Fine-grained carbonates in mid-Archean 'Oxygen Oases': Origins and implications for CO_2 level

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Fine-grained carbonates are widespread in late Mesoarchean (2.8-2.95 Ga) shallow marine platform interior limestones and dolostones in south-central Canada [1]. Neomorphism obscures the original grain-size but their mesoscopic fabrics are typical of carbonate mud deposits. These putative fine-grained sediments are very common among associated carbonate fabrics that include stromatolites, fenestral-laminites, seafloor herringbone and crystal crusts. Since stromatolites are present but not very abundant in these Archean platform interiors, oxygenation was possibly mainly accomplished by planktic rather than benthic cyanobacteria, whose distribution may reflect higher nutrient levels in nearshore environments [2].

We infer that in these Archean 'Oxygen Oases' [3], fine-grained carbonates originated as water column 'whitings', precipitated as a result of oxygenic photosynthesis. Either or both of two processes may have operated: (i) Oxidative removal (by molecular oxygen) of dissolved iron and/or (ii) Cyanobacterial CO_2-concentrating mechanisms (CCM) that cause pH increase adjacent to cells. CCM are only induced in present-day cyanobacteria when CO_2 becomes a limiting factor at ≤12 x PAL [4]. Calculations indicate that neither mechanism is excluded by current estimates of mid-Archean seawater chemistry. This fossil proxy for atmospheric CO_2 level would constrain climate models and Faint Young Sun interpretations.

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[3] Riding, Fralick & Liang (2014), Precambrian Research 251, 232-237.
[4] Riding (2006), Geobiology 4, 299–316.