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Controls of phosphogenesis on the Western Continental Margin of India

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Systematic seabed mapping and mineral exploration surveys by Geological Survey of India (GSI) within the Exclusive Economic Zone (EEZ) off the west coast of India led to the discovery of phosphorite from many locations along the continental shelf margin areas. Here a comparative examination of the phosphatic materials reported newly from I) Okha spur off Gujarat, II) Angria Bank off Maharashtra and III) Manthan North mount off Goa and the earlier reported occurrence from the IV) topographic high off Goa, V) carbonate platform off Maharashtra-Goa-Karnataka, VI) continental shelf off Maharashtra and VII) Quilon Plateau off Kerala is attempted to understand the various controlling factors like supply of organic matter, sub-oxic environment and seafloor topography.

Phosphatic material occur as concretions (upto 15 cm) or slabs (<1m thick) at sites I to IV, while as phosphatized oolites at site V, as coating on algal lime stones at site VI and as coating over tubes formed on crustacean tracks in the muddy sediment at site VII at water depth ranges of 360-800m, 650-850m, 329-436m, 320m, 73-118m, 70-150m and 260-300m, respectively. The P_2O_5 content of the recovered materials are 1.2-22.5wt.% (site I), 17-27wt.% (site II), 25-27wt.% (site III), 32.75wt.% (site IV), 0.07-0.109wt.% (site V), 0.8-10.8wt.% (site VI) and 4.9-7.6wt.% (site VII). It is apparent from the phosphatic concentration and their corresponding water depths that, the zone of enrichment coincides with the present day Oxygen Minimum Zone (OMZ-150-1200 m) of Northern Indian Ocean. High resolution multibeam bathymetric maps available for the sites-I to III & VI reveals that, amongst the reported occurrences, the highly enriched phosphorites (P_2O_5 >20 wt.%) with sizeable growth (few cm sized concretions and slabs) are occurring towards the margin of the continental shelf particularly on the marginal or plateau-like topographic highs that are isolated from the continental shelf by valleys or channels. This observation reveals that isolated seafloor topographic highs within the OMZ with low sedimentation strongly favoured phosphogenesis. Based on highly indurated nature and multiple growth textures in phosphorites, intense and prolonged events of phosphogenesis has been inferred at sites-I to IV, while short interval of phosphogenesis has been inferred for phosphathized oolites at site-V

and coating over tubes at site-VI.

It is also important that the P_2O_5 content in the phosphatic materials of the area, do not show any linear relationship with the present-day productivity zones (sites-I, II, III and V falls in the present-day intermediate surface water productivity zone; sites-IV and VI are in the low productivity zone; site-VII is at the high productivity zone) as the highest P_2O_5 enrichment is encountered at present day low productivity zone and vice versa. Significantly high Fe_2O_3 (~20wt.%) content in ferruginous phosphorite from site-II and III indicate that they were grown at the expense of Fe-rich sediments as well as fluctuating Fe-redox condition persisted at the sediment-water interface. Meanwhile at site-I, concretions recovered from the surface of sea floor sediments are characterized by the low Fe content (Fe_2O_3<5wt.%) and enriched in pyrites indicating that phosphogenesis was mainly controlled by the availability of high organic content than Fe-rich sediment. Abundant fossilized *Beggiatoa* structures in the concretion provided evidence for phosphogenesis enhanced by microbial activities. A sub-oxic to anoxic highly fluctuating depositional environment has also been inferred based the co-existence of carbonate flourapatite with pyrite at site-I. Considering various lines of evidences it is deduced that the phosphogenesis at these sites are contemporaneous with the Mid Holocene-Late Pleistocene (5.8-13.9 ka for site VI and 6.5-33 ka for site VII) age of phosphorites reported from west coast of India.