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Organo-petrographic studies for hydrocarbon generation, storage and depositional environment of coal and shale in Barjora area, West Bengal, India

Varma, A.K.[#], Biswas, S. , Misra, S., Hazra, B., and Mishra, D.K.

Coal Geology and Organic Petrology Lab., Dept. of Applied Geology, Indian School of Mines, Dhanbad-826004, India; [#]corresponding author: atulvarma@hotmail.com

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This study investigates hydrocarbon generation potential and depositional environment of coal (vitrain, fusain bands were separated manually from coal samples) and shale samples belonging to the Raniganj Formation (Upper Permian) of the Barjora area, south-eastern part of Raniganj coal basin. Rock Eval pyrolysis (REP), total organic carbon (TOC), vitrinite reflectance (R_{omv}), Fourier Transform infrared spectroscopy (FTIR), X-ray florescence (XRF) and scanning electron microscope (SEM) analyses were carried out. TOC, hydrocarbon generation potential, T_{max} and mean vitrinite reflectance in oil (R_{omv}) ranged among 40.13–70.02 wt%, 83.94–194.21 mg HC/g rock, 415–429 °C and 0.40–0.63 % respectively. The samples are dominated by admixed type II–III organic materials and have excellent hydrocarbon generation potential whereas, T_{max} values exhibit differently. The free hydrocarbon content under S1 of (REP) was larger in fusain. The calculated original Hydrogen Index (HI_O) is lower than the present day Hydrogen Index (HI_{PD}) values. It may be due to presence of some hydrogen-rich material like very fine-grained submicroscopic particles including per-hydrous vitrinites and inertinites with thermally unstable bonds [1].

Through FTIR analysis different functional groups such as long aliphatic CH_3-CH_2 bending, aliphatic C-H stretch, aromatic hydrogen and mineral matter such as kaolinite and quartz are identified in the coal samples. The FTIR analysis reveals the greater concentration of phenolic -OH in vitrain compared to those with in fusain bands. On the other side, mineral matter (mainly kaolinite and quartz) were more dominant within fusain bands. The presence of kaolinite as indicated by the peaks at approximately 3690 cm^{-1} and 3620 cm^{-1} is observed to be present within the fusain bands, while it is characteristically absent in the vitrain bands. The out of plane C-H bend appears to be masked by peaks of quartz within the fusain bands, which indicates larger mineral matter concentration within those bands. On the contrary, this bend is more clearly manifested in the FTIR spectra of the vitrain bands indicating lower mineral matter concentration within the vitrain. FTIR spectra of the shale samples depict weak aliphatic C-H stretches which may be attributed to their lower TOC content. In the shales, samples peak at approximately 1600 cm^{-1} implying the presence of both aromatic as well as water of KBr. However, the proportion of aromatics may be low due to the lower TOC content. The peak observed at approximately 1435 cm^{-1} in the shale samples may be attributed to the presence of carbonates. The moisture (W^a), volatile matter (VM^{daf}), Ash (A^d) and fuel ratio of coal samples placed in the range of 5.40-7.81, 38.87-45.75, 12.09-17.63 wt % and 1.19-1.57 respectively.

The technological characteristics indicate that the coals are non-coking, high volatile bituminous coal. Petrographic ratios like gelification index (GI), tissue preservation index (TPI), vegetation index (VI) and ground water index (GWI) indicate the formation of peat under wet forest swamp or limnic conditions, which appears to be substantiated by Relative Hydrocarbon Potential ratio [RHP = (S1+S2)/TOC].

Furthermore, XRF studies have shown that the samples suffered severe weathering [2] characterized by presence of clay minerals chiefly illite and kaolinite. In addition, SEM investigations elucidate intimate mixing of organic matter and mineral matter.

References:

[1] Varma AK et al. (2015) Mar Petrol Geol 59: 480-490
[2] Nesbitt HW, Young GM (1984) Geochim Cosmochim Acta 48: 1523-1534