AAPG Datapages/Search and Discovery Article #90254 ©2016, GEO-2016, 12th Middle East Geosciences Conference & Exhibition, Manama, Bahrain, March 7-10, 2016

Fracture detection in carbonate reservoir at multiple scales with integrated seismic, borehole image log and core data, onshore Saudi Arabia

Shahzad Ulhaq[1], Duryodhan Epili[1], Krzysztof K. Sliz[1], Luke F. LaFreniere[1]

[1] EXPLORATION, SAUDI ARAMCO, Dhahran, east, SAUDI ARABIA

ABSTRACT

Fractures in carbonates exist at all scales creating a complex network in the reservoir. To understand hydrocarbon flow in the reservoir, it is important to detect fractures, whether naturally occurring or drilling induced. Conventional seismic techniques are capable of detecting gently dipping fractures. These results are often inconclusive in structurally complex, low permeability carbonate reservoirs with significant subvertical fracturing. The duplex wave migration technique detects subvertical fracture corridors and their orientation by imaging the reflections from vertical discontinuities. Anisotropic imaging finds the direction of maximum horizontal stress by measuring seismic anisotropy caused by subvertical fractures. This study describes examples of detecting subvertical fracture zones in low permeability carbonate reservoir, comprised of clean shelfal limestones alternating with thinly interbedded argillaceous lagoonal limestones, using duplex wave migration and anisotropic imaging. Integrated borehole image log and core analysis revealed the presence of high density fracturing in the zones where duplex wave migration technique detected subvertical fracture corridors. In the presented example, the orientation of the fracture clusters identified on the borehole image log is consistent with NE-SW striking fracture corridors detected on duplex wave migration images in Lower Jurassic carbonate. The natural fracture network detected is partially mineralized and cemented fractures together with stress induced fractures. The majority of the natural fractures detected on borehole image log and core are steeply dipping (~80°) possibly extensional in origin, while few compaction and tectonic stylolites also observed. Statistical analysis of the fractures indicate that most of the natural fractures are enhanced in the direction of maximum horizontal stress, reactivating subvertical mineralized factures as observed on duplex wave migration and anisotropic imaging techniques.

Seismic imaging technique detected subvertical fracture corridors. Fracture analysis based on borehole image log and core validated the results of seismic imaging technique. Seismic imaging technique and integrated borehole image log and core analysis helped reduce subvertical fracture uncertainties in the reservoir. This integrated approach minimizes the scale gap between seismic data, image log, and core, and is a key element for improved fractured reservoir characterization.