Organic Matter Studies for Hydrocarbon Generation in the Argillaceous Sediments of the Ladakh Himalaya, India

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The Indus Suture Zone is a major crustal lineament between the Himalayan range and Tibet. This important tectonic belt covering a lateral stretch of ~2500 km from the Hindukush mountains of Afghanistan to the Mishmi hills of Assam in India, has been interpreted as a collision boundary between the Indian plate in the south to the Eurasian plate in the north and is considered to be the site of Cretaceous subduction zone along which a large portion of pre-Tertiary Tethyan ocean crust was consumed (Gansser, 1977, and many others). The pre-Tertiary Tethys ocean is believed to have an important influence on the accumulation and distribution of petroleum in the world (Bois and others, 1982). Major oil fields of the world are found close to subduction zones (Figure 1) and from this point of view, the Indus Suture Subduction Zone becomes attractive. The present work was therefore taken up to investigate the organic matter and its thermal degradation for generation of petroleum hydrocarbons in the argillaceous sediments of the Ladakh area of the Indus Suture Zone in NW Kashmir Himalaya, India.

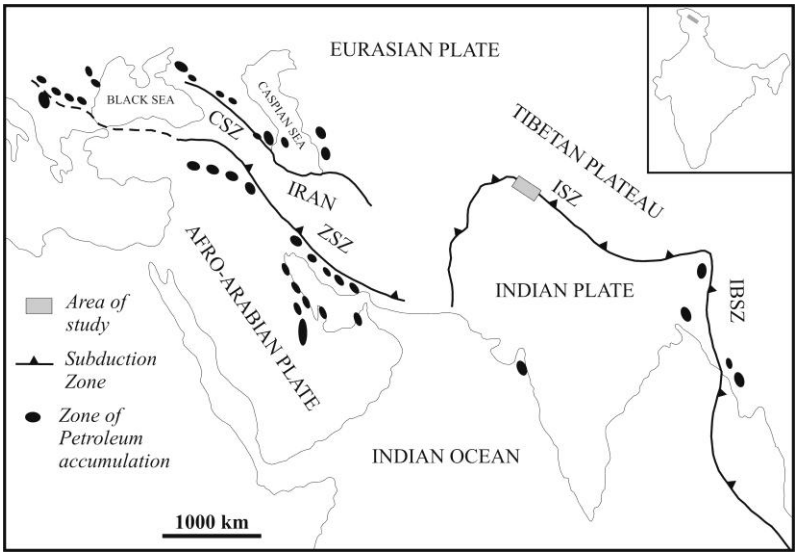

Fig. 1: Association of major oil fields with the subduction zone along Alpine-Zagros-Himalayan tectonic belt (modified after Bois and others, 1982).
ZSZ: Zagros Subduction Zone, ISZ: Indus Subduction Zone, IBSZ: Indo-Burma Subduction Zone, CSZ: Caucasus Subduction Zone.

Based on lithological character, vertical and lateral continuity and lithological associations, various lithostratigraphic units, namely the Lamayuru Formation, Nindum Formation, Indus Formation, Kargil Formation, Ladakh plutonic complex and Khardung Formation, have been identified. Organic matter content in the fine-grained, low-energy sediments such as shales is found to be higher as a rule than that in the coarse-grained high-energy sediments like sandstones and conglomerates. The present study is confined to the argillaceous sediments of the Lamayuru (Triassic-Jurassic), Nindum (Cretaceous) and Indus (Cretaceous-Eocene) formations in the Ladakh area.

The quantity, quality and thermal maturity of the organic matter contained in the shaly sediments of the Lamayuru, Nindum and Indus Formations form the subject of this study. Various geochemical and geooptical techniques have been used for characterization and evaluation of organic matter found in these sediments. A total of 35 shale samples (17 from the Lamayuru, 10 from the Nindum and 8 from the Indus Formation) were studied for this purpose.

Abundance of organic matter has been estimated on the basis of total organic carbon (TOC) content in the argillaceous sediments. The TOC percentage varies between 0.09-3.69 in the Lamayuru, 0.05-3.42 in the

Nindum and 0.03-5.18 in the Indus Formation. The mean TOC contents in the Lamayuru, Nindum and Indus formations are 1.24%, 0.94% and 1.91% by weight respectively. All these values are more than the minimum critical limit of 0.5% TOC, indicating thereby that these sediments have sufficient organic matter to be of importance in the generation of petroleum hydrocarbons in commercial amount.

The nature and type of organic matter has been determined by analysis of extractable organic matter, gas chromatographic analysis of saturate ($C\ 15^+$), optical examination of organic matter and stable carbon isotopic analysis. Higher percentage of aromatic as compared to saturated hydrocarbons, predominance of odd normal-alkane over even ones (C.P.I more than 1) and the ratio of pristane to phytane (mainly more than 1) indicate land-derived organic matter rich in type III kerogen with a minor amount of type II kerogen. This is further supported by the presence of vitrinite, fusinite, cuticle and woody organic matter found in shales of these formations. Such types of organic matter are prone to generate mainly hydrocarbon gas.

The thermal degradation (thermal maturation) of organic matter was determined on the basis of vitrinite reflectance, thermal alteration index (T.A.I) and gas chromatographic analysis of $C\ 15^+$. The mean vitrinite reflectance values vary from 0.6-1.7%, 1.44-1.51% and 1.34-1.44% in the Indus, Nindum and Lamayuru formations respectively. These values indicate that organic matter in these formations has undergone sufficient thermal maturation to generate petroleum hydrocarbons. This inference is also corroborated by T.A.I values ranging from 2.25-3.5 in the Indus Formation, 3-3.75 in the Nindum Formation and 3-3.5 in the Lamayuru Formation. Low (< 50mg/g) extractable hydrocarbon to organic carbon ratio and dominance of pristane over phytane further corroborate the deductions that these sediments have undergone sufficient maturity to produce hydrocarbons.

All the three formations have sufficient organic matter of right quality (mainly the kerogen type III with little type II) and have undergone sufficient thermal maturation to generate petroleum hydrocarbons, mainly gas with little oil. The sediments of the Indus formation are more prospective than those of Nindum and Lamayuru formations as petroleum source rocks. Though the studies are based on limited samples, the results encourage us to continue with detailed source-rock studies.

References

Gansser, A., 1977, The great suture zone between Himalaya and Tibet: a preliminary account, In: V.C.Thakur (ed.), Regional framework and geodynamic evolution of the Indus Tsango Suture Zone in the Ladakh Himalayas, Trans. Roy. Soc. Edinburgh: Earth Sciences, 73, 205-219.

Bois, C., Bonche, P. and Pelet, R., 1982, Global geologic history and distribution of hydrocarbon reserves, Am. Assoc. Petrol. Geol. Bulletin, 66, 1248-1270.

Cite as: Awasthi, A.K., Moezabadi, M.K., Jain, A.K. and Singh, S., 2010, Organic Matter Studies for Hydrocarbon Generation in the Argillaceous Sediments of the Ladakh Himalaya, India, *in* Leech, M.L., and others, eds., Proceedings for the 25th Himalaya-Karakoram-Tibet Workshop: U.S. Geological Survey, Open-File Report 2010-1099, 2 p.
[http://pubs.usgs.gov/of/2010/1099/awasthi/].