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On the genesis of phoscorite

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Phoscorite is an apatite-rich rock (also containing magnetite and one of the silicates, olivine, diopside or phlogopite) associated with carbonatites. Although there is a consensus that these rocks are cumulates, their origin and the nature of the parental magmas continues to be debated. To explain their origin, two processes are commonly invoked, namely, the fractional crystallisation of a carbonatitic magma and liquid immiscibility (exsolution of a phosphate-oxide-silicate-rich liquid from a carbonatitic magma). The first process requires that apatite (together with magnetite and a silicate mineral) is the first mineral on the liquidus (to produce a cumulate rock), which is unlikely if the parental magma is carbonatitic. This is because the solubility of apatite in carbonatitic magmas is so high (up to ~40 wt.%) that >>90 % fractional crystallisation of calcite/dolomite would be required to saturate the magma in apatite. Such a high solubility of apatite also precludes liquid immiscibility as a mechanism for forming phoscorites. Based on the results of a study of the St Honoré carbonatite, we propose an alternative model for the formation of phoscorites. Apatite in the banded carbonatite (the main apatite-bearing unit) has inclusion-rich cores, displays 120º triple junctions among its crystals and forms a matrix in the layers (bands) that also contain magnetite and phlogopite and are, therefore, phoscorites. These phoscorite layers are adjacent to thicker layers composed of calcite/dolomite that, in turn, are attached to glimmerite (biotitite). We propose that the phoscorite layers formed from a dolomitic carbonatitic magma (derived via a very low degree of partial melting of the mantle), which evolved by reacting metasomatically with the host K-rich syenite to form glimmerite (this removed MgO and CO_2 from the magma and enriched it in $CaCO_3$), crystallising calcite (consuming CaO and CO_2) and finally exsolving aqueous fluid (that enriched the magma in F and stabilised apatite). We propose that the genetic model presented here is applicable to phoscorites globally and that three processes, namely, magma-host rock metasomatic interaction, fractionation of calcite and fluid exsolution, are the keys to producing phoscorite from carbonatitic magma.