Neoproterozoic-Early Cambrian Biota and Ancient Niche: A Synthesis from Molecular Markers and Organic Petrography from Salt Range Oil Shales, Pakistan

Imran Khan[1], Ningning Zhong[2]
[1]China University of Petroleum; [2]State Key Laboratory of PetroleumResources and Prospecting (SKL- PRP)

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Abstract

The microbial ecosystem composition and sedimentary environment of the Precambrian were very different from those of the Phanerozoic. The Neoproterozoic-Early Cambrian transition marks the rapid biotic evolution when a microbial dominated life transitioned into a life dominated by advanced, multicellular fauna and flora. Biomarkers are used to visualize distant past since the tangible fossil records for this age are neither exhaustive nor robust. Neoproterozoic-Early Cambrian black shales, world-class proven source rocks, occur widely, provides an ideal condition for the preservation of biogeochemical signatures of the microbial communities that proliferated in ancient paleoenvironments. The knowledge of environmental conditions and palaeobiology of these rocks is mostly based on geochemical records from coeval petroleum system of western India, Oman, eastern Siberia, Australia, and South China. Integrated studies including organic petrography, biomarker, and isotopic analysis can open windows for a better understanding of the initial eras of earth history. The results may also help the petroleum geochemists and geologists to acquire insights into the diagnostic biomarker signatures of these rocks. The Neoproterozoic-Early Cambrian Salt Range oil shales samples collected from the Upper Indus Basin of Pakistan, showed the highest content of organic carbon (>47%) at relatively low thermal maturity (BRo~0.2-0.5), thus represent by far the most thermally immature Neoproterozoic rocks analyzed to date. A suite of 12 oil shale collected samples from different outcrops were analyzed

for source rock characterization, organic petrography, biomarker, and stable isotopic compositions. The organic petrographic results show the oil shales are mixed-type marine oil shales and composed predominantly of alginite (lamalginite and telalginite), bituminite, protobitumen (synsedimentary protobitumen and thucholite) and mineral-bituminous groundmass. The presence of mid-chain methyl alkanes suggests a cyanobacterial mats origin. The abundance of C29 steranes indicates important input from modern, eukaryotic algae. In some relatively low TOC samples, the abnormally high hopane/sterane ratios and the relatively high abundance of 27-norcholestane to 24-norcholestane suggests the high bacterial source input to the overall low productivity settings, thus, suggesting a locally bolstered microbial loop. The abundance of C24 tetracyclic terpene and gammacerane is high, which reflects the high salinity marine evaporite sedimentary environment. The entire biomarker assemblage and petrographic results are indicative of a restricted, salinity-stratified depositional environment including the presence of extensive, anoxygenic microbial mats and some of these characters mirror those of other coeval hydrocarbon successions observed around the globe.