Pt, Pd, Cu and Sulfur Contents of the Platreef on the Farm Townlands, Northern Bushveld Complex

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In much of the northern limb of the Complex, the ultramafic rocks of the Lower and Lower Critical Zones are not developed (Viljoen and Schurman, 1999, and references therein). Here, the basal rocks of the Complex consist of a relatively thin (up to 250 m) package of texturally heterogenous pyroxenites, norites, and gabbros, that contain numerous xenoliths of the floor rocks. This is overlain by a thick (up to 2000 m) package of gabbro and 3000 m of magnetite gabbros and diorites. Buchanan et al. (1981) and others correlated the basal sequence with the Upper Critical Zone, whereas the overlying gabbros and magnetite gabbros-diorites were correlated with the Main and Upper Zones, respectively.

The basal Upper Critical Zone rocks are variably sulfide-mineralized and are referred to as the Platreef in the literature. Three distinct layers are usually distinguished (Viljoen and Schurmann, 1999, and references therein). The basal A-reef commonly consists of coarse-grained norite and gabbro and contains little sulfides. The B- and C-reefs are more pyroxenitic. The bulk of the mineralization and the highest grades are found in the B-reef. Little quantitative data have been published concerning sulfide and metal contents. The most comprehensive summary available is by Viljoen and Schurmann (1999). They report that the sulfides occur largely in disseminated form, with minor pods and veins of massive sulfide being more abundant towards the basal contact of the B-reef. In Fig. 1 and 2 I present new quantitative metal and S data from a Platreef intersection on the farm Townlands where the reef overlies shale. Pt/Pd is lower than elsewhere in the Northern limb, at around 0.5. Pt+Pd tenors of the sulfides are between 10 and 60 ppm. The data show the development of three distinct intrusive phases that are separated by shale interlayers. The latter do not appear to represent xenoliths as sulfide contents are markedly different below and above the layers.

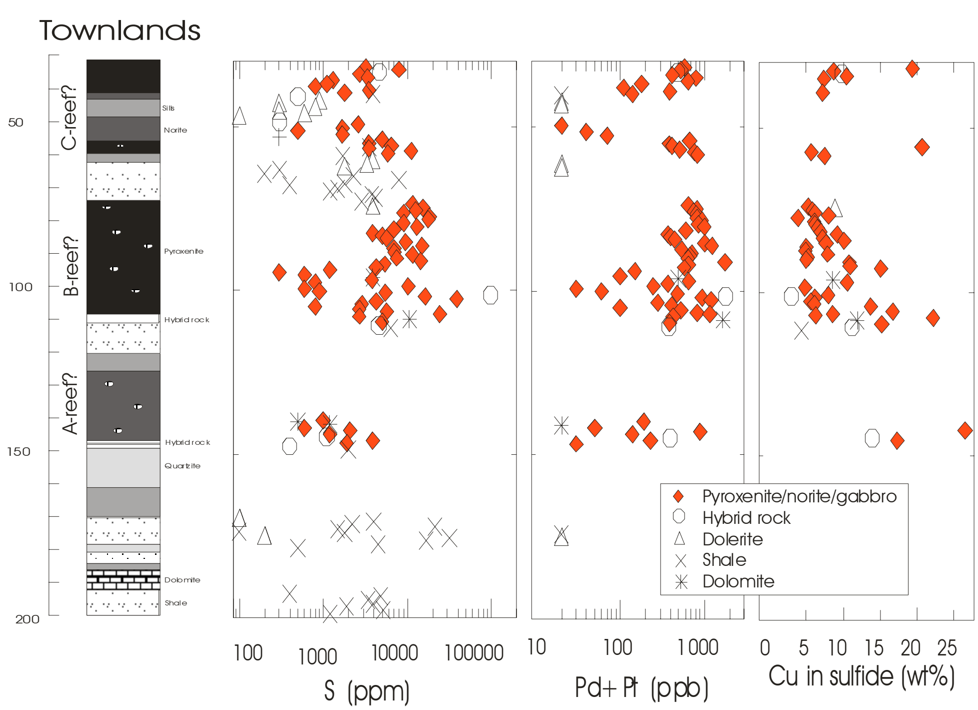

Figure 1. *Concentrations of S, Pt+Pd, and Cu in sulfide, plotted versus height in the Platreef at Townlands.*

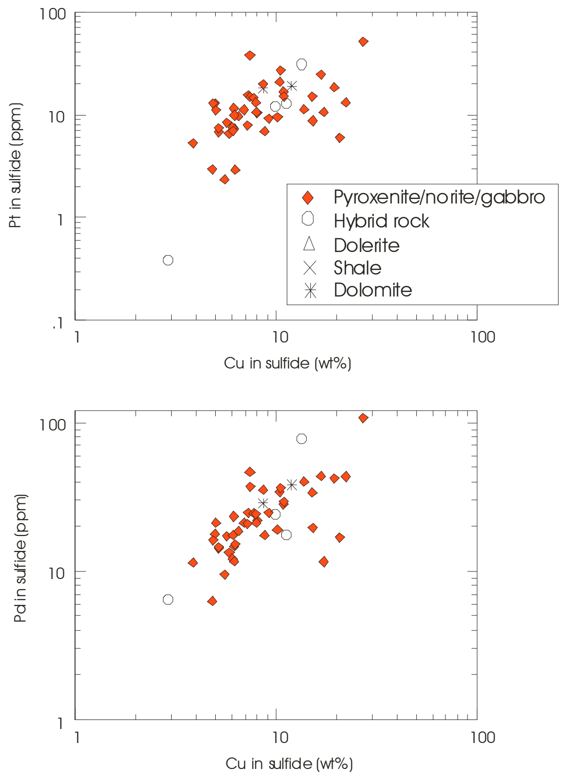

Figure 2. *Binary variation diagrams of (A) Pt in sulfide vs. Cu in sulfide, and (B) Pd in sulfide vs. Cu in sulfide.*

The origin of the sulfide mineralization remains controversial. The northern limb of the Complex intruded dolomite, shale, Fe-formation and granite, as opposed to quartzites in most of the remainder of the Complex. The field evidence suggests that the dolomites, in particular, are more reactive than the quartzites, based on the occurrence of abundant dolomite xenoliths associated with sulfides in the Platreef. Further, within the Platreef, PGE grades appear to be highest where the floor rocks are dolomite, and lower where they are granite, Fe-formation or shale (White, 1994). The published compositional data are largely in agreement with this interpretation. S isotope data of Platreef sulfides (Buchanan et al., 1981) indicate a strong crustal component of dolomitic lineage (d34S –9). Oxygen isotopic data of Harris and Chaumba (2001) suggest that the Platreef magma assimilated some 18% dolomite. One could also draw on some circumstantial evidence from the Uitkomst Complex, an intrusion of Bushveld lineage and age that was emplaced in dolomite and shale of the floor of the Bushveld Complex. Large amounts of disseminated sulfides (100mt at 0.55% Ni and 0.2% Cu, Pt/Pd about 0.4) have similar compositions to the Platreef sulfides analysed by us and are concentrated in rocks that are hosted by dolomite and that contain numerous dolomite xenoliths. In contrast, Uitkomst rocks that are hosted by shale are generally sulfide-poor.

What remains even less clear is why the interaction of the silicate magma and the dolomite should have triggered sulfide supersaturation. Some authors (Buchanan et al., 1981) suggested desulfidation of the dolomite, but apart from shaly interlayers, most of the Transvaal dolomites are relatively S poor, with between 0.5-1.5 wt% S. Other authors (de Waal, 1977; Gain and Mostert, 1982) prefer oxidation of the magma, in response to devolatization of the dolomite (see Wallmach et al., 1989, for a quantification of devolatization and associated volume loss).

The occurrence of dolomite xenoliths within Platreef where the floor rocks consist of shale or granite clearly indicates some entrainment of xenoliths within the Bushveld chamber. The fact that the xenoliths occur both to the South and the North of where the floor rocks consist of dolomite may suggest derivation from downdip. If the sulfides segregated in response to interaction of the magma with dolomite, then the sulfides must also have been entrained for some distance. Sulfide entrainment is supported by the following observations:

(i) PGE tenors of the sulfides are high (around 50 ppm) compared to many other magmatic sulfide ores and occurrences that are interpreted to have formed as a result of essentially in situ country rock assimilation (e.g. Duluth; Western Australian komatiites; Raglan). (ii) On Townlands, the B-reef consists of a sill of pyroxenite containing, on average, in excess of 1% sulfides and 0.5 ppm Pt+Pd. Therefore, the body does not seem to have crystallized from a liquid, but from a crystal mush with considerable cumulus sulfide. (iii) In the examined core, there is no tendency for sulfides to be concentrated around dolomite or other country rock xenoliths.

Some authors (Lee, 1996) go as far as to propose that the Platreef sulfides formed in a staging chamber at depth. The main argument against this model is that the amount of sulfides and the PGE grades of the Platreef in the Northern limb of the Bushveld appear to be governed by the floor lithology, i.e. sulfide contents and ore grades are highest at Sandsloot, where the reef overlies dolmite. This suggests that the sulfides formed in the Bushveld chamber. Unfortunately, too little quantitative data are available to evaluate whether the metal tenors of the sulfides vary systematically with floor lithology, but we would normally expect higher tenors with increasing distance from the source of contamination, due to continued interaction of the sulfides with the magma.

A notable feature of the Platreef at Townlands is that Cu contents in many of the sulfides are unusually high. Bushveld sulfides would be expected to have maximum sulfide contents of about 7%, assuming D values of 1000 and Cu contents of the parental magmas of 70. Yet, the Townlands Platreef sulfides have Cu contents commonly in excess of 10%. The possibility that the sulfides represent fractionated sulfide melts is rejected due to the lack of correlation between Cu and Pt or Pd, i.e. the most Cu-rich sulphides show no concommitant enrichment in PGE (Fig. 2). Alternatively, Cu may have been introduced to the rocks or S may have been resorbed by fluids from the footwall rocks. This is supported by the observed Cu enrichment of sulfides at the base of the B-reef (Fig.1), and by the fact that the most Cu-rich sulfides occur in veins associated with felsic domains of the reef.

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