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Re-Os systematics on the mafic rocks in the Acasta gneiss complex: Implications for the Hadean basaltic crust

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The first billion years of the Earth history is poorly understood because of scarcity of terrestrial rock records. Especially, the first 500 million years, named Hadean, is literally dark because no terrestrial rocks are preserved on the earth. To unravel the early history of the earth, it is important to study the oldest rocks rarely present in the Eoarchean terranes.

Acasta Gneiss Complex (AGC), located in the western part of the Slave Province, Canada, is one of the Eoarchean terranes, and mainly consists of 3.6-4.0 Ga felsic and layered gneiss suites with minor mafic rocks (e.g. Bowring et al., 1990; Iizuka et al., 2007). The mafic rocks are distributed all over the AGC and occur as rounded to elliptical enclaves and inclusions within the felsic and layered gneisses. Although field occurrence of the mafic rocks suggests that they were formed before the formation of the precursors of the orthogneisses, their formation ages have not been determined exactly because of no magmatic zircons preserved in the mafic rocks (e.g. Mojzsis et al., 2014). Therefore, the whole-rock isochron dating is the most suitable to determine the magmatic age of the mafic rocks. However, the AGC is subjected to numerous metamorphism and alteration events so that the mafic rocks suffered from more or less secondary elemental movement (e.g. Moorbath et al., 1997; Sano et al., 1999). Therefore, it is necessary to find the primary signature and reconstruct the original compositions of the mafic rocks. Our previous study revealed that compositional variations of the mafic rocks were mainly formed due to the migmatization and identified a subset of the least altered samples. This study shows the whole-rock Re-Os isotope systematics of the least altered Acasta mafic rocks.

The twenty-seven, least altered samples were analyzed for whole-rock Re-Os isotopes. They have relatively large variations in 187Os/188Os and 187Re/188Os ratios ranging from 2.0 to 150 and from 28 to 2466, respectively. The measured samples display a roughly positive correlation on a 187Os/188Os vs 187Re/188Os diagram, corresponding to reference lines between 3.3 and 4.2 Ga. But, they are highly scattered (MSWD = 266), possibly due to post-magmatic Re loss or addition during thermal metamorphism because Re is, generally speaking, more mobile than Os (e.g. Reisberg et al., 2008). The nine samples with the highest Re contents display a correlation with a gentler slope, corresponding to an age of 3453±20 Ma (MSWD=16, initial 187Os/188Os=-0.8±1.0). The gentle slope and high Re contents suggest Re addition at or after 3453±20 Ma. In the former case, the age possibly indicates the metamorphic age, in agreement within errors with the whole-rock Sm-Nd isochron age of 3371±141 Ma (e.g. Moorbath et al., 1997; Antoine et al., 2014). In the latter case, the age may be correspond to geological event; artificial.

On the other hand, eighteen samples, except for the samples with high Re concentrations, form two parallel lines with only small scattering. The line with high 187Os/188Os ratios yields an age of 4273±200 Ma (MSWD=15, initial 187Os/188Os=1.83±0.74), whereas the other yields an age of 4081±320 Ma (MSWD=11, initial 187Os/188Os =0.19±0.70). Those ages are consistent with geological occurrence that the mafic rocks occur as enclaves within the 3.6-4.0 Ga felsic gneisses, suggesting that the Acasta mafic rocks were formed in the Hadean. In addition, their high initial 187Os/188Os ratios relative to those of chondrite, 0.097 at 4273 Ma and 0.099 at 4081 Ma, suggest that the Acasta mafic rocks were formed from an enriched source.

Keywords: mafic rock, Re-Os isotopes, Acasta