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Re-Os isotopic systematics of Mesoarchean black shales in the Pilbara craton, Western Australia

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Abundance of redox sensitive elements, such as Re, Os, and Mo, in sedimentary rocks has been used to investigate the evolution of atmospheric O2 levels during the Neoarchean and Paleoproterozoic (e.g., Anbar et al., 2007 Science; Sekine et al., 2010 Nature Comm.). Under low O2 conditions, these elements are immobile in the hydrological cycle. However, as the atmospheric O2 levels rise, Re, Os and Mo possibly form mobile ions and would be transported from continent to oceans. Hence, hydrogenous enrichment of redox sensitive elements in sedimentary rocks may serve as evidence for oxidative continental weathering. Abundance of Re and Os can be also applied to the dating of ancient sedimentary rocks, because 187Re beta-decay to 187Os with a half-life of ˜41.6 Gyr. Hydrogenous Re and Os enrichment can minimalize the contribution of detrital Re and Os, therefore, this isotope system provide precise depositional ages of sedimentary rocks (e.g., Ravizza and Turekian, 1989 GCA; Cohen et al., 1999 EPSL).

In this study, we investigated the redox conditions of atmosphere and oceans during the Mesoarchean period, based on the Re-Os isotopic compositions in ˜3.2 Ga-black shales from the Dixon Island Formation of the Pilbara craton, Western Australia. The Dixon Island Formation are considered to have been deposited in an immature island arc setting, and may preserve information on deep-ocean chemistry (Kiyokawa et al., 2014 Precambrian. Res.). Freshly recovered drill core (DX core) samples were used for the analysis. Most of the samples show high contents of organic carbon (˜1%; Kiyokawa et al., 2011 JpGU abstract) and are characterized by frequent occurrence of pyrite layers and nodules. These observations may suggest that the black shales were deposited under anoxic/euxinic conditions.

The concentrations of Re and Os in the black shale samples of the Dixon Island Formation from the Pilbara Craton were 3?13 ppb and 0.2?2 ppb, respectively. These values are significantly higher than those of average upper continental crust (Re = ˜0.5 ppb, Os = ˜0.03 ppb; Peucker-Ehrenbrink and Jahn, 2001 G-cubed), and much close to those in recent anoxic/euxinic sediments (Re = 21?180 ppb, Os = 0.2?0.7 ppb; Ravizza et al, 1991 EPSL; Ravizza & Turekian, 1992 EPSL). The obtained high Re and Os contents can be explained by oxidative weathering of continental Re and Os, and subsequent authigenic enrichment in anoxic/euxinic sediments during the Mesoarchean time. However, the whole rock Re-Os isochron age was much older than a possible depositional age of the Dixon Island Formation. Hence, the old Re-Os age is not necessarily consistent with the view of hydrogenous Re and Os enrichment. Instead, the isochron suggests that the proportions of detrital Re and Os are not negligible in the samples.

Keywords: Archean, redox condition, Re-Os isotope, Pilbara, Black Shale