

Petroleum System Analysis of Mars and Beyond

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The recent detection of plumes of methane venting into the Martian atmosphere indicates the likely presence of a subjacent methane reservoir. The detection of methane establishes the subsurface of Mars as a hydrocarbon province, at least for some distance laterally in the vicinity of the plumes. Venting over 4 billion years after the onset of the planetwide cryosphere suggests that methane production is active, whether from biogenic or abiogenic processes. In addition, the production of methane is almost certainly associated with liquid water in the deep subsurface, where geothermal temperatures may elevate the temperature above freezing. Geologic evidence suggests that the equivalent of a global layer of water 0.5 - 1 km deep may be stored as ice and liquid water beneath the surface. Hydrocarbon system analysis indicates that a source for the methane gas exists as well as numerous fractures that will allow the gas to migrate both vertically and laterally over substantial distances. Natural gas on Mars may take various forms: dissolved in groundwater under pressure (from which it can be recovered upon depressurization), as concentrations of free gas (both within and beneath the gas hydrate stability zone), or as methane hydrate that is stable from a depth of as little as 10 to 15 meters beneath the surface to the base of the GHSZ, which may extend to depths of ~10 m to 20 km.

The shallow methane hydrate deposits represent a significant resource that could make Mars a stepping stone that will enable sustainable human exploration of Mars and the Solar System beyond. In addition, this resource provides the basis for fabricating facilities and implements from local Martian resources, and for making high energy density chemical rocket fuels for both return journeys to Earth and for more distant exploration.