

## Projects with Prevec 2018

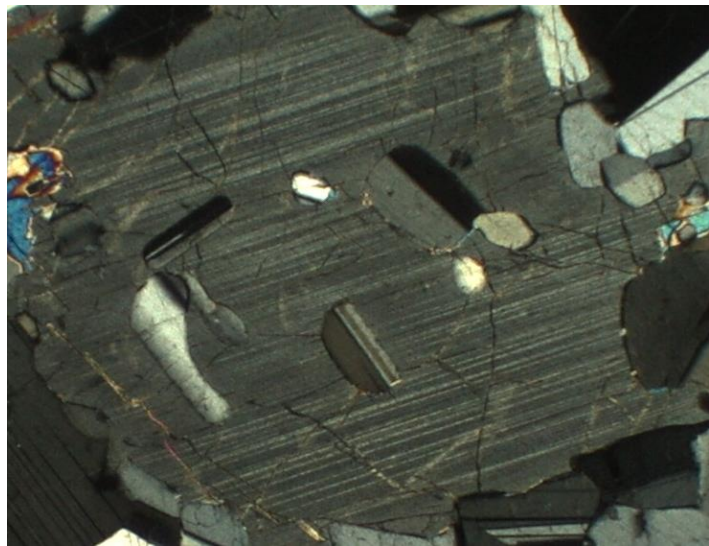
### Bushveld Complex mineralization

I am interested in petrogenetic processes in layered intrusions, particularly those relating to the origins of oxide and sulphide mineralization. These studies normally involve microscope petrography, and geochemistry (major and trace elements, sometimes PGE data, and occasionally radiogenic isotope data). Connections with Glencore (Cr, Pt and V in western and eastern lobes) and with Ivanhoe (Flatreef deposit, northern lobe) allow for a variety of possible projects involving the sampling and study of drill core from active mining areas. Core is available in the department representing sections of the Upper Critical Zone from the eastern and western Bushveld Complex, and additional samples can be acquired. Possible or ongoing projects include:

- The transition from Upper Critical Zone into Lower Main Zone, particularly across the Bastard cyclic unit and overlying mottled anorthosites, to examine the relationship between PGE and chrome enrichment and petrology.
- The relationship between oxide reefs and their leucocratic ('anorthositic', s.l.) footwalls
- Detailed studies of the Critical, Main and Upper Zones of the Bushveld involving collaborations with Dr Roger Scoon (consultant) and various industry partners.
- A collaborative project with Dr Nic Tonnelier (NMMU) is focussing on the relationship between carbonate contamination and oxide (chromite and/or magnetite) and sulphide (Cu-Ni-PGE) mineralization.



Irregular and delaminated chromitite with anorthositic footwall in core, MG-group, Eland Mine, W. Bushveld.



Resorbed plagioclase in orthopyroxene; evidence of disequilibrium in Merensky Reef footwall, Winnaarshoek, Eastern Lobe, Bushveld Complex.

Past or ongoing student projects have included:

1. Lasni Botha (2017 to present) MSc student, Rhodes University, "Effects of the Steelpoort Pericline on the eastern margin of the Rustenburg Layered Suite in the Spitskop area", supported/sponsored by BCR Minerals (Pty) Ltd.

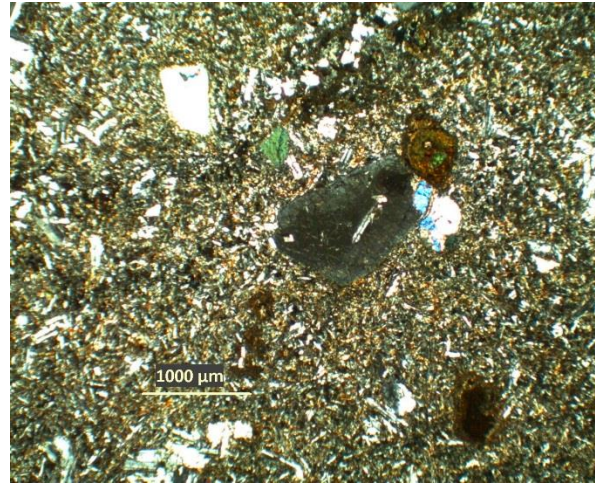
2. Yogendran Arunachellan (2014-present) MSc student, Rhodes University, "Petrogenesis of MG chromitite reefs of the Critical Zone, western Bushveld Complex, South Africa", supported by Glencore-Xstrata and funded by NRF grant to SP. (part-time; submission in early 2018 planned).
3. Darryn van Hyssteen (2017) MSc Rhodes University, "Petrology and geochemistry of magnetite V ores from the Upper Zone of the Bushveld Complex, Western Lobe", sponsored by Glencore (NRF-funded).
4. Adina Iorga-Pavel (2017) MSc Rhodes University, "Constraints on magnetite ore genesis, Bushveld Complex Upper Zone, Northern Lobe", sponsored by Bushveld Minerals (Morris Viljoen).
5. Savvas Largatzis (2016) MSc Rhodes University, "Constraints on the emplacement of PGE-chromitite reefs in the Upper Critical Zone, Bushveld Complex, South Africa", sponsored by Glencore (NRF-funded).
6. Mark Raines (2015) MSc Rhodes University, "Evolution of the Merensky Reef, Bushveld Complex, South Africa: isotopic and petrological constraints".
7. Darryn van Hyssteen (2014) Honours Rhodes University, "Petrology and geochemistry of magnetite ores from the Upper Zone of the Bushveld Complex, Northern Lobe", sponsored by Bushveld Minerals (Morris Viljoen).
8. Savvas Largatzis (2015) Honours Rhodes University, "Constraints on the emplacement of PGE-chromitite reefs in the Upper Critical Zone, Bushveld Complex, South Africa", sponsored by Glencore (NRF-funded).
9. Devin Kaminer (2014) Honours student, Rhodes University, "Petrogenesis of the Displat facies of the Platreef, Bushveld Complex, South Africa", sponsored by Anglo Platinum (James Winch).
10. Simon Everitt (2013) Economic Geology MSc student, Rhodes University, "Evolution of the UG2 unit, Bushveld Complex, South Africa: mineral composition and petrological evidence".
11. James Cumming (2008) Honours student, Rhodes University, "Influence of potholes and IRUPs on mineralised horizons, Kroondal Mine, western Bushveld Complex", sponsored by Xstrata Mining (Mr Jan-Pieter Gräbe).

### **Karoo magmatism: crystal suspensions and emplacement mechanisms**

Changes in our perceptions of how mafic intrusion emplacement and crystallization processes occur have been developing over the past two decades, based on seminal studies of lava lakes, sills, impact melts, and layered intrusions. End-Karoo magmatism has been extensively studied in the extrusive phases (e.g., work by J.S. Marsh on Drakensburg & Etendeka basalts), but relatively little geochemical work has been done on the unmineralised intrusive rocks (i.e., everything other than the Mt Ayliff Complex; see above), apart from recent work on the Golden Sill by French and South African-based researchers. Recent work building on their database suggests that early crystallization, crystal compaction, and trapped liquid remobilization can be identified near the margins of Beaufort Group sills, which are distinctive inasmuch as they form so-called saucer-shaped sill complexes with steeply-inclined sections which offer unique exposures of gravity-controlled lateral processes in the southwestern Karoo. A database is being established based on petrography, mineral chemistry, and geochemistry in order to constrain this relatively novel story.



*North-dipping inclined Karoo sill in Beaufort Gp clastic sediments, Middelburg area.*



*Phenocrysts in chilled lower marginal rocks to dolerite sill, Colesburg area.*

Past student projects have included:

1. Dylan Molyneux (2018-?) MSc student, Rhodes University, "*Petrogenesis and multiphase emplacement of late-Gondwanan Jurassic sills, Karoo Supergroup, South Africa*".
2. Dylan Molyneux (2017) Honours student, Rhodes University, "*Petrogenesis of a Jurassic Middelburg-area dolerite sill, Eastern Cape Province, South Africa*".
3. Mr Mawande Ntantiso (2016) Honours student, Rhodes University, "*A geological investigation into the paragenesis of the Jurassic-aged Colesberg Sill, Free State, South Africa*".
4. Kanyisa Sicwebu (2014) Honours student, Rhodes University, "*Petrogenesis of the Taylor's Koppie Dyke contact with Karoo sediments, Eastern Cape, South Africa*". Cosupervised with Dr P. Horváth.
5. Bantubonke Ntsaluba (in prep.) MSc student, Rhodes University, "*Petrogenesis of the Mount Ayliff Intrusion, Eastern Cape, South Africa*", sponsored by Vale Inc. (Ian Fieldhouse).

### **Non-Bushveld magmatic ores: Cu-Ni-PGE sulphide and oxide ore mineral petrogenesis**

Other studies of magmatic ores in which I have been involved have included research on the Bushveld-aged Uitkomst Complex (Mpumalanga), which hosts chromite and massive sulphide ores, the Mesoproterozoic Koperberg suite (Northern Cape), which hosts Cu ores, and the Jurassic Mount Ayliff Complex (Eastern Cape), which hosts Cu-Ni-PGE sulphides. I have suites of rock powders and thin sections for Koperberg pyroxenitic rocks which remain to be studied, thin sections from Mt Ayliff's lobes which can be further studied, and all of these have the potential to be revisited and locally remapped. There is a strong possibility of collaboration on Mt Ayliff with Dr N. Tonnelier of NMMU, probably with emphasis on mineral studies relating to mantle sources. Other studies on these rocks could include mapping, petrology and modelling of contact metamorphism and magma emplacement models.



*Cu-bearing breccia, Koperberg intrusions, Carolusberg mine, N. Cape Province.*



*Chromitite seam with pegmatoid in pyroxenite, Uitkomst Complex, Mpumalanga.*

1. Kyle Smetherham (2016) Honours Rhodes University, *“Dyke interaction with pyroxenitic lower zone rocks, Uitkomst Complex, South Africa”*.
2. Bantubonke Ntsaluba (in prep.) MSc student, Rhodes University, *“Petrogenesis of the Mount Ayliff Intrusion, Eastern Cape, South Africa”*, sponsored by Vale Inc. (Ian Fieldhouse).
3. Kanyisa Sicwebu (2014) Honours student, Rhodes University, *“Petrogenesis of the Taylor’s Koppie Dyke contact with Karoo sediments, Eastern Cape, South Africa”*. Cosupervised with Dr P. Horváth.
4. Geoffrey Howarth (2013) Ph.D. student, Rhodes University, *“A petrologic, geochemical and isotopic investigation into the origins of magnetite horizons in the Panzihua Intrusion, Sichuan Province, China”* (with Prof. Mei-Fu Zhou, Hong Kong University).
5. Yogendran Arunachellan (2013) Honours student, Rhodes University, *“Geochemistry and mineral composition of massive magnetite ore vs. gabbroic host rocks from the Baima and Taihe layered intrusions, SW China”*.
6. Gregory Viljoen (2012) Honours student, Rhodes University, *“Genesis of the lower zone of the River Valley Complex, Canada, and implications for sulphide mineralisation”*.
7. Sean Linkermann (2011) M.Sc. project; *“Origins, evolution and metallogenesis of the Palaeoproterozoic Kemi Intrusion, Finland”*, with Prof. Tuomo Alapieti (University of Oulu), supported by a grant from the Finnish Academy.
8. Salome Ashiwana (2007) Honours student, Rhodes University, *“Emplacement mechanics of Koperberg intrusions, O’okiep area, Northern Cape”*.
9. Alan Johnson (2007) Honours student, Rhodes University, *“Origins and metal potential of the Southern Cross Intrusion, Namibia”*, sponsored by Remote Exploration Services (c/o Mr Dale Verran).

Other recent/ongoing projects with no current loose ends

### **SCLM and/or depleted mantle in the Palaeoproterozoic: isotopic and geochemical evidence**

Palaeoproterozoic mafic magmatism is represented as dyke swarms, belts of fault-bounded sills, and variably-preserved flood basalts, with minor associated felsic magmatism (granitoids and rhyolites) across central Ontario (Canada), northern Finland, and the Kola Peninsula (Russia). In general, these are characterized by enriched radiogenic isotopic signatures, consistent with either modest crustal contamination by Neoarchean crust, or an enriched mantle source, possibly remelted subcontinental lithospheric mantle (SCLM). These intrusions are also typically leucogabbroic, with poorly developed ultramafic components, and lack massive magmatic sulphides, although significant

exceptions exist from the Russian and Finnish examples. Recent work on the Kemi and River Valley intrusions suggests that depleted mantle was involved, possibly of boninitic origin, with crustal contamination deriving from relatively ancient crust implicated.



*Above, sulphide-mineralised basal breccia zone, Dana Lake South showing, River Valley Complex, Canada. At right, fat, grey, old balding man saws up outcrop.*



1. Stephen Dorbor Jr (2016) Honours Rhodes University, *"Petrogenesis of the mineralised facies of the River Valley Intrusion, Grenville Province, Canada: evidence for boninitic parent magma"*.
2. Gregory Viljoen (2012) Honours student, Rhodes University, *"Genesis of the lower zone of the River Valley Complex, Canada, and implications for sulphide mineralisation"*.
3. Sean Linkermann (2011) M.Sc. project; *"Origins, evolution and metallogenesis of the Palaeoproterozoic Kemi Intrusion, Finland"*, with Prof. Tuomo Alapieti (University of Oulu), supported by a grant from the Finnish Academy.

## **Pseudotachylites, mylonites, impacts and ages**

Zircon ages are seen as incorruptible and unquestionable recorders of magmatic ages. However, evidence from rocks rendered geological complex by large bolide impacts and related shock metamorphism and crater evolutionary processes, combined with pre- and post-impact orogenic activities, demonstrate that misleading age-data can be produced, resulting in significantly erroneous geological interpretations of the geological history. Studies of regionally metamorphosed sills in volcanosedimentary rocks associated with impact heating and localised shearing are attempting to resolve these events and identify cryptic melting which has produced post-emplacement magmatic zircons and complex deformation textures.



*Pseudotachylitic and/or mylonitic breccia in Drury Twp metaleucogabbro.*



*Veinlet of partial melt cross-cutting deformational fabric, Drury Twp metaleucogabbro.*

1. John de Bruyn (2016-present) MSc. student, Rhodes University, “*Constraints on deformation and melting of the Palaeoproterozoic Drury Township leucogabbro, Southern Province, Canada*”. With in-kind support from Laurentian University (Canada) and Wallbridge Mining (Canada).
2. Bukelwa Nxesi (2011) Honours student, Rhodes University, “*Origins of pseudotachylitic breccia from the Sudbury contact aureole, and relevance to associated sulphide mineralisation*”.

## **Other projects**

There have been various other student projects which don't fall into any of my themes, such as those involving hydrothermal Cu-Pb-Zn sulphide ores, and several involving soil & groundwater contamination by Pb & Zn adjacent to mines and smelters; all of these were in Namibia.

In addition, one of my major themes hasn't had an Honours project because of the nature of the sampling, but there are possibilities here too:

## **Evolution of impact melt sheets and their target rocks**

These studies also fundamentally based on petrography, petrology and geochemistry, with a large component of thermal modelling of impact melt sheets. Most of this work is based on the Sudbury Igneous/Impact Complex in Canada, but there are some analogous features from the Vredefort impact which can be examined in a similar way. I have a sample suite of the “impact melt” rocks from Vredefort (rocks & thin sections), and additional sampling can be undertaken.