Goldschmidt 2024 Abstract
https://doi.org/10.46427/gold2024.21723

Neoarchean Ocean oxygenation and biogeochemical harmony

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Oxygenation of the Archean oceans and the emergence of oxygenic photosynthesis are the most significant geological events which have contributed towards transforming the planet Earth habitable and conducive to the development of complex life forms. The evolution of the ancient biogeochemical cycles is directly linked to the physico-chemical conditions of terrestrial reservoirs, especially the redox potential of the Precambrian oceans. The scarce preservation of Archean biomarkers and microfossils emphasizes the importance of stable isotopic systematics of marine sedimentary records in understanding the ancient biogeochemical interplay as well as the Earth's surface oxygenation. Due to inherent sensitivity of manganese (Mn) to fluctuating redox conditions and inclination to undergo phase transitions during biogeochemical cycling, Mn formations are promising tools to probe into Archean Ocean conditions. Although Mn is distributed with uneven spatio-temporal distribution, limited Archean occurrences offer significant insights on the availability of free oxygen in the Neoarchean oceans. The Archean manganese deposits of Dharwar Craton are unique in terms of their association with manganiferous stromatolitic dolomites, BIFs, carbonaceous shales which are present in Chitradurga, Sandur and Shimoga greenstone belts. Mn-arenites- Fe-arenites- Mn-argillites- Fe-argillites- banded Manganese Formations- BIFs are preserved as stratigraphic sequence at the western margins of these greenstone belts. The detrital zircons yielded from the Mn arenites/argillites display U-Pb ages ranging from 3.2-2.7 Ga and their geochemical signatures indicate clastic-chemogenic sedimentation through the mixing of Fe-Mn rich hydrothermal fluids and seawater at the passive margins resulting in their precipitation at the higher Eh region. Redox proxies such as enrichment factors of Mo, U, authigenic U from the manganese formations correspond to oxic to sub-oxic conditions suggesting the persistence of regionally oxygenated water columns in Neoarchean ocean basins. The negative δC^{13}_{org} values ranging between -23.3 to -26.7‰, recorded from the manganese ore of Dharwar Craton indicate organic carbon signatures through oxygenic photosynthesis, supported by their association with stromatolitic carbonates. Thus, the chemical precipitation of redox-sensitive metals is proposed to have reversed the toxicity of the ancient oceans favouring the proliferation of early microbial life and contributing to the development of a more habitable planet.