

## **INTEGRATING UPSTREAM AND DOWNSTREAM TECHNOLOGIES TO ADDRESS HEAVY OIL PRODUCTION AND REFINING ISSUES**

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Numerous forecasts suggest that contributions to the global portfolio from heavy and otherwise challenged crudes will continually increase. Optimal long-term production, transport, and refining strategies require early, accurate characterization and prediction of problematic components in such crudes; organic and inorganic solids, organic acids, non-hydrocarbon compounds, and numerous oil field additives may cause problems with flow assurance, crude compatibility, tubing corrosion, crude de-watering/de-salting, and refinery fouling, significantly impacting crude value and versatility. The development of effective solutions to such problems is best accomplished through continued collaboration between Upstream and Downstream researchers in industry and academia.

Flow assurance issues associated with organic solids are not new to the Upstream or Downstream; formation of asphaltenes, waxes, diamondoids, and naphthenates under different conditions, and remediation techniques have been studied for many years. Inorganic solids in oils, however, are rarely investigated by the Upstream. Formation solids (clays, silts), scales, corrosion by-products, etc. can cause plugging, fouling, erosion, and a significant reduction in throughput. They may also trigger precipitation of organic solids by providing initial nucleation sites. The characterization of inorganic solids is difficult, but their removal is critical to both Upstream and Downstream operations.

Organic acids in reservoir fluids significantly impact production and refining economics. Acids can be present in both oil and water phases. In crude oils, the presence of low molecular weight acids leads to odor and corrosion issues. High molecular weight acids, typically the naphthenic acid series, lead to refinery corrosion at high temperatures. In addition, both low and high-molecular weight naphthenic acids likely contribute to ancillary problems such as tight emulsions, which complicate separation techniques, and foaming, which complicates production. Remediation techniques include dilution with low-TAN crudes, adding corrosion inhibitors, and upgrading metallurgy. Charge geochemistry and alteration processes play an important role in determining organic acid content; such Upstream geohistory elements must be considered when evaluating potential crude stream changes.

Sulfur, nitrogen, and metal compounds in oils significantly reduce value and can have various detrimental effects on production and refining. Effects and remediation depend on the specific forms; reactive vs. non-reactive sulfur, basic nitrogen, organo-metallic complexes. In some forms, e.g. pyridinic nitrogen, they can even be advantageous with regard to wettability and recovery. Upstream evaluations of petroleum systems and basin and reservoir history help explain occurrence and speciation of non-hydrocarbon components, which in turn contributes to optimized production and refinery strategies.

Characterization and remediation of problematic compounds in petroleum is further complicated by drilling and production additives. Both oil and water-based mud systems and completion fluids may contaminate wireline and drill-stem test fluids, and oil-field additives that solve production problems (e.g., hydrate inhibitors, frac gellants) may lead to refining complications and debits further downstream. An understanding of contaminants/additives and their potential effects is critical to accurate analyses and optimized flow.

Current and future challenges related to heavy and poor quality crudes require innovative and integrated solutions. Increased awareness and collaboration between the Upstream and Downstream is essential for accurate characterization and prediction of potential production and refining issues and crude value. Various examples will be shown that demonstrate the importance and impact of such integration.