

Chromium enrichment in iron formations record Earth's first acid rock drainage during the Great Oxidation Event

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Iron formations (IF) are iron rich (~20-40% Fe) and siliceous (~40-50% SiO₂) sedimentary deposits that precipitated throughout much of the Precambrian. Their trace element composition have been used as a proxy for ancient seawater chemistry, with the view of better understanding nutrient availability for the ancient marine biosphere [1, 2]. Recently, their composition have also provided new insights into the chemical weathering processes on land and the transfer of solutes to the ocean. For instance, a recent compilation of Cr enrichment in IF shows a profound enrichment at 2.48 Gyr, coincident with the advent of the Great Oxidation Event. Given the insolubility of Cr minerals, its mobilization and incorporation into IF indicates enhanced chemical weathering at that time, most likely associated with continental pyrite oxidation. Today, aerobic chemolithoautotrophic bacteria are essential to this process, catalysing the continued oxidation of Fe (II) as pH values drop below the threshold for inorganic Fe (II) oxidation. We suggest that the Cr pulse beginning 2.48 Gyr ago indicates that such bacteria began utilising O₂ for the first time to oxidise a previously stable and abundant crustal pyrite reservoir. Sulphuric acid generated by this metabolism ultimately leached Cr from ultramafic source rocks and residual soils. This profound shift in weathering regimes constitutes Earth's first acid rock drainage and accounts for independent evidence for increased supply of sulphate and sulphide-hosted trace elements to the oceans at that time.

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Deep versus shallow slab melt signatures recorded by Nb/Ta in modern island arc lavas

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The Solomon Islands cover over 1000 km of the SW Pacific plate border and constitute a modern intra-oceanic arc system devoid of subducted sediments and continental crust. Due to a change of subduction polarity, an Eocene deeply-subducted Pacific slab and a shallower, recently subducting Indian–Australian slab remain in the subarc mantle at depths of >100 km and 35-80 km, respectively [1]. Slab melt-related lavas from the Solomons therefore provide unique insights into the residual mineralogy of two slabs at different depths and their influence on the geochemical signatures of shallow and relatively deep slab melts.

Mafic to intermediate slab melt-related lavas from the southwestern volcanic chain of the Solomon Islands show the largest range of Nb/Ta ever reported in a single modern subduction environment. They range from low, subchondritic Nb/Ta (min. ~10) to superchondritic values (max. ~27) that correlate with slab melt signatures (e.g. Gd_N/Yb_N) [2]. Isotope dilution MC-ICP-MS data confirm this large range of Nb/Ta observed in Q-ICP-MS data. One minor slab melt component characterised by a low Nb/Ta is derived from the shallow and recently subducting Indian–Australian plate where amphibole is still a significant residual phase. In contrast, the high Nb/Ta signatures can only be explained by enrichment of the sub-arc mantle source by partial melts from subducted oceanic crust in the presence of residual rutile-bearing eclogite, where amphibole is either a minor phase or entirely absent. Only the old subducted Jurassic Pacific slab is located at depths required for such mineral assemblages. The slab melts that enriched the sub-arc mantle with an unusually high Nb/Ta signature are derived from an initially intact Pacific plate that was probably subject to a slab break-off event and subsequent melting at depths >100 km. Pb isotope data support a Pacific origin of these slab melts [3]. Altogether these geochemical constraints support recent geophysical studies in that partial slab melting may also affect initially intact oceanic plates older than 50 Ma [e.g. 4].

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