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Title of Thesis: Evolutionary history of the Rampur Shale: Its lithology, biota, structure and geochemistry

ABSTRACT

The term 'Shale' has been used to describe fine-grained sedimentary rock, largely terrigenous particles with dominance of mud-size particles, containing substantial amount of clay minerals content and fine siltstones. The shales are most important rocks because they constitute by volume almost two-third of the sedimentary rock record, excellent matrix for fossil preservation and may contribute much to a better understanding of earth processes, earth history and evolution of life. The black shales which are rich in organic carbon and present in major part of the studied succession are even more important because they exclusively preserve a wealth of information about the Earth's ancient processes and conditions owing to its unique geochemical signatures. At the outset of the present study a detailed review of the black shales, considering its global distribution and different important aspects (physical, geochemical, biological, biogeochemical etc.) has been done to feel the importance of the present study.

The current study deals with 1.5 billion years-old Rampur Shale (RS) Member of the Rohtas Formation of the Semri Group, Vindhyan Basin of Son valley, Central India and presented a detailed sedimentological, geochemical attribute of the shale and an exceptionally coveted geobiological writ preserved particularly within the black shale part of the Rampur Shale. Eliciting the depositional modes of ancient shale rock is difficult because of its fine grain-size and needs a well-organized classification. A state of art facies analysis has been performed during the present study to gain insight about the palaeoenvironmental dynamics in a Mesoproterozoic basin where the Rampur shale was deposited. The apparent monotony of the finely laminated Rampur shale is broken by the intermittent presence of sandstone/siltstone alternation, mostly present in the lower part of the Rampur shale. Considering the sand: shale ratio, primary sedimentary structures, colour and body geometry of the sand/silt layer present within the shale a lower shoreface to deep marine paleogeography has been suggested for the Rampur Shale. Intermittent presence of laterally persistent sandstone/siltstone layers likely to be deposited by occasional storm intervention. Considering the sand: shale ratio present within the Rampur Shale, it has been subdivided into three segments. The lower segment is sandstone dominated (Facies A), followed by the middle segment consisting of sand-silt interlayering with shale (Facies B, C and D). The upper most segment is almost sand free (Facies E and F). The major part of the RS is forming a transgressive system tract except the uppermost facies F, which show initiation of a highstand system tract (HST). The ca.10-meter-thick black shale (BS) unit (Facies E) suggests a basin-wide marine transgression forming the maximum flooding zone (MFZ). The BS imparts a dark hue due to the preservation of organic matter in the form of abundant microbial mat growth on the sediment surface. The $\delta^{13}C_{org}$ ratio of the BS ranges between -25‰ and -34.4‰ supports this view. Several geochemical proxies suggest that the provenance could be felsic sediments. The weathering intensity was high, and the Rampur shale including the black shale part was deposited under humid climatic conditions. The palaeoredox proxies of BS suggest suboxic to anoxic depositional conditions, possibly resulting from organic matter degradation. The palaeosalinity remains low for the entire Rampur shale, possibly due to the abundant riverine freshwater supply in the epicontinental basin. The trace metal proxies suggest upwelling conditions during the BS deposition.

Numerous slide planes at successive intervals bear the signature of basin subsidence and deepening, resulting in black shale formation.

Deep-time microbial record is generally indirect, but some fortuitously preserved microbial remains makes the Rampur Shale interesting and an exceptionally coveted geobiological writ. Amongst the three distinctive segments the lower and the upper one are particularly productive. Field observations are augmented by microscopic and ultramicroscopic studies (SEM and CLSM) and followed by geochemical analyses with help of EDS. The bottommost all sandstone intervals bear numerous cracks, even though the sandstones are matrix-free. At places, the cracks are confined within the ripple troughs resembling Munchuriophycus; in a few examples, the cracks are mutually parallel in oblique direction with respect to the ripple crests. Locally the cracks are in multiple sets cross-cutting each other. The fifth interval is, in contrast, almost entirely shale that does not show any fissility plane because of being sewn through by microbial filaments. Three different kinds of microbial mat geometry are present: dark laterally persistent wrinkled mat, darker lenticular mat and darkest spherical mat. All the varieties of mat are carbon-rich. All are penecontemporaneously dolomitized, but their dolomite populations differ little in composition. Cyanobacterial filaments are preserved in form of networks both within black shale and impervious volcanic ash beds; however, patches of organic matter are revealed elsewhere too under confocal microscope. Many forms of other bacteria are also revealed under SEM. Wherever measured these elements reveal high content of carbon.

The glauconite grains occur at the middle segment (more within Facies B and D and in less amount within Facies C) is another important issue have been delt in the thesis. Their main concentration is, however, where the pyroclastic materials are most conspicuously present. Pyroclasts themselves bear glauconite patches mostly non-pelletal. Nevertheless, free glauconite grains in their close association are mostly perfectly pelletal and green in colour. Numerous stockwork silica veins separate them from each other and fragments of pyroclasts. Fine chalcedony crystals have grown vertically from the grain surfaces all around them and rest of the grain interstices are filled by colloidal silica. In areas adjacent to the pyroclastic bodies glauconite also occurs as intergranular cement that very often cracks to give rise to the pellet-like form. Further away from the pyroclastic bodies laterally or stratigraphically upward stratified glauconite pellets occur preferably in relatively coarser-grained layers, silty or sandy. Within shales their presence is meagre. However, as a whole glauconite concentration is the highest within facies B and D which decreases to only 10–15% of the rock by volume in facies C. Despite the variation in glauconite pellet morphology and concentration, the compositional spectrum of the glauconite exhibits strongly overlapping K_2O and Fe_2O_3 (total) concentration, representing a highly-evolved maturation stage. The micro-textural study of the green pellets and the mineralogy validate the highly mature state of glauconite. The rare earth and trace elemental geochemistry of the Rampur Shale Member suggests the prevalence of weathering under warm and humid conditions. The glauconites of the Rampur Shale Member are formed by the pseudomorphic replacement of the framework grains, including the pyroclastic fragments, by a substantial intake of iron and manganese at the expense of aluminium and silicon. The low oxygen environment during the Mesoproterozoic time and occasional subsidence during the deposition of the Rampur Shale might have facilitated the mobility of iron, resulting in abundant authigenic glauconite formation. The glauconites from the Lower Vindhyan succession, confined within the Rampur Shale Member and the underlying Chorhat Sandstone, are abnormally rich in MgO, which is not observed for the glauconites within the Upper Vindhyan sediments, suggesting a strong influence of Mg-rich oceans in glauconite composition or the Pyroclastic/microbial source may be responsible for the higher Mg content.

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