Precambrian Submarine Arc Volcanoes: Deep-Water Hydrothermal Oases for Anoxygenic Iron-Oxidizing Phototrophs?

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The redox states of pre-Cryogenian deep oceans involve anoxic and ferruginous conditions tempered by periodic oxygenation, chiefly in the Paleoproterozoic [1]. In contrast, transitional and/or local suboxic conditions are implied from the Mesoarchean to Ediacaran, based on occurrences of hematite-rich jasper and/or magnetite-rich iron formation closely associated with Cu-rich and deep-water (>800 m) volcanogenic massive sulfide (VMS) deposits [2]. Geological settings suggest that some of these Fe^{3+}-rich exhalites formed in or near submarine arc volcanoes. Previous models for the Fe^{3+}-rich exhalites invoked suboxic bottom waters [2]. Here we present an alternative model in which ferric iron was produced in deep anoxic waters proximal to hydrothermal vents by anoxygenic iron-oxidizing phototrophs using infrared radiation, via the following reaction:

$$4Fe^{2+} + 11H_2O + CO_2 \leftrightarrow [CH_2O] + 4Fe(OH)_3 + 8H^+$$

Our model is supported by high CO_2 contents (up to 206 mM/kg) of vent fluids in modern arc volcanoes [3] that would be conducive to autotrophy, and by the discovery of phototrophic green sulfur bacteria in anoxic vent fluids and plumes at 2390 m water depth on the East Pacific Rise [4]. Hydrothermal plumes that rose to the base of the photic zone as in some modern submarine arcs [5] may also have favored photoferrotrophs. It is unknown, however, if these types of microbes could have generated the flux of ferric iron necessary to form laterally extensive Fe^{3+}-rich exhalites.

[1] Lyons T.W. *et al.* (2014) *Nature* **506**, 307–315; [2] Bekker A. *et al.* (2014) *Treatise on Geochemistry* **7**, 561–628; [3] de Ronde C.E.J. *et al.* (2011) *Miner Deposita* **46**, 541–584; [4] Beatty J.T. *et al.* (2005) *PNAS* **102**, 9306–9310; [5] de Ronde C.E.J. *et al.* (2001) *EPSL* **193**, 359–369.