Rare earth element signatures of metal-rich hydrothermal ferromanganese deposit in the South-West Pacific

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A metal-rich hydrothermal ferromanganese deposit was discovered in the south-west Pacific during a French cruise [1]. The deposit formed at ridge axis and is hosted by pyroclastic rocks (e.g., hyaloclastite, tuffite, pumice). Mineralogical and geochemical investigation shows evidence of vertical zonation with depth. From top to bottom, we distinguished highly Ni-enriched manganese oxyhydroxides (Ni up to 4.6%) then iron oxyhydroxides ± nontronite with low metal concentrations, and barren nontronite. Here, we report rare earth element (REE) data for Fe-Mn oxyhydroxides and nontronite samples. All samples exhibit very low REE abundance (ΣREE: 12.6 – 92.7 mg/kg) and relatively low middle REE / heavy REE ratios (Nd_n/Yb_n= 0.52 – 2.13). This signature is characteristic of low temperature hydrothermal Fe-Si-Mn mineralization [2]. All samples have a slight negative Eu anomaly while the Ce negative anomaly is well developed (Ce/Ce*: 0.04 – 0.89) and negatively correlated with Mn/Fe ratio (Mn/Fe: 0.14 – 80). This opposite correlation might implicate a strong mineralogical control of Ce content in Fe-Mn oxyhydroxides possibly related to pH [3]. This observation is to be qualified as the lack of correlation between the ΣREE and Mn/Fe ratio leads to think of the differential state of the phase's crystallinity as a control factor of the REE fractionation rather than its mineralogical nature [2].

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Volcanoes, asteroid impacts and mass extinctions: A matter of timing

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The history of life on Earth is punctuated by large mass extinction events, with five large ones occurring in the Phanerozoic and several smaller ones occurring between them. Isotopic and elemental chemistry shows that the extinctions are somehow linked to drastic climate changes.

The Cretaceous-Palaeogene (K-Pg) extinction event is well-documented, but controversy as to whether this was caused by an asteroid impact or the Deccan Traps has raged for many years [1,2], in particular because both events are demonstrably synchronous witht the K-Pg boundary [3].

One important question is wether other significant extinction events were caused by impact, volcanism or the combination of both? To test these hypothese, impacts and/or volcanic eruptions *must* be exactly synchronous with a mass extinction.

Quality-filtered age compilations show that whereas at least six large volcanic province – mass extinctions pairs have been recognized (including the newly added Kalkarindji – Middle Cambrian extinction pair at 510 Ma; [4]), only one asteroid – mass extinction pair has been demonstrated [5]. A possible synchronicity between extinction and impact candidates can be tested using precise geochronology. For example, our $^{40}Ar/^{39}Ar$ data on the Siljan Impact structure [6] show that the impact occur several million years before the Frasnian-Fammenian boundary (~376 Ma). New data on Popigai and Chesapeak Bay [7] show that the two events are older than the mid-Eocene extinction. Some impact events (Rochechouart [8]; Araghuaina [9]) have ages that make them time-compatible with a major extinction levels, but there small sizes (20-40 km) rule out any possible link.

At the face value of the current age database, large outpouring of lava is a more recurent kill factor in the evolution of life than large impacts. Nevertheless, and largely understudied, is the potential of impact cratering events to have fostered life evolution [e.g., 10].

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