

Examiner 3: Corrections Report:

Abstract

Examiner: Abstract, last para, line 1: “Although there are comparison with the Bushveld succession...”

Response: Changed as suggested by the examiner. “Although there are similarities with the Bushveld succession...”

Chapter 1:

Response: All small comments have been corrected as seen in the PDF as suggest by the Examiner (i.e. grammar, punctuation and addition or removal of certain words).

Examiner: page 2, 1st para, line 2: “... of the P Block of the Periodic Table...”

Response: Changed as suggested by the examiner. “...the Groups 15 and 16 of the Periodic Table...”

Examiner: page 2, 1st para, line 3: PGM = P G Metals or Minerals?

Response: Changed as suggested by the examiner. “Minerals”

Examiner: page 2, Table 1.1: The Density (Os, Ir and Pt) and Melting points (Ru, Os and Ir).

Response: Changed as suggested by the examiner.

Examiner: page 2, 3rd para, line 4: “1-100 ppb” is NOT economic. The range of economic deposits (hard rock) is ~ 2-10 ppm 3E.

Response: Changed as suggested by the examiner.

Examiner: page 5, 1st para, line 3: Rephrased. “Most PGE-rich sulphide liquids accumulate at the base of large igneous layered intrusions or above impermeable layers such as a chromitite layer to form economic stratabound or stratiform deposits.”

Response: Changed as suggested by the examiner.

Examiner: page 9, 1st para, line 3: “modal” changed to “model”

Response: Changed as suggested by the examiner.

Chapter 2:

Response: All small comments have been corrected as seen in the PDF as suggest by the Examiner (i.e. grammar, punctuation and addition or removal of certain words).

Examiner: page 15, 2nd para, line 2: Rephrased

Response: Changed as suggested by the examiner. “The Marginal Zone is generally composed of medium-grained, poorly layered heterogeneous rocks which form the base of the Bushveld Complex, although, it is not everywhere developed (Eales and Cawthorn, 1996).”

Examiner: page 19, last para, 4th last line: Reference added “ ...Junge et al., 2015).”

Response: Changed as suggested by the examiner.

Examiner: page 21, line 2: Rephrased “Where?”

Response: Changed as suggested by the examiner. “The Merensky Reef in the northwestern part of the Bushveld Complex is much thicker and olivine is the main constituent in the lower parts of the reef (Naldrett *et al.*, 2012).”

Examiner: page 24, line 2: Rephrased.

Response: Changed as suggested by the examiner. "The base of the Zone is defined by the appearance of cumulus magnetite. The Upper Zone is approximately 2000 m thick (SACS, 1980)."

Examiner: page 26, 1st sentence: Deleted

Response: Changed as suggested by the examiner.

Chapter 3

Response: All small comments have been corrected as seen in the PDF as suggest by the Examiner (i.e. grammar, punctuation and addition or removal of certain words).

Examiner: page 30, 1st para, line 6: Rephrased.

Response: Changed as suggested by the examiner. "The Villa Nora Fragment is an area of exposed layered Bushveld rocks that strike in an east-west direction and have a southward dip (Kinnaird *et al.*, 2005)."

Examiner: page 31, Figure 3.1. "Moordrift" replaced with "Moorddrift"

Response: Changed as suggested by the examiner.

Examiner: page 35, 2nd para, line 6: "...highest Cr₂O₃ content and Cr# in the entire Bushveld Complex." Give values

Response: Changed as suggested by the examiner.

Chapter 4

Response: All small comments have been corrected as seen in the PDF as suggest by the Examiner (i.e. grammar, punctuation and addition or removal of certain words). Not all recommendations are changed as this is already a published document.

Examiner: page 50, 2nd para, line 4: "The fifth author 0%?"

Response: The fifth author on the paper is the technical manager of Platinum Group Metals (RSA) and he was the person who allowed access to the core, assay results and the PTM project. He was not a part of the research although he contributed to the discussions associated with the project.

Chapter 5

Response: All small comments have been corrected as seen in the PDF as suggest by the Examiner (i.e. grammar, punctuation and addition or removal of certain words). Not all recommendations are changed as this is already a published document.

Examiner: page 88, Abstract, line 9: "...secondary sulphide assemblage..." which? List typical minerals.

Response: This document is already published and this change cannot be made.

Examiner: page 89, 1st para, line 1: "...the topic of many studies,..." suggest that is should be deleted.

Response: This document is already published and this change cannot be made.

Examiner: page 109, 2nd para, last line: this is MLA - Schouwstra program. Not sufficient!

Response: This document is already published and this change cannot be made.

Examiner: page 109, 3rd para, line 1: 82 % of the volume or area found in the mineral separates.

Response: This document is already published and this change cannot be made.

Examiner: page 110, 3rd para, 2nd last sentence: Not so...

“Euhedral isoferroplatinum and cooperite as well as symplectitic intergrowths of isoferroplatinum with BMS are typical for the reef-style mineralisation in chromitite seams of the BC (for example, Fig. 40-2 in Cabri, 2002; Yudovskaya *et al.* 2017).”

Response: This document is already published and this change cannot be made.

Examiner: page 111, 2nd para, last sentence: Lazy! If so, why did you not analyse Pd in pn? Easy with EPMA, standard, just increase mA, V and counting times,... . Important for your interpretation, a must - please analyse yourself, before others do - that's your baby! Clearing this point is a must - if Pd in pn - why not in PGM? If not, then something is wrong with your data.

“This imbalance can be explained by an assumed Pd storage in pentlandite that is a typomorphic feature of the Bushveld reef style and low sulphide types of mineralisation (for example, Klemd *et al.*, 2016).”

Response: This document is already published and this change cannot be made.

Examiner: page 114, 1st para, line 5 and 9: why not recalculate your mineral to Pd₇₂ and Pd₇₃, for closer comparison? “[Pd_{3.85-3.96}Pt_{0.18-0.23}Sn_{0.88-0.92}Te_{0.77-0.93}] (an. 6 and 7, Table 5.4)” and Pd₇₂Sn₁₆Te₁₂ to Pd₇₃Sn₁₄Te₁₃”

Response: This document is already published and this change cannot be made.

Examiner: page 115, 1st para, last sentence: No

“The Ni-rich braggite and vysotskite (Pd, Ni)S are not widespread in the Bushveld reefs, rather they are known to be formed under postmagmatic hydrothermal conditions, for example, in massive sulphides ores of the Noril'sk deposit (Genkin *et al.*, 1981).”

Response: This document is already published and this change cannot be made. The new mineral is currently been discussed and X-ray may be done in the near future so that the exact name and composition of the mineral will be consider, this work is currently been performed in collaboration with M. Yudovskaya and L. Carbi.

Chapter 6:

Response: All small comments have been corrected as seen in the PDF as suggest by the Examiner (i.e. grammar, punctuation and addition or removal of certain words).

Examiner: page 151, 2nd para: Rephrased

Response: “According to Eales *et al.* (1986) the Sr:Al₂O₃ ratio is used to recognise different magmatic influxes. The UmS shows a large variation with the Sr:Al₂O₃ ratio through the feldspathic orthopyroxenite, harzburgite and mela-troctolite, ranging from 4 to 30 (Fig. 6.8f). There is a gradual increase in the Sr:Al₂O₃ ratio throughout the TGA sequence with a dramatic decrease associated with the anorthosite and gabbro-norite samples directly below the T zone (Fig. 6.8f). At the base of the T2 there is an increase in the Sr:Al₂O₃ ratio that decreases gradually towards the top of the T1, from 18 to 10. The UZ samples show a range from 2 to 8 associated with the Sr:Al₂O₃ ratio. According to Kinnaird (2005) the Al₂O₃:FeO+MgO ratio varies with changing pyroxene to plagioclase proportions and sudden changes may indicate whether more than one magma was involved in forming the Bushveld succession. There is only one significant change in the Al₂O₃:FeO+MgO ratio at the contact between the UmS and TGA sequence in the Waterberg stratigraphy. The UmS has Al₂O₃:FeO+MgO ratio values < 0.6 and the TGA sequence has values > 1 (Fig. 6.8e). The SiO₂:Al₂O₃ shows fairly similar

results throughout the Waterberg Bushveld succession although a few samples have slightly higher values (Fig. 6.8a).

The Fe_2O_3 values for the UmS, T zone and the UZ have large variations probably due to the Fe content within the ultramafic, sulphide-bearing and magnetite-bearing lithologies, whereas the TGA sequence has a fairly uniform amount of Fe_2O_3 (Fig. 6.4b). The TiO_2 contents in the UmS varies depending on the lithologies, the feldspathic orthopyroxenite samples have higher TiO_2 values (0.14 and 0.23 wt. %) and the TiO_2 contents ranges between 0.06 to 0.08 wt. % for the harzburgite and mela-troctolite samples. The TGA sequence has constant TiO_2 values with a slight increase within the T zone. The UZ shows a large variation in terms of the TiO_2 content (Fig. 6.8c). Both the UmS and the T zone show large variations in Sr values, whereas the TGA sequence and the UZ have constant values apart from a few anomalies (Fig. 6.8d)."

Examiner: page 153, 1st para: Rephrased

Response: "The feldspathic orthopyroxenite samples within the basal part of the UmS have elevated Cr values (1500-2200 ppm) as do one of the overlying harzburgite samples 2200 ppm Cr (Fig. 6.9a). The rest of the samples in the UmS have moderate Cr content between 200 and 600 ppm. The TGA sequence shows an upward decrease in Cr content (Fig. 6.9a). The T zone has the lowest Cr content <100 ppm. The overlying UZ has the largest variation in terms of Cr between 50 to 2400 ppm (Fig. 6.9a). The V content is constant through the Waterberg Bushveld stratigraphy with a few anomalies (Fig. 6.9b). There are elevated Co values for the UmS and the T1, which is consistent with the higher distribution coefficient for Co into olivine and pyroxene-rich lithologies compared with plagioclase-rich lithologies (Fig. 6.9c). The Rb values are low and constant with elevated values associated with the basal feldspathic orthopyroxenite and one anorthosite sample. There is a slight increase in the Rb values associated with the upper UZ samples (Fig. 6.9d). The Cr:MgO ratio shows elevated values for the basal feldspathic orthopyroxenite and one harzburgite sample, although there is a gradual decrease to the top of the UmS. At the base of the TGA sequence there is a slight increase, although from 861.50 m there is a gradual decrease towards the top of the T zone. The UZ lithologies have a large variation associated with the Cr:MgO ratio (Fig. 6.9e)."

Examiner: page 154, 2nd para: is there any chance to see "extended" data, 6PGE + Au?

Response: Currently we only have access to 2PGE and Au. Platinum-Group Metals (PTM) (RSA) is a new exploration company and some of the data is still consider confidential.

Examiner: page 162: WORD should check it throughout: replace Moordrift by Moorddrift.

Response: Changed as suggested by the examiner throughout the thesis.

Examiner: page 162, last para, line 1: Rephrased

Response: Changed as suggested by the examiner "McDonald *et al.* (2017) pointed to the importance of inverted pigeonite and orthopyroxene associated with leucogabbro in Unit 2 and 3 and compares this interval stratigraphically with the occurrence of inverted pigeonite in the Bellevue drillcore (2000-2200 m depth) (Ashwal *et al.*, 2005; Tanner *et al.*, 2014)."

Examiner: page 165, last para, last sentence that goes on to next page: "...precious metal basket..." namely - give numbers, ratios or whatsoever. Too general a basket

Response: Changed as suggested by the examiner, Rephrased "...precious metal basket (65% Pd, 30% Pt, and 5% Au)."

Examiner: page 166, 1st para, line 6: sentence Rephrased

Response: Changed as suggested by the examiner, Rephrased "Calc-silicates are absent and there is little evidence of assimilation of local S from secondary sedimentary sources as most of the sulphur

isotopic results obtained magmatic signatures (McCreesh *et al.*, 2015) associated with the ultramafic F-zone.”

Examiner: page 167, 1st para, line 7: sentence Rephrased

Response: Changed as suggested by the examiner, Rephrased “The T1 and T2 have the same precious metal basket, however, the T1 is generally has lower grades compared to the T2.”

Chapter 7:

Response: All small comments have been corrected as seen in the PDF as suggest by the Examiner (i.e. grammar, punctuation and addition or removal of certain words).

Examiner: page 169: who then made the sulfur isotope analyses?

Response: Once the preparations of the sulphur isotopes were completed the samples were submitted to the Environmental Isotope Laboratory of the iThemba Laboratories in South Africa.

Examiner: page 182, Results, 1st para, first sentence: Delete

Response: Changed as suggested by the examiner.

Chapter 8:

Response: All small comments have been corrected as seen in the PDF as suggest by the Examiner (i.e. grammar, punctuation and addition or removal of certain words).

Examiner: page 200, last para, line 3: ?

Response: “The analysis was carried out by Ni-sulfide fire assay followed by Te co-precipitation and ICP-MS (McDonald and Viljoen, 2006).”

Examiner: page 208, last para, line 1: ?

Response: “For this study 28 samples from a range of lithologies were selected for fire assay and the results, normalized to chondrite values (Lodders, 2003), are plotted in Fig. 8.11. Results for total PGE range from 12 to 12,300 ppb with 1.1 to 1100 ppb Au.”

Examiner: page 212, 1st para, line 1 and 3: “mildly”

Response: This is a published document.

Examiner: page 225, 2nd bullet point, line 2: “high-Mg”

Response: This is a published document.

Examiner: page 225, 4th bullet point: “The mineralization of the Waterberg T Zone contains approximately 20% Au in the metal budget.”

Response: This is a published document.

Examiner: page 225, 7th bullet point: “The Waterberg's F Zone does not form reefs and mineralization occurs along high-aspect ratio elongated bodies or chonoliths.”

Response: This is a published document.

Examiner: page 227, Figure 8.16: Hard to distinguish. What about closed and open circle + squares, or triangle?

Response: This is a published document.

Examiner: page 230, last para, line 1: “ex tension” to “extension”

Response: Changed as suggested by the examiner and as seen in the final published document.

Chapter 9: Discussion and Conclusion

Response: All small comments have been corrected as seen in the PDF as suggest by the Examiner (i.e. grammar, punctuation and addition or removal of certain words).

Examiner: page 231, 1st para, line 4: “Agree in principle. But please, leave out self-praise, do not underline too thick - leave this to others.

Response: Changed as suggested by the examiner. Agreed and sentence deleted.

Examiner: page 236, 2nd para, line 8: might be related to sampling density - only limited number of drill cores so far (?) “Thus far only one calc-silicate (<1 m thick) has been identified in borehole WB027 within the basal Marginal sills below the UmS on the Waterberg project.”

Response: I have worked on the project area and the company has drilled over 400 borehole core and to my knowledge this is the only calc-silicate that has been identified.

Examiner: page 236, 3rd para: Rephrased paragraph according to examiner.

Response: “In summary, the UmS in the Waterberg project area shares some similarities with mafic/ultramafic rock units in other parts of the Bushveld Complex, however, the general set-up and mineral-chemical details of the UmS are distinctly different from comparable units elsewhere in the Bushveld Complex.”

Examiner: page 240, 1st para, last sentence: Deleted “repetition” “The boundary between the TGA sequence and the Upper Zone in the Waterberg stratigraphy has therefore been drawn on the change of magnetic susceptibility values and this position is in agreement with the noted geochemical changes.”

Response: Changed as suggested by the examiner. Agreed and sentence deleted.

Examiner: page 241, 2nd para, 1st sentence: “non-Parella (350LR)” correct?

Response: Yes this is correct, it is a farm close to the Waterberg project.

Examiner: page 242, 1st para, 2nd sentence: Rewrite sentence – not clear.

Response: Changed as suggested by the examiner. “The top contact of the ultramafic/mafic succession is complex. While often very sharp and mylonitised, it is commonly marked by a hematite-rich siltstone or less commonly by a prominent fine-grained white-grey tuffaceous layer at the contact (Fig. 4.5).”

Examiner: page 246, 2nd para, line 7: “hydrid” changed to “hybrid”

Response: Changed as suggested by the examiner.

Examiner: page 246, 3rd para, line 6: “sulphides” changed to “aggregates”

Response: Changed as suggested by the examiner.

Examiner: page 247, 2nd para, last sentence: Delete “Recognition of such index PGM and their assemblages (Good *et al.*, 2017) can be used to distinguish mineralisation styles and determine exploration targets.”

Response: Changed as suggested by the examiner.

Examiner: page 248, 2nd para, line 1: “No, ~47 km”

Response: Changed as suggested by the examiner.

Examiner: page 248, Table 9.3 and last para: Why this comparison? Stillwater is OK, Rum is totally uneconomic and small. More appropriate would be Stillwater and Great Dyke (both economic), and maybe Norilsk (high Pd:Pt) and/or Skaergaard.

Response: These deposits were chosen because they all have PGE-rich olivine lithologies (troctolite and harzburgite). The F zone is an olivine-rich mineralised package and I wanted to show how it compares with other olivine-rich deposits around the world. The Great Dyke of Zimbabwe and Norilsk of Russia are pyroxenite –rich deposits.

Examiner: page 249, 2nd para, line 1: Waterberg Group ? - No. Your group + PTM should find another clear and unequivocal name for your far northern limb Bushveld intrusion

Response: We are all currently using the name provided by the company (PTM) as not to confuse everyone, however, we have highlighted to the company that a unique names needs to be thought of.

Examiner: page 253, 2nd para, last sentence: Rephrased “There are several Pd-rich layers (up to 5 enriched layers), the basal layer is regarded as the main Pd-rich layer, and the top layer is a gold rich layer with minor Pd (Anderson *et al.*, 1998).”

Response: Changed as suggested by the examiner.

Examiner: page 254, 1st para, last sentence: How is this reef related to the 5 Pd-rich layers mentioned first?

Response: These 5 layers are the Platinova Reef.