GEOCHEMISTRY OF MAGNESIAN ILMENITE MEGACRYSTS FROM SOUTHERN AFRICAN KIMBERLITES

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Ilmenite megacryst suites from 20 kimberlites in southern Africa have been analyzed for trace elements (Ni, Zn, Cu, Ga, Nb ,Ta , Zr, Hf) using the proton microprobe; major and minor elements have been analyzed by electron probe. These data, combined with those from other suites (Moore et al. 1992; Griffin et al. 1991, 1994), show that ilmenite macrocrysts in kimberlites represent a minor phase, crystallizing late in the fractionation history of mafic magmas at mantle depths.

Nb typically behaves as an incompatible element in the magma throughout the crystallization history, and the Nb content of ilmenite serves as an index of the degree of fractional crystallization. Observations on the chemistry of ilmenites intergrown with other megacryst phases (Moore et al. 1992; Griffin et al. 1991) allow interpretation of the changing composition of the ilmenite in terms of crystallisation history. Plots of other trace- and major elements in the ilmenites against their Nb content typically define smooth curves, with breaks in slope corresponding to changes in the assemblage of minerals crystallizing together with ilmenite. For example, Ni decreases with increasing Nb when ilmenite crystallises together with mafic silicates such as olivine, pyroxenes and garnet, but increases together with Nb when the coexisting phases are low in Ni (phlogopite, zircon). Coprecipitation of ilmenite with zircon leads to buffering of the Zr content of ilmenite at a near-constant value as Nb increases. The onset of phlogopite crystallisation leads to a decrease in the Ga content of the coexisting ilmenite. Relations between major- and trace elements, previously regarded as evidence against a fractional-crystallization origin for the ilmenites, are shown to be consistent with such an origin.

Ilmenite suites from different kimberlites show broadly similar crystallization histories, but differ in detail. In general the sequence of phases crystallising together with ilmenite is: Px+Gar ± Mg-Oliv ‘ Phlog ± Zirc ‘ Zirc ± Fe-oliv ±Phlog. Two groups of kimberlites may be defined, on the basis of the maximum Zr content of ilmenite reached during fractionation. One group, defined by essentially constant Zr (ca 500-700 ppm) with increasing Nb (to ≥1%), is geographically restricted to the Kimberley area and Uintjiesberg, and this trend is similar to those seen in ilmenites from peridotite xenoliths. All other suites show a positive correlation between Zr and Nb through most of the fractionation sequence, and the ilmenites in each kimberlite appear to have crystallized from a single batch of magma. These magmas were broadly similar, and modelling based on limited relevant distribution-coefficient data suggests that they were alkali-picritic in composition. Small differences in initial magma composition have been magnified by extreme fractional crystallization, to produce the distinctive characters of ilmenite suites from individual kimberlites. These observations suggest a genetic relation between the megacryst magma and the host kimberlite in each pipe, but the nature of this relation is not clear.

In general the Hem content of ilmenites increases with increasing Nb content. Ilmenite suites from most significantly diamondiferous kimberlites have ≤10% Hem on average; weakly diamondiferous kimberlites may have either low or high average Hem. Barren pipes on-craton generally contain high-Hem ilmenite suites, while those off-craton may contain low-Hem ilmenites. Ilmenite suites from significantly diamondiferous pipes tend to be dominated by high-Mg, Cr ilmenites, while poorly diamondiferous on-craton kimberlites typically have lower-Mg chromites with either low or high Cr. Barren pipes in off-craton situations show a full range of ilmenite patterns, including some with very high Mg and Cr.

Because the trace-element patterns of ilmenites from different kimberlites are commonly distinctive, even within small areas, they may be used to characterize the sources of ilmenites found in loam and drainage samples, to recognise the local vs distant distribution of the sources, and to conduct inventories of individual drainages during diamond exploration.

References

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