Paleoceanographic interpretation of the light rare earth elements

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The rare earth elements (REE) in sea water have been used as indicators of the modern oceanic and paleoceanic environments. The Nd-isotopic composition (εNd) of ferromanganese crusts and nodules successfully record water mass changes integrated over 10^4 and 10^5 years; fossil fish teeth and debris pinpoint water mass changes through the Cenozoic, though also with low temporal resolution due to the scarcity of fish remains [*2; 3*]. Records of much higher temporal resolution have been produced from the εNd of bulk sediment leach, and over glacial-interglacial timescales [*4*]. Isolating the εNd of seawater from lithogenic contamination, however, is problematic. Detrital contaminants are much more easily removed from planktonic foraminifera and therefore may be more representative of a seawater signal [*1*]. The phase in which the εNd is associated with foraminiferal calcite is of critical importance for the paleoceanographic interpretation. In addition to Nd, the full sequence of rare earth elements can speak to diagenetic indicators and bottom-water conditions in which the authigenic signal is acquired. Studies of coupled planktonic benthic REE comparison allow for clear indications of diagenetic overprinting. Here, we present data from the Iberian Margin that demonstrate coherent, diagenetic signals indicative of environmental conditions associated with climate signals. Also, we present data generated using X-ray absorption near edge structure analysis that help to identify fine-scale spatial distribution of high concentrations of REE and also the oxidation state of redox sensitive cerium. With a combination of paleorecords and different analytical approaches, we can begin to identify the distinct phases of the REE and as a result, the paleoceanographic interpretation of these elements.

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Petrology of syn-orogenic S-type leucogranites (Damara orogen; Namibia) – Constraints from Sr, Nd and Pb isotopes

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The northern central zone of the Damara Orogen (Namibia) consists of metasedimentary rocks, Pan-African syn- to late-tectonic granites, and rare basement gneisses. Leucogranites of S-Type character with ages of ca. 510-515 Ma appear to be little fractionated although the two suites have high K_2O (5.7-7.3 wt%), Th (30-74 ppm), and U (3-13 ppm) abundances and moderately high but relatively constant Rb/Sr ratios (2.7-4.4). High light rare earth elements but variable heavy rare earth elements concentrations result in high and variable La_n/Yb_n ratios ranging from 16 to 98, suggesting involvement of garnet during crustal melting. The granites have, relative to other syn-tectonic S-type suites from the Damara orogen, more unradiogenic $^{87}Sr/^{86}Sr_{init.}$ ratios (0.7095-0.7140 vs. 0.7150-0.7340). ε–Nd values range from -4.5 to -6.5; the majority of values being similar to those from syn-tectonic S-type granites (ε–Nd -3.0 to -5.5) and match those found in metasedimentary xenoliths (ε–Nd -5.0 to -7.0) from these syn-tectonic S-type granites. The Pb isotopic composition of acid-leached feldspar is broadly similar to the one of metapelitic xenoliths in Damaran syn-tectonic S-type granites suggesting that the leucogranites are derived from isotopically similar metapelitic rocks. Zircon saturation temperatures are high for crustally derived granites, but well within the range commonly accepted for S-type granites (800-840°C). U-Pb monazite ages and Rb-Sr whole rock ages indicate that the leucogranites intruded simultaneously with the main peak of metamorphism. The heating event that promoted melting of fertile rocks at depth might have been subsidized by high heat productivity, which is also reflected in the elevated K, Th, and U abundances of apparently unfractionated granites, and crustal thickening during the Pan African orogeny.