Hydrocarbon Reservoirs Imaged with Seismic Frequency Domain DHI – A Case Study from the Nile Delta

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A new frequency domain DHI technology was used to identify Tertiary age hydrocarbon charged reservoirs offshore Egypt from 3D seismic data only. Besides imaging numerous known hydrocarbon reservoirs, there were generally weak or absent frequency domain DHI anomalies at known wet sands. The technique used is referred to as Alpha Dominant Frequency ("ADF®"). ADF® anomalies are caused by fluid mobility and double as powerful DHIs because hydrocarbons typically have higher relative permeability than brine.

Carcione and Picotti 2006, show that in the presence of fluid mobility dispersion (frequency dependent velocity) occurs within the seismic bandwidth with the most pronounced effect being on the low frequencies. Taking Carcione' frequency dependent velocities forward shows that frequency dependent velocities cause frequency dependent reflection coefficients, which cause increased decay above and below Dominant Frequency and a localized drop in Dominant Frequency on the reflected wave spectra.

Common hydrocarbon fluid types like Brent, WTI and gas have anomalously high fluid mobility, which causes a spectral signature distinguishable by three characteristics. These are anomalously rapid energy decay on frequencies below Dominant Frequency, which we measure with Alpha low ("αl"), anomalously rapid decay on frequencies above Dominant Frequency, which we measure with Alpha high ("αh") and a decrease in Dominant Frequency ("DF"). Hence where reservoirs have sufficient thickness, porosity and hydrocarbon saturation, αl and αh will anomalously steepen and DF will decrease.

After spectral detuning an ADF® DHI cube was computed from αl, αh and DF such that ADF® anomalies represent places where αl, αh are relatively steep and DF is relatively low and hence the combination of these indicates hydrocarbons. Since αl, and αh are independent of amplitude shape measurements, the combined ADF® measurement is independent of amplitude.

Review of over 15 wells with Miocene-Pliocene targets showed a good match to the ADF® DHI cube.