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Detailed Hydrocarbon Microseepage Surveys Map Reservoir Heterogeneities and Identify By-passed Compartments

Daniel Hitzman
Geo-Microbial Technologies (GMT), Ochelata, Oklahoma, USA

Very small and very buoyant molecules of light hydrocarbon gases – methane, ethane, propane, butane and C5+ -- naturally escape from oil and gas reservoirs, penetrate permeable reservoir seals, and move vertically through microfractures to the surface. All reservoir seals, even shales and salts, can be penetrated by these exceptional gases. These escaping C1 - C5+ gases form a dynamic and measurable gas chimney signature. There are many seismic data sets that confirm such active gas chimneys. These direct indicator gases can be measured at the surface in both soil and offshore sediment samples.

Observing visible oil seeps at the surface -- like outcrop stains or oil slicks on water -- builds huge confidence that hydrocarbons are present in a basin or block area. Historically, parts of many basins were first targeted because of these visible surface ***macro***seeps. However, macroseeps reveal only part of the seepage spectrum story and fail to offer strong and accurate location clues since they escape along larger fault conduits. But hydrocarbon ***micro***seeps of the light hydrocarbon gases are used to locate oil and gas reservoirs at depth. These microseep gases may be invisible to the human eye, but to gas chromatographs and natural microbial cultures they are clearly discernible and are very potent indicators of hidden reservoirs with vertical chimney signatures.

Expensive 3-D, 4-D, and continuous geophysical data often determine where a development well is to be drilled. Such seismic data are imperative for making structural interpretations. Unfortunately, disappointing dry holes and low-performance wells show us that not all seismic traps contain hydrocarbons. As an industry we still drill an unacceptable -- and unnecessary -- number of dry holes. The combination and full integration of geology with geophysics and microseepage geochemistry can lead us to additional discoveries and more accurate wells.

It is well known that broad microseepage surveys are very useful tools for reconnaissance observations and for ranking seismic prospects. However, detailed microseepage surveys can reveal precise signatures that reflect original reservoir heterogeneities before drilling and also accurately track dynamic reservoir pressures as production matures. The vertical microseepage chimney of light hydrocarbons is strongly affected by production and the subsequent changing reservoir fluids and pressures. Off-set and in-fill well locations must be executed in our maturing reservoir assets -- drilling where we have already discovered reserves. Detailed microseepage surveys are ideal to identify reservoir compartments and alternate zones for mature asset operators. Futhermore, as new structural reservoirs become more and more scarce, we must look ahead for more subtle stratigraphic traps as future reserve builders. Without prejudice towards

either structure or stratigraphic trap, microseepage surveys will be a preferred exploration and development tool for discovering stratigraphic reservoirs.

Microseepage surveys are very flexible in their design and scope. This translates to great efficiency and low cost. In mature producing areas, more detailed sampling patterns to locate by-passed reservoir compartments, offset well locations, and help plan waterflood and in-fill drilling projects are completed. The number of samples, sample densities, and sampling patterns are specifically matched to the development program and expected targets. Sampling densities generally range from 50 meters to 100 meters for development drilling situations and evaluations. These densities allow for a complete examination between wells. By design the collection methodology is very robust and extremely efficient. Men on foot with shovel/augers, and GPS create no environmental issues. Using such fast, low cost, and efficient microseepage methodologies allows operators to test for and squeeze out more reserves where 3-D seismic is not practical nor affordable.

Hydrocarbon microseepage data can be utilized for two results: (1) identifying the location of reservoir compartments and heterogeneities with the quantification of the light hydrocarbon seeps and (2) qualifying the microseepage as originating from a gas, condensate, or oil source reservoir. Mapped case studies will be presented.