How much heat and REE in calcium silicate perovskite?

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A number of geochemical arguments suggest the existence of a deep mantle reservoir enriched in noble gases and heat producing elements and having a subchondritic $^{142}Nd/^{144}Nd$ ratio [1-4]. To test this hypothesis, the affinity of these elements for the phases involved in the differentiation of the deep mantle must be determined. Partitioning data between Mg- and Ca-silicate perovskites and silicate melts seem to forbid the long-term survival of a large perovskitic reservoir in the lower mantle [5-6]. These data indicate that the fractionation of such reservoir would have significantly altered the budget of the residual mantle in refractory lithophile elements, which is not observed. Despite some progress, the geochemical signature of the putative deep reservoir (either an accumulation of perovskites or a dense magma coexisiting with these minerals [7-8]) has remained unclear mainly because the affinity of REE, U and Th for Ca-silicate perovskite (CaPv) seems to be affected by the CaO melt content. This dependence may reflect a substitution mechanism involving Ca-vacancy formation, as observed on $CaTiO_3$, a low-pressure analogue of CaPv. Predictions based on this substitution mechanism indicate that the CaPv contents in REE, U and Th should increase significantly with decreasing CaO melt content. Since the experiments carried out so far have used CaO contents larger than values expected for the magma ocean, partitioning values appropriate to model mantle differentiation may have been greatly underestimated, leading to some uncertainties regarding the composition of the deep reservoir.

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Direct U-Pb zircon age dating of Archean basalts

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Greenstone belts are a hallmark of Archean cratons worldwide and provide important insight into early earth history. Integrating whole rock basalt geochemistry, high-precision U-Pb geochronology, and detailed geologic mapping indicates these assemblages often represent a collage of supracrustal rocks that can have a diversity of formation ages, possibly derived from various tectonic environments. One of the main limitations to accurate correlation of Archean supracrustal rocks is the difficulty obtaining high-precision ages for intermediate to mafic volcanic rocks, often the dominant lithologies in these sequences.

In this study, we demonstrate for the first time that it is possible to obtain high precision U-Pb zircon ages from Archean basalts. Samples were collected from thick (~20-100 meter) massive flows with quench textured pyroxene and plagioclase pseudomorphs but contain minor interstitial quartz ±biotite. A 100-m-thick flow located in the Cross Lake area yielded a small amount of colourless to tan resorbed zircon crystals. Three single abraded zircon grains display a large range in discordance (0.2-4.6%) but are collinear and define a discordia line with an upper intercept age of 2710±12 Ma, interpreted as the time of basalt eruption. A basalt flow in the Elk Island assemblage of the Gods Lake greenstone belt yielded a modest amount of broken colourless zircon prisms and shards up to 150 microns in length. Four zircon fractions all indicate high Th/U (4.8-5.8) and yield a weighted average $^{207}Pb/^{206}Pb$ age of 2729.0 ± 0.4 Ma, interpreted as the time of basalt eruption. This 2729.0 Ma eruption age is consistent with numerous other ages reported for the Oxford Lake Group throughout the region and demonstrates that accurate and precise U-Pb ages can be obtained from Archean basalts.