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Investigation of Reactivation of Fault and Wellbore Stability Analysis by the Depletion of Hydrocarbon Reservoirs

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Abstract

Over time and production from the reservoir, the pore pressure of the production layer decreases. This reduction in pressure directly changes the magnitude and direction of stresses. Changes in the magnitude of stresses can cause geomechanical changes in the reservoir and production layers. If the reservoir layers are faulted, reducing the reservoir pressure can activate these faults and also change the tensile strength of the wellbore for new drilling in the discharged layer. This research was performed in one of reservoirs located in the southwestern of Iran. In this reservoir, three production layers with different thicknesses were investigated and the probability of reactivation of faults and tensile strength in the initial state and after the pressure drop of 1800 psi was evaluated. In layer 1, the value of the stress path was 0.67, which due to the fact that it is tangent to the critical stress value, the faults will be reactivated by producing from the reservoir and reducing the reservoir pressure in this layer. Also in this layer, the maximum weight of the drilling mud allowed for non-failure of rock traction in the initial state is 17.81- 25.13 PPG and after a reduction of 1800 psi of layer pressure, it is in the range of 15.07- 23.42 PPG. In addition, the most resistant state of the wellbore is drilling with an angle of 60 degrees and in the direction of minimum horizontal stress.

Keywords: *Reservoir depletion, Pore pressure drop effect, Wellbore stability, Tensile strength, Faults reactivation*

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Extended Abstract:

1. Introduction

Rock mechanics and geomechanics are among the sciences at the center of focus in studies related to the drilling, development, and exploitation of hydrocarbon fields around the world. The careful detection of in situ stresses across the fields and the different stresses applied to the environment surrounding wellbore via different processes, and combining these data with the mechanical parameters of common formations in hydrocarbon reservoirs comprise a key for addressing a wide range of costly problems and issues in the oil industry. As far as designing hydraulic fracturing operation, well stability, and drilling programs are concerned, it is necessary to use geomechanical modeling. As such, geomechanical modeling plays an important role in cost reduction and the technical investigation of associated processes. In order to construct a geomechanical model, it is conventional to use data from porosity log, density log, sonic log, etc. along with the model calibrated using core analysis and well tests.

In general, first studies to evaluate the integrity of rocks during injection and production processes have been conducted over the last few years.

In this study, semi-analytical and closed methods for determining the variation of induced stress during the variation of pore pressure in the reservoir and surrounding rocks were obtained under plain strain and axial symmetry conditions. Finally, the general patterns of induced stress variation, in-situ stress development, faults reactivation, and induced fractures were identified.

Because of the complex tectonic position of the Southwest oil fields of Iran in terms of creating faults and gaps, paying attention to these weaknesses in EOR processes becomes more important.

In this study, from the viewpoint of rock mechanics, the analytical and numerical modeling of geomechanics is discussed. The method is based on petrophysical data available in all wells.

The data used are core analysis data and petrophysical well logs interpreted from one of the southwest Iranian reservoirs.

The data used are Azadegan oil Field and Sarvak Formation, located in southwestern Iran. Azadegan oil Field is located in the southern part of the Zagros Mountains in western Iran.

One of the most important rocks of the Azadegan oil field is Sarvak Formation, which is carbonate with a water shallow sedimentary environment that dates back to the Cenomanian and Turonian periods and is about 600-700 m thick.

2. Materials and methods

In this research, first, by designing the geomechanical model of the well and determining the behavioral and resistance parameters of the reservoir rock, such as elastic coefficients and also the stress field governing the reservoir at the depth of the study is calculated. The safe window of the drilling mud is then determined using the Mohr-Columbus refractive index. Then, by determining the direction and critical value of stresses, the reactivation of faults is calculated through the existing relationships, due to the production and discharge of the reservoir. The results obtained from the data and relationships are entered into StabView software and the diagrams and general schematic of the repository to be studied are interpreted.

3. Results and discussion

Over time and production from the reservoir, the pore pressure of the production layer decreases. This reduction in pressure directly changes the magnitude and direction of stresses. Changes in the magnitude of stresses can cause geomechanical changes in the reservoir and production layers. If the reservoir layers are faulted, reducing the reservoir pressure can activate these faults and also change the tensile strength of the wellbore for new drilling in the discharged layer. This research was performed in one of reservoirs located in the southwestern of Iran. In this reservoir, three production layers with different thicknesses were investigated and the probability of reactivation of faults and tensile strength in the initial state and after the pressure drop of 1800 psi was evaluated. In layer 1, the value of the stress path was 0.67, which due to the fact that it is tangent to the critical stress value, the faults will be reactivated by producing from the reservoir and reducing the reservoir pressure in this layer. Also in this layer, the maximum weight of the drilling mud allowed for non-failure of rock traction in the initial state is 17.81- 25.13 PPG and after a reduction of 1800 psi of layer pressure, it is in the range of 15.07- 23.42 PPG. In addition, the most resistant state of the wellbore is drilling with an angle of 60 degrees and in the direction of minimum horizontal stress.

4. Conclusion

In the first layer, the value of the stress path is 0.67, which is tangential to the critical stress value. Therefore, by producing from the reservoir and reducing the reservoir pressure in this layer, the faults will be reactivated. On the other hand, in this layer, the weight of the mud required for the tensile failure of the rock in the initial state is 17.81 - 25.13 pounds per gallon. After decreasing the tank pressure, this amount decreases and is in the range of 15.07 - 23.42 pounds per gallon. The effect of pressure drop on the tensile strength of this layer is more than the other two layers. Also, the strongest drilling path in this layer is in the initial state of drilling with an angle of 60 degrees and in the direction of horizontal stress is minimal.

References:

Aadnoy, B. and M. Chenevert. 1987. Stability of highly inclined boreholes (includes associated papers 18596 and 18736). SPE Drilling Engineering, 2(04): p. 364-374.

Al-Ajmi, A., 2006. Wellbore stability analysis based on a new true-triaxial failure criterion. KTH.

Amiri M, Lashkaripour GR, Ghabezloo S, Hafezi Moghaddas N, HeidariTajareh M., 2018. 3D spatial model of Biot′s effective stress coefficient using well logs, laboratory experiments and geostatistical method in the Gachsaran oil field, south-west of Iran. Bull Eng Geol Environ.

Amiri M, Lashkaripour GR, Ghabezloo S, Moghaddas NH, Tajareh MH, 2019. Mechanical earth modeling and fault reactivation analysis for CO 2-enhanced oil recovery in Gachsaran oil field, south-west of Iran., Environmental Earth Sciences. Feb 1;78(4):112.

Bowes, C. and R. Procter, 1997. Drillers Stuck Pipe Handbook. Ballater, Scotland: Procter & Collins Ltd.

Canady, W.J. 2011. A method for full-range Young's modulus correction. in North American Unconventional Gas Conference and Exhibition. Society of Petroleum Engineers.

Cheatham Jr, J., 1984. Wellbore stability. Journal of petroleum technology. 36(06): p. 889-896.

Doser, D.I., M.R. Baker, and D.B. Mason, 1991. Seismicity in the War-Wink gas field, Delaware Basin, west Texas, and its relationship to petroleum production. Bulletin of the Seismological Society of America, .81(3): p. 971-986.

Fjar, E., 2008. Petroleum related rock mechanics. Vol. 53. Elsevier.

Gao, Q., 2019. Initiation Pressure and Corresponding Initiation Mode of Drilling Induced Fracture in Pressure Depleted Reservoir. Journal of Energy Resources Technology, 141(1): p. 012901.

Garrouch, A.A. and A.S. Ebrahim. 2001. Assessment of the stability of inclined wells. in SPE Western Regional Meeting. Society of Petroleum Engineers.

Grasso, J.-R., 1992. Mechanics of seismic instabilities induced by the recovery of hydrocarbons. Pure and Applied Geophysics. 139(3-4): p. 507-534.

Hussain, R., 2002. Well Engineering and Construction. Entrac Consulting, London.

Kanfar, M.F., Z. Chen, and S. Rahman, 2017. Analyzing wellbore stability in chemically-active anisotropic formations under thermal, hydraulic, mechanical and chemical loadings. Journal of Natural Gas Science and Engineering, 41: p. 93-111.

Kidambi T, Kumar GS, 2016. Mechanical Earth Modeling for a vertical well drilled in a naturally fractured tight carbonate gas reservoir in the Persian Gulf. J Pet Sci Eng 141:38–51. https ://doi. org/10.1016/j.petrol.2016.01.003

Li, X. and K. Gray, 2015. Wellbore stability of deviated wells in depleted reservoir. in SPE Annual Technical Conference and Exhibition. Society of Petroleum Engineers.

Lund, B. and M. Zoback, 1999. Orientation and magnitude of in situ stress to 6.5 km depth in the Baltic Shield. International Journal of Rock Mechanics and Mining Sciences, 36(2): p. 169-190.

Maleki, S., 2014. Comparison of different failure criteria in prediction of safe mud weigh window in drilling practice. Earth-Science Reviews, 136: p. 36-58.

Moos, D., 2003. Comprehensive wellbore stability analysis utilizing quantitative risk assessment. Journal of Petroleum Science and Engineering, 38(3-4): p. 97-109.

Motiei, H., 2010. An Introduction to Zagros Petroleum Reservoirs Evaluation, (For Geologist), first ed. V:2, P 681. [In Persian].

Senseny, P.E., Pfeifle, T.W., 1984. Fracture toughness of sandstones and shales, in: The 25th US Symposium on Rock Mechanics (USRMS).

Schutjens, P.M, 2007. Wellbore stress change due to drawdown and depletion: An analytical model and its application. in International Petroleum Technology Conference. International Petroleum Technology Conference.

Stewart, D. and P. BYERLY, 1994. Reorientation of propped refracture treatment. SPE, 28078.

Zeynali, M.E., 2012. Mechanical and physico-chemical aspects of wellbore stability during drilling operations. Journal of Petroleum Science and Engineering, 82: p. 120-124.

Zoback, M., 2003. Determination of stress orientation and magnitude in deep wells. International Journal of Rock Mechanics and Mining Sciences, 40(7-8): p. 1049-1076.

Zoback, M.D. and J.C. Zinke, 2002. Production-induced normal faulting in the Valhall and Ekofisk oil fields, in The mechanism of induced seismicity, Springer. p. 403-420.

Zoback, M.D., A.D. Day-Lewis, and S. Kim, 2010. Predicting changes in hydrofrac orientation in depleting oil and gas reservoirs, US Patent No. 784,889,5B2.

Zoback, M.D., Reservoir geomechanics. 2010: Cambridge University Press, Cambridge, United Kingdom.