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Sand Production Prediction in Hydrocarbonic Reservoir Rock of Shah Deniz Field, Caspian Sea Basin using Well Logging

Ali Gholami Vijouyeh[1], Mohammad Hassanpour Sedghi*[1], Ali Kadkhodaie1 and Ahmad Shirzadi[2]

1. Department of Earth Science, Faculty of Natural Science, University of Tabriz, Iran

2 Khazar Exploration and Production Company, Tehran, Iran

hassanpour_mhd@tabrizu.ac.ir

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INTRODUCTION

Sand production is one of the major problems in oil and gas wells which is arising from formation significant failure during production due to the accumulation of stresses around the borehole. In this phenomenon, sand grains are detaching from the reservoir rocks and emigrating toward covering excessive pressures at the direction of maximum stress [1]. The modeling and prediction of sand production in the SDX-5 well of ShahDeniz gas field consist of calculation of three main parts including physical and mechanical parameters of the formation, calculation of stress parameters and, finally, software analysis for all existing formations.

METHODOLOGY

ESTIMATION OF FORMATION MECHANICAL PARAMETERS AND STRESSES

In this study, mechanical properties including compressional and shear wave velocities, density, elastic modulus such as static young's modulus, shear and bulk modulus, poisson ratio, uniaxial compressional strength (UCS) and pore pressure were calculated based on well logging data.

In order to determine the directions of the stresses in the region, we used World Stress Map as well as Bonini (2012) and Bonini and Mazzarini (2010) studies that have studied about mud volcanoes in Shah Deniz structure [2,3]. Mud calderas elongate parallel to the fold axis and local SH, and the shortening in caldera is parallel with local Sh [3]. The cumulative analysis of SH axes yields a main preferential orientation in the interval N20°–40°E with a main frequency peak trending around N30°E, and a secondary peak striking ca. N120°E (Sh). This statistical distribution is basically similar to that obtained from the World Stress Map SH axes situated on the onshore Greater Caucasus [4]. The magnitude of stresses were also achieved

from poro-elastic equations.

RESULTS AND DISCUSSION

Collapse pressure is a critical point of sand production. If the amount of drawdown pressure exceeds the amount of collapse pressure, hydrocarbon production will be with the sand production and the high pressure of drawdown will lead to detaching of the sand grains from the reservoir rock and it's moving toward the oil well with hydrocarbon. In STABView Software for numerical modeling of sand production, four main outputs were obtained. The results include depth profile, azimuth plot, inclination plot and polar plot [5] for the calculted collapse pressures. All plots were achieved for the Lower Balakhany Formation which has been considered as one of the most important reservoir rock formations in the SDX-5 well of Shah Deniz gas field.

POLAR PLOTS FOR COLLAPSE PRESSURE AND COLLAPSE DRAWDOWN PRESSURE

Based on Fig. 1A (collapse pressure) and Fig. 1B (collapse drawdown pressure), at the azimuths of 120° and 300° (parallel with minimum horizontal stress), the well with a deviation angle of 0° to 45° relative to the vertical position of the well (the well with an actual inclination of 45° to 90°), will have the lowest collapse pressure (most probability of sand production). At the azimuth of 30 degrees and 210 degrees (parallel with maximum horizontal stress (N30E)), the well with a deviation angle of 0° to 15° relative to the vertical position of the oil well (the well with an actual inclination of 75° to 90°), will have the lowest collapse pressure and most likely of sand production. Therefore, it can be seen that in every azimuth, if the inclination of the well be close to the vertical or perpendicular (center of the plot), collapse pressure will be low and the probability of sand production will be high. About the azimuth, the safest azimuth in order to avoid the hazards of the sand production is N30E azimuth. Because in the azimuth of 30 degrees relative to the azimuth of 120 degrees, collapse pressure is higher, and therefore thus the probability of sand production at the azimuth of 30 degrees is lower. Consequently, as respects central grey elliptical (the amount of low collapse pressure) is in the direction of minimum horizontal stress so this azimuth will has the most talent concerning to sand production. Therefore, drilling optimum azimuth to reduce the risks of sand production is the azimuth of 30 degrees. In general, the marginal gray parts have the highest collapse pressure (about 29177 Psi) and the lowest potential for sand production at this depth. In this formation, if the well is vertical, the maximum production pressure value should be 25549 Psi, if the production pressure exceeds this value, sand will be produced simultaneously with the production of hydrocarbons. In the horizontal state of the well, the maximum production pressure without sand production is 29177 Psi. Therefore, drilling optimum inclination is a horizontal inclination. The pressure values in the polar plots of collapse drawdown pressure have been indicated with the negative numbers, and these numbers express that how much the drawdown pressure should low relative to formation pressure that fluid and hydrocarbon flows into the well. For the Lower Balakhany Formation, if the well is in a vertical position, the drawdown pressure should be 15795 Psi less than the pressure of the reservoir which fluid flows into the well (Fig. 1B). In well horizontal condition, the drawdown pressure should be 19365 Psi less than the pressure of the reservoir which fluid flows into the well.

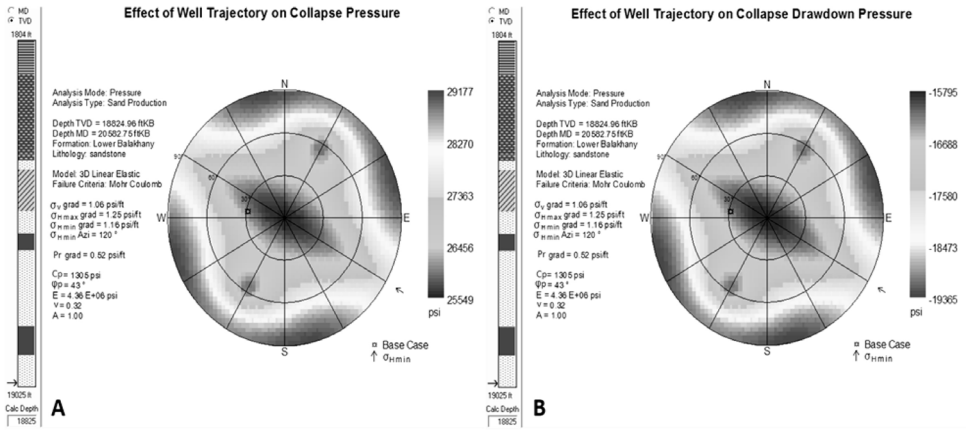

Figure 1: Collapse Pressure polar plot (A) and Collapse Drawdown Pressure and (B) Lower Balakhany Formation.

DEPTH PROFILE

Based on Fig. 2 and with consideration of the collapse pressure curve (E), if the hydrocarbon production pressure has situated below of this curve, hydrocarbon production will be performed without the production of sand; however, if the production pressure exceeds the boundary of collapse pressure, the production of hydrocarbons will produce with sand. Another type of depth profile graph is the instantaneous Drawdown (Fig. 3). According to this plot, during hydrocarbon production, increasing production pressure should be slowly (done with less pressure). Because the probability of sand production is high.

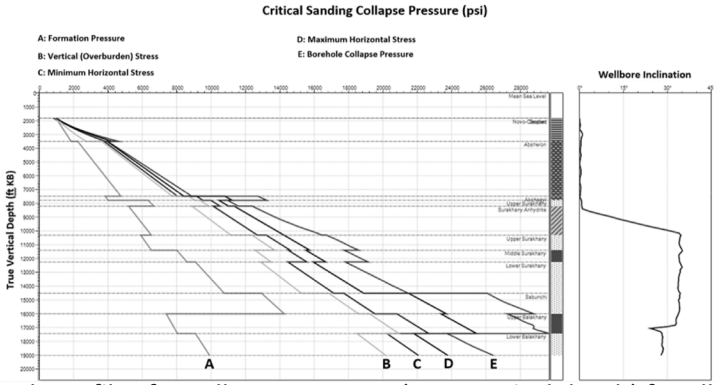

Figure 2: Depth profiles for collapse pressure (true vertical depth) for all formations.

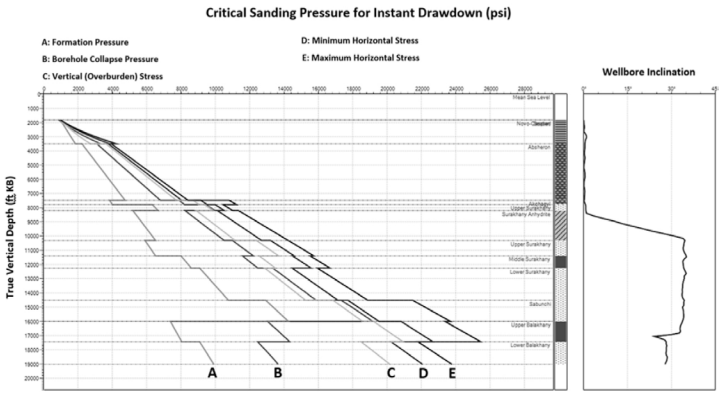

Figure 3: Depth profiles for instantaneous Drawdown (true vertical depth) for all formations.

CONCLUSIONS

According to the azimuth plots, inclination and polar plots of STABView software, drilling optimum azimuth is parallel with the maximum horizontal stress (30° azimuth), and drilling optimum inclination to prevent sand production, for all formations, specially, for Lower Balakhany reservoir formation, is a horizontal inclination. Therefore, with respect to polar plots of collapse drawdown pressure, the drawdown pressure values for each of the formations have been demonstrated by the negative numbers and these numbers express that how much the drawdown pressure should low relative to formation pressure that fluid flows into the well. In the depth profiles diagram, it was shown that the study area follows the compressional stress regime, and also the optimum discharge rate of hydrocarbon production was determined for each of the formations to prevent the production of sand. In addition to in instantaneous Drawdown depth profile graph, it was determined that during hydrocarbon production, increasing production pressure should be gradually.

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