A Well in the Wadi- an Integrated Geophysical and Geological Solution to Unravel Complex Geology

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Abstract

The subsurface below a Wadi in Saudi Arabia, required an integration of geophysical and geological data to evaluate the pre-Jurassic section. Interpretation of these data sets led to the drilling of a well in the middle of the Wadi. Analysis and integration of data, such as recently acquired or reprocessed 3D seismic, transient electromagnetic (TEM), walkaway VSP, wireline logs including borehole image, and petrographic thin-section of sidewall cores, unravelled the complex structure and stratigraphy beneath the Wadi; and helped infer the possible structural growth that formed the Wadi. Seismic pre-stack depth migration (PSDM) data was generated with TEM-seismic simultaneous joint inversion for near surface statics model and calibration to velocity, delta (δ) & epsilon (ε) from VSP. The data clearly shows the presence of a depression beneath the Wadi possibly caused by intensive faulting, fracturing, and overburden collapses. The wireline logs and petrography from the Wadi well confirmed total dissolution of the Jurassic anhydrites, and intense dolomitization in the overburden. Unlike offset wells, the Wadi well encountered drilling challenges in the pre-Jurassic overburden. Borehole image logs indicates predominant east-west, sub-vertical, open faults and fractures. The trend of these features is consistent with micro-earthquake events measured along the Wadi further to the east that conform to the regional maximum horizontal stress and the east-west orientated strike slip fault system. The structural growth of the Wadi is most likely due to a combination of regional strike-slip fault systems and dissolution of the Jurassic anhydrites. The author postulates the Pliocene-Quaternary strike-slip fault system, with associated transpressional and transtensional stresses, generated the initial depression. The surface and near-surface ground water entered the subsurface formations via surface connected fractures and faults acting as conduits, and dissolved all of the anhydrites, causing overburden collapses, which formed the present surface depression. However, these structural episodes seem to have no influence on the structure and stratigraphy of the deeper pre-Jurassic interval.