Variations in the supply of fluids to the Lesser Antilles subduction zone

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Our understaning of how the deep volatile cycle affects magmatism, earthquakes and subduction evolution is dominantly based on studying the subduction of lithosphere formed at fast spreading ridges such as the Pacific. However, the potential of oceanic plates to become hydrated increases as spreading rate decreases. This study targets the Lesser Antilles, a subduction zone end-member which subducts slow-spread lithosphere formed at the Mid-Atlantic Ridge. The downgoing South American Plate contains fracture zones and oceanic core complexes which are significant locations for serpentinisation. Serpentinite therefore has the potential to be a key source of fluids to the Lesser Antilles.

The Lesser Antilles displays along-arc variations in geochemistry, seismicity and volcanic activity. Here, we present in-situ $\delta^{11}B$ signatures, alongside volatile and trace element concentrations, of volcanic hosted melt inclusions (MI's) from 11 islands along the entire Lesser Antilles arc. A large variation in $\delta^{11}B$ values of MI's, from -2.8‰ to +11.2, ‰, covers much of the global arc range. $\delta^{11}B$ values are higher in the central arc (islands of Guadeloupe, Dominica and Martinique) than the north and south segments. $\delta^{11}B$ values also vary within each volcanic center, suggesting that $\delta^{11}B$ can be modifeid by 2-3‰ during differentiation in the crust. However, there are no consistent correlations in the data from individual islands with either indicatiors of differentiation (e.g. Rb/Sr and Ba/Sr) or indicators of fluid addition (e.g. B and B/Nb). This suggests that variations between islands are controlled by the involvement of multiple sources of fluids with distinct $\delta^{11}B$ signatures. Mixing models reveal that the heaviest $\delta^{11}B$ signatures in the central arc must result, in part, from serpentinite dehydration.

The central arc, with the heaviest $\delta^{11}B$ signature, contains the largest islands, with the highest erupted volumes. In additon, $\delta^{11}B$ correlates with multiple independent geophysical signals of water content in the mantle wedge. Therefore, our data suggest that the supply of serpentinite derived fluids (carrying a heavy $\delta^{11}B$ signature) is the key driver of both magmatism and seismicity in the Lesser Antilles arc.