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A mushy earliest silicic crust

OSCAR LAURENT[1,2], JANA BJÖRNSEN[2], JÖRN-FREDERIK WOTZLAW[3], JEAN-FRANÇOIS MOYEN[4], SIMONE BRETSCHER[2], MANUEL PIMENTA SILVA[2] AND OLIVIER BACHMANN[2]

[1]CNRS-Géosciences Environnement Toulouse
[2]ETH Zürich
[3]Institute of Geochemistry and Petrology, Department of Earth Sciences, ETH Zurich, Zurich
[4]Université de Lyon

Presenting Author: oscar.laurent@Get.omp.eu

The formation of the earliest silicic crust played a key role in the Earth's evolution towards a habitable planet, yet whether this formation involved plate tectonics, or different geodynamic settings, is hotly debated. This issue has long been addressed using the geochemistry of igneous rocks forming the backbones of the Archean cratons, i.e. granitoids of the tonalite-trondhjemite-granodiorite (TTG) suite. Compositional variations within this suite are indeed linked to distinct source depths and/or processes and, in turn, different geodynamic settings of magma generation.

However, this approach assumes that the bulk-rock compositions of TTGs are representative of melts that evolved in a closed system from deep source to shallow crystallization. The compositional diversity of Paleoarchean (3.46 Ga) TTGs from Barberton (South Africa) can be alternatively explained by crystallization from mushy magma reservoirs, formed by the differentiation of a single, parental tonalitic magma but affected by variable proportions of crystal-melt unmixing. The “high pressure” signature of some TTGs, interpreted as resulting from slab melting, is instead readily explained by plagioclase accumulation and does not necessarily imply a subduction setting for the earliest crust formation. More generally, this shows that filtering out the effects of mush dynamics is required to recover parental melt compositions and thus, identify the sources of granitoid magmas.

In addition, trace element concentrations of the Barberton TTG zircons reflect crystallization from the most evolved granitic melt, residual from differentiation of the tonalite parent. In samples affected by mineral accumulation/melt loss, this results in an apparent disequilibrium between zircon chemistry and bulk-rock compositions. Therefore, accessory minerals may record the composition of the melts, yet not necessarily the rocks, in which they formed. This is particularly important whenever detrital (i.e. out-of-context) accessory minerals are utilized to decipher global crustal evolution. For example, the composition of the Hadean Jack Hills zircons, also pointing to an evolved, granitic parental melt, is thereby permissive of a TTG source rock.