A model of S and semi-metals contamination of mafic magma by black-shales for the formation of Ni-Cu-Platinum-group elements deposits

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The basal unit of the Duluth Complex (Minnesota, USA) contains Ni-Cu sulfides. The S in these is thought to be derived from a sulfide-rich black shale unit known as the Bedded Pyrrhotite Unit (BPU). Partial melting of the BPU xenoliths in the mafic magma represents a key process in its contamination.

Petrographic observation shows that droplets of sulfide melt derived from the BPU were entrained in anatectic silicate melt of the BPU and transferred to the mafic magma by the melt (Fig. 1). Whole rock and laser ablation analysis show that in addition to S the droplets transferred Sb, Bi, As and Pb to the magma. The sulfide droplets closest to the xenoliths are richest in these elements and poor in platinum-group elements (PGE) compared with sulfide droplets farther from the xenoliths. The change in composition of the sulfides with distance from the xenoliths is thought to reflect increasing reaction of the sulfide with mafic magma.

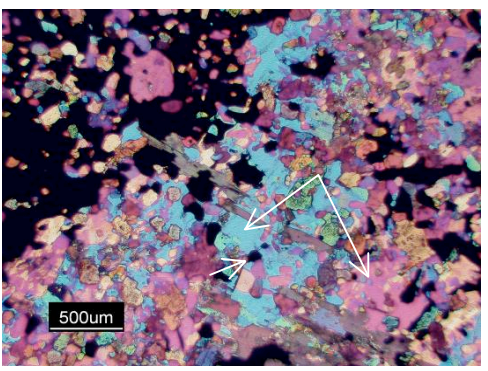

Figure 1: Sulfides droplets in the silicate anatectic melt.

An intriguing complication to this model is that sulfide droplets in the xenolith anatectic melt are richer in Ni, Cu and PGE than sulfides in the contact aureole of the intrusion. This suggests that these elements diffused in from the mafic magma through anatectic melt and into the sulfide droplets before the sulfide droplets transferred to the mafic magma. Diffusion is possibly driven by chemical potential gradients.