THE GEOLOGY OF FINSCH MINE, NORTHERN CAPE PROVINCE, SOUTH AFRICA

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INTRODUCTION

Finsch Mine, an 118Ma old Group 2 kimberlite with a surface area of 17.9ha, is located 160 km WNW of Kimberley, South Africa.

Figure 1: Locality Map

The main orebody (Finsch pipe) occurs on a north-east striking dyke called the Smuts dyke and forms part of the Finsch kimberlite cluster. The cluster is made up of 3 kimberlite pipes (Finsch, Shone and Bowden) and 3 dyke sets (Botha, Smuts and Bonza). The pipe intruded into sequences of the Karoo and Precambrian Griqualand West Groups totaling 1.2km in thickness. Fragments of the latter, as well as basalt and sediments from the Karoo Supergroup range in abundance from moderate to common throughout the pipe. The Karoo Supergroup in this area has been removed by post emplacement erosion, but has been estimated at a thickness of at least 100-200m (de Wit, pers. comm.).

The first report of a possible kimberlite was by a prospector called De Bruyn who unsuccessfully worked several pits in a "pan" on the farm Brits. During the late 1950's – early 1960's two prospectors, named Fincham and Schwabel, were unsuccessfully prospecting for asbestos in the area and subsequently turned their attention towards diamonds. They obtained a prospecting permit for precious stones in February 1961 and founded the Finsch Diamond Mining Company – the first three letters of the founders' names. Later that year washing commenced on the farm Brits with the discovery of a pipe proclaimed soon afterwards (Hallam, 1961).

Mining started in 1964 with the stripping of the overburden and the treatment of the kimberlite ore through a pilot plant. The main treatment plant commenced operation in 1965 with full production attained in 1967. The pipe was initially overlain by an ironstone-rich breccia that ranged in depth from 2 to 6.5 meters. (A.P Du Toit, pers. comm.) The contact between the overburden and "yellow ground" was undulating and uneven and the two could not be separated effectively during the early stages of mining. The so-called "yellow ground" (weathered kimberlite) persisted to a depth of 80m below surface.

Open pit mining (Blocks 1, 2 and 3) was terminated in 1990, with the pit reaching a depth of 430 meters below surface. Thereafter underground mining commenced using a modified blast-hole open stoping mining method for Block 2 (350m – 430 m below surface) and Block 3 (430m – 510 m below surface) extending the pit to 510 meters below surface (See Figure 2). The feasibility study for mining Block 4, by mechanised block caving, has been completed and approved. The infrastructure development for this block cave is in progress, with the production start-up commencing in 2003. An exploration drilling programme is currently being undertaken to determine the feasibility of Block 5 (See Figure 2). The average operating grade for Finsch mine has ranged between 45.8 and 47 cpht since 2000.

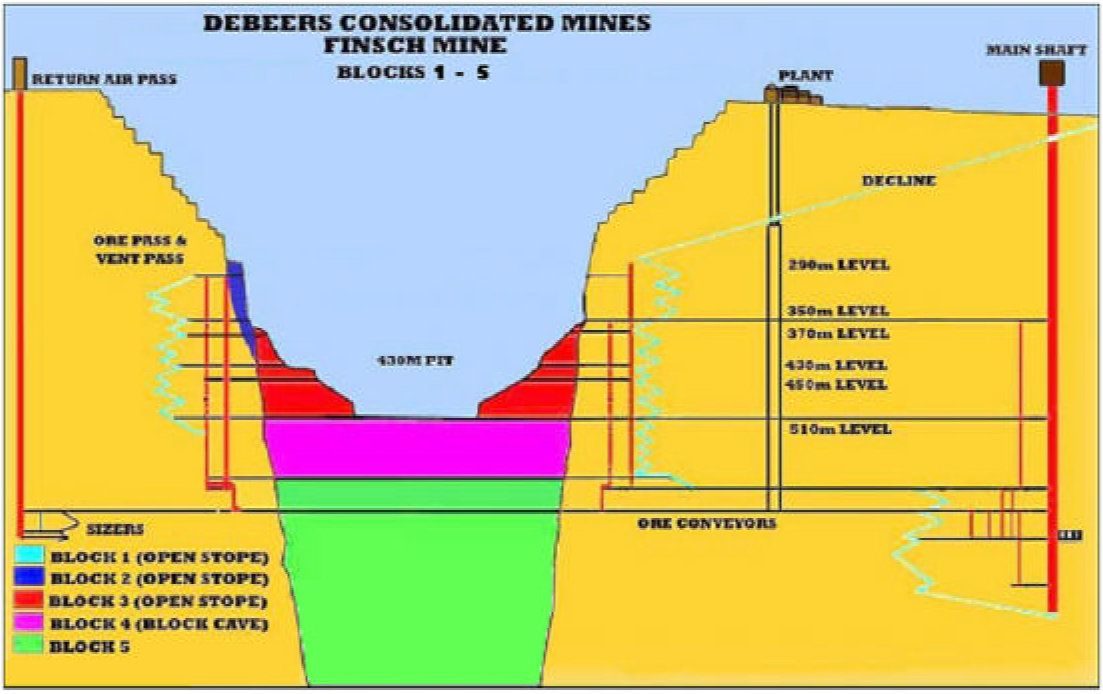

Figure 2: Schematic section of Finsch pipe showing the existing underground development and mining blocks.

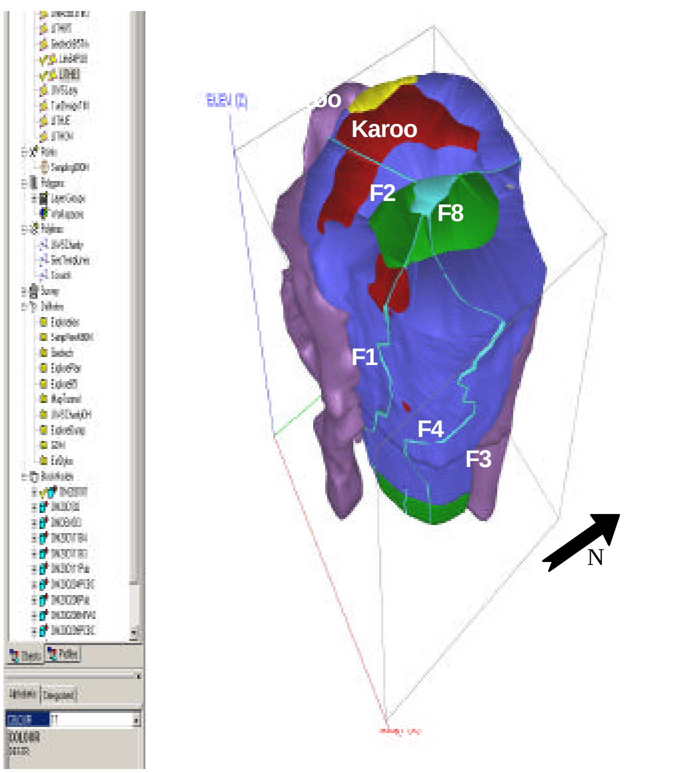

Figure 3: *GEMCOM™* image of the Finsch kimberlite pipe and precursor intrusions (Distribution of Karoo sediments simplified). Note the complex geometry of the hypabyssal kimberlites (F2, F3, F4, F5 and F6).

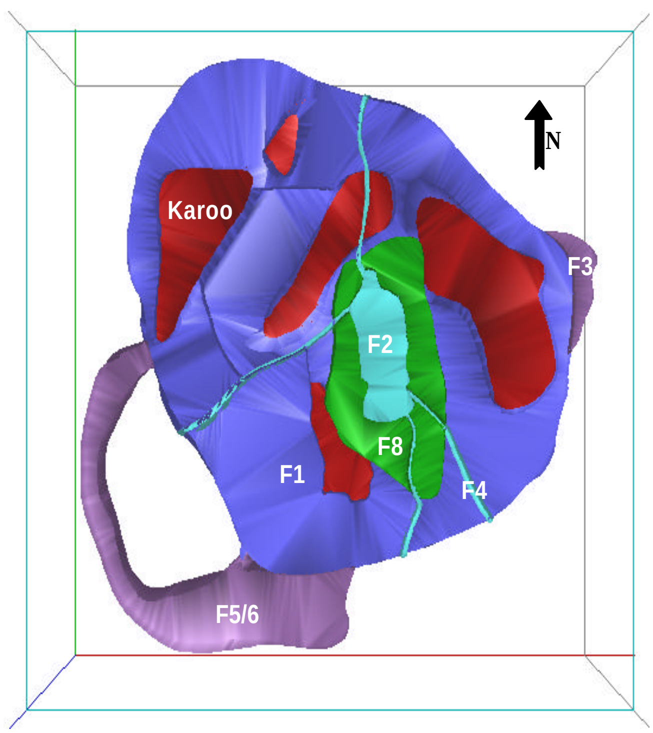

Figure 4: A plan view of the Geology on 510 m level (Distribution of Karoo sediments simplified). Note the occurrence of the Karoo sediments within the F1 kimberlite.

THE GEOLOGY OF THE FINSCH KIMBERLITE

The Finsch pipe consists of eight main kimberlite types, some but not all, representing individual eruptive events. These have been designated F1 to F8 in the order in which they were recognised. The volumetrically significant units are labelled F1, F5/F6 and F8, and are distinguished from the minor types F2, F3, F4 and F7. These distinctions are based on megascopic contact relationships, percentage dilution, density, petrology and diamond grade. The salient features of each rock type are summarized in Table 1.

A 3D *GEMCOM*™ model has been created from exploration drilling and underground mapping. Figures 3 and 4 illustrate the spatial relationship of the various units with respect to each other.

The kimberlite types were emplaced in the following order:

- Emplacement of several kimberlite dykes along a north-east-striking lineament which already contained highly brecciated dolomite with a kimberlitic inter-clast matrix in places.
- Intrusion of the south-west and north-east Precursor bulges (F3, F5 and F6 varieties) which truncated the earlier kimberlite dykes. The intrusion sequence of these precursors is unknown since contact relationships were destroyed by emplacement of the main pipe. The presence of common Karoo sedimentary clasts within these structures suggest that they extended well into the Karoo Supergroup and it could be speculated that they reached the land surface at the time of emplacement. No evidence now remains, since the upper parts were truncated by the main pipe emplacement process.
- Emplacement of the main pipe (F1, F7 and F8) and truncation of the south-west and north-east Precursor bulges. During this stage of emplacement crater blocks and large quantities of Karoo basalt and sediments were incorporated into the pipe. The gradational contact between the F1 and F8 kimberlite, and the complex geometry of F8 suggests that they might be the same kimberlite, and that the differences are the result of crustal contamination (Bartlett, pers. comm.).
- The final phase of activity was the intrusion of late-stage magmatic dykes and plugs (F4 and F2) which truncated the earlier kimberlites. These dykes are contained within the pipe and do not extend into the country rock. They are characterised by irregular geometries that could be attributed to the internal heterogeneous nature of its host rock, the pipe.

Table 1: General features of each kimberlite type.

Unit name	General features
F1	Volumetrically the most abundant (60%). A kimberlite breccia located along the outer periphery of the kimberlite, containing on average 30% crustal dilution (See Figure 3 and 4). Exhibits variations in colour with associated high levels of dilution in places, due to localized sidewall failure. Visibly fragmental with a clast-supported texture and well-rounded magmaclasts. The latter may show large localized variation in abundance. Structure ranging from massive, through diffusely layered to locally well-bedded. Average density 2.55t/m^3. Mineralogically classified as a phlogopite kimberlite containing extensive ash to dust-sized material in the matrix resulting in a relatively friable rock mass frequently requiring support.
F8	Occupies the central part of the pipe, characterized by 15% crustal dilution on average. The unit is characterised by a decrease in the abundance of Karoo Supergroup xenoliths, but an increased abundance in Precambrian dolomite and chert compared to F1. Visibly fragmental with a high (50%+) volume of well-rounded, often large magmaclasts. Structure is massive to diffusely layered. Variable, gradational contact with F1. Average density equals 2.63t/m^3 . Mineralogically classified as a phlogopite kimberlite, but with notably less ash to dust-sized material in the matrix.

F7	Now occupies an area in the south-east of the pipe immediately adjacent to F8, but with a gradational contact. Intermediate in texture between a hypabyssal (magmatic) and magmaclastic rock. Exhibits areas that are uniformly hypabyssal as well as areas with poorly/incompletely developed magmaclasts. Crustal dilution may be as low as 5% in the hypabyssal areas and may reach 20% in more magmaclastic textures. The crustal material is largely comprised of dolerite and dolomite, with lesser sedimentary fragments (Safranek, pers. comm.). Average density equals 2.71t/m^3 Geological and petrological relationships suggest that this unit could potentially be interpreted as the magmatic precursor to the F8 (M. Safranek, pers. comm.). The unit may be classified mineralogically as a melilite-rich phlogopite kimberlite with the modal abundance of melilite decreasing with increasing hypabyssal character (M. Safranek, pers. comm.).
F2	Occupies a central plug-like geometry in the pipe, which varies with depth and consists of hypabyssal kimberlite (See Figures 3 and 4). Dark brown in colour and contains abundant dolomite xenoliths with lesser dolerite, representing a total crustal dilution of 30%. The crustal xenoliths are highly altered. Very competent with an average density of 2.80t/m^3. One of the last phases of magmatic activity within the kimberlite. Mineralogically classified as a clinopyroxene-phlogopite kimberlite.
F3	Occupies the north-east Precursor and is truncated by the main pipe along a sharp contact. Hypabyssal in nature and can be subdivided into F3a breccia and F3b (See Figures 3 and 4). F3a is brownish in colour with prominent white calcite segregations. Typically contains up to 20% crustal dilution, representing virtually the entire country rock stratigraphy from the Precambrian upwards. F3b is dyke-like in geometry, more uniform in texture and contains less than 5% crustal xenoliths, compared to F3a. Contacts between the two range from sharp to gradational. F3b contains only dolomite and chert xenoliths and is volumetrically less abundant than F3a. Average density equals 2.70t/m^3 . Both can mineralogically be classified as phlogopite kimberlite, but with different textures.
F4	Occurs as a system of internal dykes and sills within the main pipe and represents the final phase of magmatic activity (See Figures 3 and 4). Represented by several variants. Crustal dilution is low (<10%) and the xenoliths consist of variably altered dolomite and chert. Average density equals 2.81t/m^3 . Mineralogically classified as clinopyroxene-phlogopite kimberlites containing coarse-grained perovskite.
F5/F6	Together forming the south-west Precursor, truncated by the main pipe along a sharp contact. There is no mineralogical difference between F5 and F6, but each represents a distinct lobe of the south-west Precursor (See Figures 3 and 4) and a significant difference in waste content. Similar in appearance to F3, also with regards to the segregationary texture and contains on average 20% crustal material, i.e. a kimberlite breccia. Average density equals 2.80t/m^3. Classified as phlogopite kimberlite.

REFERENCES

Hallam, C. (1961), Newspaper article in Diamond Fields Advertiser dated 24 November 1961.

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