

## **Thermal Recovery of Heavy and Extra-Heavy Oil: Challenges, Risks and Opportunities in the Colombian Llanos Basin**

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Thermal recovery exists since in-situ combustion was patented in the early 1920s. In the 1960s it received a significant boost, particularly due to pioneer work in Venezuela. But only in the 1990s, when technological breakthroughs were achieved in drilling (e.g. horizontals, multilaterals), reservoir modeling, and 3D seismic acquisition and processing, did thermal recovery become more common for a larger variety of reservoir types and contractual regimes.

Many thermal recovery technologies have now been developed and applied in various heavy oil environments around the globe, often supplemented by other methods such as miscible or immiscible gas injection or polymer injection. Depth of reservoir and viscosity of the crude determine which methodology is best suited for which environment.

The viscosity of heavy oils found to date in the Colombian Llanos depends partly on the source rock variety that generated the oils – a type I/II oil tends to develop significantly higher viscosities than a type II/III fluid. Which thermal or other secondary recovery methods may be used may thus be also depending on the original source system.

Whether or not thermal recovery will be applied in the Eastern and Southern Llanos depends on geological and reservoir engineering constraints (viscosity, size of accumulation, depth and consolidation of reservoir, proximity to water table, etc.). A crucial unknown exists regarding availability of energy (e.g. electricity, gas, and fuel oil) required for all thermal recovery processes. Finally, oil price and contract stability will also have a significant input into the decision process.