Paleoenvironmental investigation of the Proterozoic Hokkalampi paleosol, eastern Finland

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Precambrian soil profiles (paleosols) are important records of terrestrial conditions during early Earth history. To better understand Proterozoic paleoenvironmental conditions, we have begun an isotopic and trace element study of the Hokkalampi paleosol in eastern Finland. Stratigraphy and Sm-Nd ages constrain soil formation to 2.1 to 2.5 Ga [1], possibly overlapping with the proposed "Great Oxidation Event" at ca. 2.1 Ga [2]. The weathering profile formed on Archean basement and glaciogenic material and is unconformably overlain by metasediments. The sequence underwent greenschist metamorphism at 1.9 Ga [3].

Speciation and mobility of metals (particularly redox-sensitive elements like iron) are often used to constrain redox conditions during pedogenesis. Rare earth element (REE) patterns for two sections of the Hokkalampi paleosol (Nuutilanvaara and Paukkajanvaara) exhibit strong LREE enrichment, consistent with the pattern expected for weathered granodiorite [4]. Both have >40% iron loss at the top of the section and an enrichment in total iron and Fe^{3+} down profile. Europium (Eu) is depleted in the upper part of the Nuutilanvaara section, most likely due to weathering removal of plagioclase. A small negative cerium (Ce) anomaly in the same part of that profile indicates REE accumulation from an oxidized zone above, and suggests possible decoupling of expected behaviours for Fe and Ce in the upper Nuutilanvaara profile. In contrast, the topographically lower Paukkajanvaara section does not have a Ce anomaly, in agreement with Marmo's [3] interpretation that this section formed under reducing conditions, possibly below the paleowater table.

References

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Strontium isotopes in the Red Sea-Gulf of Aden during the past 530 kyr: the role of hydrothermal and "erosional" components during glacial interglacial cycles

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We report on investigation of the behaviour of strontium isotopes during the past 530 kyr (marine isotope stages 1 to 14) in the Red Sea – Gulf of Aden (GOA) system. This system provides a unique geological setting for the assessment of the relative contributions of hydrothermal and "erosional" strontium to seawater during glacial-interglacial (G-I) cycles. This is because the Red Sea turned into a closed basin during glacial periods, and it contains one of the most active deep-sea hydrothermal systems, while the GOA is opened to the Indian Ocean. We analyze planktic forams and HCL-insoluble residue (< 63 μm) from two sedimentary cores, one located in the central trough of the Red Sea near the Atlantis Deep, and the other in the GOA. The GOA forams show secular trend of increase in the $^{87}Sr/^{86}Sr$ ratios, from 0.709140 to 0.709185. The maximum ratio (0.709195) is reached during isotope stage 5.5, and then it declines to the present day ratio of 0.709185. The $^{87}Sr/^{86}Sr$ of the Red Sea forams generally follow the GOA trend but they show larger G-I fluctuations and yield a significantly lower $^{87}Sr/^{86}Sr$ ratio of 0.709152 during the last Glacial period. This probably reflects an enhanced hydrothermal activity during low sea level and closed basin conditions.

The HCl-insoluble residues display large variation in $^{87}Sr/^{86}Sr$ ratios, which is comparable to total range of Phanerozoic seawater. The Red Sea and GOA samples lie in the ranges of 0.7066 to 0.7085 and 0.7076 to 0.7108, respectively. The lower ratios in the Red Sea insoluble residue converge to the compositions of hydrothermal water from the Red Sea brines, while the higher ratios shown by the GOA insoluble residues represent an "erosional" contribution. An enhanced contribution of the "erosional" strontium during interglacial episodes is indicated by higher $^{87}Sr/^{86}Sr$ ratios in the residues.