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

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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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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

2. 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: -
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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. © 2021, Natural Gas Industry Journal Agency. All right reserved.
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

3. 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)
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Pages: 102-117
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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

4. 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)
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Corresponding author: Wu, Jianfa(wu_jianfa@petrochina.com.cn)
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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

5. 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)
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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

6. Prospect of deep shale gas resources in China

Accession number: 20210609884018
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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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. © 2021, Natural Gas Industry Journal Agency. All right reserved.
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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Compendex references: YES
Database: Compendex

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7. 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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Pages: 59-71
Language: Chinese
ISSN: 10000976
CODEN: TIGOE3
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
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8. 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)
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Language: Chinese
ISSN: 10000976
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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.
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

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9. 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

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Title of translation: -
Authors: Liang, Yunpei (1, 2); Chen, Qiang (1, 2); Liao, Zhiwei (1, 2); Lin, Dan (3)
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Language: Chinese
ISSN: 10000976
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

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Compendex references: YES
Database: Compendex

Data Provider: Engineering Village

10. 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)
Author affiliation: (1) Southwest Geophysical Research Institute, BGP Inc., CNPC, Chengdu; 610200, China
Corresponding author: Zhou, Shiyu(zhoushy_wt@cnpc.com.cn)
Source title: Natural Gas Industry
Abbreviated source title: Natur. Gas Ind.
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Publication year: 2021
Pages: 198-204
Language: Chinese
ISSN: 10000976
CODEN: TIGOE3
Document type: Journal article (JA)
Publisher: Natural Gas Industry Journal Agency
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

11. 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

12. 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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Publication year: 2021
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

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)
Author affiliation: (1) Shale Gas Research Institute, PetroChina Southwest Oil & Gasfield Company, Chengdu; 610051, China; (2) 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.
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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. 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)
Author affiliation: (1) Xihua University, Chengdu; 610039, China; (2) State Key Laboratory of Oil and Gas Reservoir Geology and Exploitation, Chengdu University of Technology, Chengdu; 610059, China; (3) College of Energy, Chengdu University of Technology, Chengdu; 610059, China; (4) Key Laboratory of Strategy Evaluation for Shale Gas, Ministry of Natural Resources, China University of Geosciences, Beijing; 100083, China; (5) Exploration and Development Research Institute, PetroChina Southwest Oil & Gasfield Company, Chengdu; 610051, China
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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.
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

15. 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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Publication year: 2021
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

16. 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
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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.
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
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Compendex references: YES
Database: Compendex

Data Provider: Engineering Village

17. 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)
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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.
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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
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18. Evolution laws of fracture permeability of deep shale in the process of shear slip

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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
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Uncontrolled terms: Comprehensive effect - Fracture permeability - High injection pressures - Injection pressures - Large displacements - Permeability reduction - Reservoir permeability - Surface asperities
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