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**Geochemistry of an oil seep and gas hydrate on the lower slope, central Gulf of Mexico: Significance to paleogeography and possible source rocks**

A high-flux seep with free crude oil and gas hydrate occurs on the seafloor in 1,930 meters water depth on Atwater Valley (AT) Block 425 in the Gulf of Mexico. Molecular and isotopic properties of the oil and relatively unaltered hydrocarbon gas from the hydrate on AT 425 are unusual. A group of high-sulfur oils in seeps and reservoirs from Green Canyon (GC) and western Mississippi Canyon (MC) has diagnostic molecular and isotopic properties suggesting a “carbonate” source family. The high-sulfur oils are hypothesized to be from a Tithonian source facies that is clastic-starved and that lacks significant input of terrestrial kerogen. However, the hydrocarbons from the AT 425 seep are so different that they are unlikely to be derived from the same or related source facies. Instead, biomarkers of the AT 425 oil are consistent with generation by a calcareous shale facies with some terrestrially derived higher-plant input. In addition, the isotopic properties of hydrocarbon gases from the AT 425 seep are extremely enriched in light carbon isotopes relative to gases that typify the common high-sulfur oil family. The AT 425 seep is near the downdip limit of Louann Salt. Erosion of possible Jurassic or pre-Jurassic paleo-highlands is hypothesized to have resulted in the deposition of calcareous shale source rocks on the margin of the ancestral Gulf basin. On the basis of available geochemistry and geophysics, we hypothesize that a thin but organic-rich Oxfordian calcareous shale source facies *may have been* deposited along the downdip limit of the Gulf of Mexico. However, given the uncertain basement geology in the AT 425 area, it is also prudent to assess the possibility of Middle Jurassic or older source rocks.