

Behaviour of first-row transition elements during early differentiation of arc magmas, Solomon Islands, SW Pacific: Implications for the redox state of sub-arc mantle

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Many first-row transition elements (FRTE) are redox-sensitive, making them ideal candidates in exploring the redox states in magmatic systems. Because arc lavas in general are differentiated, it is challenging to apply proxies involving these elements to investigate the oxygen fugacity of sub-arc mantle. A cogenetic suite of arc magmas, wherein the most primitive members are in direct equilibrium with the mantle, is thus valuable because it gives an opportunity to examine source geochemistry and how elemental systematics changes with differentiation. Here, we document new geochemical analyses for picritic and basaltic lavas from the Solomon arc, SW Pacific with a specific focus placed on FRTE. The lavas have variable MgO with the picritic ones mostly in Fe/Mg exchange equilibrium with Fo₈₉₋₉₁ olivine. With MgO as a proxy for differentiation, Cr, Co and Ni behave compatibly, and V, Cu and Ga behave incompatibly. Iron and Zn might have partitioning behaviour intermediate between compatible and incompatible. Scandium gently increases with decreasing MgO before it plummets at ~8 wt.% MgO, consistent with the onset of clinopyroxene fractionation. The above trends indicate that the oxybarometric proxies V/Sc, V/Ga and Zn/Fe_T can be applied to the picritic and relatively primitive basaltic lavas for oxygen fugacity estimation. The oxygen fugacity of the mantle source from which these lavas derived can be tightly constrained at FMQ to FMQ - 1. Covariation of MgO and Cu further indicates that the oxygen fugacity during differentiation did not exceed FMQ + 1.3. Our results concur with the view that the redox state of sub-arc mantle asthenosphere is similar to that of MORB-source mantle, and that high Fe³⁺/Fe_T generally seen in arc lavas and basaltic glasses therein is a result of transcrustal magmatic processes. We speculate that subducted slab-derived fluids, while rich in incompatible trace elements and probably oxidizing, do not have much leverage in resetting the redox state of sub-arc mantle asthenosphere.