Geology and genesis of the Toongi rare metal (Zr, Hf, Nb, Ta, Y, REE) deposit, New South Wales, Australia

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Rare metal mineralisation associated with silicate magmatism is mainly hosted by alkaline plutonic rocks and pegmatites where the primary ore textures and mineralogy may be modified during slow cooling. The Toongi deposit, located near Dubbo in central NSW, Australia, hosts significant resources of Zr, Hf, Nb, Ta, Y and HREE within a small, rapidly-cooled trachyte laccolith, and hence, may provide unique insights into the primary processes of rare metal ore formation. Toongi is just one of many small Jurassic alkaline volcanic bodies in the region, which (based on bulk-rock geochemical and Nd isotope data) are interpreted to represent the extrusive products of highly-fractionated mantle-derived magma. Despite the common source, the Toongi deposit is distingushed from other trachytic bodies in the region by its peralkaline composition and economically-significant rare metal content that is homogenously distributed throughout the trachyte body.

The Toongi trachyte is fine- to medium-grained, sometimes porphyritic rock composed of aegirine and feldspar crystals with oscillatory zoning between K-feldspar and near end-member albite. The primary ore minerals are evenly dispersed throughout the rock and include natroniobite and complex Na-Fe-Zr silicate minerals that likely belong to the eudialyte mineral group, based on chemical composition and Raman spectroscopic analysis. These Na-Fe-Zr silicate phases account for more than 90% of the ore metal inventory. They occur in a unique textural setting in the rock, commonly forming spheroidal or irregular-shaped 'globules' (up to 300 μm) within the rock matrix. These globules are often protruded by aegirine and/or feldspar phenocrysts, and contain swarms of fine aegirine and feldspar grains that often form spiral or swirling patterns within the globule. Secondary ore minerals include REE carbonates, Y-milarite and a second phase of eudialyte that fill fractures and vesicles in the rock.

We propose an ore genesis model that involves extensive fractionation of alkaline parental magma under low fO_2 and low H_2O activity conditions. Limited volatile release allowed build-up of rare metal (+F) contents to ore grades. We speculate that the Zr ore minerals originally formed from rare metal rich sodic-silicate fluid or 'gel' that formed immiscible globules (subsequently crystallised to eudialyte) in the magma shortly before emplacement and rapid cooling.