Magnesium isotopic composition of the deep continental crust

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ABSTRACT

To constrain the behavior of Mg isotopes during deep crustal processes and the Mg isotopic composition of the middle and lower continental crust, 30 composite samples from high-grade metamorphic terranes and 18 granulite xenoliths were investigated. The composites derive from eight different high-grade metamorphic terranes in the two largest Archean cratons of China, including 13 TTG gneisses, 5 amphibolites, 4 felsic, 4 intermediate, and 4 mafic granulites. They have variable bulk compositions with SiO2 ranging from 45.7 to 72.5%, representative of the middle crust beneath eastern China. The δ26Mg values of these samples vary from −0.40 to +0.12‰, reflecting heterogeneity of their protoliths, which could involve upper crustal sediments. The granulite xenoliths from the Cenozoic Hannuoba basalts also have a diversity of compositions with MgO ranging from 2.95 to 20.2%. These xenoliths equilibrated under high temperatures of 800–950 ºC, corresponding to depths of the lower continental crust (>30 km). They yield a large δ26Mg variation of −0.76 to −0.24‰. The light Mg isotopic compositions likely result from interactions with isotopically light metamorphic fluids, probably carbonate fluids. Together with previously reported data, the average δ26Mg values of the middle and lower continental crusts are estimated to be −0.21 ±0.07‰ and −0.26 ±0.06‰, respectively. The bulk continental crust is estimated to have an average δ26Mg of −0.24 ±0.07‰, which is similar to the average of the mantle. The large Mg isotopic variation in the continental crust reflects the combination of several processes, such as continental weathering, involvement of supracrustal materials in the deep crust, and fluid metasomatism.

Keywords: Magnesium isotope, deep continental crust, high-grade metamorphic terrane, granulite xenolith, Invited Centennial article

INTRODUCTION

Magnesium is a fluid-mobile, major element, and has three isotopes of 24Mg, 25Mg, and 26Mg. Magnesium isotope fractionation is limited during high-temperature processes (Teng et al. 2007, 2010a; Handler et al. 2009; Yang et al. 2009; Bourdon et al. 2010; Liu et al. 2010), but is significant during low-temperature processes (Young and Galy 2004; Tipper et al. 2006a, 2006b, 2010; Handler et al. 2009; Yang et al. 2009; Bourdon et al. 2010; Dauphas et al. 2010; Pogge von Strandmann et al. 2011; Xiao et al. 2013), whereas the upper continental crust is highly heterogeneous (δ26Mg = −1.64 ±0.92‰) and on average heavier than the mantle (Shen et al. 2009; Li et al. 2010; Liu et al. 2010; Huang et al. 2013a; Teng et al. 2013). The hydrosphere has a very light Mg isotopic composition, as represented by seawater (δ26Mg = −0.83 ±0.09‰, 2 SD) (Foster et al. 2010; Ling et al. 2011 and references therein) and the flux weighted average of major rivers (δ26Mg = −1.09‰) (Tipper et al. 2006b). These Mg isotopic characteristics are considered to result from continental weathering, during which light Mg isotopes are preferentially partitioned into the hydrosphere, causing a shift in the weathered residues toward a heavier isotopic composition (Pogge von Strandmann et al. 2008b; Teng et al. 2010b; Tipper et al. 2010; Huang et al. 2012; Liu et al. 2014).

To better constrain the interaction between the crust and the hydrosphere, Mg isotopic composition of the middle and lower continental crustal materials should also be investigated since they contain large proportions of Mg in the crust. However, thus far, only one study on this issue has been reported. Teng et al. (2013) investigated two well-characterized suites of lower-crustal