Re-Os constraints on the formation age of Acasta mafic rocks

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To unravel the early history of the Earth, it is necessary to study the oldest rocks. Acasta Gneiss Complex (AGC), located in the western part of the Slave Province, Canada, is one of the Eoarchean terrains, and mainly consists of 3.6-4.0 Ga felsic and layered gneiss suites (e.g. [1, 2]). The absolute age of minor mafic rocks occurring as enclaves within the felsic gneisses still remains unknown because of no magmatic zircons in the rocks (e.g. [3]). The analyzed samples still preserve magmatic features, and are distributed over the AGC. They have basaltic compositions with 48-51 % SiO_2 and 5.4-7.8 % MgO contents, and have chondritic rare earth element (REE) patterns. Here, we report a comprehensive dataset of Re-Os isotopes and highly siderophile element (HSE: Os, Ir, Ru, Pt, Pd and Re) concentrations for them. The $^{187}Re/^{188}Os$ and $^{187}Os/^{188}Os$ ratios range from 28 to 418 and from 2 to 30, respectively, displaying a broad positive correlation. Four samples are plotted below the general trend in the $^{187}Re/^{188}Os$ vs. $^{87}Os/^{188}Os$ diagram. These four samples have the highest Re concentrations and no correlation between Re and Cu contents compared with the other samples, suggesting that they suffered from post-magmatic Re addition or were derived from a different source. All data but the four data define a positive correlation, corresponding to an age of 4272 ± 300 Ma and initial $^{187}Os/^{188}Os$ = 0.4 ± 1.1 (MSWD = 118). This age is older than surrounding 3.6-4.0 Ga felsic gneisses, consistent with the field observation. Despite significant error on the isochron, this result suggests that the Acasta mafic rocks were formed in the Hadean. They exhibit IPGE-depleted and PPGE-enriched chondrite-normalized HSE patterns, which are similar to those of modern basaltic rocks. These data suggest the origination of the Acasta mafic rocks from the upper mantle that had an HSE composition similar to the modern mantle. This indicates that the upper mantle in the middle Hadean already had high HSE contents.

[1]Bowring & Williams (1999) Contrib. Mineral. Petrol., 134, 3-16. [2]Iizuka et al. (2007) Precamb. Res. 153, 179–208. [3]Mojzsis et al. (2014) GCA 133, 68-96.