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Carbonatites: The products of complex armouring of the crust by carbonate magmas?

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The idea that the mantle is metasomatised by dolomitic magmas (wehrlitisation) was proposed decades ago and is widely accepted as a means of providing armoured conduits for the ascent of these magmas into the crust. According to this hypothesis, dolomitic magma reacts with orthopyroxene in the mantle to produce a layer of olivine plus clinopyroxene (wehrlite), thereby providing an inert pathway for the ascent of subsequent batches of magma. The question that has not been fully addressed is what happens when carbonatitic magmas encounters continental crust.

To investigate the interaction of dolomitic liquid (alkali-bearing) with continental crust, we conducted experiments at 800-1100 ºC and 2-5 kbars. The continental crust was represented by silicate glass having the composition of granitic gneiss (Glass 1) and sodic fenite (Glass 2). All the experiments produced a rind on the glass comprising the following zones: 1) an innermost alkali silicate melt quenched to silicate glass (phonolite); 2) nepheline and aegirine-augite (ijolite); 3) fine-grained diopside, olivine, phlogopite and calcite (pyroxenite or glimmerite); and 4) an outermost coarse-grained calcite carbonatite containing phlogopite and olivine. Zones 1 and 2 are interpreted to be products of melting of the glass induced by a Na-enriched carbonate liquid, Zone 3 is the product of the metasomatic alteration of the glass by Mg- and Ca-rich carbonate liquid, and Zone 4 crystallised from the carbonate liquid, which assimilated silicate components from the glass. The proportions of the zones varied with temperature and the composition of the glass; pressure had a major effect on the generation of Zones 1 and 2.

The interaction of carbonatitic magmas with the continental crust armours the magma conduits in a manner similar to that in which the mantle is wehrlitised, but more extensive than in the mantle due to the higher Si chemical potential gradient in the continental crust. This explains the common occurrence of ultramafic and/or alkaline silicate rocks in carbonatite complexes and their relative proportions.