Normal Merensky Reef on Northam Platinum Mine, Zwartklip Facies, Upper Critical Zone, Western Bushveld Complex

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Introduction – The Bushveld Complex

The Upper Critical Zone (UCZ) of the western lobe of the Rustenburg Layered Suite (RLS) of the Bushveld Complex (e.g. Eales et al., 1993; Eales and Cawthorn, 1996) hosts the Northam Platinum Mine (Fig. 1), exploiting subsurface down-dip extensions of the Merensky and UG2 chromitite seams (e.g. Von Gruenewaldt, 1977). The western Bushveld Complex comprises two main facies: the Rustenburg Facies to the south of the Pilansberg Complex and the Swartklip Facies to the north of the Pilansberg (Wagner, 1929). This subdivision relates to the much smaller UG2-Merensky separation and widespread olivine-bearing layers in the Swartklip Facies, which consists of two reef sub-facies, i.e. Normal and Regional Pothole Merensky Reef (Viljoen, 1994; Maier and Eales, 1997; Viljoen, 1999). The Merensky Reef at Northam is divided into Normal and "Pothole" reef sub-facies (Viljoen et al., 1986 a, b; Viring and Cowell, 1999).

Normal and Regional Pothole Merensky Reef

Normal Merensky Reef (NR) at Northam has a footwall of Upper Pseudoreef Cyclic Unit mottled anorthosite overlain by an orthocumulate stringer (4X) chromitite, followed by reconstitution pegmatoids and mg. to cg. pyroxenite and harzburgite, the latter overlain by the Merensky Cyclic Unit (MCU), consisting of a basal refractory chromitite stringer (Merensky chromitite) overlain by a mg. poikilitic orthopyroxenite. NR sub-facies occurs where the base of the MCU does not transgress the 4X chromitite although reconstitution, petrographic character and PGE mineralization of the inter-chromitite pegmatoid vary with reef thinning. Transgression of the 4X chromitite and underlying stratigraphic markers by the MCU produces the Regional Pothole sub-facies. Three main pothole reef types, separated by transition zones, are termed the NP2, P2 and FWP2 reefs (Viring and Cowell, 1999; Reid and Basson, in press). In addition, potholing 1) affects the extent of reconstitution and PGE/sulphide distributions in inter-chromitite pegmatoid and the reef footwall (e.g. de Klerk, 1982); 2) causes zoning, with Pt-Pd tellurides at pothole edges and Pt-Fe alloys at pothole centers (Kinloch and Peyerl, 1990) and 3) show more reduced mineralization/reconstitution conditions, suggesting the localization of C- and S-rich reducing fluids during footwall erosion and MCU deposition (e.g. Buntin et al., 1985; Campbell, 1986). Three broad subdivisions of the Normal Merensky Reef in the proximity of the Regional Pothole sub-facies/4X transgression are defined by the Merensky-4X separation at Northam. A fourth subdivision, where Merensky merges with the 4X chromitite, is included (Figs. 1-1 to 1-4):

1) *>300 cm 4X-Merensky separation*: Basal pegmatoidal dunite, grading upwards into a mg. harzburgite/orthopyroxenite, succeeded by upper pegmatoidal orthopyroxenite. Sulphide phases comprise intercumulous pentlandite-pyrrhotite-chalcopyrite as coarse clusters in the upper and lower pegmatoids and as sparse, finely disseminated intergrowths in the intervening poorly mineralised mg. harzburgite/orthopyroxenite. Chalcopyrite decreases upwards, pentlandite increases downwards; pyrrhotite remains constant. Sulphide and concomitant PGE content display two distinct spikes, one centred 10-20 cm above the 4X chromitite, and the other coincident with or immediately below the Merensky chromitite.

2) *160-300 cm 4X-Merensky separation*: Basal pegmatoidal harzburgite, grading upwards into a pegmatoidal pyroxenite. Sulphide phases comprise intercumulus pentlandite-pyrrhotite-chalcopyrite, as coarse clusters in a zone centred 10 cm above the 4X chromitite and coincident with the Merensky chromitite, and as smaller disseminated clusters in the pegmatoid. PGE content mimics sulphide distribution, with peaks in a zone centred 10cm above the 4X chromitite, and associated with Merensky chromitite. The two PGE peaks, evident in the >300 cm reef, merge in the inter-peak area.

3) *<160 cm 4X-Merensky separation*: Heterogeneous pegmatoidal pyroxenite ± minor olivine. Intercumulous pentlandite-pyrrhotite-chalcopyrite occurs as randomly distributed irregular clusters to fine disseminations. Chromitite-related PGE and sulphide peaks become progress-

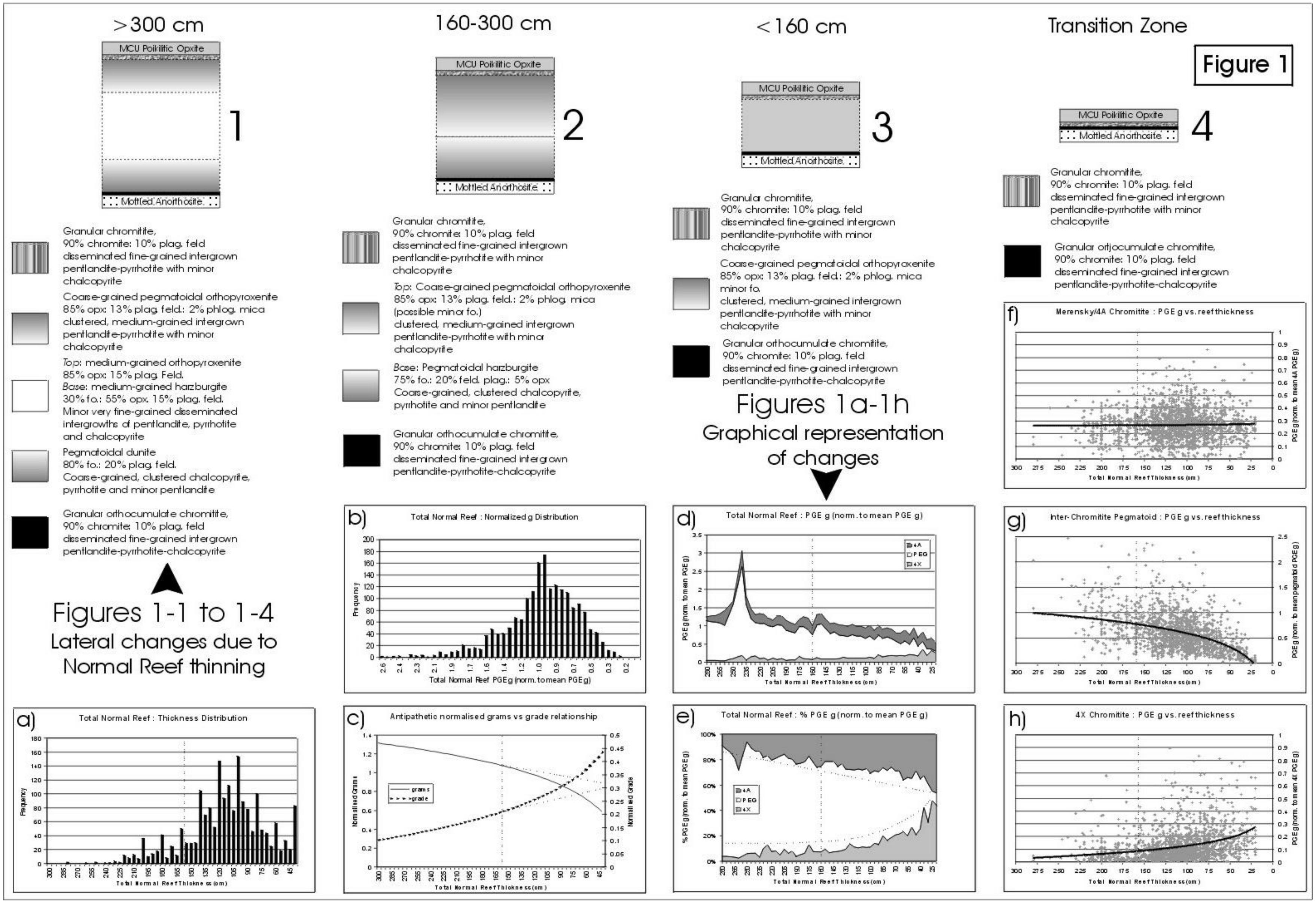

Figure 1
>300 cm
160-300 cm
<160 cm
Transition Zone
MCU Poikilitic Opxite
Mottled Anorthosite
1
2
3
4
Granular chromitite, 90% chromite: 10% plag. feld disseminated fine-grained intergrown pentlandite-pyrrhotite with minor chalcopyrite
Coarse-grained pegmatoidal orthopyroxenite 85% opx: 13% plag. feld.: 2% phlog. mica clustered, medium-grained intergrown pentlandite-pyrrhotite with minor chalcopyrite
Top: medium-grained orthopyroxenite 85% opx: 15% plag. Feld.
Base: medium-grained harzburgite 30% fo.: 55% opx. 15% plag. feld.
Minor very fine-grained disseminated intergrowths of pentlandite, pyrrhotite and chalcopyrite
Pegmatoidal dunite 80% fo.: 20% plag. feld. Coarse-grained, clustered chalcopyrite, pyrrhotite and minor pentlandite
Granular orthocumulate chromitite, 90% chromite: 10% plag. feld disseminated fine-grained intergrown pentlandite-pyrrhotite-chalcopyrite
Top: Coarse-grained pegmatoidal orthopyroxenite 85% opx: 13% plag. feld.: 2% phlog. mica (possible minor fo.) clustered, medium-grained intergrown pentlandite-pyrrhotite with minor chalcopyrite
Base: Pegmatoidal harzburgite 75% fo.: 20% feld. plag.: 5% opx Coarse-grained, clustered chalcopyrite, pyrrhotite and minor pentlandite
Coarse-grained pegmatoidal orthopyroxenite 85% opx: 13% plag. feld.: 2% phlog. mica minor fo. clustered, medium-grained intergrown pentlandite-pyrrhotite with minor chalcopyrite
Granular ortjocumulate chromitite, 90% chromite: 10% plag. feld disseminated fine-grained intergrown pentlandite-pyrrhotite-chalcopyrite
Figures 1-1 to 1-4
Lateral changes due to Normal Reef thinning
Figures 1a-1h
Graphical representation of changes
a) Total Normal Reef : Thickness Distribution
Frequency
Total Normal Reef Thickness (cm)
b) Total Normal Reef : Normalized g Distribution
Frequency
Total Normal Reef PGEg (norm. to mean PGEg)
c) Antipathetic normalised grams vs grade relationship
Normalised Grams
Normalised Grade
grams
grade
Total Normal Reef Thickness (cm)
d) Total Normal Reef : PGE g (norm. to mean PGE g)
PGEg (norm. to mean PGEg)
4A
PEG
4X
Total Normal Reef Thickness (cm)
e) Total Normal Reef : % PGE g (norm. to mean PGE g)
% PGEg (norm. to mean PGEg)
f) Merensky/4A Chromitite : PGE g vs. reef thickness
PGEg (norm. to mean 4A PGEg)
g) Inter-Chromitite Pegmatoid : PGE g vs. reef thickness
PGEg (norm. to mean pegmatoid PGEg)
h) 4X Chromitite : PGE g vs. reef thickness
PGEg (norm. to mean 4X PGEg)
Total Normal Reef Thickness (cm)

ively more indistinct with progressive thinning.

4) *4X-Merensky chromitites merged*: The MCU rests directly on the 4X chromitite; granular chromite of each stringer is amalgamated and no inter-chromitite pegmatoid remains.

Routine mapping and sampling of NR at the southern edge of the Regional Pothole reef sub-facies yields a geo-referenced data set, consisting of: a) separation of Merensky and 4X chromitite (cm); b) hangingwall thickness above Merensky chromitite (cm); c) footwall thickness below 4X chromitite (cm - the latter 3 parameters are combined to produce a total sampled NR thickness); d) the grams/concentration of 3 PGEs+Au; e) the PGE grade and; f) separate Merensky, inter-chromitite and 4X 3 PGEs+Au grams and grade (data in d, e and f are for 10-20 cm long, 5 cm wide samples within each sampling channel, normalized to the arithmetic mean of grams and grade, simply referred to as "grams" and "grade" in this study).

- Total NR thickness and grams distribution plots are skewed towards lower values due to the proximity of the Regional Pothole Reef sub-facies (Figs. 1a+b)
- There is a +tive lognormal relationship between NR thickness and total platinum group element grams and a –tive lognormal relationship between NR thickness and PGEs (inverse grade:grams relationship from 50 cm to 300 cm reef thickness; Fig. 1c)
- Thinning of NR has a significant affect on sulphide and PGE distribution in proximity to the 4X chromitite (Figs 1d+e).
- Thinning of NR has no discernable effect on Merensky PGE content (Fig. 1f).
- Inter-chromitite PGE values display –tive lognormal relationship with NR thinning (Fig. 1g).
- 4X chromitite values display +tive lognormal relationship with NR thinning (Fig. 1h).
- Sulphide and PGE remobilization in inter-chromitite reconstituted pegmatoidal feldspathic pyroxenite/harzburgite is pronounced at a reef thickness of 160 cm or less, where upper and lower inter-chromitite pegmatoidal lithologies have merged (Figs. 1c,d,e,g,h).

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