Variation of PGM in a Cross Section Through the Merensky Reef at Impala Mines

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Summary

Location and identification of PGM in samples from a section of Merensky Reef has shown that in norites, melanorites and leuconorites the PGM assemblage is almost exclusively Pt- and Pd-bearing bismuth-tellurides. In the chromite-rich lithologies this bismuth-telluride assemblage is joined by a Pt-, Rh-, Pd-, base metal sulfide PGM assemblage with laurite and rare Sn-bearing PGM and this additional assemblage tends to be Pd-poor. All the PGM are predominantly associated with base metal sulfides and have not been observed enclosed in chromite grains.

Introduction

PGE analysis of samples collected from a section of Merensky Reef at Impala mines (Barnes and Maier, 2002) has shown that Pd, Ni, Cu and Au correlate with S throughout the reef. In Cr-poor and S-bearing units Pt, Ir, Ru and Rh also correlate with S but in Cr-rich zones there is an excess of Pt, Ir, Ru and Rh for the quantity of S present. It was proposed that a study of the PGM mineralogy, determining the distribution of the PGE, would help to determine the reasons for this lack of correlation of Pt, Ir, Ru and Rh with sulfur in the chromite-rich lithologies. Eight samples (Table 1) were chosen for study and systematically searched for PGM. PGM were identified in polished thin sections using a Cambridge 360 SEM at Cardiff University.

Results

More than 200 PGM were located and identified. Most of the PGM are associated with base metal sulfides and are commonly situated on the edges of sufides surrounded by silicate, often plagioclase. PGM are occasionally surrounded by interstitial quartz especially in the chromite-poor samples including sample 8. PGM usually are not enclosed in chromite. Only in the chromite-rich sample 24 are PGM rarely totally or partially enclosed by chromite grains and in these cases the PGM are always surrounded by sulfides, either in a rounded inclusion in or on the edge of chromite. The distribution of the different types of PGM in these samples is shown in Table 2.

Chromite-poor samples 8, 20, 26 and 28 host almost exclusively Pt- and Pd-bearing-bismuth-tellurides usually associated with sulfides and these PGM are usually elongate, sometimes extremely so and they may have ragged outlines especially where enclosed in altered silicates.

In the chromite-rich sample 24 there is a variety of PGM formed from different combinations of PGE and base metals including commonly Pt-sulfides, Pt- and Pd-sulfides, and Pt-,Rh-,Co-, Cu-sulfides. The Pt-Pd- sulfides are equant with well defined edges and are almost always situated on the edge of base metal sulfides whether pyrrhotite, pentlandite or chalcopyrite. Only 4 out of the 48 Pt-Pd-bearing sulfides identified are not in contact with sulfides and two show Pd zoning.

Table 1. *Lithological sample descriptions of the 8 samples from the Merensky Reef.*

8	TOP	Norite with sulfides and biotite, interstitial quartz,
20		Melanorite with sulfides and biotite,
22a		Melanorite with sulfides and biotite,
22b		A chromite layer in the same section as 22a
23		Melanorite pegmatite with few sulfides and minor chromite,
24		Chromite layer within a melanorite, minor sulfides at the chromite / melanorite junction and minor quartz,
25a		Chromite layer sulfide-poor,
25b		Anorthosite sulfide-poor,
28	BASE	Very plag-rich leuconorite with minor sulfides and quartz,

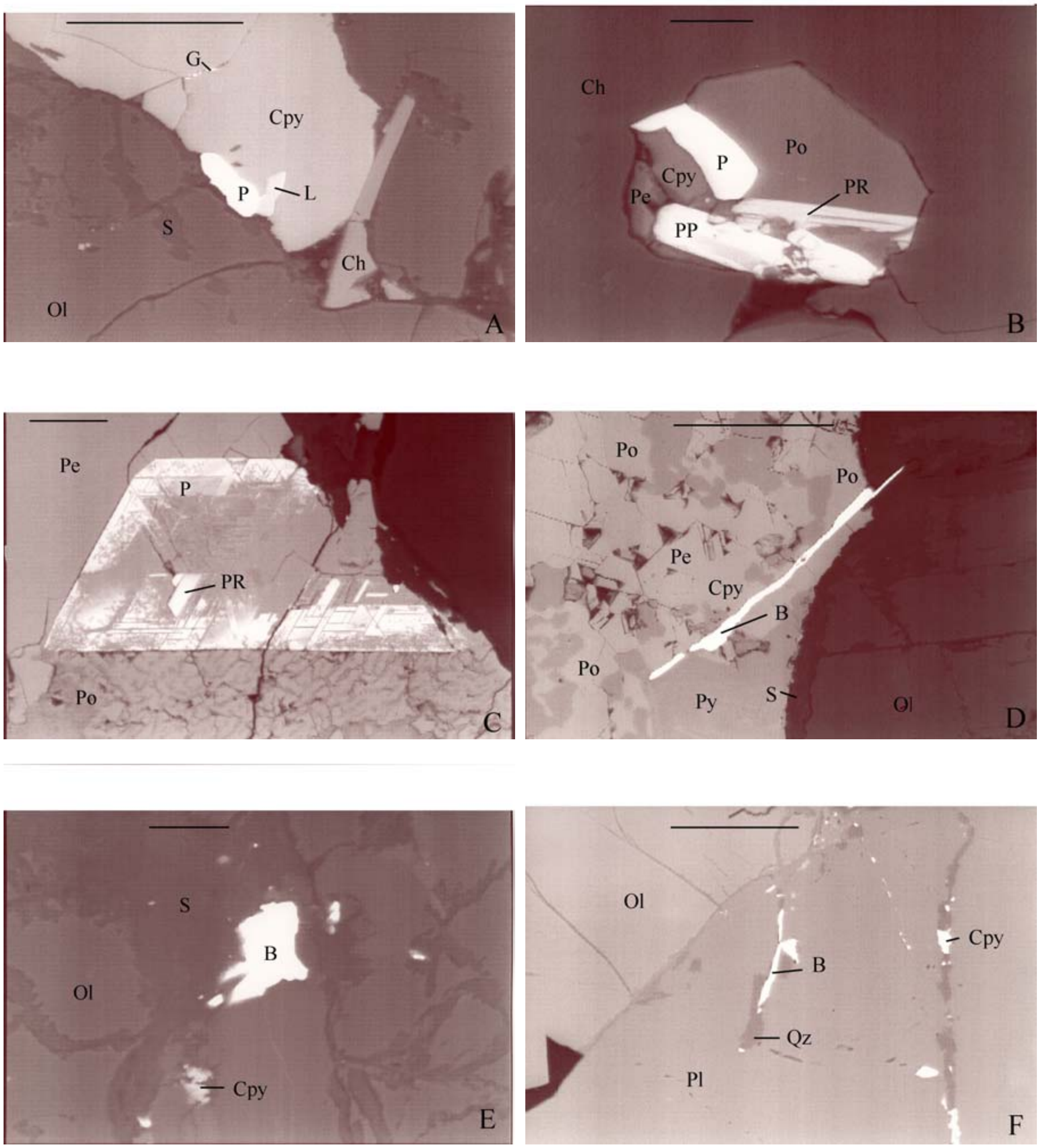

Figure 1. A) Pt-sulfide with laurite on the edge of chalcopyrite, sample 24. Scale bar represents 50 μm. B) PGM in sulphides that are enclosed in chromite, sample 24. Scale bar represents 20 μm. C) Euhedral Pt-Rh-basemetal –bearing PGM in base metal sulfides, sample 24. Scale bar represents 20 μm. D) Elongate Pt-bismuth-telluride in base metal sulfides and extending into silicates, sample 22. Scale bar represents 100 μm. E) Ragged Pd-(Pt-)-bismuth-telluride in serpentine, sample 24. Scale bar represents 20 μm. F) Pt-bismuth-telluride enclosed in quartz, sample 26. Scale bar represents 50 μm. Key to symbols: B = Pt-, Pd- bismuth-tellurides, Ch = chromite, Cpy = chalcopyrite, G = galena, L = laurite, Ol = olivine, P = Pt-sulfide, Pl = plagioclase, Pn = pentlandite, Po = pyrrhotite, PP = Pt-, Pd-, Ni sulfide, PR = Pt-, Rh-, Cu-, + Co in plate C and + Ir in plate B, sulfide, Py = pyrite, Qz = quartz, S = serpentine.

Table 2.

Sample No.	**Cr, S**	**Pt sulfide**	**Pd,Pt sulfide**	**Pt,Rh,Co sulfide**	**Cu+Pd**	**RuS_2**	**Pt,Bi**	**Te +Pd**	**Pd,Bi,Te**	**% PGM Pd-bearing**
8	S						5	5		100
20	S						4	2	3	70
22a	S	1	1				11			8
22b	Cr	12	1			1	13	2		12
23	S	6					2	1		12
24	Cr	30	19	24	1	11	9	1		25
25a	Cr	1	2	1		1				50
25b	S		4				8	1		50
26	S						11	5		50
28	S						2	1		30

Cr indicates presence of a chromite layer, S the presence of visible sulfides in hand specimen. Other PGM (and precious metals) are rare and include the following:- PtAsS in sample 20, PtAsS, Pt,Sn,S, Au,Ag in sample 22, Pt,Pd,Sn, Au,Ag in sample 23, Pt,Pd,Sn, IrRhAsS in sample 24, Pt,Sn,S, Au,Ag in sample 25 and Pd,Hg,Te, Au,Ag in sample 26.

The Rh-bearing PGM-sulfides are always Cu-bearing and 50% are Co-bearing, one is Ni-bearing and 2 are Ir-bearing. They are either lath shaped or trapezium shaped with euhedral outlines and good cleavages or raggid or needle-like within pentlandite or pyrrhotite. Laths sometimes cross grains of pentlandite or pyrrhotite and rarely extend or stick out into silicates but usually sit within the outline of the sulfide.

The Rh-bearing PGM tend to be associated with pyrrhotite and pentlandite rather than chalcopyrite; that is of 19 PGM, 16 have no chalcopyrite associated, 2 are on the edge of chalcopyrite adjacent to pyrrhotite and one is on the edge of chalcopyrite and silicate. Of these 19 PGM, 11 are associated with pyrrhotite and 8 with pentlandite. The laurites are almost all located in sample 24 and all (16) are associated with sulfides. All but 2 laurites are in contact with sulfides, one is partially surrounded by chromite, 11 are enclosed in sulfides, 6 are with pentlandite or pyrrhotite, 8 are with chalcopyrite, 11 are very close to Pt-bearing PGM, namely 9 Pt-sulfides and 2 PtBiTe. The hosts for the PGM and associated sulfides are very varied including plagioclase, olivine, pyroxene, serpentine and chlorite.

In contrast the Pt-, Pd-, bismuth-tellurides are rare in sample 24, spindley, raggid when in serpentine and over half (6 out of 10) are surrounded by silicates rather than sulfides or chromite. One is partially enclosed in chromite. Pd-bearing minerals also are much rarer in the chromite-rich sample 24 and in the other chromite-rich samples compared with the chromite-poor samples.

Discussion

The PGE-mineralogy in this section of Merensky Reef offers new insight into the relative importance of the magmatic processes that concentrate and fractionate PGE.

Os, Ir, Ru and Rh are known to be collected into monosulphide solid solution (MSS) crystallising from an immiscible sulphide liquid and Pt, Pd and Au fractionate into intermediate solid solution (ISS) (eg. Barnes et al. 1997). In these samples the Rh- bearing PGM tend to be enclosed by pyrrhotite and pentlandite whereas Pt and Pd-sulfides, Pt- and Pd- bismuth-tellurides and laurite are more evenly distributed between Ni-rich and Cu-rich sulfides. So in these samples it is clear that Rh is retained in MSS.

The contrast between the PGM in the chromite-poor sulfide-bearing samples and the chromite-rich and relatively sulfide-poor samples is very distinctive. The sulfide-bearing PGM are almost entirely confined to the chromite-rich lithologies suggesting an additional process of PGM concentration to that represented by the ubiquitous bismuth-telluride-rich PGM. The association of the PGM with sulfides rather than chromite indicates a strong link with sulfide precipitation. However a lack of base metal sulfides in the Cr-rich samples caused Barnes and Maier (2002) to propose that PGM may have directly precipitated from the magma rather than entering immiscible sulfide liquids. Certainly the strong association of PGE with sulfides either indicates exsolution from these sulfides or direct crystallisation of the PGM from the magma with the sulfides. Exsolution is supported in some cases by the morphology of the PGM, especially Rh-bearing PGM, which often form laths within the sulfides.

Although the excess Pt, Rh, Os, Ir and Ru in the chromite-rich lithologies is not explained by this mineralogical study, it is clearly accounted for by a distinct additional PGM sulfide assemblage.

References

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