The magmatic and metasomatic formation of zircon in the Nechalacho deposit at Thor Lake, Northwest Territories, Canada

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The Nechalacho Rare Metal Deposit represents a world-class resource of REE, Y, Nb, Ta, Zr and Ga. Two densely mineralized horizons are hosted in intensely altered rocks of the upper part of the Nechalacho Layered Syenite Suite. These evolved, fluorine-rich peralkaline rocks are dominated by acmite, annite, sodalite, nepheline and feldspars. Primary REE- and HFSE-minerals include eudialyte, zircon, pyrochlore, britholite and Na-zircono-silicates. During alteration, eudialyte syenites were converted to an assemblage of zircon, quartz, magnetite and phlogopite. Secondary REE- and HFSE-bearing phases in the two REE-mineralized horizons comprise zircon, fergusonite, allanite-(Ce), bastnäsite-(Ce), synchisite-(Ce), parisite-(Ce), monazite and columbite[1].

The average whole rock content of ZrO_2 ranges from 2 to 3 wt. % and locally exceeds 10 wt. % in the deposit, making zircon an important rock-forming mineral. Three textural types of this mineral have been recognized: 1. rare magmatic phenocrysts in fresh or partially altered syenite; 2. quartz-hosted euhedral zoned crystals in the upper mineralized zone; 3. unzoned subhedral crystals intergrown with quartz in pseudomorphs after eudialyte in the lower mineralized zone.

Based on new Laser ICP-MS and electron microprobe data, magmatic zircon has a low trace element content (e.g., 80 to 6500 ppm REE) and displays heavy REE-enriched, near-linear chondrite-normalized profiles with strong positive Ce and negative Eu anomalies (avg. Ce/Ce*=3.4, avg. Eu/Eu*=0.44). Secondary type 2 and 3 zircon varies widely in composition, is strongly enriched in REE, Y, Nb and F, has elevated P and displays non-linear chondrite-normalized REE profiles with weak or absent Ce anomalies and strong Eu anomalies. Type 2 zircon has an average content of 2.3 wt. % REE, 1.1 wt. % Y and 1.3 wt. % Nb, has light and heavy REE enriched rims and cores respectively and contains significant fluorine. Relict magmatic cores and rims in the upper zone are distinguished by their low REE-contents and positive Ce anomalies which are comparable to type 1 zircon. Secondary zircon in the lower zone (Type 3) is strongly enriched in heavy REE and contains 2.8 wt. % REE, 1.7 wt. % Y and 1.6 wt. % Nb on average.

The HFSE mineralogy suggests that miaskitic and agpaitic rocks occurred in close spatial association. Metasomatic-hydrothermal replacement of both magmatic zircon and zircono-silicates was important for the formation of REE-enriched varieties of zircon. A possible mechanisms for the incorporation of such high levels of the REE is the formation of hydrated varieties at the alteration stage.

[1] Sheard, E.R, Williams-Jones, A.E., Heiligmann, M., Pederson, C and Trueman, D.L. (2012) *Controls on the concentration of zirconium, niobium, and the rare earth elements in the Thor Lake Rare Metal Deposit, Northwest Territories, Canada* **Economic Geology 107**, 81-104.

Deglacial forcing of rapid deoxygenation and seafloor ecological change, Santa Barbara Basin, CA

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Background

Deglacial sediment from Santa Barbara Basin (SBB) are high-resolution records of regional climate, intermediate and surface water processes, and benthic ecology. Patterns of bottom water oxygenation in sediment records, and thus the presence of Oxygen Minimum Zones (OMZs), can be reconstructed by proxy using the oxygenation and environmental tolerances of modern taxa. We construct a record of deglacial community ecology, intermediate water oxygenation and coastal oceanography for SBB (34° 15'N, 119° 45'W) using a core from the northwestern basin slope at 418 m water depth (MV0811-15JC).

Results

The 9.2m core, which spans 4-16ky, is completely bioturbated. Significant faunal community deoxygenation horizons are evident at deglacial Termimation 1A (~14.5 ky) and 1B (~10.9 ky), demarcated by the loss of ostracod, mollusc and brittle star fossils. The faunal record has high-resolution structure across taxa groups, indicating that stressful hypoxic events occur very rapidly at this depth. Results indicate the capacity for both rapid and sustained expansion of OMZs, the gradation of biological responses, and the spatial oceanographic processes that impact oxygenation across the coastal basin feature through the deglaciation.

Figure 1: Spetangoid heart urchin fossills in deglacial marine sediment, Santa Barbara Basin, CA. Note the biological orientation of the respiratory structures, indicating preservation at the time of death.