Application of Advanced Mud Gas Analytics for Reservoir Evaluation and Optimizing Completion Efforts.

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Abstract

Modern well site geology often includes the use of a mass spectrometer for detection of various components in the continuous mud gases while drilling. With this comprehensive data set comes the need for advanced analytics which can provide a cost effective science tool for reservoir evaluation and augmenting completion designs. This data set and analysis is useful in most mud systems and both vertical and lateral drilling operations. Especially useful in unconventional systems, the mass spectrometer can differentiate the reservoir fluids from the mud additives. Vertical data applications include identifying fluid contacts, bulk porosity, stacked pay potential, and endorsement for lateral placement. Lateral data applications include finding evidence for compartmentalization, compositional variations, “sweet spots”, and secondary poro/perm features. Zones of elevated water saturation and hydrocarbon depletion can also be indicated from appropriate data treatments. The mass spectrometer data set, when analyzed and presented appropriately, provides information to improve production as well as failure avoidance.

Advanced mud gas analytics with the DQ1000™ mass spectrometer far surpasses results using traditional equipment.

Cross plot analysis and standardized data treatment in vertical wellbores helps isolate:
- fluid contacts
- gas and oil bearing rock
- bulk porosity
- elevated water saturation

Standardized data treatment in lateral wellbores:
- removes scales and shows relative proportions of certain components to ROP (FPH)
- highlights above and below average gas signals
- helps to locate compartmentalization, “sweet spots”, and depletion zones

For the standardized data presentation, several curves are statistically standardized, scaled in standard deviations from the mean, then compared to others for analytical purposes. Rate of penetration (ROP) is typically the main driver of introducing gases into the mud system. Generally, the faster the ROP the higher the gas volumes, and the lower the ROP the lower the gas volumes, yet better rock and geologic conditions can obviously yield better gas volumes. Therefore, particular gas curves (Std C1, C4, C6 and Benzene) are overlain on ROP (in FPH, feet/hour) to present relative activity.

Benzene (a ringed, aromatic C6) is almost 80X more water soluble than normal hexane (a paraffin, straight chain C6). When Benzene dissolves in formation water it stays dissolved until drilled and moved up to the surface where it is volatilized and detected by the mass spectrometer. The general principle is that Std Benzene and Std nC6 are overlain on ROP (in FPH, feet/hour) to present relative activity.

Cross Plot Ratios

The entire data set is imported into software which allows the analyst to find the set of ratios that are important to the particular data set. Literally hundreds of cross plot ratios are performed to find zones of “likeliness”, and also outliers. One especially interesting component is Helium. It is mostly produced from the radioactive decay of heavy elements in the basement rock. Helium is a noble gas, never forms a compound, is very small in size, and easily moves up through available spaces. In a vertical, above trend Helium values can indicate better bulk porosity in a zone. A He/C1 ratio can be a fingerprint for same sourced rock until a new ratio is encountered as the well deepens. In a lateral, since it is generally within the same stratigraphic section, an elevated He/C1 ratio can be evidence of a secondary poro/perm feature, such that methane has migrated and Helium remains in place. Crown Geochemistry has a proprietary curve called the Frac Geochemistry plot. Helium and other components are used to generate the curve. Initially using FMI data, this formula was scaled to correlate with it in frac/foot. While this is not with 100% confidence, it is good at indicating zones with better poro/perm. Although completely different technologies, the FMI interprets near wellbore conditions, and the Frac Geochemistry plot indicates communication back into the formation.

Optimizing Completion Design

Engineering frequently utilizes these advanced analytics to augment stage and perf placement. One method in particular is to avoid straddling the lateral chemistry boundaries with a frac stage. If straddled, there is a greater probability that the weaker rock will take all the frac energy and reduce the overall efficiency. By avoiding zones of greater water saturation, positioning more perforations in the oilier zones, and avoiding “dead” rock, operators can improve production and sometimes reduce completions costs.

Conclusions-low risk, cost effective

This service and advanced analytics costs less than 0.5% of most drilling budgets, saving time or getting stuck in the hole, this science can help you find more oil and avoid failure.