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Delineating Oman Maximum Stress Orientation Using Microseismic Data from Hydraulic Fracturing Monitoring

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ABSTRACT

Microseismic technology is widely used to monitor hydraulic fracturing evolution. It is based on using surface and/or downhole arrays of geophones for passive listening to micro-scale earthquakes caused by opening and closing of fractures or reactivation of faults. From rock mechanics, it is known that hydraulic fractures should grow parallel to the maximum horizontal stress orientation and perpendicular to the minimum horizontal stress orientation.

In this study we analyze microseismic results from hydraulic fracturing jobs to infer Oman present day maximum stress orientation. Since 2011, a total of 9 hydraulic fracturing monitoring (HFM) projects with more than 30 fracturing stages were conducted by Petroleum Development Oman (PDO). Most of the stages yielded hundreds of microseismic events. HFM has been tested in different geological settings in Oman. In North Oman, most of the HFM projects were performed in tight sandstone and carbonate reservoirs. In South Oman, HFM projects were performed in silicilyte formations encompassed within salt.

The obtained microseismic results were analyzed in time and space to determine hydraulic fracture dimensions and orientations. Overall, the results from North Oman fields indicate hydraulic fracture orientations in agreement with Oman present day maximum stress orientation (NNE to NE). In contrast, the results from hydraulic fracturing in South Oman indicate NW maximum stress orientation within the silicilyte formations encompassed within salt. This discrepancy in maximum stress orientation between North and South Oman is most likely due to the presence of salt in South Oman. The observed hydraulic fracture orientations from North and South Oman are supported by measurements of breakouts and induced fracturing from borehole Formation Micro Images (FMI).

Such studies of stress orientations are valuable for hydraulic fracturing designs, deciding on horizontal well directions and wellbore stability analysis.