improve the natural gas quality control level. After collecting abundant experimental data, this paper evaluates and compares the calculation accuracy of the GERG-2008 and AGA8-92DC equations on the density (compression factor) of gaseous natural gas, and evaluates the calculation accuracy of GERG-2008 on the compression factor of high-sulfur natural gas, on the density of LNG and on the hydrocarbon dew points of natural gas. The following research results can be obtained. Firstly, as for the pipeline natural gas with simple compositions as stipulated in the standard, the accuracy of GERG-2008 equation is similar to the AGA8-92DC equation on the density calculation, which is within ±0.10% under pipeline transmission temperature and pressure. For natural gas with high content of heavy compositions, when the critical condensation temperature is close to the calculation temperature, both equations' density calculation accuracy get worse under the pipeline natural gas pressure and their relative average absolute deviation is 0.30% and 0.50%, respectively. The GERG-2008 equation is slightly superior to the AGA8-92DC equation. Secondly, when the GERG-2008 equation is used to calculate the density of LNG with C5+ mole fraction lower than 0.20%, its relative average absolute deviation from the measurement results is lower than 0.10%. Thirdly, the GERG-2008 equation can be used to calculate the hydrocarbon dew point of natural gas without or with trace C6+ isomers. Its calculation accuracy is higher than that by PR or SRK equations of state. In conclusion, the GERG-2008 equation is capable of calculating the physical property of natural gas accurately and comprehensively and can be widely applied in natural gas industry. Therefore, it is recommended that the relevant organizations of natural gas industry speed up the formulation of relevant national standards. 
**Number of references:** 32
**Main heading:** Density of gases
**Controlled terms:** Compressibility of gases - Equations of state - Gas industry - Gases - Hydrocarbons - Isomers - Liquefied natural gas - Pipelines - Quality control - Temperature
**Uncontrolled terms:** Average absolute deviation - Compressibility factor - Condensation temperature - Gas compressibility factors - High sulfur natural gas - International standards - Pipeline transmission - Temperature and pressures
**Classification code:** 522 Gas Fuels - 523 Liquid Fuels - 619.1 Pipe, Piping and Pipelines - 641.1 Thermodynamics - 804 Chemical Products Generally - 804.1 Organic Compounds - 913.3 Quality Assurance and Control - 931.2 Physical Properties of Gases, Liquids and Solids
**Numerical data indexing:** Percentage 1.00e-01%, Percentage 2.00e-01%, Percentage 3.00e-01%, Percentage 5.00e-01%
**DOI:** 10.3787/j.issn.1000-0976.2021.07.015
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 81. Self-diffusion flow and heat coupling model applicable to the production simulation and prediction of deep shale gas wells

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**Title of translation:**
**Authors:** Xia, Yang (1); Wei, Shiming (1); Jin, Yan (1); Chen, Kangping (2)
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**Abbreviated source title:** Natur. Gas Ind.
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**Issue date:** February 25, 2021
**Publication year:** 2021
**Pages:** 111-118
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** Clarifying the flow laws of shale gas under high temperature and high pressure is the prerequisite to accurately predicting the productivity of deep shale gas wells. In this paper, a self-diffusion flow model of flow field and temperature field coupling (referred to as self-diffusion flow and heat coupling model) was established based on the previously proposed self-diffusion flow model, while considering the influence of the temperature field change. Then, its calculation result was compared with that of the flow model based on Darcy's law and Knudsen diffusion (referred to as modified Darcy flow model). Based on the self-diffusion flow and heat coupling model, the self-diffusion flow behaviors of deep shale gas under the influence of temperature field change were analyzed, and the influence of bottom hole temperature on the degree of reserve recovery of deep shale gas was discussed. Finally, the self-diffusion flow and heat coupling model was applied to simulate the production of one shale-gas horizontal well in the Upper Ordovician Wufeng Formation-Lower Silurian Longmaxi Formation in the Changning Block of the Sichuan Basin. And the following research results were obtained. First, at the same parameters, the shale gas production calculated by the self-diffusion flow and heat coupling model is higher than the result calculated by the modified Darcy flow model. Second, when temperature field change is taken into consideration, the self-diffusion coefficient profile presents a peak, the gas density profile presents a valley and the data points corresponding to the peak/valley move synchronously to the internal formation, which indicates that the self-diffusion coefficient influences the gas mass transfer rate, and the influence range of near well low temperature on gas self-diffusion increases continuously as the production continues. Third, when the bottom hole temperature is lower than the formation temperature, the self-diffusion coefficient of the gas near the well decreases and the gas is blocked near the well, which reduces the gas well production. Fourth, the production simulation result of the case well shows that the self-diffusion flow and heat coupling model can predict the production of deep shale gas more accurately if temperature field change is taken into consideration. In conclusion, the self-diffusion flow and heat coupling model established in this paper is of higher reliability and accuracy and can be used for productivity simulation and prediction of deep shale gas wells.The conclusion of this paper has certain guiding significance for deep shale gas production and gas well productivity prediction. 
**Number of references:** 34
**Main heading:** Gas industry
**Controlled terms:** Density of gases - Diffusion in liquids - Flow of fluids - Forecasting - Gases - High temperature operations - Horizontal wells - Low temperature production - Natural gas well production - Natural gas wells - Productivity - Proven reserves - Shale gas - Temperature
**Uncontrolled terms:** Bottom hole temperatures - Degree of reserve recoveries - Gas well productivities - High temperature and high pressure - Production simulation - Productivity simulation - Self-diffusion coefficients - Temperature field change
**Classification code:** 512 Petroleum and Related Deposits - 522 Gas Fuels - 631.1 Fluid Flow, General - 641.1 Thermodynamics - 931.2 Physical Properties of Gases, Liquids and Solids
**DOI:** 10.3787/j.issn.1000-0976.2021.02.013
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 82. Characteristics and well location deployment ideas of strike-slip fault controlled carbonate oil and gas reservoirs: A case study of the Tarim Basin

**Accession number:** 20211710247364

**Title of translation:** --
**Authors:** Deng, Xingliang (1); Yan, Ting (1); Zhang, Yintao (1); Wan, Xiaoguo (1); Feng, Kai (1); Yuan, Anyi (1); Yao, Chao (1); Xiao, Chunyan (1)
**Author affiliation:** (1) Exploration and Development Research Institute, PetroChina Tarim Oilfield Company, Korla; 841000, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
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**Issue:** 3
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**Publication year:** 2021
**Pages:** 21-29
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** Carbonate oil and gas reservoirs in the Tarim Basin are one of the important fields of deep oil and gas exploration and development in China. In recent years, the exploration targets in this basin have gradually shifted to the northern depression which is mainly controlled by faults. However, the efficient development of oil and gas in this area is hampered by the unclear mechanisms of fault controlled reservoirs and hydrocarbon accumulation, great reservoir depth and high development costs. After investigating the regional geological situations in the northern depression of the Tarim basin, this paper systematically analyzes the characteristics of fault controlled carbonate oil and gas reservoirs and their reservoirs and clarified the control effect of strike-slip faults on oil and gas reservoirs. On this basis, the ideas on the well placement in this type of reservoirs were put forward. And the following research results were obtained. First, the strike-slip faults of Late Caledonian, Late Hercynian and Yanshan period are developed in the northern depression of the Tarim Basin, which form a three-layer structural style. Second, the carbonate reservoirs in the northern depression are mainly distributed in Ordovician Yijianfang Formation-Yingshan Formation. The reservoir space mainly includes pores, vugs and fractures which are formed by dissolution and tectonic rupture. The reservoirs are reworked strongly along the faults, and dissolved caverns and cavities are well developed. And thus, three types of fault controlled dissolved reservoirs are developed, i.e., cavern sealing type, cavern edge type and fracture-vug type. Third, discordogenic strike-slip faults have an obvious effect of "reservoir control, hydrocarbon accumulation control and enrichment control", and the NE trending fault is dominant in controlling hydrocarbon accumulation. Fourth, the high-efficiency well characteristics of "strike-slip fault + positive geomorphology + multi-phase bead reflection" in the main oil source are summarized, and the well location deployment method of "four determinations" is put forward, including zone determination, stage determination, well determination and trajectory determination. In conclusion, the new well location deployment idea improves the drilling success rate and the efficient well ratio, realizes the efficient development of fault controlled reservoirs in the Tarim Basin and is of referential significance to the development deployment of similar oil and gas reservoirs. 
**Number of references:** 20
**Main heading:** Oil field development
**Controlled terms:** Carbonation - Caves - Fault slips - Gases - Hydrocarbons - Location - Oil well drilling - Petroleum prospecting - Petroleum reservoir engineering - Petroleum reservoirs - Strike-slip faults
**Uncontrolled terms:** Carbonate reservoir - Drilling success rates - Exploration targets - Hydrocarbon accumulation - Oil and gas exploration - Oil and gas reservoir - Well characteristics - Yijianfang formations
**Classification code:** 481.1 Geology - 484.1 Earthquake Measurements and Analysis - 512.1.1 Oil Fields - 512.1.2 Petroleum Deposits : Development Operations - 802.2 Chemical Reactions - 804.1 Organic Compounds
**DOI:** 10.3787/j.issn.1000-0976.2021.03.003
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 83. Sweet spot evaluation system and enrichment and high yield influential factors of shale gas in Nanchuan area of eastern Sichuan Basin

**Accession number:** 20210609883873
**Title of translation:**
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**Author affiliation:** (1) Exploration and Development Research Institute, Sinopec East China Oil & Gas Company, Nanjing; 210000, China
**Corresponding author:** He, Xipeng(hexp.hdsj@sinopec.com)
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**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** The Nanchuan area in the eastern Sichuan Basin is located in a high-normal pressure transition zone, where the shale gas reservoirs are mainly deep and middle-deep and geologically complex and single-well gas production varies greatly. In order to reveal the factors influencing the enrichment and high yield of shale gas in this area, this paper analyzed the geological characteristics of shale gas reservoirs in this area based on drilling data and well testing results of typical wells. Then, the evaluation system of sweet spot target was established, sweep spot areas were defined, and the shale gas production characteristics of different sweet spot areas were clarified. Finally, the factors influencing the enrichment and high yield of shale gas were discussed. And the following research results were obtained. First, the sedimentary and geochemical characteristics in the Nanchuan area are basically consistent. Under the influence of multi-stage tectonic reworking, however, it presents the characteristics of greater porosity, smaller pressure coefficient, worse gas bearing property and lower in-situ stress from north to south and from west to east. Second, a reservoir classification and evaluation standard of six parameters (total organic carbon included) is established based on the fractal theory. It is determined that - layers are class I reservoirs and they are sweet spot sections of shale gas exploration. Third, a quantitative evaluation system and criteria of shale gas sweet spot target with 13 items in three categories of "material base, preservation condition and volumetric stimulation" as evaluation parameters are established. And accordingly, Pingqiao Anticline is selected as the class I sweet spot area, and Dongsheng South Slope, Dongsheng Anticline and Pingqiao South Slope are classified as the class II sweet spot areas. Fourth, the production characteristics of shale gas are zoned. The shale gas production in class I area is characterized by high gas production, low fluid production, long stable production period, low decline rate and higher single-well test production and estimated ultimate recovery (EUR). Fifth, the productivity of shale-gas horizontal wells is mainly controlled by sedimentary facies belt, preservation condition and volumetric stimulation degree. In conclusion, the research results can provide guidance and reference for high-quality exploration and large-scale benefit development of shale gas along the margin of the Sichuan Basin. 
**Number of references:** 29
**Main heading:** Gas industry
**Controlled terms:** Gases - Geological surveys - Horizontal wells - Organic carbon - Parameter estimation - Petroleum prospecting - Petroleum reservoir evaluation - Petroleum reservoirs - Sedimentology - Shale gas - Well stimulation - Well testing
**Uncontrolled terms:** Classification and evaluations - Estimated ultimate recoveries - Evaluation parameters - Geochemical characteristic - Geological characteristics - Preservation condition - Production characteristics - Quantitative evaluation
**Classification code:** 481.1 Geology - 512.1.1 Oil Fields - 512.1.2 Petroleum Deposits : Development Operations - 522 Gas Fuels - 804.1 Organic Compounds
**DOI:** 10.3787/j.issn.1000-0976.2021.01.005
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 84. Research progress on the pore characteristics of deep shale gas reservoirs: An example from the Lower Paleozoic marine shale in the Sichuan Basin

**Accession number:** 20210609884051
**Title of translation:** -

**Authors:** Liu, Shugen (1, 2, 3); Jiao, Kun (2, 3); Zhang, Jinchuan (4); Ye, Yuehao (2, 3); Xie, Guoliang (2, 3); Deng, Bin (2, 3); Ran, Bo (2); Li, Zhiwu (2); Wu, Juan (2, 3); Li, Jinxi (2); Liu, Wenping (5); Luo, Chao (5)
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**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 1
**Issue date:** January 25, 2021
**Publication year:** 2021
**Pages:** 29-41
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** Pore structure provides a certain indication on the maintenance of abnormal pressure in deep shale gas reservoirs and the preservation and enrichment of shale gas and is an important research content related to the preservation and enrichment of deep sale gas. This paper systematically analyzed the heterogeneity and connectivity of pores in deep shale gas reservoirs by investigating and analyzing the pore characteristics of deep shale gas reservoirs abroad and comparing the latest research results on the pores in the deep and ultradeep shale of the Sichuan Basin. Then, the influences of overpressure on the pore structures in deep shale reservoirs were clarified further. Finally, the research achievements on the pore characteristics of deep shale gas reservoirs in recent years were summarized. And the following research results were obtained. First, micropores and meso-macropores in typical deep and ultradeep shale have multifractal characteristics. The multifractal spectrum parameter $\alpha 5_{-}-\alpha 5_{+}$ and the multifractal dimension parameter H index can well indicate pore connectivity and heterogeneity of deep shale reservoirs, respectively. Second, the pore connectivity and heterogeneity of the Lower Paleozoic shale reservoirs in the Sichuan Basin is not in obvious correlation with the burial depth, but is influenced more by total organic carbon (TOC), mineral content and organic maturity of shale. Third, the mechanical compaction caused by high overburden pressure has significant influence on ultradeep shale, but limited influence on pore size and pore morphology of deep shale, as well as characteristic ratios, such as mesopore volume/micropore volume ratio and mesopore specific surface area/micropore specific surface area ratio. Fourth, the overpressure of shale strata can balance out the mechanical compaction of overburden pressure on pores (especially micropores) to a certain extent, and can slow down or even change the decreasing trend of porosity and pore form factor with the increase of burial depth, which is of positive significance to the preservation and enrichment of shale gas. Fifth, the pore form factors of solid bitumen in deep shale are moderately correlated to the overpressure characteristics of the closed fluid system where it is located. © 2021, Natural Gas Industry Journal Agency. All right reserved.
**Number of references:** 100
**Main heading:** Petroleum reservoirs
**Controlled terms:** Approximation theory - Compaction - Fractals - Gases - Marine engineering - Microporosity - Morphology - Organic carbon - Pore size - Pore structure - Shale gas - Specific surface area
**Uncontrolled terms:** Characteristic ratio - Mechanical compaction - Multi-fractal dimensions - Multi-fractal spectrum - Multifractal characteristics - Overburden pressures - Pore characteristics - Research achievements
**Classification code:** 512.1.1 Oil Fields - 522 Gas Fuels - 675 Marine Engineering - 804.1 Organic Compounds - 921 Mathematics - 921.6 Numerical Methods - 931.2 Physical Properties of Gases, Liquids and Solids
**DOI:** 10.3787/j.issn.1000-0976.2021.01.003
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 85. Key technologies for the efficient development of ultra-deep ancient dolomite karst gas reservoirs: A case study of the Sinian Dengying Formation gas reservoir in the Anyue Gas Field of the Sichuan Basin

**Accession number:** 20213010677961
**Title of translation:** -

**Authors:** Xie, Jun (1); Guo, Gui'an (2); Tang, Qingsong (2); Peng, Xian (3); Deng, Hui (3); Xu, Wei (3)
**Author affiliation:** (1) CNPC Planning Department, Beijing; 100007, China; (2) PetroChina Southwest Oil & Gasfield Company, Chengdu; 610051, China; (3) Exploration and Development Research Institute, PetroChina Southwest Oil & Gasfield Company, Chengdu; 610041, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 6
**Issue date:** June 25, 2021
**Publication year:** 2021
**Pages:** 52-59
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** The Sinian Dengying Formation gas reservoir in the Anyue Gas Field of the Sichuan Basin is an ultra-deep ancient dolomite karst gas reservoir, whose development is of high difficulty, for the reservoir is thin and scattered with strong heterogeneity and is overall characterized by low porosity and low permeability. In order to provide support for the large-scale productivity construction of the gas reservoir of the fourth Member of Dengying Formation (Deng 4 Member) in the marginal platform belt of the Anyue Gas Field, this paper carries out multi-discipline comprehensive researches on the technical bottlenecks based on the geological characteristics of the gas reservoir. In addition, the targeted key technologies for the efficient development of gas reservoirs were developed in the mode of "simultaneous research, application and improvement". And the following research results are obtained. First, based on the modeling technology of fractured-vuggy dolomite karst reservoirs, accurate modeling of karst reservoirs is realized. Late actual drilling results show that the model's coincidence rate is increased from 63.0% to 90.7% and the "transparency" of gas reservoirs is achieved. Second, based on the reserve mobility evaluation technology of low-porosity and strong-heterogeneity karst reservoirs, the recovery factors of different reservoirs are determined. And consequently, the lower limit of well control reserves and radius for the efficient development of different reservoirs are obtained and type I and II reservoirs are selected as the main development targets. Third, based on the development optimization design technology of strong-heterogeneity karst gas reservoirs, it is recommended to apply high-ly-deviated wells (the maximum deviation angle of 75°-84°) in the situations with multiple reservoirs crossed and superimposed. If type I and II reservoirs are developed intensively, it is recommended to adopt horizontal well drilling with a horizontal section of 800-1 100 m. What's more, the reasonable well spacing in type I and II reservoirs shall be 1.6-3.3 km and 0.9-1.4 km, respectively. Fourth, based on the distinguished drilling technology of highly-deviated wells/horizontal wells in deep carbonate rocks, the fault complexity ratio is decreased from 20.7% to 4.9%, so safe and fast drilling and completion of highly-deviated wells/horizontal wells is realized and well control risks are diminished. What's more, the drilling rates of type I and II reservoirs are increased from 24.2% to 87.3%, indicating an effective improvement of reservoir drilling rates. Fifth, based on the open-hole segmented accurate acid fracturing technology of highly-deviated and horizontal wells, the difficulty in the strong-heterogeneity reservoir stimulation by horizontal well drilling is solved by conducting the differentiated acid fracturing process of "one segment, one strategy". Based on the application of these innovative development technologies in the Deng 4 Member gas reservoir in the marginal platform belt of the Anyue Gas Field, the annual natural gas production capacity and cumulative natural gas production by the end of December 2020 are 60×108 m3 and 103×108 m3, respectively. In this way, the Sinian Dengying Formation gas reservoir of the Anyue Gas Field, the economic benefit of which is close to the marginal benefit, becomes the main force of conventional natural gas production increase. 
**Number of references:** 36
**Main heading:** Low permeability reservoirs
**Controlled terms:** Deflected boreholes - Fracture - Gas industry - Gases - Horizontal drilling - Horizontal wells - Infill drilling - Landforms - Natural gas - Natural gas fields - Natural gas well production - Petroleum reservoir evaluation - Porosity - Well completion - Well drilling - Well spacing - Well stimulation
**Uncontrolled terms:** Comprehensive research - Development technology - Drilling and completion - Geological characteristics - Natural-gas production - Research , application - Reservoir stimulations - Strong heterogeneities
**Classification code:** 481.1 Geology - 511.1 Oil Field Production Operations - 512 Petroleum and Related Deposits - 522 Gas Fuels - 931.2 Physical Properties of Gases, Liquids and Solids - 951 Materials Science
**Numerical data indexing:** Percentage 2.07e+01% to 4.90e+00%, Percentage 2.42e+01% to 8.73e+01%, Percentage 6.30e+01% to 9.07e+01%, Size 1.60e+03m to 3.30e+03m, Size 8.00e+02m to 1.10e+03m, Size 9.00e+02m to 1.40e+03m
**DOI:** 10.3787/j.issn.1000-0976.2021.06.006
**Compendex references:** YES

**Database:** Compendex
**Data Provider:** Engineering Village


## 86. Characterizing the characteristics of natural fractures in shale based on the modified petrophysical model

**Accession number:** 20211210117027
**Title of translation:**
**Authors:** Guan, Quanzhong (1); Dong, Dazhong (2); Zhang, Hualing (3); Zhang, Surong (2); Lyu, Xiuxiang (4); Wang, Yuman (2)
**Author affiliation:** (1) College of Energy, Chengdu University of Technology, Chengdu; 610059, China; (2) PetroChina Research Institute of Petroleum Exploration & Development, Beijing; 100083, China; (3) University of Houston, Houston; TX; 77004, United States; (4) China University of Petroleum, Beijing, Beijing; 102249, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 2
**Issue date:** February 25, 2021
**Publication year:** 2021
**Pages:** 56-64
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** In order to provide technical support for the shale gas exploration and development in the Lower Silurian Longmaxi Formation of the Sichuan Basin, this paper takes the Longmaxi Formation in the Changning and Fuling shale gas fields as the research object to quantitatively characterize the development characteristics of natural fractures in Longmaxi Formation shale by means of helium pycnometry, X-ray diffraction (XRD), true density testing and other methods, with the aid of the modified petrophysical model. Then, the development types and genetic mechanisms of natural fractures and their influences on shale gas development are discussed. And the following research results were obtained. First, the modified petrophysical model can accurately describe the pore system in the Changning shale with a fitting rate of 0.74. Second, the development of natural fractures in the shale is different in different regions. The natural fractures in the Changning Shale Gas Field, controlled by basement thrust faults, decollement layers and internal folds, are locally developed and filled with calcareous, and the average fracture porosity is 0.15%. In the Fuling Shale Gas Field, however, natural fractures, mainly controlled by reverse faults and slippage effect, are commonly more developed and unfilled or semi-filled with siliceous, and the average fracture porosity is 1.30%. Third, under the formation conditions, the opening of natural fractures is different. The natural fractures in the Changning Shale Gas Field are basically closed with a weak flowing ability while those in the Fuling Shale Gas Field are relatively open with a strong flowing ability. Fourth, the occurrence mode of shale gas is influenced by natural fractures and it is internally dominated by free gas. The initial gas production of shale gas well is higher. In conclusion, the regression coefficient is introduced to calculate the actual total organic matter content, which promotes the modified petrophysical model to describe matrix pores and fracture pores more accurately. What's more, the development of natural fractures in the shale pay zone of the Sichuan Basin is relatively beneficial to shale gas enrichment and exploitation, but its effect will be weakened under the formation conditions. 
**Number of references:** 34
**Main heading:** Natural gas fields
**Controlled terms:** Faulting - Fracture - Gas industry - Gases - Geological surveys - Natural gas well production - Petroleum prospecting - Petrophysics - Porosity - Shale gas
**Uncontrolled terms:** Development characteristics - Formation condition - Genetic mechanism - Helium pycnometry - Petrophysical models - Regression coefficient - Technical support - Total organic matter
**Classification code:** 481.1 Geology - 484.1 Earthquake Measurements and Analysis - 512.1.2 Petroleum Deposits : Development Operations - 512.2.1 Natural Gas Fields - 522 Gas Fuels - 931.2 Physical Properties of Gases, Liquids and Solids - 951 Materials Science
**Numerical data indexing:** Percentage 1.30e+00%, Percentage 1.50e-01%
**DOI:** 10.3787/j.issn.1000-0976.2021.02.007
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village

## 87. Performance evaluation and working parameter optimization of milling tools for oil and gas wells

**Accession number:** 20211210116995
**Title of translation:**
**Authors:** Che, Jiaqi (1, 2); Wang, Hanxiang (2); Zhang, Yanwen (1, 2); Liu, Yanxin (1, 2); Wang, Yuting (3); Du, Mingchao (2); Ma, Shaohua (2, 4); Zhao, Yuming (4)
**Author affiliation:** (1) National Engineering Laboratory of Offshore Geophysical and Exploration Equipment, China University of Petroleum - East China, Qingdao; 266580, China; (2) College of Mechanical and Electronic Engineering, China University of Petroleum - East China, Qingdao; 266580, China; (3) CNPC Offshore Engineering - Qingdao Co., Ltd., Qingdao; 266500, China; (4) Petroleum Industry Training Center, China University of Petroleum - East China, Qingdao; 266580, China
**Corresponding author:** Liu, Yanxin(liuyanxin1985@163.com)
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 2
**Issue date:** February 25, 2021
**Publication year:** 2021
**Pages:** 140-148
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** Aiming at solving the problems of small footage, easy skid, and immovability of milling tools in deepsea oil and gas wells and considering their irregular structures, diverse types and difficult modeling, this paper takes the M97 slope milling tool as the research object to establish a 3D scanning model by means of the 3D laser scanner. Then, a full-scale milling tool simulation model was established based on reverse engineering. Besides, an experimental system for milling tools was developed to verify the simulation results. Finally, performance evaluation and working parameter optimization of milling tools were completed. And the following research results were obtained. First, the surfaces of the work pieces after simulation and experiment are both circular cuts with a central fulcrum, and the error of the simulation torque is only 7.78%. Second, the working process of milling tools can be divided into three stages, i.e., single abrasive grain cutting stage, plane cutting stage and deep cutting stage. The abrasive grains shall be arranged on the same plane in the drilling direction as much as possible to avoid the single abrasive grain cutting stage and prevent the single abrasive grain from being overloaded and causing failure problems. Third, the weight on bit (WOB) and the rotating speed affect each other, which jointly determine the working efficiency and safety of milling tools. Fourth, a working performance evaluation chart and a working parameter optimization table are established for milling tools, based on which working parameters can be optimized according to the field construction demands, so as to improve the working performance of milling tools. In conclusion, this analysis method has high precision and its analysis results are helpful to effectively improve the working performance of milling tools so as to meet the requirements of efficient and safe development of deepsea oil and gas wells. © 2021, Natural Gas Industry Journal Agency. All right reserved.
**Number of references:** 28
**Main heading:** Oil field equipment
**Controlled terms:** 3D modeling - Abrasives - Cutting tools - Milling (machining) - Natural gas wells - Oil field development - Parameter estimation - Petroleum reservoir evaluation - Respirators - Reverse engineering - Scanning
**Uncontrolled terms:** Construction demands - Evaluation charts - Experimental system - Irregular structures - Single abrasive grains - Working efficiency - Working parameters - Working performance
**Classification code:** 462.1 Biomedical Equipment, General - 511.2 Oil Field Equipment - 512.1.2 Petroleum Deposits : Development Operations - 512.2.1 Natural Gas Fields - 603.2 Machine Tool Accessories - 604.2 Machining Operations - 606.1 Abrasive Materials
**Numerical data indexing:** Percentage 7.78e+00%
**DOI:** 10.3787/j.issn.1000-0976.2021.02.017
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village

## 88. Characteristics of natural gas accumulation in the Cambrian weathering crust in the southwestern Ordos Basin

**Accession number:** 20212010375694
**Title of translation:**
**Authors:** Liu, Xianyang (1, 2); Wei, Liubin (1, 2, 3, 4); Liu, Baoxian (1, 2); Zhang, Lei (1, 2); Guo, Wei (1, 2); Zhang, Jianwu (1, 2); Zheng, Jie (1, 2)
**Author affiliation:** (1) PetroChina Changqing Oilfield Company, Xi'an; Shaanxi; 710018, China; (2) National Engineering Laboratory of Low-permeability Oil & Gas Exploration and Development, Xi'an; Shaanxi; 710018, China; (3) State Key Laboratory of Oil & Gas Reservoir Geology and Exploitation, Chengdu University of Technology, Chengdu; Sichuan; 610059, China; (4) Institute of Sedimentary Geology, Chengdu University of Technology, Chengdu; Sichuan; 610059, China
**Corresponding author:** Wei, Liubin(weilb_cq@petrochina.com.cn)
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 4
**Issue date:** April 25, 2021
**Publication year:** 2021
**Pages:** 13-21
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** The Cambrian weathering crust formed in the Lower Paleozoic central paleouplift of the Ordos Basin and its periphery has always been a key target for oil and gas exploration in this basin, and important breakthroughs in oil and gas exploration have been made there. In order to further accelerate the process of natural gas exploration in this field, this paper systematically analyzes the source-reservoir configurations and trap types in the Cambrian weathering crust in the southwestern Ordos Basin. Then, natural gas exploration potentials and favorable exploration zones in the Cambrian weathering crust inf the southwestern Ordos Basin are evaluated. And the following research results were obtained. First, in the Ordos Basin, the Upper Paleozoic coal-measure source rocks are the main gas source rocks, which together with the Cambrian reservoir form a source-reservoir pattern of "upper source and lower reservoir". Second, the types of the reservoir spaces in the Cambrian weathering crust reservoir are mainly dolomite intercrystalline (dissolution) pores and karst fractures and vugs, whose development is controlled by grain shoal microfacies and karstification in the weathering crust stage, respectively. Third, the traps in the Cambrian weathering crust are mainly lithologic-stratigraphic traps, which are formed in the tectonic setting of the eastern Ordos Basin uplifting in the Yanshanian. There are geological conditions of lithologic and stratigraphic barriers in the updip direction, which is beneficial to the short-distance natural gas migration and accumulation. In conclusion, Huanxian-Zhengning area on the east side of the central paleouplift in the southwestern Ordos Basin is a favorable exploration zone of Cambrian weathering crust gas reservoirs, and Middle Cambrian Zhangxia Formation and Upper Cambrian Sanshanzi Formation are favorable intervals of oil and gas exploration. © 2021, Natural Gas Industry Journal Agency. All right reserved.
**Number of references:** 29
**Main heading:** Petroleum prospecting
**Controlled terms:** Gases - Geological surveys - Metamorphic rocks - Natural gas - Natural gas fields - Petroleum reservoirs - Stratigraphy - Weathering
**Uncontrolled terms:** Central paleouplift - Geological conditions - Natural gas exploration - Natural gas migration and accumulations - Natural-gas accumulation - Oil and gas exploration - Research results - Tectonic settings
**Classification code:** 481.1 Geology - 512 Petroleum and Related Deposits - 522 Gas Fuels
**DOI:** 10.3787/j.issn.1000-0976.2021.04.002
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 89. Structural characteristics, formation & evolution and genetic mechanisms of strike-slip faults in the Tarim Basin

**Accession number:** 20213910945561
**Title of translation:** ,
**Authors:** Jia, Chengzao (1); Ma, Debo (1); Yuan, Jingyi (2); Wei, Guoqi (1); Yang, Min (1); Yan, Lei (1); Tian, Fanglei (3); Jiang, Lin (1)
**Author affiliation:** (1) PetroChina Research Institute of Petroleum Exploration & Development, Beijing; 100083, China; (2) Exploration and Development Research Institute, PetroChina Tarim Oilfield Company, Korla; 841000, China; (3) School of Energy Resources, China University of Geosciences, Beijing; 100083, China
**Corresponding author:** Ma, Debo(315875367@qq.com)
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
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**Issue:** 8
**Issue date:** August 25, 2021
**Publication year:** 2021
**Pages:** 81-91
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** Exploration and development practices prove that intracratonic strike-slip faults control the development of carbonate reservoirs and the enrichment of oil and gas in the Tarim Basin. Intracratonic strike-slip faults are characterized by short displacement, small throw and great burial depth, so there are still many controversies on their structural evolution and formation mechanisms. In order to settle these controversies, this paper firstly analyzes the geometric and kinematic characteristics of the intracratonic strike-slip faults in the central Tarim Basin. Then, based on extensive high-accuracy 3D seismic data and 2D seismic data, the formation and evolution process of the intracratonic strike-slip faults in the Tarim Basin are discussed deeply, and their genetic mechanisms are explored. And the following research results are obtained. First, the strike-slip faults in the study area have the characteristics of vertical stratification, plane zonation and segmentation along the strike. Second, the movement direction of the deep transpressional strike-slip fault is simple. The NE and NNE strike-slip faults are sinistral, and the NNW strike-slip faults are dextral. However, the shallow transtensional faults are more different in the movement direction. The strike-slip faults have a displacement of 400-1 500 m, and they are classified as intracratonic strike-slip fault with a small slip distance. Third, strike-slip faults were formed in the middle Caledonian, and some faults were reactivated in the late Caledonian-early Hercynian, late Hercynian, and Yanshanian-early Himalayan. The distribution of faults is different in different periods. Fourth, the formation of the strike-slip faults in the middle Caledonian is controlled by the basement heterogeneity and the compression action from the closure and subduction of the Proto-Tethys Ocean. The transtensional faults are R-shear branch faults or tensile break faults generated by the later activation of middle Caledonian strike-slip faults, and their formation is controlled by the subduction and closure of ocean basins around the basins in different periods. In conclusion, the structural characteristics, formation & evolution and genetic mechanisms of intracratonic strike-slip faults are in close relation to oil and gas, where great benefit of oil and gas exploration and development is achieved. Besides the Tarim Basin, the Sichuan Basin and the Ordos Basin have similar geological and structural settings, so the studies on typical basins will surely enrich and complete the theories on the intracratonic strike-slip faults in domestic micro landblocks and multi-cycle basins and point out the direction for the discovery of more oil and gas resource. 
**Number of references:** 37
**Main heading:** Strike-slip faults
**Controlled terms:** Buildings - Fault slips - Geophysical prospecting - Oceanography - Petroleum prospecting - Petroleum reservoir engineering - Seismic response - Seismic waves - Structural geology
**Uncontrolled terms:** Basement heterogeneity - Closure of the peripheral ocean basin - Craton - Exploration direction - Formation & evolution - Genetic mechanism - Petroleum exploration - Petroleum exploration direction - Structural characteristics - Tarim Basin
**Classification code:** 402 Buildings and Towers - 471.1 Oceanography, General - 481.1 Geology - 481.4 Geophysical Prospecting - 484 Seismology - 484.1 Earthquake Measurements and Analysis - 484.2 Secondary Earthquake Effects - 512.1.2 Petroleum Deposits : Development Operations
**Numerical data indexing:** Size 5.00E+02m
**DOI:** 10.3787/j.issn.1000-0976.2021.08.008
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village

## 90. Distribution and gas exploration of the strike-slip faults in the central Sichuan Basin

**Accession number:** 20213910945562
**Title of translation:**
**Authors:** Jiao, Fangzheng (1); Yang, Yu (2); Ran, Qi (2); Wu, Guanghui (3); Liang, Han (2)
**Author affiliation:** (1) China National Petroleum Corporation, Beijing; 100007, China; (2) PetroChina Southwest Oil & Gasfield Company, Chengdu; 610051, China; (3) Southwest Petroleum University, Chengdu; 610500, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 8
**Issue date:** August 25, 2021
**Publication year:** 2021
**Pages:** 92-101
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** The Sichuan Basin has abundant oil and gas resources and it has been generally acknowledged as a super petroliferous basin. In recent years, immense exploration and development potential of deep natural gas emerges in the Sichuan Basin. The identification of strike-slip faults and their reservoir controlling effects are of great significance to develop a new exploration domain of fault-controlled gas reservoirs. In order to clarify the distribution of strike-slip faults in the Sichuan Basin and their relationships with natural gas exploration, in view that the strike-slip faults in this basin are small and complex with poor seismic data and influenced more by the fold deformation of Tertiary gypsum salt beds, this paper identifies strike-slip faults and analyzes their characteristics, distribution and genesis based on the interpretation of continuous 3D seismic data of the central Sichuan Basin. Then, the fault-controlled gas reservoir model of strike-slip fault is established by reviewing old wells and evaluating geological conditions of hydrocarbon accumulation. Finally, the exploration potential and exploration direction of fault-controlled gas reservoirs are discussed. And the following research results are obtained. First, intraplate weak strike-slip faults can be identified by combining the seismic profile marker of strike-slip fault with the plane marker. Second, eight large strike-slip fault zones with a total length of 1 280 km are identified and confirmed in the central Sichuan Basin. Third, strike-slip faults are mainly distributed in the Sinian-Permian System, mainly composed of small-displacement oblique faults and echelon faults, and different in stratification, grading, classification and segmentation. Fourth, under the control of the oblique subduction of the Proto-Tethys Ocean and the different structures of the basement, the strike-slip faults in the central Sichuan Basin were formed in the Sinian and there are multiple stages of inherited Caledonian-Hercynian activities. Fifth, the strike-slip faults in the central Sichuan Basin play a role in source-reservoir connection, reservoir reconstruction, and gas accumulation and high yield, and constitute the fault-controlled natural gas accumulation system of "three-element controlling reservoir and composite hydrocarbon accumulation" based on source rock, fault and reservoir. In conclusion, a large intraplate strike-slip fault system is developed in the Sichuan Basin, which has the geological conditions of hydrocarbon accumulation to form strike-slip fault-controlled large gasfield, and the large source connecting strike-slip fault zones are the main breakthrough directions of natural gas exploration in fault-controlled carbonate rocks. 
**Number of references:** 33
**Main heading:** Strike-slip faults
**Controlled terms:** Energy resources - Fault slips - Gases - Geological surveys - Grading - Hydrocarbons - Natural gas - Petroleum prospecting - Petroleum reservoirs - Seismic response - Seismic waves
**Uncontrolled terms:** Condition - Deep - Exploration direction - Fault distribution - Fault identifications - Fault-controled gas reservoir - Gas reservoir - Hydrocarbon accumulation - Hydrocarbon accumulation condition - Natural gas exploration - Natural gas exploration direction - Sichuan Basin
**Classification code:** 481.1 Geology - 484 Seismology - 484.1 Earthquake Measurements and Analysis - 484.2 Secondary Earthquake Effects - 512.1.1 Oil Fields - 512.1.2 Petroleum Deposits : Development Operations - 522 Gas Fuels - 525.1 Energy Resources and Renewable Energy Issues - 804.1 Organic Compounds
**Numerical data indexing:** Size 2.80E+05m
**DOI:** 10.3787/j.issn.1000-0976.2021.08.009
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village

## 91. Sedimentary characteristics and main reservoir control factors of deep shale in the Sichuan Basin: A case study on the Longmaxi Formation in the eastern Weiyuan area

**Accession number:** 20212510530577
**Title of translation:** -
**Authors:** Wu, Yijia (1); Wang, Ying (1); Li, Jing (1)
**Author affiliation:** (1) Research Institute of Geological Exploration and Development, CNPC Chuanqing Drilling Engineering Company Limited, Chengdu; 610051, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 5
**Issue date:** May 25, 2021
**Publication year:** 2021
**Pages:** 55-65
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** Middle-shallow marine shale gas above 3500 m in the Sichuan Basin has been successfully developed industrially, and PetroChina and Sinopec have established Weiyuan-Changning and Zhaotong National Shale Gas Demonstration Areas and Chongqing Fuling National Shale Gas Demonstration Area, respectively. Shale gas production of these three National Shale Gas Demonstration Areas in 2020 was up to 200×108 m3. In the Sichuan Basin, however, marine shale gas resources are mainly distributed in the deep layers below 3 500 m, so scale benefit development of deep marine shale gas is the key to the orderly replacement and effective production of marine shale gas resources. In order to clarify the exploration and development potential of deep marine shale gas in the Sichuan Basin, this paper takes the deep shale gas of Lower Silurian Longmaxi Formation in the eastern Weiyuan area in south-middle of Sichuan Basin as an example to systematically study its sedimentary characteristics and main reservoir control factors based on the analysis of palaeo-oxygenation facies, total organic carbon and mineral composition of the samples taken from actual wells. And the following research results were obtained. First, the optimal sedimentary facies belt includes organic-rich mud shed and organic siliceous-rich mud shed, whose U/Th value is mostly higher than 1.25, i.e., strong reducing environment. Second, the lithofacies belt to form quality shale gas reservoirs is mainly medium-carbon siliceous shale facies or high-carbon siliceous shale facies, whose TOC, porosity, total gas content and brittleness index are mostly greater than 4%, 5%, 5 m3/t and 55%, respectively. Third, vertically, the optimal sedimentary facies belt and the optimal lithofacies belt are mainly distributed at the bottom of Longmaxi Formation in the study area, and laterally, they get thicker gradually from the northwest to the southeast. In conclusion, this sedimentary facies classification standard of Longmaxi Formation deep shale in the eastern Weiyuan area newly established on the basis of palaeo-oxygenation facies and lithofacies provides the technical support for defining the large-scale production construction zone of deep shale gas in this area in the following step and the guidance for selecting the favorable zones of deep shale gas in the similar areas. 
**Number of references:** 36
**Main heading:** Gas industry
**Controlled terms:** Demonstrations - Energy resources - Fracture mechanics - Gases - Marine engineering - Mineral exploration - Organic carbon - Oxygenation - Petroleum prospecting - Petroleum reservoirs - Sedimentology - Shale gas
**Uncontrolled terms:** Classification standard - Exploration and development - Large scale productions - Mineral composition - Reducing environment - Sedimentary characteristics - Shale gas reservoirs - Total Organic Carbon
**Classification code:** 481.1 Geology - 501.1 Exploration and Prospecting Methods - 512.1.1 Oil Fields - 512.1.2 Petroleum Deposits : Development Operations - 522 Gas Fuels - 525.1 Energy Resources and Renewable Energy Issues - 675 Marine Engineering - 804.1 Organic Compounds - 931.1 Mechanics
**Numerical data indexing:** Percentage 4.00e+00%, Percentage 5.00e+00%, Percentage 5.50e+01%, Size 3.50e+03m
**DOI:** 10.3787/j.issn.1000-0976.2021.05.006
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village

## 92. Independent research and development of LNG cryogenic, large flow rate and high pressure export pumps

**Accession number:** 20213010678009
**Title of translation:** LNG
**Authors:** Bi, Xiaoxing (1); Chen, Haiping (1); Huang, Yu (1); Wan, Xueli (2)
**Author affiliation:** (1) CNOOC Gas & Power Group, Beijing; 100028, China; (2) Dalian Deep Blue Pump Co., Ltd., Dalian; 116031, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 6
**Issue date:** June 25, 2021
**Publication year:** 2021
**Pages:** 127-133
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Number of references:** 20
**Main heading:** Temperature
**Controlled terms:** Aluminum alloys - High pressure engineering - High strength alloys - Hydraulic machinery - Hydraulic models - Pumps - Structural design
**Uncontrolled terms:** Equipment investment - High pressure - High pressure export pump - Hydraulic performance - Independence - LNG submersible pump - LNG terminal - Low temperature test - Lows-temperatures - Temperature test - Vibration
**Classification code:** 408.1 Structural Design, General - 531.1 Metallurgy - 541.2 Aluminum Alloys - 618.2 Pumps - 632.1 Hydraulics - 632.2 Hydraulic Equipment and Machinery - 641.1 Thermodynamics
**Numerical data indexing:** Size 1.50E+03m
**DOI:** 10.3787/j.issn.1000-0976.2021.06.015
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 93. Natural gas supply capacity calculation method construction and analysis software development

**Accession number:** 20213210735550
**Title of translation:**
**Authors:** Zhao, Suping (1); Lu, Jialiang (1); Huang, Cheng (2); Liu, Lifang (1)
**Author affiliation:** (1) PetroChina Research Institute of Petroleum Exploration & Development, Beijing; 100083, China; (2) Southwest Petroleum University, Chengdu; 610500, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 7
**Issue date:** July 25, 2021
**Publication year:** 2021
**Pages:** 144-151
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Number of references:** 21
**Main heading:** Forecasting
**Controlled terms:** Economics - Gas industry - Gas supply - Gases - Investments - Natural gas fields - Proven reserves - Reliability analysis - Software design

**Uncontrolled terms:** Calculation method - Domestic gas - Gas fields - Gas production prediction - Gas productions - Imported gas - Natural gas supply - New reserve prediction - Production prediction - Supply capacity
**Classification code:** 512.1.2 Petroleum Deposits : Development Operations - 512.2.1 Natural Gas Fields - 522 Gas Fuels - 723.1 Computer Programming - 723.5 Computer Applications - 971 Social Sciences
**DOI:** 10.3787/j.issn.1000-0976.2021.07.016
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 94. Organic pores in deep shale controlled by macerals: Classification and pore characteristics of organic matter components in Wufeng Formation-Longmaxi Formation of the Sichuan Basin

**Accession number:** 20214311047246
**Title of translation:** :-
**Authors:** Xie, Guoliang (1, 2, 3); Liu, Shugen (3, 4); Jiao, Kun (2, 3); Deng, Bin (2, 3); Ye, Yuehao (2, 3); Sun, Wei (3); Li, Zeqi (2, 3); Liu, Wenping (5); Luo, Chao (5); Li, Zhangchang (2, 3)
**Author affiliation:** (1) School of Civil Engineering & Architecture, Tongling University, Tongling; 244000, China; (2) College of Energy, Chengdu University of Technology, Chengdu; 610059, China; (3) State Key Laboratory of Oil and Gas Reservoir Geology and Exploitation, Chengdu University of Technology, Chengdu; 610059, China; (4) Xihua University, Chengdu; 610039, China; (5) Exploration and Development Research Institute, PetroChina Southwest Oil & Gasfield Company, Chengdu; 610051, China
**Corresponding authors:** Liu, Shugen(lsg@cdut.edu.cn); Liu, Shugen(lsg@cdut.edu.cn)
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 9
**Issue date:** September 25, 2021
**Publication year:** 2021
**Pages:** 23-34
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** At present, the identification of organic matter components in deep shale and the quantitative characterization of their pores are not researched sufficiently, which makes it difficult to evaluate the exploration and development potential of deep shale gas in the Sichuan Basin. Taking the deep shale of Upper Ordovician Wufeng Formation-Lower Silurian Longmaxi Formation in the Sichuan Basin as an example, this paper effectively identifies the organic matter components in deep shale by means of optical microscope, scanning electron microscope (SEM) and energy dispersion spectrometry(EDS) analysis. In addition, the pore growth characteristics of different organic matter components are quantitatively compared by using the PCAS software, and the growth of organic pores, the preservation mechanism of pyrobitumen pores and their geological significance are discussed. And the following research results are obtained. First, the organic matter components in deep shale are mainly bitumen and kerogen, and bitumen is dominated by pyrobitumen. Shape and non-fixed shape pyrobitumen can be identified. Algal fragment, bacteria-like aggregate, graptolite and micrinite can be identified in kerogen. Second, the growth characteristics of organic pores are closely related to the type of organic matter components. The pores in pyrobitumen are quite developed and they are mostly bubble and spongy shaped pores. There are a few or no pores in algal fragments. Irregular pores are developed in bacteria-like aggregates. And, visual pores are basically undeveloped in graptolite and micrinite. Third, the pyrobitumen pores in siliceous shale are more developed than those in clay shale, and quartz is superior to pyrite and carbonates minerals in pore protection. Fourth, the pores in non-fixed shape pyrobitumen, bacteria-like aggregates and algal fragments are mainly mesopores, whereas spherical pyrobitumen is dominated by large mesopores and macropores. The growth of the pores in algal fragments is related to their original types. In conclusion, the parameters (e.g. diameter and form factor) of pyrobitumen pores in deep shale can reflect the pressure environment of strata to some extent and further reflect the enrichment situations of shale gas indirectly. © 2021, Natural Gas Industry Journal Agency. All right reserved.
**Number of references:** 47
**Main heading:** Shale gas

**Controlled terms:** Aggregates - Bacteria - Biogeochemistry - Gases - Kerogen - Oil shale - Organic minerals - Petroleum prospecting - Pyrites - Scanning electron microscopy
**Uncontrolled terms:** Deep shale - Enrichment situation of shale gas - Ordovician - Organic matter component - Organics - Pore characteristics - Pyrobitumen - Sichuan Basin - Silurian - Upper ordovician wufeng formation-low silurian longmaxi formation
**Classification code:** 406 Highway Engineering - 412.2 Concrete Reinforcements - 481.2 Geochemistry - 482.2 Minerals - 512.1 Petroleum Deposits - 512.1.2 Petroleum Deposits : Development Operations - 512.2 Natural Gas Deposits - 522 Gas Fuels - 801.2 Biochemistry - 804.1 Organic Compounds
**DOI:** 10.3787/j.issn.1000-0976.2021.09.003
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 95. Attenuation model of gas breakthrough permeability in porous media under the influence of multiple factors

**Accession number:** 20214311047309
**Title of translation:**
**Authors:** Li, Yun (1); Wen, Menggang (1); Gao, Xiufeng (1); Su, Junwei (2)
**Author affiliation:** (1) School of Chemical Engineering and Technology, Xi'an Jiaotong University, Xi'an; 710049, China; (2) School of Human Settlements and Civil Engineering, Xi'an Jiaotong University, Xi'an; 710049, China
**Corresponding author:** Gao, Xiufeng(xfgao@mail.xjtu.edu.cn)
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 9
**Issue date:** September 25, 2021
**Publication year:** 2021
**Pages:** 75-86
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** Breakthrough permeability is an important indicator to evaluate shale gas development and CO2 geological sequestration, but its influential factors and synergistic effect mechanisms have not been figured out. To this end, this paper establishes an attenuation model of breakthrough permeability in partially saturated porous media based on the S-curve model of breakthrough pressure in partially saturated porous media and the slippage effect theory. Then, the validity of this model is verified by means of the visual air breakthrough and seepage experiment through a higher-permeability glass plane porous network, combined with previous breakthrough and seepage experiment results of CO2 and CO2-CH4 in low-permeability sandstone and shale samples. Finally, the influential factors and synergistic mechanisms of breakthrough permeability are analyzed. And the following research results are obtained. First, the synergistic effect of initial wetting phase saturation, outlet backpressure and slippage factor can be taken into consideration to establish an attenuation model of gas breakthrough permeability. Second, the visual air breakthrough and seepage experiment through glass plane porous network and the previous breakthrough and seepage experiment in low-permeability cores verify the validity of the attenuation model of gas breakthrough permeability. Third, compared with the exponential model, the attenuation model can more clearly reveal the inverted S-curve or exponential curve attenuation characteristics of breakthrough permeability with the initial wetting phase saturation. Fourth, initial wetting phase saturation, outlet backpressure and slippage factor have a synergistic effect on gas breakthrough permeability. When initial wetting phase saturation is lower, the increase of outlet backpressure can significantly decrease the breakthrough permeability of gas with a higher slippage factor. When initial wetting phase saturation is higher, the influence of outlet backpressure on gas breakthrough permeability will reduce, no matter whether gas slippage factor is high or not. In conclusion, the attenuation model of gas breakthrough permeability in porous media are of great significance to strengthen the development of unconventional gas reservoirs and guide CO2 geological sequestration and helps drive the realization of "carbon neutrality" in China. © 2021, Natural Gas Industry Journal Agency. All right reserved.
**Number of references:** 26
**Main heading:** Carbon dioxide

**Controlled terms:** Carbon - Gas permeability - Gases - Geology - Glass - Petroleum reservoir engineering - Porous materials - Seepage - Shale gas - Wetting
**Uncontrolled terms:** Attenuation model - Back pressures - Breakthrough permeability - Carbon neutralities - CO2 geological sequestration - Geological sequestration - Initial saturation - Outlet backpressure - Slippage factor - Wetting phasis
**Classification code:** 481.1 Geology - 512.1.2 Petroleum Deposits : Development Operations - 512.2 Natural Gas Deposits - 522 Gas Fuels - 804 Chemical Products Generally - 804.2 Inorganic Compounds - 812.3 Glass - 931.2 Physical Properties of Gases, Liquids and Solids - 951 Materials Science
**DOI:** 10.3787/j.issn.1000-0976.2021.09.008
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 96. Overpressure evolution process in shale gas reservoir: Evidence from the fluid inclusions in the fractures of Wufeng Formation-Longmaxi Formation in the southern Sichuan Basin

**Accession number:** 20214311047226
**Title of translation:** :-
**Authors:** Liu, Dongdong (1); Guo, Jing (2); Pan, Zhankun (1, 3); Du, Wei (4); Zhao, Fuping (4); Chen, Yi (4); Shi, Fulun (4); Song, Yan (1); Jiang, Zhenxue (1)
**Author affiliation:** (1) State Key Laboratory of Petroleum Resources and Prospecting, China University of Petroleum , Beijing; 102249, China; (2) No.10 Oil Production Plant, PetroChina Changqing Oilfield Company, Qingyang; 745100, China; (3) No.4 Gas Production Plant, PetroChina Changqing Oilfield Company, Xi'an; 710018, China; (4) Guizhou Provincial Oil and Gas Exploration and Development Engineering Research Institute, Guiyang; 550001, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 9
**Issue date:** September 25, 2021
**Publication year:** 2021
**Pages:** 12-22
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** Overpressure is a common phenomenon in the shale gas reservoirs of Upper Ordovician Wufeng Formation-Lower Silurian Longmaxi Formation in the southern Sichuan Basin, and the pressure coefficient of shale reservoir in some wells is even over 1.5. However, the pressure evolution process in shale gas reservoirs has not been understood clearly. In order to reveal the formation mechanism and evolution process of the overpressure in the Wufeng Formation-Longmaxi Formation shale gas reservoir of this area, this paper clarifies the filling periods of fracture composite vein cements by performing thin section analysis and cathodoluminescent scanning electron microscope (CL-SEM) observation on the samples of composite veins in the shale fractures in the typical wells in Luzhou and Weiyuan of southern Sichuan Basin. Then, thermometry and laser Raman analyses are carried out on the inclusions in fracture vein minerals of different periods, and combined with burial history and geothermal history study, the opening time of fractures of different periods is revealed. Finally, its relationship with the overpressure evolution process in shale gas reservoirs is discussed. And the following research results are obtained. First, there are mainly two stages of veins in the shale fractures in the typical wells of the study area. The fracture veins of stage one are mainly distributed on fracture walls, the particle size is small and the homogenization temperature of the fluid inclusions in the veins is accordant with the temperature of main gas generation period, which indicates that the opening process of stage-one fractures is related to the hydrocarbon-generation pressurization. The fracture veins of stage two are mainly distributed in the middle of the fractures, the particle size is larger and the temperatures range of the fluid inclusions in the veins is wider and accordant with the formation temperature in the process of uplifting, which indicates that the opening process of stage-two fractures is related to the pressure relief caused by structural uplifting. Second, the trapping pressure of methane inclusions before the maximum burial depth in the study area is 103.06-139.82 MPa and the pressure coefficient is 2.05-2.50. The trapping pressure of methane inclusions in the process of reservoir uplifting is 101.32-127.73 MPa, and the pressure coefficient is 1.89-2.18. Third, the overpressure in shale gas reservoirs results from the cracking gas generation pressurization of liquid hydrocarbon and the uplifting

stage is a process of progressive pressure relief. In conclusion, the shale gas reservoir of Wufeng Formation-Longmaxi Formation in the southern Sichuan Basin has good preservation conditions, and its pressure coefficient still remains higher now. 
**Number of references:** 38
**Main heading:** Fracture
**Controlled terms:** Flow of fluids - Gases - Hydrocarbons - Mineralogy - Particle size - Particle size analysis - Pressurization - Scanning electron microscopy
**Uncontrolled terms:** Evolution process - Fluid inclusion - Fracture composite - Fracture composite vein - Hydrocarbon generation - Hydrocarbon-generation pressurization - Low silurian longmaxi formation - Ordovician - Overpressure - Overpressure evolution process - Shale gas reservoirs - Sichuan Basin - Silurian - Southern sichuan basin - Upper ordovician wufeng formation
**Classification code:** 482 Mineralogy - 631.1 Fluid Flow, General - 804.1 Organic Compounds - 951 Materials Science
**Numerical data indexing:** Pressure 1.0132E+08Pa to 1.2773E+08Pa, Pressure 1.0306E+08Pa to 1.3982E+08Pa
**DOI:** 10.3787/j.issn.1000-0976.2021.09.002
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 97. Application of GeoSphere geosteering tool to the drilling of horizontal wells in deepwater gas fields

**Accession number:** 20212010375770
**Title of translation:** GeoSphere
**Authors:** He, Shenglin (1); Li, Ming (1); Wang, Guang (1); Tan, Shun (1); Zhu, Shaopeng (1)
**Author affiliation:** (1) CNOOC China Limited Zhanjiang Company, Zhanjiang; Guangdong; 524057, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 4
**Issue date:** April 25, 2021
**Publication year:** 2021
**Pages:** 91-96
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** Gas Field L is China's first independently developed deepwater gas field in the South China Sea and its gas reservoirs are classified as those with strong edge and bottom water. The accuracy of seismic velocity volume model is not high enough and the gravity flow deposits are reworked by the later muddy channels, so there are great uncertainties in structure error and lateral sand body distribution, which bring about the risks of delayed "landing" and target missing to the drilling trajectory of horizontal wells. To this end, the ultra deep boundary detection geosteering technology (GeoSphere) was adopted to forecast the reservoir top boundary in advance. By virtue of this technology, the formation resistivity 20-30 m in front of the tool can be detected. The real-time interaction and matching judgment between the gas reservoir model of quantitative multi-layer inversion and the original model are carried out based on the returned resistivity information. The order of angle holding, angle building up or angle dropping is sent in time in the angle hold section so as to ensure the drilling trajectory at the optimal "landing" points. The actual drilling of Well A10H shows that massive mudstone is dominant at the hole depth of 3 670 m (vertical depth 3 430.7 m) and the target layer is deeper than the geophysical interpretation result. By virtue of the GeoSphere boundary detection inversion, however, a more continuous high-impedance top boundary is identified at the vertical depth of 3 455.7 m, and the inversion resistivity is in the range of 7-9 #•m. Therefore, it is decided to decrease the angle buildup rate to drill into the more continuous high-resistivity layer (10-20 #•m) indicated by the inversion result. And thus, the correlatability of electrical log curves gets better gradually, the target layer is encountered at the hole depth of 3 853.3 m (vertical depth 3 460.1 m), and the top boundary of the target layer defined by the boundary detection inversion is basically accordant with the actual drilling result. In conclusion, this technology can forecast the reservoir top boundary more accurately and can be used for the landing of horizontal well drilling or the implementation of horizontal section in the areas with greater uncertainty of seismic interpretation structure. 
**Number of references:** 20
**Main heading:** Horizontal drilling

**Controlled terms:** Boreholes - Deepwater drilling - Gases - Gravitation - Horizontal wells - Infill drilling - Offshore gas fields - Oil field equipment - Petroleum reservoirs - Seismology - Well drilling
**Uncontrolled terms:** Boundary detection - Formation resistivity - High resistivity - Horizontal section - Inversion results - Real time interactions - Seismic interpretation - Seismic velocities
**Classification code:** 484.1 Earthquake Measurements and Analysis - 511.1 Oil Field Production Operations - 511.2 Oil Field Equipment - 512.1.1 Oil Fields - 512.2.1 Natural Gas Fields - 931.5 Gravitation, Relativity and String Theory
**Numerical data indexing:** Electrical_Resistivity 1.00e+01Ohms*m to 2.00e+01Ohms*m, Electrical_Resistivity 7.00e+00Ohms*m to 9.00e+00Ohms*m, Size 2.00e+01m to 3.00e+01m, Size 3.67e+03m, Size 4.31e+02m, Size 4.56e+02m, Size 4.60e+02m, Size 8.53e+02m
**DOI:** 10.3787/j.issn.1000-0976.2021.04.010
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 98. Optimization of the development prospect of gas power industry under the goal of carbon neutrality

**Accession number:** 20213010677898
**Title of translation:**
**Authors:** Gong, Chengzhu (1); Jia, Weidong (1); Wu, Desheng (1); Pan, Kai (2)
**Author affiliation:** (1) School of Economics and Management, China University of Geosciences-Wuhan, Wuhan; 430074, China; (2) PetroChina Planning and Engineering Institute, Beijing; 100083, China
**Corresponding author:** Pan, Kai(pankai1988@petrochina.com.cn)
**Source title:** Natural Gas Industry
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**Issue:** 6
**Issue date:** June 25, 2021
**Publication year:** 2021
**Pages:** 144-151
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** The gas power industry, as an important part of the clean energy process in China, plays a special role under the goal of carbon neutrality. In order to quantify the development prospect of gas power industry under the goal of carbon neutrality, this paper constructs a dynamic nonlinear profit optimization model of gas power industry by maximizing the profit of natural gas supply and electricity demand under multiple economic environments based on the levelized cost of energy (LCOE). Then, carries out scenario quantitative analysis on the development prospect of gas power industry under the goal of carbon neutrality by comparatively analyzing the status quo (reference scenario) and the carbon neutrality scenario. And the following conclusions are reached. First, the long-term development prospect of gas power enterprises is better in the carbon neutrality scenario than in the reference scenario. Second, power generation subsidies are the main income sources of gas power enterprises in the carbon neutrality scenario, so the government shall provide gas power enterprises with appropriate subsidies. Third, gas power enterprises are influenced more by the natural gas market price. Lower natural gas price is conducive to the better development of gas power enterprises. Therefore, the government shall pay attention to natural gas market price and appropriately increase the subsidies to ensure the basic income of gas power enterprises when the natural gas price rises. Fourth, the government shall reduce or cancel the constraint of minimum power generation scale to gas power enterprises, which is favorable for the healthy development of gas power enterprises and promotes the marketization of power generation and peak shaving. And meanwhile, gas power enterprises shall strengthen technological development and innovation and improve management efficiency. 
**Number of references:** 32
**Main heading:** Gas industry
**Controlled terms:** Carbon - Commerce - Gas supply - Gases - Profitability
**Uncontrolled terms:** Carbon neutralities - Development prospects - Economic environment - Long-term development - Management efficiency - Natural gas markets - Profit optimization - Technological development
**Classification code:** 522 Gas Fuels - 804 Chemical Products Generally - 911.2 Industrial Economics
**DOI:** 10.3787/j.issn.1000-0976.2021.06.017

**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 99. Strategies for scale benefit development of deep shale gas in China

**Accession number:** 20210609883958
**Title of translation:**
**Authors:** Xu, Fengsheng (1); Wang, Fuping (2); Zhang, Jintao (3); Fu, Bin (2); Zhang, Yong (3); Yang, Pincheng (3); Wu, Wei (4)
**Author affiliation:** (1) PetroChina Policy Research Department, Beijing; 100007, China; (2) Natural Gas Economic Research Institute, PetroChina Southwest Oil & Gasfield Company, Chengdu; 610051, China; (3) PetroChina Southwest Oil & Gasfield Company, Chengdu; 610051, China; (4) Shale Gas Research Institute, PetroChina Southwest Oil & Gasfield Company, Chengdu; 610051, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 1
**Issue date:** January 25, 2021
**Publication year:** 2021
**Pages:** 205-213
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** China is abundant in deep shale gas resources, which is a real field for the production increase of natural gas in the future, so their scale benefit development is of great strategic significance to ensure the national energy security. After reviewing the progresses and achievements in the scale benefit development of deep shale gas resources, this paper analyzes and summarizes four great opportunities and five major challenges. The four great opportunities are as follows. First, in China, the natural gas market has huge space and the development prospect of shale gas is promising. Second, the state and local governments pay attention to and support shale gas exploration and development. Third, there is a resource base for deep shale gas production increase and stabilization. And fourth, technological progress will accelerate the scale benefit development of deep gas. The five major challenges are follows. First, the exploration and development of deep shale gas is more difficult than that of shallow shale gas. Second, the capacity of exploration and development technologies and equipment is not sufficient. Third, the exploration and development cost is higher and the cost reduction and efficiency improvement is of high difficulty. Fourth, the production, operation and management system needs optimizing further. And fifth, the coordination between enterprises and local governments gets more and more difficult. In conclusion, the basic principles shall be followed strictly, such as top-level design, co-construction and win-win, market operation, and inheritance and innovation. In addition, it is recommended to optimize and improve the following measures to promote the scale benefit development of deep shale gas in China by referring to domestic and foreign experiences in the scale benefit development of typical shale gas blocks. First, improve the production organization mode and maximize synergistic effect. Second, strengthen technological researches and promote science and technology leading. Third, establish market-oriented engineering and technology service mechanism and vitalize shale gas development. Fourth, deepen the cooperation between enterprises and local governments and promote co-construction and win-win. Fifth, speed up the cultivation of natural gas utilization industrial clusters and promote the in-situ utilization of shale gas. And sixth, actively strive for industrial support from governments and optimize the policy environment. © 2021, Natural Gas Industry Journal Agency. All right reserved.
**Number of references:** 17
**Main heading:** Petroleum prospecting
**Controlled terms:** Commerce - Cost reduction - Energy security - Gas industry - Gases - Geological surveys - Natural gas - Natural gas fields - Petroleum deposits - Shale gas
**Uncontrolled terms:** Cost reduction and efficiencies - Engineering and technology - Exploration and development - Exploration and development technologies - Natural gas utilization - Operation and management - Production organizations - Technological researches
**Classification code:** 481.1 Geology - 512 Petroleum and Related Deposits - 522 Gas Fuels - 525.6 Energy Policy
**DOI:** 10.3787/j.issn.1000-0976.2021.01.019
**Compendex references:** YES
**Database:** Compendex

## 100. Optimization of fracturing timing of infill wells in shale gas reservoirs: A case study on Well Group X1 of Fuling Shale Gas Field in the Sichuan Basin

**Accession number:** 20210609884015
**Title of translation:** -X1
**Authors:** Zhu, Haiyan (1, 2); Song, Yujia (2); Tang, Xuanhe (1, 3); Li, Kuidong (4); Xiao, Jialin (4)
**Author affiliation:** (1) State Key Laboratory of Oil & Gas Reservoir Geology and Exploitation, Chengdu University of Technology, Chengdu; 610059, China; (2) State Key Laboratory of Oil & Gas Reservoir Geology and Exploitation, Southwest Petroleum University, Chengdu; 610500, China; (3) Department of Earth and Environmental Science, University of Waterloo, Waterloo; N2L 3G1, Canada; (4) Petroleum Engineering Technology Research Institute, Sinopec Jianghan Oilfield Company, Wuhan; 430035, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
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**Publication year:** 2021
**Pages:** 154-168
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** Fracturing timing of infill wells directly influences the ultimate development effect of shale gas reservoirs. In order to provide effective guidance for the deployment and fracturing treatment of infill wells in shale gas reservoirs, this paper proposed a set of method for optimizing the fracturing timing of infill wells in shale gas reservoirs based on discrete fracture network (DFN), finite difference model (FDM) and finite element model (FEM). According to this method, a multi-physics field model of 4D geostress evolution and complex fracture propagation coupled flow and geomechanics is established based on the development status and well pattern infilling demand of the shale gas field, combined with reservoir heterogeneity and development characteristics of natural fractures. Then, the propagation morphology of hydraulic fractures in the infill well and the development effect of the infill well (group) are simulated. Finally, the optimal fracturing timing of infill wells is determined. By taking Well Group X1 of Fuling Shale Gas Field in the Sichuan Basin as an example, this optimization method was applied to study the effects of fracturing timing and treatment parameters of infill wells on the propagation morphology of complex fracture and the productivity of single well and well group. And the following conclusions were reached. First, this optimization method can effectively simulate the change of reservoir physical properties and geomechanical state during the production of parent wells, predict the production after fracturing and optimize fracturing parameters and timing of infill wells. Second, as the perforation cluster spacing of infill wells is decreased and the fracturing fluid volume of each cluster is increased, the stimulated volume of hydraulic fracturing and the fracture density are increased and the production rate after fracturing is improved. If the perforation cluster spacing of infill wells is too short and the fracturing fluid volume of each cluster is too large, however, the branch fractures may be connected and overlapped, which will decrease the efficiency of fracturing fluid and impact the productivity after fracturing. Third, the later the fracturing timing is, the denser the branch fractures near the wellbore of the infill well is, but the smaller the stimulated volume is and the lower the initial production rate is. Fourth, when infill well fracturing is performed after the target well group production for 36 months, its cumulative shale gas production is the highest and the development effect is the best. 
**Number of references:** 46
**Main heading:** Infill drilling
**Controlled terms:** Complex networks - Fracturing fluids - Gas industry - Gases - Geomechanics - Hydraulic fracturing - Morphology - Natural gas wells - Petroleum reservoirs - Productivity - Shale gas - Timing circuits - Well perforation - Well spacing
**Uncontrolled terms:** Development characteristics - Discrete fracture network - Finite difference models (FDM) - Fracturing parameter - Fracturing treatments - Reservoir heterogeneity - Reservoir physical property - Well pattern infilling
**Classification code:** 481 Geology and Geophysics - 511.1 Oil Field Production Operations - 512 Petroleum and Related Deposits - 522 Gas Fuels - 713.4 Pulse Circuits - 722 Computer Systems and Equipment - 951 Materials Science

**Numerical data indexing:** Age 3.00e+00yr
**DOI:** 10.3787/j.issn.1000-0976.2021.01.014
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 101. Geological understanding and evaluation technology of fault controlled carbonate reservoir development: A case study of the Tarim Basin

**Accession number:** 20211710247366
**Title of translation:** --
**Authors:** Jiang, Tongwen (1, 2); Chang, Lunjie (2); Deng, Xingliang (2); Li, Shiyin (2); Wu, Guanghui (3); Wan, Xiaoguo (2); Guan, Baozhu (2)
**Author affiliation:** (1) PetroChina Exploration & Production Company, Beijing; 100007, China; (2) Exploration and Development Research Institute, PetroChina Tarim Oilfield Company, Korla; 841000, China; (3) Southwest Petroleum University, Chengdu; 610500, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
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**Pages:** 1-9
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** There are abundant oil and gas resources in the Ordovician marine carbonate rocks of the Tarim Basin. However, the geological conditions of the oil and gas reservoirs are complicated, oil and gas production is extremely unstable, and oil and gas development is quite difficult. In recent years, a great breakthrough has been made in the exploration and development of strike-slip fault controlled oil and gas reservoirs and benefit development has been realized based on the research and practice of oil and gas reservoir evaluation and development. In this paper, the geological understandings and development technologies of strike-slip fault controlled carbonate oil and gas reservoir development were overviewed and summarized after the characteristics of carbonate oil and gas reservoirs in the Tarim Basin were analyzed. And the following research results were obtained. First, a strike-slip fault system with an area of 9×104 km2 is discovered surrounding Manxi, and the theory of strike-slip fault controlled carbonate oil and gas reservoirs is established. Second, fault controlled oil and gas reservoir description technologies based on high-precision seismic acquisition and processing are researched and developed, including high-density seismic acquisition and processing technology, fine strike-slip fault identification technology, and seismic description technology of fractured-vuggy reservoirs at fault zones. Third, the development methods and key engineering technologies for fault controlled oil and gas reservoirs are formed, including a three-level evaluation method of fault-reserve-reservoir unit, horizontal well development technology for fault zones, staged stimulation technology for carbonate reservoirs by horizontal wells, and reasonable production method and technology for fault controlled reservoirs. In conclusion, based on the innovatively developed geological theories and evaluation and development technologies for strike-slip fault controlled oil and gas reservoirs, the traditional understandings and theories of "paleo-uplift controlled hydrocarbon" and "facies controlled" quasi-layered reservoirs are broken through, a significant discovery of a giant strike-slip fault controlled oil and gas field in the ultradeep layer of depression area is realized, and the benefit development and large-scale productivity construction of complex carbonate oil and gas reservoirs in the Tarim Basin are achieved. The research results provide theoretical and technological support for the evaluation and development of ultradeep fault controlled oil and gas reservoirs. 
**Number of references:** 35
**Main heading:** Oil field development
**Controlled terms:** Carbonation - Energy resources - Fault slips - Gas engineering - Gas industry - Gases - Horizontal wells - Hydrocarbon refining - Oil well production - Petroleum industry - Petroleum reservoir evaluation - Petroleum reservoirs - Proven reserves - Reserves to production ratio - Seismology - Strike-slip faults - Technology transfer - Well stimulation

**Uncontrolled terms:** Development technology - Exploration and development - Fault identifications - Fractured-vuggy reservoirs - Oil and gas production - Processing technologies - Strike-slip fault systems - Technological supports
**Classification code:** 484.1 Earthquake Measurements and Analysis - 511.1 Oil Field Production Operations - 512 Petroleum and Related Deposits - 522 Gas Fuels - 525.1 Energy Resources and Renewable Energy Issues - 802.2 Chemical Reactions - 802.3 Chemical Operations
**DOI:** 10.3787/j.issn.1000-0976.2021.03.001
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 102. Tight sandstone gas reservoirs in the Sulige Gas Field: Development understandings and stable-production proposals

**Accession number:** 20211210117186
**Title of translation:**
**Authors:** Wang, Jiping (1, 2); Zhang, Chengwei (3); Li, Jianyang (4); Li, Ya (1, 2); Li, Xiaofeng (1, 2); Liu, Ping (1, 2); Lu, Jiachun (5)
**Author affiliation:** (1) Exploration and Development Research Institute, PetroChina Changqing Oilfield Company, Xi'an; 710018, China; (2) National Engineering Laboratory of Low-Permeability Oil & Gas Exploration and Development, Xi'an; 710018, China; (3) School of Petroleum Engineering, China University of Petroleum, Beijing; 100249, China; (4) Development Department, PetroChina Changqing Oilfield Company, Xi'an; 710018, China; (5) Sulige Gas Field Development Branch, PetroChina Changqing Oilfield Company, Xi'an; 710018, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 2
**Issue date:** February 25, 2021
**Publication year:** 2021
**Pages:** 100-110
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** The Sulige Gas Field in the Ordos Basin ranks the first in China in terms of reserve scale and annual gas production of tight sandstone gas reservoirs. In order to further extend the stable production time and enhance the recovery factor of tight sandstone gas reservoirs in the Sulige Gas Field, this paper summarizes the geological and gas reservoir engineering understandings obtained in the development process of tight sandstone gas in this gas field, sorts out the difficulties impacting its sustainable stable production, and proposes suggestions for the following development of tight sandstone gas reservoirs in this field. And the following research results were obtained. First, the effective sand body scale, reservoir physical property and gas bearing property are strongly heterogeneous and the local gas-water relationship is complex in the tight sandstone gas reservoirs of the Sulige Gas Field. Second, there are obvious differences in gas well production, accumulative gas production and decline rate in different regions. The recovery factor of the gas reservoirs is affected more by reservoir quality and development well pattern. Third, the reserve producing degree of good-quality reservoirs is high, the tendency of poor-quality reserves is obvious and the fragmentation of remaining reserves is serious, which increases the production stabilization difficulty in the tight sandstone gas reservoirs of the Sulige Gas Field. Fourth, in order to realize sustainable stable production in the Sulige Gas Field, considering the strong heterogeneity characteristics of tight sandstone gas reservoirs, it is recommended to popularize the well pattern deployment strategy of "basic well group + basic well pattern + differential infilling" further, continuously improve fine reservoir description technology and mixed well deployment technology with combined dynamic and static analysis, apply layer reviewing and reperforating of old wells, horizontal well sidetracking and re-stimulation to improve the reserve producing degree, adopt the geology-engineering integrated stimulation technology to improve the effectiveness of reservoir stimulation, make use of intelligent and efficient drainage gas recovery technology by horizontal well to improve the fine management level of gas field, and popularize the "negative pressure" production technology as soon as possible to recover the production capacity of wells on the verge of abandonment. Fifth, seeking for the necessary fiscal and tax support is an important guarantee for the full utilization of tight gas resources. 
**Number of references:** 21

**Main heading:** Abandoned wells
**Controlled terms:** Energy resources - Gas engineering - Gas industry - Gases - Horizontal wells - Intelligent well technology - Natural gas well production - Oil bearing formations - Proven reserves - Recovery - Sandstone - Tight gas - Well stimulation
**Uncontrolled terms:** Drainage gas recovery - Gas reservoir engineering - Production technology - Reservoir description - Reservoir physical property - Reservoir stimulations - Strong heterogeneities - Tight sandstone gas
**Classification code:** 482.2 Minerals - 512 Petroleum and Related Deposits - 522 Gas Fuels - 525.1 Energy Resources and Renewable Energy Issues
**DOI:** 10.3787/j.issn.1000-0976.2021.02.012
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 103. Main controlling factors and natural gas exploration potential of Permian scale volcanoclastic reservoirs in the western Sichuan Basin

**Accession number:** 20211710247365
**Title of translation:**
**Authors:** Xie, Jirong (1); Li, Ya (1); Yang, Yueming (2); Zhang, Benjian (1); Liu, Ran (1, 3); He, Qinglin (1); Wang, Wei (1); Wang, Yufeng (4)
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**Source title:** Natural Gas Industry
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**Publication year:** 2021
**Pages:** 48-57
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** Great breakthroughs and new progresses have been realized in the exploration of volcanoclastic gas reservoirs in the Sichuan Basin since a porous volcanoclastic reservoir was discovered in Well YT1 in the western Sichuan Basin in 2018 followed by another one of 79 m in thickness discovered in Well TF2. In order to clarify the exploration prospect of the Permian volcanic gas reservoir in the western Sichuan Basin, this paper systematically studies the characteristics and main controlling factors of volcanoclastic reservoir in this area by using geological, geophysical and geochemical technologies and methods comprehensively, based on the petrological and petrographical analysis results on the Permian volcanoclastic rock, combined with the latest physical property data. Then, the natural gas exploration potential in this area is discussed based on the match relationships between hydrocarbon accumulation factors. And the following research results were obtained. First, Permian volcanic rocks in the Sichuan Basin are the products of intraplate mantle plume activity. In the western Sichuan Basin mainly develops an eruptive volcanoclastic reservoir, whose reservoir space is dominated by diffuse devitrified dissolved micropores with better pore throat sorting. Second, volcanic edifice and eruptive cycle are the main factors controlling the development of scale reservoir. In the early stage of volcanic activity, the energy is strong and a thick eruptive reservoir is formed, which is the most favorable facies belt for reservoir development. The closer it is to the center of the volcanism, the thicker the eruptive facies is and the more complete the cycle is. Third, the Permian volcanoclastic gas reservoir is underlain by high-quality source rocks of Lower Cambrian Qiongzhusi Formation under the control of fault trough whose oil and gas migrates into the high-quality eruptive reservoir along high angle faults, and its overlying Permian Longtan Formation provides high-quality cap rocks. Thus, the favorable play for large-scale natural gas migration and accumulation is formed. In conclusion, the Permian volcanoclastic rocks in the western Sichuan Basin have the geological conditions for the development of scale high-quality reservoir. In addition, the conditions of hydrocarbon play in this area are good, natural gas resource abundance is large and natural gas exploration and development potential is great. Therefore, it is one of the important fields for the reserves and production increase of natural gas in the Sichuan Basin. © 2021, Natural Gas Industry Journal Agency. All right reserved.

**Number of references:** 28
**Main heading:** Natural gas fields
**Controlled terms:** Energy resources - Exploratory geochemistry - Faulting - Gas industry - Gases - Geological surveys - Hydrocarbons - Natural gas - Petroleum reservoirs - Proven reserves - Quality control - Volcanic rocks - Volcanoes
**Uncontrolled terms:** High quality reservoir - High-quality source rocks - Hydrocarbon accumulation - Main controlling factors - Natural gas exploration - Natural gas migration and accumulations - Natural gas resources - Western Sichuan basin
**Classification code:** 481.1 Geology - 481.2 Geochemistry - 482.2 Minerals - 484 Seismology - 484.1 Earthquake Measurements and Analysis - 512 Petroleum and Related Deposits - 522 Gas Fuels - 525.1 Energy Resources and Renewable Energy Issues - 804.1 Organic Compounds - 913.3 Quality Assurance and Control
**Numerical data indexing:** Size 7.90e+01m
**DOI:** 10.3787/j.issn.1000-0976.2021.03.006
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 104. A mathematical model of wellbore transient temperature of high-temperature directional wells and its application

**Accession number:** 20211710247362
**Title of translation:**
**Authors:** Zheng, Youzhi (1, 2); Gu, Tao (1, 3); Shu, Gang (1); Yang, Mou (3); Yu, Jiang (1); Wu, Wei (4); Zhang, Zhanwu (1); Zhao, Jun (1)
**Author affiliation:** (1) Engineering Technology Research Institute, PetroChina Southwest Oil & Gasfield Company, Guanghan; 618300, China; (2) National Research and Development Center for High-sulfur Gas Reservoir Exploitation, Guanghan; 618300, China; (3) State Key Laboratory for Oil & Gas Reservoir Geology and Exploitation, Southwest Petroleum University, Chengdu; 610500, China; (4) Exploration Department, PetroChina Southwest Oil & Gasfield Company, Chengdu; 610051, China
**Corresponding author:** Gu, Tao(gutao_xn@petrochina.com.cn)
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**Pages:** 119-126
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** The target layers of ultradeep natural gas wells in the western Sichuan Basin are at the depth about 8 000 m, the bottom hole original temperature is over 150, and the drilling mode of directional well is generally adopted here to drill to the target layers. In order to accurately predict the wellbore transient temperature in the drilling process of directional wells in the western Sichuan Basin and evaluate the influences of temperature environmental change on fluid performance and pressure distribution, this paper established a wellbore-formation two-dimensional transient heat transfer model of directional well and a wellbore pressure calculation model of temperature and pressure coupling on the basis of the momentum and energy conservation principles, combined with the characteristics of the directional wells in this area and the radial and axial heat transfer mechanisms in each region under the control of wellbore- formation. Then, this mathematical model was solved using the fully implicit finite difference method. Finally, the influences of circulation time and displacement on the wellbore temperature were analyzed, and the evolution characteristics of fluid density and pressure under temperature and pressure coupling were evaluated. And the following research results were obtained. First, as circulation time and displacement increase, the fluid temperature at the lower hole section and the formation temperature near the wellbore decrease and they are both lower than original formation temperature, while the fluid temperature at the upper section and the casing and cement sheath temperature near the wellbore are higher than the original formation temperature. Second, the wellbore circulation pressure, static density and equivalent circulating density under temperature and pressure coupling are lower than those without temperature and pressure conditions, and they are 2.1 MPa, 0.065 g/cm3 and 0.045 g/cm3, respectively.

In conclusion, the research results can provide a reliable decision basis for analyzing the operational environment of directional drilling tools, evaluating the fluid performance in the full hole and controlling the wellbore pressure. 
**Number of references:** 29
**Main heading:** Natural gas wells
**Controlled terms:** Boreholes - Drilling machines (machine tools) - Finite difference method - Heat transfer performance - Infill drilling - Oil field equipment - Oil well cementing - Temperature
**Uncontrolled terms:** Energy conservation principle - Equivalent circulating density - Evolution characteristics - Fully implicit finite differences - Operational environments - Temperature and pressures - Two-dimensional transient - Western Sichuan basin
**Classification code:** 511.1 Oil Field Production Operations - 511.2 Oil Field Equipment - 512.1.2 Petroleum Deposits : Development Operations - 512.2.1 Natural Gas Fields - 603.1 Machine Tools, General - 641.1 Thermodynamics - 921.6 Numerical Methods
**Numerical data indexing:** Mass_Density 4.50e+01kg/m3, Mass_Density 6.50e+01kg/m3, Pressure 2.10e+06Pa, Size 8.00e+03m
**DOI:** 10.3787/j.issn.1000-0976.2021.03.014
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 105. The unconformity caused by the Huaiyuan movement and the deep natural gas exploration field in the Ordos Basin

**Accession number:** 20213010677917
**Title of translation:**
**Authors:** Liu, Huaqing (1); Li, Xiangbo (1); Ma, Yuhu (1); Bai, Yunlai (1); Huang, Junping (1)
**Author affiliation:** (1) Northwest Branch, PetroChina Research Institute of Petroleum Exploration & Development, Lanzhou; 730020, China
**Source title:** Natural Gas Industry
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**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** In order to clarify the hydrocarbon accumulation significance and exploration prospect of the unconformity caused by the Huaiyuan movement in the Ordos Basin, this paper studies the spatial distribution characteristics and structural surface characteristics of this unconformity and its relationships with hydrocarbon accumulation by observing field outcrops and cores and analyzing logging data, based on the previous research results and the interpretation results of 2D and new 3D seismic data. And the following research results are obtained. First, the unconformity was mainly formed in the Floian Age of Early Ordovician and widely occurs at the bottom of the Jiawang Formation and the top of the Sanshanzi Formation underlying the Majiagou Formation of Middle-Lower Ordovician. And the related tectonism lasts 30 Myr. Second, basal conglomerate and sandstone less than 1 m in thickness are developed above the unconformity at the edge of the basin, while thin mudstone, argillaceous dolomite (limestone) and marl are developed above the unconformity in the central part of the basin. Third, the unconformity structurally consists of three layers, including a basal conglomerate layer, a paleosoil layer and a fully-semi weathered carbonate layer from top to bottom, among which, the last one is 20-90 m in thickness with developed dissolution fractures and pores to form a quality reservoir. Fourth, the unconformity results in the development of a series of large valleys landforms, which incise the Lower Ordovician-Upper Cambrian. Fifth, the unconformity can act as a good channel for hydrocarbon migration, and it connects with the unconformity caused by the Caledonian movement within the paleo-uplift of the Ordos Basin, which is favorable for the re-migration of hydrocarbon of different sources in the west side of the basin eastwards to accumulate and form a gas reservoir. In conclusion, the deep Lower Paleozoic related to the Huaiyuan unconformity is expected to be an important natural gas exploration field in the Ordos Basin. 

**Number of references:** 47
**Main heading:** Petroleum prospecting
**Controlled terms:** Fertilizers - Geological surveys - Hydrocarbons - Lime - Metamorphic rocks - Natural gas - Natural gas fields - Petroleum reservoirs - Seismology
**Uncontrolled terms:** Carbonate layers - Distribution characteristics - Exploration prospects - Hydrocarbon accumulation - Hydrocarbon migration - Majiagou formation - Natural gas exploration - Structural surfaces
**Classification code:** 481.1 Geology - 484.1 Earthquake Measurements and Analysis - 512 Petroleum and Related Deposits - 522 Gas Fuels - 804 Chemical Products Generally
**Numerical data indexing:** Age 3.00e+07yr, Size 1.00e+00m, Size 2.00e+01m to 9.00e+01m
**DOI:** 10.3787/j.issn.1000-0976.2021.06.001
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 106. Geomechanical mechanisms and prevention countermeasures of casing deformation in shale gas horizontal wells

**Accession number:** 20210609883965
**Title of translation:**
**Authors:** Tong, Hengmao (1, 2); Zhang, Ping (3); Zhang, Hongxiang (2); Liu, Ziping (3); Ren, Xiaohai (3); Xiao, Kunze (2); Zhou, Yibo (3); Deng, Cai (3)
**Author affiliation:** (1) State Key Laboratory of Petroleum Resources and Prospecting, China University of Petroleum, Beijing; 102249, China; (2) College of Geosciences, China University of Petroleum, Beijing; 102249, China; (3) CNPC Chuanqing Drilling Engineering Co., Ltd., Chengdu; 610051, China
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**Pages:** 189-197
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** Since large-scale industrial development of shale gas started in China in 2014, many shale-gas horizontal wells in the southwestern Sichuan Basin have undergone casing deformation, which cannot be solved effectively by means of casing engineering mechanics. In order to solve this problem, this paper analyzes the casing deformation phenomena in this area and defines the mechanism of casing deformation based on the fundamental theory of structural geology and geomechanics, namely "generalized shear activity criterion". And accordingly the countermeasures and strategies to prevent casing deformation are put forward. And the following research results were obtained. First, casing deformation is result of the result of fluid (water) pressure transfer to the fault and fracture (fault-fracture)surface during hydraulic fracturing, which induces stratum shear slip that acts on the casing to result in its deformation. And all the casing deformation phenomena are in line with the characteristics of shear deformation. Second, the geomechanical research content of casing deformation include identifying the possible active fault-fracture (risk point of casing deformation), the potential activity of fault-fracture, the shear slippage of fault-fracture and the coupling relationship between casing deformation and stratum shear deformation (the stratum deformation transmitting degree of cement sheath). Third, the fundamental measure to prevent casing deformation is to prevent large quantities of fracturing fluid from entering fault-fractures (e.g. temporary plugging of major fractures) and drive it to generate fractures without loss along fault-fractures. Fourth, the on-site test of the temporary major fracture plugging engineering to control the loss of fracturing fluid shows good achievements in the prevention of casing deformation, which effectively reverses the adverse situation of casing deformation. In conclusion, casing deformation caused by shale gas development can be prevented and controlled. © 2021, Natural Gas Industry Journal Agency. All right reserved.
**Number of references:** 29
**Main heading:** Faulting
**Controlled terms:** Fracturing fluids - Geomechanics - Horizontal wells - Hydraulic fracturing - Loss prevention - Oil well cementing - Shale gas - Shear deformation - Structural geology

**Uncontrolled terms:** Casing deformation - Coupling relationships - Engineering mechanics - Fundamental theory - Industrial development - Potential activities - Pressure transfer - Stratum deformation
**Classification code:** 481 Geology and Geophysics - 481.1 Geology - 484.1 Earthquake Measurements and Analysis - 512.1.1 Oil Fields - 512.1.2 Petroleum Deposits : Development Operations - 522 Gas Fuels
**DOI:** 10.3787/j.issn.1000-0976.2021.01.017
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 107. Status of and suggestions on the survey and evaluation of natural gas resource exploitation and utilization level: A case study of China National Petroleum Corporation

**Accession number:** 20211710247358
**Title of translation:** --
**Authors:** Cui, Yongping (1); Chen, Jingyuan (2); Ji, Lidan (3); Guo, Jianlin (3); Geng, Meng (3)
**Author affiliation:** (1) PetroChina Exploration & Production Company, Beijing; 100007, China; (2) PetroChina Southwest Oil & Gasfield Company, Chengdu; 610051, China; (3) PetroChina Research Institute of Petroleum Exploration & Development, Beijing; 100083, China
**Corresponding author:** Ji, Lidan(jilidan@petrochina.com.cn)
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**Publication year:** 2021
**Pages:** 90-96
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** To investigate the current exploitation and utilization level of natural gas resources and promote the saving and efficient utilization of oil and gas resources, this paper takes China National Petroleum Corporation (CNPC) as the sample to carry out the related survey and evaluation activities and analyze the overall development situations of its natural gas business. In addition, the natural gas "three-ratio" (recovery factor, recovery ratio and utilization ratio of syngenetic and associated resources) indexes of its 12 subordinate oilfield companies were analyzed. On this basis, the evaluation results were obtained and the related suggestions were proposed. And the following research results were obtained. First, CNPC's natural gas "three-ratio" indexes are overall better. Second, CNPC's natural gas recovery factor during 2016-2019 averages 59.02 % and the average natural gas recovery factor of five types of gas reservoirs exceeds the minimum standard. Third, CNPC's natural gas recovery ratio during 2016-2019 averages 98.16 % and the natural gas recovery ratio of each oilfield reaches the standard. Fourth, CNPC'S utilization ratio of syngenetic and associated resources during 2016-2019 is different. The utilization ratio of condensate oil averages 99.92% (up to the standard), the utilization ratio of hydrogen sulfide averages 96.21%, the utilization ratio of carbon dioxide averages 66.97% and that of helium gas ranges from 30% to 50%. CNPC'S utilization ratio of hydrogen sulfide during 2018-2019 reaches the standard. Finally, several suggestions on the "three-ratio" index system were proposed. First, adjust the extra low permeability gas reservoirs into the category of tight gas reservoir and introduce two new types, i.e., shale gas and coalbed methane. Second, decrease the minimum recovery factor standard of gas reservoirs with inactive water drive by 10% to 60%, increase the minimum recovery factor standard of low permeability gas reservoirs by 10% to 40%, and increase the minimum recovery factor standard of extra low permeability gas reservoirs (tight gas reservoirs) by 10% to 24%. Third, the recovery ratio of natural gas is defined as the percentage of the sum of commodity volume and self consumption in the industrial production of natural gas, which is more accordant to the field actuality. Fourth, syngenetic and associated resources are different in the content and utilization value, so it is not suitable to adopt the "one-size-fits-all" measure to pursue the high utilization ratio of all syngenetic and associated resources, and it is suggested to cancel the evaluation standard of the utilization ratio of syngenetic and associated resources. Fifth, oilfield companies shall establish the normal-state standard survey and evaluation system of natural gas exploitation and utilization level and include the "three-ratio" index evaluation in the annual routine work of natural gas development. 
**Number of references:** 20
**Main heading:** Low permeability reservoirs

**Controlled terms:** Carbon dioxide - Coal deposits - Energy resources - Gas industry - Gas permeability - Gases - Gasoline - Hydrogen sulfide - Methane - Natural gas - Natural gas fields - Natural gasoline plants - Oil field development - Petroleum analysis - Petroleum reservoir evaluation - Recovery - Sulfur compounds - Sulfur determination - Surveys - Tight gas
**Uncontrolled terms:** China national petroleum corporations - Development situations - Extra low-permeability - Industrial production - Low permeability gas reservoirs - Natural gas development - Natural gas recoveries - Utilization ratio of carbon
**Classification code:** 503 Mines and Mining, Coal - 512 Petroleum and Related Deposits - 513.2 Petroleum Refineries - 522 Gas Fuels - 523 Liquid Fuels - 525.1 Energy Resources and Renewable Energy Issues - 801 Chemistry - 804.1 Organic Compounds - 804.2 Inorganic Compounds - 931.2 Physical Properties of Gases, Liquids and Solids
**Numerical data indexing:** Percentage 1.00e+01% to 2.40e+01%, Percentage 1.00e+01% to 4.00e+01%, Percentage 1.00e+01% to 6.00e+01%, Percentage 3.00e+01% to 5.00e+01%, Percentage 5.90e+01%, Percentage 6.70e+01%, Percentage 9.62e+01%, Percentage 9.82e+01%, Percentage 9.99e+01%
**DOI:** 10.3787/j.issn.1000-0976.2021.03.010
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 108. Regional diversity of low-carbon efficiency in Sichuan province under the goal of carbon neutrality

**Accession number:** 20213010678005
**Title of translation:**
**Authors:** Chen, Junhua (1); Li, Qiaochu (1); He, Jing (1)
**Author affiliation:** (1) School of Economics and Management, Southwest Petroleum University, Chengdu; 610500, China
**Corresponding author:** Li, Qiaochu(252651625@qq.com)
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 6
**Issue date:** June 25, 2021
**Publication year:** 2021
**Pages:** 162-170
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** Regional low-carbon efficiency calculation and spatial differentiation evaluation are an important basis for formulating differentiated emission reduction measures. As a "clean energy demonstration province", Sichuan province shall make active contribution to carbon neutrality based on its own advantages in resource endowment. In order to calculate the low-carbon efficiency of Sichuan province from the perspective of carbon neutrality, this paper adopts the Undesirable-Super-SBM model and introduces forest carbon sequestration and technological innovation into the evaluation index system. Then, based on the panel data containing more degrees of freedom and sample variability, the low-carbon efficiency of Sichuan province and its internal 21 cities (prefectures) during 2005-2019 were calculated. Finally, the spatial differentiation of low-carbon efficiency between different regions was researched and determined by virtue of GIS spatial analysis technology. And the following conclusions are reached. First, the low-carbon efficiency of Sichuan province during 2005-2019 presents a trend of overall rising. Second, Chengdu has a high level of economic development, a reasonable industrial structure and a steady increase in forest coverage. Heavy industrial cities such as Panzhihua and Deyang are focusing on the green transformation of high energy consumption and heavy pollution industries, and have achieved remarkable results in energy conservation and emission reduction. They are the first-mover advantage regions of low-carbon transformation. Third, Zigong, Mianyang, Suining, Leshan and other regions have advantages in terms of national policy support and energy conservation and emission reduction space, and they are the development regions of low-carbon transformation, but in the future, they shall seek new growth points on the basis of traditional pillar industries. Fourth, Aba Tibetan and Qiang Autonomous Prefecture and Ganzi Tibetan Autonomous Prefecture have a harsh ecologic environment and low development level, and Dazhou and Ya'an are weak in geographical advantage without sufficient endogenous motivation for transformation, so they are the potential regions of low-carbon transformation. © 2021, Natural Gas Industry Journal Agency. All right reserved.

**Number of references:** 21
**Main heading:** Carbon
**Controlled terms:** Aerospace industry - Degrees of freedom (mechanics) - Emission control - Energy conservation - Energy utilization - Forestry - Geographical regions - Green manufacturing
**Uncontrolled terms:** Energy conservation and emission reductions - Evaluation index system - First mover advantages - Forest carbon sequestration - High energy consumption - Low carbon transformations - Spatial differentiation - Technological innovation
**Classification code:** 451.2 Air Pollution Control - 525.2 Energy Conservation - 525.3 Energy Utilization - 804 Chemical Products Generally - 931.1 Mechanics
**DOI:** 10.3787/j.issn.1000-0976.2021.06.019
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 109. Volume fracturing and drainage technologies for low-pressure marine shale gas reservoirs in the Ordos Basin

**Accession number:** 20211710247370
**Title of translation:**
**Authors:** Fu, Suotang (1, 2); Wang, Wenxiong (1, 2); Li, Xianwen (1, 2); Xi, Shengli (1, 2); Hu, Xifeng (1); Zhang, Yanming (1, 2)
**Author affiliation:** (1) PetroChina Changqing Oilfield Company, Xi'an; 710018, China; (2) National Laboratory for Exploration and Development of low Permeability Oil and Gas Fields, Xi'an; 710021, China
**Corresponding author:** Wang, Wenxiong(wwx1_cq@petrochina.com.cn)
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 3
**Issue date:** March 25, 2021
**Publication year:** 2021
**Pages:** 72-79
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** There are abundant natural gas resources in the marine shale gas reservoir of Middle Ordovician Wulalike Formation in the Ordos Basin, which is an important resource base for PetroChina Changqing Oilfield Company to increase the reserves and production of oil and gas. Compared with the other shale gas reservoirs at home and aboard, however, the marine shale gas reservoir of Middle Ordovician Wulalike Formation in the Ordos Basin has a lower formation pressure coefficient and poorer reservoir physical properties and gas-bearing property, so its production increase difficulty is higher. In this paper, horizontal-well volume fracturing was studied and tested based on the earlier vertical well tests. According to the technical idea of the staged multi-cluster massive fracturing of long horizontal section, the propagation mechanisms and morphological characteristics of fractures were studied and analyzed based on the fracturing geological characteristics of the shale gas reservoir in the Ordos Basin. On this basis, a full three-dimensional fracture model was optimally established for parameter optimization. The fracturing of the test well ZP1 was carried out with 15 stages and 103 clusters. After the fracturing, a more complex fracture network was formed with a fracture complexity index of 0.4-0.6. The microseismic monitoring zone is 579 m long and 266 m wide and the fracture is 146 m high. To address the drainage difficulty after large-volume fracturing of low-pressure shale gas in the Ordos Basin, this paper carries out a gas energized fracturing test. Considering the characteristics of reservoir physical properties, gas-bearing property and segmented fractures, 805 m3 liquid nitrogen was injected in stages during the fracturing of the test horizontal well. The formation pressure coefficient measured from pressure buildup data is increased from 0.7-0.8 to 1.88. The wellbore gas-liquid flow model was established and the parameters of long-period control-pressure drainage under were optimized. The critical surface equipment was upgraded to achieve accurate measurement, safety and environmental protection. And the following research and practice results were obtained. First, based on the technological innovation and optimization, continuous gas-liquid two-phase flow is realized in the test well ZP1 and its production rate and pressure during the test are stable with the tested daily shale gas production at the wellhead of 6.42×104 m3. Second, after fracturing, the absolute open flow of the test well reaches 26.4×104 m3/d, which is more than 10 times higher than the production rate of the vertical well in the same

block during the test. Thus, a significant breakthrough is realized in the exploration of marine shale gas in North China.

**Number of references:** 21
**Main heading:** Oil bearing formations
**Controlled terms:** Catchments - Complex networks - Energy resources - Fracture - Gas bearings - Gas industry - Gases - Horizontal wells - Liquefied gases - Metamorphic rocks - Microseismic monitoring - Natural gas - Natural gasoline plants - Oil wells - Petroleum industry - Petroleum reservoirs - Physical properties - Proven reserves - Reserves to production ratio - Shale gas - Two phase flow - Well testing - Wellheads
**Uncontrolled terms:** Changqing oilfield companies - Full three-dimensional - Gas - liquid two-phase flows - Geological characteristics - Morphological characteristic - Parameter optimization - Reservoir physical property - Technological innovation
**Classification code:** 512 Petroleum and Related Deposits - 513.2 Petroleum Refineries - 522 Gas Fuels - 525.1 Energy Resources and Renewable Energy Issues - 601.2 Machine Components - 631.1 Fluid Flow, General - 722 Computer Systems and Equipment - 931.2 Physical Properties of Gases, Liquids and Solids - 951 Materials Science
**Numerical data indexing:** Size 1.46e+02m, Size 2.66e+02m, Size 5.79e+02m, Volume 8.05e+02m3
**DOI:** 10.3787/j.issn.1000-0976.2021.03.008
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 110. Pore-scale analysis of coal structure and mechanical properties evolution through liquid nitrogen thermal shock

**Accession number:** 20213210735511
**Title of translation:**
**Authors:** Yang, Ruiyue (1, 2); Cong, Richao (1, 2); Liu, Han (3); Huang, Zhongwei (1, 2); Wen, Haitao (1, 2); Hong, Chunyang (1, 2)
**Author affiliation:** (1) State Key Laboratory of Petroleum Resources and Prospecting, China University of Petroleum, Beijing; 102249, China; (2) CBM Research Center, China University of Petroleum, Beijing; 102249, China; (3) Engineering & Design Institute of CPOE, CNPC Offshore Engineering Company Limited, Beijing; 100028, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 7
**Issue date:** July 25, 2021
**Publication year:** 2021
**Pages:** 82-92
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Number of references:** 35
**Main heading:** Efficiency
**Controlled terms:** Coal - Coal bed methane - Coal deposits - Computerized tomography - Elastic moduli - Firedamp - Fracture - Liquid nitrogen - Matrix algebra - Methane - Nanotechnology - Pore structure - Rocks - Seepage - Surface roughness - Three dimensional computer graphics
**Uncontrolled terms:** Atomic force - Atomic force microscope - CT scanning - Digital core - Liquid nitrogen fracturing - Micro-nano scale - Pore throat - Pore throat connectivity - Reservoir stimulation efficiency - Reservoir stimulations
**Classification code:** 503 Mines and Mining, Coal - 512.2 Natural Gas Deposits - 522 Gas Fuels - 524 Solid Fuels - 723.2 Data Processing and Image Processing - 723.5 Computer Applications - 761 Nanotechnology - 804.1 Organic Compounds - 804.2 Inorganic Compounds - 913.1 Production Engineering - 921.1 Algebra - 931.2 Physical Properties of Gases, Liquids and Solids - 951 Materials Science
**Numerical data indexing:** Percentage 1.30E+02%, Percentage 1.40E+02%, Percentage 1.70E+02%, Percentage 2.00E+02%, Percentage 7.70E+00%, Percentage 8.10E+01%, Percentage 9.00E+01%, Percentage 9.10E+01%
**DOI:** 10.3787/j.issn.1000-0976.2021.07.009
**Compendex references:** YES
**Database:** Compendex

**Data Provider:** Engineering Village


## 111. Application of natural gas pressure differential power generation technology in underground gas storages

**Accession number:** 20211710247363
**Title of translation:**
**Authors:** Zhu, Liyang (1); Xiong, Bo (2); Wang, Zhijun (2); Zou, Yin (2); Zhong, Minglang (3)
**Author affiliation:** (1) PetroChina Southwest Oil & Gasfield Company, Chengdu; 610051, China; (2) Market Development Department, PetroChina Southwest Oil & Gasfield Company, Chengdu; 610051, China; (3) Gas Transmission Division, PetroChina Southwest Oil & Gasfield Company, Chengdu; 610051, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 3
**Issue date:** March 25, 2021
**Publication year:** 2021
**Pages:** 142-146
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Number of references:** 22
**Main heading:** Energy efficiency
**Controlled terms:** Economics - Energy utilization - Gas industry - Investments - Natural gas - Natural gas fields
**Uncontrolled terms:** Differential power - Gas electricities - Gas pressures - Gas-electricity dual storage - Natural gas pressure differential power generation - Power - Power generation by turbo expander - Power sale - Power-generations - Pressure differential - Pressure loss - Turbo expanders - Xiangguosi underground gas storage
**Classification code:** 512.2.1 Natural Gas Fields - 522 Gas Fuels - 525.2 Energy Conservation - 525.3 Energy Utilization - 971 Social Sciences
**Numerical data indexing:** Power 1.747E+06W, Power 1.80E+06W
**DOI:** 10.3787/j.issn.1000-0976.2021.03.017
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 112. Ethane recovery process with "mixed refrigerant precooling + expander cooling + double gas overcooling"

**Accession number:** 20212510530518
**Title of translation:** "++"
**Authors:** Qiu, Peng (1); Chang, Zhibo (1); Liu, Zibing (1); Huang, Changmeng (2); Li, Jiangang (2); Zhou, Xiaohu (2)
**Author affiliation:** (1) PetroChina Changqing Engineering Design Co., Ltd., Xi'an; 710001, China; (2) PetroChina Changqing Oilfield Company, Yulin; 719000, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 5
**Issue date:** May 25, 2021
**Publication year:** 2021
**Pages:** 121-126
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Number of references:** 20

**Main heading:** Carbon dioxide
**Controlled terms:** Cryogenics - Ethane - Gases - Geochronology - Ice - Metamorphic rocks - Natural gas - Natural gas fields - Recovery - Refrigerants - Temperature
**Uncontrolled terms:** Carbon dioxide concentrations - Cryogenic separation - Dry ice - Ethane recovery - Gas reservoir - Mixed refrigerants - Ordos Basin - Reflux rate - Upper Paleozoic - Upper paleozoic gas reservoir
**Classification code:** 481.1 Geology - 481.3 Geophysics - 512.2.1 Natural Gas Fields - 522 Gas Fuels - 641.1 Thermodynamics - 644.2 Refrigerants - 644.4 Cryogenics - 803 Chemical Agents and Basic Industrial Chemicals - 804.1 Organic Compounds - 804.2 Inorganic Compounds
**Numerical data indexing:** Amount of substance 0.00E00mol, Percentage 2.00E+01%, Percentage 9.57E+01%
**DOI:** 10.3787/j.issn.1000-0976.2021.05.013
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 113. Recommendations on the improvement of the proposed government new rules for the operation of natural gas pipeline networks and management of natural gas supply emergency in China

**Accession number:** 20213210735561
**Title of translation:** ()()
**Authors:** Bai, Jun (1); Zhang, Xiongjun (1); Zhang, Liyue (1)
**Author affiliation:** (1) Research Institute, Beijing Gas Group Company Limited, Beijing; 100011, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 7
**Issue date:** July 25, 2021
**Publication year:** 2021
**Pages:** 172-178
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Number of references:** 22
**Main heading:** Gases
**Controlled terms:** Emergency services - Gas supply - Natural gas pipelines - Natural gas transportation
**Uncontrolled terms:** Capacity service - Gas pipeline networks - Management rule - Natural gas pipeline network - Natural gas supply - Natural gas supply emergency - Operation - Pipechina - Pipeline management - Unbalanced service
**Classification code:** 522 Gas Fuels - 619.1 Pipe, Piping and Pipelines - 914.1 Accidents and Accident Prevention
**DOI:** 10.3787/j.issn.1000-0976.2021.07.019
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 114. Simulation of multi-method CO2 capture and purification process

**Accession number:** 20212510530591
**Title of translation:** CO2
**Authors:** Shi, Bohui (1); Wang, Jingyi (2); Liao, Qingyun (1); Wang, Ting (1); Wang, Shanshan (3); Yang, Meng (3); Xiao, Yaqi (4); Zhang, Haoyue (1); Song, Chenxi (1); Gong, Jing (1, 5)
**Author affiliation:** (1) National Engineering Laboratory for Pipeline Safety//Key Laboratory of Petroleum Engineering Education Ministry, Beijing Key Laboratory of Urban Oil and Gas Distribution Technology, China University of Petroleum (Beijing), Beijing; 102249, China; (2) China Petroleum Pipeline Engineering Corporation, Langfang; 065000, China; (3) Beijing Engineering Branch, China Petroleum Engineering & Construction Corporation, Beijing; 100101, China; (4) Natural Gas Marketing Center of Sichuan-East Natural Gas Transmission Project, Sinopec Gas Company,

Wuhan; 430014, China; (5) State Key Laboratory of Gas Hydrate, China University of Petroleum (Beijing), Beijing; 102249, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 5
**Issue date:** May 25, 2021
**Publication year:** 2021
**Pages:** 110-120
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Number of references:** 29
**Main heading:** Carbon dioxide
**Controlled terms:** Air purification - Computer software - Digital storage - Energy utilization - Floods - Gas industry - Gas permeable membranes - Gases - Geology - Membrane technology - Natural gas fields - Oil well flooding
**Uncontrolled terms:** CO2 capture - CO2 flooding - Deacidification - Floodings - Geological storage - Hydramine method - HYSYS software - Membrane separation - Produced gas - Reinjection
**Classification code:** 451.2 Air Pollution Control - 481.1 Geology - 511.1 Oil Field Production Operations - 512.2.1 Natural Gas Fields - 522 Gas Fuels - 525.3 Energy Utilization - 643 Space Heating, Ventilation and Air Conditioning - 722.1 Data Storage, Equipment and Techniques - 723 Computer Software, Data Handling and Applications - 802.3 Chemical Operations - 804.2 Inorganic Compounds - 951 Materials Science
**DOI:** 10.3787/j.issn.1000-0976.2021.05.012
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 115. Neural network based intelligent control system of natural gas flowmeter verification process

**Accession number:** 20213210735735
**Title of translation:**
**Authors:** Wen, Kai (1); Han, Xu (1); Li, Can (2); Niu, Jinhao (2); Zhou, Lei (2); Xu, Hongtao (3)
**Author affiliation:** (1) China University of Petroleum (Beijing), Beijing Key Laboratory of Urban Oil and Gas Distribution Technology, Beijing; 102249, China; (2) PipeChina West East Gas Pipeline Company, Shanghai; 200122, China; (3) PipeChina (Fujian) Emergency Maintenance Co., Ltd., Putian; 351254, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 7
**Issue date:** July 25, 2021
**Publication year:** 2021
**Pages:** 124-133
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Number of references:** 22
**Main heading:** Natural gas
**Controlled terms:** Automation - Controllers - Flow measurement - Flow of gases - Flowmeters - Gases - Hydraulic models - Natural gas pipelines - Neural networks - Process control - Software testing - Verification
**Uncontrolled terms:** BP neural networks - Flow regulation - Flowmeter - Gas flow meters - Hydraulic simulation - Intelligent regulations - Measurement verification - Neural-networks - Station modeling - Verification process
**Classification code:** 522 Gas Fuels - 619.1 Pipe, Piping and Pipelines - 631.1 Fluid Flow, General - 631.1.2 Gas Dynamics - 632.1 Hydraulics - 721.1 Computer Theory, Includes Formal Logic, Automata Theory, Switching Theory,

Programming Theory - 723.5 Computer Applications - 731 Automatic Control Principles and Applications - 732.1 Control Equipment - 943.1 Mechanical Instruments - 943.2 Mechanical Variables Measurements
**DOI:** 10.3787/j.issn.1000-0976.2021.07.014
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 116. Research progress on hydrogen production and solid hydrogen storage

**Accession number:** 20212010375753
**Title of translation:**
**Authors:** Wang, Lu (1, 2); Jin, Zhijun (1, 2, 3); Huang, Xiaowei (4)
**Author affiliation:** (1) Institute of Energy, Peking University, Beijing; 100871, China; (2) School of Earth and Space Sciences, Peking University, Beijing; 100871, China; (3) Sinopec Exploration & Production Research Institute, Beijing; 100083, China; (4) School of Energy Resources, China University of Geosciences, Beijing; 100083, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 4
**Issue date:** April 25, 2021
**Publication year:** 2021
**Pages:** 124-136
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Number of references:** 80
**Main heading:** Hydrogen storage
**Controlled terms:** Carbon - Gas industry - Hydrogen production - Natural gas fields - Sedimentary rocks - Solar power generation
**Uncontrolled terms:** Complex hydrides - Generation mechanism - Hydrogen Energy - Hydrogen storage density - Hydrogen storage materials - Natural hydrogen - Serpentinization - Solid hydrogen - Solid hydrogen storage - Storage densities
**Classification code:** 482.2 Minerals - 512.2.1 Natural Gas Fields - 522 Gas Fuels - 615.2 Solar Power - 804 Chemical Products Generally
**DOI:** 10.3787/j.issn.1000-0976.2021.04.014
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 117. Development prospect of natural gas industry in the Sichuan Basin in the next decade

**Accession number:** 20213910945480
**Title of translation:**
**Authors:** Zhang, Daowei (1)
**Author affiliation:** (1) PetroChina Southwest Oil & Gasfield Company, Chengdu; 610051, China
**Corresponding author:** Zhang, Daowei(zdwqh@petrochina.com.cn)
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 8
**Issue date:** August 25, 2021
**Publication year:** 2021
**Pages:** 34-45
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)

**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** The Sichuan Basin is the earliest natural gas discovery and utilization area in the world, where the modern natural gas industry of New China started. Through nearly 7 decades of development, a natural gas industrial system with complete upstream, middle and downstream industry chain has been established, and its natural gas production has led the other places of China for half a century. And it has played an important role in the process of improving the primary energy consumption structure and constructing a "beautiful China". The evaluation result of national oil and gas resources in the 13th Five-Year Plan shows that the natural gas resource extent in the Sichuan Basin is 39.94×1012 m3, ranking the first in domestic petroliferous basins. In addition, the proven rate is only 15% and it is still in the early and middles stages of exploration. Therefore, the Sichuan Basin has great potential in natural gas exploration and development. The natural gas production in the Sichuan Basin in 2020 is 565×108 m3 (including all production enterprises of PetroChina and Sinopec in the Sichuan Basin), taking the first place in domestic major gas producing areas. Speaking of the next decade, the state puts forward new development concepts from the perspective of development circumstances. The construction of Chengdu-Chongqing economic circle will be promoted and a national natural gas strategic production base with yearly gas production of 1 000×108 m3 will be built up in the Sichuan Basin, which marks a new golden development period of natural gas industry in the Sichuan Basin. From the perspective of development potential, deep and ultra-deep marine carbonate gas reservoirs, deep shale gas and continental tight sandstone gas will be the key exploration and development fields to search for giant gas fields in the Sichuan Basin. It is recommended to strengthen core technology researches according to the thoughts of "simultaneous development of marine and continental, conventional and unconventional, structural and lithologic" and relying on theoretical and technological progress. In the future, it will enter a great development period when the quality of natural gas resources will be continuously upgraded and the production rate will be increased continuously. In the meantime, take advantage of the opportunities of great development to break through the development bottleneck of increasingly complex work objects, incomplete pipeline network system and insufficient high end and high additional value industries. Under the situation of normalized low oil price, construct a new-type industrial system with the coordinative development of natural gas production, transportation, storage and marketing and the innovation and efficiency improvement in the whole industrial chain. In conclusion, the natural gas industry in the Sichuan Basin will pace in a new peak growth period and a high-quality development period in the next decade, and its yearly natural gas production will exceed 1 000×108 m3, and the yearly natural gas production of PetroChina Southwest Oil & Gasfield Company will reach 800×108 m3 in 2030. Obviously, the Sichuan Basin will be a world-class natural gas production and supply base. 
**Number of references:** 27
**Main heading:** Natural gas
**Controlled terms:** Energy resources - Energy utilization - Gas industry - Gases - Natural gas fields - Natural gas well production - Petroleum prospecting - Petroleum reservoirs - Tight gas
**Uncontrolled terms:** High quality - High-quality development - Industrial systems - Natural gas production and supply base - Natural gas supply - Natural-gas production - New-type industrial system - Peak growth - Sichuan Basin - Supply base - Yearly natural gas production
**Classification code:** 512.1.1 Oil Fields - 512.1.2 Petroleum Deposits : Development Operations - 512.2 Natural Gas Deposits - 512.2.1 Natural Gas Fields - 522 Gas Fuels - 525.1 Energy Resources and Renewable Energy Issues - 525.3 Energy Utilization
**Numerical data indexing:** Percentage 1.50E+01%
**DOI:** 10.3787/j.issn.1000-0976.2021.08.004
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 118. Connotation, innovation and vision of "carbon neutral"

**Accession number:** 20213910945170
**Title of translation:** "",
**Authors:** Zou, Caineng (1); Xue, Huaqing (1); Xiong, Bo (1); Zhang, Guosheng (1); Pan, Songqi (1); Jia, Chengye (1); Wang, Ying (1); Ma, Feng (1); Sun, Qian (2); Guan, Chunxiao (1); Lin, Minjie (1)
**Author affiliation:** (1) PetroChina Research Institute of Petroleum Exploration & Development, Beijing; 100083, China; (2) Southwest Petroleum University, Chengdu; 610500, China
**Corresponding authors:** Xue, Huaqing(hqxue@petrochina.com.cn); Pan, Songqi(pansongqi@pku.edu.cn)
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 8
**Issue date:** August 25, 2021

**Publication year:** 2021
**Pages:** 46-57
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** Global climate change caused by geological processes is one of the main causes of the 5 global mass extinctions in geological history. Human industrialization activities have caused serious damage to the ecosystem, the greenhouse effect of atmospheric CO2 has intensified, and the living environment is facing threats and challenges. Carbon neutral is the active action and common goal of mankind in the face of the climate change crisis, including theoretical and technological connotation, scientific and technological innovation system, and has far-reaching significance and broad prospects. Studies indicate that (1) Carbon neutral embodies the theoretical connotations of "energy science" and "carbon neutral science", including technical connotations of carbon emission reduction, zero carbon, negative carbon, and carbon trading. (2) Carbon neutral spawns a carbon industry centered on CO2 capture, utilization, and storage (CCUS, or CO2 capture and storage CCS), and a hydrogen industry centered on green hydrogen. "Gray carbon" and "black carbon" are the two application attributes of CO2. "Carbon+", "Carbon-", and "Carbon=" are three carbon-neutral products and technologies. (3) China faces three major challenges in achieving the goal of carbon neutral: first, the energy transition is large in scale and the cycle is short; Second, there are many problems in the process of energy transition, such as security uncertainties, economic utilization, and unpredictable disruptive technologies; Third, after the transition, we may face new key technological "bottlenecks" and "broken chain" of key mineral resources. (4) Based on current knowledge to predict the top 10 disruptive technologies and industries in the energy field: underground coal gasification, in-situ conversion process of medium and low-mature shale oil, CCUS/CCS, hydrogen energy and fuel cells, bio-photovoltaic power generation, space-based solar power generation, optical storage smart micro-grid, super energy storage, controllable nuclear fusion, wisdom energy Internet. Five strategic projects will be implemented, including energy conservation and efficiency improvement, carbon reduction and sequestration, scientific and technological innovation, emergency reserve and policy support. (5) In the future, different types of energy will have different orientations. Coal will play the role of ensuring the national energy strategy "reserve" and "guarantee the bottom". Petroleum will play the role of ensuring national energy security "urgent need" and the "cornerstone" of raw materials for people's livelihood. Natural gas will play the role in ensuring national energy "safety" and "best partner" of new energy. New energy will play the role in ensuring the "replacement" and "main force" of the national energy strategy. (6) Carbon neutral is a major practice of the green industrial revolution, carbon reduction energy revolution, and ecological technology revolution, which will bring new and profound changes to human society, the environment and the economy. (7) Carbon neutral needs to follow the four principles of "disruptive breakthroughs in technology, guarantee of energy security, realization of economic feasibility, and controllable social stability". We should rely on technological innovation and management changes to ensure the realization of national energy "independence" and carbon neutral goal, and make China's contribution to the construction of a livable earth, green development, and ecological civilization. 
**Number of references:** 23
**Main heading:** Carbon dioxide
**Controlled terms:** Carbon - Carbon capture - Coal - Coal deposits - Coal industry - Coal storage - Emission control - Energy policy - Geology - Greenhouse effect - Greenhouse gases - Hydrogen production - Photovoltaic cells - Proven reserves - Solar energy - Solar power generation
**Uncontrolled terms:** Carbon emissions reductions - Carbon industry - Carbon neutral science - Carbon neutrals - Carbon peaks - Energy - Energy independence - Energy science - Energy transitions
**Classification code:** 443.1 Atmospheric Properties - 451 Air Pollution - 451.1 Air Pollution Sources - 451.2 Air Pollution Control - 454 Environmental Engineering - 481.1 Geology - 503 Mines and Mining, Coal - 512.1.2 Petroleum Deposits : Development Operations - 522 Gas Fuels - 524 Solid Fuels - 525.6 Energy Policy - 615.2 Solar Power - 657.1 Solar Energy and Phenomena - 694.4 Storage - 804 Chemical Products Generally - 804.2 Inorganic Compounds
**DOI:** 10.3787/j.issn.1000-0976.2021.08.005
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 119. Some research advances in well engineering technology for unconventional hydrocarbon

**Accession number:** 20213910945161
**Title of translation:**

**Authors:** Gao, Deli (1)
**Author affiliation:** (1) MOE Key Laboratory of Petroleum Engineering, China University of Petroleum, Beijing; 102249, China
**Corresponding author:** Gao, Deli(gaodeli@cup.edu.cn)
**Source title:** Natural Gas Industry
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**Publication year:** 2021
**Pages:** 153-162
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** How to exploit efficiently unconventional hydrocarbon has become an important step to solve the problem of increasing reserve and production of oil & gas in China. Aiming at unconventional oil & gas well engineering problems such as large cluster well design, single trip drilling operation, downhole radiofrequency heating, efficient exploitation of coalbed methane and so on, this article analyzes the related research progress briefly at home and abroad, and focuses on the research results of the author's team. Technical contents introduced in this article mainly include: the design methods of large cluster horizontal wells with considerations of directional drilling operation limit and the anti-collision while drilling; research advances in key techniques for the single trip drilling operation related to the innovative research work on efficient PDC bits, steering bottomhole assembly, drilling parameter optimization, new type of drilling fluid and so on; general situation of development and the research results in downhole radiofrequency heating technology for unconventional oil recovery by the in-situ conversion process; finally, briefly introducing significance and technical challenge of the coalbed methane development and utilization, and focusing on the representative achievement of coaled methane exploitation in China, which is related to key techniques involving the geological evaluation, magnetic steering drilling, well completion & washing, efficient fracturing with combination of the preposed nitrogen and activated water and so on. A review of the research advances may be used as beneficial reference in optimal design and operation control of well engineering technology for unconventional hydrocarbon. 
**Number of references:** 49
**Main heading:** Methane
**Controlled terms:** Coal bed methane - Coal deposits - Directional drilling - Drilling fluids - Firedamp - Horizontal drilling - Horizontal wells - Oil well drilling - Proven reserves - Well completion
**Uncontrolled terms:** Cluster horizontal well - Downhole radiofrequency heating technology - Downholes - Drilling operation - Heating technology - PDC bit - Radio frequency heating - Research advances - Unconventional hydrocarbons - Well engineering
**Classification code:** 503 Mines and Mining, Coal - 511.1 Oil Field Production Operations - 512.1.1 Oil Fields - 512.1.2 Petroleum Deposits : Development Operations - 512.2 Natural Gas Deposits - 522 Gas Fuels - 804.1 Organic Compounds
**DOI:** 10.3787/j.issn.1000-0976.2021.08.014
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 120. An intelligent well test interpretation method based on data driven technology: A case study from one water-producing gas well of water-bearing gas reservoirs

**Accession number:** 20211210117171
**Title of translation:** -
**Authors:** Mi, Lidong (1); Gu, Shaohua (1); Xue, Liang (2); Zhao, Lin (2)
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**Corresponding author:** Xue, Liang(xueliang@cup.edu.cn)
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41

**Issue:** 2
**Issue date:** February 25, 2021
**Publication year:** 2021
**Pages:** 119-124
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** Correct identification of interpretation model is the prerequisite to obtain reasonable and reliable well test interpretation results. In order to improve the accuracy of well test interpretation results, this paper constructs a model parameter-well test curve sample set under multiple modes according to the numerical reservoir simulation technology and the stochastic inversion theory. Then, based on data-driven, a well test interpretation model was identified according to the multi-mode stochastic analysis theory, the well test curve was fitted using the ensemble Kalman filter (EnKF) method, and the data driven technology was applied into the whole process of well test model identification-parameter interpretation. Finally, a set of intelligent well test interpretation method based on data driven technology was put forward. Besides, one water-producing gas well in X water-bearing gas reservoir was selected for field application test. And the following research results were obtained. First, the intelligent well test interpretation method proposed in this paper can provide well test interpretation in the situations with complex flow and boundary, avoid the excessive simplification of conventional well test model and reduce the interpretation error caused by model simplification. Second, by using the multi-mode EnKF method, and combined with the principle of fitting error minimization, the water invasion model matching the real situations of the gas reservoir can be identified, so as to accurately clarify the dynamic characteristics of water invasion in the gas reservoir. In conclusion, by virtue of using the intelligent well test interpretation method based on data driven technology, well test model can be identified and parameters can be interpreted automatically. What's more, this method is of strong adaptability and high interpretation accuracy and has a promising application prospect. 
**Number of references:** 20
**Main heading:** Intelligent well technology
**Controlled terms:** Gases - Natural gas well production - Natural gas wells - Stochastic models - Stochastic systems - Well testing
**Uncontrolled terms:** Application prospect - Dynamic characteristics - Ensemble Kalman Filter - Interpretation errors - Interpretation model - Numerical reservoir simulations - Water- bearing gas reservoirs - Well test interpretation
**Classification code:** 512.2.1 Natural Gas Fields - 922.1 Probability Theory - 961 Systems Science
**DOI:** 10.3787/j.issn.1000-0976.2021.02.014
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 121. Optimization of application of perforation parameters of deep shale gas reservoirs in complex structural areas: a case study of the Baima Block of Fuling Shale Gas Field

**Accession number:** 20210609884063
**Title of translation:** -
**Authors:** Liu, Yaowen (1)
**Author affiliation:** (1) Sinopec Chongqing Fuling Shale Gas Exploration and Development Co., Ltd., Chongqing; 408014, China
**Corresponding author:** Liu, Yaowen(jhyt_lyw@163.com)
**Source title:** Natural Gas Industry
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**Publication year:** 2021
**Pages:** 136-145
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)

**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** Baima complex structure area in Fuling Shale Gas Field of the Sichuan Basin is characterized by complex geological structures, strong reservoir heterogeneity, great reservoir burial depth and difficult fracturing stimulation. And in order to realize the effective production of deep shale gas reserves in this area, this paper simulates the influences of different factors (e.g. trajectory position, number of fracturing clusters and number of perforations) on the propagation differences of multi-cluster fractures by considering the differences in physical properties and stress between different sublayers, based on the calculation model of plane three-dimensional fully coupled "wellbore-multifracture propagation". And the following research results were obtained. First, multi-cluster intensive cutting by reducing the cluster spacing and increasing the number of single-stage fracturing clusters is beneficial to increasing the density of main fractures and shortening the gas migration distance in the stimulated section. Second, increasing the number of clusters in one section does not mean better effects. Under the same injection rate and fracturing scale, the fracture length and fracture height of each cluster presents a decreasing trend and the non-uniform propagation of multiple fractures aggravates as the number of fracturing clusters increases. Third, the physical characteristics and stress state of horizontal-well trajectory position and each sublayer also influence the propagation morphology of hydraulic fractures and enhance the stimulation nonuniformity of different sublayers, which results in the differences in the optimal number of clusters. Fourth, the limited entry fracturing that reduces the number of single-cluster perforations is beneficial to improving the stimulation uniformity in the fracturing section and decreasing the reduction coefficient of fluid volume difference between different clusters, but a smaller number of perforations will increase the perforation friction and greatly improve the ground construction pressure. Field practice results show that the stimulation effect of the gas well after fracturing is remarkable by optimizing the fracturing process parameters according to the horizontal-well trajectory position, combined with the limited entry perforation. In conclusion, the research results provide theoretical guidance and practical experience for the effective production of deep shale gas resources in the Baima Block. 
**Number of references:** 16
**Main heading:** Fracture
**Controlled terms:** Energy resources - Gas industry - Gases - Horizontal wells - Hydraulic fracturing - Natural gas well production - Petroleum reservoirs - Proven reserves - Shale gas - Trajectories - Well stimulation
**Uncontrolled terms:** Geological structures - Ground construction - Limited entry perforations - Physical characteristics - Practical experience - Reduction coefficient - Reservoir heterogeneity - Shale gas reservoirs
**Classification code:** 512 Petroleum and Related Deposits - 522 Gas Fuels - 525.1 Energy Resources and Renewable Energy Issues - 951 Materials Science
**DOI:** 10.3787/j.issn.1000-0976.2021.01.012
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 122. Dissolution effect of carbonate minerals on shale pores and its significance: A case study on the Lower Silurian Longmaxi Formation shale in the eastern Sichuan Basin

**Accession number:** 20210609884059
**Title of translation:** -
**Authors:** Liang, Yunpei (1, 2); Chen, Qiang (1, 2); Liao, Zhiwei (1, 2); Lin, Dan (3)
**Author affiliation:** (1) State Key Laboratory of Coal Mine Disaster Dynamics and Control, Chongqing University, Chongqing; 400044, China; (2) School of Resources and Safety Engineering, Chongqing University, Chongqing; 400044, China; (3) Chengdu University, Chengdu; 610106, China
**Corresponding author:** Chen, Qiang(chenqiang2019@foxmail.com)
**Source title:** Natural Gas Industry
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**Issue date:** January 25, 2021
**Publication year:** 2021
**Pages:** 93-101
**Language:** Chinese
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**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency

**Abstract:** Carbonate minerals are closely related to pore structures in shale gas reservoirs, and the discussion on their quantitative relationship is conducive to deepening the quantitative characterization of shale petrology and the understanding on pore transformation in the micrometer/nanometer scale. In this paper, the shale of Lower Silurian Longmaxi Formation in the Pengshui area of the eastern Sichuan Basin was selected to perform dilute hydrochloric acid-shale reaction experiment. Then, the pore structures before and after the dissolution were characterized by means of field-emission scanning electron microscopy, micro-CT and low-pressure nitrogen adsorption comprehensively. The influence of carbonate minerals on the pore structures in shale gas reservoirs was studied. Finally, the geological and engineering indicating significance of dissolution pores was discussed. And the following research results were obtained. First, after 120 hours of acid-rock reaction under room temperature, carbonate minerals are completely dissolved while the other minerals don't change obviously. Second, after carbonate minerals are completely dissolved, a large number of dissolution pores with a diameter of 3.9-62.5 μm appear and their total volume fraction percentage is 6.8%, which is close to the acid-induced dissolution rate of the sample, 6.9%. Besides, the shape, volume, pore size, surface area and other parameters of nanopores do not change significantly. Third, after carbonate minerals are dissolved completely by acid, only micropores are generated and the phenomenon of pore increase and enlargement does not occur in the nanometer scale, indicating that the carbonate crystal grains are in a micrometer scale. In conclusion, the image statistical parameters of micro-scale dissolution pores can effectively invert the characteristic parameters of carbonate minerals (such as microscopic distribution, morphology, quantity and particle size) and provides a new method for the quantitative research of shale petrology. In addition, dissolution pores, together with hydraulic fracture networks are conducive to accelerating the production of shale gas. © 2021, Natural Gas Industry Journal Agency. All right reserved.
**Number of references:** 30
**Main heading:** Nanopores
**Controlled terms:** Carbonate minerals - Carbonation - Computerized tomography - Dissolution - Field emission microscopes - Gas adsorption - Gas industry - Gasoline - Hydrochloric acid - Micrometers - Morphology - Particle size - Petroleum reservoirs - Petrology - Pore size - Pore structure - Rocks - Scanning electron microscopy - Shale gas
**Uncontrolled terms:** Field emission scanning electron microscopy - Microscopic distribution - Nitrogen adsorption - Pore transformations - Quantitative characterization - Quantitative research - Shale gas reservoirs - Statistical parameters
**Classification code:** 481.1.2 Petrology (Before 1993, use code 482) - 482.2 Minerals - 512.1.1 Oil Fields - 522 Gas Fuels - 523 Liquid Fuels - 723.5 Computer Applications - 741.3 Optical Devices and Systems - 761 Nanotechnology - 802.2 Chemical Reactions - 802.3 Chemical Operations - 804.2 Inorganic Compounds - 931.2 Physical Properties of Gases, Liquids and Solids - 933 Solid State Physics - 943.1 Mechanical Instruments
**Numerical data indexing:** Percentage 6.80e+00%, Percentage 6.90e+00%, Size 3.90e-06m to 6.25e-05m, Time 4.32e+05s
**DOI:** 10.3787/j.issn.1000-0976.2021.01.008
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 123. Theory and method of temporary macrofracture plugging to prevent casing deformation in shale gas horizontal wells

**Accession number:** 20212510530553
**Title of translation:**
**Authors:** Tong, Hengmao (1, 2); Liu, Ziping (3); Zhang, Hongxiang (2); Zhang, Ping (3); Deng, Cai (3); Ren, Xiaohai (3); Xiao, Kunze (2); Zhou, Yibo (3)
**Author affiliation:** (1) State Key Laboratory of Petroleum Resources and Prospecting, China University of Petroleum, Beijing; 102249, China; (2) College of Geosciences, China University of Petroleum, Beijing; 102249, China; (3) CNPC Chuanqing Drilling Engineering Company Limited, Chengdu; 610051, China
**Source title:** Natural Gas Industry
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**Issue date:** May 25, 2021
**Publication year:** 2021
**Pages:** 92-100
**Language:** Chinese
**ISSN:** 10000976

**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** Since the industrial development of shale gas in China began at the end of 2013, many horizontal wells have undergone casing deformation, which seriously impacts the development efficiency and benefits of shale gas. In order to prevent and control casing deformation in shale-gas horizontal wells, this paper firstly confirms that casing deformation is caused by the shear activity of faults and macrofractures (referred to as fault-fracture) in the process of hydraulic fracturing. Then, according to the generalized shear activity criterion, the influences of the fluid pressure of hydraulic fracturing on fault-fracture shear activity are analyzed, the comprehensive criterion of preferred flow channel of fracturing fluid under the state of in-situ stress is established, and the factors influencing the flow capacity of natural fractures are quantitatively analyzed, so as to provide theoretical basis for temporary macrofracture plugging. Finally, fault-fracture risks are divided into three levels according to activity coefficient (fa) and fault-fracture scale, and the temporary plugging timing of faults-fractures of different risk levels is determined. And the following research results were obtained. First, macrofractures are the high-speed flow channels of fracturing fluid loss. Second, controlling the loss of fracturing fluid along macrofractures can effectively prevent casing deformation. Third, the combined temporary plugging can cut off or prevent the loss of fracturing fluid along macrofractures. Field tests of temporary macrofracture plugging were carried out in 19 wells, and the casing deformation rate decreased from 50.4% (before the test) to 15.8%. Great effects have been achieved, and significant progress has been made in the prevention of casing deformation. In conclusion, temporary macrofracture plugging is an effective method to prevent casing deformation in shale gas development, and is worthy of further popularization and application. © 2021, Natural Gas Industry Journal Agency. All right reserved.
**Number of references:** 33
**Main heading:** Horizontal wells
**Controlled terms:** Channel flow - Deformation - Fracturing fluids - Gases - Hydraulic fracturing - Loss prevention - Shale gas - Shear flow
**Uncontrolled terms:** Casing deformation - Efficiency and benefit - Fluid pressures - High speed flows - Industrial development - Natural fracture - Research results - Theory and methods
**Classification code:** 512.1.1 Oil Fields - 512.1.2 Petroleum Deposits : Development Operations - 522 Gas Fuels - 631.1 Fluid Flow, General
**Numerical data indexing:** Percentage 1.58e+01%, Percentage 5.04e+01%
**DOI:** 10.3787/j.issn.1000-0976.2021.05.010
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 124. Innovative technology system I-STADIUMS and its application in China's "South to North Gas Transmission" Project

**Accession number:** 20211210117056
**Title of translation:** ""I-STADIUMS
**Authors:** Fu, Zihang (1); Liu, Fang (1); Yang, Yuxia (1); Feng, Liang (1); Huang, Jiexin (1)
**Author affiliation:** (1) Technical Research & Development Center, CNOOC Co., Ltd., Beijing; 100028, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
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**Issue date:** February 25, 2021
**Publication year:** 2021
**Pages:** 149-159
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** In order to alleviate the seasonal shortage of gas supply in the northern China in winter, CNOOC has implemented and expanded the "South to North Gas Transmission" project for three consecutive years. In view of this, we summarized the unique natural gas pipeline innovation technology system I-STADIUMS benefitted from this project, reflecting the technical characteristics of "deep cultivation" of gas consumption in southern coastal market. First, I-STADIUMS includes nine technical sub-systems: Intelligence, Hourly Peak-Shaving, Quality-Tracking, Calorific

Value Adjusting, Optimal Dispatching, Integrity Technology, Third-Party Access (Unbundling), Energy Metering, and Reliability-Safeguard. Second, I-STADIUMS fully studies and reflects the objective technical problems of gas-fired power plants in Guangdong, Hong Kong and Macao, such as high load profile, large amplitude of hourly peak shaving, great differences in gas capacity allocation needs, huge gaps in trade measurement methods, high requirements for gas quality stability, reliability and open-access operation, and so on. Third, based on the application requirements of "resource allocation optimization" and "flow direction optimization", I-STADIUMS guides and optimizes the "production capacity release", "debottlenecking" and "inter-connection" engineering practices. Fourth, through the integration of resources and infrastructure, and reconstruction of technical capabilities, I-STADIUMS supports the "South to North Gas Transmission" project to expand, upgrade and innovate in geographical scope, gas volume scale, logistics type and business model. In conclusion, we suggested that the integration of intelligence, system simulation and dispatching optimization should be further promoted in the further application of I-STADIUMS, so as to provide reliable solutions for the opening-access of multi-user facilities in the new era of China. 
**Number of references:** 27
**Main heading:** Production platforms
**Controlled terms:** Commerce - Gases - Natural gas pipelines - Natural gasoline plants - Recreation centers - Stadiums - Transmissions
**Uncontrolled terms:** Application requirements - Engineering practices - Gas-fired power plants - Innovation technology - Innovative technology - Production capacity - Resource allocation optimization - Technical capabilities
**Classification code:** 402.2 Public Buildings - 403 Urban and Regional Planning and Development - 513.2 Petroleum Refineries - 522 Gas Fuels - 602.2 Mechanical Transmissions - 674.2 Marine Drilling Rigs and Platforms
**DOI:** 10.3787/j.issn.1000-0976.2021.02.018
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 125. Exploration prospects of Lower Cambrian shale gas in the central-western Sichuan Basin under the pattern of tectonic-depositional differentiation: From high-quality source rocks to reservoirs

**Accession number:** 20212510530408
**Title of translation:** : -
**Authors:** Liang, Xiao (1, 2); Li, Xianghua (1); Xu, Jianliang (1); He, Jia (1); Han, Youping (3); Cui, Jian (1); Li, Guoqin (1); Kou, Yilong (1)
**Author affiliation:** (1) Research Institute of Geological Exploration and Development, CNPC Chuanqing Drilling Engineering Company Limited, Chengdu; 610051, China; (2) State Key Laboratory of Oil and Gas Reservoir Geology and Exploitation, Chengdu University of Technology Chengdu, Chengdu; 610059, China; (3) Southwest Geophysical Prospecting Institute, CNPC Bureau of Geophysical Prospecting Inc., Chengdu; 610213, China
**Source title:** Natural Gas Industry
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**Publication year:** 2021
**Pages:** 30-41
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** The Lower Cambrian Maidiping-Qiongzhusi Formation is another major layer of shale gas exploration and development strata after the Upper Ordovician Wufeng Formation and Lower Silurian Longmaxi Formation in the Sichuan Basin. However, the stratigraphic division and correlation of the Lower Cambrian in the central-western Sichuan Basin is still disputed, which restricts the research and evaluation on the Lower Cambrian shale gas. To this end, this paper systematically analyzes the stratigraphic and time frame of Lower Cambrian (as conventional oil and gas source rocks) in the central-western Sichuan Basin and the formation and distribution laws of black shale. Then, combined with its structural setting of great burial depth, strong uplifting and strong reworking, the thermal evolution process of Lower Cambrian shale organic and the enrichment conditions of shale gas are studied. Finally, the

favorable areas are pointed out. And the following research results were obtained. First, referring to the international Cambrian stratigraphic and time correlation sequence, the time-spatial distribution relationship of the Lower Cambrian black rock series in this area is controlled by the difference of Sinian-Cambrian contact, and the Maidiping-Qiongzhusi Formation is not completely pure black rock series. Second, in the pattern of tectonic-depositional differentiation, the thickness of the Maidiping-Qiongzhusi Formation in the central-western Sichuan Basin varies greatly and the middle-northern section of the Mianyang-Changning Intracratonic Sag is the depositional center of organic-rich black shale, as well as the optimal shale gas enrichment area. Third, there is a local moderate-maturity area of Maidiping-Qiongzhusi Formation in the Sichuan Basin. In conclusion, on the basis of effective fracturing technical problems for 4 000 m deep engineering, the Ziyang-Neijiang-Dazu on the east of Weiyuan structure in the Sichuan Basin is the most favorable exploration area, and the Kuangshanliang-Nianziba-Hewanchang area in the foreland expanded deformation zone of northern section of western Sichuan Depression and the Micang Mountain front area can be taken as the favorable exploration shale gas areas in the next step. 
**Number of references:** 60
**Main heading:** Petroleum prospecting
**Controlled terms:** Deposition - Gases - Geological surveys - Oil shale - Rocks - Shale gas - Stratigraphy - Tectonics
**Uncontrolled terms:** Conventional oil and gas - Exploration prospects - Gas enrichment areas - High-quality source rocks - Lower Cambrian black rock series - Research and evaluation - Structural setting - Western Sichuan basin
**Classification code:** 481.1 Geology - 512.1 Petroleum Deposits - 512.1.2 Petroleum Deposits : Development Operations - 522 Gas Fuels - 802.3 Chemical Operations
**Numerical data indexing:** Size 4.00e+03m
**DOI:** 10.3787/j.issn.1000-0976.2021.05.004
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 126. Whole-life cycle countermeasures to improve the stimulation effect of network fracturing in deep shale gas reservoirs of the Southern Sichuan Basin

**Accession number:** 20210609883973
**Title of translation:**
**Authors:** Shen, Cheng (1); Xie, Jun (2); Zhao, Jinzhou (3); Fan, Yu (4); Ren, Lan (3)
**Author affiliation:** (1) Shale Gas Research Institute, PetroChina Southwest Oil & Gasfield Company, Chengdu; 610051, China; (2) CNPC Planning Department, Beijing; 100724, China; (3) State Key Laboratory of Oil & Gas Reservoir Geology and Exploitation, Southwest Petroleum University, Chengdu; 610500, China; (4) Engineering Technology Research Institute, PetroChina Southwest Oil & Gasfield Company, Chengdu; 610017, China
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**Publication year:** 2021
**Pages:** 169-177
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** In order to realize scale efficient development of deep shale gas, this paper systematically analyzes the geological and engineering factors influencing the stimulation effect of network fracturing in shale reservoirs in the whole life cycle of shale gas well covering well location deployment, drilling & completion and production by taking the deep shale gas reservoir of Upper Ordovician Wufeng Formation-Lower Silurian Longmaxi Formation in the Luzhou-Yuxi Block of the southern Sichuan Basin as the research object. Then, corresponding technological countermeasures and the next development direction were pointed out. And the following research results were obtained. First, stress state and fault system are the principal factors influencing the propagation degree of fracture networks, unequal-timing target and its drilling rate are the prerequisite to the formation of complex fracture networks, the developed natural weak plane zone is an important medium to induce fracture propagation, and the thickness of high-quality shale reservoir is the geological basis for evaluating vertical resource development capacity. Second, liquid carrying

efficiency and close cluster spacing are the technological guarantee to improve the complexity of hydraulic fractures, finest aged perforation technology is the core technology to realize the lateral reservoir development sufficiently, integrated fracturing scheme design is an innovative process to avoid the occurrence of complex downhole situations and maximize reservoir stimulation effect, and reasonable well soaking and production system is the necessary measure to ensure a long-term stable production of gas wells at a high level. Third, the connotation of the whole-life cycle countermeasures to improve the stimulation effect of network fracturing for deep shale gas wells includes establishing a suitable vertical and lateral reservoir development pattern to stimulate the high-quality reservoirs sufficiently, effectively identifying faults and weak planes to reduce the occurrence of complex borehole situations, optimizing cluster spacing and sand fluid systems to maximize the scale of hydraulic fracture networks, and formulating a rational production system to reach the maximum estimated ultimate recovery (EUR) of gas wells. Fourth, the next development direction of network fracturing technology for deep shale gas reservoirs include carrying out fine fracturing scheme design of gas wells with long horizontal sections, continuously optimizing sand fluid systems, cluster spacing and construction intensity, and researching multilayer tridimensional fracturing technology. 
**Number of references:** 26
**Main heading:** Life cycle
**Controlled terms:** Complex networks - Faulting - Fracture - Gas industry - Gases - Horizontal wells - Hydraulic fracturing - Infill drilling - Natural gas well completion - Natural gas well production - Natural gas wells - Petroleum reservoirs - Shale gas - Well perforation - Well spacing - Well stimulation
**Uncontrolled terms:** Development directions - Estimated ultimate recoveries - Fracture propagation - High quality reservoir - Reservoir development - Reservoir stimulations - Resource development - Shale gas reservoirs
**Classification code:** 484.1 Earthquake Measurements and Analysis - 511.1 Oil Field Production Operations - 512 Petroleum and Related Deposits - 522 Gas Fuels - 722 Computer Systems and Equipment - 951 Materials Science
**DOI:** 10.3787/j.issn.1000-0976.2021.01.015
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 127. Stratigraphic division and correlation and karst palaeo-geomorphology restoration of the Middle Permian Maokou Formation in the eastern Sichuan Basin

**Accession number:** 20213010677971
**Title of translation:** ,
**Authors:** Chen, Weidong (1); Chen, Yicai (2); Xu, Fabo (1); Li, Shilin (1); Li, Yanjun (3); Zeng, Liyuan (3); Tan, Qian (2); Kang, Yu (2)
**Author affiliation:** (1) Chongqing Division, PetroChina Southwest Oil & Gasfield Company, Chongqing; 400021, China; (2) Chengdu University of Technology, Chengdu; 610059, China; (3) Chengdu ChuangYuan Oil and Gas Technology Development Co., Ltd., Chengdu; 610500, China
**Corresponding author:** Chen, Yicai(3446174160@qq.com)
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**Pages:** 27-36
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** The Middle Permian Maokou Formation in the eastern Sichuan Basin experienced complex sedimentary facies change in the late stage, and there is no unified division standard of the top and bottom boundaries of Maokou Formation, so the restored karst palaeogeomorphological pattern of Maokou Formation is much different from the actual situation. In order to provide support for the natural gas exploration in the Maokou Formation karst reservoirs of this area, this paper, through precise division and correlation of the Maokou Formation referring to the marker bed, using the data of outcrop geological survey, drilling core, logging and seismic artificial virtual wells, based on the analysis of residual formation thickness, formation lithology and denuded formation interval, aims to establish a division standard of the Maokou Formation karst palaeogeomorphological unit, and describe the distribution pattern of karst

highlands, karst slopes and karst basins. And the following research results are obtained. First, the residual formation thickness of Maokou Formation presents the distribution characteristics of "thin in the north and thick in the south". The thickness of the first Member of Maokou Formation (P2m1) is stable while the residual formation thickness of the second Member of Maokou Formation (P2m2) varies greatly. Second, the sedimentation of the Gufeng Member of trough facies begins in the P2m2b stage and ends in the late P2m2a stage. Its formation thickness is generally less than 25 m and its distribution is limited in the northeastern Sichuan Basin. Third, the 3rd and 4th Members of Maokou Formation (P2m3 and P2m4) are denuded to different degrees in the central and northern part of eastern Sichuan Basin. Fourth, the palaeogeomorphology at the end of Maokou Formation can be divided into two karst highlands, three karst basins and two karst slopes. In conclusion, the Maokou Formation in the eastern Sichuan Basin is palaeogeomorphologically characterized by primary karst slopes, secondary karst highlands and smaller karst basins. In the northern and central part, the upper zone of Maokou Formation in the karst highlands and karst slopes is more denuded, and karst reservoirs are mainly developed in the P2m2b, the P2m2c and the middle and upper zones of P2m1; while in the southern part, karst reservoirs are mainly developed in the P2m3, P2m2a and P2m2b. 
**Number of references:** 22
**Main heading:** Landforms
**Controlled terms:** Geological surveys - Lithology - Natural gas well logging - Natural gas wells - Petroleum prospecting - Restoration - Stratigraphy
**Uncontrolled terms:** Distribution characteristics - Distribution patterns - Karst reservoirs - Maokou Formation - Natural gas exploration - Northeastern Sichuan - Research results - Sedimentary facies
**Classification code:** 481.1 Geology - 512 Petroleum and Related Deposits
**Numerical data indexing:** Size 2.50e+01m
**DOI:** 10.3787/j.issn.1000-0976.2021.06.003
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 128. Type and genesis of condensate gas reservoir in the Tazhong uplift of the Tarim Basin

**Accession number:** 20213210735553
**Title of translation:**
**Authors:** Han, Jianfa (1); Wu, Guanghui (2, 3); Yang, Haijun (1); Dai, Lan (2); Su, Zhou (1); Tang, Hao (2); Xiong, Chang (1)
**Author affiliation:** (1) PetroChina Tarim Oilfield Company, Korla; 841000, China; (2) School of Geoscience and Technology, Southwest Petroleum University, Chengdu; 610500, China; (3) Qiangtang Basin Research Institute, Southwest Petroleum University, Chengdu; 610500, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 7
**Issue date:** July 25, 2021
**Publication year:** 2021
**Pages:** 24-32
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** Giant Ordovician carbonate condensate gas field in the Tazhong uplift of the Tarim Basin has complicated geological characteristics, fluid property and distribution, so it is of great significance to figure out its genesis for its evaluation and development. In order to provide theoretical basis for the exploration and development of the carbonate condensate gas field in the Tarim Basin, this paper analyzes its characteristics and accumulation evolution history and discusses its type and genesis based on its dynamic and static production data, combined with organic geochemical indexes and other experimental data. And the following research results are obtained. First, the Tazhong condensate gas field is mainly a secondary condensate gas reservoir formed from the paleo oil reservoir suffering the late gas invasion and gas washing. Second, the Lower Cambrian kerogen cracking gas and oil cracking gas in ultra deep strata can supply hydrocarbon in the phase state of condensate gas to form primary condensate gas reservoirs, which is mainly distributed in the ultra-deep Cambrian-Lower Ordovician and the eastern buried-hill area lack of paleo oil reservoirs. Third, the Tazhong condensate gas field was formed in the Himalayan stage and is in close relationship with the fast rising formation pressure, and its hydrocarbon accumulation pattern has a variety of phase state types

and geneses. In conclusion, there are simultaneously two genetic types of primary and secondary condensate gas reservoirs in the Tazhong condensate gas field, and formation pressure system, gas invasion intensity and paleo oil reservoir scale lead to complicated fluid distribution and oil/gas production, which is different from conventional condensate gas reservoirs, so it shall be treated differently during its evaluation and development. 
**Number of references:** 31
**Main heading:** Gas condensates
**Controlled terms:** Gases - Oil field development - Petroleum industry - Petroleum prospecting - Petroleum reservoir evaluation - Petroleum reservoirs
**Uncontrolled terms:** Condensate gas reservoirs - Evolution history - Exploration and development - Fluid distribution - Formation pressure - Geological characteristics - Hydrocarbon accumulation - Oil/gas production
**Classification code:** 512.1.1 Oil Fields - 512.1.2 Petroleum Deposits : Development Operations - 522 Gas Fuels
**DOI:** 10.3787/j.issn.1000-0976.2021.07.003
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 129. Shale gas exploration and development in the Sichuan Basin: Progress, challenge and countermeasures

**Accession number:** 20213910945425
**Title of translation:** ,
**Authors:** Zhang, Liehui (1); He, Xiao (2); Li, Xiaogang (1); Li, Kuncheng (1); He, Jiang (1); Zhang, Zhi (1); Guo, Jingjing (1); Chen, Yinan (1); Liu, Wenshi (1)
**Author affiliation:** (1) State Key Laboratory of Oil & Gas Reservoir Geology and Exploitation, Southwest Petroleum University, Chengdu; 610500, China; (2) PetroChina Southwest Oil & Gasfield Company, Chengdu; 610051, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 8
**Issue date:** August 25, 2021
**Publication year:** 2021
**Pages:** 143-152
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** China's shale gas production in 2020 exceeds 200×108 m³, which creates a miracle in the history of natural gas development in China. The Sichuan Basin has already been and will be the main battlefield of shale gas exploration and development in China. In order to further promote the large-scale efficient development of shale gas in China, under the new situation of global COVID-19 spread and domestic "carbon peak and carbon neutrality" goal, this paper analyzes the progress and challenges of shale gas exploration and development in the Sichuan Basin from four aspects, including resource exploration, gas reservoir engineering, drilling and production engineering and industrial regulation, and puts forward countermeasures and suggestions for achieving large-scale efficient development of shale gas. And the following research results are obtained. First, the large-scale efficient development of shale gas in the Sichuan Basin has to take the sustainable and stable production of middle-shallow shale gas and the large-scale productivity construction of deep shale gas as the base. Second, compared with the shale gas exploration and development in the North America, the Sichuan Basin has its own characteristics in terms of geographical setting, geological condition, drilling and production technology and industrial regulation, which makes it difficult to copy the development mode of large scale, high density and continuous well deployment from the North America, so it is necessary to adopt the strategy of "high production with few wells". On the one hand, continue to apply the geology and engineering integration technology to carry out "integrated research, integrated design, integrated implementation and integrated iteration" in the whole life cycle of shale gas well; and on the other hand, carry out problem-oriented continuous researches from the aspects of geological evaluation, development policy, engineering technology and industrial regulation, so as to improve geological evaluation theory and technology, innovate gas reservoir engineering theory and method, research and develop engineering technology for cost reduction and efficiency improvement, improve shale gas industrial regulation, and form a new pattern of collaborative promotion of technical and non-technical elements. In conclusion, the research results provide important reference and guidance for the large-scale

efficient development of shale gas in the Sichuan Basin and even the whole country. 
**Number of references:** 41
**Main heading:** Gases
**Controlled terms:** Cost engineering - Cost reduction - Geology - Infill drilling - Iterative methods - Life cycle - Natural gas - Natural gas well production - Petroleum prospecting - Petroleum reservoir evaluation - Productivity - Shale gas
**Uncontrolled terms:** Deep - Efficient development - Exploration and development - Gas development - High production with few well - Large-scale development - Large-scales - Middle-shallow - Sichuan Basin - Sustainable and stable production
**Classification code:** 481.1 Geology - 511.1 Oil Field Production Operations - 512.1.2 Petroleum Deposits : Development Operations - 512.2 Natural Gas Deposits - 512.2.1 Natural Gas Fields - 522 Gas Fuels - 911 Cost and Value Engineering; Industrial Economics - 921.6 Numerical Methods
**DOI:** 10.3787/j.issn.1000-0976.2021.08.013
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 130. Research progress and development prospect of deep supercritical geothermal resources

**Accession number:** 20211710247380
**Title of translation:**
**Authors:** Xu, Tianfu (1); Wang, Yu (1); Feng, Guanhong (1)
**Author affiliation:** (1) Key Laboratory of Groundwater Resource and Environment of Ministry of Education, Jilin University, Jilin; 130021, China
**Corresponding author:** Feng, Guanhong(guanhong_feng@jlu.edu.cn)
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 3
**Issue date:** March 25, 2021
**Publication year:** 2021
**Pages:** 155-167
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Number of references:** 85
**Main heading:** Energy conservation
**Controlled terms:** Application programs - Emission control - Equations of state - Geothermal fields - High temperature applications - Rock drilling
**Uncontrolled terms:** Commercial development - Drilling and completion - Geothermal resources - Hydrothermal flow - Mechanical characteristics - Prospect - Research progress - Supercritical - Supercritical geothermal resource - Theoretical research
**Classification code:** 451.2 Air Pollution Control - 481.3.1 Geothermal Phenomena - 525.2 Energy Conservation - 615.1 Geothermal Energy - 723 Computer Software, Data Handling and Applications
**DOI:** 10.3787/j.issn.1000-0976.2021.03.019
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 131. Effect of N2/CO2 injection pressure on CH4 desorption in gas-bearing coal rock

**Accession number:** 20211710247357
**Title of translation:** N2/CO2
**Authors:** Li, Shugang (1, 2); Bai, Yang (1); Lin, Haifei (1, 2); Yan, Min (1, 2); Long, Hang (1); Guo, Doudou (1)

**Author affiliation:** (1) School of Safety Science and Engineering, Xi'an University of Science and Technology, Xi'an; 710054, China; (2) Engineering Research Center of West Mine Gas Intelligent Drainage and Utilization, Xi'an; 710054, China
**Corresponding author:** Lin, Haifei(lhaifei@163.com)
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 3
**Issue date:** March 25, 2021
**Publication year:** 2021
**Pages:** 80-89
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Number of references:** 31
**Main heading:** Methane
**Controlled terms:** Carbon dioxide - Coal - Coal bed methane - Coal deposits - Desorption - Gases - Monte Carlo methods - Oil well flooding
**Uncontrolled terms:** CH 4 - Co 2 injections - CO2 injection to promote CH4 desorption - Coal model containing adsorbed methane - Coal models - Desorption kinetics - GCMC method - Molecular simulations - N2 injection to promote CH4 desorption
**Classification code:** 503 Mines and Mining, Coal - 511.1 Oil Field Production Operations - 512.2 Natural Gas Deposits - 522 Gas Fuels - 524 Solid Fuels - 802.3 Chemical Operations - 804.1 Organic Compounds - 804.2 Inorganic Compounds - 922.2 Mathematical Statistics
**Numerical data indexing:** Pressure 2.00E+06Pa to 4.00E+06Pa, Pressure 3.00E+06Pa to 4.00E+06Pa
**DOI:** 10.3787/j.issn.1000-0976.2021.03.009
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 132. Integrated development strategy of natural gas and hydropower in Sichuan-Chongqing area

**Accession number:** 20212510530582
**Title of translation:**
**Authors:** Li, Baojun (1); Zhu, Liyang (1); Wang, Wenli (2); Xiong, Bo (1); Jiang, Long (3); Hu, Rongtao (4); Mei, Qi (3)
**Author affiliation:** (1) PetroChina Southwest Oil & Gasfield Company, Chengdu; 610051, China; (2) PetroChina Huabei Oilfield Company, Renqiu; 062552, China; (3) Natural Gas Economic Research Institute, PetroChina Southwest Oil & Gasfield Company, Chengdu; 610051, China; (4) Sichuan Company, China Huadian Corporation Ltd., Chengdu; 610094, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 5
**Issue date:** May 25, 2021
**Publication year:** 2021
**Pages:** 136-143
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Number of references:** 21
**Main heading:** Natural gas
**Controlled terms:** Construction equipment - Costs - Energy efficiency - Energy utilization - Gases - Hydroelectric power - Natural gas deposits - Proven reserves - Rivers

**Uncontrolled terms:** Electricity prices - Gas storage - Gas-fired - Gas-fired power - Natural gas and hydropower integration - Policy support - Power - Sichuan - Sichuan power export - Strategic cooperation - Strategic cooperation alliance - Two-part electricity price
**Classification code:** 405.1 Construction Equipment - 512.1.2 Petroleum Deposits : Development Operations - 512.2 Natural Gas Deposits - 522 Gas Fuels - 525.2 Energy Conservation - 525.3 Energy Utilization - 611.1 Hydroelectric Power Plants - 911 Cost and Value Engineering; Industrial Economics
**DOI:** 10.3787/j.issn.1000-0976.2021.05.015
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 133. Fault system in the intensely superimposed reworked zone of Middle Yangtze area and its formation mechanism: Fault characteristics of Dangyang synclinorium and its influence on shale gas preservation

**Accession number:** 20214311047288
**Title of translation:** :
**Authors:** He, Yong (1); Zhang, Dongtao (1); Li, Weimin (1); Zhang, Jiehui (1); Yao, Qiuchang (1); Zhang, Wenping (2); Niu, Weitao (2); Mei, Jue (1)
**Author affiliation:** (1) PetroChina Zhejiang Oilfield Company, Hangzhou; 311100, China; (2) Geological Research Institute, BGP Inc., CNPC, Zhuozhou; 072750, China
**Corresponding author:** Zhang, Dongtao(zhangdt85@petrochina.com.cn)
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 9
**Issue date:** September 25, 2021
**Publication year:** 2021
**Pages:** 1-11
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** The distribution laws and formation mechanisms of the fault system of Dangyang synclinorium in the intensely superimposed reworked zone of Middle Yangtze area have not been understood clearly, which restricts the exploration and development process of the Upper Ordovician Wufeng Formation-Lower Silurian Longmaxi Formation shale gas in this area. In order to clarify the distribution laws and formation mechanisms of the fault system in this area and reveal the difference in the influence of the fault of different genesis on the preservation condition of shale gas, this paper systematically analyzes the characteristics and formation mechanisms of the fault in the Xunjian slope block by using the foreland thrust theory and the Riedel shear model, based on the seismic data of this block. In addition, the influence of the fault system of Dangyang synclinorium on the preservation condition of Wufeng Formation-Longmaxi Formation shale gas is discussed. And the following research results are obtained. First, the fault system in the Xunjian slope block can be divided into three systems vertically(i.e., deep, medium and shallow) and three blocks areally. The main control faults, namely FA and FB fault zone, are in the initial and early development stage of strike slip fault. Second, under the action of the NEE compression and SE compression-torsion stress fields during Middle Yanshanian and the nearly EW left-lateral tension-torsion stress field during Late Yanshanian, three fault systems are formed in the study area, i.e., thrust structure system, compression-torsion structure system, and tension-torsion structure system. Third, the strong strike slip deformation reworking since the Yanshanian brings significant damage to the preservation condition of Longmaxi Formation shale gas in the late stage, but the thrust fault, the R'plane fault and the east section of FB fault have weak damage to the preservation condition of shale gas and are favorable for the preservation of shale gas. © 2021, Natural Gas Industry Journal Agency. All right reserved.
**Number of references:** 33
**Main heading:** Torsional stress
**Controlled terms:** Fault slips - Gases - Petroleum prospecting - Seismology - Shale gas - Strike-slip faults
**Uncontrolled terms:** Dangyang synclinorium - Distribution law - Fault system - Formation mechanism - Intensely reworked - Middle yangtze area - Preservation condition - Riedel shear - Shale gas preservation - Structure systems

**Classification code:** 484.1 Earthquake Measurements and Analysis - 512.1.2 Petroleum Deposits : Development Operations - 512.2 Natural Gas Deposits - 522 Gas Fuels
**DOI:** 10.3787/j.issn.1000-0976.2021.09.001
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 134. The inhibition effect of D-amino acid on the microbial corrosion of mixed bacteria

**Accession number:** 20214411102682
**Title of translation:** D-
**Authors:** Xu, Congmin (1); Wang, Wenyuan (1); Liu, Li (2); Song, Pengdi (1); Gao, Haoran (1); Chen, Yueqing (1)
**Author affiliation:** (1) School of Materials Science and Engineering, Xi'an Shiyou University, Xi'an; 710065, China; (2) The Sixth Natural Gas Plant, PetroChina Changqing Oilfield Company, Jingbian; 718500, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 2
**Issue date:** February 25, 2021
**Publication year:** 2021
**Pages:** 160-170
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** In order to better mitigate the hazards of microbial corrosion in the actual operating environment of oil and gas fields, this paper prepared mixed bacteria from sulfate reducing bacteria (SRB) and aerobic iron bacteria (IOB) cultured in the produced water of oil and gas field to explore the bactericidal enhancement effect and metal corrosion inhibition behavior of D-amino acid. The influence laws of D-tyrosine on the biofilm removal effects and bactericidal and corrosion inhibition behaviors of carbon steel in SRB+IOB medium were studied by means of weight loss experiment, electrochemical test and surface analysis. And the following research results were obtained. First, the highest corrosion inhibition rate of D-tyrosine + bactericide THPS to SRB and IOB is 73.07% and the number and depth of pitting pits are the smallest, indicating that its effect is obviously better than that added with single THPS. Second, after D-tyrosine and THPS are added, the content of phosphide and sulfide are the lowest, indicating that D-tyrosine has a significant biofilm decomposition and inhibition effect, and combined with THPS, it can kill the bacteria effectively so as to destroy the oxygen concentration difference environment and consequently mitigate the corrosion greatly. Third, the addition of D-tyrosine improves the corrosion inhibition effect and reduces the consumption of bactericide greatly. In conclusion, the research results can provide theoretical support and engineering practice guidance for microbial corrosion control under the actual working conditions of oil and gas fields. © 2021, Natural Gas Industry Journal Agency. All right reserved.
**Number of references:** 28
**Main heading:** Corrosion inhibitors
**Controlled terms:** Aerobic bacteria - Amino acids - Biofilms - Corrosive effects - Gas industry - Microbial corrosion - Oil fields - Pitting - Steel corrosion - Sulfur compounds - Surface analysis
**Uncontrolled terms:** Bactericidal enhancement effect - Biofilm removal - Corrosion behaviour - Corrosion inhibition - Corrosion inhibition rate - D-tyrosine - Enhancement effects - Inhibition rate - Microbial corrosion - Pittings - THPS
**Classification code:** 461 Bioengineering and Biology - 462.5 Biomaterials (including synthetics) - 512.1.1 Oil Fields - 522 Gas Fuels - 539.1 Metals Corrosion - 539.2.1 Protection Methods - 545.3 Steel - 803 Chemical Agents and Basic Industrial Chemicals - 804.1 Organic Compounds - 951 Materials Science
**Numerical data indexing:** Percentage 7.307E+01%
**DOI:** 10.3787/j.issn.1000-0976.2021.02.019
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 135. A method for predicting the build-up rate of "push-the-bit" rotary steering tool

**Accession number:** 20213210735468
**Title of translation:**
**Authors:** Huang, Wenjun (1); Wang, Ge (1); Gao, Deli (1)
**Author affiliation:** (1) Key Laboratory of Petroleum Engineering Education Ministry, China University of Petroleum , Beijing; 102249, China
**Corresponding author:** Gao, Deli(gaodeli_team@126.com)
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 7
**Issue date:** July 25, 2021
**Publication year:** 2021
**Pages:** 101-106
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** Push-the-bit rotary steering system can greatly improve the rate of penetration (ROP), hole conditions and hole extension length and represents the development direction of modern steering drilling technology. In order to accurately predict and evaluate the build-up rate of push-the-bit rotary steering tool, this paper establishes the drilling trajectory prediction model and the calculation methods of "limit build-up rate" and "corrected build-up rate" for push-the-bit rotary steering tool by comprehensively considering the interaction between biasing unit and sidewall and between bit and formation, the structure of steering bottom hole assembly (BHA) and other influential factors based on the mechanical model of the conventional steering BHA. Then, the influence mechanisms on the build-up rate are revealed from the aspects of "leverage effect", "pendulum effect" and "thrust effect". Finally, the influence laws of thrust force, weight on bit (WOB), hole deviation angle, bit and formation anisotropy on the build-up rate are analyzed. And the following research results are obtained. First, the build-up rate of steering BHA is the comprehensive result of various effects, among which "thrust effect" plays a dominant role and "leverage effect" and "pendulum effect" play a secondary role. Second, as for the push-the-bit rotary steering BHA, the proportion of "leverage effect" increases, the proportion of "thrust effect" decreases and the build-up rate declines with the increase of WOB. Third, the build-up rate is in a close relationship with BHA structural parameters, thrust force, bit properties and drilling parameters. In conclusion, the research results can provide an important theoretical basis for the prediction of build-up rate of "push-the-bit" rotary steering tool and the structural optimization design of BHA. 
**Number of references:** 22
**Main heading:** Bottom-hole assembly
**Controlled terms:** Boreholes - Forecasting - Infill drilling - Pendulums - Predictive analytics - Structural optimization
**Uncontrolled terms:** Development directions - Drilling parameters - Formation anisotropy - Influential factors - Rate of penetration - Structural optimization design - Structural parameter - Trajectory prediction
**Classification code:** 511.1 Oil Field Production Operations - 511.2 Oil Field Equipment - 921.5 Optimization Techniques
**DOI:** 10.3787/j.issn.1000-0976.2021.07.011
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 136. Propagation characteristics of Doppler ultrasonic wave in gas-liquid two-phase flow in an offshore deepwater riser

**Accession number:** 20213010678026
**Title of translation:**
**Authors:** Gu, Chunwei (1); Li, Qian (2); Ma, Rui (3); Lin, Yingsong (3); Li, Xiangfang (4); Li, Yiming (4); Zhang, Aixia (5); Li, Yingjie (5); Yin, Bangtang (3)
**Author affiliation:** (1) CNOOC China Limited, Beijing; 100010, China; (2) Exploration and Development Research Institute, PetroChina Southwest Oil & Gasfield Company, Chengdu; 610041, China; (3) School of Petroleum Engineering, China University of Petroleum-East China, Qingdao; 266580, China; (4) College of Petroleum

Engineering, China University of Petroleum, Beijing; 102249, China; (5) CNPC Offshore Engineering Co., Ltd., Beijing; 100028, China
**Corresponding author:** Li, Qian(liqian05@petrochina.com.cn)
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 6
**Issue date:** June 25, 2021
**Publication year:** 2021
**Pages:** 97-103
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** During offshore deepwater drilling, the strata with abnormal pressure are often encountered and gas invasion and overflow occur easily. If they cannot be detected and controlled in time, blowout may happen and even get out of control, which will cause considerable economic loss and irreparable casualties and may even damage the marine ecologic environment seriously. How to monitor overflow early during deepwater drilling is a global research hot, focus and difficulty at present. In order to provide theoretical guidance for the early monitoring of overflow in the riser during offshore deepwater drilling, this paper designed an experimental device for the early monitoring of gas invasion based on the propagation principle of Doppler ultrasonic wave. Then, the installation mode and angle of Doppler probe were optimized. Finally, the propagation of Doppler ultrasonic wave in the gas-liquid two-phase flow with a void fraction of 0-46% and a liquid flow velocity of 0-0.7 m/s was experimentally studied, and the change laws of Doppler ultrasonic wave with void fraction were revealed. And the following research results are obtained. First, when the void fraction changes, the signal voltage will jump up and down at different amplitudes and frequencies on the basis of initial curve. The signal voltage amplitude increases firstly and then decreases with the increase of void fraction. Second, when the increase amplitude of mean signal voltage caused by multiple reflection is greater than the attenuation degree of ultrasonic wave, the mean signal voltage increases. Otherwise, the signal voltage decreases. Third, the fitting curve of mean signal voltage scatters and void fraction under different flow velocities and void fractions during pump stopping and starting present a change law of quadratic function. In conclusion, void fraction can be quantitatively predicted based on the measured signal voltage, so as to provide guidance for the early monitoring of riser overflow and well kill operation during offshore deepwater drilling. 
**Number of references:** 22
**Main heading:** Two phase flow
**Controlled terms:** Curve fitting - Damage detection - Deepwater drilling - Flow velocity - Infill drilling - Liquids - Losses - Marine risers - Offshore oil well production - Oil field development - Ultrasonic waves - Void fraction
**Uncontrolled terms:** Abnormal pressure - Experimental devices - Gas - liquid two-phase flows - Liquid flow velocity - Multiple reflections - Propagation characteristics - Provide guidances - Quadratic function
**Classification code:** 511.1 Oil Field Production Operations - 511.2 Oil Field Equipment - 512.1.2 Petroleum Deposits : Development Operations - 631 Fluid Flow - 631.1 Fluid Flow, General - 753.1 Ultrasonic Waves - 911.2 Industrial Economics - 921.6 Numerical Methods - 951 Materials Science
**Numerical data indexing:** Percentage 0.00e+00% to 4.60e+01%, Velocity 0.00e+00m/s to 7.00e-01m/s
**DOI:** 10.3787/j.issn.1000-0976.2021.06.011
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 137. A new method for calculating shape factor and asymptotic solution of bottom hole pressure of complex-structure wells during the pseudo-steady flowing period

**Accession number:** 20213010678043
**Title of translation:**
**Authors:** Xu, Youjie (1); Liu, Qiguo (1); Li, Xiaoping (1); Yang, Sihan (1); Zhang, Kai (2); Tan, Xiaohua (1)
**Author affiliation:** (1) State Key Laboratory of Oil & Gas Reservoir Geology and Exploitation, Southwest Petroleum University, Chengdu; 610500, China; (2) Exploration and Development Research Institute, PetroChina Southwest Oil & Gasfield Company, Chengdu; 610041, China
**Corresponding author:** Liu, Qiguo(liuqg2002@163.com)

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**Abbreviated source title:** Natur. Gas Ind.
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**Issue date:** June 25, 2021
**Publication year:** 2021
**Pages:** 74-82
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** A practical and effective shape factor calculation method for the shape and position factor of oil and gas reservoirs (referred to as shape factor) is of great significance to calculate the asymptotic solution of bottom hole pressure and the productivity index in the pseudo-steady flowing period of complex-structure wells. For vertical wells in oil and gas reservoirs with different shapes of closed boundaries, the shape factor was recalculated on the basis of well test analysis curves (i.e. the re-lationship between pressure and pressure derivative curves), and then compared with the Dietz shape factor. Based on this, the asymptotic solution of bottom hole pressure of complex-structure wells during the pseudo-steady flowing period was deduced and verified, and the typical chart of Blasingame decline curves was plotted. And the following research results are obtained. First, the shape factor can be calculated reversely from the difference between dimensionless bottom hole pressure and its derivative of vertical wells during the pseudo-steady flowing period for oil and gas reservoirs with different shapes of closed boundaries. And its calculation result is quite close to the Dietz shape factor, which verifies the accuracy of this calculation method. Second, by calculating the difference between dimensionless bottom hole pressure and its derivative of complex-structure wells during the pseudo-steady flowing period, the asymptotic solution coefficient of bottom hole pressure (bDpss) of complex-structure wells during the pseudo-steady flowing period can be obtained and then the asymptotic solution of bottom hole pressure of complex-structure wells during the pseudo-steady flowing period can be worked out. Third, the relative error between the pseudo skin factor of highly deviated well calculated by the new method and the calculation result by Ozkan is less than 1%, which proves the accuracy of the new method. Fourth, for the conventional vertical wells in the oil and gas reservoirs with rectangle closed boundaries, the slope of the dimensionless production curve of Blasingame decline curve in the pseudo-steady flowing period is -1, and the larger the aspect ratio, the more obvious the linear flow characteristics in the late stage. Fifth, for the fractured vertical wells in the oil and gas reservoirs with rectangle closed boundaries, the larger the aspect ratio, the smaller the single-well control area, the greater the bDpss, the more obvious the linear flow characteristics in the late stage and the higher the position of the Blasingame decline curve in the pseudo-steady flowing period when the outer boundary length is constant. When the single-well control area is the same, the greater the dimensionless fracture flow conductivity, the smaller the bDpss and the higher the position of the Blasingame decline curve in the pseudo-steady flowing period. In conclusion, the asymptotic solution of bottom hole pressure in the pseudo steady flowing period of any complex-structure well can be obtained quickly and accurately by this new method, which provides an effective and convenient method for plotting the typical chart of Blasingame decline curve of complex-structure wells. 
**Number of references:** 21
**Main heading:** Flowing wells
**Controlled terms:** Aspect ratio - Bottom hole pressure - Gases - Oil well production - Oil well testing - Oil wells - Petroleum reservoir engineering - Petroleum reservoirs
**Uncontrolled terms:** Asymptotic solutions - Calculation results - Complex structure well - Highly deviated wells - Oil and gas reservoir - Pressure derivatives - Productivity index - Well-test analysis
**Classification code:** 511.1 Oil Field Production Operations - 512 Petroleum and Related Deposits
**Numerical data indexing:** Percentage 1.00e+00%
**DOI:** 10.3787/j.issn.1000-0976.2021.06.008
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 138. Discovery of Bozhong 13-2 Archean large monoblock volatile buried hill oilfield and its oil and gas exploration significance

**Accession number:** 20211210117054
**Title of translation:** 13-2
**Authors:** Li, Huiyong (1); Niu, Chengmin (1); Xu, Peng (1); Liu, Qingshun (1); Zhang, Xin (1); Cui, Haizhong (1)

**Author affiliation:** (1) CNOOC China Limited Tianjin Company, Tianjin; 300450, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 2
**Issue date:** February 25, 2021
**Publication year:** 2021
**Pages:** 19-26
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** The hydrocarbon accumulation pattern of the Mesozoic covered Archean buried hill in the Bohai Oilfield was not clarified before, which restricts the oil and gas exploration progress in this area. In recent years, reservoir development modes and reservoir prediction technologies have been researched after the structural evolution and stratigraphic distribution characteristics of the buried hill in the Bozhong sag were investigated based on new 3D seismic data and a large number of cores and logging data of newly drilling wells. Then, the hydrocarbon accumulation pattern of covered type Archean buried hill was analyzed. Finally, this pattern was applied to guide the oil and gas exploration deployment in Bozhong 13-2 structure, and a significant discovery of Bozhong 13-2 large monoblock volatile buried hill oilfield was realized. And the following research results were obtained. First, the structure in this area mainly experienced multi-period tectonic movements, such as Indosinian, Yanshanian and Himalayan, and it is characterized by compression and thrusting to form a hill during Indosinian-early Yanshanian, extension and inversion transformation during middle Yanshanian, and burial and finalization during Himalayan, forming Bozhong 13-2 Mesozoic covered Archean large buried hill trap. Second, under the effect of Mesozoic cover and the control of multi-stage stress superposition, the reservoir development in this area has the distribution characteristics of "different vertical top, internal lateral continuity". Third, the fracture prediction technology based on smooth reflection strength filter is developed. And by means of this technology, multi-scale fractured reservoirs inside buried hills can be predicted effectively. Fourth, the hydrocarbon accumulation pattern of "overpressure injection-relay migration" for covered type buried hills is established, which provides a basis for long-distance migration and large-scale accumulation of oil and gas in covered type buried hills. In conclusion, these understandings guide the discovery of Bozhong 13-2 Oilfield, achieve a breakthrough in the oil and exploration of Mesozoic covered buried hill in the Bohai Oilfield and can be used as the reference for the oil and gas exploration in the similar covered type buried hills of the Bohai Bay Basin and other areas. 
**Number of references:** 26
**Main heading:** Petroleum prospecting
**Controlled terms:** Gases - Geological surveys - Hydrocarbons - Oil fields - Oil well logging - Seismology - Stratigraphy
**Uncontrolled terms:** Distribution characteristics - Hydrocarbon accumulation - Inversion transformation - Oil and gas exploration - Reservoir development - Reservoir prediction - Significant discovery - Stress superpositions
**Classification code:** 481.1 Geology - 484.1 Earthquake Measurements and Analysis - 512.1.1 Oil Fields - 512.1.2 Petroleum Deposits : Development Operations - 804.1 Organic Compounds
**DOI:** 10.3787/j.issn.1000-0976.2021.02.003
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 139. DTS based hydraulic fracture identification and production profile interpretation method of horizontal well

**Accession number:** 20212510530413
**Title of translation:** DTS
**Authors:** Li, Haitao (1); Luo, Hongwen (1); Xiang, Yuxing (1); Li, Ying (1); Jiang, Beibei (1); Cui, Xiaojiang (1); Gao, Sujuan (1); Zou, Shunliang (2); Xin, Ye (3)
**Author affiliation:** (1) State Key Laboratory of Oil and Gas Reservoir Geology and Exploitation, Southwest Petroleum University, Chengdu; 610500, China; (2) Shale Gas Exploitation Technology Service company of Sinopec Jianghan Petroleum Engineering Company Limited, Wuhan; 430000, China; (3) CNOOC Energy Technology & Services Limited, Tianjin; 300450, China
**Corresponding author:** Luo, Hongwen(rojielhw@163.com)

**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 5
**Issue date:** May 25, 2021
**Publication year:** 2021
**Pages:** 66-75
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** In order to accurately evaluate the fracturing stimulation effect of horizontal wells in shale gas reservoirs, it is suggested to establish a model to predict the temperature distribution in the wellbore of horizontal well and an inversion model of DTS data by using MCMC algorithm, and optimize the production profile interpretation process. In this paper, the characteristics of temperature profile of fractured horizontal wells in shale gas reservoirs were analyzed and the main factors affecting the temperature profile were figured out. Finally, the newly established inversion model was applied to the production profile interpretation of one case well in a certain shale gas reservoir. And the following research results were obtained. First, the temperature profile of fractured horizontal wells is in the shape of irregular "saw tooth", and each "saw tooth" corresponds to an effective hydraulic fracture with inflow fluid. Second, the longer the fracture is, the greater the wellbore temperature drop at the corresponding fracture location is, and the gas flow rate in the fracture is positively correlated with the temperature drop. Third, from the perspective of influence degree, the factors influencing the temperature profile of fractured horizontal wells in shale gas reservoirs are ranked from the strong to the weak as follows: half fracture length, gas flow velocity, permeability of stimulated area, wellbore diameter, fracture conductivity, horizontal dip angle and comprehensive thermal conductivity, among which, the first three are main influential factors. Fourth, the MCMC inversion method is applied to invert the DST temperature data of the case well. The temperature profile predicted in the model is better accordant with the measured DTS profile, and the absolute error of the predicted temperature at different levels of effective hydraulic fractures is less than 0.02. The interpreted gas flow rate of each fracturing stage is closer to the field measurement, and the deviation of the maximum gas flow rate of single fracturing stage is only 180.35 m3/d. The absolute error between single-well gas production rate and gas production rate measured at the wellhead is less than 3 m3/d, which proves the reliability of this newly developed inversion model. © 2021, Natural Gas Industry Journal Agency. All right reserved.
**Number of references:** 31
**Main heading:** Horizontal wells
**Controlled terms:** Boreholes - Drops - Flow of gases - Flow rate - Flow velocity - Fracture - Gas industry - Gas permeability - Gases - Hydraulic fracturing - Oil field equipment - Petroleum reservoir engineering - Petroleum reservoirs - Shale gas - Temperature control - Thermal conductivity of gases - Well stimulation - Wellheads
**Uncontrolled terms:** Fracture conductivities - Fracture identification - Fractured horizontal wells - Interpretation methods - Production profiles - Shale gas reservoirs - Temperature profiles - Wellbore temperature
**Classification code:** 511.2 Oil Field Equipment - 512.1.1 Oil Fields - 512.1.2 Petroleum Deposits : Development Operations - 522 Gas Fuels - 631 Fluid Flow - 631.1.2 Gas Dynamics - 641.1 Thermodynamics - 731.3 Specific Variables Control - 931.2 Physical Properties of Gases, Liquids and Solids - 951 Materials Science
**DOI:** 10.3787/j.issn.1000-0976.2021.05.007
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 140. Geology-engineering integration key technologies for ten billion cubic meters of shale gas productivity construction in the Southern Sichuan Basin

**Accession number:** 20210609884072
**Title of translation:**
**Authors:** Chen, Gengsheng (1); Wu, Jianfa (2); Liu, Yong (1); Huang, Haoyong (2); Zhao, Shengxian (2); Chang, Cheng (2); Zhong, Chengxu (2)
**Author affiliation:** (1) PetroChina Southwest Oil & Gasfield Company, Chengdu; 610051, China; (2) Shale Gas Research Institute, PetroChina Southwest Oil & Gasfield Company, Chengdu; 610051, China
**Corresponding author:** Wu, Jianfa(wu_jianfa@petrochina.com.cn)
**Source title:** Natural Gas Industry

**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
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**Issue date:** January 25, 2021
**Publication year:** 2021
**Pages:** 72-82
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** There are abundant shale gas resources in the Lower Silurian Longmaxi Formation of the southern Sichuan Basin, but its geological and engineering conditions are complex, which brings severe challenges to the scale benefit development of shale gas in this area. In order to solve the problems in shale gas development in the southern Sichuan Basin, such as "difficult deployment design, difficult to improve the drilling rate of high-quality reservoirs, difficult to form complex fracture network and difficult to increase single-well production and estimated ultimate recovery (EUR)", this paper developed a high-yield well cultivation method based on geology-engineering integration suitable for shale gas in this area by systematically analyzing and summarizing the shale gas exploration and development achievements in the last ten years. In addition, this method was tested on site and popularized for further application. And the following research results were obtained. First, four key technologies (including three-dimensional geological modeling, three-dimensional geomechanical modeling, complex fracture network simulation and numerical productivity simulation) provide important decision-making basis and guidance for the scheme design, field implementation and real-time adjustment in the whole life cycle of shale gas wells and effectively improve the single-well production and EUR of shale gas. Second, the implementation of the high-yield well cultivation method based on geology-engineering integration can greatly improve the single-well production of shale gas in Changning-Weiyuan National Shale Gas Demonstration Area. The average daily well testing production in Changning Block is increased from 10.9×104 m3 to 26.3×104 m3, and the maximum value reaches 62×104 m3. The average daily well testing production in Weiyuan Block is increased from 11.6×104 m3 to 23.9×104 m3, and the maximum value reaches 71×104 m3. Third, the popularization and application of the high-yield well cultivation method based on geology-engineering integration can realize the replication of high-yield wells. As a result, several high-yield wells with EUR greater than 1.5×108 m3, some of which even exceed 2×108 m3 have been cultivated. And the average EUR of four deep shale gas wells in Luzhou Block is up to 1.98×108 m3.In conclusion, the high-yield well cultivation method based on geology-engineering integration is an effective measure to deal with the difficulties in the large-scale benefit development of shale gas, and it can provide reference for the scale benefit development of unconventional oil and gas reservoirs at home and abroad. © 2021, Natural Gas Industry Journal Agency. All right reserved.
**Number of references:** 19
**Main heading:** Well testing
**Controlled terms:** Complex networks - Decision making - Energy resources - Gas industry - Gases - Geological surveys - Geology - Integration - Life cycle - Natural gas well production - Natural gas wells - Oil field development - Oil wells - Petroleum prospecting - Petroleum reservoir engineering - Petroleum reservoirs - Productivity - Shale gas
**Uncontrolled terms:** Billion cubic meters - Estimated ultimate recoveries - Field implementation - High quality reservoir - Productivity simulation - Single well production - Three-dimensional geological modeling - Unconventional oil and gas
**Classification code:** 481.1 Geology - 512 Petroleum and Related Deposits - 522 Gas Fuels - 525.1 Energy Resources and Renewable Energy Issues - 722 Computer Systems and Equipment - 912.2 Management - 921.2 Calculus
**DOI:** 10.3787/j.issn.1000-0976.2021.01.006
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 141. Numerical simulation on three-dimensional acid fracturing of deep fractured carbonate oil and gas reservoirs

**Accession number:** 20212010375893
**Title of translation:**
**Authors:** Ren, Jichuan (1, 2); Guo, Jianchun (1); Gou, Bo (1); Wang, Shibin (1); Liu, Zhuang (1)

**Author affiliation:** (1) State Key Laboratory of Oil & Gas Reservoir Geology and Exploitation//Southwest Petroleum University, Chengdu; Sichuan; 610500, China; (2) Post-Doctoral Research Center, Southwest Petroleum University, Chengdu; Sichuan; 610500, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
**Issue:** 4
**Issue date:** April 25, 2021
**Publication year:** 2021
**Pages:** 61-71
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** To stimulate the reservoirs of deep fractured carbonate oil and gas reservoirs effectively, we established a multi-field coupling acid fracturing model considering hydraulic fracture propagation, acid leak-off through complex media and heat conduction in the process of acid fracturing comprehensively based on the technical concept of three-dimensional acid fracturing, combined with the characteristics of fractured carbonate reservoirs. Then, numerical simulation research was carried out on acid-etched natural fractures and hydraulic fractures. On this basis, the stimulation volume and dimensionless productivity index of the "acid-etched fracture system" induced by three-dimensional acid fracturing technology were analyzed, and the main factors controlling the effect of three-dimensional acid fracturing were clarified. And the following research results were obtained. First, the matrix permeability and the initial flow capacity of natural fractures are the main factors influencing the stimulation volume of "acid-etched fracture system" after three-dimensional acid fracturing. In the case of lower matrix permeability (less than or equal to 1.0 mD) and wide natural fractures (greater than or equal to 150 μm), larger stimulation volume can be obtained by using the three-dimensional acid fracturing. Second, the greater the acid injection volume is, the larger the stimulation volume is and the higher the dimensionless productivity index is, but the increase of the latter two parameters decreases gradually. Third, in the case with a matrix permeability of 0.1 mD and natural fracture width of 250 μm, the incremental stimulation volume quickly drops below 10 m3/m3, while the incremental dimensionless productivity index tends to be stable after the acid injection volume exceeds 600 m3. Fourth, at the same matrix permeability, the larger the natural fracture width is, the higher the dimensionless productivity index is. And when the fracture width and density are the same, the lower the matrix permeability is, the higher the dimensionless productivity index is. Fifth, creating the "acid-etched fracture system" by means of the three-dimensional acid fracturing technology is more effective in improving the productivity of oil and gas wells in fractured low-permeability carbonate reservoirs. Sixth, to obtain a better stimulation effect of natural fractures and hydraulic fractures simultaneously, it is suggested that acid injection volume be increased appropriately in the process of three-dimensional acid fracturing. 
**Number of references:** 27
**Main heading:** Fracture
**Controlled terms:** Carbonation - Heat conduction - Hydraulic fracturing - Leakage (fluid) - Low permeability reservoirs - Natural gas well production - Numerical models - Petroleum industry - Petroleum reservoir engineering - Productivity
**Uncontrolled terms:** Dimensionless productivity index - Fractured carbonate reservoirs - Fractured carbonates - Hydraulic fracture propagation - Multi-field coupling - Numerical simulation research - Oil and gas reservoir - Simulation on three-dimensional
**Classification code:** 512 Petroleum and Related Deposits - 641.2 Heat Transfer - 802.2 Chemical Reactions - 921 Mathematics - 951 Materials Science
**Numerical data indexing:** Size 1.50e-04m, Size 2.50e-04m, Volume 6.00e+02m3
**DOI:** 10.3787/j.issn.1000-0976.2021.04.007
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 142. New cognition on pore structure characteristics of Permian marine shale in the Lower Yangtze Region and its implications for shale gas exploration

**Accession number:** 20213210735469
**Title of translation:**

**Authors:** Zhu, Wenbo (1, 2, 3); Zhang, Xunhua (2); Zhou, Daorong (3); Fang, Chaogang (3); Li, Jianqing (3); Huang, Zhengqing (3)
**Author affiliation:** (1) College of Marine Geosciences, Ocean University of China, Qingdao; 266100, China; (2) Qingdao Institute of Marine Geology, China Geological Survey, Qingdao; 266071, China; (3) Nanjing Geological Survey Center, China Geological Survey, Nanjing; 210016, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
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**Issue:** 7
**Issue date:** July 25, 2021
**Publication year:** 2021
**Pages:** 41-55
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** Shale of the Middle-Upper Permian Dalong Formation and Gufeng Formation in the Lower Yangtze region is characterized by large thickness, high total organic carbon (TOC), wide distribution and moderate organic thermal evolution degree, so it may be the next important field of shale gas exploration. In order to point out the target and direction of shale gas exploration and development in this region, this paper selects the Dalong Formation and Gufeng Formation shale in the Xuanjing area of Lower Yangtze as the research object to quantitatively describe the development characteristics of shale pores of different scales by means of scanning electron microscopy (SEM), high pressure mercury injection, CO2 and N2 adsorption. Then, the fractal dimension of sample pores is calculated by using the FHH (Frenkel-Halsey-Hill) model. Finally, combined with TOC and mineral compositions, the relationship between pore structure and fractal dimension is discussed. And the following research results are obtained. First, dominant lithofacies of Dalong Formation are argillaceous-rich siliceous shale and argillaceous-rich/siliceous mixed shale, which has smaller specific surface area and pore volume, larger average pore diameter. The pore development is mainly controlled by clay mineral content. Dominant lithofacies of Gufeng Formation is siliceous shale, which has a larger specific surface area and pore volume, and smaller average pore diameter. The pore development is controlled by organic matter and brittle mineral content. Second, the influencing factors of fractal dimension can be attributed to the controlling factors of micropore development. The fractal dimension D1 of Dalong Formation ranges from 2.451 5 to 2.551 3 (average 2.522 7), and D2 ranges from 2.581 7 to 2.657 8 (average 2.624 6). The fractal dimension D1 of Gufeng Formation ranges from 2.581 7 to 2.657 8 (average 2.624 6), and D2 ranges from 2.722 7 to 2.871 (average 2.813). Gufeng Formation shale presents the characteristics of more complex pore structure. Third, the fractal dimension D1 is more sensitive to specific surface area, pore development and mineral composition, while D2 is more effective in characterizing the average pore diameter. In conclusion, Dalong Formation shale with high D1 and D2 and Gufeng Formation shale with low D1 and high D2 can be taken as the favorable exploration targets of Permian marine shale gas in the Lower Yangtze region, and the regional overpressure zones (belts) with weaker structural deformation in hydrocarbon rich sags will be the favorable shale gas exploration targets in this area. 
**Number of references:** 33
**Main heading:** Fractal dimension
**Controlled terms:** Clay minerals - Gases - Geological surveys - Organic carbon - Petroleum prospecting - Pore structure - Scanning electron microscopy - Shale gas - Specific surface area
**Uncontrolled terms:** Controlling factors - Development characteristics - Exploration targets - High pressure mercury - Mineral composition - Structural deformation - Structure characteristic - Total Organic Carbon
**Classification code:** 481.1 Geology - 482.2 Minerals - 512.1.2 Petroleum Deposits : Development Operations - 522 Gas Fuels - 804.1 Organic Compounds - 921 Mathematics - 931.2 Physical Properties of Gases, Liquids and Solids
**DOI:** 10.3787/j.issn.1000-0976.2021.07.005
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 143. "Multi-series and quasi-continuous" tight gas accumulation pattern and giant gas field exploration practice in Linxing area

**Accession number:** 20211710247356
**Title of translation:** ""

**Authors:** Du, Jia (1); Zhu, Guanghui (1); Wu, Luofei (1); Zhang, Zhenghe (1); Gao, Jixian (1); Yu, Yujie (1); Ma, Zunjing (1); Zhang, Ming (1)
**Author affiliation:** (1) China United Coalbed Mehante Co., Ltd, Beijing; 100011, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
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**Issue:** 3
**Issue date:** March 25, 2021
**Publication year:** 2021
**Pages:** 58-71
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** Linxing area is located in Jinxi flexure zone of the eastern Ordos Basin, where the first high-yield gas well was explored in the Carboniferous-Permian at the end of 2013 and since then several high-yield gas wells have been discovered. For the purpose of providing support for the evaluation of the Upper Paleozoic natural gas resources in Linxing area, studies and exploration and development practices were conducted on the hydrocarbon accumulation conditions, enrichment laws and hydrocarbon accumulation patterns of tight sandstone gas in this area by means of geological setting investigation, structural evolution dissection, drilling geological analysis and abundant core sampling and experiments. And at the end of 2020, Linxing giant gas field with hundreds of billions of reserves was discovered. The following research results were obtained. First, the Upper Paleozoic source rocks in Linxing area are mainly coal-bearing series deposited in a transitional environment, and they are characterized by high organic abundance, great thickness and a large distribution area. Second, the reservoir is dominated by water or underwater distributary channel deposits that swing frequently and migrate back and forth. Sand bodies are superimposed vertically and connected areally. Secondary dissolution pores are developed. Argillaceous cap rocks are distributed widely in vertical and horizontal directions. Third, the Upper Paleozoic reservoirs were generally densificated in the period of Middle Jurassic. A large number of coal-measure source rocks of Upper Carboniferous Benxi Formation and Lower Permian Taiyuan Formation began to expel hydrocarbon in the Late Jurassic. After hydrocarbon was accumulated and enriched in the reservoirs inside the source rocks, it migrated gradually to the tight sandstone of Middle Permian Lower Shihezi Formation near the source rocks. The top was under the barrier of the regional major cap rocks in the middle of Shihezi Formation. In this way, an intra-source and near-source hydrocarbon accumulation system was formed. Fourth, the Zijinshan Mountain invaded into the Upper Paleozoic in the Early Cretaceous to form a large number of through fault systems. As a result, the regional cap rock in the middle of Shihezi Formation was destroyed, and intra-source and near-source natural gas migrated to Middle Permian Upper Shihezi Formation and Upper Permian Shiqianfeng Formation along faults to form a far-source hydrocarbon accumulation system. Fifth, the effective configuration of source rock-reservoir-cap rock assemblage lays the foundation for the formation of Linxing giant gas field. In conclusion, Linxing gas field has sufficient gas source conditions, "sandwich" lithology combination of quality sandstone-mudstone interbed and good fault and fracture system, which jointly form the "multi-series and quasi-continuous" tight gas accumulation pattern. These research results provide a practical way for CNOOC to realize a breakthrough in onshore oil and gas reserves and production. 
**Number of references:** 36
**Main heading:** Proven reserves
**Controlled terms:** Coal deposits - Energy resources - Faulting - Gas industry - Gases - Hydrocarbons - Lithology - Metamorphic rocks - Natural gas - Natural gas wells - Reserves to production ratio - Sandstone - Tight gas
**Uncontrolled terms:** Coal-bearing series - Exploration and development - Hydrocarbon accumulation - Natural gas resources - Reservoir-caprock assemblage - Structural evolution - Transitional environments - Underwater distributary channels
**Classification code:** 481.1 Geology - 482.2 Minerals - 484.1 Earthquake Measurements and Analysis - 503 Mines and Mining, Coal - 512 Petroleum and Related Deposits - 522 Gas Fuels - 525.1 Energy Resources and Renewable Energy Issues - 804.1 Organic Compounds
**DOI:** 10.3787/j.issn.1000-0976.2021.03.007
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village

## 144. Cleaning effect of a drill pipe's axial movement on cuttings bed in horizontal well sections

**Accession number:** 20213010678032
**Title of translation:**
**Authors:** Sun, Xiaofeng (1); Mao, Ning (1); Ju, Guoshuai (1); Hu, Qiaobo (1); Sun, Minghao (1); Yu, Furui (1)
**Author affiliation:** (1) College of Petroleum Engineering, Northeast Petroleum University, Daqing; 163318, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
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**Issue:** 6
**Issue date:** June 25, 2021
**Publication year:** 2021
**Pages:** 89-96
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** In order to study the influences of back reaming or short tripping on the cuttings transportation laws in horizontal hole sections and to guide the short tripping operation in the field and the evaluation of hole cleanliness during short tripping, this paper studies the damage mechanisms of cuttings bed caused by drill pipe tripping out speed, drilling fluid viscosity and other parameters using the CFD numerical simulation method, combined with the Euler two-fluid model. And the following research results are obtained. First, when the tripping out speed of a drill pipe is between 0.10 m/s and 0.25 m/s, axial movement only destroys the original morphology of cuttings bed and redistributes the cuttings to disperse along the axial direction, but doesn't improve the hole cleaning efficiency. Second, when the tripping out speed is greater than 0.25 m/s, the reverse flow erosion of drilling fluid reaccumulates the cuttings into a higher mound-shaped cuttings bed, which may influence the retripping and increase the risk of pipe sticking. Third, when the drilling fluid viscosity is lower than 30 mPa•s, the cuttings transportation in the annulus is dominated by the drag of the drill pipe. Fourth, when the drilling fluid viscosity is higher than 30 mPa•s, the cuttings transportation in the annulus is dominated by the suction pressure. Fifth, when the drilling fluid viscosity is fixed, if the axial movement velocity of the drill pipe is not set reasonably, the pressure fluctuation in the well will be increased and correspondingly the risks of well kick and overflow will be greater. Therefore, during the tripping operation in the field, the tripping out speed shall be kept between 0.25 m/s and 0.75 m/s when the drilling fluid viscosity in the hole is lower than 30 mPa•s, and between 0.10 m/s and 0.25 m/s when the drilling fluid viscosity is higher than 30 mPa•s. 
**Number of references:** 33
**Main heading:** Infill drilling
**Controlled terms:** Boreholes - Cleaning - Computational fluid dynamics - Drill pipe - Drilling fluids - Drills - Horizontal drilling - Horizontal wells - Numerical methods - Oil well drilling equipment - Two phase flow - Viscosity
**Uncontrolled terms:** Axial direction - CFD numerical simulations - Damage mechanism - Pressure fluctuation - Research results - Suction pressures - Tripping operation - Two fluid model
**Classification code:** 511.1 Oil Field Production Operations - 511.2 Oil Field Equipment - 512.1.1 Oil Fields - 603.2 Machine Tool Accessories - 631.1 Fluid Flow, General - 723.5 Computer Applications - 802.3 Chemical Operations - 921.6 Numerical Methods
**Numerical data indexing:** Velocity 1.00e-01m/s to 2.50e-01m/s, Velocity 2.50e-01m/s, Velocity 2.50e-01m/s to 7.50e-01m/s
**DOI:** 10.3787/j.issn.1000-0976.2021.06.010
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 145. Development and utilization prospect of the geothermal resources in the buried hills of the Xiong'an New Area and its periphery

**Accession number:** 20213210735557
**Title of translation:**
**Authors:** Luo, Ning (1); Zhang, Jun (2); Li, Jianmin (2); Xin, Shouliang (3)

**Author affiliation:** (1) PetroChina Huabei Oilfield Company, Renqiu; 062552, China; (2) Hebei Xiong'an Huayou Clean Energy Co., Ltd., Renqiu; 062552, China; (3) Exploration and Development Research Institute, PetroChina Huabei Oilfield Company, Renqiu; 062552, China
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**Pages:** 160-171
**Language:** Chinese
**ISSN:** 10000976
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**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Number of references:** 21
**Main heading:** Geothermal fields
**Controlled terms:** Geothermal wells
**Uncontrolled terms:** Buried hill - Closed production and reinjection - Collaborative development - Development and utilizations - Geothermal power generation - Geothermal reservoir - Geothermal resources - Reinjection - Resource extent - Xiong'an new area
**Classification code:** 481.3.1 Geothermal Phenomena - 615.1 Geothermal Energy
**Numerical data indexing:** Size 0.00E00m
**DOI:** 10.3787/j.issn.1000-0976.2021.07.018
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 146. Unconventional natural gas accumulation system

**Accession number:** 20213910945268
**Title of translation:**
**Authors:** Jin, Zhijun (1, 2); Zhang, Jinchuan (3, 4); Tang, Xuan (3, 4)
**Author affiliation:** (1) Institute of Energy, Peking University, Beijing; 100091, China; (2) State Key Laboratory of Shale Oil & Gas Enrichment Mechanism and Effective Development, Sinopec Exploration and Production Research Institute, Beijing; 102206, China; (3) School of Energy and Resource, China University of Geosciences, Beijing; 100083, China; (4) Key Laboratory of Shale Gas Resource Strategic Evaluation, Ministry of Natural Resources, Beijing; 100083, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
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**Publication year:** 2021
**Pages:** 58-68
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** Different from the conventional, unconventional natural gas accumulations have obvious particularity in reservoir forming conditions, enrichment mechanism, distribution modes, prediction method and exploration technology. Analyzing the reservoir forming process and main controlling factors of unconventional natural gas accumulations under guide of the hydrocarbon accumulation system theory is of great significance for unconventional natural gas reservoir evaluation and prediction. Based on the reservoir forming mechanism and distribution mode, the unconventional natural gas accumulation systems are divided into six types, including shale gas, coalbed methane, tight carbonate gas, tight sandstone gas, water-soluble gas and gas hydrate. According to the concept of "element-function-structure" in the hydrocarbon accumulation system theory and the relationship of "gas source rock-migration system-accumulations distribution", the unconventional gas accumulation system is divided into six "source-location" types. The characteristics of the other five types of unconventional gas accumulation systems except gas hydrate are analyzed. The following results were obtained. (1) Shale gas, coalbed methane and tight carbonate gas belong to an

intra-source type unconventional gas accumulation system, characterized by intense gas supply capacity, the lack of either a transport system or secondary migration, integration of source, reservoir and caprock, in-situ accumulation, and so on; (2) Tight sandstone gas and water-soluble gas belong to a source marginal type unconventional gas accumulation system, characterized by diverse gas origin, near source accumulation in adjacent layers of source rock, internal migration within reservoirs, and so on. (3) Basin tectonic evolution, sedimentary environment and late tectonic events control the types of unconventional gas accumulation systems: The Paleozoic marine sediments in South China are conducive to the formation of shale gas and tight carbonate gas accumulation systems; The marine-continental transitional facies deposits of Upper Paleozoic distributed in the South and North China are conducive to the development of coalbed methane, shale gas and tight sandstone gas accumulation systems; In the Middle and East China, Mesozoic-Cenozoic deep-water continental deposits are more conducive to the deep tight sandstone gas and shale gas accumulation systems, while shallow water continental basins are more conducive to the formation of coalbed methane, tight sandstone gas and shale gas accumulation systems. Water-soluble gas is widely found in the Cenozoic shallow-buried areas rich in organic matter or high-pressure reservoirs adjacent to gas source rocks. 
**Number of references:** 40
**Main heading:** Coal deposits
**Controlled terms:** Carbonation - Coal bed methane - Firedamp - Forecasting - Gas hydrates - Methanation - Methane - Natural gas - Petroleum reservoirs - Sandstone - Sedimentology - Sediments - System theory
**Uncontrolled terms:** Aggregation mechanism - Controlling factors - Distribution modes - Gas accumulation - Gas accumulation system - Major controling factor - Reservoir forming characteristic - Sedimentary facies - Source-location structure - Sources location - Unconventional natural gas
**Classification code:** 481.1 Geology - 482.2 Minerals - 483 Soil Mechanics and Foundations - 503 Mines and Mining, Coal - 512.1.1 Oil Fields - 512.2 Natural Gas Deposits - 522 Gas Fuels - 802.2 Chemical Reactions - 804.1 Organic Compounds - 961 Systems Science
**DOI:** 10.3787/j.issn.1000-0976.2021.08.006
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 147. Natural gas exploration progress of Sinopec during the 13th Five-Year Plan and prospect forecast during the 14th Five-Year Plan

**Accession number:** 20213910945309
**Title of translation:** ""
**Authors:** Guo, Xusheng (1); Cai, Xunyu (1); Liu, Jinlian (1); Liu, Chaoying (2); Cheng, Zhe (2); Gao, Bo (2); Shi, Lei (2)
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**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
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**Publication year:** 2021
**Pages:** 12-22
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** Since the 13th Five-Year Plan, Sinopec has been thoroughly carrying out the new energy security strategy of "four revolutions and one cooperation" and the spirit of the important instruction of "powerful promotion of petroleum exploration and development". Focusing on strategic breakthrough and large-scale reserve increase, the petroleum exploration enhances the theoretical and technological innovation and highlights high-quality exploration battles, so that a series of important petroleum exploration achievements have been gained. In order to accelerate and promote the development of Sinopec's natural gas business, this paper forecasts Sinopec's exploration direction and development potential of natural gas in the future after comprehensively sorting out the achievements and theoretical and technological progresses of natural gas exploration since the 13th Five-Year Plan. And the following research results are obtained. First, since the 13th Five-Year plan, the Sinopec has been persisting in the strategic deployment of "balancing marine and continental facies and focusing conventional and unconventional resources". According

to the idea of "extending marine conventional gas, strengthening marine shale gas and optimizing continental tight gas", Sinopec innovatively develops the hydrocarbon accumulation theory of marine shale gas in southern China, marine carbonate rock in central-western China and tight clastic rock in central-western China. Second, by virtue of researches, a 3D seismic exploration technology with reservoir identification and description as the basis and sweet spot prediction as the core is developed, and several support equipment and tools are integrated, such as deep and ultra deep drilling and completion, acid fracturing testing, long horizontal well fracturing and high power electric fracturing, and drillable composite bridge plug. Third, a series of natural gas exploration achievements are obtained in three major fields of marine shale, marine carbonate rock and continental tight clastic rock, and new proved natural gas reserves of 1.006 8×1012 m3 is achieved, which provides Sinopec with high-quality resource guarantee for the fast increase of natural gas production. Fourth, looking forward, there are abundant natural gas resource bases in Sinopec's exploration areas, and the main development directions of its natural gas exploration are marine carbonate rock in central-western China, tight clastic rock and shale in central-western China, marine deep clastic rock, and deep clastic rock and igneous rock in the mature areas of eastern China. In conclusion, Sinopec's new proved natural gas reserves during the 14th Five-Year Plan is predicted to be 1.16×1012-1.36×1012 m3, which can provide a solid resource base for the great development of natural gas in China. 
**Number of references:** 25
**Main heading:** Forecasting
**Controlled terms:** Carbonates - Carbonation - Energy security - Gas industry - Gases - Gasoline - Horizontal wells - Infill drilling - Natural gas - Natural gas fields - Natural gas well production - Oil well drilling - Petroleum reservoirs - Proven reserves - Resource valuation - Sedimentary rocks - Seismology - Shale gas - Tight gas
**Uncontrolled terms:** Clastic rock - Exploration progress during the 13th five-year plan - Five-year plans - Natural gas exploration - Natural gas reserves - Prospect forecast during the 14th five-year plan - Proved natural gas reserve - Sinopec - Western China
**Classification code:** 482.2 Minerals - 484.1 Earthquake Measurements and Analysis - 511.1 Oil Field Production Operations - 512.1.1 Oil Fields - 512.1.2 Petroleum Deposits : Development Operations - 512.2 Natural Gas Deposits - 512.2.1 Natural Gas Fields - 522 Gas Fuels - 523 Liquid Fuels - 525.6 Energy Policy - 802.2 Chemical Reactions - 804.2 Inorganic Compounds
**DOI:** 10.3787/j.issn.1000-0976.2021.08.002
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 148. Fields and directions for shale gas exploration in China

**Accession number:** 20213910945171
**Title of translation:**
**Authors:** Zhang, Jinchuan (1); Shi, Miao (2); Wang, Dongsheng (1); Tong, Zhongzheng (1); Hou, Xudong (1); Niu, Jialiang (1); Li, Xingqi (1); Li, Zhongming (3); Zhang, Peng (4); Huang, Yuqi (4)
**Author affiliation:** (1) Key Laboratory of Strategy Evaluation for Shale Gas, Ministry of Natural Resources, China University of Geosciences, Beijing; 100083, China; (2) Hebei GEO University, Shijiazhuang; 050031, China; (3) Henan Institute of Geological Survey, Zhengzhou; 450000, China; (4) Liupanshui Normal University, Guiyang; 553004, China
**Corresponding author:** Li, Zhongming(lzm87122@126.com)
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
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**Issue date:** August 25, 2021
**Publication year:** 2021
**Pages:** 69-80
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** China is highly dependent on foreign oil and gas, and the exploration and exploitation of shale gas is an important way to alleviate the energy and environmental pressure of China. Although a series of significant progress has been made in a short time, China is still at the crossroads of shale gas exploration direction. Therefore, this paper systematically reviews the particularity of shale gas geological conditions in China, and points out China's exploration direction of shale gas in different fields combined with the research achievements of shale gas accumulation

mechanism. The following results were obtained. (1) China's shale gas exploration fields can be divided into three major parts, i.e., marine, continental and marine-continental transitional facies. The geological characteristics of shale gas in North China, Yangtze and Tarim plates are different. The interaction of multiple factors, including tectonic and sedimentary evolution, shale gas accumulation, late-stage transformation and etc., has led the complexity of the geological distribution and the diversity of exploration fields of shale gas in China. (2) The organic pores and fractures of marine shale are developed. The Ordovician Wufeng-Silurian Longmaxi Formation will still be the primary target of shale gas exploration in future. Meanwhile, the Cambrian Niutitang and Sinian Doushantuo Formation in the Yangtze region, the Devonian Luofu and Carboniferous Jiusi Formation in the Yunnan-Guizhou-Guangxi region, the Jixianian Hongshuizhuang and Mesoproterozoic Xiamaling Formation will be the targets of strategic breakthrough in shale gas exploration. (3) The structural deep and slop of middle-large basins and the sedimentation centers of small-middle basins are the main directions of continental shale gas exploration. Inter-laminar cracks and intergranular pores are well developed in continental shale. The coupling of various organic matter types and thermal evolution results in the symbiosis of shale oil and shale gas, which will become an important field for further exploration of continental shale gas. (4) The transitional shale, which mainly formed in Late Carboniferous-Permian, is characterized by cyclic association with sandstone, mudstone, coal and carbonate. Diagenetic fractures are well developed in transitional shale. The favorable structural and diagenetic preservation are the two major factors for the enrichment of this type of shale gas. The flat-lagoon and delta sedimentary systems, middle-large superimposed and small-middle residual basins, and deep layers with quality caprock and good structural preservation are the favorable directions for shale gas exploration in transitional facies. 
**Number of references:** 41
**Main heading:** Shale gas
**Controlled terms:** Gases - Geological surveys - Petroleum prospecting - Textures
**Uncontrolled terms:** Accumulation and distribution - China - Continental facies - Exploration direction - Gas accumulation - Gas type - Marine facies - Marine-continental transitional facies - Oil and gas - Shale gas type
**Classification code:** 481.1 Geology - 512.1.2 Petroleum Deposits : Development Operations - 512.2 Natural Gas Deposits - 522 Gas Fuels
**DOI:** 10.3787/j.issn.1000-0976.2021.08.007
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 149. Deep and ultra-deep oil/gas well drilling technologies: Progress and prospect

**Accession number:** 20213910945139
**Title of translation:**
**Authors:** Wang, Haige (1); Huang, Hongchun (1); Bi, Wenxin (1); Ji, Guodong (1); Zhou, Bo (1); Zhuo, Lubin (1)
**Author affiliation:** (1) CNPC Engineering Technology R&D Co., Ltd., Beijing; 102206, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
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**Publication year:** 2021
**Pages:** 163-177
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** In the period of "13th Five-Year Plan", domestic deep and ultra-deep oil/gas well drilling technologies were developed quickly and a great number of technological achievements were obtained by means of continuous researches, including: (1) high-end devices, such as automatic drilling rig, managed pressure drilling, logging, cementing and completion technology, high-torque top drive system, and deep-well coiled tubing operation unit; (2) advanced tools, such as vertical drilling tool, non-planar tooth bit, high-strength expandable tubular, high-temperature, high-torque and long-life screw rod, torsion impact tool, synergistic damping based rock breaking tool, measurement while drilling tool, and safety monitoring tool; (3) core additives, such as temperature-resistance high-density oil based drilling fluid, high-performance water based drilling fluid, ductile cement slurry, and self-healing cement slurry; (4) life-cycle wellbore integrity technology system. Nevertheless, oil and gas well drilling and completion still faces severe challenges, including deep (great burial depth), steep (large formation dip), narrow (narrow pressure window), thick (thick gravel layer, salt bed and other complex intervals), difficult (complex multi-pressure system, abundant complex

accidents and poor drillability) and high (high temperature, high pressure and high acid). Facing these challenges, the following suggestions are proposed. The key to the oil and gas reserve and production increase during the 14th Five-Year Plan and afterwards is till deep and ultra-deep layers. And it is necessary to focus on above mentioned geological difficulties to research key core technologies, such as automatic and intelligent drilling equipment, ultra-high temperature wellbore working fluid, pre-exploration while drilling and digital twin well construction, so as to realize the iterative upgrading of traditional superior technologies and improve the ability to drill deep and ultra-deep wells safely, quickly and optimally. In conclusion, during the 13th Five-Year Plan, China exceeded America in the number of ultra-deep wells for the first time and its well depth stepped up to a new stage of 8 000 m, which plays an important role in supporting the development of deep oil and gas exploration and development and improving the market competitiveness of drilling and completion. 
**Number of references:** 57
**Main heading:** Oil field equipment
**Controlled terms:** Additives - Boreholes - Construction equipment - Drilling equipment - Drilling fluids - Gases - Gasoline - Geology - Infill drilling - Life cycle - Natural gas well completion - Natural gas wells - Oil field development - Oil well drilling - Oil wells - Proven reserves - Well equipment
**Uncontrolled terms:** Core technology - Deep and ultra-deep well - Five-year plans - Geological difficulty - Key core technology - Oil and gas well drilling - Oil/gas wells - Technological system - Ultra deeps - Ultra-deep wells
**Classification code:** 405.1 Construction Equipment - 481.1 Geology - 511.1 Oil Field Production Operations - 511.2 Oil Field Equipment - 512.1.1 Oil Fields - 512.1.2 Petroleum Deposits : Development Operations - 512.2.1 Natural Gas Fields - 512.2.2 Natural Gas Deposits: Development Operations - 523 Liquid Fuels - 803 Chemical Agents and Basic Industrial Chemicals
**Numerical data indexing:** Size 0.00E00m
**DOI:** 10.3787/j.issn.1000-0976.2021.08.015
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 150. Development progress, potential and prospect of shale gas in China

**Accession number:** 20210609884008
**Title of translation:** ,
**Authors:** Zou, Caineng (1, 2); Zhao, Qun (1, 2); Cong, Lianzhu (3); Wang, Hongyan (1, 2); Shi, Zhensheng (1); Wu, Jin (1); Pan, Songqi (1)
**Author affiliation:** (1) PetroChina Research Institute of Petroleum Exploration & Development, Beijing; 100083, China; (2) National Energy Shale Gas R & D Center, Beijing; 100083, China; (3) PetroChina Exploration & Production Company, Beijing; 100083, China
**Corresponding author:** Zhao, Qun(zhaoqun69@petrochina.com.cn)
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
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**Issue:** 1
**Issue date:** January 25, 2021
**Publication year:** 2021
**Pages:** 1-14
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Number of references:** 45
**Main heading:** Shale gas
**Controlled terms:** Energy resources - Gases - Geological surveys - Geology - Horizontal wells - Natural gas - Petroleum deposits - Proven reserves - Shale
**Uncontrolled terms:** "natural gas daqing" - Deep shale gas - Development potential - Gas productions - Marine shale gas - Marine shales - Non-marine shale gas - Production scale - Sichuan Basin - Yearly gas production scale
**Classification code:** 481.1 Geology - 512.1 Petroleum Deposits - 512.1.1 Oil Fields - 512.1.2 Petroleum Deposits : Development Operations - 512.2 Natural Gas Deposits - 522 Gas Fuels - 525.1 Energy Resources and Renewable Energy Issues
**Numerical data indexing:** Size 3.50E+03m

**DOI:** 10.3787/j.issn.1000-0976.2021.01.001
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 151. Quartz genesis in organic-rich shale and its indicative significance to reservoir quality: A case study on the first submember of the first Member of Lower Silurian Longmaxi Formation in the southeastern Sichuan Basin and its periphery

**Accession number:** 20211210117059
**Title of translation:** -1
**Authors:** Guo, Wen (1, 2); Dong, Dazhong (1, 2); Li, Ming (1); Sun, Shasha (1, 2); Guan, Quanzhong (3); Zhang, Surong (1, 2)
**Author affiliation:** (1) PetroChina Research Institute of Petroleum Exploration & Development, Beijing; 100083, China; (2) National Energy Shale Gas R& D Center, Langfang; 065007, China; (3) Chengdu University of Technology, Chengdu; 610051, China
**Corresponding author:** Dong, Dazhong(ddz@petrochina.com.cn)
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
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**Issue date:** February 25, 2021
**Publication year:** 2021
**Pages:** 65-74
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** Quartz is one of the most common and important minerals in marine organic-rich shale, and its origins and contents are more correlated with the total organic carbon (TOC) and the fracability of shale gas reservoirs. So far, however, its genetic mechanism and its influences on the quality of shale gas reservoirs have not been studied thoroughly and no unified understanding has been reached on them. To this end, this paper takes the shale gas reservoir in the first submember of the first Member of Lower Silurian Longmaxi Formation (S1l11) in the southeastern Sichuan Basin and its periphery as the research object. After 37 shale samples taken from five typical field outcrops were investigated by means of X-ray diffraction (XRD) analysis, scanning electron microscope (SEM) observation, energy dispersion spectrum analysis, cathodoluminescence analysis and major and trace element test, quartz micromorphology was observed. Then, combined with geochemical element analysis, the silica source of quartz was clarified. The genetic mechanism of quartz was analyzed and the percentage of quartz of different geneses and its variation were characterized quantitatively. Finally, its indicative significance to the quality of shale gas reservoirs was discussed. And the following research results were obtained. First, four types of quartz are totally developed in the S1l11 submember, namely terrigenous clastic quartz, authigenic quartz transformed from organic remains, secondary overgrowth of terrigenous quartz transformed from clay minerals, and micron quartz particle transformed from clay minerals. Second, terrigenous quartz indicates the input of terrigenous clastics. Biogenic quartz forms a large number of intergranular pores while constructing a rigid framework to avoid the compaction of primary pores, provide the space for the injection of organic matter pores and protect organic matter pores. At the same time, biogenic quartz can increase reservoir brittleness and fracability. And the content of biogenic quartz is positively correlated with the TOC. The quartz transformed from clay minerals is mainly formed in the middle stage of diagenesis, and it commonly acts as cement to reduce reservoir porosity while increasing reservoir stiffness and density. Third, biogenic quartz accounts for 50-80 % of the total quartz at the bottom of the S1l11 submember and it decreases gradually upwards, whereas, terrigenous quartz and the quartz transformed from clay minerals increase gradually. In conclusion, the 2-4 m thick section at the bottom of S1l11 submember is the best shale gas reservoir section due to its high content of biogenic quartz, abundant organic matters and best shale gas preservation capacity and fracability. 
**Number of references:** 36
**Main heading:** Quartz
**Controlled terms:** Biogeochemistry - Clay minerals - Fracture mechanics - Gases - Organic carbon - Organic minerals - Petroleum reservoirs - Scanning electron microscopy - Shale gas - Spectrum analysis - Textures - Trace elements - X ray diffraction analysis

**Uncontrolled terms:** Energy dispersion spectrum - Geochemical elements - Intergranular pores - Major and trace elements - Organic-rich shales - Reservoir porosity - Shale gas reservoirs - Total Organic Carbon
**Classification code:** 481.2 Geochemistry - 482.2 Minerals - 512.1.1 Oil Fields - 522 Gas Fuels - 804.1 Organic Compounds - 931.1 Mechanics
**Numerical data indexing:** Percentage 5.00e+01% to 8.00e+01%, Size 2.00e+00m to 4.00e+00m
**DOI:** 10.3787/j.issn.1000-0976.2021.02.008
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 152. Dissociation experiment and dissociation rate model of CO2 hydrate

**Accession number:** 20213210735540
**Title of translation:** CO2
**Authors:** Cao, Xuewen (1); Yang, Kairan (1); Xia, Wenzhu (1); Tang, Guoxiang (1); Bian, Jiang (1)
**Author affiliation:** (1) College of Pipeline and Civil Engineering, China University of Petroleum Qingdao, Qingdao; 266580, China
**Corresponding author:** Bian, Jiang(bj@upc.edu.cn)
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
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**Issue date:** July 25, 2021
**Publication year:** 2021
**Pages:** 152-159
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Number of references:** 29
**Main heading:** Carbon dioxide
**Controlled terms:** Dissociation - Gas hydrates - Heat exchangers - Hydration - Volume fraction
**Uncontrolled terms:** CO2 hydrate - Depressurization induced dissociation - Depressurizations - Dissociation mechanisms - Dissociation models - Dissociation rates - Experimental simulations - Heat-exchange - Induced dissociation - Mass-exchange
**Classification code:** 512.2 Natural Gas Deposits - 522 Gas Fuels - 616.1 Heat Exchange Equipment and Components - 641.1 Thermodynamics - 802.2 Chemical Reactions - 804.2 Inorganic Compounds
**DOI:** 10.3787/j.issn.1000-0976.2021.07.017
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 153. Construction of natural gas chemical industry clusters in the Si-chuan-Chongqing area: Necessity, feasibility and implementation measures

**Accession number:** 20213010677908
**Title of translation:** ,
**Authors:** Wang, Sheng (1, 2); Li, Xingyue (1); Liu, Jingcheng (3); Xiang, Ying (4)
**Author affiliation:** (1) Chongqing Technology and Business University, Chongqing; 400067, China; (2) Chongqing Academy of Social Sciences, Development Research Center of Chongqing Municipal People's Government, Chongqing; 400020, China; (3) Chongqing University of Science & Technology, Chongqing; 401331, China; (4) Chongqing Research Institute of Chemical Industry Ltd., Chongqing; 400021, China
**Source title:** Natural Gas Industry
**Abbreviated source title:** Natur. Gas Ind.
**Volume:** 41
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**Pages:** 111-119
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)
**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** In order to provide a reference for scientifically formulating natural gas de-velopment strategies and optimizing the layout of China's chemical industry, and in view of the shortage of oil and gas in the Sichuan-Chongqing area and the high degree of dependence on olefins, this paper analyzed the strategic value of developing natural gas chemical industry, especially natural gas to olefins, from the dimensions of national industrial security, regional economic development, and energy strategy support, demonstrated the necessity of building natural gas chemical industry clusters in the Sichuan-Chongqing area from multiple angles, and demonstrated its feasibility from multiple dimensions such as policy, resources, market, technology, and ecology. And the following research results were obtained. First, the con-struction of natural gas chemical industry clusters in the Sichuan-Chongqing area to fundamentally solve the bottlenecking problem is a need to create a backup for China's industry, to help the construction of the Chengdu-Chongqing economic circle, to promote the economic development of adjacent areas in the Sichuan-Chongqing area, and to activate the oil and gas trading center in China. And it is feasible from the perspectives of policy trends, natural gas resource endowments, olefin supply and demand gaps, key natural gas chemical technologies, natural gas chemical supporting foundations, and impact on the ecological environment. Second, in order to promote the construction of natural gas chemical industry clusters in the Sichuan-Chongqing area, we should adhere to government guidance, scientific and technological leadership, and enterprise entities, and strive to build a world-class natural gas chemical industry belt, jointly create an independent innovation highland for natural gas chemical industry, and protect the decisive role of the market mechanism. Finally, several implementation suggestions were proposed. First, to establish a joint meeting system for the comprehensive development and utilization of natural gas in the Sichuan-Chongqing area. Second, to formulate the mid- and long-term development plan of the Sichuan-Chongqing natural gas chemical industry. Third, to establish a pilot zone for the reform of the natural gas system in the Sichuan Basin. Fourth, to set up a joint natural gas comprehensive utilization and refined industry development fund. Fifth, to explore the realization path and operation rules for the proper separation of economic zone and administrative zone. Sixth, to speed up the construction of oil and gas trading and price generation centers. 
**Number of references:** 21
**Main heading:** Gas industry
**Controlled terms:** Chemical analysis - Chemical industry - Commerce - Crude oil price - Ecology - Economic and social effects - Gases - Natural gas - Natural gas deposits - Olefins - Petroleum refining - Regional planning
**Uncontrolled terms:** Chemical technologies - Comprehensive utilizations - Development and utilizations - Ecological environments - Independent innovation - Long term development plans - Natural gas resources - Regional economic development
**Classification code:** 403.2 Regional Planning and Development - 454.3 Ecology and Ecosystems - 512.2 Natural Gas Deposits - 513.1 Petroleum Refining, General - 522 Gas Fuels - 804.1 Organic Compounds - 805 Chemical Engineering, General - 971 Social Sciences
**DOI:** 10.3787/j.issn.1000-0976.2021.06.013
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 154. An improved seismic-constrained multi-factor pore pressure prediction method for shale gas reservoirs

**Accession number:** 20210609884010
**Title of translation:**
**Authors:** Wu, Furong (1); Zhou, Shiyu (1); Deng, Xiaojiang (1); Yang, Xiao (1); Huang, Cheng (1); Jiang, Bo (1); Wang, Xiaolan (1); Wang, Meng (1); Li, Yangjing (1)
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**Abstract:** Pore pressure and pore pressure coefficient are key parameters for the evaluation of shale gas preservation conditions and the selection of development technologies and measures. They are also important input parameters for geostress prediction. Affected by unique geological characteristics (such as ancient and current structures and rapid change of burial depth), the pore pressure of Lower Silurian Longmaxi Formation in the Shunan shale gas field of the Sichuan Basin varies greatly in the lateral direction and is influenced by many factors, so the conventional pore pressure prediction methods based on P-wave velocity (e.g. Eaton method) cannot provide accurate prediction. In this paper, a multiple-factor pore pressure and pressure coefficient prediction method considering P-wave, S-wave, lithology and denudation was developed based on the geological characteristics of the Shunan shale gas field and the seismic prestack simultaneous inversion data of P-wave and S-wave, combined with the influences of lithological change and denudation on pore pressure and pore pressure coefficient. And the following research results were obtained. First, the introduction of seismic inversion data improves prediction accuracy and detail richness on the plane. Second, the introduction of lithological change improves the vertical prediction stability of pressure coefficient. Third, for the reservoirs with stronger denudation, the introduction of denudation intensity can well predict the pressure coefficient of low-pressure wells nearby. The pressure data of more than 10 actual wells shows that the relative error of the prediction results by this method is less than 5%. In conclusion, this newly developed prediction method has small errors and high accuracy and can provide higher-quality data support for subsequent "sweet spot" area selection, well location deployment, horizontal stress parameter prediction and so on. 
**Number of references:** 16
**Main heading:** Pore pressure
**Controlled terms:** Erosion - Forecasting - Horizontal wells - Lithology - Petroleum reservoirs - Seismic waves - Seismology - Shale gas - Shear waves - Wave propagation
**Uncontrolled terms:** Development technology - Geological characteristics - Pore pressure prediction - Preservation condition - Pressure coefficients - Seismic inversion data - Seismic prestack simultaneous inversion - Shale gas reservoirs
**Classification code:** 481.1 Geology - 483.1 Soils and Soil Mechanics - 484 Seismology - 484.1 Earthquake Measurements and Analysis - 512.1.1 Oil Fields - 522 Gas Fuels - 931.1 Mechanics
**Numerical data indexing:** Percentage 5.00e+00%
**DOI:** 10.3787/j.issn.1000-0976.2021.01.018
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 155. Shear compression deformation test and deformation prevention practice of casing in shale gas horizontal wells

**Accession number:** 20212510530433
**Title of translation:**
**Authors:** Zhang, Ping (1); He, Yunbin (2); Liu, Ziping (3); Tong, Hengmao (4); Deng, Cai (3); Ren, Xiaohai (3); Zhang, Hongxiang (4); Li, Yanchao (3); Qu, Ling (3); Fu, Qiang (1); Wang, Xiangyang (5)
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**Abstract:** With the rapid development of shale gas exploration and development in China, casing deformation in shale gas horizontal wells happens frequently, which directly impacts the development efficiency and benefits of shale gas. In order to explore casing deformation prediction, prevention and treatment methods, this paper analyzes the geological and engineering causes of casing deformation in shale-gas horizontal wells through laboratory work, such as the casing resistance to internal pressure alternating test, the ground simulation test and systematical casing deformation characteristic analysis of MIT24 caliper logging, and the large-scale physical simulation test and numerical simulation of casing deformation. Then, combined with the generalized shear activity criterion, a new method for evaluating casing deformation risk points and some technical measures for preventing casing deformation were formulated. And the following research results were obtained. First, the deformation characteristics of 119 casing deformation points in 23 wells interpreted by MIT24 caliper logging are consistent with the mechanical behaviors of shear compression deformation test. Second, the large-scale physical simulation test shows that natural fractures slip obviously under the state of strike slip stress. Third, numerical simulation shows that the compression stress on casing increases with the increase of fault slip. When the fault slip is between 7.5 mm and 9.0 mm, the casing reaches the critical yield strength and begins to undergo plastic deformation. The "temporary fracture plugging + long segment and multiple clusters" and other technologies are field tested in 28 wells in Weiyuan area of southern Sichuan Basin. The casing deformation rate decreases from 54% (before this research) to 14.3%, and the segment loss rate decreases from 7.8% to 0, which reveals remarkable achievements in casing deformation treatment. In conclusion, the shear slip of faults and macro fractures (referred to as fault-fracture) is the main cause of casing deformation in shale gas horizontal wells, and some measures (e.g." temporary fracture plugging + long segment and multiple clusters", reducing fracturing scale and releasing wellbore pressure properly) shall be taken in advance to reduce the fault-fracture activity before the risk point of casing deformation is fractured, so as to reach the goal of casing deformation prevention. © 2021, Natural Gas Industry Journal Agency. All right reserved.
**Number of references:** 24
**Main heading:** Horizontal wells
**Controlled terms:** Fault slips - Fracture - Gases - Geological surveys - Numerical methods - Numerical models - Petroleum prospecting - Risk assessment - Shale gas
**Uncontrolled terms:** Casing deformation - Compression stress - Deformation Characteristics - Efficiency and benefit - Mechanical behavior - Physical simulation - Prevention practices - Technical measures
**Classification code:** 481.1 Geology - 484.1 Earthquake Measurements and Analysis - 512.1.1 Oil Fields - 512.1.2 Petroleum Deposits : Development Operations - 522 Gas Fuels - 914.1 Accidents and Accident Prevention - 921 Mathematics - 921.6 Numerical Methods - 951 Materials Science
**Numerical data indexing:** Percentage 1.43e+01%, Percentage 5.40e+01%, Size 7.50e-03m to 9.00e-03m
**DOI:** 10.3787/j.issn.1000-0976.2021.05.009
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 156. Evaluation of shale gas preservation conditions using calcite vein inclusions and C/O isotopes: A case study on the Cambrian strata of Middle Yangtze area

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**Title of translation:** -
**Authors:** Liu, An (1); Zhou, Peng (1, 2); Chen, Xiaohong (1); Cai, Quansheng (1); Li, Hai (1); Miao, Fengbin (1); Peng, Zhongqin (1); Huang, Huilan (1)
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**ISSN:** 10000976
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**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** C/O isotopes and inclusions in fracture veins are of great indicative significance to the study on oil and gas preservation conditions. In order to reveal the differences of shale gas preservation conditions in the Cambrian of Middle Yangtze area, this paper selects three wells (YY1, YD4 and ZD1) representing different structural conditions and gas bearing properties of this area as the main research objects to carry out comparative study based on the testing and analysis data of fracture vein inclusions and calcite vein C/O isotopes. And the following research results were obtained. First, the inclusions in the Cambrian fracture veins of this area are mainly classified into four types, including liquid hydrocarbon inclusions, methane inclusions, gas-liquid two-phase inclusions and brine inclusions, and like grains containing oil inclusions (GOI), the (liquid hydrocarbon + methane) inclusion/(gas-liquid two-phase + brine) inclusion ratio is of great indicative significance to hydrocarbon accumulation and preservation. Well YY1 is dominated by high-evolution liquid hydrocarbon and methane inclusions and Well ZD1 by gas-liquid two-phase and brine inclusions. And the ratio is moderate in Well YD4. The more complex the tectonic setting is, the lower the percentage of hydrocarbon in the paleofluid is and the higher the proportion of water is. Second, the preservation condition is correlated with the change range of #13C (#13C surrounding rock-#13C calcite) and #18O (#18O surrounding rock-#18O calcite vein), which is much larger in Well ZD1 than that in Well YY1. The #13C and #18O of highly sealed shale section approach to 0. The occurrence of layer-crossing fluid inside the shale and the intrusion of external fluid can lead to the change of #13C and #18O. Third, inclusions and calcite vein C/O isotopes indicate that there are two kinds of gas escape. The fractures in Well YY1 lead to the upward escape of shale gas and those in Wells YD4 and ZD1 lead to the downward escape. Fourth, the indicators for evaluating the shale gas preservation conditions in the Cambrian of Middle Yangtze area based on inclusions and calcite vein C/O isotopes are established preliminarily. In conclusion, the shale gas preservation condition in the Cambrian of Middle Yangtze area gets worse gradually from Huangling uplift to Jiangnan-Xuefeng uplift, and the Cambrian in the periphery of Huangling uplift is the shale gas exploration focus in the next step. © 2021, Natural Gas Industry Journal Agency. All right reserved.
**Number of references:** 33
**Main heading:** Petroleum prospecting
**Controlled terms:** Calcite - Fracture - Fracture testing - Gases - Geological surveys - Hydrocarbons - Isotopes - Liquids - Methane - Oil bearing formations - Shale gas - Wall rock - Well testing
**Uncontrolled terms:** Bearing properties - Brine inclusions - Comparative studies - Hydrocarbon accumulation - Liquid hydrocarbons - Preservation condition - Structural condition - Tectonic settings
**Classification code:** 481.1 Geology - 482.2 Minerals - 512.1.1 Oil Fields - 512.1.2 Petroleum Deposits : Development Operations - 522 Gas Fuels - 804.1 Organic Compounds - 951 Materials Science
**DOI:** 10.3787/j.issn.1000-0976.2021.02.006
**Compendex references:** YES
**Database:** Compendex
**Data Provider:** Engineering Village


## 157. Prospect of deep shale gas resources in China

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**Title of translation:**
**Authors:** Zhang, Jinchuan (1); Tao, Jia (1); Li, Zhen (1); Wang, Xiwei (1); Li, Xingqi (1); Jiang, Shengling (2); Wang, Dongsheng (1); Zhao, Xingxu (1)
**Author affiliation:** (1) Key Laboratory of Strategy Evaluation for Shale Gas, Ministry of Natural Resources, China University of Geosciences, Beijing; 100083, China; (2) Longdong University, Qingyang; 745000, China
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**Pages:** 15-28
**Language:** Chinese
**ISSN:** 10000976
**CODEN:** TIGOE3
**Document type:** Journal article (JA)

**Publisher:** Natural Gas Industry Journal Agency
**Abstract:** In order to discuss the development direction of the shale gas industry in China, the resource prospects and exploration potential of deep shale gas were discussed and evaluated from the aspects of shale gas accumulation geological conditions, resource distribution, and exploration prospects. Research results show that: (1)The sixteen sets of potential shale formations with different types were developed since Mesoproterozoic and all of them have the geological basic conditions for the formation of deep shale gas. Specifically, South China is dominated by early Paleozoic marine shale, North China is dominated by Mesozoic and Cenozoic continental shale, and is restricted by various basin types, the late Paleozoic transitional facies are both developed in the north and south. (2)All of the Yangtze, North China and Tarim Plates have the basic geological conditions for the formation of deep shale gas, but the type and distribution characteristics of shale gas are obviously different, forming the north-south division and the east-west zoning distribution pattern. (3) Estimated by depth trend analysis method under certain conditions, the geological and recoverable resources (P50) of deep shale gas in China at 4 500 m-6 000 m are 61.10×1012 m3 and 11.07×1012 m3, respectively. The total geological and recoverable resources (P50) of deep shale gas at 3 000 m-6 000 m are 115.72×1012 m3 and 20.93×1012 m3, respectively. Large-scale deep shale gas is mainly distributed in large and medium-sized basins and their peripheries, such as Sichuan, Junggar, Tarim, Ordos, Bohai Bay and Songliao basins. As a result, the distribution centers of deep shale gas resources in the Upper Yangtze, Northwest, North China and Northeast China have been formed, among which the Sichuan Basin and their peripheries are the most realistic areas for the distribution and exploration of deep shale gas resources. (4) In petroliferous basins, deep shale gas is mainly distributed in the subsidence-deposition centers. In addition to the early Paleozoic marine shale, the late Paleozoic transitional and the Mesozoic Cenozoic terrigenous (including small and medium-sized basins) shales are also favorable directions for the distribution of deep shale gas resources. In the Meso Cenozoic continental basins, Upper Paleozoic shale strata under different structural positions are also important fields for the distribution and exploration of deep shale gas resources. In conclusion, deep shale gas characterized by high abundance, multiple types and wide distribution has good resource potential and great exploration significance, which is a basic direction of shale gas exploration and development in China. 
**Number of references:** 52
**Main heading:** Petroleum prospecting
**Controlled terms:** Energy resources - Gas industry - Gases - Geological surveys - Geology - Petroleum deposits - Shale gas
**Uncontrolled terms:** Development directions - Distribution characteristics - Distribution patterns - Exploration potential - Exploration prospects - Geological conditions - Petroliferous basins - Resource distribution
**Classification code:** 481.1 Geology - 512.1 Petroleum Deposits - 512.1.2 Petroleum Deposits : Development Operations - 522 Gas Fuels - 525.1 Energy Resources and Renewable Energy Issues
**Numerical data indexing:** Size 3.00e+03m to 6.00e+03m, Size 4.50e+03m to 6.00e+03m
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