MGS Virtual Luncheon Meeting

Wednesday, May 12th

12:00 – 1:00pm

Open to MGS members via Zoom

RSVP to montanageologicalsociety@gmail.com
by Tuesday May 11th to receive the Zoom link

DR. MARC HENDRIX
UNIVERSITY OF MONTANA, MISSOULA, MT

Evolution of an economic giant: Depositional, diagenetic, and tectonic history of the Permian Phosphoria Formation, western USA.

Phosphate rock is a globally strategic mineral resource that is used primarily for fertilizer. The Permian Phosphoria Formation of the U.S. Northern Rocky Mountain region has accounted for a significant percentage of global phosphate rock production over the past ~70 years. In 2018 alone, the Phosphoria produced approximately 7 million tons of marketable phosphate rock or approximately 2.5% of total global production, valued at approximately $450M. The formation has been mined as a source of phosphate rock continuously since 1906. Currently almost all phosphate rock mined in the U.S. is used to manufacture wet-process phosphoric acid and superphosphoric acid, used as intermediate feedstocks in the manufacture of granular and liquid ammonium phosphate fertilizers and animal feed supplements.

The Phosphoria Formation also constitutes a major petroleum system that includes thermally- mature world-class source rock facies, high quality conventional reservoir facies, and a regionally- extensive overlying seal. Middle Permian organic-rich mudstone facies of the Phosphoria Formation occur in two separate depocenters. The Retort Member of southwestern Montana contains a phosphatic mudstone facies with up to 25% measured TOC. Retort mudstone decreases in %TOC and increases in %P away from the depocenter. At the depositional margins of the Retort depocenter, very well-sorted ore grade peloidal phosphorite is present. The Meade Peak depocenter occurs in southeastern Idaho where it forms ~150m of organic-rich mudstone and phosphorite and is mined extensively.

Stone (1967) was the first to suggest that organic-rich mudrocks of the Phosphoria depocenter provided the charge for much, if not all, of the sub-Cretaceous conventional petroleum and gas recovered from the Bighorn basin of Wyoming. Since Stone's (1967) initial publication, many authors have suggested that sub-Cretaceous hydrocarbons in western Wyoming basins were not locally sourced, but rather were derived from organic-rich rocks in the Meade Peak Member depocenter, centered roughly in southeastern Idaho several hundred kilometers to the west. The basic model is that the large size and high organic content of Phosphoria source rocks in the Meade Peak depocenter provided for Mesozoic generation of oil that migrated generally eastward, up-dip onto the Wyoming shelf, being confined above by relatively impermeable shale of the Triassic Dinwoody Formation and using mainly porous permeable facies in the Pennsylvanian Tensleep Sandstone and Permian Park City Group as carrier beds.

This idea of long-distance migration of Phosphoria oils into the Laramide basins of Wyoming is remarkable because it requires that the hydrocarbons migrated into the region before structural partitioning of the Late Cretaceous foreland basin by basement-cored uplifts, including the Wind River, Bighorn, and

Owl Creek Ranges. Compelling geochemical evidence in the form of oil-source rock biomarker correlations have demonstrated that Permian Phosphoria-sourced oils occur widely across the Laramide basins of Wyoming and account for most if not all the sub-Cretaceous production.

Most paleogeographic reconstructions interpret the Phosphoria Formation to have been separated from the open Panthalassa Ocean by an archipelago of islands and larger landmasses that inhibited the influx of normal marine water. Paleowinds directions induced oceanic upwelling within the Phosphoria 'basin', leading to high levels of surface productivity and deposition of organic-rich mud in an anoxic setting that was also at times euxinic. Thermohaline flow of hypersaline water from the Wyoming shelf into the Phosphoria basin likely contributed to bottom water anoxia and euxinia. Collectively, these conditions fostered the world-class accumulations of organic-rich mudstone and phosphorite for which the Phosphoria is famous. This talk will describe the depositional history and tectonic setting of the Phosphoria Formation, examine its diagenetic history – particularly as regards thermal maturity and conventional petroleum reservoir quality – and examine the evidence behind the long-distance migration hypothesis.

Biography

Marc S. Hendrix is a Professor of Geology at The University of Montana in Missoula, Montana. Growing up in Gettysburg, Pennsylvania, Marc developed an early love of geology in the 1970's while working as a field assistant for his father, a biology professor at Gettysburg College. Marc received a BA in geology from Wittenberg University in Springfield Ohio in 1985 and a MS in geology and geophysics from The University of Wisconsin-Madison in 1987. In 1992, he graduated with a Ph.D. in Applied Earth Sciences from Stanford University, where he conducted research on the geologic record of mountain building and ancient climate in western China. Afterwards, he worked at Stanford as a post-doctoral researcher, analyzing the geologic history of Mongolia. Marc joined the faculty at The University of Montana in 1994 where he has developed a field-based research program focused on the geology of the northern Rocky Mountains. Marc and his students have published a variety of technical papers on the geology of North America, Asia, and Africa. In 2011, Marc authored and illustrated the book *Geology Underfoot in Yellowstone Country.* He co-authored two college-level textbooks on Earth Sciences in 2014 and 2019 and most recently co-authored the first edition of the high school textbook *Introduction to Earth and Space Sciences*, published by National Geographic/Cengage Learning. In 2012, Marc co-founded AIM GeoAnalytics, a Missoula-based geologic consulting company that provides technical services to the energy industry. Marc has served as an expert witness in the field of geology, and he continues to conduct geologic research mostly in the northern Rocky Mountains. He currently lives in Missoula with his wife and two sons.