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Silicate liquid immiscibility and the formation of magmatic Fe-Ti-V-P deposits

Bernard Charlier*

*University of Liege, Sart Tilman, Belgium, Email: b.charlier@ulg.ac.be

Liquid immiscibility in magmatic systems corresponds to the separation of a homogeneous melt into two or more liquids. This process generates sudden changes in the evolution of magmas by producing melts of contrasted compositions, possibly at the origin of ore deposits. Immiscibility between two silicate melts (ferrobasalt-rhyolite) has been recognized experimentally and in natural systems. However, evidence for the large-scale separation of two silicate melts in natural systems is rarely recorded in fully crystallized rocks because of the transient nature of immiscibility. The lack of a clear record for the formation of conjugate immiscible melts therefore renders this process highly controversial. When immiscibility occurs, the same phases with similar compositions crystallize from two immiscible melts making this process extremely hard to identify in plutonic setting. As a consequence, immiscibility only produces variations in mineral modes of cumulate rocks which are hardly distinguishable from the effect of simple crystal sorting.

In this presentation, natural and experimental evidences for the onset of liquid immiscibility between ferrobasaltic and rhyolitic melts will be presented. The importance of this process for the formation of Fe-Ti-V±P-rich cumulate rocks associated with tholeiitic basalts, ferrodiorites, and andesitic magmas will be discussed. We will first illustrate obvious examples of coexisting melts droplets in typical quenched tholeiitic lavas flows (Snake River Plain, Hawaii). The Sept Iles layered intrusion, the Upper Zone of the Bushveld complex, and the Fe-F Kiruna-type Vergenoeg deposit will then be used as case studies to illustrate the role of immiscibility in plutonic environments. Our observations in natural systems are supported by experiments in the laboratory that define controlling factors for the onset of liquid immiscibility. We will show how liquid composition, temperature, oxygen fugacity, and the presence of volatiles influence the extent of the two-liquid field. Our complementary approaches that combines the study of natural samples with experiments strongly support that liquid immiscibility is a major process responsible for the formation of Fe-Ti-P ores related to layered intrusions, massif-type anorthosites, and Kiruna-type deposits.