Quantifying the Volume Changes During Incipient Serpentinization

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Serpentinization of peridotite leads to a substantial decrease of rock density and is commonly invoked to be accompanied by a volume increase of 25–45% [1,2]. In contrast, pseudomorphic replacement textures have been used to argue for isovolumetric serpentinization and substantial element mobility[3]. Because of the widespread occurrence of serpentinized peridotite, the implications of volume changes and element mobility are of global geological importance. This study integrates results from time-series hydrothermal laboratory experiments and high-resolution 3-D x-ray micro-computed tomography (µ-CT) to provide quantitative constraints on volume changes and mass transfer during serpentinization. Cores of unaltered natural dunite and harzburgite were scanned using µ-CT before and after reacting them with artificial seawater at 300 °C and 35 MPa in gold capsules for 5, 10, and 18 months. Measured fluid compositions are consistent with previous experiments and suggest that Mg and Fe behave conservatively. Initial loss of SiO_2 (0.25 - 0.49 wt.%) from the reacted harzburgite to the reactant fluid is trivial compared to the 35 wt.% SiO_2 loss required if serpentinization was isovolumetric. Volume changes were calculated from 3-D displacements of inert internal markers. We observed a linear increase in rock volume with time and extent of reaction for dunites. The relationship between volume increase and extent of reaction is more scattered for serpentinized harzburgites, which we attribute to variable proportions of olivine and pyroxene in the protoliths. While our results demonstrate that incipient serpentinization in closed systems is not strictly isochemical, substantial volume increases are evident. These findings have strong implications for the formation of serpentinites in a wide range of major geodynamic settings.

References: 1. O'Hanley, D. S. Geology 20, 705–708 (1992). 2. Coleman, R. G. Geol. Soc. Am. Bull. 82, (1971). 3. Velbel, M. A., Tonui, E. K. & Zolensky, M. E. Geochim. Cosmochim. Acta 148, 402–425 (2015).