Arc lavas form from melting of mélange rocks; sediment melts and slab-derived fluids are not major contributors.

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In studies of subduction zones, the prevailing paradigm is that fluids released from metamorphic dehydration processes and sediment melts are transferred from the top of the slab into the mantle wedge where they mix with the mantle and cause melting. These melts then eventually erupt at the surface to form volcanic arcs.

Direct geophysical observations of sub-arc processes presently lack the resolution to obtain reliable information on material transfer between the slab and mantle. Therefore, the chemical and isotopic compositions of arc lavas offer the best opportunity to obtain information about this critical region of subduction zones. Although numerous studies have reported the isotopic compositions of arc lavas and linked them to specific signatures of subducted components, a critical aspect of the physical implications of those isotopic data has been entirely overlooked for the past two decades.

We present a meta-study of 8 globally representative arcs where we model the Sr and Nd isotope compositions predicted for lavas if they were controlled by release of fluids and/or sediment melts from the top of the slab [1]. We show that mixing between fluids/sediment melts and the mantle wedge would generate curvature in Sr vs Nd isotope space that is very different to those mixing lines that form when bulk sediment and oceanic crust mix with the mantle. This difference is caused by fractionation of Sr and Nd during fluid release and sediment melting. Instead, bulk mixing fits with the literature data almost perfectly in every arc, while the sediment melt/fluid mixing lines plot far from the actual data.

We show that melting of mélange layers that initially formed at the top of the slab can account for essentially all arc lavas considered. Overall our study provides strong evidence that individual slab components rarely act as the source of metasomatism in the mantle wedge. These components are, therefore, inappropriate to investigate the physico-chemical interaction between slab and mantle.

[1] Nielsen, S.G. and H.R. Marschall, Science Advances, 2017. 3: p. e1602402.