A general model for carbonatite petrogenesis in shallow alkaline intrusions

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On Brava Island (Cape Verde) various silica undersaturated rocks form a continuous intrusive suite, which can be explained by fractional crystallization of olivine, clinopyroxene, perovskite, biotite, apatite, titanite, sodalite and FeTi-oxides. This fractionation leads to alkali enrichment and drives the melts into the carbonatite-silicate miscibility gap resulting in the formation of carbonatitic melts. On the other hand, early saturation in feldspatoids or feldspars would effectively prevent alkali-enrichment and hence also the formation of carbonatites. We also show that an initial CO_2-content of as little as 0.4 wt % is sufficient to saturate in CO_2 and to unmix carbonatites from nephelinites.

This model of fractionation and unmixing is also supported by the mineral chemistry within the conjugate carbonatite and nephelinite rocks on Brava. The modeled carbonatite compositions also correspond well with the natural samples, albeit with a much lower alkali-contents in the latter. The alkali-poor character of carbonatites on Brava is likely a consequence of the release of alkali-rich fluids during the final stages of crystallization (resulting in fenitization of the surrounding country rocks).

We thus conclude that Brava documents a complete and continuous fractionation line from primitive melts to syenitic compositions, with repeated immiscibility events that produces carbonatitic liquids. We also propose that this process is not only restricted to Brava island but is likely to operate in many shallow alkaline intrusions around the world.