Dykes formed by replacement and re-melting of the Rustenburg Layered Suite, Bushveld Complex

D.L. Reid, I.J. Basson and D.J. Anderson
Department of Geological Sciences, University of Cape Town, South Africa

The spectacular layering developed in the Upper Critical Zone of the Bushveld Complex is host to two of the world's most important PGE resources, namely the Merensky Reef and UG2 chromite seam. Detailed investigation of these two stratiform reefs both above- and underground has revealed a number of post-layering phenomena that cause disruption, replacement and redistribution of the PGE mineralisation.

One example of post-layering activity is the widespread development of iron-rich ultramafic pegmatite (IRUP) that occurs as cross-cutting pipes, dykes, inclined and sub-concordant sheets. It is unlikely that the bulk IRUP composition represents a magmatic liquid, while the field relations rule out the injection of a crystal mush. Moreover, the dykes, pipes and sheets are not dilational structures, and thus appear to have been formed by passive replacement.

IRUP bodies are well exposed in underground exposures of the Merensky Reef footwall layers at Northam platinum mine, and are characterised by a megacrystic assemblage of Fe-olivine and Fe-augite, with minor amounts of Fe-Ti oxide and Ca-plagioclase. While it seems that plagioclase-rich layers (norite - anorthosite) are particularly prone to replacement by IRUP, extensive bodies are also found in the pyroxenites. Chromite seams appear to be barriers to IRUP migration, as several concordant sheets seem to pond under UG1, UG2, P2 and the Merensky chromite seams.

Several geochemical features of the IRUP point to crystallisation from a highly evolved mafic melt, such as high Fe/Mg ratios in olivine and pyroxene, and a computed REE pattern in the melt that shows strong LREE enrichment and a pronounced negative Eu anomaly. Strontium and Neodymium isotope signatures in the IRUP differ from those observed for the Upper Critical Zone, and rather resemble those in the Upper Zone.

In view of the observed field relations and petrological features, the IRUP bodies are thought to have been formed by either (1) reaction between the country rock layers and an infiltrating melt derived from an extraneous source, or (2) partial melting of still hot country rock layers in response to the introduction of fluids along fractures. It is also possible that both processes could operate in tandem, in the sense that a volatile-rich melt could perhaps cause both replacement and partial melting. Several examples of dyke- and pipe-like bodies in plutonic complexes possessing features incompatible with conventional emplacement, could have produced by in situ partial melting in response to fluid+melt transfer.