Geochemical Correlation of Late Mississippian-Sourced Crude Oils from the Western USA

John Curtis[1], John Zumberge[2], J Zumberge[2]
[1]GeoMark Research, Ltd./Colorado School of Mines; [2]Geomark Research Ltd.

9.29.2020 - 10.1.2020 – AAPG Annual Convention and Exhibition 2020, Online/Virtual

Abstract

Some twenty-five million years after the deposition of the renowned Late Devonian/Early Mississippian black shales across North America, Middle to Late Mississippian sediments also generated oils in western North America. These areas include Central Montana, western North Dakota in the Williston Basin, the Las Animas Arch area of eastern Colorado, the Arkoma, Ft. Worth and Permian basins of Oklahoma and Texas, as well as Railroad Valley of Nevada and the Thrust Belt in Central Utah. Using sterane and terpane biomarkers and carbon isotopes, these Mississippian-sourced oils indicate a wide range of source-rock depositional environments. The Heath Formation of Central Montana generated oils with evaporitic/carbonate biomarker features including both photic zone euxinia (PZE, suggesting shallow water anoxia and enhanced preservation of organic matter) and stratified water column indications. However, workers have been challenged to correlate these type-area outcrop units of Central Montana to the sub-surface of the Williston Basin of western North Dakota (Bottjer et al., 2019). The Heath-sourced oils in the Williston are strikingly different than those of Central Montana. Although they both have PZE, Williston Heath/Amsden oils lack the evaporitic signatures seen in the Heath/Amsden oils of Central Montana, have very low sterane to hopane ratios (i.e., low algae/bacteria relative abundances), and most surprisingly, have extremely high C28/C29 regular sterane ratios. Prasinophytes are a unique class of green algae that produce C28 sterols as major steroid constituents and thrive in oxygen-depleted environments that are unfavorable for other planktonic primary producers (Schwark and Empt, 2006). High C28/C29 sterane values have only been measured in oils from Late Cretaceous to Miocene source rocks (reflecting the evolutionary rise of the diatoms),

except for Late Mississippian reservoired oils on the Las Animas Arch. In fact, the Late Mississippian Las Animas Arch oils, likely sourced from Late Mississippian shales (perhaps from the Hugoton Embayment to the east in Kansas), correlate best with the Williston Heath/Amsden oils with respect to the classic pristane/phytane ratio, carbon isotopic compositions, and lack of upwelling biomarkers. The Late Mississippian Williston and Las Animas Arch oils are the only pre-Cretaceous sourced oils we are aware of that have these exceptionally high C28 steranes (C28/C29 > 1.5), and likely reflect a dominance of Prasinophyte algae in oxygen-depleted waters. The Mississippian Barnett (TX), Caney (OK), and Chainman (NV) shale-sourced oils are generally correlative with each other amid some variation in degree of upwelling and algal/bacteria sources. All have typically low Paleozoic C28/C29 sterane ratios (<1). The Covenant Field oil from the central Utah Thrust Belt correlates best with the Heath carbonate facies oils from Central Montana.