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Low-frequency (LF) Passive Seismic Imaging - A New Technique for Reservoir Wealth and Health

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SUMMARY

The existence of coherent patterns relating to oil and gas reservoirs in the low frequency domain has been established in many parts of the world. The underlying physical mechanisms of these so-called Direct Hydrocarbon Indicators (DHI) is a key focus of our research. Two mechanisms that can generate DHI in the background spectrum are of special interest: resonant amplification and resonant scattering. Resonant amplification effects of ambient seismic waves are likely candidates for hydrocarbon micro-scale tremor signals. Resonant amplification effects behave like a secondary source within the reservoir. They are supported by the following observations: An often narrow frequency range of the anomaly, The mean absolute power of hydrocarbon tremors depends on the level of environmental noise, Signal power is proportional to hydrocarbon-bearing layer thickness of the reservoir, Three component recordings show a trough instead of a peak in the H/V-ratio, Investigations of the wave-field propagation directions using directionally-sensitive sensor arrays show that the signals causing the anomaly originate from the reservoir direction, Time reverse modeling indicates that the origin of the tremor signals is located within the reservoir

Low-Frequency seismic gives Geophysicists a new seismic imaging technique to look into wealth & health of reservoir, Hydrocarbon reservoirs can be the origin of a continuous source of low-frequency seismic waves. These phenomena are sometimes called “hydrocarbon microtremors”. Low frequency (LF) passive seismic is a breakthrough Direct Hydrocarbon Indicator (DHI) technology for identifying and delineating oil and gas reservoirs by analyzing the spectral attributes of naturally occurring, low frequency (<10Hz) seismic wavefields. One such technology is low-frequency (LF) passive seismic technology, which is helping to improve the value of conventional seismic data by overlaying structural interpretations with reservoir information.

One future development we will look at is how LF passive seismic is localizing hydrocarbon microtremors through the technique of Time reverse Modeling (TRM).

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Two physical models for spectral anomalies in the low frequency domain

Resonant scattering occurs on a macro-scale, where characteristic maxima are generated by reflections, both between the reservoir and the surface and within the reservoir, caused by complex impedance contrast due to the reservoir. When seismic waves propagate from one medium to another medium with different complex impedance (e.g. a sharp change in the value of the quality factor) then a part of the wave is reflected.

Importantly, the effective impedance contrast can be enhanced, or solely generated, by high attenuation in reservoir rocks. Frequency-dependent reflections take place if the seismic waves hit a layer with diffusive attenuation properties or if waves propagate from an elastic medium to a poroelastic medium.

Key words : Resonant Frequency, H/V ratio , LF passive seismic

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