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Hadean Protocrust and Early Mantle Depletion: Isotopic Evidence, Complementarity and Origin

MARION GARÇON[1] AND MAUD BOYET[2]

[1]CNRS - Université Clermont Auvergne - Laboratoire Magmas et Volcans

[2]Université Clermont Auvergne, CNRS, IRD, OPGC, Laboratoire Magmas et Volcans

Presenting Author: marion.garcon@uca.fr

Differentiation processes occurring in the first 500 Ma of Earth's history (Hadean era) are difficult to constrain because barely any mineral and rock formed before 3.8 Ga have survived. The rare exceptions are zircon minerals from about ten cratons worldwide and few formations mainly located in Canada and Greenland. The sources and conditions of formation of the oldest terrestrial samples have been studied through many isotopic systematics that have provided contradictory views on the existence of a Hadean depleted reservoir with supra-chondritic ratios and the presence of a mafic/felsic Hadean crust with sub-chondritic ratios.

In an attempt to clarify and draw a coherent history for the differentiation of the primitive mantle in the Hadean, we present an overview of short-lived ^{146}Sm-^{142}Nd, and long-lived ^{147}Sm-^{143}Nd, ^{176}Lu-^{177}Hf isotopic systematics measured in the oldest rocks and minerals from various cratons worldwide. As shown in many recent studies, negative ^{142}Nd anomalies and Hf isotopic compositions of zircons suggest that a (mafic) protocrust formed about 4.4 Ga ago remained stable during the Hadean up until 3.8 Ga. The existence of an extended Hadean depleted-mantle domain is much more debated. The preservation of positive ^{142}Nd anomalies in SW Greenland around 3.8 Ga however requires that some part of the mantle was depleted before 4 Ga. If such a domain existed in the Hadean, was it genetically linked to the Hadean protocrust? Were the Hadean protocrust and early depleted-mantle reservoir the products of magma ocean processes following the moon-forming impact or were they produced by classical mantle-melting processes? We here try to discuss the potential complementarity and origin of the two reservoirs through an isotopic model based on mass balance calculations. This model builds on the new Sm-Nd isotopic composition suggested by Frossard et al.[1] and Jonhston et al.[2] for the primitive mantle and estimates the amount of mafic or felsic crusts that should be generated during the Hadean to reach the degree of depletion recorded by SW Greenland samples.

[1] Frossard et al. (2022), *Science* 377, 1529–1532

[2] Jonhston et al. (2022), *Nature* 611, 501-510