A review of chlorine stable isotopes as a fluid tracer in subduction zones

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Chlorine stable isotopes are an excellent geochemical tracer of volatiles in subduction zones because 1) chlorine always strongly partitions into an aqueous fluid phase and 2) the δ^{37}Cl values of various potential Cl sources in a subduction zones (sediments, pore fluids, subducted oceanic crust, serpentinites) are distinct. Here we present an overview of the chlorine chemistry of the Izu-Bonin-Mariana (IBM) and Central America (CA) subduction systems.

There are no systematic variations in δ^{37}Cl values along the Quaternary IBM volcanic front in either gas or ash samples; however, distinct variations occur across the arc. Serpentinite clasts and serpentine muds from forearc seamounts (~30 km above the slab) have δ^{37}Cl values of +0.4 ± 0.4‰ (n=24), identical to most seafloor serpentinites, suggesting a serpentinite (chrysotile/lizardite to antigorite transition) fluid source. Volcanic gases and tephras from the VF (~115-130 km above the slab) have δ^{37}Cl values averaging –1.1 ± 1.0‰ (n=29), precisely overlapping the range measured in sediments from ODP cores (–1.1 ± +0.7‰, n=11) and limited altered oceanic crust (AOC) data (–1.6 to –0.9, n=3 [1]). Both sediments and AOC are possible Cl sources in the VF. Rear-arc basalts (Guguan cross-chains, ~200 km above the slab) have δ^{37}Cl values of 0.0 to +0.5‰ (n=3), suggesting a second serpentine-derived source, in this case from antigorite breakdown.

In contrast, ashes and tephras from 23 volcanic centers in CA range from –2.6 to +3.0‰ with systematic variations along the length of the arc. Values from the northern-most (Guatemala and El Salvador) and southern-most (Costa Rica) ends of the arc have mantle-like signatures. In contrast, δ^{37}Cl values are both positive and negative in the center of the arc (Nicaragua), implying a sediment and/or serpentinite-derived component. Geophysical observations are consistent with extensive hydration of the Cocos plate offshore of Nicaragua, lending credence to the likelihood of a serpentinite fluid source. Fluids from dehydrating serpentinites may also mobilize Cl from overlying sediments, resulting in a mixed chlorine signature.

[1] Bonifacie *et al*. (2007) *Chem. Geol.* **242**, 187-201.

Komatiite magmas and nickel sulfide deposits: A comparison of variably endowed terranes

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A comprehensive geochemical database for a number of komatiite-bearing Archaean and Proterozoic greenstone terranes, with varying endowments of nickel sulfide deposits, reveals an association between sulfide mineralisation and strongly olivine-enriched cumulates. However, the composition of the dominant parent magmas in each belt is highly variable, ranging from komatiite with MgO 25-30% in the East Yigarn to komatiitic basalts with 12-18% MgO in the Cape Smith (Raglan) Belt. In all these belts there is a strong association between mineralisation and crustal contamination on the basis of lithophile incompatible elements. Magma and cumulate compositions in all the belts fall on a common trend of Ni and PPGE/Ti vs MgO. This trend can be modelled almost entirely by olivine control, indicating a lack of variability of Ni and PGE in the mantle sources, and that komatiites in all cases were erupted sulfide-undersaturated.

Parent magmas to mineralisation include both typical Munro-type Al-undepleted (Yilgarn and Abitibi) and Al-depleted Barberton type (Forrestania) komatiites. The Forrestania belt is the only known example of Barberton-type komatiites hosting nickel sulfides, but significantly it also the only known location for komatiite dunites (olivine adcumulates) developed within this type. Coupled with the overwhelming dominance of the overall nickel sulfide inventory by the East Yilgarn and Thompson belts, both of which contain abundant meso-and adcumulates, this is evidence that the set of conditions leading to the formation of the dunites is the critical pre-requisite to the formation of a large nickel sulfide province. The association with olivine-rich cumulates implies that magma flux and eruption rate are the proximal controls, with the (metaphorically and literally) deep control being the nature of plume-lithosphere interaction, and the relative ease of passage through the crust of dense, primitive magmas along critical lines of weakness at the margins of Archaean cratonic blocks (‘Archons’). The hypothesis of Zhang et al. [1], that nickel mineralisation is favoured by interaction with Ni and PGE enriched subcontinental lithospheric mantle, finds no support from the komatiitic end of the LIPS spectrum.

[1] Zhang *et al.* (2008) *Earth Science Reviews* **86**, 145-174.