The role of volatiles in generating continental crust

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Experimental studies and natural observations suggest a direct link between water delivery to the mantle via subduction and the generation of the calc-alkaline magmas characteristic of Earth's continental crust. Experiments show that elevated water activity alone supresses the crystallization of silicates, allowing oxides to dominate the assemblage and deplete Fe in the melt [e.g. 1-2]. Experimental observations therefore create a sensible framework in which to interpret the correlation between calc-alkaline affinity and water activity [e.g. 3] as cause and effect. Here we explore how oxygen fugacity (fO_2) may exercise far greater direct control than water in driving magmas to differentiate along calc-alkaline trends. We will examine experimental evidence as well as observations of natural systems, highlighting new measurements on tephras recently collected in the Western Aleutians, an intra-oceanic convergent margin where calc-alkaline volcanism is prevalent.

The direct effect of fO_2 may exceed the effect of water in driving calc-alkaline differentiation; however, water enables the high fO_2 environment found at arcs. Water itself does not oxidize magmas, but water likely plays an important indirect role in generating oxidized magmas through (1) delivery of compounds with high reduction potential to the mantle wedge and (2) serpentinization accompanied by oxidation of the oceanic lithosphere.

[1] Yoder, Andesite Conf. (1968) [2] Sisson and Grove, CMP (1993) [3] Zimmer et al., JPET (2010)