Paper Number: 3892

Genesis of Chromite by Dynamic Upgrading of Xenocrystic Fe ± Ti Oxide

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A fundamental problem in the genesis of chromite deposits in layered mafic-ultramafic intrusions is how to generate layers of massive to semi-massive chromite that are often up to 1m thick (e.g., Bushveld, Stillwater) and commonly up to 2-10m thick (e.g., Inyala, Ipueira-Medrado, Uitkomst, Sukinda), but sometimes up to 100m thick (e.g., Kemi, Black Thor-Blackbird) from magmas with relatively low Cr contents that normally crystallize chromite in very small (Ol/Chr ~ 60) amounts. Models involving oxidation, silica addition, magma mixing, pressure changes, assimilation of iron-formation (IF), and hydration, with or without physical transport, have been proposed [see reviews by 1-3]. Most require the amount of magma to greatly exceed the thickness of the magma chamber, which was more likely to have been much thinner at that stage. Dynamic (open) systems involving any of those processes must operate continuously, a balance difficult to maintain. Wholesale assimilation of IF will not work if the magma is already saturated in oxide. Mechanically transporting chromite requires it to be extracted from another location and simply relocates the mass balance problem. An alternative process is that the parental magma partially melted and assimilated silicates (chert/quartz and Fe-rich silicates) in silicate-magnetite IF (common in these environments), but not oxide [3]. Assimilation of Si would produce Opx in magmas that would normally not crystallize Opx. Fine-grained (<0.2 mm) xenocrystic magnetite would be easily transported in and upgraded through interaction with the magma [3], analogous to the sulfide xenomelt upgrading model [4] favoured for most magmatic Ni-Cu-PGE deposits. Using conservative parameterizations, magma:chromite ratios as low as 100 (low end estimated for many magmatic Ni-Cu-PGE deposits) can produce Cr-rich chromites. Diffusion models permit complete upgrading of magnetite to chromite in ~1000 yrs, well within the time such systems would have been active. No relict magnetite cores have been reported in the originally uniformly very fine-grained (<0.2 mm) high-Cr chromite in the ore zones, but grains with 1: intermediate-Cr intermediate-Fe chromite inner cores (interpreted as modified xenocrysts), 2: intermediate-Cr low-Fe outer cores (interpreted as magmatic overgrowths), and 3: thick magnetite rims (interpreted as metamorphic overgrowths) (Fig. 1) are locally preserved in IF xenoliths.

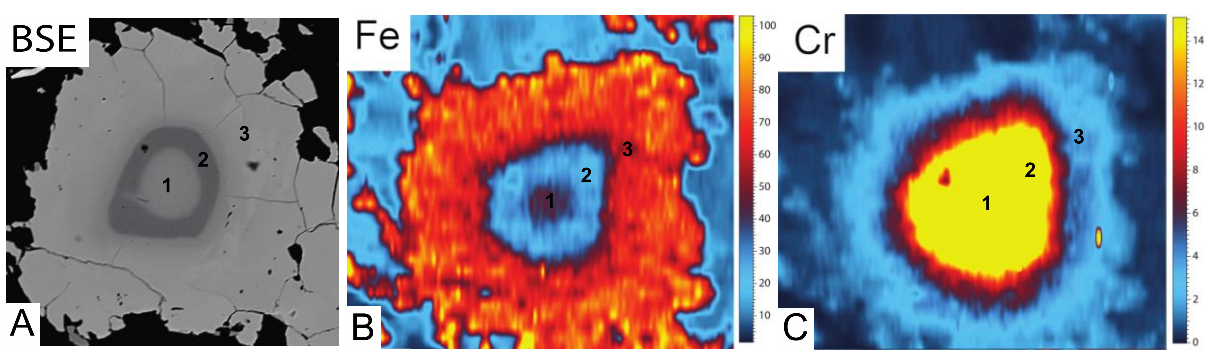

Figure 1. Backscattered electron (A) and LA-ICP-MS (B-C) images of a 175 μm dia. reverse-zoned Cr-magnetite with thick magnetite rim in an iron-formation xenolith, Black Thor Intrusive Complex, northern Ontario. Fe scale is 0-100; Cr scale is 0-15%.

References

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