Integrating Hydrocarbon Migration Pathways Detected in Seismic Data with Surface Geochemistry

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Surface geochemical data can detect both micro-seepage and macro-seepage of hydrocarbons. Micro-seepage is a buoyancy driven process resulting in predominately vertical migration, while macro-seepage may also have a significant lateral component. In evaluating deep prospects, it is critical to understand the type of seepage related to the trap itself. If a trap leaks at the flank, it is a High Integrity Trap and will be filled to spill. If a trap leaks vertically through micro-seepage, it will have a high chance of being filled out to the extent of the leakage. However, if a trap leaks via faults at its crest, it will have a high probability or being breached. Thus, by detecting these hydrocarbon migration pathways in seismic data, understanding their morphology, and understanding their correlation to surface geochemical anomalies, we can risk the traps for charge and seal. Secondarily, we can provide more realistic assessments of hydrocarbon column height used in volumetric calculations.

On seismic data, these hydrocarbon migration paths are generally recognized as vertically aligned zones of chaotic, low amplitude reflectivity, described as gas chimneys or gas clouds. A method for detection of gas chimneys in 3D seismic data was developed to map their distribution, and to allow visualization in three dimensions. This chimney probability volume is produced by a neural network from multiple seismic attributes.

A case study from the Neuquen Basin in Argentina will be shown which demonstrates the integration of gas chimney processing and surface geochemistry. Although the upper 300 msec of data was not useable, a good correlation was observed between the shallow chimneys and most of the surface geochemical anomalies. There is also a strong correlation between producing fields and gas chimneys. There is little geochemical data over producing fields, since contamination is a major issue. Very strong chimneys associated with trap forming faults correlated with weak surface geochemical anomalies. These traps are higher risk for seal failure. In contrast, subtle chimneys associated with supra-trap faults correlated to the stronger surface geochemical anomalies. Producing wells are generally associated with these more subtle chimneys. The integration of surface geochemistry and chimney processing provides validation for both technologies and provides a link from the geochemical anomaly to the prospective trap.