Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Petroleum Engineering
February 2015, Volume 40, Issue 2, pp 615-625

Uncertainty Analysis Method for Intersecting Process of U-Shaped Horizontal Wells

- Baobin Xi , Deli Gao , Pengju Chen

Abstract:

Accurate monitoring and determination of the trajectory and relative position are two very important concerns during drilling the connection of two wells to form a U-shaped horizontal well. The composite error circle based on trajectory uncertainty analysis is introduced. The timing of using the magnetic ranging tool is established by comparing the diameter of the composite error circle with that of the ranging scope of the magnetic ranging tool. The profile is designed, and the key extension formula is given according to the characteristics of the magnetic ranging tool. The measurement principle of a Rotating Magnetic Ranging System, which is widely used during the drilling of U-shaped wells, is introduced in order to analyze the relative position uncertainty. Through analysis of the error sources, a covariance matrix of the relative position uncertainty is constructed, and its error ellipsoid and error ellipse are determined. The error ellipse is found to be beneficial in using the magnetic ranging tool during the drilling of U-shaped horizontal wells by comparing the semi-axis of the error ellipse and the radius of the borehole.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Petroleum Engineering
April 2015, Volume 40, Issue 4, pp 1223-1237

Tight Gas Sandstone Reservoirs Evaluation from Nuclear Magnetic Resonance (NMR) Logs: Case Studies

- Xiao Liang, Mao Zhi-qiang , Jin Yan

Abstract:

Tight gas sandstone reservoirs parameters, such as porosity, permeability and initial water saturation, are difficult to be precisely estimated from conventional logs. What's more, the effective gas-bearing formations cannot be directly identified either due to the characteristics of complicated pore structure, strong heterogeneity and high irreducible water saturation. Nuclear magnetic resonance (NMR) logs, which are usually used to evaluate reservoir pore structure, are found to be effective in evaluating tight gas sandstone reservoirs. In this study, typical tight gas sandstone reservoirs of southwest China are used as examples; techniques of estimating porosity, permeability, initial water saturation and constructing pseudo-capillary pressure curve to quantitative evaluate tight sandstone reservoirs pore structure are studied. The acoustic and NMR logs are combined to calculate porosity. The technique proposed by Volokitin et al. (1999) is used to construct pseudo-capillary pressure curves from NMR logs. The saturation-height-function method is used to estimate initial water saturation, and the Swanson parameter based model is established to calculate permeability from constructed pseudo-capillary pressure curves. Comparisons of estimating porosity, permeability and water saturation with core-derived results illustrate that these techniques are effective in tight gas sands evaluation. Finally, the effective tight gas sands can be identified through combined use of the estimated reservoir parameters and constructed pseudo-capillary pressure curves from NMR logs, which is verified by the drill stem test data.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Petroleum Engineering
April 2015, Volume 40, Issue 4, pp 1205-1222

Silica Particles Mobility Through Fractured Rock

- Mohammed Alaskar, Kewen Li , Roland Horne

Abstract:

Functionalized particles are being investigated as a potential tool to measure temperature distribution in fractured reservoirs. Acquiring reservoir temperature data within the formation could be used to correlate such information to fracture connectivity and geometry. Existing reservoir characterization tools allow temperature to be measured only at the wellbore. Temperature-sensitive nanosensors would enable in situ measurements within the reservoir. Such detailed temperature information enhances the ability to infer reservoir and fracture properties and inform reservoir engineering decisions. This study provides the details of the experimental work performed in the process of developing temperature nanosensors. Specifically, silica particles mobility through fractured media was investigated. Experimental results showed that the recovery of the particles was dependent on the particle size and suspension concentration. The particle size has a direct effect on its recovery. The controlling mechanisms for transport of silica particles were identified. Among all, transport by gravitational sedimentation (gravity settling) was prominent. Results also showed that the existence of the fracture facilitated the particle transport. Particles were found to flow with the fast-moving streamlines within the fracture.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Petroleum Engineering
June 2015, Volume 40, Issue 6, pp 1757-1776

Development of an Empirical Model for Settling of Solids in Gelled Foams

- Amit Saxena , Keka Ojha , A. K. Pathak

Abstract:

The underbalanced drilling fluid plays a vital role in the field of exploration of coal bed methane and tight gas reservoirs. It is used to minimize the formation damage and other drilling associated problems. Foam is considered as a popular alternative over the air in underbalanced drilling operations. Development of stable and uniform foam and prediction of its rheological behaviour under dynamic borehole conditions are real challenges in the successful drilling operations. If not designed properly, drilling fluid will fail to transport the cuttings to the surface efficiently. The present study focuses on the development of an empirical correlation for settling velocity of solid cuttings through gelled foams. A number of solids such as coal, sand and shale with variable particle sizes were selected for the present study. Foam fluids prepared with different compositions were characterized. Effects of various parameters such as foam density, composition, viscosity, gel strength, stability and quality, which control the hydrodynamic behaviour during drilling, were studied in detail. The settling velocities of cuttings were experimentally determined for foams with variable compositions. An empirical model has been developed for settling velocity of solid cuttings through gelled foams. This correlation is validated using different solid–fluid experimental data. The model is found to satisfactorily trace the experimental data. This model can be used in designing and characterizing the gelled foam better than the existing models.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Petroleum Engineering
August 2015, Volume 40, Issue 8, pp 2437-2446

Dynamic Analysis of Solid Expandable Tubular and Its Applications in Tahe Oilfield

- Jianhong Fu , Xuanhe Tang , Wei Zhou , Lantian Yang

Abstract:

For ultra-deep horizontal wells in Tahe Oilfield in China, the solid expandable tubular (SET) technology was applied in the buildup section to isolate unstable mud stone with clays above the pay zone. This technology satisfies the requirements of geological water avoidance, and a larger hole size is adopted in the pay zone. This paper proposed a finite element dynamic model to analyze the expansion of the SET, and the impacts of the following factors on the expansion force required for the expandable tubular were analyzed: yield strength of the tubular material, solid tubular expansion ratio, the coefficient of friction between the expansion cone and the tubular, the angle of the expansion cone, movements velocity of the expansion cone, and DLS (dogleg severity). The calculation results indicate that a higher expansion ratio, a higher yield strength, and a higher friction coefficient of the SET result in a larger expansion force to different degrees, whereas the other factors have little effect on the expansion force. The dynamic expansion force calculation model established in this paper is consistent with the actual conditions, and the simulation calculation results can be applied to provide theoretical guidance for SET expansion operations.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Petroleum Engineering
September 2015, Volume 40, Issue 9, pp 2795-2804

A Novel Experimental Method to Generate Steam Within a Small Optical Cell for Measuring Interfacial Properties

- M. A. Naser , A. K. Permadi , W. S. Bae , W. S. Ryoo , S. T. Dang

Abstract:

Steam injection in heavy oil reservoirs does not only change the fluid properties, but also affects the interfacial tension of aqueous phase/hydrocarbon and the wettability of sand/hydrocarbon systems. Understanding the alteration of those properties is crucial for a successful steam injection, and it is expected to play an important role in heavy oil recovery from sands. However, studies on the measurements of interfacial properties of steam, heavy oil, and sand systems have not been well documented in the literature. This paper describes a new experimental technique and procedure which have been developed for generating steam within a small optical cell at high saturated pressure and temperature conditions. After that, image processing technique was applied to measure the interfacial tension of heavy oil/steam and the contact angle of heavy oil/steam/quartz systems. They have several advantages which are fast, relatively cheap and reliable. They potentially would have a wide range of applications in steam injection such as measuring the rock wettability, examining the effects of steam acidity and steam quality, and optimization for the purposes of prevention and/or reduction in damages to the formation. The experimental results indicate that steam injection has caused the alteration of interfacial properties. Interfacial tension measured in steam/heavy oil systems tends to decrease, while contact angle measured in quartz/heavy oil/steam systems tends to increase at saturated temperature and pressure conditions. As the aging time increases, the quartz's wettability changes from mixed-wet to more oil-wet.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Petroleum Engineering
November 2015, Volume 40, Issue 11, pp 3345-3349

Total Organic Carbon Prediction in Shale Gas Reservoirs from Well Logs Data Using the Multilayer Perceptron Neural Network with Levenberg Marquardt Training Algorithm: Application to Barnett Shale

- Sid-Ali Ouadfeul , Leila Aliouane

Abstract:

The main goal of this paper was to predict the total organic carbon (TOC) from well logs data using the multilayer perceptron (MLP) neural network machine. This can replace the Schmoker's method in case of discontinuous measurement of the bulk density log. The MLP machine is composed of three layers, an input layer with four neurons corresponding to the Gamma ray, the neutrons porosity, and the slowness of the P and S waves well logs. The output layer is formed with one neuron, which corresponds to the predicted TOC log, and a hidden layer with ten neurons. The MLP machine is trained using the Levenberg–Marquardt algorithm. Data of two horizontal wells drilled in the lower Barnett formation located in USA are used. Comparison between the predicted and calculated TOC log using the Schmoker's method clearly shows the use of the neural network method to predict the TOC in shale gas reservoirs.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Petroleum Engineering
July 2016, Volume 41, Issue 7, pp 2681–2691

Investigation of Hydraulic Fracture Networks in Shale Gas Reservoirs with Random Fractures

- Bing Hou, Mian Chen, Wan Cheng

Abstract

As shown in hydraulic fracture monitoring, the hydraulic fracture path in naturally fractured shale reservoirs is complex, and the method for describing the propagation of fractures in homogeneous sandstone cannot achieve sufficient accuracy when used in shale reservoirs. In this study, a discrete fracture network model is proposed by performing a Monte Carlo simulation on the fracture characteristics of downhole shale cores and shale outcrops in the Longmaxi formation in the Sichuan basin of China. Given the fracture fluid pressure drop and intersections between hydraulic and natural fractures, a 2D numerical model is developed to examine the hydraulic fracture propagation in a randomly fractured shale reservoir using the displacement discontinuity method. Numerical simulations show that (1) the density and length of natural fractures are positively correlated with the complexity of natural fractures when the orientation of such fractures is similarly distributed, (2) the influence of small natural fractures on a hydraulic fracture is localized and cannot change the overall direction of the hydraulic fracture, and (3) hydraulic fractures can cross the natural fracture when the intersection angle and minimum horizontal stress are small enough. The rationality of the numerical model results is supported by the hydraulic fracturing tests on fractured shale outcrops with a true triaxial fracturing system and microseismic monitoring from a hydraulic fracture test well in the Longmaxi shale formation.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Petroleum Engineering
July 2016, Volume 41, Issue 7, pp 2693–2698

A New 3-D Fluid Potential Calculation Method and Its Application in Petroleum Migration and Accumulation Prediction

- Jinge Liu, Honghai Fan, Qi Peng

Abstract

With the aim to calculate more accurately 3-D fluid potential and predict the direction of petroleum migration and accumulation, a new method is presented based on Hubbert's fluid potential model and a comprehensive 3-D pore pressure prediction method. An improved global pore pressure prediction algorithm is used in conjunction with an integrated 3-D pore pressure prediction method to reduce 3-D pore pressure uncertainties and improve 3-D fluid potential accuracy. Then, 3-D fluid potential is obtained according to the relationship between 3-D fluid potential and 3-D pore pressure through programming. The new 3-D fluid potential calculation method has high continuity and accuracy both vertically and horizontally which is helpful in analyzing the characteristic of formation fluid potential and predicting the oil and gas migration and accumulation. The application of the new method in Boxing Sag presents satisfactory result for prediction of petroleum migration direction and favorable oil accumulation.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Petroleum Engineering
July 2016, Volume 41, Issue 7, pp 2699–2706

Comparisons of the Driller's Method and the Wait and Weight Method in Deepwater Well Killing Operation

- Jian Feng, Jianhong Fu, Ping Chen

Abstract

With the rapid development of deepwater exploration, safety issues associated with deepwater well control have been highlighted in recent years. Due to the effect of large choke line friction losses and the narrow drilling window in the deepwater scenario, the risk of well control is higher, leading to an increase in the demand for a more desirable well killing method. The Driller's Method and the Wait and Weight Method (W&W Method), both of which are the most widely used approaches in the well killing operation, have advantages and disadvantages. Therefore, the aim of this work was to present a quantitative analysis and provide a comparison between the two methods. The behavior of the drill pipe and choke pressures of the two methods was investigated by considering the influence of the choke line friction loss, gas expansion and circulation temperature. In order to evaluate their handling capacity in the deepwater well killing scenario, a mathematical model for kick tolerance and critical pit gain was developed. Moreover, a field case in the South China Sea, which has involved both the Driller's Method and the W&W Method during construction, was applied to study the differences in the two methods in the view of field application. The results recommended that the W&W Method has an advantage over the Driller's Method from the perspective of safety of the wellhead equipment and the handling capacity of the well kick, especially when the preparation ability of the killing mud is not strictly limited.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Petroleum Engineering
July 2016, Volume 41, Issue 7, pp 2707–2714

An Optimization Method of Top Tension in Drilling Riser–Conductor System

- Song Deng, Honghai Fan

Abstract

Drilling riser–conductor system is crucial to the offshore drilling. Complex marine environment can give rise to a series of problems such as buckling and stability on riser–conductor system. A novel method that introduces the optimization of top tension and calculates axial force has been proposed. Effective axial stress equations for the whole riser–conductor system are established in this paper considering these factors such as rising velocity of drilling fluid, temperature, pressure, and current force. Then, the neutral point of effective axial stress is introduced in marine drilling and top tension can be adjusted to ensure the neutral point is located at BOP. Compared with other methods, a case study shows that a higher accuracy of effective axial stress can be expected with this method. Meanwhile, top tension should be optimized to allow the neutral point to locate at BOP and ensure the BOP keep enough bending strength.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Petroleum Engineering
July 2016, Volume 41, Issue 7, pp 2715–2729

Numerical Investigation of Memory-Based Diffusivity Equation: The Integro-Differential Equation

- M. Enamul Hossain, M. Enamul Hossain

Abstract

The classical momentum balance equation discovered by Darcy in 1856 is expressed as the flux is proportional to the pressure gradient. However, the passage of the fluid through the porous matrix is very complex in general and hence may cause a local variation of the permeability. Thus, a one-dimensional model for an oil reservoir is introduced by considering the modification of conventional momentum balance equation. The modification is performed by introducing a derivative of fractional distributed orders as memory formalism. The fractional order is equivalent to a time-dependent diffusivity, and the distributed orders represent a variety of memory mechanisms to model the pressure response with a varied distribution of porosity and permeability. The time-domain and space-domain solutions are obtained by means of a numerical solution of the model equation. Results show that memory-based diffusivity equation has less pressure drops compared to Darcy model for a given distance and time. The differences in pressure drop between the two models become more significant when reservoir life becomes longer. The memory has an effect on the reservoir porosity and permeability which increases with time. If reservoir production continues, memory effect becomes more visible and contributes more in pressure response, which may be considered as a memory-driven mechanism. The proposed model is validated using Middle East filed data. The findings of this research establish the contribution of memory in reservoir fluid flow through porous media.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Research Article - Petroleum Engineering
July 2016, Volume 41, Issue 7, pp 2731–2750

Characterizing the Role of Clay and Silica Nanoparticles in Enhanced Heavy Oil Recovery During Polymer Flooding

- Seyyed Shahram Khalilinezhad, Goshtasp Cheraghian, Mohammad Saber Karambeigi

Abstract

Polymer flooding as one of the most effective methods for enhancing oil recovery has a significant effect on tertiary production of reservoirs with poor vertical sweep efficiencies and those which are extremely heterogeneous. Water-soluble polymers are used to both increase the viscosity of water and decrease the mobility ratio of the displaced and displacing fluids. However, due to high amount of polymer adsorption, presence of divalent cations and mechanical degradation, polymer molecules may lose their properties. Hence it is necessary to further improve the displacement effectiveness of polymer flooding. Despite the fact that several ways have been suggested to enhance the performance of polymer flooding, application of nanoparticles in the improvement of rheological properties of the polymer solution used in enhanced oil recovery has not been reported previously and is still an ongoing subject. This paper investigates the effects of nanoparticles on flow behavior of polymer solution in porous media by employing both experimental studies and numerical simulations. The simulation model first is validated against well-controlled laboratory experiment to have reliable predictions of the full-field implementations. The results show that the amount of polymer adsorption and viscosity of polymer solution will improve when the clay or silica nanoparticles is present in the injectant, and accordingly, the cumulative oil recovery and breakthrough time will be bettered. The result of sensitivity analysis demonstrates that polymer molecules are more degradable during polymer flooding compared to nanoparticles-assisted polymer flooding. Based on the validated model, 3D simulations of nanoparticles-assisted polymer field pilot were performed and the results revealed that the cumulative oil recovery, water cut and breakthrough time will improve when the injectant has some dispersed nanoparticles.

Arabian Journal for Science and Engineering (Arab J Sci Eng)

Review Article - Petroleum Engineering
December 2016, Volume 41, Issue 12, pp 4719–4741

A Review of Modeling Thermal Displacement Processes in Porous Media

- Abiola David Obembe, Sidqi A. Abu-Khamsin, M. Enamul Hossain

Abstract

The subject of heat transfer in oil reservoirs has gained huge attention, due to its diverse range of applications in petroleum reservoir management and thermal recovery for enhanced oil recovery. Thermal recovery methods entail the addition of heat energy into the reservoir through injection wells with the aim of reducing the in situ oil viscosity which is usually around several thousand centipoise cP (in S.I unit kg/m s) at reservoir conditions to very low values at steam temperatures. In addition, several other mechanisms are associated with thermal recovery methods. These include thermal expansion of oil, steam distillation, and relative permeability changes, which contribute to the ultimate recovery of the reservoir. In this article, a detailed review of non-isothermal modeling in an oil reservoir is presented. In addition, a few remarks regarding the momentum transport and the energy balance equations and its various modifications through the years are provided. Finally, a memory-based formulation is proposed to capture the alteration of rock and fluid properties with time as well as accounting for other phenomena not described by classic diffusion equations.