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Mechanisms of realization of physicochemical regularities during solidification of layered intrusions

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Detailed studying of large layered intrusions of different composition showed that solidification of their inner parts was realized by moving upwards of subhorizontal relatively thin (3-4 m) crystallization zone. It's upper boundary (front of crystallization beginning, FCB) coincides with liquidus isotherm of melt in magma chamber, and lower boundary (front of crystallization completion) with solidus isotherm. Because the zone of crystallization continuously moving upwards, the crystals, precipitated on the FCB (cumulus phases) were buried by newly formed crystals and were practically isolated from the main volume of the melt in the intrusion chamber. Composition of this melt was constantly leveled off by convection. Prolonging moving away of the most high-temperature solid phases had to lead to changing of it's composition and, according to physicochemical laws, led to precipitation of consecutive lower-temperature phases. Such changing of mineral phases exactly represent the phenomenon of primary magmatic layering as well. Cumulus phases in layered rocks are not accidental, sorted on their physical properties, but represent one of mineral associations, which have to precipitate from appropriate parental melt according to experimental physicochemical data. In other words, process of fractional crystallization of the parental melt occurred during layered intrusions hardening and their cross-sections represent succession of corresponding mineral phases.

This is evident from data on good studied layered intrusion of different composition. So, for example, crystallization of intrusions, derived from the tholeiitic magmas (Rhum and Duke islands, Skaergaard (Greenland), Yoko-Dovyren (Siberia), etc.) are characterized by general succession of cumulates: Ol+Chr $\rightarrow$ Ol+Pl$\pm$Chr $\rightarrow$ Ol+Pl+Cpx and could be described in framework of the experimentally studied system Fo-Di-An; from the siliceous high-Mg series (Bushveld (SAR), Stillwater (USA),

Monchegorsk (Fennoscandian Shield), etc.) with cumulate succession: Ol+Chr $\rightarrow$ Ol+Opx$\pm$Crt $\rightarrow$ Opx $\rightarrow$ Opx+Pl$\pm$Cpx - by the system Fo-An-SiO_2; from the Ne-phonolite (Lovozero (Fennoscandian Shield) with succession: Ne $\rightarrow$ Ne+Fsp $\rightarrow$ Ne+Fsp+Aeg - by the system Or-Ne-Aeg; from the K-phonolite (Yuzhno-Sakunsky (Siberia)): Fsp $\rightarrow$ Fsp+Lc $\rightarrow$ Ne+Fsp – by the system Ks-Ne-SiO_2, etc.

So, studying of layered intrusions could help to establish intercommunication between experimental petrology and real magmatic processes, to reveal how exactly physico-chemical laws are realized in the Nature, and to clear up the ways for use the physicochemical data in petrological practice.

However, two circumstances was complicated the process of such studying. They are: (1) replenishment of fresh magma of different composition into hardening intrusive chamber, which lead to mixing of evolved and new magmas, and (2) phenomenon of rhythmic layering, which is a side effect of the directional solidification, an example of dissipative textures (Sharkov, 2006). But they are only complicated the situation and not change it's essence. Moreover, replenishment of fresh magmas could carry additional information about evolution of magma source, processes of magma's differentiation and contamination into deep-seated transitional magma chambers, etc. Studying of rhythmic layering could help to understand mechanism of the dissipative textures origin during solidification of large volumes of melt.