Mesoarchaean oxidative shallow marine environment in the Pongola Supergroup, South Africa

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The c. 3.0 Pongola Supergroup is the oldest continental volcano-sedimentary succession deposited on the southeastern Kaapvaal Craton in South Africa and Swaziland, and hosts some of the oldest carbonate rocks on Earth. Sedimentary carbonates older than 2.9 Ga are extremely rare in the geological record due to the absence of physico-chemical conditions in the oceans favouring biogenic and/or abiogenic carbonate precipitation.

The stromatolite-bearing carbonate rocks of the Nsuze Group, Pongola Supergroup, are intercalated with shallow-marine siliciclastic deposits, and locally contain mafic-ultramafic ash-fall deposits. Microbialites occur in deep subtidal to supratidal shallow marine environments. They are locally closely associated with ash-fall lapillistones, which suggests that volcanic activity may have provided local geochemical environments ideal for microbial colonization and development.

The negative $\delta^{18}O$ (-11.9 to -19.7 ‰ VPDB) and radiogenic Sr isotope (Sr_i = 0.708 to 0.770) values of the carbonates are explained, in part, by isotopic exchange with a non-carbonate fraction during alteration and, possibly, by high continental influx into the epicontinental setting in which the carbonates were deposited. Petrographic and geochemical evidence which suggests the presence of oxygenic photosynthetic bacteria includes 1) the presence of conical stromatolites with features such as crestal thickening and inclination in different sets of laminae, similar to those that have oxygenic photosynthetic metabolism; and 2) a negative Ce anomaly (Ce/Ce*= 1.05 to 1.12) in carbonate rocks, indicating that seawater from which carbonates precipitated was oxidative. The localized oxidative removal of dissolved Fe^{2+} by photosynthetic microorganisms may have led to the carbonate precipitation within a restricted shallow marine setting. This does not preclude abiogenic carbonate precipitation.