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Chlorine isotope evidence for multiple Farallon-derived components in the North American lithospheric mantle

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Flat slab subduction of the Farallon plate beneath North America metasomatized the sub-continental lithospheric mantle (SCLM) beneath the Colorado Plateau and Rio Grande Rift. Marshall et al. [2017] suggested a subducted serpentinite or gabbroic altered oceanic crust (AOC) source of metasomatizing fluids [1]. We examine the chlorine isotope ratios (δ^{37}Cl) of hydrous-mineral-bearing peridotite xenoliths from the Navajo Volcanic Field (NVF; Colorado Plateau) and anhydrous mantle xenoliths from Elephant Butte (EB; central Rio Grande Rift) to further constrain the source of Farallon-derived fluids.

NVF xenoliths have high Cl abundances (30-330 ppm) and high δ^{37}Cl values (+0.3‰ to +1.9‰) relative to the depleted mantle ([Cl] = 1-10 ppm, δ^{37}Cl = -0.2‰) [2]. Similarly, one EB xenolith has a δ^{37}Cl value of +1.2‰ and a Cl abundance of 17 ppm. The similarity between EB and NVF δ^{37}Cl values indicates that the EB SCLM has been cryptically metasomatized by the same fluid as the NVF SCLM.

Xenolith δ^{37}Cl values negatively correlate with clinopyroxene δ^{18}O and positively correlate with bulk xenolith Br/F and I/F ratios. The δ^{37}Cl values also correlate with relative abundance of hydrous minerals (e.g. chlorite abundance relative to overall hydrous mineral abundance), indicating either Cl isotope fractionation, a single heterogeneous metasomatic fluid source, or multiple fluid sources. Given that chlorine isotopes do not fractionate significantly at mantle temperatures [3], the latter two possibilities are more likely. The higher δ^{37}Cl values are consistent with a subducted gabbroic AOC source [4]. The lower δ^{37}Cl values are consistent with a subducted serpentinite [5], AOC [4], or sediment source [6] (Figure 1). The high Cl abundance in all analyzed xenoliths disfavors a significant sediment source. This work demonstrates that subducted AOC and potentially serpentinite significantly enrich the SCLM with Cl, isolating Cl from cycling between the surface and the convecting mantle for up to 1 Ga.

[1] Marshall et al. (2017), *Geology* 45, 1103-1106.
[2] Sharp et al. (2007), *Nature* 446, 1062-1065.
[3] Schauble et al. (2003), *GCA* 67, 3267−3281.
[4] Barnes & Cisneros (2012), *Chem. Geol.* 326, 51-60.
[5] Barnes & Sharp (2006), *Chem. Geol.* 228, 246-265.
[6] Barnes et al. (2008), *Geology* 36, 883-886.

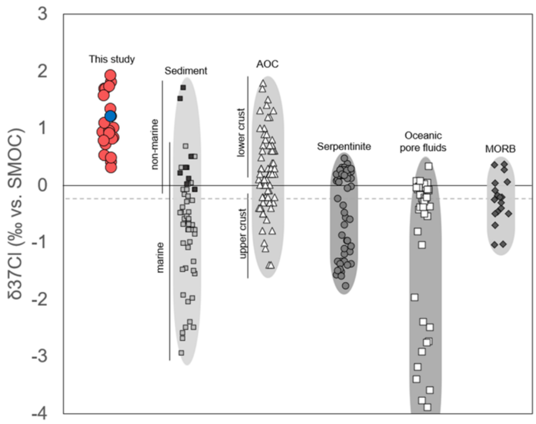

Figure 1: Range of δ^{37}Cl values of the mantle xenoliths from this study and potential metasomatic fluid sources. Red circles are from the Navajo Volcanic Field, blue circle is from Elephant Butte. Dashed line is the average upper mantle δ^{37}Cl value from Sharp et al., 2007. AOC = altered oceanic crust (Barnes & Cisneros, 2012). MORB = mid-ocean ridge basalt (MORB; Sharp et al., 2007). Sediment data from Barnes et al., 2008; Barnes et al., 2009; Selverstone & Sharp, 2015. Serpentinite data from Barnes & Sharp, 2006; Bonifacie et al., 2008. Pore fluid data from Godon et al., 2004.