# The chevkinite group and its extraordinary range of compositions and occurrences

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Minerals of the chevkinite group (CGM) are commonly considered to be "rare accessory minerals in alkaline rocks". They are, in fact, known from hundreds of terrestrial localities and have also been recorded in lunar and Martian rocks. The main occurrences are in igneous rocks ranging from kimberlites through mafic and intermediate lithologies to metaluminous and (per)alkaline felsic rocks. They also occur in metamorphic rocks, including granulites, metacarbonates and jadeitites, and in metasomatic rocks and ore deposits. CGM have formed over the pressure range 5 - <1 GPa, and at temperatures of $\sim$1260°C (?) to $\sim$350C (?). Their formation appears to be *relatively* insensitive to pH_2O and fO_2.

CGM are dominantly REE-Ti silicates $((REE,Ca)_4Fe^{2+}(Fe^{2+},Fe^{3+},Ti)_2Ti_2(Si_2O_7)_2O_8)$, with REE_2O_3 contents up to 50 wt%, but Sr-, Nb-, Th-, Zr- and Cr-rich types are also known. Altogether a total of 56 elements, ranging in abundance from ppm to percent levels, have been recorded in the group. Eleven members have been approved by the CNMNC IMA but more will undoubtedly be identified. Overall compositional variation can be expressed (Vlach and Gualda 2007) as:

$$(Ca+Sr)_A + (Ti + Zr)_C = (REE, Y)_A + (M^{2+,3+})$$
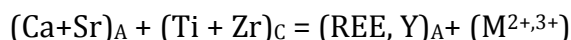
which represents an amalgam of several cation substitution schemes.

Chevkinite and perrierite are overwhelmingly the most abundant CGM. In igneous parageneses they tend to occur in rocks of different compositions. Chevkinite is found mainly in rather evolved, Ca-poor hosts (e.g. syenites, trachytes, granites and rhyolites), whereas perrierite has been recorded in more mafic lithologies (e.g. basalts, trachyandesites, calcic granites and latites).

The stability of CGM *vis-à-vis* other REE-Ti-bearing accessories is poorly understood. There is, for example, experimental and observational evidence that it precedes allanite in the crystallization of certain granites. However, in A-type granites of the Graciosa Province, Brazil, allanite-(Ce) formed in metaluminous to weakly peraluminous granites whereas chevkinite-(Ce) formed in granites of the alkaline association (Vlach and Gualda 2007). Monazite generally forms in peraluminous rocks but in the Miocene Joe Lott Tuff, Utah, CGM from the highest level in the pre-eruptive magma chamber was replaced as the main REE-bearing phase at greater depth by monazite, which in turn was replaced by a CGM.

The CGM are often the major carriers of REE and actinides and they have a high potential for fractionating the (L)REE and Th from U. Very little systematic work has been done in determining CGM-melt partition coefficients, with the exception of the work of Padilla and Gualda (2016) on the Peach Springs Tuff, south-west USA, yet such data are critical in, *inter alia*, geochemical modelling. Similarly, CGM are amenable to geochronology due to their high Th abundances, commonly at the several percent level. Vasquez (2008) showed, for example, that for young chevkinite (<350 ka) the

compositional variations in single crystals can be linked to absolute age through ^{238}U-^{230}U dating by ion microprobe analysis.

In common with other REE-bearing accessories, CGM are prone to alteration by hydrothermal fluids. The nature and extent of the alteration is primarily determined by the composition of the fluids. Fluids poor in ligands tend to generate a Ti-enriched phase whose nature is unknown but is probably amorphous. With increasing F + CO_2 levels, complex replacement assemblages are formed, usually in more than one step, e.g. chevkinite-(Ce) → ferriallanite + davidite-(La) + aeschynite → rutile + titanite + quartz + aeschynite assemblages. Although observational evidence of the effects of alteration and element mobility is accumulating and chemical equations can be constructed to approximate the reactions, there is still no firm geochemical basis for understanding element redistribution.

References:

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