Geotechnical Assessment of a Kimberlite Pipe in Greenstone Belt Granites

Jurgens Petrus Eden Hamman

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SUMMARY OF STUDY

The potentially hazardous nature of open pit mining requires the application of sound geotechnical engineering practice to mine design, for the purpose of permitting safe and economic mining of any commodity within any rock mass.

The Lerala Diamond Project is situated in the south west of Botswana near the Martin's Drift Border Post. A 2m-soil cover made surface mapping of geological features impossible, so a number of geotechnical holes were drilled to evaluate the characteristics of the kimberlite pipes and the Granite/gneiss host rock.

The Lerala Diamond Project is a typical example of the geotechnical assessment of a kimberlite pipe in Greenstone belt granites. The explosive nature of the formation of these pipes was seen in the various types of joint and fracture pattern identified during this study that could have an influence on the stability of the open pit.

Estimating the stability of rock slopes is required by the mining engineering industry for a wide variety of projects. Of importance in this regard is the preliminary evaluation of slope stability at the feasibility stage, excavation stage, and operating stage. The Lerala Diamond Project is currently undertaking a preliminary evaluation as part of a feasibility study.

The aim of the geotechnical assessment was to divide the local rock into easily identifiable types that could be geotechnically evaluated. Two classification systems were used during the quantification of the rock mass types. These are the Rock Mass Rating (RMR) system of Bieniawski (1976) and the Mining Rock Mass Rating (MRMR) system of Laubscher (1990).

Observations and recordings of the drill core were carried out and these, in conjunction with laboratory results, enabled the determining of the characteristics of the rock mass that will be exposed in the slopes.

Computer modelling programmes such as ROCKPAK III were used to test the designs against potential failures. The various potential failures were identified for the different highwalls.

Recommendations including the continuous logging of geotechnical features were proposed for the purpose of developing a sound geotechnical model for identifying potential unstable areas within the pit.

Geotechnical assessment of a kimberlite pipe in Greenstone belt granites

Jurgens Petrus Eden Hamman

Supervisor: Professor MF Handley

Co-Supervisor:

Department: Mining Engineering

University: University of Pretoria

Degree: Master of Science (Mining)

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CHAPTER ONE – INTRODUCTION TO THE STUDY AND DISSERTATION

The design of large excavated slopes for both mining engineering and civil engineering projects presents the engineer with two opposing elements that have to be considered together (Hoek and Bray, 1981). On the one hand, steepening the slopes can save vast sums of money through a reduction of the amount of material to be excavated. On the other, loss of life and serious damage to property can result from failures induced by excessive steepening of a slope. The aim for the geotechnical engineer is to achieve an optimum design for a slope, one that considers both economic feasibility and safety for mineworkers and mine property.

This research was carried out for the specific purpose of achieving such an optimum design by means of an investigation of the geotechnical aspects of the proposed Lerala Diamond Project, situated near Lerala in Botswana. The specific objectives of the research were to:

- Produce recommendations on hard rock slope angles for all pit slopes within the pits, with cognisance being taken of the different rock types within the highwalls;
- Provide special recommendations with respect to weathered material; and
- Suggest ongoing geotechnical input to further define the findings from this research.

1.1 Geology of the Lerala Area

The Lerala Project is in the eastern part of Botswana, approximately 50 km from the Martin’s Drift border post, on the Limpopo River. The site topography is generally flat, with drainage towards the Limpopo River in the east. Vegetation predominantly comprises Mopane Bushveld and the annual average rainfall is approximately 450 mm.

The Lerala area lies within the high-grade metamorphic terrain of the Limpopo Mobile Belt. The country rocks are grey gneisses, migmatites (banded gneisses) and amphibolites, with lenses of metaquartzites, marbles and calc-silicates assigned to the Archaean (3.2 Ba) Beit Bridge Complex (Carney et al., 1994). The Limpopo Belt has a complex history, but appears to have been essentially cratonised from about 2,000 Ma. It is the tectonic setting for the diamondiferous kimberlites at Venetia and The Oaks in South Africa, and the River Ranch kimberlite in Zimbabwe (Carney et al., 1994).

The area is covered with about 2 m of residual soil, with alluvium along the river courses. Calcrete is largely limited to the vicinity of drainages. The Kalahari sands are absent. Small bedrock outcrops are quite common. The few inselbergs are mainly formed from very resistive quartzite lenses within the gneisses. The landforms are very mature, and are the products of epeirogenic uplift and downwearing since the end of the Cretaceous (Carney et al., 1994).

The project area consists mainly of light grey to pink granitic gneiss exhibiting various levels of foliation (Figures 1 and 2). Five kimberlite pipes (K002, K003, K004, K005 and K006) of various dimensions are present in the lease area (Figure 3).

Figure 1: Granitic Gneiss


Figure 2: Pink granite

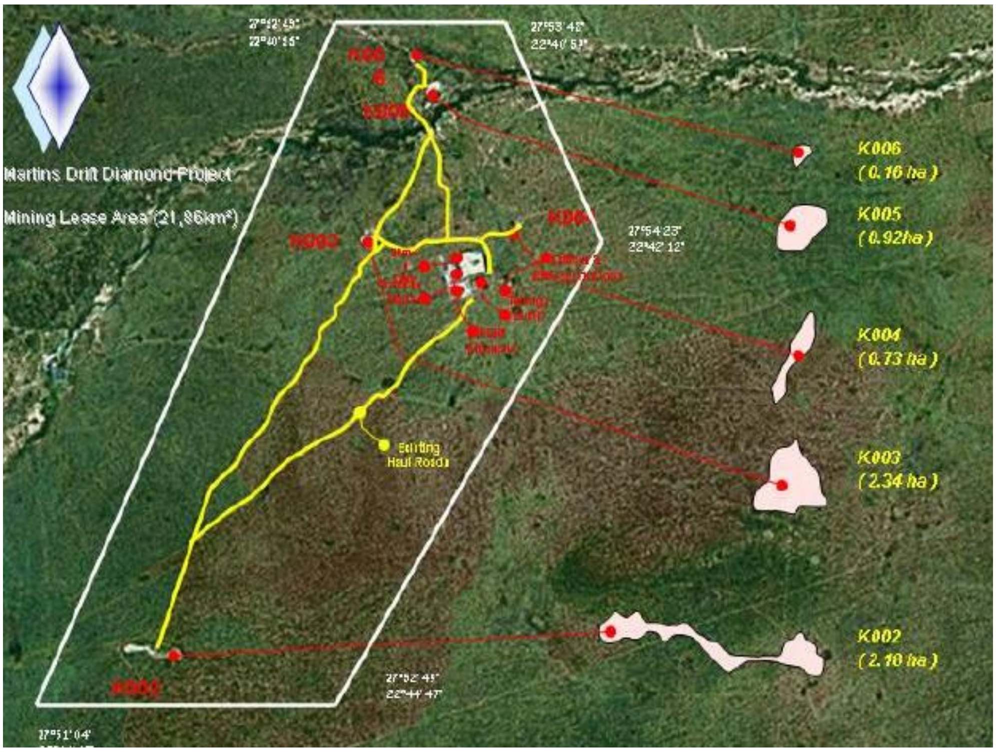

Figure 3: Lerala lease area

There are five main kimberlite facies recognised within the project. These are hypabyssal kimberlite, hypabyssal kimberlite breccia, tuffistic kimberlite breccia, marginal breccia, and kimberlite breccia (Figure 4).

Figure 4: Kimberlite breccia

Pipes are mostly near vertical with shear zones/kimberlite breccias at the contact with the host rock. Ten Karoo-age dolerite dykes (Figure 5) are present and generally strike east-west.

Figure 5: Dolerite dyke

1.2 Slope Design

The Lerala Project is no different from any other similar mining projects in terms of designing an optimal slope. As the rock mass behind any slope is unique, there are no standard solutions that are guaranteed to produce the correct result each time they are applied. Instead, in each case, a practical solution can only be based on basic geological data, rock strength, groundwater and a good measure of engineering common sense. These ingredients are mixed in different proportions for each slope to be designed and the only assistance available is a collection of techniques for information gathering and, ultimately, analysis.

1.2.1 The collection of geological data

The cornerstone of any practical rock mechanics analysis is the geological data upon which the definition of rock types, structural discontinuities and material properties is based. Methods for the collection of geological data have not changed a great deal and there is still no acceptable substitute for field mapping and core logging (Hoek and Bray, 1981). Authors such as Dempers (1994) and Marjoribanks (2002) have developed methods and procedures to improve the quantity and quality of data collection. These methods were followed in the execution of the current research to ensure conformity to an industry-based guideline that is acceptable for the representation of logged geotechnical data.

Drilling techniques such as triple tube have improved the quality of core recovery greatly. Directional drilling at predetermined angles to intersect prominent geological features such as structures, surveying and core logging techniques have improved the collection of quality structural data.

1.2.2 Laboratory testing

Laboratory testing gives an insight into the behaviour of the rock mass on a small scale. In the slope-design investigation for the Lerala Project ROCKLAB's (Pretoria, South Africa) properly calibrated testing machines were used for conducting the laboratory tests. Industry-accepted procedures as specified by the International Society for Rock Mechanics (ISRM) (1978) were used in all the tests conducted by ROCKLAB.

1.2.3 Rock mass classifications systems

Rock mass classification systems as described by Haines and Terbrugge (1991) form the basis for the empirical designing of slopes. These authors explain that estimating the stability of rock slopes is required by the civil and mining engineering industry for a wide variety of projects. Of importance in this regard is the preliminary evaluation of slope stability at the feasibility stage, the excavation stage, and the operating stage. It has become increasingly popular to make use of classification systems to estimate the stable angle of a required slope – during the feasibility stage, as in the case of the Lerala project – or of an existing slope.

In this study, the overall slope angles in the jointed rock mass were determined by using Laubscher's (1977) adjusted MRMR rock mass classification and Haines and Terbrugge's (1991) design charts. Rock mass classification systems such as Barton's Q (1974), Bieniawski's RMR (1976, 1989) and Laubscher's MRMR (1976, 1990, 1994) are all industry-accepted systems. The RMR and MRMR methods were used in this research to compare the empirical values for the different ratings.

These two classifications methods include information on the strength of the intact rock material and the spacing, number and surface properties of the structural discontinuities. The methods also make allowances for the influence of subsurface groundwater, in situ stresses, and the orientation and inclination of dominant discontinuities. These rock mass classification systems proved to be very useful for the Lerala investigation since no reliable surface exposures were available nor had any mining been done in the area investigated.

Exposure of geological discontinuities in a rock slope gives rise to the potential for sliding- and toppling-type failure, which will be referred to in the context of the Lerala Project in Chapter 4 of this report. The friction angle (Hoek, 1990) of the discontinuity surface that has been exposed is a critical factor controlling whether slip will occur or not. The frictional strength of a discontinuity surface is dictated by the basic friction angle, the degree of undulation or waviness of the surface, and the cohesion that may exist between the surfaces.

1.2.4 The use of applicable computer programs

Once the structural geological data has been collected, computer processing of this data can be of great assistance in plotting the information and in the interpretation of trends. The ROCSCIENCE Dips Version 5.1 is an example of such a data-processing program. ROCKPACK III for Windows was also used because of its ability to assist in the kinematic analysis of jointed rock slopes and to determine the potential for structural instabilities.

1.2.5 Slope types

Two types of slopes are expected to be formed in the Lerala Mine. They are jointed hard rock slopes and soil (or highly weathered) slopes. The overall slope angles in the jointed rock mass at Lerala were determined using the Adjusted MRMR (Laubscher 1977, 1990) rock mass classification and appropriate design charts. The mechanical properties for the highly weathered material obtained from laboratory testing was used, together with the design charts, to determine the optimum slope angle and slope height in weathered material.

As jointed rock slopes can experience structural instability such as plane, topple and wedge failure, a kinematic analysis was conducted on the final highwalls.

Figure 6 (Gibson et al., 2006) shows the terminology that is used in this report for the features of the open pit that are referred to.

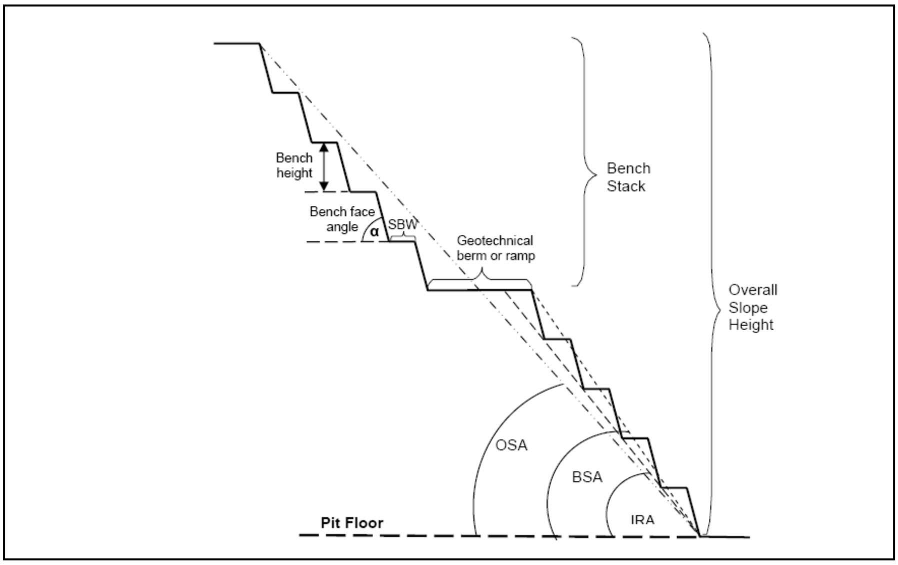

Figure 6: Open pit terminology
SBW – Spill Berm Width ; OSA – Overall Slope Angle ;
BSA – Bench Stack Angle ; IRA – Inter Ramp Angle

1.2.6 Influence of slope curvature upon stability

The planned curvature of the slope affects both the potential for failure and the consequences of failure. Concave slopes are preferred because:

- The confinement inherently provided by the concave geometry enhances stability; and
- If instability occurs, the volume of the failure is less.

The rock mass classification method of Barton et al. (1974) indicates that the *Q* value of a tightly confined rock mass can be up to ten times greater than the quality of the same mass in an unconfined condition. This figure corresponds to a decrease in quality in Laubscher's (1977, 1990) MRMR (Mining Rock Mass Rating) classification value of about 33%. Based on the Haines and Terbrugge (1991) chart shown in Figure 32, for a 100 m high mine slope, the slope angle could be decreased from 67^{o} to 56^{o}. This is a rough indication of the potential influence of a convex slope profile in plan, in which the slope is laterally unconfined.

Hoek and Bray (1981) suggest that when the radius of curvature of a concave slope is less than the height of the slope, the slope angle can be 10^{o} steeper than determined by conventional slope stability analysis. Conversely, for a convex slope, with the radius of curvature less than the slope height, the slope angle could be 10^{o} flatter than conventionally determined.

The designs put forward by the author referred to above must be used with some circumspection since other factors, in particular the presence of major geological planes of weakness, may be of overriding importance.

1.3 Research Problem

As was mentioned earlier, a geotechnical evaluation of the area required a thorough investigation of the surface geology of the Lerala Project. As the soil cover and lack of surface outcrops made such an investigation impossible, a few exploration pits/trenches were dug for bulk sampling purposes. These pits exposed some geotechnical characteristics of the kimberlite ore body but none of the host rock (granitic gneiss), which would be exposed in the final pit highwalls.

It was therefore decided to make use of diamond drill rigs to drill strategically placed holes in order to recover host rock in which the final pit highwalls would be situated. The information from these holes would then be used to determine the rock mass characteristics, which would form the basis of the pit slope design process.

The structural data (joints, faults, intrusive and shear zones) from the boreholes needed to be analysed in detail since the majority of failures along the slopes would be related to these features. It was therefore important to determine the orientations of these features. A drilling method that includes the marking and orientation of the core, as developed by an Australian company 2ic (http://www.2icaustralia.com) was used.

1.4 Structure of this Dissertation

The methodology used to complete the geotechnical assessment of the rock mass is the topic of the next chapter – Chapter 2. Chapter 3 systematically sets out the findings derived from the assessment that are relevant for the design of the mining slope. Chapter 4 presents an analysis of these findings and the final chapter – Chapter 5 – contains the conclusions from the study and the recommendations on hard rock slope design that represent the specific objectives of this research.

CHAPTER TWO – LERALA PROJECT: METHODOLOGY

Following careful scrutiny of the available information from surface exposure, geotechnical boreholes and laboratory testing, the rock mass was divided and simplified to conform to a number of basic mining rock types. These are set out in Table 1.

Table 1: Basic mining rock types

Rock Type	Description
Soil	Sandy soil and calcrete (Thickness < 2 m)
Saprolite	Saprolite at various levels of weathering (Thickness < 10 m for granitic gneiss)
Granitic Gneiss (GG)	Pink granite, dark grey/pink granitic gneiss Foliated light/dark grey granitic gneiss
Kimberlite (K)	**Main Orebody** (K3 diameter < 200 m)
Kimberlite Breccia (KB)	Associated with the kimberlite contact rock. Prominent in the SE – SW area of K3
Dolerite Dyke (DD)	Various minor dykes. Major dyke (+40 m wide) in the NE corner of K5

2.1 Geotechnical Mapping

Geotechnical mapping was carried out to determine the major joint orientation before a drilling program could be finalised. Joint mapping of hard rock exposures (Figure 7) indicated a potential of three major joint sets (Figure 8).

Figure 7: Two major joint sets in pit K4

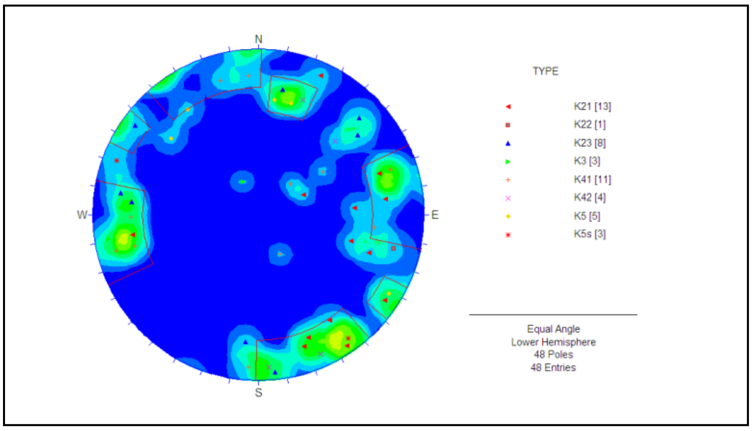

Figure 8: Major joint sets from surface mapping

The three major joint sets were measured as striking approximately East-northeast (ENE) to West-southwest (WSW), Northwest (NW) to Southeast (SE) and North (N) to South (S), dipping steeply at between 70° and 90°. From the measurements it was calculated that vertical drilling would not have been very effective because coring could have been parallel to these joints, without proper intersections. It was calculated that holes drilled at -50° to -60° from the horizontal in directions S45°E, N45°E, N45°W and S45°W would intersect the maximum joint set orientations.

Figure 9: Drill rig drilling at -60°

Four holes per pit were planned to be drilled 10 m to 15 m from the inside contact of the kimberlite pipe. The calculations indicated that the host rock should be intersected at vertical depths of between 17 m and 26 m. The planned pit slope (Figure 10) with an overall slope angle of 60° (Figure 9) would then be intersected at a vertical depth of 58 m. The last 42 m would then be drilled into the highwall host rock to determine any potential structural instability behind the planned highwall.

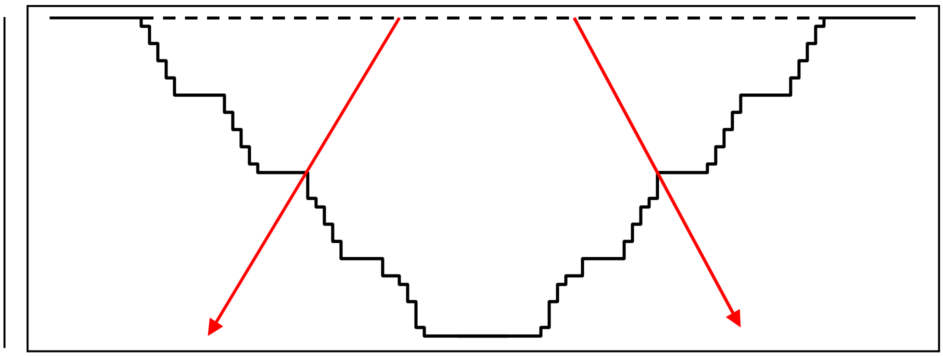

Figure 10: Schematic pit section indicating drill hole target areas

2.2. Drilling Layouts and Core Logging Method

A total of 23 holes were drilled as indicated in Table 2.

Table 2: Drilling layouts

GT Hole No	X (m)	Y (m)	Z (m)	Azimuth(º)	Decl. (º)	Hole Dir. (º)	Hole Dip (º)
K2 GT01	588 418	7484 786	840	146	9	137	-60
K2 GT02	588 418	7484 785	840	232	9	223	-59
K2 GT03	588 530	7484 764	840	49	9	40	-60
K2 GT04	588 338	7484 813	833	325	9	316	-52
K2 GT05	588 803	7484 714	837	145	9	136	-50
K3GT01	590 787	7489 014	812	135	9	126	-60
K3GT02	590 758	7489 104	817	45	9	36	-50
K3GT03	590 728	7489 128	818	315	9	306	-50
K3GT04	590 691	7489 016	814	225	9	216	-50
K4GT01	592 159	7489 050	813	141	9	132	-51
K4GT02	592 219	7489 144	816	57	9	48	-48
K4GT03	592 210	7489 165	815	319	9	310	-50
K4GT04	592 209	7489 162	815	230	9	221	-62
K4GT05	592 209	7489 162	813	318	9	309	-52
K5GT01	591 379	7490 527	811	135	9	126	-50
K5GT02	591 428	7490 574	816	48	9	39	-50
K5GT03	591 376	7490 619	816	321	9	312	-60
K5GT04	591 325	7490 564	817	224	9	215	-50
K5GT05	591 419	7490 557	816	44	9	35	-51
K6GT01	591 168	7490 891	810	134	9	125	-50
K6GT02	591 169	7490 894	810	45	9	36	-50
K6GT03	591 164	7490 880	811	219	9	210	-50
K6GT04	591 163	7490 890	810	314	9	305	-50

The holes were drilled HQ3 to ensure high-quality recovery and were surveyed every 30 m for direction and inclination. Downhole marking was carried out every 1.5 m to 6.0 m, depending on the quality of the core.

Logging the core for strike and dip angles of structural features such as the dolerite dykes, shear zones, foliation and, most importantly, the joints, was carried out with an Ezy-Mark Goniometer™. The Goniometer measures the

Beta angle of a structure from 0 to 360°, simply by positioning the 0° mark on one of the end protractors, over the core orientation line marked on the core sample and then reading of the position off the nose of the elliptical structure being measured from the 360° end protractor.

Two alternately coloured protractors measure the Alpha angle of an elliptical structure 0° on the horizontal plane to 90° on the vertical plane in the downhole position. This is achieved by simply sliding the Goniometer up or down the core sample while holding it relative to the Beta angle (nose of the ellipse) and selecting the line of best fit on the side that matches the structure being measured. The two colours for the Alpha protractors (blue and orange) allow easy visual measurement over a variety of rock colors. The core was also logged to determine the different geological lithologies and geotechnical characteristics (Appendices 1 and 2).

2.3 Determining Rock Mass Mechanical Properties

Rock mass mechanical properties were obtained from samples collected from the 23 boreholes. The purpose of the laboratory testing was to establish, in broad terms, the expected behaviour of the rock mass on exposure in the slopes. Samples were selected to gain insight into the strength of the basic mining rock types as indicated in Table 1, as well as discontinuity frictional properties, the saprolite strength, and the extent of weathering.

2.3.1 Rock strength

The rock strength was determined from Uniaxial Compressive Strength (UCS) tests as summarised in Table 3. The table depicts the summary of the UCS (MPa) tests that were conducted. Average – 1 Standard Deviation (statistically evaluated data) values were used for the RMR and MRMR calculations.

The UCS laboratory work was done by ROCKLAB (Appendix 3) and the test procedure used conforms to the ISRM specifications. Samples that failed on preexisting interfaces were ignored when considering the UCS of the rock.

Table 3: UCS values

Rock Type	Number of Samples	Range UCS (MPa)	Mean UCS (MPa)	Standard Deviation (MPa)	Mean – 1 Standard Deviation (MPa)
Granitic Gneiss **Foliated Granitic Gneiss** **Granite**	19	101 - 320	245	56	189
Kimberlite Breccia	5	75 - 149	107	29	78
Kimberlite	4	116 - 151	128	16	113
Dolerite Dyke	4	202 - 248	231	20	211

2.3.2 Discontinuity frictional properties

When geological discontinuities are exposed in a rock slope the potential for sliding-type failure arises. The friction angle of the discontinuity surface that has been exposed is a critical factor controlling whether slip will occur or not.

The trial mining pits and borehole core were observed in order that the discontinuity surfaces could be determined. Basic friction angles (Appendix 4) were determined from the samples collected from the three main rock types that would be exposed in the highwalls – granitic gneiss, kimberlite breccia, and dolerite dyke – for the purpose of calculating shear strength (instantaneous friction angles) of discontinuity surfaces.

Core samples, cut perpendicular to the axis of the core, were tested using the direct shear test to determine the basic friction angles. Three tests were conducted on each sample at three different normal stresses. The normal stress and shear stress were then used to create a Coulomb shear strength envelope, whose slope yielded the basic friction angle (Hoek 1990).

The basic friction angles (Appendix 4) were mathematically calculated and the arithmetic mean for each rock type was obtained.

The actual friction angle of the joints could be significantly higher than the basic friction angle since most of the joints that had reasonable exposures in core demonstrated a high degree of undulation. Roughness and undulation or waviness will assist in resisting sliding on the surface and, therefore, increase the friction angle. Some joints in the Lerala project area indicated an infilling acting as a cementing material bonding the rock, where upon a tensile force would have to be applied to overcome the cohesive bond.

Hoek (1990) indicated that the relationship between the peak shear strength τ_p and the normal stress σ_n can be represented by the Mohr-Coulomb equation:

$$\tau_p = c + \sigma_n \tan\varphi$$

Where: *c* is the cohesive strength of the cemented surface and φ is the angle of friction.

Hoek (1990) stated that the basic friction angle is a quantity that is fundamental to the understanding of the shear strength of discontinuity surfaces. This is approximately equal to the residual friction angle, but it is generally measured by testing sawn or ground rock surfaces.

Hoek (1990) further commented that a natural discontinuity surface in hard rock is never as smooth as a sawn or ground surface of the type used for determining the basic friction angle. Generally, this surface roughness increases the shear strength of the surface, and this strength increase is extremely important in terms of the stability of excavations in rock.

Patton (1966) demonstrated the influence of surface roughness on shear strength by means of an experiment in which he carried out shear tests on 'saw-tooth' specimens. Shear displacement in these specimens occurred as a result of the surfaces moving up the inclined faces, causing dilation (an increase in volume) of the specimens. The shear strength of Patton's ‘saw-tooth specimens’ can be represented by:

$$\tau = \sigma_n \tan(\varphi_b + i)$$

Where: φ_b is the basic friction angle of the surface and i is
the angle of the saw-tooth face

The above equation is valid at low normal stresses where shear displacement is due to sliding along the inclined surfaces. At higher normal stresses, the strength of the intact material will be exceeded and the teeth will tend to break off, resulting in a shear strength behaviour that is more closely related to the intact material strength than to the frictional characteristics of the surfaces. While Patton's approach has the merit of being simple, it does not reflect the reality that changes in shear strength with increasing normal stress are gradual rather than abrupt. Barton and his co-workers (1973, 1976, 1977, 1990) studied the behaviour of natural rock joints and proposed that the equation be re-written as:

$$\tau = \sigma_n \tan(\varphi_b + JRC \log 10\ JCS/\sigma_n)$$

Where: JRC is the joint roughness coefficient and
JCS is the joint wall compressive strength

Field estimates for JRC and JCS were determined using design charts published by Barton (1977, 1982) and ISRM (1978). The residual friction angle yielded for the granitic gneiss could then be used until detailed data could be collected from the jointed rock mass exposed during the mining process (Appendix 5).

2.3.3 Saprolite / soil strength

In order to quantify optimum slope angles in highly weathered material the mechanical properties of the saprolite, an in-situ weathered soft rock type that has not been transported, (Figure 11) had to be determined. For the design of slopes in weathered material the angle of internal friction, density, and cohesion are required.

Figure 11: Typical example of saprolite

Soil slope stability charts have been produced by numerous researchers (Bishop and Morgenstern, 1960; Spencer, 1969; O'Connor and Mitchell, 1977; Chandler and Peiris, 1989; Barnes, 1991). The stability charts developed by Hoek and Bray (1981) will be used in this dissertation. They produced a set of charts corresponding with five different groundwater conditions.

These conditions are included on the slope stability chart in Figure 12. The input data required for the use of the chart are as follows:

C	cohesion of the soil mass (kPa)
γ	density of the soil mass (kg/m3)
ϕ	angle of internal friction of the soil mass (°)
H	height of the slope (m)

Hoek and Bray (1981) explained the method of use of the chart to determine the factor of safety of a slope is as follows:

1. Calculate the value of $c/(\gamma H \cdot \tan\phi)$ and find the corresponding point on the circumference of the chart.

2. Translate radially inwards on the chart from this point to meet the required slope angle isoline.
3. For this intersection point, read off the corresponding ordinate value *tanϕ /F* (or the abscissa value) and hence calculate the value of the factor of safety *F*.

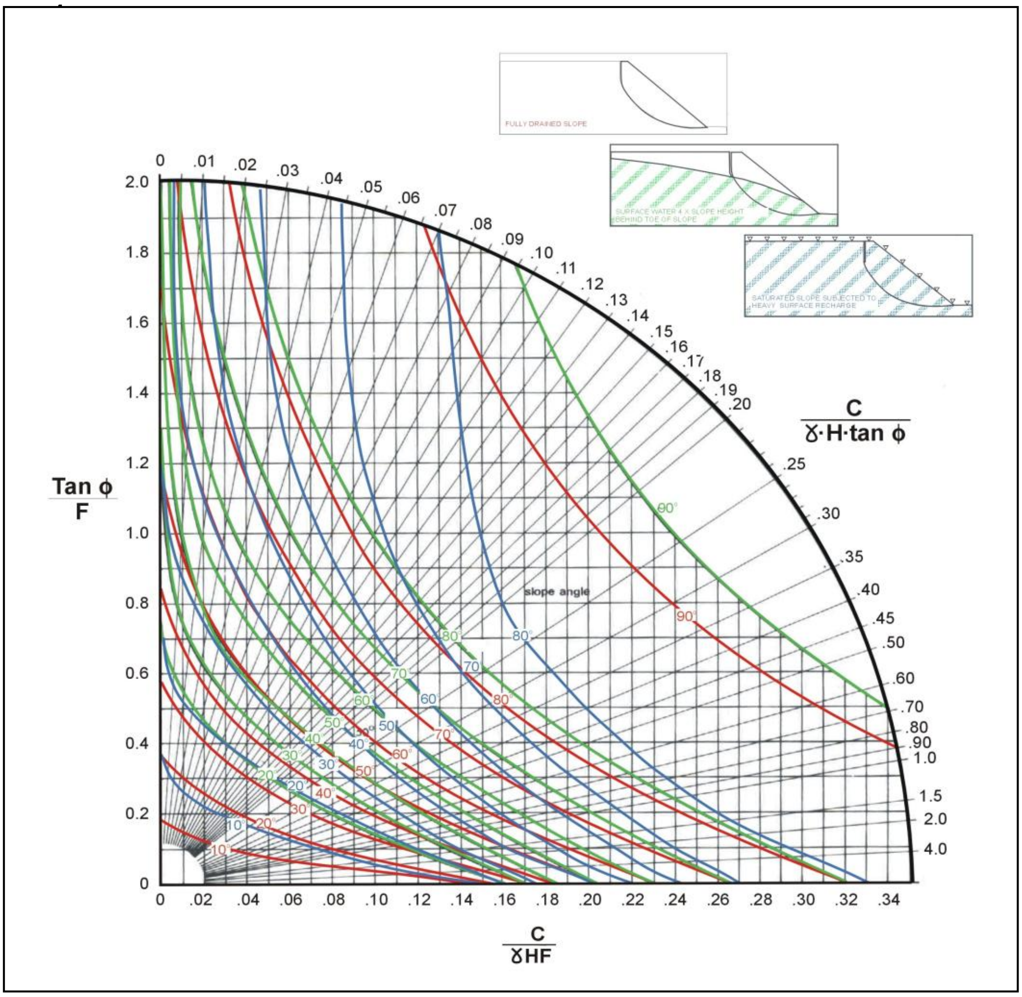

Figure 12: Weathered material design charts (Hoek and Bray, 1981)

Exploration and geotechnical holes were used to indicate the thickness of the soil and the saprolite. The saprolite samples were tested by ROCKLAB (Appendix 6) according to ISRM guidelines and the minimum laboratory results for the Lerala samples were used for the evaluation of the soil/saprolite slopes.

2.4 Analysis of Discontinuities

In an unweathered rock mass discontinuities play a significant role in the stability of a slope and, for this reason, will influence the slope geometry. Discontinuities may influence rock slopes in two ways: first, by weakening a rock mass and making it more susceptible to failure; and, second, by creating surfaces on which structural instability may occur depending on joint interaction with the slope. It is important, therefore, to identify all possible discontinuities. The most common way of identifying and quantifying discontinuities is by mapping exposures of the rock on surface.

Discontinuities were mapped in seven trial pits (Figures 7 and 8), logged in the 23 boreholes (Table 2), and categorised on the basis of their visibility and how well they were defined. The dip and strike information of all the identified geological features was then analysed with the use of lower hemispherical stereographic projection.

CHAPTER THREE: RESULTS

The results for the geotechnical assessment have been set out in this chapter in a sequence that corresponds to that used for describing the methods in Chapter Two, apart from the results of the initial geotechnical mapping that were given in Chapter Two. The results from core logging to determine the different geological lithologies and geotechnical data are shown in appendices 1 and 2.

3.1 Rock Mass Mechanical Properties

Samples from the 23 boreholes were selected to gain insight into the strength of the basic mining rock types as indicated in Table 1, as well as discontinuity frictional properties, the saprolite strength, and the extent of weathering.

3.1.1 Rock strength

Table 3 depicts the summary of the UCS (MPa) tests that were conducted. Mean – 1 Standard Deviation values were used for calculations.

3.1.2 Discontinuity frictional properties

To establish the discontinuity properties the basic friction angles were computed from laboratory test data and the arithmetic mean for each rock type was obtained. (See Appendix 4) It was found that the values of the different granitic gneiss types did not differ significantly, which finding prompted the investigation of the possibility that the basic friction angle of all the granitic gneiss rock types is the same.

It can be seen from Figure 13 that the data suggest a linear relationship which is to be expected from the Mohr-Coulomb failure criterion. The rock tests show a relatively large variance for each normal stress, especially the greatest normal stress of 1.8 MPa, i.e. an increase in the size of the standard error with increase in confinement. These patterns are to be expected from geotechnical data. The variability in the data almost certainly arises from the variability of the condition of the rock and its composition, rather than from the variability in the friction angle. Hence an estimate of 37º is therefore considered good, and representative for the granitic gneiss and granites.

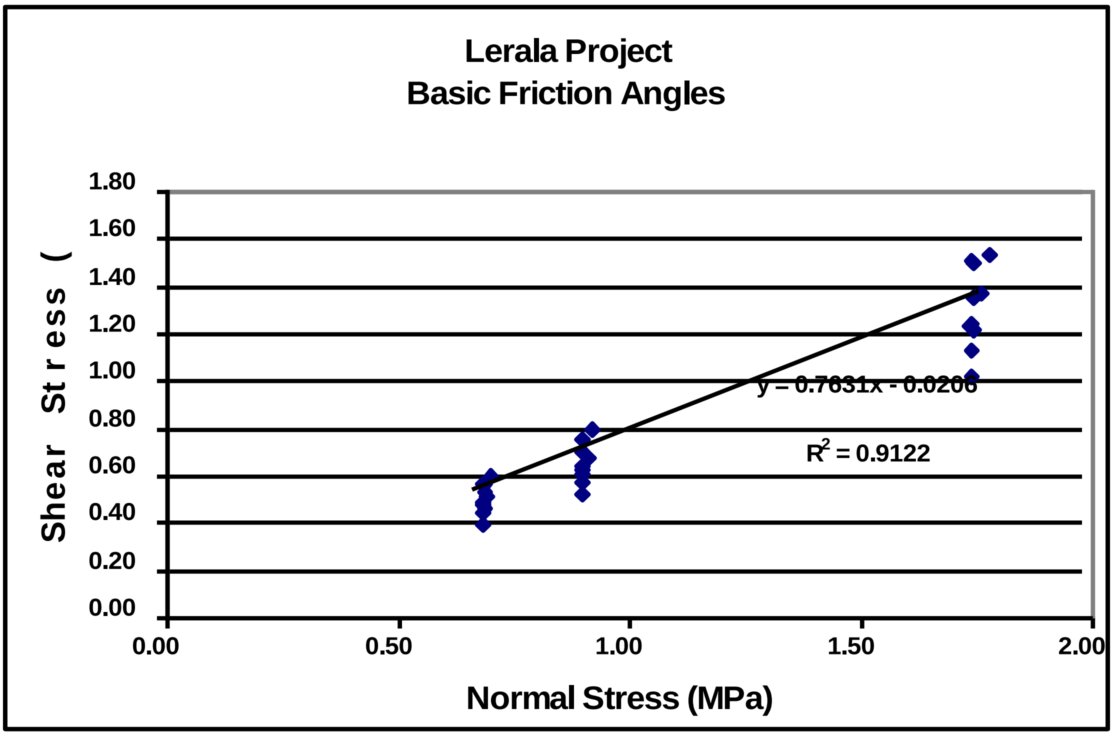

Figure 13: Combined basic friction angle data for all the granitic gneiss samples

Similar mathematical analysis was done for the other rock types and the analysis indicates the following basic friction angles :

- Granitic gneiss 37°
- Dolerite dyke 40°
- Kimberlite breccia 27°

Field estimates for joint roughness coefficient (JRC) and joint wall compressive strength (JCS) were determined using design charts (Appendix 5) published by Barton (1977, 1982, 1990) and ISRM (1978). A computer analysis (Appendix 5) for the updated shear strength formula was used to determine the instantaneous friction angle (φi) from the basic friction angle (φb) and the JRC and JCS values (Table 4).

Table 4: JRC, JCS values, basic and instantaneous friction angles for the main three rock types

Rock Type	Number of Samples	Basic Friction Angle (φb)	JRC	JCS	Instantaneous Friction Angle (φi)
Granitic Gneiss	10	37º	5	89	45º
Kimberlite Breccia	2	27º	5	48	34º
Dolerite Dyke	1	40º	5	111	49º

3.1.3 Saprolite

Table 5 shows the ranges of the laboratory results for the saprolite (Appendix 6). The minimum values will be used for the evaluation of saprolite slopes.

Table 5: Data of Lerala laboratory results for saprolite

	Number of Tests	Friction (°)	Cohesion (kPa)	Density (kN/m³)
Lerala Lab	2	39 ; 74	14 ; 28	21 ; 24

3.2 Discontinuties

Discontinuities that were identified were jointing, shear zones, contacts, foliation and intrusives. The most prominent small-scale discontinuities such as jointing and foliation in the granitic gneiss and jointing in the dolerite dyke were plotted separately (Figures 14, 15 and 16) for the five different target areas (K2, K3, K4, K5 and K6) to determine if any variations existed over the project area. No major variations were found to exist and data are presented for the total project area and not for individual target areas.

3.2.1 Analysis of discontinuities

The three main discontinuity types were analysed separately to determine their orientations.

Joints – granitic gneiss

Due to the poor quality of core recovery in the vicinity of structurally complex areas such as shear zones, the directional characteristics and properties could not be measured. Considering the explosive nature and mechanics of intrusive kimberlite pipes, complex fracture patterns could be expected in the host rock. Apart from the regional joint patterns, additional localised radial and concentric fracture patterns were found. These additional fracture patterns could also have an influence on the pit slope stability, because of the orientation of the concentric fracture patterns parallel to the kimberlite pipe and the associated high walls.

The combined borehole data (Figure 14 and Table 6) from the five target areas confirmed the three prominent conjugate joint sets as identified in the trial pit mapping (Figure 7).

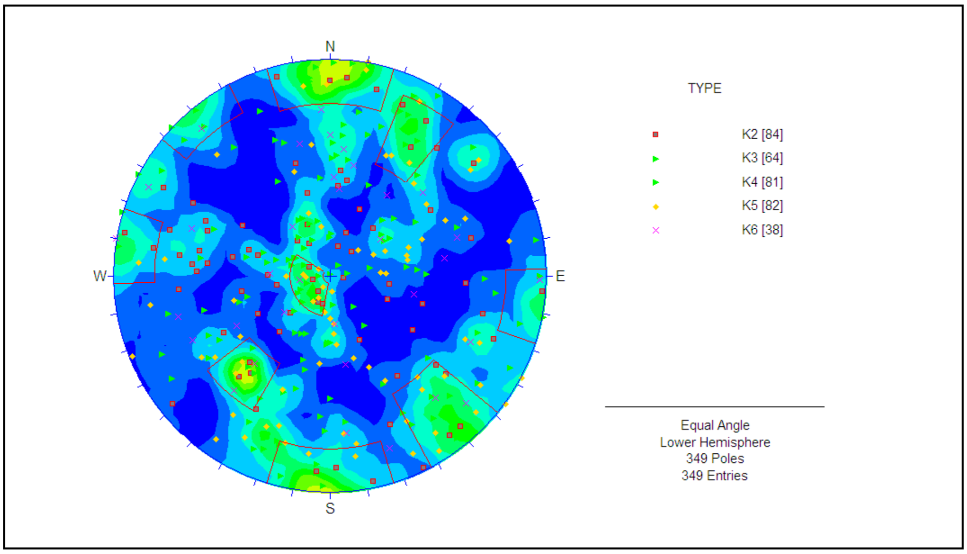

Figure 14: Stereo plot of joint patterns in the granitic gneiss

Table 6: Joint data set for granitic gneiss

Joint Set	Average Dip Dir / Dip	Comment
1	98° / 83° 278° / 83°	Conjugate Set
2	180° / 83° 360° / 83°	Conjugate Set
3	140° / 85° 320° / 76°	Conjugate Set
4	210° / 70°	Shallow Dipping Set
5	41° / 60°	Shallow Dipping Set
6		Flat Dipping Set

Joints – dolerite dyke (K5)

A major dolerite dyke was intersected in the northern sector of the K5 target area. Jointing in the dolerite dyke (Figure 15 and Table 7) indicates two prominent steep- and one prominent shallower-dipping set. There are only minor comparisons between the joint patterns within the dolerite dyke and granitic gneiss. The northern sector of K5 was analysed and classified according to the dolerite dyke rock mass and structural characteristics.

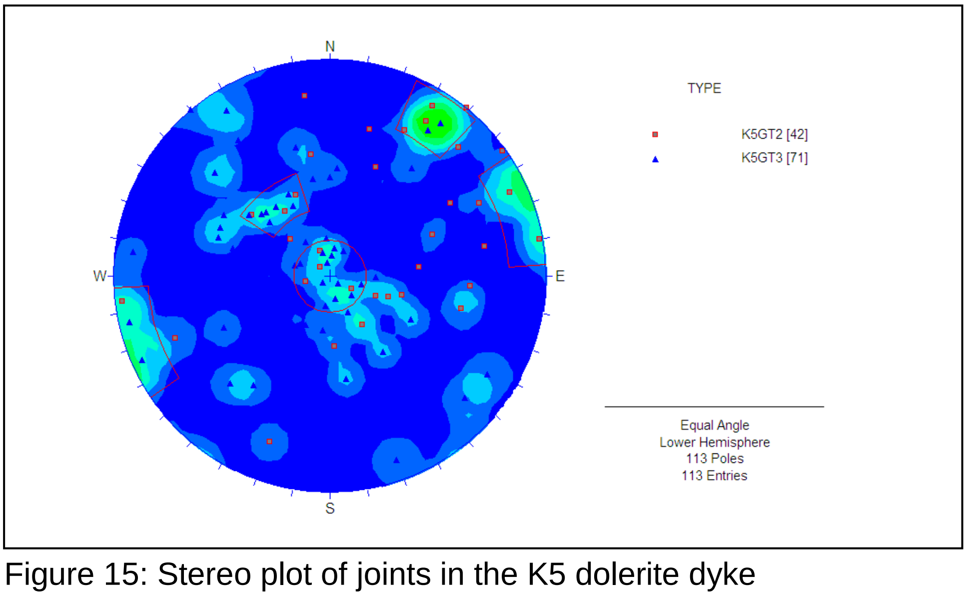

Figure 15: Stereo plot of joints in the K5 dolerite dyke

Table 7: Joint data set for dolerite dyke in K5

Joint Set	Average Dip Dir / Dip	Comment
1	251° / 85° 71° / 85°	Conjugate Set
2	212° / 80°	Steep Dipping Set
3	143° / 43°	Shallow Dipping Set
4		Flat Dipping Set

Foliation – granitic gneiss

The combined borehole data of all the target areas indicate two prominent sets of foliation (Figure 16 and Table 8).

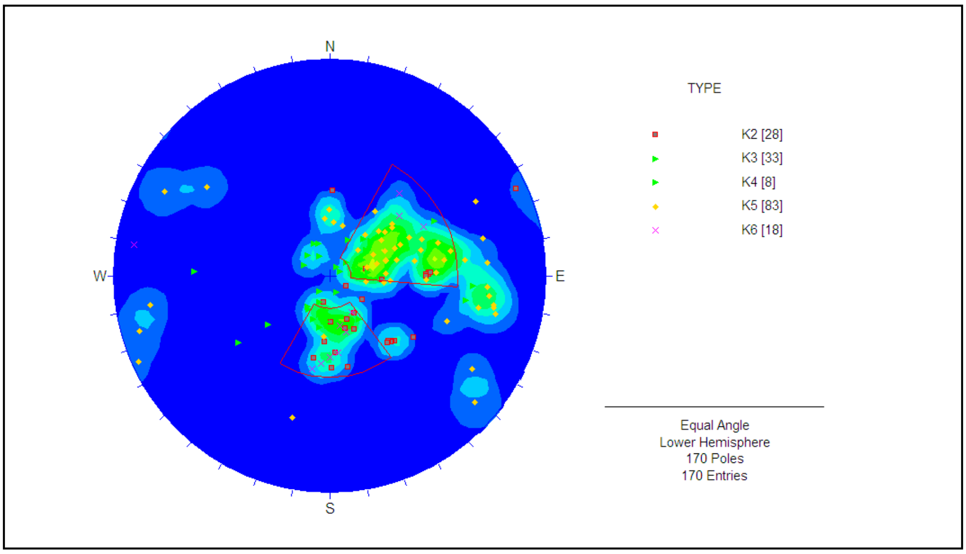

Figure 16: Stereo plot of foliation in the granitic gneiss

Table 8: Foliation data set for granitic gneiss

Foliation Set	Average Dip Dir / Dip
1	241° / 36°
2	356° / 32°

3.3 Main Geological Features

Various large-scale geological structural features such as intrusions and shear zones were intersected in the geotechnical boreholes (Figures 17, 18, 19, 20 and 21). The directional characteristics of the Karoo Age dolerite dykes could be measured and the data are presented in Table 9.

Table 9: Directional properties of the dolerite dykes

Pit	X (m)	Y (m)	Z (m)	Strike (º)	Dip (º)	Dip Dir (º)	Width (m)
K2	588 550	7484 820	On Surface	76	90	166	2
K2	588 900	7484 500	On Surface	75	70	335	10
K4	592 180	7489 200	On Surface	100	70	190	5
K5	591 440	7490 590	On Surface	110	90	200	+40
K6	591 160	7490 930	On Surface	105	75	195	5

Owing to the poor quality of core recovery in the vicinity of the structurally complex areas such as the shear zones, directional properties could not be measured. The 2 m to 20 m wide shear zones were intersected along the kimberlite/kimberlite breccia/granitic gneiss contacts and are not expected, therefore, to be present in any of the final highwalls. Table 10 gives the legend for the boreholes as shown in Figures 17 to 21.

Table 10: Legend for boreholes

Line Colour	Interpretation
Orange	Kimberlite
Pink	Kimberlite Breccia
Blue	Granitic Gneiss
Green	Dolerite Dyke
Red	Shear Zone

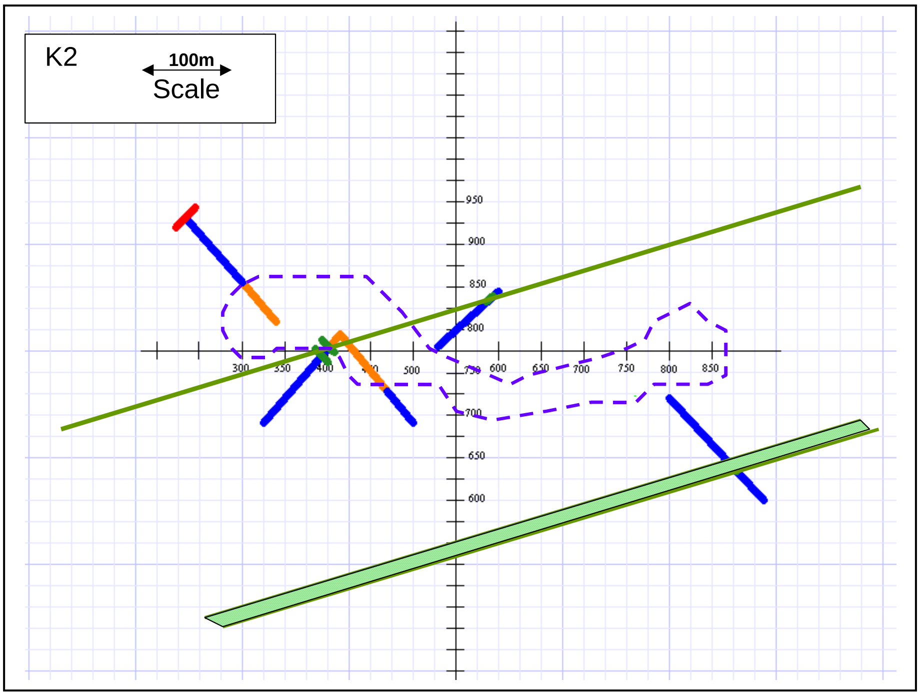

Figure 17: Large-scale structural features in K2

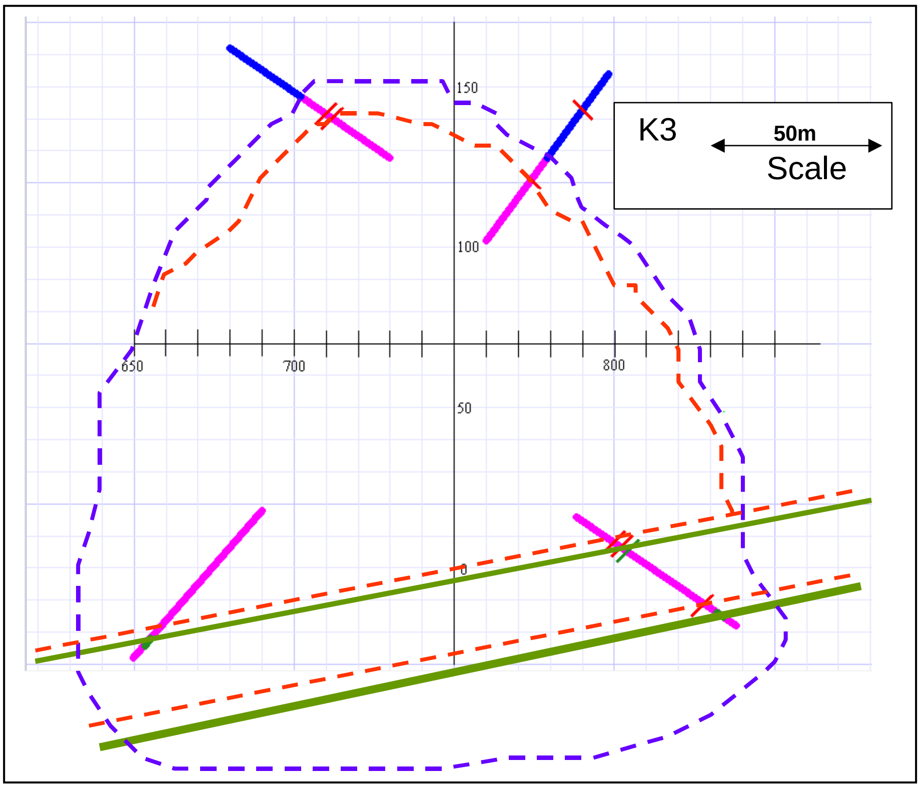

Figure 18: Large-scale structural features in K3

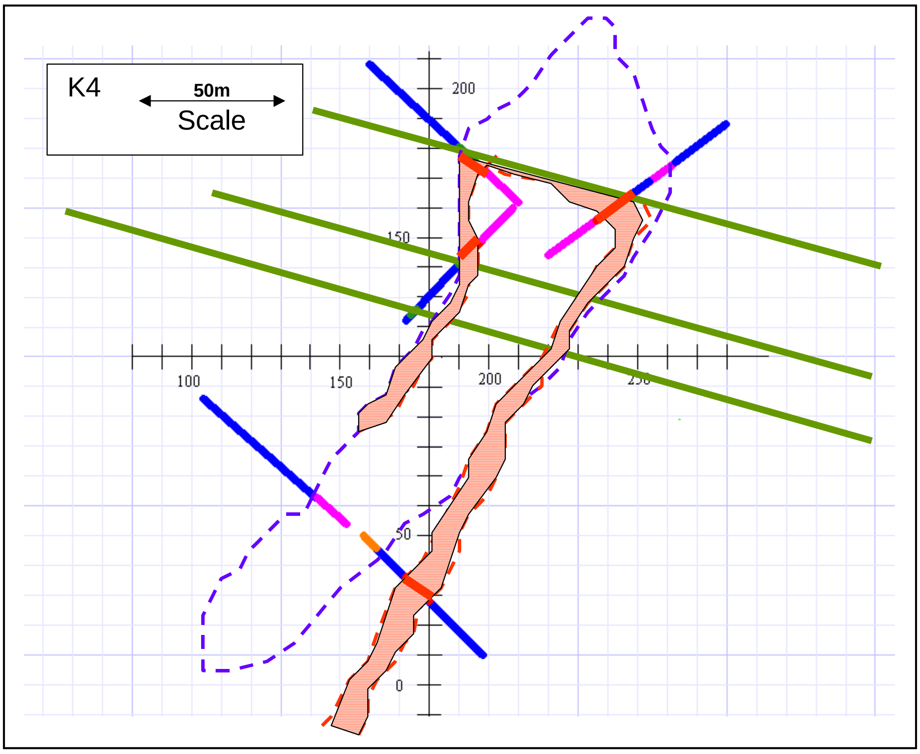

Figure 19: Large-scale structural features in K4

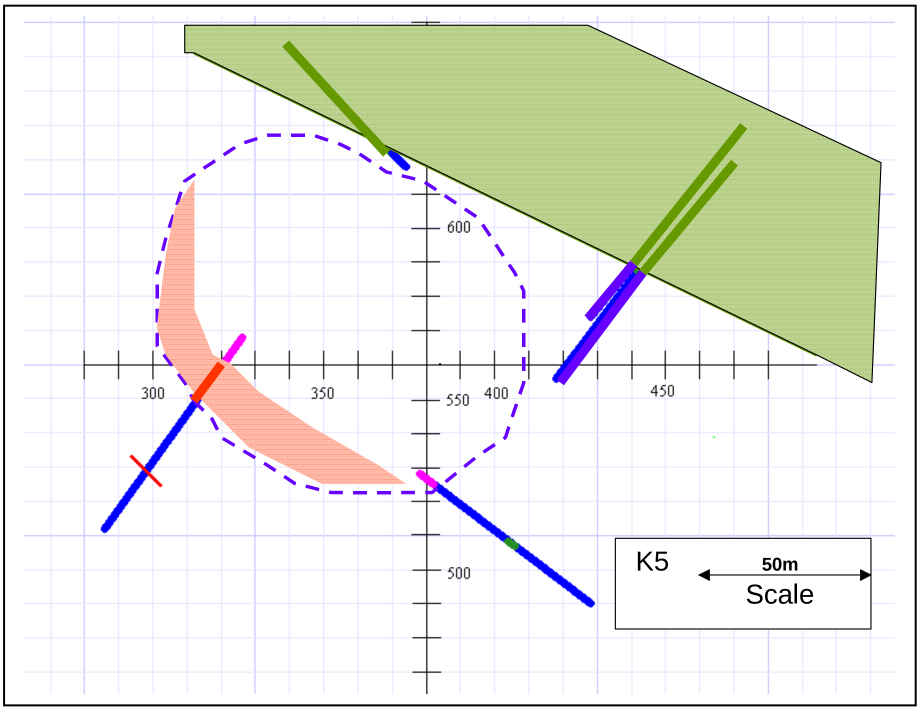

Figure 20: Large-scale structural features in K5

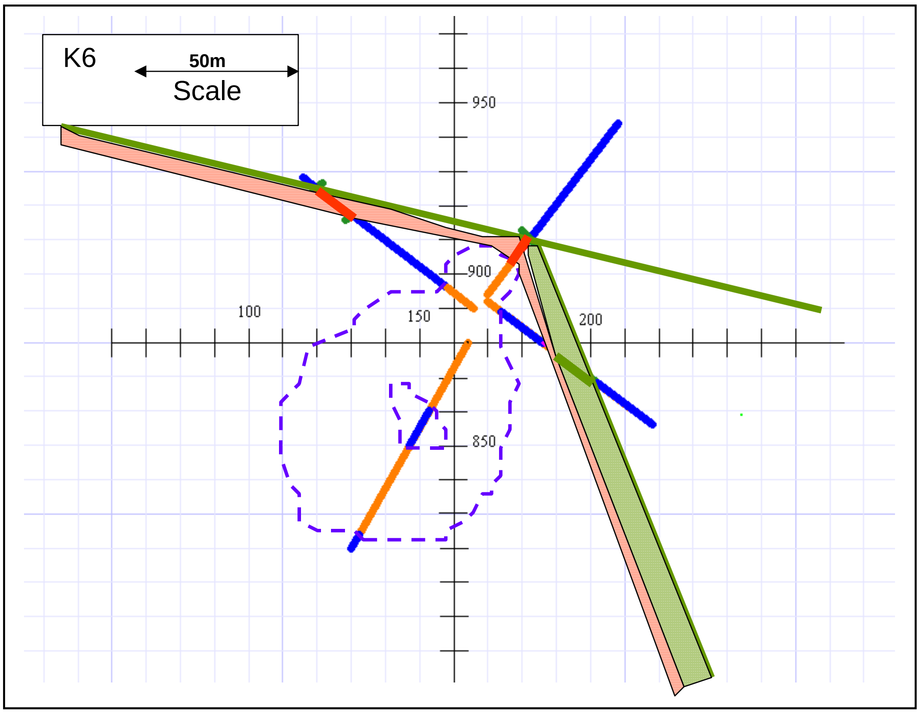

Figure 21: Large-scale structural features in K6

3.4 Weathering and Water

A cover of soil and weathered material overlies the area of interest. The extent of weathering was obtained from the core logs of the large diameter (LDD) and geotechnical (GT) series boreholes, as this would give a reasonable estimate of the height of pitwalls situated in weathered material.

Groundwater was intersected in the kimberlites and not within the granitic gneiss host rock. To quantify the water table elevation and flow rate of water, a detailed geohydrological investigation will have to be conducted. Such an investigation was not within the scope of this project.

3.5 Rock Mass Classification

Following careful scrutiny of the available information, the rock mass was divided and simplified to conform to a number of basic mining rock types.

3.5.1 RMR Classification

The Geomechanics Classification System (Bieniawski 1976, 1989) of jointed rock masses was applied to the main rock types that will be exposed in pit slopes (Table 11). Note that all the values are ratings (Stacey and Swart, 2001). A detailed analysis is presented in Appendix 7.

Table 11: RMR Classification of the major rock types

	UCS	RQD	Js	Jc	Jw	RMR
Granitic Gneiss	12	18	13	22	10	75
Kimberlite	11	16	10	12	10	59
Kimberlite Breccia	7	17	10	12	10	56
Dolerite Dyke	13	15	10	10	10	58

(UCS – Uniaxial Compressive Strength (MPa); RQD – Rock Quality Designation (%); Js – Joint Spacing; Jc – Joint Condition; Jw – Joint Water)

3.5.2 Adjusted MRMR Rating

The MRMR, developed by Laubscher and Taylor (1976) and refined by Laubscher (1977, 1990, 1994), of jointed rock masses was applied to the main rock types that will be exposed in the pit slopes. Table 12 indicates the MRMR and adjusted MRMR values for the unweathered rocks. The adjusted MRMR values were used to determine the overall slope and bench stack angles. A detail analysis is presented in Appendix 8.

Table 12: Adjusted MRMR Classification of the major rock types

	RQD	UCS	Js	Jcw	MRMR	Weathering	Jo	Stress	Blasting	Adjusted MRMR
Granitic Gneiss	14	19	18	23	74	1	0.9	1	0.94	63
Kimberlite	12	12	16	16	56	0.7	0.9	1	0.94	33
Kimberlite Breccia	13	8	16	16	53	0.7	0.9	1	0.94	31
Dolerite Dyke	11	20	13	14	58	1	0.9	1	0.94	49

(UCS – Uniaxial Compressive Strength (MPa); RQD – Rock Quality Designation (%); Js – Joint Spacing; Jcw – Joint Condition and Water; Jo – Joint Orientation)

Table 13 summarises the comparisons between the two rock mass rating systems as well as South African mining industry-related values for the various rock types (Stacey and Swart, 2001). A good corelation exists between the various methods of rock mass classification and industry values.

Table 13: Comparisons between the RMR / MRMR Classification and industry values for the major rock types

	RMR	MRMR	Industry
Granitic Gneiss	75	74	60 - 84
Kimberlite	59	56	35 - 55
Kimberlite Breccia	56	53	35 - 55
Dolerite Dyke	58	58	57 - 63

CHAPTER FOUR – ANALYSIS OF RESULTS

The presence of joints in a rock mass that has been exposed by a slope may result in failure along discontinuities. Three primary modes of failure could occur in hard rock. These are plane, toppling, and wedge failure (Hoek and Bray, 1981).

The first of these, plane failure, may occur when a single plane exposed in a pitwall has a dip direction of within 20° of the dip direction of the slope. For the potential for failure to occur, the plane must dip at an angle shallower than the slope angle but steeper than the residual friction angle. In the case of toppling, a joint set with reasonable persistence needs to have a steep dip and dip in a direction within 30° of the dip direction of the slope. Wedge failure requires the presence of two orthogonal joints or sets of joints, with a line of intersection that daylights in the slope and has a plunge steeper than the residual friction angle. The potential for kinematics can be investigated using lower hemispherical stereo net projections (Watts, 2003 - ROCKPACK III).

In the section on pit classifications that follows, kinematic stability is based on a limited number of data points and has been documented to indicate the potential type of instabilities that could occur along the final highwall position.

4.1 Pit Classifications

Owing to the shape of the kimberlite pipes in K3, K5 and K6 the pits were designed to be circular, to have concave slope orientations on plan, and to be cone shaped in section. The pits in K2 and K4 have been designed to be elongated and have semi-circular edges.

To simplify the kinematic analysis the pit designs were classified according to the slope orientations – e.g. dip direction and dip.

The preliminary slope designs (Van Heerden and Odendaal, 2006) were supplemented by the structural data gathered and set out in Chapter Three of this report to produce the highwall failure types that are discussed under 4.3. From the preliminary slope designs the pits were divided into the main slope orientation categories (Figure 22). Additional slope orientations were calculated when required. The five pits were divided into the main slope orientation categories as indicated in Figures 23 to 27.

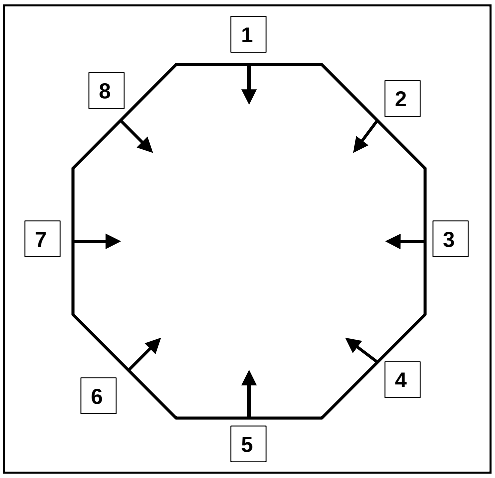

Figure 22: Main slope orientation categories

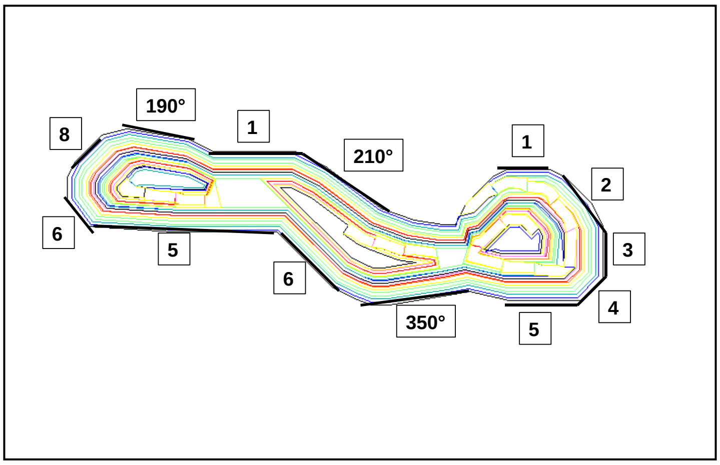

Figure 23: Preliminary pit design for K2

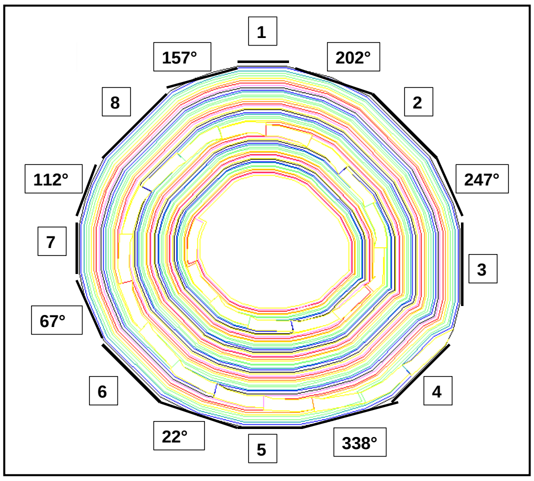

Figure 24: Preliminary pit design for K3

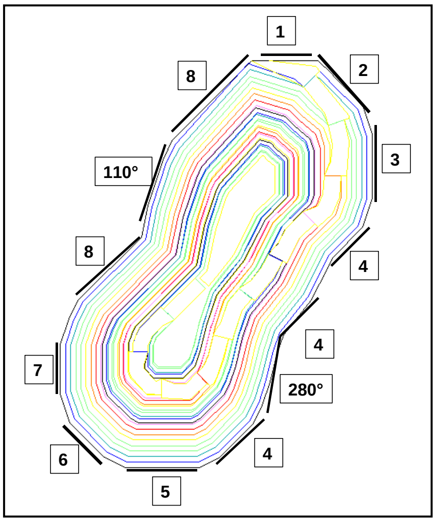

Figure 25: Preliminary pit design for K4

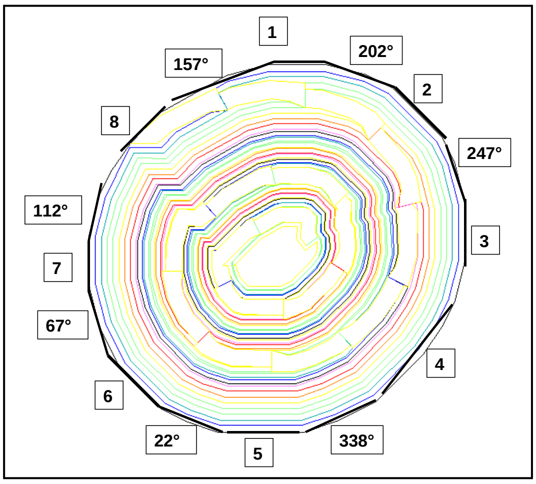

Figure 26: Preliminary pit design for K5

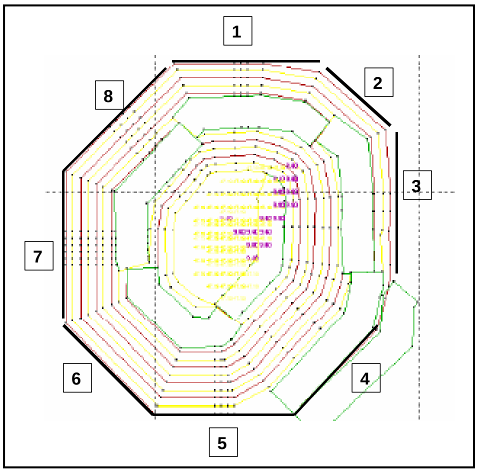

Figure 27: Preliminary pit design for K6

4.2 Joint Data Sets and Residual Friction Angles

From the joint identification and classification four limiting boundaries were established for each joint/foliation set. Five prominent joint sets and two foliation sets were used for the granitic gneiss (Table 14).

Table 14: ROCKPACK III - Joint/foliation set symbols for granitic gneiss

Joint Set	ROCKPACK III Symbols	Comment
1	□	Conjugate Set
2	△	Conjugate Set
3	▼	Conjugate Set
4	+	Shallow Dipping Set
5	○	Shallow Dipping Set
6	■	Foliation
7	●	Foliation

Three prominent joint sets were used for the dolerite dyke (Table 15).

Table 15: ROCKPACK III - Joint set symbols for dolerite dyke

Joint Set	ROCKPACK III Symbols	Comment
1	□	Conjugate Set
2	△	Steep Dipping Set
3	▼	Shallow Dipping Set

The instantaneous friction angle calculated in 2.3.2 and 3.1.2 was used (Table 16).

Table 16: Instantaneous friction angles

	Granitic Gneiss	Dolerite Dyke	Kimberlite Breccia
Instantaneous Friction Angle	45°	49°	34°

4.3 Potential Failures in Granitic Gneiss

Owing to the numerous examples of the failure types for the different pit slope orientations, only one example of each failure type is illustrated in a figure. The remainder of the examples are presented in tables 17 to 19 for plane failure, tables 20 to 22 for toppling failure, and tables 23 to 25 for wedge failure.

4.3.1 Plane failure

Figure 28 represents plane failure for a slope dipping 85º in a southerly (180º) direction. No plane failure is expected for this slope orientation, although joint set 2 is on the border of the failure envelope.

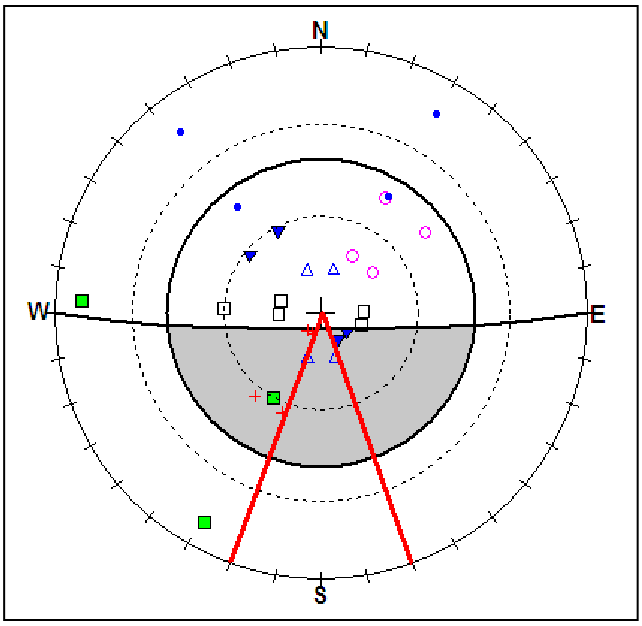

Figure 28: Plane failure for a slope with dip direction of 180º and a dip of 85º

Table 17: Joint types that are prone to plane failure for the major slope directions and dip

Dip	1 180º	2 225º	3 270º	4 315º	5 360º	6 45º	7 90º	8 135º
65º	-	4/6	6	3/7	-	5/7	-	-
75º	-	4/6	6	3/7	-	5/7	-	-
85º	2	4/6	1/6	2/3/7	-	5/7	1	3

Table 18: Joint types that are prone to plane failure for the minor slope directions and dip

Dip	9 202º	10 247º	11 292º	12 338º	13 22º	14 67º	15 112º	16 157º
65º	4/6	-	-	3/7	5/7	5	-	-
75º	4/6	-	-	3/7	5/7	5	-	-
85º	4/6	-	1	2/3/7	2/5/7	5	1	2/3

Table 19: Joint types that are prone to plane failure for the additional slope directions and dip

Dip	K2 190º	K2 210º	K2 350º	K4 110º	K4 280º
65º	4	4/6	-	-	1
75º	4	4/6	-	-	1
85º	2/4	2/4/6	-	1	1

4.3.2 Toppling failure

Figure 29 represents toppling failure for a slope dipping 85º in a southerly (180º) direction. Toppling failure for joint sets 2 and 3 is predicted. Joint set 5 and a foliation set are on the border of the failure envelope.

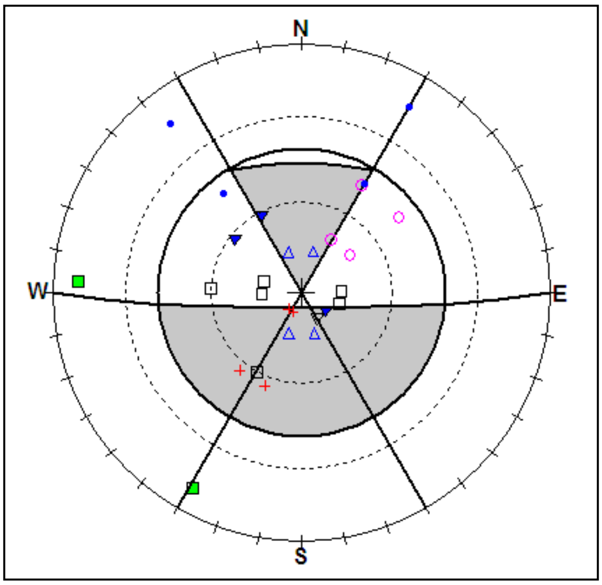

Figure 29: Toppling failure for a slope with dip direction of 180º and a dip of 85º

Table 20: Joint types that are prone to toppling failure for the major slope directions and dip

Dip	1 180º	2 225º	3 270º	4 315º	5 360º	6 45º	7 90º	8 135º
65º	2	2/5	1	3	2	4	1	-
75º	2/3	2/5	1	3	2/4	4/6	1/6	3
85º	2/3/5	2/5	1	3	2/4	4/6	1/6	3/7

Table 21: Joint types that are prone to toppling failure for the minor slope directions and dip

Dip	9 202º	10 247º	11 292º	12 338º	13 22º	14 67º	15 112º	16 157º
65º	2/5	1/5	1/3	2/3	2/4	1/4	1	2
75º	2/5	1/5	1/3	2/3	2/4/6	1/4	1/3	2/3
85º	2/5/7	1/5	1/3	2/3	2/4/6	1/4	1/3	2/3/7

Table 22: Joint types that are prone to toppling failure for the additional slope directions and dip

Dip	K2 190º	K2 210º	K2 350º	K4 110º	K4 280º
65º	2/5	2/5	2/3	1	1
75º	2/5	2/5	2/3	1/3/6	1
85º	2/5/7	2/5/7	2/3	1/3/6	1

4.3.3 Wedge failure

Figure 30 represents wedge failure for a slope dipping 85º in a southerly (180º) direction. Wedge failure for combinations of joint sets 1, 2, 3, 4 and 6 is predicted.

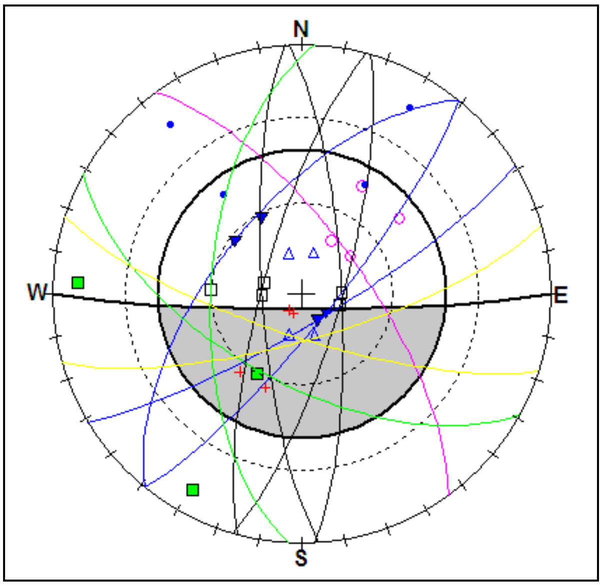

Figure 30: Wedge failure for a slope with dip direction of 180º and a dip of 85º

Table 23: Joint types that are prone to wedge failure for the major slope directions and dip

Dip	1 180º	2 225º	3 270º	4 315º	5 360º	6 45º	7 90º	8 135º
65º	1/3/4/6	1/2/3/4/6	2/3/4/6/7	1/2/3/4/5/6/7	1/3/5/6/7	1/2/3/5/7	2/3/5/4/7	1/2/4/5/6
75º	1/2/3/4/6	1/2/3/4/6	1/2/3/4/5/6/7	1/2/3/4/5/6/7	1/2/3/4/5/6/7	1/2/3/5/7	1/2/3/4/5/7	1/2/4/5/6
85º	1/2/3/4/6	1/2/3/4/6/7	1/2/3/4/5/6/7	1/2/3/4/5/6/7	1/2/3/4/5/6/7	1/2/3/5/6/7	1/2/3/4/5/6/7	1/2/3/4/5/6

Table 24: Joint types that are prone to wedge failure for the minor slope directions and dip

Dip	9 202º	10 247º	11 292º	12 338º	13 22º	14 67º	15 112º	16 157º
65º	1/2/3/4/6	1/2/3/4/6	1/2/3/4/5/6/7	1/2/3/4/5/6/7	1/2/3/5/7	1/2/3/5/7	1/2/3/4/5/6/7	1/3/4/5/6
75º	1/2/3/4/6	1/2/3/4/6	1/2/3/4/5/6/7	1/2/3/4/5/6/7	1/2/3/5/6/7	1/2/3/4/5/7	1/2/3/4/5/6/7	1/2/3/4/5/6
85º	1/2/3/4/6	1/2/3/4/5/ 6/7	1/2/3/4/5/6/7	1/2/3/4/5/6/7	1/2/3/5/6/7	1/2/3/4/5/7	1/2/3/4/5/6/7	1/2/3/4/5/6

Table 25: Joint types that are prone to wedge failure for the additional slope directions and dip

Dip	K2 190º	K2 210º	K2 350º	K4 110º	K4 280º
65º	1/2/3/4/6	1/2/3/4/6	1/2/3/4/5/6/7	1/2/3/4/5/6/7	2/3/4/6/7
75º	1/2/3/4/6	1/2/3/4/6	1/2/3/4/5/6/7	1/2/3/4/5/6/7	1/2/3/4/5/6/7
85º	1/2/3/4/6	1/2/3/4/6	1/2/3/4/5/6/7	1/2/3/4/5/6/7	1/2/3/4/5/6/7

4.4 Potential Failure in Dolerite Dyke (Pit K5)

An indication of the joint sets that are prone to plane, toppling and wedge failure is given in tables 26, 27, and 28 respectively.

Table 26: Joint types that are prone to plane failure for the major slope directions and dip

Dip	1 180º	2 225º	3 270º	9 202º	10 247º
65º	-	-	-	-	-
75º	-	2	-	2	-
85º	-	2	1	2	1

Table 27: Joint types that are prone to toppling failure for the major slope directions and dip

Dip	1 180º	2 225º	3 270º	9 202º	10 247º
65º	-	1	1	-	1
75º	-	1	1	-	1
85º	-	1	1	-	1

Table 28: Joint types that are prone to wedge failure for the major slope directions and dip

Dip	1 180º	2 225º	3 270º	9 202º	10 247º
65º	1/2/3	1/3	2	1/2/3	-
75º	1/2/3	1/2/3	1/2	1/2/3	1/2/3
85º	1/2/3	1/2/3	1/2/3	1/2/3	1/2/3

Owing to the nature of the joints (radial and concentric), it is expected that most of the pit slopes at Lerala will have a potential for planar, toppling and wedge failures.

4.5 Slope Design

As was stated in the first chapter of this report, jointed hard rock slopes and highly weathered (soil) slopes are the two types of slopes expected to be formed in the Lerala Mine. For this reason, the first two objectives of the research were to provide recommendations on hard rock slope angles for all pits and to provide recommendations with respect to weathered material.

It should be kept in mind that the data collected for this study came primarily from boreholes. The values contained in the report are thus justifiably conservative. Only once rock surfaces have been exposed could more detailed analyses be made of the rock mass properties and the optimisation of slope angles conducted.

Overall slope angles should conform to the 1.5 factor of safety. Where combinations of rock types are present in a pit perimeter slope, the bench stack angle (BSA) for the various rock types should be used. The various combinations will entail a variation in heights, widths, and angles.

Bench heights of 10m and ramp widths / geotechnical berms between 10m and 26m were selected due to the restrictions of the selected equipment.

4.5.1 Hard rock slopes

The correlation between recommended overall slope angles (OSA) and adjusted MRMR values (Haines and Terbrugge 1991) is given in Table 29 for a factor of safety (FoS) of 1.5.

Table 29: Correlation between adjusted MRMR values and OSA's

Adjusted *MRMR*	100	90	80	70	60	50	40	30	20	10	0
OSA	>75°	75°	70°	65°	60°	55°	50°	45°	40°	35°	<35°

The recommended (preliminary) overall slope angles (OSA's) for the four major rock types found at Lerala, for a FoS of 1.5 are indicated in Table 30 below.

Table 30: Overall slope angles

	Granitic Gneiss	Kimberlite	Kimberlite Breccia	Dolerite Dyke
Adjusted MRMR	63	33	31	49
OSA FOS 1.5	61°	46°	45°	55°

The design chart shown in Figure 31 was developed by Haines and Terbrugge (1991) is applicable in selecting the bench stack angles (BSA).

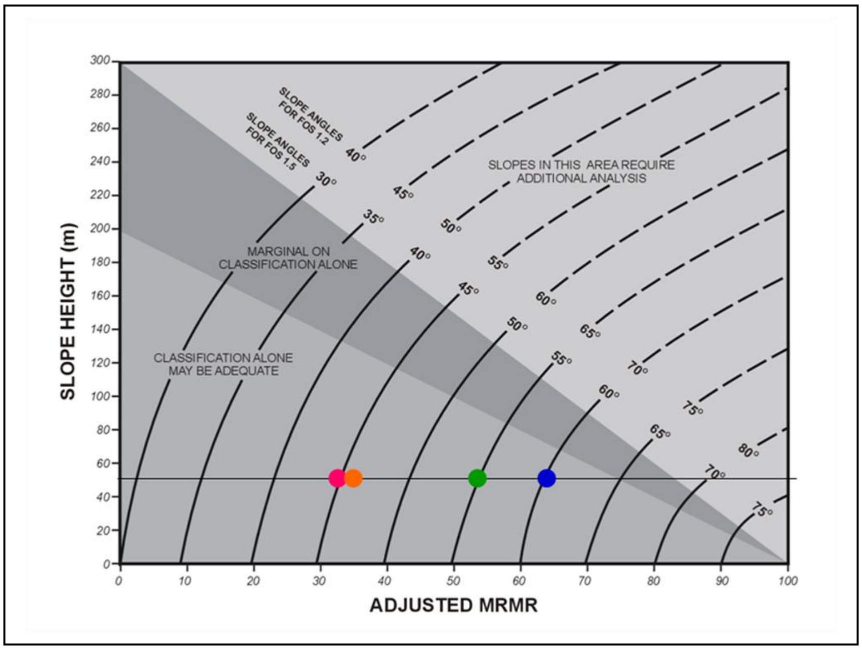

Figure 31: Slope design chart (Haines and Terbrugge, 1991) for BSA's

Bench heights of 10m and bench stack heights of 50m were used due to equipment restrictions. The adjusted MRMR values obtained for **granitic gneiss (GG)**, **kimberlite (K)**, **kimberlite breccia (KB)** and **dolerite dyke (DD)** were plotted on the chart in Figure 31. Bench stack angles were then selected at a factor of safety (FoS) of 1.35.

The design chart indicates the following bench stack angles :

- Granitic gneiss <66°
- Kimberlite breccia <50°
- Dolerite dyke <60°

Gibson et al (2006) identified methods to calculate the volume of failed rock from benches for varying bench heights and bench angles onto spill berms. These methods were used to calculate the volume of failed rock for wedge type failures forming either conical or pyramid shaped failed material.

To determine the volume of failed rock for the three main rock types at Lerala, a plane failure geometry was used to determine the maximum volume of failure. The following formula was proposed by Gibson et al (2006) to determine the maximum extent of the failed mass to be contained by the berms.

$$R = \sqrt[3]{\frac{6KV}{\pi} + \frac{\tan \propto - \tan \emptyset}{\tan \propto . \tan \emptyset}}$$

Where K = 1.5 swelling factor
R = radius of failed material
V = volume of failed material (m^3)
α = bench face angle (◦)
ø = angle of repose of failed material (38◦)

The spill berm widths (SBW) for the three main rock types at Lerala are shown in Table 31.

Table 31: Spill berm widths for the three main rock types at Lerala

	Granitic Gneiss	Kimberlite Breccia	Dolerite Dyke
SBW	5.4 m	5.3 m	5.2 m

The slope designs shown for granitic gneiss, kimberlite breccia and dolerite dyke are based on various slope heights and associated OSA's, ramp widths for fixed bench heights, bench face angles, BSA's, and SBW's.

Each rock type (granitic gneiss, kimberlite breccia, dolerite dyke) has different design parameters and these should be implemented on the basis of the geological model.

It should be noted that, based on the preliminary pit designs (MINXCON, September 2007), granitic gneiss is present in all the pits, kimberlite breccia only in K3, and dolerite dyke only in pit K5 – in the northeast corner.

The following slope design process was followed:

- Benches were fixed at 10m high
- Bench angles for the three rock types were based on their rock mass classification (Granitic gneiss 90º ; Kimberlite breccia 70º ; Dolerite dyke 85º)
- Spill berms were calculated as indicated in Table 31
- Bench stack heights were fixed at 50m
- BSA's were selected at a FoS of 1.35 from the design chart in Figure 31 (Granitic gneiss <66° ; Kimberlite breccia <50° ; Dolerite dyke <60°***)***
- Maximum OSA's were selected at a FoS of 1.5 as indicated in Tables 29 and 30
- Varying OSA's and ramp widths / geotechnical berms were determined using the Basson (2004) slope design computer program

Granitic gneiss

Table 32: Design criteria for granitic gneiss slopes

Overall Slope Height*	Overall Slope Angle**	Bench Height	Bench Face Angle	Spill Berm Width	Benches / Bench Stacks	Ramp Width	Bench Stack Angle
50 m	65°	10 m	90°	5.8 m	1 stack 5 benches	-	-
100 m	56°	10 m	90°	5.8 m	2 stacks 5 / 5 benches	20.8 m	65°
150 m	54°	10 m	90°	5.8 m	3 stacks 5 / 5 / 5 benches	19.5 m	65°
200 m	52°	10 m	90°	5.8 m	4 stacks 5 / 5 / 5 / 5 benches	21.0 m	65°

*Hard rock slope height; **crest to toe

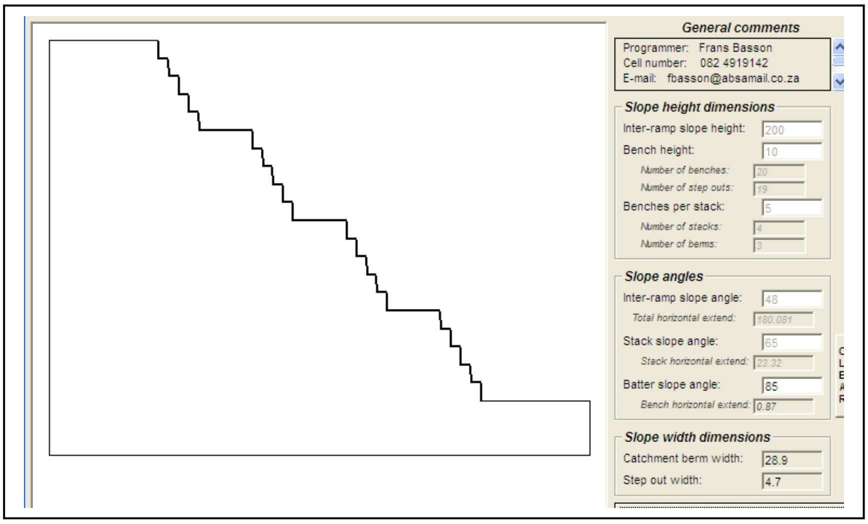

Figure 32: Schematic presentation of slope design (Basson, 2004)

Ramp widths in granitic gneiss

Varying ramp widths / geotechnical berms and OSA’s were calculated for depths of 100 m, 150 m and 200 m at the recommended OSA’s, BSA’s, face angles, and bench heights. The ramp widths that comply with the design criteria for OSA’s, BSA’s and SBW’s are presented in Table 33 (for granitic gneiss), Table 35 (for kimberlite breccia) and Table 37 (for dolerite dykes).

The following parameters/values for the granitic gneiss slopes were used:

- OSA of <61°
- BSA of 65°
- Bench heights of 10 m
- Bench face angles of 90°
- Bench stack heights of 50 m
- SBW of 5.8 m

Table 33: Design criteria for different ramp widths in granitic gneiss

Slope height of 100 m		Slope height of 150 m		Slope height of 200 m	
Ramp Width	**Overall Slope Angles**	**Ramp Width**	**Overall Slope Angles**	**Ramp Width**	**Overall Slope Angles**
10 m	60.5°	**10 m**	59.0°	**10 m**	58.3°
12 m	59.5°	**12 m**	58.0°	**12 m**	57.0°
14 m	58.7°	**14 m**	56.7°	**14 m**	56.0°
16 m	58.0°	**16 m**	55.7°	**16 m**	54.7°
18 m	57.0°	**18 m**	54.7°	**18 m**	53.7°
20 m	56.5°	**20 m**	53.7°	**20 m**	52.5°
22 m	55.5°	**22 m**	52.7°	**22 m**	51.5°
24 m	54.7°	**24 m**	51.8°	**24 m**	50.5°
26 m	54.0°	**26 m**	50.8°	**26 m**	49.5°

Kimberlite breccia

As stated under 4.5.1 kimberlite breccia is found only in the K3 pit area.

Table 34: Design criteria for kimberlite breccia slopes

Overall Slope Height*	Overall Slope Angle	Bench Height	Bench Face Angle	Spill Berm Width	Benches / Bench Stacks	Ramp Width	Bench Stack Angle
50 m	50°	10 m	70°	5.9 m	1 Stack 5 Benches	-	
100 m	44°	10 m	70°	5.9 m	2 Stacks 5 / 5 Benches	19.6 m	50°
150 m	42°	10 m	70°	5.9 m	3 Stacks 5 / 5 / 5 Benches	20.4m	50°
200 m	41°	10 m	70°	5.9 m	4 Stacks 5 / 5 / 5 / 5 Benches	20.8 m	50°

*Hard rock slope height; **crest to toe

Ramp widths in kimberlite breccia

The following parameters/values for the kimberlite breccia slopes were used:

Overall Slope Angle of <45°

Bench Stack Angles of 50°

Bench heights of 10 m

Bench face angles of 70°

Bench stack heights of 50 m

SBW of 5.9 m

Table 35: Design criteria for different ramp widths in kimberlite breccia

Slope height of 100 m		Slope height of 150 m		Slope height of 200 m	
Ramp Width	Overall Slope Angles	Ramp Width	Overall Slope Angles	Ramp Width	Overall Slope Angles
10 m	46.8°	10 m	45.8°	10 m	45.3°
12 m	46.2°	12 m	45.0°	12 m	44.4°
14m	45.6°	14m	44.2°	14m	43.6°
16 m	45.0°	16 m	43.5°	16 m	42.8°
18 m	44.5°	18 m	42.8°	18 m	42.0°
20 m	43.9°	20 m	42.1°	20 m	41.3°
22 m	43.3°	22 m	41.4°	22 m	40.5°
24m	42.8°	24m	40.8°	24m	39.8°
26 m	42.3°	26 m	40.1°	26 m	39.1°

Dolerite dyke

As stated under 4.5.1 a dolerite dyke is found only in the northeast corner of the K5 pit area.

Table 36: Design criteria for dolerite dyke slopes

Overall Slope Height*	Overall Slope Angle	Bench Height	Bench Face Angle	Spill Berm Width	Benches / Bench Stacks	Ramp Width	Bench Stack Angle
50 m	60°	10 m	85°	6.1 m	1 Stack 5 Benches	-	60°
100 m	52°	10 m	85°	6.1 m	2 Stacks 5 / 5 Benches	20.4m	60°
150 m	50°	10 m	85°	6.1 m	3 Stacks 5 / 5 / 5 Benches	19.6 m	60°
200 m	49°	10 m	85°	6.1 m	4 Stacks 5 / 5 / 5 / 5 Benches	19.5 m	60°

*Hard rock slope height; **crest to toe

Ramp widths in dolerite dyke

The following parameters/values for the dolerite dyke slopes were used:

Overall Slope Angle of <55°

Bench Stack Angles of 60°

Bench heights of 10 m

Bench face angles of 85°

Bench stack height of 50 m

SBW of 6.1m

Table 37: Design criteria for different ramp widths in dolerite dyke

Slope height of 100 m		Slope height of 150 m		Slope height of 200 m	
Ramp Width	**Overall Slope Angles**	**Ramp Width**	**Overall Slope Angles**	**Ramp Width**	**Overall Slope Angles**
10 m	55.9°	**10 m**	54.6°	**10 m**	54.0°
12 m	55.1°	**12 m**	53.6°	**12 m**	52.8°
14m	54.3°	**14m**	52.6°	**14m**	51.8°
16 m	53.6°	**16 m**	51.6°	**16 m**	50.8°
18 m	52.9°	**18 m**	50.7°	**18 m**	49.7°
20 m	52.1°	**20 m**	49.8°	**20 m**	48.7°
22 m	51.4°	**22 m**	48.9°	**22 m**	47.8°
24 m	50.7°	**24 m**	48.1°	**24 m**	46.8°
26 m	50.0°	**26 m**	47.3°	**26 m**	45.9°

4.5.2 Weathered material

The thickness of the saprolite profile on Lerala varies between 5 m and 35 m and is related to the rock type. The kimberlite-type rocks are more susceptible to weathering than the granitic-type rocks. The depth of weathering will, therefore, is deeper in kimberlite / pit areas than in the surrounding granitic / highwall areas.

The weathered material slopes were quantified using a design chart (Figure 33) proposed by Hoek and Bray (1981). The method utilises the cohesion, angle of internal friction, and the density of the material with the proposed height and the assumed factor of safety of the slope.

Values were obtained for various factors of safety at overall slope heights ranging from 5 m to 20 m. The factors of safety and slope angles were determined for a dry to semi-saturated slope (surface water 8 slope heights behind toe of slope) since groundwater levels were intersected at depths 25 m to 80 m and only within the kimberlites.

A factor of safety of 1.5 was used for the final saprolite slope design.

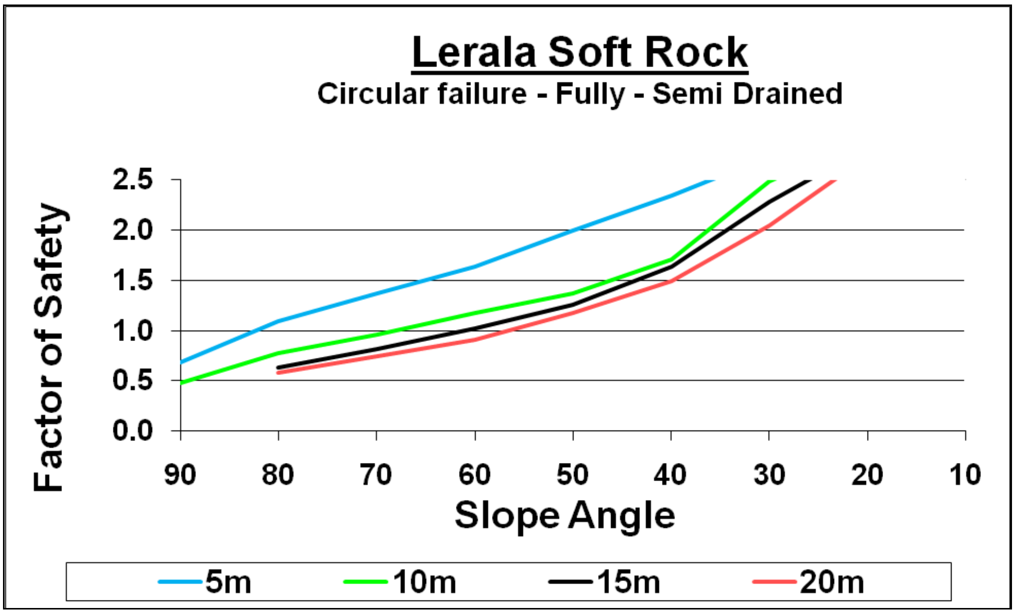

Figure 33: Slope angles and factors of safety for bench heights

A detailed breakdown is tabulated below (Table 38), indicating designs for 5m and 10 m benches.

Table 38: Design criteria for slopes within the saprolite gneiss slopes

Overall Slope Height	Overall Slope Angle	Bench Height	Bench Face Angle	Spill Berm Width	Benches
5 m	65°	5 m	65°		1 Bench
10 m	45°	5 m	65°	3.6 m	2 Benches
15 m	45°	5 m	65°	3.6 m	3 Benches
20 m	40°	5 m	65°	3.6 m	4 Benches
or					
10 m	45°	10 m	45°		1 Bench
20 m	40°	10 m	45°	3.8 m	2 Benches

The following design parameters are proposed for the soil/saprolite slopes:

- Saprolite bench heights = 5 m or 10 m
- Saprolite berm widths = 3.6 m – 3.8 m
- Saprolite bench/batter angle 65° or 45° depending on bench heights
- Overall saprolite slope angle of 40° – 65° depending on the slope height

CHAPTER FIVE – CONCLUSIONS

It is concluded that :

- Lerala is a green fields diamond mining project in a flat area where rock outcrops are rare ;
- All the rock types known to exist in the area are covered by 2m of soil, thereby making mapping of exposures impossible ;
- All the structural information for the analysis was derived from borehole cores obtained from 23 geotechnical boreholes, and some surface pitting ;
- The information used for the analysis is sufficient to design preliminary open pits and slope angles for a feasibility study ;
- More detailed designs will only be possible once larger exposures from preliminary pitting have been created.

The material properties were quantified from samples taken from exploration core. It is believed that the information gained is useful and sufficient for feasibility purposes; however the data need to be augmented by further tests to evaluate possible spatial and normal variance in properties. Discontinuity shear strength can be significantly increased by undulation or waviness. Although strong indications of waviness of joints could be seen in the borehole core it could not be effectively quantified. This will only be possible once the rock mass has been exposed.

Rock mass classification from boreholes is not as accurate as when it is conducted from exposed rockwalls. In this case no rockwall exposures are available and therefore the information from boreholes had to suffice.

Currently very little is known about the sources and distribution of water in the rock mass, which is an issue that will have to be investigated in the next stage of the evaluation.

5.1 Recommendations for Future Work

The following work is recommended based on the knowledge and experienced gained from this study:

- Discontinuity properties such as undulation and waviness need to be quantified in order to improve on the shear strength parameters of joint sets;
- More detailed data are required regarding joint sets and rock mass strength in the exposed rock walls;
- This same data should be used to improve and refine the rock mass classification;
- The kinematic analyses of pit walls need to be conducted in more detail, once more information becomes available from joint mapping;
- Additional soil / saprolite samples should be taken for expanding the database and updating the soil / saprolite slope design angles; and
- Hard rock data should be re-analysed as soon as the rock is exposed during the trial mining phase.

Reference list

1. Barnes, G.E (1991) A simplified version of the Bishop and Morgenstern slope stability charts, Can. Geotech. J., Vol. 28, pp 630-637.

2. Barton, N.R., Bandis, S.C. 1990. Review of predictive capabilities of JRC-JCS model in engineering practice. In *Rock joints, proc. int. symp. on rock joints,* Loen, Norway, (eds N. Barton and O. Stephansson), 603-610. Rotterdam: Balkema.

3. Barton, N.R. and Bandis, S.C. 1982. Effects of block size on the the shear behaviour of jointed rock. *23rd U.S. symp. on rock mechanics*, Berkeley, 739-760.

4. Barton, N.R., Choubey, V. 1977. The shear strength of rock joints in theory and practice. *Rock Mech.* 10(1-2), 1-54.

5. Barton, N.R. 1976. The shear strength of rock and rock joints. *Int. J. Mech. Min. Sci. & Geomech. Abstr*. **13**(10), 1-24.

6. Barton, N., Lien, R. And Lunde,J. (1974) Engineering classification of rock masses for the design of tunnel support, Rock Mech., Vol. 6, No. 4, pp 189-236.

7. Barton, N.R. 1973. Review of a new shear strength criterion for rock joints. *Engng Geol.* **7**,287-332.

8. Basson, F. 2004. Slope Optimizer. Windows 95 – XP Version 1.

9. Bieniawski, Z.T. 1976. Rock mass classification in rock engineering. In Exploration for rock engineering, proc. of the symp., (ed. Z.T. Bieniawski) 1, 97-106. Cape Town: Balkema.

10. Bieniawski, Z.T. (1989) Engineering Rock Mass Classification, John Wiley and Sons, New York.

11. Bishop, A.W. and Morgenstern, N.P. (1960) Stability coefficients for earth slopes, Geotechnique, Vol. 10, pp 129-150.

12. Carney, J.N., Aldiss, D.T., Lock, N.P. 1994. The Geology of Botswana. *Bulletin 37,* Dept of Geological Survey, Botswana.

13. Chandler, R.J. and Peiris, T.A. (1989) Further extensions to the Bishop and Morgenstern slope stability charts, Ground Engineering, Vol. 22, No. 4, pp 33-38.

14. Dempers, G.D. 1994. Optimal usage of exploration core for geotechnical purposes, Proc. Symp. Integral Approach to Applied Rock Mechanics, Int. Soc. Rock Mech. Santiago, Chile, 219-230.

15. Gibson, W.H., De Bruyn, I.A., Walker, D.J.H. 2006. Considerations in the optimization of bench face angle and berm width geometries for open pit mines. SAIMM International Symposium on Stability of rock slopes in open pit and civil engineering status. Symposium Series S44. April 2006, 557–578.

16. Haines, A., Terbrugge, P.J. 1991. Preliminary estimation of rock slope stability using rock mass classifications systems, Proc. 7th Int. Cong. Int. Soc. Rock Mech. 2, 887-892.

17. Hoek, E., Bray, J.W. 1981. Rock Slope Engineering (3rd Edition). The Institution of Mining and Metallurgy, London.

18. Hoek, E. 1990. Estimating Mohr-Coulomb friction and cohesion values from the Hoek-Brown failure criterion. *Intnl. J. Rock Mech. & Mining Sci*. *&Geomechanics Abstracts.* 12(3), 227-229.

19. **http://www.2icaustralia.com**

20. International Society for Rock Mechanics Commission on Standardisation of Laboratory and Field Tests. 1978. Suggested methods for the quantitative description of discontinuities in rock masses. *Int. J. Rock Mech. Min. Sci. & Geomech. Abstr.* 15, 319-368.

21. Laubscher, D.H. and Taylor, H.W. (1976) The importance of geomechanics classification of jointed rock masses in mining operations, Proc. Symp. Exploration for Rock Engineering, Johannesburg, Vol. 1, A.A. Balkema, pp 119-128.

22. Laubscher, D.H. 1977. Geomechanics classification of jointed rock masses – mining applications. *Trans. Instn. Min. Metall.* 86, A1-8.

23. Laubscher, D.H. 1990. A geomechanics classification system for the rating of rock mass in mine design, *Jl S. Afr. Inst. Min. Metall*. 90(10), 257-273.

24. Laubscher, D H (1994) Cave mining – state of the art, Jl S. Afr. Inst. Min. Metall., Vol. 94, pp 279-293.

25. Marjoribanks, R. 2002. Structural logging of drill core. Australian Institute on Geoscientis. AIG Handbook 5.

26. McGeorge, I.B. 2003. Prospectus. DiamonEx Limited. Independent consulting geologist’s report on the Martin’s Drift and Molopo diamond projects, Gaborone.

27. O'Connor, M.J. and Mitchell, R.J. (1977) An extension of the Bishop and Morgenstern slope stability charts, Can. Geotech, J., Vol. 14, pp 144-151.

28. Patton, F.D. 1966. Multiple modes of shear failure in rock. *Proc. 1st congr. Int. Soc. Rock Mech.* Lisbon 1, 509-513.

29. Rocscience Dips Version 5.1 Computer Program.

30. Spencer, E. (1969) Circular and logarithmic spiral slip surfaces, J. Soil Mech. Fdn Div., ASCE, Vol. 95, No. SM1, pp 227-234.

31. Stacey, T.R., Swart, A.H. 2001. Practical Rock Engineering for Shallow and Opencast Mines. SIMRAC. OTH 602.

32. Van Heerden, D. and Odendaal, N.J. 2006. Promet Engineers Africa. Feasibility report for Martin's Drift Diamond Project. DiamonEx Botswana Ltd.

33. Watts, C.F. 2003. ROCKPACK III for Windows Computer Program – A Rock Slope Stability Computerized Analysis Package.

Appendix 1 K2GT01

GEOTECHNICAL BOREHOLE LOG

PROJECT: Lerala **BOREHOLE NO:** K2 GT01 **FINAL DEPTH:** 101.6m **DATE:** 27/11/2006

ZONE: K2 **INCLINATION:** 50 **LOGGED BY:** JPE Hamman

Interval From	RQD %	Geotech interval	Rock Type	Rock competence: Solid m	Rock competence: Matrix m	Rock competence: Matrix type	Weath'ng 1-5	Hardness 1-5	Alpha Angle	Beta Angle	Joint Surface Condition: Micro 1-9	Joint Surface Condition: Macro 1-5	Joint Surface Condition: Infilling Type 1-7	Joint Surface Condition: Wall Alter 1-3
0		0m - 21m	Tricone				4	3						
21		21m - 34.2	Sapprolite Kimberlite				4	3						
34.2	90	34.2m - 44m	Kimberlite				4	3						
44	85	44m - 50.6m	Kimberlite Breccia				4	3						
50.6	40	50.6m - 62.8	Weathered Kimberlite				4	3						
62.8	97	62.8m - 85.05	Granitic Gneiss				1	4						
68.2			Granitic Gneiss	68.2			1	4	65	300	2/3	1/2		1
68.3			Granitic Gneiss	68.3			1	4	60	160	2/3	1/2		1
68.5			Granitic Gneiss	68.5			1	4	25	140	2/3	1/2		1
68.6			Granitic Gneiss	68.6			1	4	70	330	2/3	1/2		1
69.6			Granitic Gneiss	69.6			1	4	45	120	2/3	1/2		1
74.5			Granitic Gneiss	74.5			1	4	50	350	2/3	1/2		1
74.55			Granitic Gneiss	74.55			1	4	50	350	2/3	1/2		1
74.7			Granitic Gneiss	74.7			1	4	45	30	2/3	1/2		1
77.5			Granitic Gneiss	77.5			1	4	35	130	2/3	1/2		1
83.7			Granitic Gneiss	83.7			1	4	45	230	2/3	1/2		1
83.8			Granitic Gneiss	83.8			1	4	70	330	2/3	1/2		1
84.2			Granitic Gneiss	84.2			1	4	65	190	2/3	1/2		1
84.3			Granitic Gneiss	84.3			1	4	15	45	2/3	1/2		1
84.4			Granitic Gneiss	84.4			1	4	45	210	2/3	1/2		1
84.5			Granitic Gneiss	84.5			1	4	30	20	2/3	1/2		1
84.9			Granitic Gneiss	84.9			1	4	55	210	2/3	1/2		1
90	100	85.05m - 101.6	Foliated Gneiss	90			1	4			2/3	1/2		1
89			Foliated Gneiss	89			1	4	35	180	2/3	1/2		1
90			Foliated Gneiss	90			1	4	40	150	2/3	1/2		1
91.3			Foliated Gneiss	91.3			1	4	65	150	2/3	1/2		1
90.5			Foliated Gneiss	90.5			1	4	30	100	2/3	1/2		1
92.7			Foliated Gneiss	92.7			1	4	30	100	2/3	1/2		1
93			Foliated Gneiss	93			1	4	25	100	2/3	1/2		1
93.3			Foliated Gneiss	93.3			1	4	30	105	2/3	1/2		1
94.3			Foliated Gneiss	94.3			1	4	25	100	2/3	1/2		1
95.7			Foliated Gneiss	95.7			1	4	55	350	2/3	1/2		1
96.3			Foliated Gneiss	96.3			1	4	20	160	2/3	1/2		1
96.4			Foliated Gneiss	96.4			1	4	25	160	2/3	1/2		1
97.3			Foliated Gneiss	97.3			1	4	20	200	2/3	1/2		1
97.7			Foliated Gneiss	97.7			1	4	20	200	2/3	1/2		1
99			Foliated Gneiss	99			1	4		340	2/3	1/2		1

MATRIX TYPE
M1 Fault
M2 Shears
M3 Intense fracturing
M4 Intense mineralisation
M5 Deformable material

WEATHERING
1. Unweathered
2. Slightly
3. Moderately
4. Highly
5. Completely

JOINT SURFACE

MICRO ROUGHNESS
1. Polished
2. Smooth planar
3. Rough planar
4. Slickensided undulated
5. Smooth undulating
6. Rough undulating
7. Slickensided stepped
8. Smooth stepped
9. Rough stepped / irregular

MACRO ROUGHNESS
1. Planar
2. Undulating
3. Curved
4. Irregular
5. Multi irregular

INFILLING TYPE
1. Gauge thickness > Amplitude of irregularities
2. Gauge thickness < Amplitude of irregularities
3. Soft Sheared Material- Fine
4. Soft Sheared Material-Med
5. Soft Sheared Material- Crse
6. Non Softening Material-Fine
7. Non Softening Material-Med
8. Non Softening Material-Crse
9. Clean

JOINT WALL ALTERATION
1. Wall = Rock Hard
2. Wall > Rock Hard
3. Wall < Rock Hard

Appendix 1 K2GT02

GEOTECHNICAL BOREHOLE LOG

PROJECT: Lerala **BOREHOLE NO:** K2 GT02 **FINAL DEPTH:** 100.4m **DATE:** 21/11/2006

ZONE: K2 **INCLINATION:** 60 **LOGGED BY:** JPE Hamman

Interval	RQD	Geotech interval	Rock Type	Rock competence			Weath'ng	Hardness			Joint Surface Condition			
From	%			Solid m	Matrix m	Matrix type	1-5	1-5	Alpha Angle	Beta Angle	Micro 1-9	Macro 1-5	Infilling Type 1-7	Wall Alter 1-3
0		0m - 20.5m	Sapprolite Kimberlite				4	3						
20.5	10	20.5m - 23.0	Dolerite Dyke				3	4						
23	30	23m - 30.0m	Pink Granitic Gneiss				1	4						
30	5	30m - 32m	Dolerite Dyke				1	4						
32	95	32m - 43m	Pink Granitic Gneiss				1	4						
49.8	99	43.0m - 100.4m	Foliated Gneiss		49.8	f	1	4	70	260	2/3	1/2		1
50.3			Foliated Gneiss	50.3			1	4	20	330	2/3	1/2		1
52.6			Foliated Gneiss		52.6	f	1	4	60	280	2/3	1/2		1
52.7			Foliated Gneiss	52.7			1	4	45	170	2/3	1/2		1
52.9			Foliated Gneiss	52.9			1	4	50	150	2/3	1/2		1
54			Foliated Gneiss	54			1	4	35	10	2/3	1/2		1
55			Foliated Gneiss		55	f	1	4	55	270	2/3	1/2		1
55.1			Foliated Gneiss	55.1			1	4	10	350	2/3	1/2		1
60			Foliated Gneiss	60			1	4	50	90	2/3	1/2		1
61			Foliated Gneiss	61			1	4	50	340	2/3	1/2		1
61.3			Foliated Gneiss	61.3			1	4	20	340	2/3	1/2		1
62			Foliated Gneiss	62			1	4	35	70	2/3	1/2		1
62.4			Foliated Gneiss		62.4	f	1	4	70	200	2/3	1/2		1
65			Foliated Gneiss	65			1	4	20	300	2/3	1/2		1
72.8			Foliated Gneiss	72.8			1	4	20	10	2/3	1/2		1
73.4			Foliated Gneiss	73.4			1	4		50	2/3	1/2		1

MATRIX TYPE
M1 Fault
M2 Shears
M3 Intense fracturing
M4 Intense mineralisation
M5 Deformable material

WEATHERING
1. Unweathered
2. Slightly
3. Moderately
4. Highly
5. Completely

JOINT SURFACE

MICRO ROUGHNESS
1. Polished
2. Smooth planar
3. Rough planar
4. Slickensided undulated
5. Smooth undulating
6. Rough undulating
7. Slickensided stepped
8. Smooth stepped
9. Rough stepped / irregular

MACRO ROUGHNESS
1. Planar
2. Undulating
3. Curved
4. Irregular
5. Multi irregular

INFILLING TYPE
1. Gauge thickness > Amplitude of irregularities
2. Gauge thickness < Amplitude of irregularities
3. Soft Sheared Material- Fine
4. Soft Sheared Material-Med
5. Soft Sheared Material- Crse
6. Non Softening Material-Fine
7. Non Softening Material-Med
8. Non Softening Material-Crse
9. Clean

JOINT WALL ALTERATION
1. Wall = Rock Hard
2. Wall > Rock Hard
3. Wall < Rock Hard

Appendix 1 K2GT03

GEOTECHNICAL BOREHOLE LOG

PROJECT: Lerala | BOREHOLE NO: K2 GT03 | FINAL DEPTH: 91.0m | DATE: 12/01/2006

ZONE: K2 | INCLINATION: 60 | LOGGED BY: JPE Hamman

Interval	RQD	Geotech interval	Rock Type	Rock competence			Weath'ng	Hardness			Joint Surface Condition			
From	%			Solid m	Matrix m	Matrix type	1-5	1-5	Alpha Angle	Beta Angle	Micro 1-9	Macro 1-5	Infilling Type 1-7	Wall Alter 1-3
0		0m - 15m	Kimberlite				4	3						
15		15m - 22.4m	Pink Granite				1	4						
22.4		22.4m - 45.80m	Granitic Gneiss				1	4						
45.8		45.8m - 56.0m	Grey Granitic Gneiss				1	4						
54.6			Grey Granitic Gneiss		54.6	f	1	4	55	80	2/3	1/2		1
54.6			Grey Granitic Gneiss		54.6	f	1	4	55	81	2/3	1/2		1
54.6			Grey Granitic Gneiss		54.6	f	1	4	55	82	2/3	1/2		1
54.6			Grey Granitic Gneiss		54.6	f	1	4	55	83	2/3	1/2		1
54.6			Grey Granitic Gneiss		54.6	f	1	4	55	79	2/3	1/2		1
58.4		56m - 76.0m	Granitic Gneiss		58.4	f	1	4	35	110	2/3	1/2		1
58.7			Granitic Gneiss		58.7	f	1	4	35	120	2/3	1/2		1
58.7			Granitic Gneiss		58.7	f	1	4	35	121	2/3	1/2		1
58.7			Granitic Gneiss		58.7	f	1	4	35	122	2/3	1/2		1
58.7			Granitic Gneiss		58.7	f	1	4	35	123	2/3	1/2		1
58.7			Granitic Gneiss		58.7	f	1	4	35	124	2/3	1/2		1
60			Granitic Gneiss	60			1	4	45	0	2/3	1/2		1
60			Granitic Gneiss		60	f	1	4	40	160	2/3	1/2		1
60.5			Granitic Gneiss	60.5			1	4	35	140	2/3	1/2		1
66			Granitic Gneiss		66	f	1	4	30	30	2/3	1/2		1
66.3			Granitic Gneiss	66.3			1	4	30	320	2/3	1/2		1
70.5			Granitic Gneiss		70.5	f	1	4	60	160	2/3	1/2		1
75.5			Granitic Gneiss	75.5			1	4	20	300	2/3	1/2		1
76			Granitic Gneiss		76	d	1	4	35	240	2/3	1/2		1
77.5		76m - 77.03	Dolerite Dyke		77.5	d	1	4	25	340	2/3	1/2		1
82		77.03m - 91m	Pink Granitic Gneiss	82			1	4	60	300	2/3	1/2		1
83.7			Pink Granitic Gneiss	83.7			1	4	65	290	2/3	1/2		1
83.9			Pink Granitic Gneiss	83.9			1	4	65	300	2/3	1/2		1
84.2			Pink Granitic Gneiss	84.2			1	4	20	120	2/3	1/2		1
85.2			Pink Granitic Gneiss	85.2			1	4	60	240	2/3	1/2		1
85.5			Pink Granitic Gneiss	85.5			1	4	45	50	2/3	1/2		1
86			Pink Granitic Gneiss	86			1	4	20	80	2/3	1/2		1
87.2			Pink Granitic Gneiss	87.2			1	4	45	280	2/3	1/2		1
87.5			Pink Granitic Gneiss	87.5			1	4	40	350	2/3	1/2		1
88			Pink Granitic Gneiss	88			1	4	30	240	2/3	1/2		1
88.2			Pink Granitic Gneiss	88.2			1	4	55	120	2/3	1/2		1
88.3			Pink Granitic Gneiss	88.3			1	4	35	210	2/3	1/2		1
90.5			Pink Granitic Gneiss	90.5			1	4	55	200	2/3	1/2		1
90.6			Pink Granitic Gneiss	90.6			1	4	60	30	2/3	1/2		1

MATRIX TYPE
M1 Fault
M2 Shears
M3 Intense fracturing
M4 Intense mineralisation
M5 Deformable material

WEATHERING
1. Unweathered
2. Slightly
3. Moderately
4. Highly
5. Completely

JOINT SURFACE MICRO ROUGHNESS
1. Polished
2. Smooth planar
3. Rough planar
4. Slickensided undulated
5. Smooth undulating
6. Rough undulating
7. Slickensided stepped
8. Smooth stepped
9. Rough stepped / irregular

MACRO ROUGHNESS
1. Planar
2. Undulating
3. Curved
4. Irregular
5. Multi irregular

INFILLING TYPE
1. Gauge thickness > Amplitude of irregularities
2. Gauge thickness < Amplitude of irregularities
3. Soft Sheared Material- Fine
4. Soft Sheared Material-Med
5. Soft Sheared Material- Crse
6. Non Softening Material-Fine
7. Non Softening Material-Med
8. Non Softening Material-Crse
9. Clean

JOINT WALL ALTERATION
1. Wall = Rock Hard
2. Wall > Rock Hard
3. Wall < Rock Hard

Appendix 1 K2GT04

GEOTECHNICAL BOREHOLE LOG

PROJECT: Lerala | **BOREHOLE NO:** K 2GT04 | **FINAL DEPTH:** 101.5m | **DATE:** 12/09/2006

ZONE: K2 | **INCLINATION:** 50 | **LOGGED BY:** JPE Hamman

Interval	RQD	Geotech interval	Rock Type	Rock competence			Weath'ng	Hardness			Joint Surface Condition			
From	%			Solid m	Matrix m	Matrix type	1-5	1-5	Alpha Angle	Beta Angle	Micro 1-9	Macro 1-5	Infilling Type 1-7	Wall Alter 1-3
0		0m - 24m	Kimberlite				4	3						
24		24m - 38.5m	Kimberlite				4	3						
38.5	10	38.5m - 44m	Granitic Gneiss				1	4						
44.6		44.6m - 101.5	Granitic Gneiss		44.6	f	1	4	30	160	2/3	1/2		1
44.7			Granitic Gneiss		44.7	f	1	4	60	100	2/3	1/2		1
45.8			Granitic Gneiss	45.8			1	4	40	290	2/3	1/2		1
45.9			Granitic Gneiss	45.9			1	4	40	310	2/3	1/2		1
46.3			Granitic Gneiss	46.3			1	4	60	310	2/3	1/2		1
46.4			Granitic Gneiss	46.4			1	4	55	330	2/3	1/2		1
46.5			Granitic Gneiss	46.5			1	4	50	120	2/3	1/2		1
47			Granitic Gneiss		47	f	1	4	30	185	2/3	1/2		1
47.1			Granitic Gneiss	47.1			1	4	50	290	2/3	1/2		1
47.3			Granitic Gneiss	47.3			1	4	50	295	2/3	1/2		1
50			Granitic Gneiss		50	f	1	4	30	190	2/3	1/2		1
50.1			Granitic Gneiss	50.1			1	4	55	290	2/3	1/2		1
50.2			Granitic Gneiss	50.2			1	4	55	300	2/3	1/2		1
59			Granitic Gneiss		59	f	1	4	40	160	2/3	1/2		1
71.5			Granitic Gneiss	71.5			1	4	60	320	2/3	1/2		1
71.7			Granitic Gneiss	71.7			1	4	35	260	2/3	1/2		1
71.8			Granitic Gneiss	71.8			1	4	25	160	2/3	1/2		1
80.5			Granitic Gneiss	80.5			1	4	45	220	2/3	1/2		1
80.7			Granitic Gneiss	80.7			1	4	45	200	2/3	1/2		1

MATRIX TYPE
M1 Fault
M2 Shears
M3 Intense fracturing
M4 Intense mineralisation
M5 Deformable material

WEATHERING
1. Unweathered
2. Slightly
3. Moderately
4. Highly
5. Completely

JOINT SURFACE

MICRO ROUGHNESS
1. Polished
2. Smooth planar
3. Rough planar
4. Slickensided undulated
5. Smooth undulating
6. Rough undulating
7. Slickensided stepped
8. Smooth stepped
9. Rough stepped / irregular

MACRO ROUGHNESS
1. Planar
2. Undulating
3. Curved
4. Irregular
5. Multi irregular

INFILLING TYPE
1. Gauge thickness > Amplitude of irregularities
2. Gauge thickness < Amplitude of irregularities
3. Soft Sheared Material- Fine
4. Soft Sheared Material-Med
5. Soft Sheared Material- Crse
6. Non Softening Material-Fine
7. Non Softening Material-Med
8. Non Softening Material-Crse
9. Clean

JOINT WALL ALTERATION
1. Wall = Rock Hard
2. Wall > Rock Hard
3. Wall < Rock Hard

Appendix 1 K2GT04

GEOTECHNICAL BOREHOLE LOG

PROJECT: Lerala **BOREHOLE NO:** K 2GT04 **FINAL DEPTH:** 101.5m **DATE:** 12/09/2006

ZONE: K2 **INCLINATION:** 50 **LOGGED BY:** JPE Hamman

Interval	RQD	Geotech interval	Rock Type	Rock competence			Weath'ng	Hardness			Joint Surface Condition			
From	%			Solid m	Matrix m	Matrix type	1-5	1-5	Alpha Angle	Beta Angle	Micro 1-9	Macro 1-5	Infilling Type 1-7	Wall Alter 1-3
0		0m - 24m	Kimberlite				4	3						
24		24m - 38.5m	Kimberlite				4	3						
38.5	10	38.5m - 44m	Granitic Gneiss				1	4						
44.6		44.6m - 101.5	Granitic Gneiss		44.6	f	1	4	30	160	2/3	1/2		1
44.7			Granitic Gneiss		44.7	f	1	4	60	100	2/3	1/2		1
45.8			Granitic Gneiss	45.8			1	4	40	290	2/3	1/2		1
45.9			Granitic Gneiss	45.9			1	4	40	310	2/3	1/2		1
46.3			Granitic Gneiss	46.3			1	4	60	310	2/3	1/2		1
46.4			Granitic Gneiss	46.4			1	4	55	330	2/3	1/2		1
46.5			Granitic Gneiss	46.5			1	4	50	120	2/3	1/2		1
47			Granitic Gneiss		47	f	1	4	30	185	2/3	1/2		1
47.1			Granitic Gneiss	47.1			1	4	50	290	2/3	1/2		1
47.3			Granitic Gneiss	47.3			1	4	50	295	2/3	1/2		1
50			Granitic Gneiss		50	f	1	4	30	190	2/3	1/2		1
50.1			Granitic Gneiss	50.1			1	4	55	290	2/3	1/2		1
50.2			Granitic Gneiss	50.2			1	4	55	300	2/3	1/2		1
59			Granitic Gneiss		59	f	1	4	40	160	2/3	1/2		1
71.5			Granitic Gneiss	71.5			1	4	60	320	2/3	1/2		1
71.7			Granitic Gneiss	71.7			1	4	35	260	2/3	1/2		1
71.8			Granitic Gneiss	71.8			1	4	25	160	2/3	1/2		1
80.5			Granitic Gneiss	80.5			1	4	45	220	2/3	1/2		1
80.7			Granitic Gneiss	80.7			1	4	45	200	2/3	1/2		1

MATRIX TYPE
M1 Fault
M2 Shears
M3 Intense fracturing
M4 Intense mineralisation
M5 Deformable material

WEATHERING
1. Unweathered
2. Slightly
3. Moderately
4. Highly
5. Completely

JOINT SURFACE

MICRO ROUGHNESS
1. Polished
2. Smooth planar
3. Rough planar
4. Slickensided undulated
5. Smooth undulating
6. Rough undulating
7. Slickensided stepped
8. Smooth stepped
9. Rough stepped / irregular

MACRO ROUGHNESS
1. Planar
2. Undulating
3. Curved
4. Irregular
5. Multi irregular

INFILLING TYPE
1. Gauge thickness > Amplitude of irregularities
2. Gauge thickness < Amplitude of irregularities
3. Soft Sheared Material- Fine
4. Soft Sheared Material-Med
5. Soft Sheared Material- Crse
6. Non Softening Material-Fine
7. Non Softening Material-Med
8. Non Softening Material-Crse
9. Clean

JOINT WALL ALTERATION
1. Wall = Rock Hard
2. Wall > Rock Hard
3. Wall < Rock Hard

Appendix 1 K3GT01

GEOTECHNICAL BOREHOLE LOG

PROJECT: Lerala **BOREHOLE NO:** GT01 **FINAL DEPTH:** 91.0m **DATE:** 16/10/2006

ZONE: K3 **INCLINATION:** 50 **LOGGED BY:** JPE Hamman

Interval	RQD	Geotech interval	Rock Type	Rock competence			Weath'ng	Hardness			Joint Surface Condition			
From	%			Solid m	Matrix m	Matrix type	1-5	1-5	Alpha Angle	Beta Angle	Micro 1-9	Macro 1-5	Infilling Type 1-7	Wall Alter 1-3
0		0m - 5.8m	Tricone				4	3						
5.8		5.8m - 24.4m	Kimberlite Breccia				1	3						
24.4		24.4m - 39.2	Kimberlite Breccia				1	3						
39.2		39.2m - 48.12	Kimberlite Breccia				1	3						
48.12		48.12m - 49.62	Granite Inclusion				1	4						
49.62		49.62m - 56.9	Kimberlite Breccia				1	3						
53.7			Kimberlite Breccia		53.7	M4	1	3	20	20	2/3	1/2		1
57		56.9m - 57.53m	Granite Inclusion	57			1	4	60	180	2/3	1/2		1
57.9		57.53m - 105.04m	Kimberlite Breccia		57.9	M4	1	3	45	30	2/3	1/2		1
61.2			Kimberlite Breccia		61.2	M4	1	3	25	45	2/3	1/2		1
64			Kimberlite Breccia	64			1	3	35	45	2/3	1/2		1
64.5			Kimberlite Breccia		64.5	M4	1	3	20	70	2/3	1/2		1
67.1			Kimberlite Breccia	67.1			1	3	70	160	2/3	1/2		1
71.4			Kimberlite Breccia	71.4			1	3	40	240	2/3	1/2		1
75			Kimberlite Breccia		75	M4	1	3	30	80	2/3	1/2		1
76.4			Kimberlite Breccia		76.4	M4	1	3	25	40	2/3	1/2		1
78.7			Kimberlite Breccia	78.7			1	3	30	290	2/3	1/2		1
80.2			Kimberlite Breccia	80.2			1	3	20	160	2/3	1/2		1
82.6			Kimberlite Breccia	82.6			1	3	25	90	2/3	1/2		1
83.6			Kimberlite Breccia	83.6			1	3	40	30	2/3	1/2		1
88.2			Kimberlite Breccia	88.2			1	3	60	210	2/3	1/2		1
88.6			Kimberlite Breccia	88.6			1	3	50	10	2/3	1/2		1
109.9		105.04m - 110.80m	Granite	109.9			1	4	45	130	2/3	1/2		1
110		110.8m - 116.40	Kimberlite Breccia	110			1	3	45	130	2/3	1/2		1
113.8			Kimberlite Breccia	113.8			1	3	55	90	2/3	1/2		1
114.5			Kimberlite Breccia	114.5			1	3	35	350	2/3	1/2		1
114.6			Kimberlite Breccia	114.6			1	3	60	170	2/3	1/2		1
114.9			Kimberlite Breccia	114.9			1	3	60	125	2/3	1/2		1

MATRIX TYPE
M1 Fault
M2 Shears
M3 Intense fracturing
M4 Intense mineralisation
M5 Deformable material

WEATHERING
1. Unweathered
2. Slightly
3. Moderately
4. Highly
5. Completely

JOINT SURFACE

MICRO ROUGHNESS
1. Polished
2. Smooth planar
3. Rough planar
4. Slickensided undulated
5. Smooth undulating
6. Rough undulating
7. Slickensided stepped
8. Smooth stepped
9. Rough stepped / irregular

MACRO ROUGHNESS
1. Planar
2. Undulating
3. Curved
4. Irregular
5. Multi irregular

INFILLING TYPE
1. Gauge thickness > Amplitude of irregularities
2. Gauge thickness < Amplitude of irregularities
3. Soft Sheared Material- Fine
4. Soft Sheared Material-Med
5. Soft Sheared Material- Crse
6. Non Softening Material-Fine
7. Non Softening Material-Med
8. Non Softening Material-Crse
9. Clean

JOINT WALL ALTERATION
1. Wall = Rock Hard
2. Wall > Rock Hard
3. Wall < Rock Hard

Appendix 1 K3GT02

GEOTECHNICAL BOREHOLE LOG

PROJECT: Lerala **BOREHOLE NO:** GT02 **FINAL DEPTH:** 102 **DATE:** 20/10/2006

ZONE: K3 **INCLINATION:** 50 **LOGGED BY:** JPE Hamman

Interval	RQD	Geotech interval	Rock Type	Rock competence			Weath'ng	Hardness			Joint Surface Condition			
From	%			Solid m	Matrix m	Matrix type	1-5	1-5	Alpha Angle	Beta Angle	Micro 1-9	Macro 1-5	Infilling Type 1-7	Wall Alter 1-3
0		0m - 3.2m	Tricone				4	3						
3.2		3.2m - 19m	Weathered Kimberlite Breccia				4	3			2/3	1/2		
19		19m - 23.7	Dolerite				1	3			2/3	1/2		
23.7		23.7m - 30m	Weathered Kimberlite Breccia				4	3			2/3	1/2		
37.3		30m - 40.3	Breccia	37.3			1	4	85	30	2/3	1/2		1
37.8				37.8			1	4	85	260	2/3	1/2		1
38.1				38.1			1	4	80	270	2/3	1/2		1
39.4				39.4			1	4	45	60	2/3	1/2		1
41		40.3m - 101.7m	Granitic Gneiss	41			1	4	65	330	2/3	1/2		1
41.2			Granitic Gneiss	41.2			1	4	50	200	2/3	1/2		1
42.2			Granitic Gneiss		42.2	f	1	4	80	230	2/3	1/2		1
43			Granitic Gneiss		43	f	1	4	70	10	2/3	1/2		1
51.1			Granitic Gneiss	51.1			1	4	50	210	2/3	1/2		1
51.3			Granitic Gneiss		51.3	F	1	4	60	80	2/3	1/2		1
51.6			Granitic Gneiss	51.6			1	4	40	205	2/3	1/2		1
52.3			Granitic Gneiss		52.3	F	1	4	65	160	2/3	1/2		1
52.5			Granitic Gneiss	52.5			1	4	35	190	2/3	1/2		1
52.8			Granitic Gneiss	52.8			1	4	40	190	2/3	1/2		1
52.9			Granitic Gneiss		52.9	F	1	4	65	60	2/3	1/2		1
53.1			Granitic Gneiss	53.1			1	4	50	180	2/3	1/2		1
53.6			Granitic Gneiss	53.6			1	4	25	185	2/3	1/2		1
53.9			Granitic Gneiss		53.9	F	1	4	30	180	2/3	1/2		1
54.4			Granitic Gneiss	54.4			1	4	60	270	2/3	1/2		1
54.8			Granitic Gneiss	54.8			1	4	25	340	2/3	1/2		1
55.5			Granitic Gneiss		55.5	F	1	4	60	160	2/3	1/2		1
56.7			Granitic Gneiss		56.7	F	1	4	60	160	2/3	1/2		1
56.8			Granitic Gneiss		56.8	F	1	4	60	160	2/3	1/2		1
57.3			Granitic Gneiss	57.3			1	4	50	340	2/3	1/2		1
57.4			Granitic Gneiss		57.4	F	1	4	75	155	2/3	1/2		1
58.4			Granitic Gneiss	58.4			1	4	45	345	2/3	1/2		1
58.7			Granitic Gneiss	58.7			1	4	35	180	2/3	1/2		1
60.4			Granitic Gneiss	60.4			1	4	45	200	2/3	1/2		1
60.6			Granitic Gneiss	60.6			1	4	45	200	2/3	1/2		1
61.3			Granitic Gneiss		61.3	F	1	4	55	180	2/3	1/2		1
63			Granitic Gneiss		63	F	1	4	75	170	2/3	1/2		1
63.8			Granitic Gneiss		63.8	F	1	4	55	175	2/3	1/2		1
64.3			Granitic Gneiss		64.3	F	1	4	60	150	2/3	1/2		1
67.2			Granitic Gneiss	67.2			1	4	15	240	2/3	1/2		1
70			Granitic Gneiss	70			1	4	30	320	2/3	1/2		1
77.4			Granitic Gneiss	77.4			1	4	50	220	2/3	1/2		1
78.9			Granitic Gneiss		78.9	F	1	4	45	200	2/3	1/2		1
83			Granitic Gneiss	83			1	4	55	60	2/3	1/2		1
83.3			Granitic Gneiss		83.3	F	1	4	40	180	2/3	1/2		1
84			Granitic Gneiss		84	F	1	4	45	170	2/3	1/2		1
84.2			Granitic Gneiss		84.2	F	1	4	60	175	2/3	1/2		1
85.5			Granitic Gneiss	85.5			1	4	50	320	2/3	1/2		1
85.8			Granitic Gneiss		85.8	F			45	200	2/3	1/2		1
86.5			Granitic Gneiss		86.5	F			70	190	2/3	1/2		1
91			Granitic Gneiss	91					65	300	2/3	1/2		1
91.5			Granitic Gneiss	91.5					60	290	2/3	1/2		1
92.4			Granitic Gneiss		92.4	F			70	160	2/3	1/2		1
93.5			Granitic Gneiss	93.5					20	160	2/3	1/2		1
95			Granitic Gneiss	95					25	325	2/3	1/2		1
95.5			Granitic Gneiss		95.5	F			30	170	2/3	1/2		1
95.7			Granitic Gneiss	95.7					60	350	2/3	1/2		1

MATRIX TYPE
M1 Fault
M2 Shears
M3 Intense fracturing
M4 Intense mineralisation
M5 Deformable material

WEATHERING
1. Unweathered
2. Slightly
3. Moderately
4. Highly
5. Completely

JOINT SURFACE

MICRO ROUGHNESS
1. Polished
2. Smooth planar
3. Rough planar
4. Slickensided undulated
5. Smooth undulating
6. Rough undulating
7. Slickensided stepped
8. Smooth stepped
9. Rough stepped / irregular

MACRO ROUGHNESS
1. Planar
2. Undulating
3. Curved
4. Irregular
5. Multi irregular

INFILLING TYPE
1. Gauge thickness > Amplitude of irregularities
2. Gauge thickness < Amplitude of irregularities
3. Soft Sheared Material- Fine
4. Soft Sheared Material-Med
5. Soft Sheared Material- Crse
6. Non Softening Material-Fine
7. Non Softening Material-Med
8. Non Softening Material-Crse
9. Clean

JOINT WALL ALTERATION
1. Wall = Rock Hard
2. Wall > Rock Hard
3. Wall < Rock Hard

Appendix 1 K3GT03

GEOTECHNICAL BOREHOLE LOG

PROJECT: Lerala **BOREHOLE NO:** GT03 **FINAL DEPTH:** 102 **DATE:** 23/10/2006

ZONE: K3 **INCLINATION:** 50 **LOGGED BY:** JPE Hamman

Interval	RQD	Geotech interval	Rock Type	Rock competence			Weath'ng	Hardness			Joint Surface Condition			
From	%			Solid m	Matrix m	Matrix type	1-5	1-5	Alpha Angle	Beta Angle	Micro 1-9	Macr o 1-5	Infilling Type 1-7	Wall Alter 1-3
0		0m - 3.2m	Tricone				4	3						
3.2		3.2m - 32.70m	Kimberlite Breccia				1	4			2/3	1/2		1
32.7		32.7m - 34.78	Dolerite Dyke				1	4			2/3	1/2		1
34.78		34.78m - 48m	Granite											
40.2			Granite		40.2	B	1	4	70	150	2/3	1/2		1
41.5			Granite		41.5	B	1	4	40	115	2/3	1/2		1
42.6			Granite	42.6			1	4	65	40	2/3	1/2		1
43			Granite	43			1	4	55	60	2/3	1/2		1
44.2			Granite		44.2	B	1	4	50	40	2/3	1/2		1
44.3			Granite	44.3			1	4	35	135	2/3	1/2		1
44.5			Granite		44.5	B	1	4	50	30	2/3	1/2		1
45.6			Granite	45.6			1	4	65	145	2/3	1/2		1
46.5			Granite	46.5			1	4	45	145	2/3	1/2		1
46.6			Granite		46.6	M4	1	4	45	145	2/3	1/2		1
48			Dolerite Dyke	48			1	4	60	210	2/3	1/2		1
48.4			Dolerite Dyke	48.4			1	4	35	165	2/3	1/2		1
48.6			Dolerite Dyke	48.6			1	4	55	200	2/3	1/2		1
51			Dolerite Dyke	51			1	4	45	160	2/3	1/2		1
51.1			Dolerite Dyke		51.1	B	1	4	35	290	2/3	1/2		1
51.3			Dolerite Dyke		51.3	B	1	4	55	70	2/3	1/2		1
57.6		51.8m - 55.72	Granite Breccia	57.6			1	4	45	180	2/3	1/2		1
54.6			Granite Breccia		54.6	F	1	4	55	300	2/3	1/2		1
56		55.72m - 101.7	Granitic Gneiss		56	F	1	4	65	160	2/3	1/2		1
56.2			Granitic Gneiss	56.2			1	4	30	335	2/3	1/2	4	1
57.6			Granitic Gneiss	57.6			1	4	30	0	2/3	1/2		1
57.8			Granitic Gneiss	57.8			1	4	70	190	2/3	1/2		1
58.5			Granitic Gneiss		58.5	F	1	4	45	210	2/3	1/2		1
58.9			Granitic Gneiss		58.9	F	1	4	40	170	2/3	1/2		1
59			Granitic Gneiss	59			1	4	30	59	2/3	1/2		1
59.2			Granitic Gneiss	59.2			1	4	25	10	2/3	1/2		1
62.3			Granitic Gneiss	62.3			1	4	50	210	2/3	1/2		1
62.6			Granitic Gneiss	62.6			1	4	35	350	2/3	1/2		1
62.7			Granitic Gneiss	62.7			1	4	35	330	2/3	1/2		1
65			Granitic Gneiss		65	F	1	4	45	200	2/3	1/2		1
65.3			Granitic Gneiss	65.3			1	4	45	10	2/3	1/2		1
66.2			Granitic Gneiss	66.2			1	4	45	20	2/3	1/2		1
66.3			Granitic Gneiss	66.3			1	4	60	305	2/3	1/2		1
66.8			Granitic Gneiss		66.8	F	1	4	35	210	2/3	1/2		1
67			Granitic Gneiss	67			1	4	25	90	2/3	1/2		1
67.7			Granitic Gneiss		67.7	F	1	4	40	210	2/3	1/2		1
67.9			Granitic Gneiss		67.9	F	1	4	35	205	2/3	1/2		1
68.2			Granitic Gneiss	68.2			1	4	35	20	2/3	1/2		1
69.5			Granitic Gneiss		69.5	F	1	4	40	205	2/3	1/2		1
70.5			Granitic Gneiss		70.5	F	1	4	35	200	2/3	1/2		1
72.4			Granitic Gneiss	72.4			1	4	55	260	2/3	1/2		1
72.6			Granitic Gneiss	72.6			1	4	15	240	2/3	1/2		1
72.9			Granitic Gneiss	72.9			1	4	15	235	2/3	1/2		1
74.7			Granitic Gneiss	74.7					40	350	2/3	1/2		1
74.8			Granitic Gneiss		74.8	F			40	200	2/3	1/2		1
75.4			Granitic Gneiss	75.4					50	210	2/3	1/2		1
77.1			Granitic Gneiss		77.1	F			25	190	2/3	1/2		1
77.4			Granitic Gneiss	77.4					20	15	2/3	1/2		1
75.6			Granitic Gneiss	75.6					55	210	2/3	1/2		1
76.2			Granitic Gneiss	76.2					75	270	2/3	1/2		1
76.5			Granitic Gneiss	76.5					55	30	2/3	1/2		1
80.8			Granitic Gneiss	80.8					20	345	2/3	1/2		1
81			Granitic Gneiss	81					25	250	2/3	1/2		1
81.2			Granitic Gneiss	81.2					25	20	2/3	1/2		1
81.4			Granitic Gneiss	81.4					15	250	2/3	1/2		1
86			Granitic Gneiss	86					30	15	2/3	1/2		1
84			Granitic Gneiss	84					30	90	2/3	1/2		1
84.2			Granitic Gneiss	84.2					15	100	2/3	1/2		1
88			Granitic Gneiss	88					15	90	2/3	1/2		1
88.2			Granitic Gneiss		88.2	F			45	240	2/3	1/2		1
90			Granitic Gneiss	90					45	90	2/3	1/2		1
92.5			Granitic Gneiss	92.5					20	330	2/3	1/2		1
92.9			Granitic Gneiss	92.9					35	80	2/3	1/2		1
93.7			Granitic Gneiss	93.7					40	20	2/3	1/2		1
94.6			Granitic Gneiss	94.6					30	270	2/3	1/2		1
94.8			Granitic Gneiss	94.8					30	60	2/3	1/2		1
95.6			Granitic Gneiss	95.6					35	250	2/3	1/2		1
95.8			Granitic Gneiss	95.8					25	260	2/3	1/2		1
95.9			Granitic Gneiss	95.9					40	10	2/3	1/2		1
96.2			Granitic Gneiss	96.2					40	20	2/3	1/2		1
96.4			Granitic Gneiss	96.4					40	20	2/3	1/2		1

MATRIX TYPE
M1 Fault
M2 Shears
M3 Intense fracturing
M4 Intense mineralisation
M5 Deformable material

WEATHERING
1. Unweathered
2. Slightly
3. Moderately
4. Highly
5. Completely

JOINT SURFACE

MICRO ROUGHNESS
1. Polished
2. Smooth planar
3. Rough planar
4. Slickensided undulated
5. Smooth undulating
6. Rough undulating
7. Slickensided stepped
8. Smooth stepped
9. Rough stepped / irregular

MACRO ROUGHNESS
1. Planar
2. Undulating
3. Curved
4. Irregular
5. Multi irregular

INFILLING TYPE
1. Gauge thickness > Amplitude of irregularities
2. Gauge thickness < Amplitude of irregularities
3. Soft Sheared Material- Fine
4. Soft Sheared Material-Med
5. Soft Sheared Material- Crse
6. Non Softening Material-Fine
7. Non Softening Material-Med
8. Non Softening Material-Crse
9. Clean

JOINT WALL ALTERATION
1. Wall = Rock Hard
2. Wall > Rock Hard
3. Wall < Rock Hard

Appendix 1 K3GT04

GEOTECHNICAL BOREHOLE LOG

PROJECT: Lerala **BOREHOLE NO:** GT01 **FINAL DEPTH:** 91.0m **DATE:** 18/10/2006

ZONE: K3 **INCLINATION:** 50 **LOGGED BY:** JPE Hamman

Interval	RQD	Geotech interval	Rock Type	Rock competence			Weath'ng	Hardness			Joint Surface Condition			
From	%			Solid m	Matrix m	Matrix type	1-5	1-5	Alpha Angle	Beta Angle	Micro 1-9	Macro 1-5	Infilling Type 1-7	Wall Alter 1-3
0		0 - 15m	Tricone				4	3						
15	47	15m - 22.5m	Granitic Gneiss				1	4						
22.5	90	22.5m - 32.7	Kimberlite Breccia				1	4						
32.7	88	32.7m - 44.7m	Kimberlit Breccia/Granitic Gneiss				1	4						
40.8				40.8			1	4			2/3	1/2		1
41.4				41.4			1	4			2/3	1/2		1
42.1				42.1			1	4			2/3	1/2		1
42.3				42.3			1	4			2/3	1/2		1
42.4				42.4			1	4			2/3	1/2		1
42.7				42.7			1	4			2/3	1/2		1
43				43			1	4			2/3	1/2		1
43.6				43.6			1	4			2/3	1/2		1
44				44			1	4			2/3	1/2		1
44.4				44.4			1	4			2/3	1/2		1
53.5	90		Kimberlite Breccia	53.5			1	4			2/3	1/2		1
53.8			Kimberlite Breccia	53.8			1	4			2/3	1/2		1
54.8			Kimberlite Breccia	54.8			1	4			2/3	1/2		1
55			Kimberlite Breccia	55			1	4			2/3	1/2		1
55.7			Kimberlite Breccia	55.7			1	4			2/3	1/2		1
56			Kimberlite Breccia	56			1	4			2/3	1/2		1
56.6			Kimberlite Breccia	56.6			1	4			2/3	1/2		1
56.9			Kimberlite Breccia	56.9			1	4			2/3	1/2		1
57			Kimberlite Breccia	57			1	4			2/3	1/2	4	1
64.3	92	60.0m - 71.6m	Kimberlite Breccia	64.3			1	4			2/3	1/2		1
64.6			Kimberlite Breccia		64.6	M4	1	4			2/3	1/2		1
67.9			Kimberlite Breccia	67.9			1	4			2/3	1/2		1
69			Kimberlite Breccia	69			1	4			2/3	1/2		1
69.1			Kimberlite Breccia	69.1			1	4			2/3	1/2		1
69.2			Kimberlite Breccia	69.2			1	4			2/3	1/2		1
69.4			Kimberlite Breccia	69.4			1	4			2/3	1/2		1
69.6			Kimberlite Breccia	69.6			1	4			2/3	1/2		1
70.6			Kimberlite Breccia	70.6			1	4			2/3	1/2		1
70.9			Kimberlite Breccia	70.9			1	4			2/3	1/2		1
71			Kimberlite Breccia	71			1	4			2/3	1/2		1
71.2			Kimberlite Breccia	71.2			1	4			2/3	1/2		1
71.5			Kimberlite Breccia	71.5			1	4			2/3	1/2		1
71.6			Kimberlite Breccia	71.6			1	4			2/3	1/2		1
72.1	94	71.6m - 81.0m	Granitic Gneiss	72.1			1	4			2/3	1/2		1
73.2			Granitic Gneiss	73.2			1	4			2/3	1/2		1
72.5			Granitic Gneiss	72.5			1	4			2/3	1/2		1
72.6			Granitic Gneiss	72.6			1	4			2/3	1/2		1
73			Granitic Gneiss	73			1	4			2/3	1/2		1
73.1			Granitic Gneiss	73.1			1	4			2/3	1/2		1
73.2			Granitic Gneiss	73.2			1	4			2/3	1/2		1
73.4			Granitic Gneiss	73.4			1	4			2/3	1/2		1
73.9			Granitic Gneiss	73.9			1	4			2/3	1/2		1
74			Granitic Gneiss	74			1	4			2/3	1/2		1
74.8			Granitic Gneiss	74.8			1	4			2/3	1/2		1
75.6			Granitic Gneiss	75.6			1	4			2/3	1/2		1
75.7			Granitic Gneiss	75.7			1	4			2/3	1/2		1
75.9			Granitic Gneiss	75.9			1	4			2/3	1/2		1
76.3			Granitic Gneiss	76.3			1	4			2/3	1/2		1
77			Granitic Gneiss	77			1	4			2/3	1/2		1
77.2			Granitic Gneiss	77.2			1	4			2/3	1/2		1
77.9			Granitic Gneiss	77.9			1	4			2/3	1/2		1
78.9			Granitic Gneiss	78.9			1	4			2/3	1/2		1
79.1			Granitic Gneiss	79.1			1	4			2/3	1/2		1
81.2	94	81.0m - 92.70	Hyper Basal Kimberlite	81.2			1	4			2/3	1/2		1
81.4			Hyper Basal Kimberlite	81.4			1	4			2/3	1/2		1
81.6			Hyper Basal Kimberlite	81.6			1	4			2/3	1/2		1
86.8			Hyper Basal Kimberlite	86.8			1	4			2/3	1/2		1
87.2			Hyper Basal Kimberlite	87.2			1	4			2/3	1/2		1
87.3			Hyper Basal Kimberlite	87.3			1	4			2/3	1/2		1
87.4			Hyper Basal Kimberlite	87.4			1	4			2/3	1/2		1
87.6			Hyper Basal Kimberlite	87.6			1	4			2/3	1/2		1
87.8			Hyper Basal Kimberlite	87.8			1	4			2/3	1/2		1
87.9			Hyper Basal Kimberlite	87.9			1	4			2/3	1/2		1
88.1			Hyper Basal Kimberlite	88.1			1	4			2/3	1/2		1
88.6			Hyper Basal Kimberlite	88.6			1	4			2/3	1/2		1
88.7			Hyper Basal Kimberlite	88.7			1	4			2/3	1/2		1
88.65			Hyper Basal Kimberlite	88.65			1	4			2/3	1/2		1
88.75			Hyper Basal Kimberlite	88.75			1	4			2/3	1/2		1
88.8			Hyper Basal Kimberlite	88.8			1	4			2/3	1/2		1
89.1			Hyper Basal Kimberlite	89.1			1	4			2/3	1/2		1
89.5			Hyper Basal Kimberlite	89.5			1	4			2/3	1/2		1
89.7			Hyper Basal Kimberlite	89.7			1	4			2/3	1/2		1

MATRIX TYPE
M1 Fault
M2 Shears
M3 Intense fracturing
M4 Intense mineralisation
M5 Deformable material

WEATHERING
1. Unweathered
2. Slightly
3. Moderately
4. Highly
5. Completely

JOINT SURFACE
MICRO ROUGHNESS
1. Polished
2. Smooth planar
3. Rough planar
4. Slickensided undulated
5. Smooth undulating
6. Rough undulating
7. Slickensided stepped
8. Smooth stepped
9. Rough stepped / irregular

MACRO ROUGHNESS
1. Planar
2. Undulating
3. Curved
4. Irregular
5. Multi irregular

INFILLING TYPE
1. Gauge thickness > Amplitude of irregularities
2. Gauge thickness < Amplitude of irregularities
3. Soft Sheared Material- Fine
4. Soft Sheared Material-Med
5. Soft Sheared Material- Crse
6. Non Softening Material-Fine
7. Non Softening Material-Med
8. Non Softening Material-Crse
9. Clean

JOINT WALL ALTERATION
1. Wall = Rock Hard
2. Wall > Rock Hard
3. Wall < Rock Hard

Appendix 1 K3GT04

GEOTECHNICAL BOREHOLE LOG

PROJECT: Lerala **BOREHOLE NO:** GT01 **FINAL DEPTH:** 91.0m **DATE:** 18/10/2006

ZONE: K3 **INCLINATION:** 50 **LOGGED BY:** JPE Hamman

Interval	RQD	Geotech interval	Rock Type	Rock competence			Weath'ng	Hardness			Joint Surface Condition			
From	%			Solid m	Matrix m	Matrix type	1-5	1-5	Alpha Angle	Beta Angle	Micro 1-9	Macro 1-5	Infilling Type 1-7	Wall Alter 1-3
0		0 - 15m	Tricone				4	3						
15	47	15m - 22.5m	Granitic Gneiss				1	4						
22.5	90	22.5m - 32.7	Kimberlite Breccia				1	4						
32.7	88	32.7m - 44.7m	Kimberlit Breccia/Granitic Gneiss				1	4						
40.8				40.8			1	4			2/3	1/2		1
41.4				41.4			1	4			2/3	1/2		1
42.1				42.1			1	4			2/3	1/2		1
42.3				42.3			1	4			2/3	1/2		1
42.4				42.4			1	4			2/3	1/2		1
42.7				42.7			1	4			2/3	1/2		1
43				43			1	4			2/3	1/2		1
43.6				43.6			1	4			2/3	1/2		1
44				44			1	4			2/3	1/2		1
44.4				44.4			1	4			2/3	1/2		1
53.5	90		Kimberlite Breccia	53.5			1	4			2/3	1/2		1
53.8			Kimberlite Breccia	53.8			1	4			2/3	1/2		1
54.8			Kimberlite Breccia	54.8			1	4			2/3	1/2		1
55			Kimberlite Breccia	55			1	4			2/3	1/2		1
55.7			Kimberlite Breccia	55.7			1	4			2/3	1/2		1
56			Kimberlite Breccia	56			1	4			2/3	1/2		1
56.6			Kimberlite Breccia	56.6			1	4			2/3	1/2		1
56.9			Kimberlite Breccia	56.9			1	4			2/3	1/2		1
57			Kimberlite Breccia	57			1	4			2/3	1/2	4	1
64.3	92	60.0m - 71.6m	Kimberlite Breccia	64.3			1	4			2/3	1/2		1
64.6			Kimberlite Breccia		64.6	M4	1	4			2/3	1/2		1
67.9			Kimberlite Breccia	67.9			1	4			2/3	1/2		1
69			Kimberlite Breccia	69			1	4			2/3	1/2		1
69.1			Kimberlite Breccia	69.1			1	4			2/3	1/2		1
69.2			Kimberlite Breccia	69.2			1	4			2/3	1/2		1
69.4			Kimberlite Breccia	69.4			1	4			2/3	1/2		1
69.6			Kimberlite Breccia	69.6			1	4			2/3	1/2		1
70.6			Kimberlite Breccia	70.6			1	4			2/3	1/2		1
70.9			Kimberlite Breccia	70.9			1	4			2/3	1/2		1
71			Kimberlite Breccia	71			1	4			2/3	1/2		1
71.2			Kimberlite Breccia	71.2			1	4			2/3	1/2		1
71.5			Kimberlite Breccia	71.5			1	4			2/3	1/2		1
71.6			Kimberlite Breccia	71.6			1	4			2/3	1/2		1
72.1	94	71.6m - 81.0m	Granitic Gneiss	72.1			1	4			2/3	1/2		1
73.2			Granitic Gneiss	73.2			1	4			2/3	1/2		1
72.5			Granitic Gneiss	72.5			1	4			2/3	1/2		1
72.6			Granitic Gneiss	72.6			1	4			2/3	1/2		1
73			Granitic Gneiss	73			1	4			2/3	1/2		1
73.1			Granitic Gneiss	73.1			1	4			2/3	1/2		1
73.2			Granitic Gneiss	73.2			1	4			2/3	1/2		1
73.4			Granitic Gneiss	73.4			1	4			2/3	1/2		1
73.9			Granitic Gneiss	73.9			1	4			2/3	1/2		1
74			Granitic Gneiss	74			1	4			2/3	1/2		1
74.8			Granitic Gneiss	74.8			1	4			2/3	1/2		1
75.6			Granitic Gneiss	75.6			1	4			2/3	1/2		1
75.7			Granitic Gneiss	75.7			1	4			2/3	1/2		1
75.9			Granitic Gneiss	75.9			1	4			2/3	1/2		1
76.3			Granitic Gneiss	76.3			1	4			2/3	1/2		1
77			Granitic Gneiss	77			1	4			2/3	1/2		1
77.2			Granitic Gneiss	77.2			1	4			2/3	1/2		1
77.9			Granitic Gneiss	77.9			1	4			2/3	1/2		1
78.9			Granitic Gneiss	78.9			1	4			2/3	1/2		1
79.1			Granitic Gneiss	79.1			1	4			2/3	1/2		1
81.2	94	81.0m - 92.70	Hyper Basal Kimberlite	81.2			1	4			2/3	1/2		1
81.4			Hyper Basal Kimberlite	81.4			1	4			2/3	1/2		1
81.6			Hyper Basal Kimberlite	81.6			1	4			2/3	1/2		1
86.8			Hyper Basal Kimberlite	86.8			1	4			2/3	1/2		1
87.2			Hyper Basal Kimberlite	87.2			1	4			2/3	1/2		1
87.3			Hyper Basal Kimberlite	87.3			1	4			2/3	1/2		1
87.4			Hyper Basal Kimberlite	87.4			1	4			2/3	1/2		1
87.6			Hyper Basal Kimberlite	87.6			1	4			2/3	1/2		1
87.8			Hyper Basal Kimberlite	87.8			1	4			2/3	1/2		1
87.9			Hyper Basal Kimberlite	87.9			1	4			2/3	1/2		1
88.1			Hyper Basal Kimberlite	88.1			1	4			2/3	1/2		1
88.6			Hyper Basal Kimberlite	88.6			1	4			2/3	1/2		1
88.7			Hyper Basal Kimberlite	88.7			1	4			2/3	1/2		1
88.65			Hyper Basal Kimberlite	88.65			1	4			2/3	1/2		1
88.75			Hyper Basal Kimberlite	88.75			1	4			2/3	1/2		1
88.8			Hyper Basal Kimberlite	88.8			1	4			2/3	1/2		1
89.1			Hyper Basal Kimberlite	89.1			1	4			2/3	1/2		1
89.5			Hyper Basal Kimberlite	89.5			1	4			2/3	1/2		1
89.7			Hyper Basal Kimberlite	89.7			1	4			2/3	1/2		1

MATRIX TYPE
M1 Fault
M2 Shears
M3 Intense fracturing
M4 Intense mineralisation
M5 Deformable material

WEATHERING
1. Unweathered
2. Slightly
3. Moderately
4. Highly
5. Completely

JOINT SURFACE
MICRO ROUGHNESS
1. Polished
2. Smooth planar
3. Rough planar
4. Slickensided undulated
5. Smooth undulating
6. Rough undulating
7. Slickensided stepped
8. Smooth stepped
9. Rough stepped / irregular

MACRO ROUGHNESS
1. Planar
2. Undulating
3. Curved
4. Irregular
5. Multi irregular

INFILLING TYPE
1. Gauge thickness > Amplitude of irregularities
2. Gauge thickness < Amplitude of irregularities
3. Soft Sheared Material- Fine
4. Soft Sheared Material-Med
5. Soft Sheared Material- Crse
6. Non Softening Material-Fine
7. Non Softening Material-Med
8. Non Softening Material-Crse
9. Clean

JOINT WALL ALTERATION
1. Wall = Rock Hard
2. Wall > Rock Hard
3. Wall < Rock Hard

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Appendix 1 K4GT01

GEOTECHNICAL BOREHOLE LOG

PROJECT: Lerala **BOREHOLE NO:** GT01 **FINAL DEPTH:** 91.7m **DATE:** 25/10/2006

ZONE: K4 **INCLINATION:** 50 **LOGGED BY:** JPE Hamman

Interval From	RQD %	Geotech interval	Rock Type	Rock competence: Solid m	Rock competence: Matrix m	Rock competence: Matrix type	Weath'ng 1-5	Hardness 1-5	Alpha Angle	Beta Angle	Joint Surface Condition: Micro 1-9	Joint Surface Condition: Macro 1-5	Joint Surface Condition: Infilling Type 1-7	Joint Surface Condition: Wall Alter 1-3
0		0m - 3.2m	Tricone				4	3						
3.2	63	3.2m - 8.7m	Kimberlite				2	3						
8.7	58	8.7m - 20.8m	Intense altered rock				2	4						
20.8	74	20.8m - 28.2m	Granitic Gneiss				1	4						
28.2	89	28.2m - 91.70	Granitic Gneiss				1	4						
33.8			Granitic Gneiss	33.8			1	4	60	160	2/3	1/2		1
34			Granitic Gneiss	34			1	4	45	130	2/3	1/2		1
34.3			Granitic Gneiss	34.3			1	4	60	270	2/3	1/2		1
35.3			Granitic Gneiss	35.3			1	4	50	160	2/3	1/2		1
43			Granitic Gneiss	43			1	4	60	260	2/3	1/2		1
44.8			Granitic Gneiss	44.8			1	4	35	200	2/3	1/2		1
44.9			Granitic Gneiss	44.9			1	4	50	130	2/3	1/2		1
45.1			Granitic Gneiss	45.1			1	4	35	330	2/3	1/2		1
51			Granitic Gneiss	51			1	4	30	310	2/3	1/2		1
53.8			Granitic Gneiss	53.8			1	4	25	300	2/3	1/2		1
54			Granitic Gneiss	54			1	4	45	230	2/3	1/2		1
54.1			Granitic Gneiss	54.1			1	4	60	120	2/3	1/2		1
55.3			Granitic Gneiss	55.3			1	4	20	80	2/3	1/2		1
55.8			Granitic Gneiss	55.8			1	4	20	60	2/3	1/2		1
55.9			Granitic Gneiss	55.9			1	4	60	250	2/3	1/2		1
59.1			Granitic Gneiss	59.1			1	4	20	90	2/3	1/2		1
67.7			Granitic Gneiss	67.7			1	4	10	270	2/3	1/2		1
68.2			Granitic Gneiss		68.2	f	1	4	50	300	2/3	1/2		1
68.3			Granitic Gneiss		68.3	f	1	4	50	300	2/3	1/2		1
68.4			Granitic Gneiss		68.4	f	1	4	55	305	2/3	1/2		1
75			Granitic Gneiss	75			1	4	65	50	2/3	1/2		1
75.1			Granitic Gneiss	75.1			1	4	45	300	2/3	1/2		1
75.4			Granitic Gneiss	75.4			1	4	50	30	2/3	1/2		1
75.5			Granitic Gneiss	75.5			1	4	55	35	2/3	1/2		1
79.5			Granitic Gneiss	79.5			1	4	25	50	2/3	1/2		1
80.6			Granitic Gneiss	80.6			1	4	50	80	2/3	1/2		1
84			Granitic Gneiss	84			1	4	20	60	2/3	1/2		1
84.5			Granitic Gneiss	84.5			1	4	25	80	2/3	1/2		1
84.6			Granitic Gneiss	84.6			1	4	20	70	2/3	1/2		1
87.9			Granitic Gneiss	87.9			1	4	50	190	2/3	1/2		1
88			Granitic Gneiss	88			1	4	30	320	2/3	1/2		1
91.2			Granitic Gneiss		91.2	f	1	4	35	190	2/3	1/2		1
91.3			Granitic Gneiss		91.3	f	1	4	40	185	2/3	1/2		1
91.4			Granitic Gneiss		91.4	f	1	4	40	185	2/3	1/2		1
91.45			Granitic Gneiss		91.45	f	1	4	35	180	2/3	1/2		1

MATRIX TYPE
M1 Fault
M2 Shears
M3 Intense fracturing
M4 Intense mineralisation
M5 Deformable material

WEATHERING
1. Unweathered
2. Slightly
3. Moderately
4. Highly
5. Completely

JOINT SURFACE
MICRO ROUGHNESS
1. Polished
2. Smooth planar
3. Rough planar
4. Slickensided undulated
5. Smooth undulating
6. Rough undulating
7. Slickensided stepped
8. Smooth stepped
9. Rough stepped / irregular

MACRO ROUGHNESS
1. Planar
2. Undulating
3. Curved
4. Irregular
5. Multi irregular

INFILLING TYPE
1. Gauge thickness > Amplitude of irregularities
2. Gauge thickness < Amplitude of irregularities
3. Soft Sheared Material- Fine
4. Soft Sheared Material-Med
5. Soft Sheared Material- Crse
6. Non Softening Material-Fine
7. Non Softening Material-Med
8. Non Softening Material-Crse
9. Clean

JOINT WALL ALTERATION
1. Wall = Rock Hard
2. Wall > Rock Hard
3. Wall < Rock Hard

Appendix 1 K4GT03

GEOTECHNICAL BOREHOLE LOG

PROJECT: Lerala **BOREHOLE NO:** GT03 **FINAL DEPTH:** 101.2 **DATE:** 28/10/2006

ZONE: K4 **INCLINATION:** 50 **LOGGED BY:** JPE Hamman

Interval	RQD	Geotech interval	Rock Type	Rock competence			Weath'ng	Hardness			Joint Surface Condition			
From	%			Solid m	Matrix m	Matrix type	1-5	1-5	Alpha Angle	Beta Angle	Micro 1-9	Macro 1-5	Infilling Type 1-7	Wall Alter 1-3
0		0m - 5.7m	Tricone				4	3						
5.7		5.7m - 21.08m	Kimberlite Breccia				4	3						
21.08		21.08m - 37.66m	Dolerite Dyke				1	4						
37.5		37.66m - 101.2	Granitic Gneiss	37.5			1	4	45	40	2/3	1/2		1
37.6			Granitic Gneiss	37.6			1	4	35	30	2/3	1/2		1
37.7			Granitic Gneiss	37.7			1	4	35	30	2/3	1/2		1
38.8			Granitic Gneiss	38.8			1	4	45	350	2/3	1/2		1
39.4			Granitic Gneiss	39.4			1	4	35	220	2/3	1/2		1
39.5			Granitic Gneiss	39.5			1	4	20	130	2/3	1/2		1
39.8			Granitic Gneiss	39.8			1	4	70	60	2/3	1/2		1
40.2			Granitic Gneiss	40.2			1	4	70	200	2/3	1/2		1
40.3			Granitic Gneiss	40.3			1	4	40	200	2/3	1/2		1
40.8			Granitic Gneiss	40.8			1	4	35	160	2/3	1/2		1
41			Granitic Gneiss	41			1	4	30	130	2/3	1/2		1
41.2			Granitic Gneiss	41.2			1	4	25	210	2/3	1/2		1
41.4			Granitic Gneiss	41.4			1	4	35	130	2/3	1/2		1
42.7			Granitic Gneiss	42.7			1	4	10	0	2/3	1/2		1
42.8			Granitic Gneiss	42.8			1	4	55	55	2/3	1/2		1
45.2			Granitic Gneiss	45.2			1	4	35	270	2/3	1/2		1
56.9			Granitic Gneiss	56.9			1	4	60	150	2/3	1/2		1
57			Granitic Gneiss	57			1	4	75	130	2/3	1/2		1
57.1			Granitic Gneiss	57.1			1	4	35	290	2/3	1/2		1
68.8			Granitic Gneiss	68.8			1	4	45	80	2/3	1/2		1
69.2			Granitic Gneiss	69.2			1	4	40	80	2/3	1/2		1
69.4			Granitic Gneiss	69.4			1	4	25	60	2/3	1/2		1
69.6			Granitic Gneiss	69.6			1	4	20	110	2/3	1/2		1
77.7			Granitic Gneiss	77.7			1	4	40	80	2/3	1/2		1
77.8			Granitic Gneiss	77.8			1	4	55	50	2/3	1/2		1
78.8			Granitic Gneiss	78.8			1	4	45	40	2/3	1/2		1
80.8			Granitic Gneiss	80.8			1	4	25	250	2/3	1/2		1
81.5			Granitic Gneiss	81.5			1	4	40	110	2/3	1/2		1
99.8			Granitic Gneiss	99.8			1	4	30	140	2/3	1/2		1
100.1			Granitic Gneiss		100.1	f	1	4	35	255	2/3	1/2		1

MATRIX TYPE
M1 Fault
M2 Shears
M3 Intense fracturing
M4 Intense mineralisation
M5 Deformable material

WEATHERING
1. Unweathered
2. Slightly
3. Moderately
4. Highly
5. Completely

JOINT SURFACE
MICRO ROUGHNESS
1. Polished
2. Smooth planar
3. Rough planar
4. Slickensided undulated
5. Smooth undulating
6. Rough undulating
7. Slickensided stepped
8. Smooth stepped
9. Rough stepped / irregular

MACRO ROUGHNESS
1. Planar
2. Undulating
3. Curved
4. Irregular
5. Multi irregular

INFILLING TYPE
1. Gauge thickness > Amplitude of irregularities
2. Gauge thickness < Amplitude of irregularities
3. Soft Sheared Material- Fine
4. Soft Sheared Material-Med
5. Soft Sheared Material- Crse
6. Non Softening Material-Fine
7. Non Softening Material-Med
8. Non Softening Material-Crse
9. Clean

JOINT WALL ALTERATION
1. Wall = Rock Hard
2. Wall > Rock Hard
3. Wall < Rock Hard

Appendix 1 K4GT04

GEOTECHNICAL BOREHOLE LOG

PROJECT: Lerala **BOREHOLE NO:** GT04 **FINAL DEPTH:** 101.6 **DATE:** 31/10/2006

ZONE: K4 **INCLINATION:** 60 **LOGGED BY:** JPE Hamman

Interval	RQD	Geotech interval	Rock Type	Rock competence			Weath'ng	Hardness			Joint Surface Condition			
From	%			Solid m	Matrix m	Matrix type	1-5	1-5	Alpha Angle	Beta Angle	Micro 1-9	Macro 1-5	Infilling Type 1-7	Wall Alter 1-3
0		0m - 6.2m	Tricone				4	3						
6.2	92	6.2m - 11.6m	Kimberlite Breccia				4	3						
11.6	30	11.6m - 29.50m	Kimberlite Breccia				2	3						
26.7			Kimberlite Breccia	26.7			2	3	50	150	2/3	1/2		1
29.5			Kimberlite Breccia	29.5			2	3	65	350	2/3	1/2		1
29.6	90	29.5m - 41.95m	Granite/Kimberlite	29.6			1	4	60	200	2/3	1/2		1
40			Granite/Kimberlite	40			1	4	60	250	2/3	1/2		1
40.1			Granite/Kimberlite	40.1			1	4	60	250	2/3	1/2		1
40.2			Granite/Kimberlite	40.2			1	4	50	130	2/3	1/2		1
40.25			Granite/Kimberlite	40.25			1	4	60	220	2/3	1/2		1
40.6			Granite/Kimberlite	40.6			1	4	20	320	2/3	1/2		1
60.3	86	68.90m - 80.60m	Granite	60.3			1	4	60	220	2/3	1/2		1
60.8			Granite	60.8			1	4	50	150	2/3	1/2		1
60.9			Granite	60.9			1	4	40	150	2/3	1/2		1
61.1			Granite	61.1			1	4	65	170	2/3	1/2		1
66.2			Granite	66.2			1	4	55	240	2/3	1/2		1
66.3			Granite	66.3			1	4	50	50	2/3	1/2		1
69.7			Granite	69.7			1	4	45	310	2/3	1/2		1
70.1			Granite	70.1			1	4	55	190	2/3	1/2		1
70.5			Granite	70.5			1	4	40	300	2/3	1/2		1
72			Granite	72			1	4	30	190	2/3	1/2		1
72.1			Granite	72.1			1	4	55	30	2/3	1/2		1
72.3			Granite	72.3			1	4	60	120	2/3	1/2		1
74.7			Granite	74.7			1	4	40	140	2/3	1/2		1
74.9			Granite	74.9			1	4	42	145	2/3	1/2		1
75.1			Granite	75.1			1	4	70	310	2/3	1/2		1
75.3			Granite	75.3			1	4	65	70	2/3	1/2		1
75.4			Granite	75.4			1	4	65	310	2/3	1/2		1
77			Granite	77			1	4	60	140	2/3	1/2		1
77.1			Granite	77.1			1	4	50	150	2/3	1/2		1
77.5			Granite	77.5			1	4	55	190	2/3	1/2		1
78			Granite	78			1	4	35	20	2/3	1/2		1
78.3			Granite	78.3			1	4	25	350	2/3	1/2		1
78.6			Granite	78.6			1	4	60	110	2/3	1/2		1
78.7			Granite	78.7			1	4	35	340	2/3	1/2		1
86.4	86	80.6m - 95.25	Granitic Gneiss	86.4			1	4	40	310	2/3	1/2		1
91.7			Granitic Gneiss	91.7			1	4	55	110	2/3	1/2		1
92			Granitic Gneiss	92			1	4	35	30	2/3	1/2		1

MATRIX TYPE
M1 Fault
M2 Shears
M3 Intense fracturing
M4 Intense mineralisation
M5 Deformable material

WEATHERING
1. Unweathered
4. Highly
5. Completely

JOINT SURFACE

MICRO ROUGHNESS
1. Polished
2. Smooth planar
3. Rough planar
4. Slickensided undulated
5. Smooth undulating
6. Rough undulating
7. Slickensided stepped
8. Smooth stepped
9. Rough stepped / irregular

MACRO ROUGHNESS
1. Planar
2. Undulating
3. Curved
4. Irregular
5. Multi irregular

INFILLING TYPE
1. Gauge thickness > Amplitude of irregularities
2. Gauge thickness < Amplitude of irregularities
3. Soft Sheared Material- Fine
4. Soft Sheared Material-Med
5. Soft Sheared Material- Crse
6. Non Softening Material-Fine
7. Non Softening Material-Med
8. Non Softening Material-Crse
9. Clean

JOINT WALL ALTERATION
1. Wall = Rock Hard
2. Wall > Rock Hard
3. Wall < Rock Hard

Appendix 1 K5GT01

GEOTECHNICAL BOREHOLE LOG

PROJECT: Lerala | **BOREHOLE NO:** GT 01 | **FINAL DEPTH:** 92.5 | **DATE:** 13/11/2006

ZONE: K5 | **INCLINATION:** 50 | **LOGGED BY:** JPE Hamman

Interval	RQD	Geotech interval	Rock Type	Rock competence			Weath'ng	Hardness	Jointing Distribution		Joint Surface Condition			
From	%			Solid m	Matrix m	Matrix type	1-5	1-5	Alpha Angle	Beta Angle	Micro 1-9	Macro 1-5	Infilling Type 1-7	Wall Alter 1-3
0	90	0m - 7m	Kimberlite Breccia				4	3						
7	90	7m -10m	Granitic Gneiss				1	3						
14.8	95	10m - 48.8m	Granitic Gneiss	14.8			1	4	40	170	2/3	1/2		1
15.2			Granitic Gneiss	15.2			1	4	40	270	2/3	1/2		1
15.5			Granitic Gneiss	15.5			1	4	30	165	2/3	1/2		1
17.7			Granitic Gneiss	17.7			1	4	20	50	2/3	1/2		1
17.9			Granitic Gneiss	17.9			1	4	60	30	2/3	1/2		1
19.3			Granitic Gneiss	19.3			1	4	65	100	2/3	1/2	4	1
19.6			Granitic Gneiss		19.6	F	1	4	55	240	2/3	1/2		1
24.6			Granitic Gneiss		24.6	F	1	4	50	320	2/3	1/2		1
24.65			Granitic Gneiss		24.65	F	1	4	50	325	2/3	1/2		1
24.7			Granitic Gneiss		24.7	F	1	4	50	315	2/3	1/2		1
24.85			Granitic Gneiss		24.85	F	1	4	50	322	2/3	1/2		1
25.4			Granitic Gneiss	25.4			1	4	65	60	2/3	1/2		1
25.6			Granitic Gneiss		25.6	F	1	4	30	280	2/3	1/2		1
25.65			Granitic Gneiss		25.65	F	1	4	40	290	2/3	1/2		1
25.7			Granitic Gneiss		25.7	F	1	4	45	300	2/3	1/2		1
25.75			Granitic Gneiss		25.75	F	1	4	50	310	2/3	1/2		1
25.8			Granitic Gneiss		25.8	F	1	4	55	320	2/3	1/2		1
28.4			Granitic Gneiss	28.4			1	4	50	210	2/3	1/2		1
31.3			Granitic Gneiss	31.3			1	4	60	120	2/3	1/2		1
34.8			Granitic Gneiss	34.8			1	4	50	110	2/3	1/2		1
35			Granitic Gneiss	35			1	4	20	200	2/3	1/2		1
35.8			Granitic Gneiss		35.8	F	1	4	60	230	2/3	1/2		1
25.8			Granitic Gneiss		25.8	F	1	4	55	240	2/3	1/2		1
35.8			Granitic Gneiss		35.8	F	1	4	55	230	2/3	1/2		1
36.3			Granitic Gneiss	36.3			1	4	65	30	2/3	1/2		1
36.5			Granitic Gneiss	36.5			1	4	60	140	2/3	1/2		1
36.6			Granitic Gneiss		36.6	F	1	4	50	210	2/3	1/2		1
36.6			Granitic Gneiss		36.6	F	1	4	50	230	2/3	1/2		1
36.6			Granitic Gneiss		36.6	F	1	4	50	230	2/3	1/2		1
38.8			Granitic Gneiss	38.8			1	4	60	340	2/3	1/2		1
39.1			Granitic Gneiss	39.1			1	4	60	10	2/3	1/2		1
39.1			Granitic Gneiss	39.1			1	4	25	90	2/3	1/2		1
39.1			Granitic Gneiss	39.1			1	4	40	0	2/3	1/2		1
39.3			Granitic Gneiss		39.3	F	1	4	45	230	2/3	1/2		1
39.3			Granitic Gneiss		39.3	F	1	4	45	220	2/3	1/2		1
39.3			Granitic Gneiss		39.3	F	1	4	45	240	2/3	1/2		1
41.4			Granitic Gneiss	41.4			1	4	65	220	2/3	1/2		1
41.7			Granitic Gneiss		41.7	F	1	4	60	210	2/3	1/2		1
41.7			Granitic Gneiss		41.7	F	1	4	60	210	2/3	1/2		1
41.7			Granitic Gneiss		41.7	F	1	4	60	240	2/3	1/2		1
41.7			Granitic Gneiss		41.7	F	1	4	60	220	2/3	1/2		1
42.4			Granitic Gneiss	42.4			1	4	55	340	2/3	1/2		1
43			Granitic Gneiss		43	F	1	4	30	90	2/3	1/2		1
43.2			Granitic Gneiss		43.2	F	1	4	55	130	2/3	1/2		1
43.2			Granitic Gneiss		43.2	F	1	4	55	240	2/3	1/2		1
43.2			Granitic Gneiss		43.2	F	1	4	55	230	2/3	1/2		1
43.2			Granitic Gneiss		43.2	F	1	4	55	260	2/3	1/2		1
47.2			Granitic Gneiss	47.2			1	4	40	350	2/3	1/2		1
47.3			Granitic Gneiss		47.3	F	1	4	55	280	2/3	1/2		1
47.2			Granitic Gneiss		47.2	F	1	4	55	220	2/3	1/2		1
47.2			Granitic Gneiss		47.2	F	1	4	55	280	2/3	1/2		1
47.2			Granitic Gneiss		47.2	F	1	4	55	280	2/3	1/2		1
48.7	95	48.8m - 49.8m	Dyke intrusion	48.7			1	4	30	240	2/3	1/2		1
51.2	95	49.8m - 92.5m	Granitic Gneiss		51.2	F	1	4	65	200	2/3	1/2		1
51.3			Granitic Gneiss	51.3			1	4	55	170	2/3	1/2		1
51.4			Granitic Gneiss		51.4	F	1	4	70	230	2/3	1/2		1
51.4			Granitic Gneiss		51.4	F	1	4	70	220	2/3	1/2		1
51.4			Granitic Gneiss		51.4	F	1	4	70	220	2/3	1/2		1
51.9			Granitic Gneiss	51.9			1	4	35	60	2/3	1/2	4	1
52.1			Granitic Gneiss	52.1			1	4	35	300	2/3	1/2		1
54.2			Granitic Gneiss	54.2			1	4	55	250	2/3	1/2		1
54.4			Granitic Gneiss	54.4			1	4	60	130	2/3	1/2		1
62.3			Granitic Gneiss	62.3			1	4	20	330	2/3	1/2		1
64			Granitic Gneiss	64			1	4	60	250	2/3	1/2		1
65.4			Granitic Gneiss	65.4			1	4	35	260	2/3	1/2		1
65.7			Granitic Gneiss	65.7			1	4	55	250	2/3	1/2		1
65.8			Granitic Gneiss	65.8			1	4	58	250	2/3	1/2		1
68.6			Granitic Gneiss	68.6			1	4	55	150	2/3	1/2		1
70			Granitic Gneiss	70			1	4	40	40	2/3	1/2		1
70.3			Granitic Gneiss	70.3			1	4	55	230	2/3	1/2		1
70.5			Granitic Gneiss	70.5			1	4	45	30	2/3	1/2		1
70.8			Granitic Gneiss		70.8	F	1	4	50	290	2/3	1/2		1
70.8			Granitic Gneiss		70.8	F	1	4	50	310	2/3	1/2		1
70.8			Granitic Gneiss		70.8	F	1	4	50	290	2/3	1/2		1
70.8			Granitic Gneiss		70.8	F	1	4	50	280	2/3	1/2		1
70.8			Granitic Gneiss		70.8	F	1	4	50	280	2/3	1/2		1
71.2			Granitic Gneiss	71.2			1	4	50	160	2/3	1/2		1
71.7			Granitic Gneiss	71.7			1	4	40	30	2/3	1/2		1
71.8			Granitic Gneiss		71.8	F	1	4	50	260	2/3	1/2		1
71.8			Granitic Gneiss		71.8	F	1	4	50	270	2/3	1/2		1
71.8			Granitic Gneiss		71.8	F	1	4	50	280	2/3	1/2		1
71.8			Granitic Gneiss		71.8	F	1	4	50	260	2/3	1/2		1
71.8			Granitic Gneiss		71.8	F	1	4	50	270	2/3	1/2		1
72.2			Granitic Gneiss	72.2			1	4	50	260	2/3	1/2		1
72.3			Granitic Gneiss	72.3			1	4	50	260	2/3	1/2		1
74.5			Granitic Gneiss	74.5			1	4	55	220	2/3	1/2		1
77.7			Granitic Gneiss	77.7			1	4	40	70	2/3	1/2		1
83.5			Granitic Gneiss	83.5			1	4	45	10	2/3	1/2		1
84			Granitic Gneiss		84	F	1	4	30	350	2/3	1/2		1
84			Granitic Gneiss		84	F	1	4	30	350	2/3	1/2		1
84			Granitic Gneiss		84	F	1	4	30	350	2/3	1/2		1
86			Granitic Gneiss	86			1	4	50	0	2/3	1/2		1
88			Granitic Gneiss	88			1	4	30	200	2/3	1/2		1
90			Granitic Gneiss		90	F	1	4	20	0	2/3	1/2		1
90			Granitic Gneiss		90	F	1	4	20	0	2/3	1/2		1
90			Granitic Gneiss		90	F	1	4	20	0	2/3	1/2		1

MATRIX TYPE
M1 Fault
M2 Shears
M3 Intense fracturing
M4 Intense mineralisation
M5 Deformable material

WEATHERING
1. Unweathered
2. Slightly
3. Moderately
4. Highly
5. Completely

JOINT SURFACE
MICRO ROUGHNESS
1. Polished
2. Smooth planar
3. Rough planar
4. Slickensided undulated
5. Smooth undulating
6. Rough undulating
7. Slickensided stepped
8. Smooth stepped
9. Rough stepped / irregular

MACRO ROUGHNESS
1. Planar
2. Undulating
3. Curved
4. Irregular
5. Multi irregular

INFILLING TYPE
1. Gauge thickness > Amplitude of irregularities
2. Gauge thickness < Amplitude of irregularities
3. Soft Sheared Material- Fine
4. Soft Sheared Material-Med
5. Soft Sheared Material- Crse
6. Non Softening Material-Fine
7. Non Softening Material-Med
8. Non Softening Material-Crse
9. Clean

JOINT WALL ALTERATION
1. Wall = Rock Hard
2. Wall > Rock Hard
3. Wall < Rock Hard

Appendix 1 K5GT02

GEOTECHNICAL BOREHOLE LOG

PROJECT: Lerala | **BOREHOLE NO:** K5 GT02 | **FINAL DEPTH:** 91.0m | **DATE:** 13/11/2006

ZONE: K5 | **INCLINATION:** 50 | **LOGGED BY:** JPE Hamman

Interval	RQD	Geotech interval	Rock Type	Rock competence			Weath'ng	Hardness			Joint Surface Condition			
From	%			Solid m	Matrix m	Matrix type	1-5	1-5	Alpha Angle	Beta Angle	Micro 1-9	Macro 1-5	Infilling Type 1-7	Wall Alter 1-3
0	0	0m - 8.2m	Sapprolite				4	3						
11.6	66	8.2m - 15m	Dolerite Dyke	11.6			1	4	30	50	2/3	1/2		1
11.65			Dolerite Dyke	11.65			1	4	45	220	2/3	1/2		1
11.9			Dolerite Dyke	11.9			1	4	50	40	2/3	1/2		1
24	83	15m 29.9m	Granite Gneis	24			1	4	70	10	2/3	1/2		1
24.3			Granite Gneis	24.3			1	4	55	50	2/3	1/2		1
34.6	85	29.9m - 91.0m	Dolerite Dyke	34.6			1	4	40	35	2/3	1/2		1
34.65			Dolerite Dyke	34.65			1	4	40	35	2/3	1/2		1
34.7			Dolerite Dyke	34.7			1	4	40	35	2/3	1/2		1
34.72			Dolerite Dyke	34.72			1	4			2/3	1/2		1
35.3			Dolerite Dyke	35.3			1	4	30	240	2/3	1/2		1
35.5			Dolerite Dyke	35.5			1	4	35	90	2/3	1/2		1
36.9			Dolerite Dyke	36.9			1	4	25	340	2/3	1/2		1
45			Dolerite Dyke	45			1	4	45	60	2/3	1/2		1
45.7			Dolerite Dyke	45.7			1	4	70	320	2/3	1/2		1
45.7			Dolerite Dyke	45.7			1	4	20	30	2/3	1/2		1
50.7			Dolerite Dyke	50.7			1	4	65	70	2/3	1/2		1
51			Dolerite Dyke	51			1	4	50	10	2/3	1/2		1
52.3			Dolerite Dyke	52.3			1	4	55	340	2/3	1/2		1
52.5			Dolerite Dyke	52.5			1	4	55	320	2/3	1/2		1
58			Dolerite Dyke	58			1	4	40	0	2/3	1/2		1
58.2			Dolerite Dyke	58.2			1	4	50	280	2/3	1/2		1
61.9			Dolerite Dyke	61.9			1	4	60	100	2/3	1/2		1
62			Dolerite Dyke	62			1	4	50	350	2/3	1/2		1
62.5			Dolerite Dyke	62.5			1	4	40	190	2/3	1/2		1
63.5			Dolerite Dyke	63.5			1	4	50	120	2/3	1/2		1
63.8			Dolerite Dyke	63.8			1	4	50	160	2/3	1/2		1
65.7			Dolerite Dyke	65.7			1	4	60	40	2/3	1/2		1
67.1			Dolerite Dyke	67.1			1	4	45	240	2/3	1/2		1
67.5			Dolerite Dyke	67.5			1	4	25	50	2/3	1/2		1
68.8			Dolerite Dyke	68.8			1	4	35	90	2/3	1/2		1
69			Dolerite Dyke	69			1	4	50	190	2/3	1/2		1
69.4			Dolerite Dyke	69.4			1	4	45	350	2/3	1/2		1
72.8			Dolerite Dyke	72.8			1	4	55	200	2/3	1/2		1
73			Dolerite Dyke	73			1	4	65	70	2/3	1/2		1
73.8			Dolerite Dyke	73.8			1	4	40	20	2/3	1/2		1
74.3			Dolerite Dyke	74.3			1	4	50	130	2/3	1/2		1
74.7			Dolerite Dyke	74.7			1	4	35	300	2/3	1/2		1
74.9			Dolerite Dyke	74.9			1	4	50	130	2/3	1/2		1
75.2			Dolerite Dyke	75.2			1	4	50	250	2/3	1/2		1
75.8			Dolerite Dyke	75.8			1	4	50	140	2/3	1/2		1
78			Dolerite Dyke	78			1	4	35	145	2/3	1/2		1
78.1			Dolerite Dyke	78.1			1	4	35	145	2/3	1/2		1
78.2			Dolerite Dyke	78.2			1	4	35	145	2/3	1/2		1
78.9			Dolerite Dyke	78.9			1	4	40	80	2/3	1/2		1
79.2			Dolerite Dyke	79.2			1	4	20	155	2/3	1/2		1

MATRIX TYPE
M1 Fault
M2 Shears
M3 Intense fracturing
M4 Intense mineralisation
M5 Deformable material

WEATHERING
1. Unweathered
2. Slightly
3. Moderately
4. Highly
5. Completely

JOINT SURFACE
MICRO ROUGHNESS
1. Polished
2. Smooth planar
3. Rough planar
4. Slickensided undulated
5. Smooth undulating
6. Rough undulating
7. Slickensided stepped
8. Smooth stepped
9. Rough stepped / irregular

MACRO ROUGHNESS
1. Planar
2. Undulating
3. Curved
4. Irregular
5. Multi irregular

INFILLING TYPE
1. Gauge thickness > Amplitude of irregularities
2. Gauge thickness < Amplitude of irregularities
3. Soft Sheared Material- Fine
4. Soft Sheared Material-Med
5. Soft Sheared Material- Crse
6. Non Softening Material-Fine
7. Non Softening Material-Med
8. Non Softening Material-Crse
9. Clean

JOINT WALL ALTERATION
1. Wall = Rock Hard
2. Wall > Rock Hard
3. Wall < Rock Hard

Appendix 1 K5GT03

GEOTECHNICAL BOREHOLE LOG

PROJECT: Lerala **BOREHOLE NO:** GT03 **FINAL DEPTH:** 92.5 **DATE:** 13/11/2006

ZONE: K5 **INCLINATION:** 60 **LOGGED BY:** JPE Hamman

Drilled Interval From	RQD %	Geotech interval	Rock Type	Rock competence Solid m	Matrix m	Matrix Type	Weath'ng 1-5	Hardness 1-5	Jointing Distribution Alpha Angle	Beta Angle	Joint Surface Condition Micro 1-9	Macro 1-5	Infilling Type 1-7	Wall Alter 1-3
0		0m - 3.9m	Kimberlite Breccia				4	3						
7.5		3.9m -7.5m	Dyke Sapprolite				4	3						
19.9		7.5m - 19.1	Weathered Dolerit	19.90			4	3	50	50	2/3	1/2		1
19.95	90	19.1m - 92.4m	Dolerite dyke	19.95			1	4	50	50	2/3	1/2		1
20			Dolerite dyke	20.00			1	4	50	0	2/3	1/2		1
20.4			Dolerite dyke	20.40			1	4	30	10	2/3	1/2		1
21.8			Dolerite dyke	21.80			1	4	45	20	2/3	1/2		1
22			Dolerite dyke	22.00			1	4	70	140	2/3	1/2		1
22.2			Dolerite dyke	22.20			1	4	55	80	2/3	1/2		1
22.5			Dolerite dyke	22.50			1	4	60	190	2/3	1/2		1
22.6			Dolerite dyke	22.60			1	4	70	50	2/3	1/2		1
22.7			Dolerite dyke	22.70			1	4	55	230	2/3	1/2		1
23.7			Dolerite dyke	23.70			1	4	20	260	2/3	1/2		1
23.9			Dolerite dyke	23.90			1	4	80	0	2/3	1/2		1
24.9			Dolerite dyke	24.90			1	4	20	350	2/3	1/2		1
25.1			Dolerite dyke	25.10			1	4	55	180	2/3	1/2		1
25.6			Dolerite dyke	25.60			1	4	20	0	2/3	1/2		1
25.8			Dolerite dyke	25.80			1	4	45	170	2/3	1/2		1
26.2			Dolerite dyke	26.20			1	4	75	10	2/3	1/2		1
26.25			Dolerite dyke	26.25			1	4	40	190	2/3	1/2		1
27			Dolerite dyke	27.00			1	4	60	10	2/3	1/2		1
27			Dolerite dyke	27.00			1	4	15	170	2/3	1/2		1
27.3			Dolerite dyke	27.30			1	4	80	150	2/3	1/2		1
27.9			Dolerite dyke	27.90			1	4	65	310	2/3	1/2		1
28			Dolerite dyke	28.00			1	4	75	200	2/3	1/2		1
28.3			Dolerite dyke	28.30			1	4	50	190	2/3	1/2		1
29.6			Dolerite dyke	29.60			1	4	60	150	2/3	1/2		1
30.1			Dolerite dyke	30.10			1	4	40	300	2/3	1/2		1
30.3			Dolerite dyke	30.30			1	4	20	300	2/3	1/2		1
31			Dolerite dyke	31.00			1	4	60	330	2/3	1/2		1
33.5			Dolerite dyke	33.50			1	4	35	20	2/3	1/2		1
35			Dolerite dyke	35.00			1	4	60	190	2/3	1/2		1
35.3			Dolerite dyke	35.30			1	4	65	150	2/3	1/2		1
35.9			Dolerite dyke	35.90			1	4	40	270	2/3	1/2		1
36			Dolerite dyke	36.00			1	4	60	70	2/3	1/2		1
36.9			Dolerite dyke	36.90			1	4	40	270	2/3	1/2		1
37.1			Dolerite dyke	37.10			1	4	20	250	2/3	1/2		1
37.2			Dolerite dyke	37.20			1	4	25	100	2/3	1/2		1
38.8			Dolerite dyke	38.80			1	4	15	190	2/3	1/2		1
43.9			Dolerite dyke	43.90			1	4	15	290	2/3	1/2		1
44.3			Dolerite dyke	44.30			1	4	75	0	2/3	1/2		1
44.7			Dolerite dyke	44.70			1	4	40	110	2/3	1/2		1
45.4			Dolerite dyke	45.40			1	4	45	220	2/3	1/2		1
46.7			Dolerite dyke	46.70			1	4	75	250	2/3	1/2		1
46.1			Dolerite dyke	46.10			1	4	40	160	2/3	1/2		1
47.7			Dolerite dyke	47.70			1	4	70	160	2/3	1/2		1
48			Dolerite dyke	48.00			1	4	65	170	2/3	1/2		1
48.2			Dolerite dyke	48.20			1	4	10	90	2/3	1/2		1
52.8			Dolerite dyke	52.80			1	4	75	210	2/3	1/2		1
53			Dolerite dyke	53.00			1	4	15	210	2/3	1/2		1
55.6			Dolerite dyke	55.60			1	4	40	240	2/3	1/2		1
57.9			Dolerite dyke	57.90			1	4	30	320	2/3	1/2		1
58			Dolerite dyke	58.00			1	4	75	30	2/3	1/2		1
58.4			Dolerite dyke	58.40			1	4	20	30	2/3	1/2		1
59.1			Dolerite dyke	59.10			1	4	75	110	2/3	1/2		1
60.7			Dolerite dyke	60.70			1	4	65	160	2/3	1/2		1
60.75			Dolerite dyke	60.75			1	4	40	340	2/3	1/2		1
62.2			Dolerite dyke	62.20			1	4	70	350	2/3	1/2		1
62.4			Dolerite dyke	62.40			1	4	50	320	2/3	1/2		1
62.6			Dolerite dyke	62.60			1	4	60	330	2/3	1/2		1
66.6			Dolerite dyke	66.60			1	4	50	80	2/3	1/2		1
68.4			Dolerite dyke	68.40			1	4	65	260	2/3	1/2		1
70			Dolerite dyke	70.00			1	4	40	210	2/3	1/2		1
70.4			Dolerite dyke	70.40			1	4	75	60	2/3	1/2		1
74			Dolerite dyke	74.00			1	4	50	0	2/3	1/2		1
75			Dolerite dyke	75.00			1	4	15	90	2/3	1/2		1
75.6			Dolerite dyke	75.60			1	4	60	320	2/3	1/2		1
75.7			Dolerite dyke	75.70			1	4	50	200	2/3	1/2		1
76.2			Dolerite dyke	76.20			1	4	60	340	2/3	1/2		1
77.5			Dolerite dyke	77.50			1	4	35	20	2/3	1/2		1
78.3			Dolerite dyke	78.30			1	4	50	360	2/3	1/2		1
78.8			Dolerite dyke	78.80			1	4	50	190	2/3	1/2		1
78.2			Dolerite dyke	78.20			1	4	45	180	2/3	1/2		1

MATRIX TYPE
M1 Fault
M2 Shears
M3 Intense fracturing
M4 Intense mineralisation
M5 Deformable material

WEATHERING
1. Unweathered
2. Slightly
3. Moderately
4. Highly
5. Completely

JOINT SURFACE
MICRO ROUGHNESS
1. Polished
2. Smooth planar
3. Rough planar
4. Slickensided undulated
5. Smooth undulating
6. Rough undulating
7. Slickensided stepped
8. Smooth stepped
9. Rough stepped / irregular

MACRO ROUGHNESS
1. Planar
2. Undulating
3. Curved
4. Irregular
5. Multi irregular

INFILLING TYPE
1. Gauge thickness > Amplitude of irregularities
2. Gauge thickness < Amplitude of irregularities
3. Soft Sheared Material- Fine
4. Soft Sheared Material-Med
5. Soft Sheared Material- Crse
6. Non Softening Material-Fine
7. Non Softening Material-Med
8. Non Softening Material-Crse
9. Clean

JOINT WALL ALTERATION
1. Wall = Rock Hard
2. Wall > Rock Hard
3. Wall < Rock Hard

Appendix 1 K5GT04

GEOTECHNICAL BOREHOLE LOG

PROJECT: Lerala **BOREHOLE NO:** GT04 **FINAL DEPTH:** **DATE: 16/11/2006**

ZONE: K5 **INCLINATION:** 50 **LOGGED BY:** JPE Hamman

Drilled Interval From	RQD %	Geotech interval	Rock Type	Rock competence: Solid m	Rock competence: Matrix m	Rock competence: Matrix Type	Weath'ng 1-5	Hardness 1-5	Jointing Distribution: Alpha Angle	Jointing Distribution: Beta Angle	Joint Surface Condition: Micro 1-9	Joint Surface Condition: Macro 1-5	Joint Surface Condition: Infilling Type 1-7	Joint Surface Condition: Wall Alter 1-3
0		0.0m - 0.70m	Kimberlite Breccia				4	3						
0.7		0.7m - 25.85m	Kimberlite Breccia				4	3						
20.7			Kimberlite Breccia	20.7			4	3	50	170	2/3	1/2		1
25.8		25.85m - 91.2	Granitic Gneiss	25.8			4	3	45	0	2/3	1/2		1
33.5	90		Granitic Gneiss	33.5			1	4	25	320	2/3	1/2		1
33.7			Granitic Gneiss	33.7			1	4	65	210	2/3	1/2		1
38.1			Granitic Gneiss	38.1			1	4	35	330	2/3	1/2		1
38.2			Granitic Gneiss	38.2			1	4	33	330	2/3	1/2		1
38.3			Granitic Gneiss	38.3			1	4	50	350	2/3	1/2		1
39.2			Granitic Gneiss		39.2	F	1	4	25	200	2/3	1/2		1
39.7			Granitic Gneiss	39.7			1	4	70	330	2/3	1/2		1
39.7			Granitic Gneiss		39.7	F	1	4	25	160	2/3	1/2		1
39.7			Granitic Gneiss		39.7	F	1	4	25	170	2/3	1/2		1
39.7			Granitic Gneiss		39.7	F	1	4	25	165	2/3	1/2		1
39.7			Granitic Gneiss		39.7	F	1	4	25	160	2/3	1/2		1
39.8			Granitic Gneiss		39.8	F	1	4	10	220	2/3	1/2		1
39.8			Granitic Gneiss		39.8	F	1	4	10	200	2/3	1/2		1
39.8			Granitic Gneiss		39.8	F	1	4	10	190	2/3	1/2		1
39.8			Granitic Gneiss		39.8	F	1	4	10	180	2/3	1/2		1
40.2			Granitic Gneiss		40.2	F	1	4	15	240	2/3	1/2		1
40.2			Granitic Gneiss		40.2	F	1	4	15	240	2/3	1/2		1
40.2			Granitic Gneiss		40.2	F	1	4	15	220	2/3	1/2		1
40.2			Granitic Gneiss		40.2	F	1	4	15	210	2/3	1/2		1
40.2			Granitic Gneiss		40.2	F	1	4	15	200	2/3	1/2		1
40.2			Granitic Gneiss		40.2	F	1	4	15	190	2/3	1/2		1
40.2			Granitic Gneiss	40.2			1	4	25	20	2/3	1/2		1
40.4			Granitic Gneiss		40.4	F	1	4	10	190	2/3	1/2		1
40.4			Granitic Gneiss		40.4	F	1	4	10	200	2/3	1/2		1
40.9			Granitic Gneiss	40.9			1	4	55	160	2/3	1/2		1
44			Granitic Gneiss	44			1	4	35	60	2/3	1/2		1
43.5			Granitic Gneiss		43.5	F	1	4	10	270	2/3	1/2		1
43.5			Granitic Gneiss		43.5	F	1	4	10	270	2/3	1/2		1
43.5			Granitic Gneiss		43.5	F	1	4	10	270	2/3	1/2		1
43.5			Granitic Gneiss		43.5	F	1	4	10	260	2/3	1/2		1
43.5			Granitic Gneiss		43.5	F	1	4	10	260	2/3	1/2		1
44.9			Granitic Gneiss	44.9			1	4	70	60	2/3	1/2		1
45.2			Granitic Gneiss	45.2			1	4	60	90	2/3	1/2		1
45.4			Granitic Gneiss	45.4			1	4	55	340	2/3	1/2		1
47.8			Granitic Gneiss	47.8			1	4	50	260	2/3	1/2		1
49.7			Granitic Gneiss	49.7			1	4	25	70	2/3	1/2		1
49.9			Granitic Gneiss	49.9			1	4	65	20	2/3	1/2		1
50.9			Granitic Gneiss	50.9			1	4	55	40	2/3	1/2		1
52.7			Granitic Gneiss	52.7			1	4	45	320	2/3	1/2		1
53.1			Granitic Gneiss	53.1			1	4	40	300	2/3	1/2		1
55.7			Granitic Gneiss	55.7			1	4	70	30	2/3	1/2		1
59			Granitic Gneiss		59	F	1	4	35	60	2/3	1/2		1
59			Granitic Gneiss		59	F	1	4	35	50	2/3	1/2		1
59			Granitic Gneiss		59	F	1	4	35	60	2/3	1/2		1
59			Granitic Gneiss		59	F	1	4	35	50	2/3	1/2		1
59			Granitic Gneiss		59	F	1	4	35	40	2/3	1/2		1
59.2			Granitic Gneiss	59.2			1	4	65	180	2/3	1/2		1
67.1			Granitic Gneiss	67.1			1	4	30	280	2/3	1/2		1
67.5			Granitic Gneiss		67.5	F	1	4	20	160	2/3	1/2		1
67.5			Granitic Gneiss		67.5	F	1	4	20	160	2/3	1/2		1
67.5			Granitic Gneiss		67.5	F	1	4	20	160	2/3	1/2		1
67.5			Granitic Gneiss	67.5			1	4	50	330	2/3	1/2		1
67.9			Granitic Gneiss	67.9			1	4	55	0	2/3	1/2		1
68.4			Granitic Gneiss	68.4			1	4	25	180	2/3	1/2		1
72.2			Granitic Gneiss	72.2			1	4	60	40	2/3	1/2		1
72.8			Granitic Gneiss	72.8			1	4	15	0	2/3	1/2		1

MATRIX TYPE
M1 Fault
M2 Shears
M3 Intense fracturing
M4 Intense mineralisation
M5 Deformable material

WEATHERING
1. Unweathered
2. Slightly
3. Moderately
4. Highly
5. Completely

JOINT SURFACE MICRO ROUGHNESS
1. Polished
2. Smooth planar
3. Rough planar
4. Slickensided undulated
5. Smooth undulating
6. Rough undulating
7. Slickensided stepped
8. Smooth stepped
9. Rough stepped / irregular

MACRO ROUGHNESS
1. Planar
2. Undulating
3. Curved
4. Irregular
5. Multi irregular

INFILLING TYPE
1. Gauge thickness > Amplitude of irregularities
2. Gauge thickness < Amplitude of irregularities
3. Soft Sheared Material- Fine
4. Soft Sheared Material-Med
5. Soft Sheared Material- Crse
6. Non Softening Material-Fine
7. Non Softening Material-Med
8. Non Softening Material-Crse
9. Clean

JOINT WALL ALTERATION
1. Wall = Rock Hard
2. Wall > Rock Hard
3. Wall < Rock Hard

Appendix 1 K5GT05

GEOTECHNICAL BOREHOLE LOG

PROJECT: Lerala **BOREHOLE NO:** GT05 **FINAL DEPTH:** 83.4 **DATE:** 29/11/2006

ZONE: K5 **INCLINATION:** 60 **LOGGED BY:** JPE Hamman

Drilled Interval	RQD	Geotech interval	Rock Type	Rock competence			Weath'ng	Hardness	Jointing Distribution		Joint Surface Condition			
From	%			Solid m	Matrix m	Matrix Type	1-5	1-5	Alpha Angle	Beta Angle	Micro 1-9	Macr o 1-5	Infilling Type 1-7	Wall Alter 1-3
0		0m - 6.2m	Tricone				4	3						
6.2		6.2m - 9.05mm	Granitic Gneiss				1	4						
9.05		9.05m - 16.50m	Granite				1	4						
16.5		16.5m - 56.86m	Granitic Gneiss				1	4						
51.4			Granitic Gneiss	51.4			1	4	50	290	2/3	1/2		1
51.5			Granitic Gneiss	51.5			1	4	65	345	2/3	1/2		1
51.7			Granitic Gneiss	51.7			1	4	50	270	2/3	1/2		1
52			Granitic Gneiss	52			1	4	45	25	2/3	1/2		1
52.1			Granitic Gneiss	52.1			1	4	65	340	2/3	1/2		1
52.2			Granitic Gneiss	52.2			1	4	60	130	2/3	1/2		1
53.4			Granitic Gneiss	53.4			1	4	45	350	2/3	1/2		1
53.7			Granitic Gneiss	53.7			1	4	45	180	2/3	1/2		1
55.4			Granitic Gneiss	55.4			1	4	20	270	2/3	1/2		1
56.6			Granitic Gneiss	56.6			1	4	30	40	2/3	1/2		1
56.6			Granitic Gneiss	56.6			1	4	60	130	2/3	1/2		1
56.8			Granitic Gneiss	56.8			1	4	55	290	2/3	1/2		1
		56.86m - 83.40m	Dolerite dyke				1	4			2/3	1/2		1

MATRIX TYPE
M1 Fault
M2 Shears
M3 Intense fracturing
M4 Intense mineralisation
M5 Deformable material

WEATHERING
1. Unweathered
2. Slightly
3. Moderately
4. Highly
5. Completely

JOINT SURFACE

MICRO ROUGHNESS
1. Polished
2. Smooth planar
3. Rough planar
4. Slickensided undulated
5. Smooth undulating
6. Rough undulating
7. Slickensided stepped
8. Smooth stepped
9. Rough stepped / irregular

MACRO ROUGHNESS
1. Planar
2. Undulating
3. Curved
4. Irregular
5. Multi irregular

INFILLING TYPE
1. Gauge thickness > Amplitude of irregularities
2. Gauge thickness < Amplitude of irregularities
3. Soft Sheared Material- Fine
4. Soft Sheared Material-Med
5. Soft Sheared Material- Crse
6. Non Softening Material-Fine
7. Non Softening Material-Med
8. Non Softening Material-Crse
9. Clean

JOINT WALL ALTERATION
1. Wall = Rock Hard
2. Wall > Rock Hard
3. Wall < Rock Hard

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Appendix1 K6GT01

GEOTECHNICAL BOREHOLE LOG

PROJECT: Lerala **BOREHOLE NO:** GT01 **FINAL DEPTH:** 90 **DATE:** 11/07/2006

ZONE: K6 **INCLINATION:** 50 **LOGGED BY:** JPE Hamman

Drilled Interval	RQD	Geotech interval	Rock Type	Rock competence			Weath'ng	Hardness	Jointing Distribution		Joint Surface Condition			
From	%			Solid m	Matrix m	Matrix Type	1-5	1-5	Alpha Angle	Beta Angle	Micro 1-9	Macr o 1-5	Infilling Type 1-7	Wall Alter 1-3
0		0m - 12m	Kimberlite				4	3						
12		12m - 40.70m	Granitic Gneiss				1	4						
23.4			Granitic Gneiss	23.4			1	4	60	140	2/3	1/2		1
23.5			Granitic Gneiss	23.5			1	4	30	330	2/3	1/2		1
23.7			Granitic Gneiss	23.7			1	4	35	350	2/3	1/2		1
23.8			Granitic Gneiss	23.8			1	4	35	145	2/3	1/2		1
23.9			Granitic Gneiss	23.9			1	4	55	25	2/3	1/2		1
64.5		40.7m - 64.60m	Dolerite	64.5			1	4	55	250	2/3	1/2		1
65		64.6m - 90.0m	Granitic Gneiss	65			1	4	60	100	2/3	1/2		1
76			Granitic Gneiss	76			1	4	75	270	2/3	1/2		1
76.2			Granitic Gneiss	76.2			1	4	55	25	2/3	1/2		1
76.3			Granitic Gneiss	76.3			1	4	40	50	2/3	1/2		1
77.3			Granitic Gneiss	77.3			1	4	55	280	2/3	1/2		1
78.2			Granitic Gneiss	78.2			1	4	20	190	2/3	1/2		1
78.3			Granitic Gneiss	78.3			1	4	45	280	2/3	1/2		1
78.4			Granitic Gneiss	78.4			1	4	40	70	2/3	1/2		1
84.7			Granitic Gneiss	84.7			1	4	40	230	2/3	1/2		1
84.9			Granitic Gneiss	84.9			1	4	50	230	2/3	1/2		1
87.3			Granitic Gneiss	87.3			1	4	35	330	2/3	1/2		1
89			Granitic Gneiss	89			1	4	45	260	2/3	1/2		1

MATRIX TYPE
M1 Fault
M2 Shears
M3 Intense fracturing
M4 Intense mineralisation
M5 Deformable material

1. Unweathered
2. Slightly
3. Moderately
4. Highly
5. Completely

JOINT SURFACE

MICRO ROUGHNESS
1. Polished
2. Smooth planar
3. Rough planar
4. Slickensided undulated
5. Smooth undulating
6. Rough undulating
7. Slickensided stepped
8. Smooth stepped
9. Rough stepped / irregular

MACRO ROUGHNESS
1. Planar
2. Undulating
3. Curved
4. Irregular
5. Multi irregular

INFILLING TYPE
1. Gauge thickness > Amplitude of irregularities
2. Gauge thickness < Amplitude of irregularities
3. Soft Sheared Material- Fine
4. Soft Sheared Material-Med
5. Soft Sheared Material- Crse
6. Non Softening Material-Fine
7. Non Softening Material-Med
8. Non Softening Material-Crse
9. Clean

JOINT WALL ALTERATION
1. Wall = Rock Hard
2. Wall > Rock Hard
3. Wall < Rock Hard

Appendix1 K6GT02

GEOTECHNICAL BOREHOLE LOG

PROJECT: Lerala **BOREHOLE NO:** GT02 **FINAL DEPTH:** 101.7 **DATE:** 11/04/2006

ZONE: K6 **INCLINATION:** 50 **LOGGED BY:** JPE Hamman

Drilled Interval	RQD	Geotech interval	Rock Type	Rock competence			Weath'ng	Hardness	Jointing Distribution		Joint Surface Condition				MATRIX TYPE M1 Fault M2 Shears M3 Intense fracturing M4 Intense mineralisation M5 Deformable material
From	%			Solid m	Matrix m	Matrix Type	1-5	1-5	Alpha Angle	Beta Angle	Micro 1-9	Macro 1-5	Infilling Type 1-7	Wall Alter 1-3	
6.2	70	0m - 6.0m	Kimberlite				4	3							
14.8	70	6.0m - 14.8m	Kimberlite Breccia				4	3							
32	10	14.8m - 32m	Kimberlite Breccia+Granitic Gneiss				4	3							**WEATHERING**
33.2	30	32m - 33.2m	Dolerite Dyke				1	4							1. Unweathered
101.7	93	33.2m - 101.7m	Granitic Gneiss				1	4							2. Slightly
															3. Moderately
															4. Highly
															5. Completely
															JOINT SURFACE
															MICRO ROUGHNESS
															1. Polished
															2. Smooth planar
															3. Rough planar
															4. Slickensided undulated
															5. Smooth undulating
															6. Rough undulating
															7. Slickensided stepped
															8. Smooth stepped
															9. Rough stepped / irregular
															MACRO ROUGHNESS
															1. Planar
															2. Undulating
															3. Curved
															4. Irregular
															5. Multi irregular
															INFILLING TYPE
															1. Gauge thickness > Amplitude
															of irregularities
															2. Gauge thickness < Amplitude
															of irregularities
															3. Soft Sheared Material- Fine
															4. Soft Sheared Material-Med
															5. Soft Sheared Material- Crse
															6. Non Softening Material-Fine
															7. Non Softening Material-Med
															8. Non Softening Material-Crse
															9. Clean
															JOINT WALL ALTERATION
															1. Wall = Rock Hard
															2. Wall > Rock Hard
															3. Wall < Rock Hard

Appendix1 K6GT03

GEOTECHNICAL BOREHOLE LOG

PROJECT: Lerala **BOREHOLE NO:** GT 03 **FINAL DEPTH:** 102 **DATE:** 13/11/2006

ZONE: K6 **INCLINATION:** 50 **LOGGED BY:** JPE Hamman

Interval	RQD	Geotech interval	Rock Type	Rock competence			Weath'ng	Hardness	Jointing Distribution		Joint Surface Condition			
From	%			Solid m	Matrix m	Matrix type	1-5	1-5	Alpha Angle	Beta Angle	Micro 1-9	Macro 1-5	Infilling Type 1-7	Wall Alter 1-3
0		0m - 3.7m	WeatheredKimberlite				4	3						
3.7		3.7m - 4.9m	Foliated Gneiss				4	3						
4.9		4.9m - 11.7m	WeatheredKimberlite				4	3						
11.7	95	11.7m - 34.38m	Kimberlite				1	4						
34.38	85	34.38m - 48.4m	Foliated Gneiss				1	4						
48.5	95	48.5 - 95.1	Kimberlite				1	4						
95.1	90	95.1m - 101.7	Granitic Gneiss				1	4						

MATRIX TYPE
M1 Fault
M2 Shears
M3 Intense fracturing
M4 Intense mineralisation
M5 Deformable material

WEATHERING
1. Unweathered
2. Slightly
3. Moderately
4. Highly
5. Completely

JOINT SURFACE

MICRO ROUGHNESS
1. Polished
2. Smooth planar
3. Rough planar
4. Slickensided undulated
5. Smooth undulating
6. Rough undulating
7. Slickensided stepped
8. Smooth stepped
9. Rough stepped / irregular

MACRO ROUGHNESS
1. Planar
2. Undulating
3. Curved
4. Irregular
5. Multi irregular

INFILLING TYPE
1. Gauge thickness > Amplitude of irregularities
2. Gauge thickness < Amplitude of irregularities
3. Soft Sheared Material- Fine
4. Soft Sheared Material-Med
5. Soft Sheared Material- Crse
6. Non Softening Material-Fine
7. Non Softening Material-Med
8. Non Softening Material-Crse
9. Clean

JOINT WALL ALTERATION
1. Wall = Rock Hard
2. Wall > Rock Hard
3. Wall < Rock Hard

Appendix 2 K2GT01

Borehole Number		K2/GT/01	Diameter (in/cm)			Type	DD
Xcoordinate	588418	Ycoordinate		7484786	Collar Elevation (mamsl)		
Inclination	-60 degrees	Date Start		21/11/2006	Date Finish		27/11/2006

Depth (m)		Lithology	Susceptibility	Vis. Log
From	To			
0.00	21.40	Tricone		
21.40	34.40	Weathered hypabyssal kimberlite breccia		
34.40	47.00	Hypabyssal kimberlite breccia with more pink granitic xenoliths at the bottom		
47.00	50.52	Pink granitic zone with amphibolitic gneiss and kimberlite breccia		
50.52	62.90	Hypabyssal kimberlite breccia		
62.90	85.05	Pink granite with grey gneissic granite patches		
85.05	101.60	Grey gneissic granite		
		EOH = 101.60m		

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Appendix 2 K2GT02

Borehole Number	**K2/GT/02**	**Diameter (in/cm)**		**Type**	DD
Xcoordinate	588418	**Ycoordinate**	7484785	**Collar Elevation (mamsl)**	
Inclination	-60 degrees	**Date Start**	**16/11/2006**	**Date Finish**	**21/11/2006**

Depth (m)				
From	**To**	**Lithology**	**Susceptibility**	**Vis. Log**
0.00	15.00	Tricone (hypabyssal kimberlite)		
15.00	20.00	Hypabyssal kimberlite		
20.00	20.50	Dolerite dyke		
20.50	22.50	Pink granite		
22.50	23.00	Dolerite dyke		
23.00	29.73	Pink granite		
29.73	34.30	Grey gneissic granite		
34.30	43.40	Pink granite with grey gneissic granite patches		
43.40	100.40	Pinkish-grey gneissic granite		
		EOH = 100.40m		

	Appendix 2 K2GT03						
Borehole Number		**K2/GT/03**	**Diameter (in/cm)**			**Type**	DD
Xcoordinate	588530	**Ycoordinate**		7484764	**Collar Elevation (mamsl)**		
Inclination	-60 degrees	**Date Start**		**28/11/2006**	**Date Finish**	**2006/01/12**	

Depth (m)				
From	**To**	**Lithology**	**Susceptibility**	**Vis. Log**
0.00	15.00	Tricone (kimberlite mined out and backfilled)		
15.00	22.40	Pink granite		
22.40	45.80	Pinkish grey gneissic granite, highly broken core zone		
45.80	56.00	Grey gneissic granite, slightly broken core zone		
56.00	76.00	Grey gneissic granite		
76.00	77.03	Dolerite dyke		
77.03	91.00	Pink-grey granite, gneissic in places		
		EOH = 91.00m		

	Appendix 2 K2GT04							
Borehole Number		K2/GT/04	Diameter (in/cm)			Type	DD	
Xcoordinate	588338	Ycoordinate		7484813	Collar Elevation (mamsl)			
Inclination	-50 degrees	Date Start		2006/07/12	Date Finish		2006/09/12	
Depth (m)								
From	To	Lithology				Susceptibility		Vis. Log
0.00	24.00	Tricone, (hypabyssal kimberlite)						
24.00	38.50	Hypabyssal kimberlite						
38.50	44.00	Grey gneissic granite, highly broken						
44.00	53.60	Grey gneissic granite, less broken						
53.60	75.00	Pink granite with grey gneissic patches						
75.00	95.40	Grey gneissic granite with pink granite patches (highly broken in places						
95.40	101.00	Pink granite with grey gneissic patches						
101.00	101.50	Mylonitized grey gneisiic granite (shear zone).						
		EOH = 101.50m						

	Appendix 2 K2GT05						
Borehole Number		**K2/GT/05**	**Diameter (in/cm)**			**Type**	DD
Xcoordinate	588803	**Ycoordinate**		7484714	**Collar Elevation (mamsl)**		
Inclination	-50 degrees	**Date Start**		**2006/02/12**	**Date Finish**	**2006/06/12**	

Depth (m)				
From	**To**	**Lithology**	**Susceptibility**	**Vis. Log**
0.00	15.00	Tricone (kimberlite breccia)		
15.00	17.20	Kimberlite breccia		
17.20	33.00	Pink granite (highly broken core + core loss)		
33.00	45.60	Grey gneissic granite with pink granite portions		
45.60	57.95	Dolerite dyke		
57.95	101.50	Whitish-grey gneissic granite		
		EOH = 101.50m		

	Appendix 2 K3GT01							
Borehole Number		K3/GT/01	Diameter (in/cm)			Type	DD	
Xcoordinate	590787	Ycoordinate		7489014	Collar Elevation (mamsl)			
Inclination	-60 degrees	Date Start		2006/12/10	Date Finish		16/10/2006	

Depth (m)		Lithology	Susceptibility	Vis. Log
From	To			
0.00	5.80	Tricone		
5.80	24.45	Weathered tuffisitic kimberlite breccia		
24.45	39.20	Fresh tuffisitic kimberlite breccia		
39.20	40.48	Mafic xenolith/inclusion		
40.48	48.12	Tuffisitic kimberlite breccia		
48.12	49.62	Granitic xenolith/inclusion		
49.62	56.90	Tuffisitic kimberlite breccia		
56.90	57.53	Granitic xenolith/inclusion		
57.53	105.04	Tuffisitic kimberlite breccia		
105.04	110.80	Sheared altered granite (intense shearing towards bottom)		
110.80	113.43	Tuffisitic kimberlite breccia		
113.43	115.15	Altered granite		
115.15	116.40	Tuffisitic kimberlite breccia		
		E.O.H = 116.40m		

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	Appendix 2 K3GT02							
Borehole Number		K3/GT/02	Diameter (in/cm)			Type	DD	
Xcoordinate	590758	Ycoordinate		7489104	Collar Elevation (mamsl)			
Inclination	-50 degrees	Date Start		19/10/2006	Date Finish		20/10/2006	

Depth (m)		Lithology	Susceptibility	Vis. Log
From	To			
0.00	3.20	Tricone		
3.20	19.00	Weathered tuffisitic kimberlite breccia		
19.00	23.70	Dolerite (dyke?)		
23.70	30.00	Weathered tuffisitic kimberlite breccia with abundant granitic & mafic xenoliths		
30.00	40.30	Zone of brecciated country rock (Contact breccia)		
40.30	70.38	Gneissic granite with patches of pink feldspars		
70.38	93.15	Gneissic granite with predominantly amphibolitic zones and minor pink feldspar zones		
93.15	101.70	Pink gneissic granite, whitish grey in places		
		E.O.H = 101.70m		

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	Appendix 2 K3GT03							
Borehole Number		K3/GT/03	Diameter (in/cm)			Type	DD	
Xcoordinate	590728	Ycoordinate		7489128	Collar Elevation (mamsl)			
Inclination	-50 degrees	Date Start		21/10/2006	Date Finish		23/10/2006	

Depth (m)		Lithology	Susceptibility	Vis. Log
From	To			
0.00	3.20	Tricone		
3.20	25.30	Weathered tuffistic kimberlite breccia with abundant granitic & mafic xenoliths		
25.30	32.70	Zone of brecciated country rock (contact breccia)		
32.70	34.78	Dolerite (dyke?)		
34.78	48.00	Granite with pink feldspar patches, brecciated zones in places		
48.00	51.80	Dolerite (dyke?)		
51.80	55.72	Brecciated granitic country rock		
55.72	66.22	Gneissic granite with pink feldspar patches		
66.22	71.62	Grey gneissic granite		
71.62	101.70	Gneissic granite with pink feldspar patches		
		E.O.H = 101.70m		

Appendix 2 K3GT04

Borehole Number	**K3/GT/04**	**Diameter (in/cm)**			**Type**	DD
Xcoordinate	590691	**Ycoordinate**	7489016	**Collar Elevation (mamsl)**		
Inclination	-50 degrees	**Date Start**	16/10/2006	**Date Finish**	18/10/2006	

Depth (m)				
From	**To**	**Lithology**	**Susceptibility**	**Vis. Log**
0.00	15.00	Tricone (kimberlite)		
15.00	23.20	Granitie with lenses of kimberlite breccia (tkb) in places		
23.20	30.32	Tuffisitic kimberlite breccia		
30.32	31.10	Granite		
31.10	32.70	Tuffisitic kimberlite breccia		
32.70	34.83	Granite		
34.83	35.20	Tuffisitic kimberlite breccia		
35.20	39.30	Granite		
39.30	40.75	Kimberlitic breccia		
40.75	44.40	Granite		
44.40	45.13	Tuffisitic kimberlite breccia		
45.13	47.93	Granite with lenses of kimberlite breecia in places		
47.93	50.35	Tuffisitic kimberlite breccia		
50.5	61.30	Granite with lenses of kimberlite breecia in places		
61.30	68.16	Tuffisitic kimberlite breccia		
68.16	84.12	Mafic intrusion with breccia material		
84.12	89.15	Hypabyssal kimberlite (younger consequent dyke intrusion)		
89.15	92.70	Mafic intrusion with breccia material (older than hypabyssal kimberlite dyke)		
		E.O.H = 92.70m		

Appendix 2 K4GT01

Borehole Number	**K4/GT/01**	**Diameter (in/cm)**		**Type**	DD
Xcoordinate	592159	**Ycoordinate**	7489050	**Collar Elevation (mamsl)**	
Inclination	-50 degrees	**Date Start**	**24/10/2006**	**Date Finish**	**25/10/2006**

Depth (m)				
From	**To**	**Lithology**	**Susceptibility**	**Vis. Log**
0.00	3.20	Tricone		
3.20	8.70	Hypabyssal kimberlite		
8.70	20.80	Zone of intense altered country rock		
20.80	28.20	Gneissic granite, brecciated in places		
28.20	88.35	Gneissic granite with pink feldspar patches		
88.35	91.70	Grey gneissic granite with minor pink feldspar patches		
		E.O.H = 91.70m		

	Appendix 2 K4GT02					
Borehole Number	K4/GT/02	Diameter (in/cm)			Type	DD
Xcoordinate	592219	Ycoordinate		7489144	Collar Elevation (mamsl)	
Inclination	-50 degrees	Date Start		2006/02/11	Date Finish	2006/04/11

Depth (m)		Lithology	Susceptibility	Vis. Log
From	To			
0.00	6.20	Ticone, backfilled tuffisistic kimberlite breccia rock.		
6.20	7.45	Tuffisitic kimberlite breccia, fresh rock		
7.45	13.55	Weathered tuffisitic kimberlite breccia section		
13.55	31.65	Tuffisitic kimberlite breccia, fresh rock with zones of large inclusions		
31.65	32.30	Hypabyssal kimberlite		
32.30	34.00	Shear zone, (contact zone)		
34.00	46.70	Gnessic granite, sheared in places		
46.70	48.40	Hypabyssal kimberlite breccia		
48.40	50.10	Gnessic granite, sheared in places		
50.10	70.10	Gnessic granite, foliated and sheared especially towards the base		
70.10	78.76	Tuffisitic kimberlite breccia		
78.76	101.70	Gneissic granite, foliated and sheared in places		
		EOH = 101.70m		

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	Appendix 2 K4GT03							
Borehole Number		K4/GT/03	Diameter (in/cm)			Type	DD	
Xcoordinate	592210	Ycoordinate		7489165	Collar Elevation (mamsl)			
Inclination	-50 degrees	Date Start		26/10/2006	Date Finish		28/10/2006	

Depth (m)				
From	To	Lithology	Susceptibility	Vis. Log
0.00	5.70	Tricone		
5.70	21.08	Tuffisitic kimberlite breccia		
21.08	37.66	Dolerite (dyke?)		
37.66	101.20	Grey gneissic granite with pink feldspar zones		
		E.O.H = 101.20m		

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	Appendix 2 K4GT04				
Borehole Number	K4/GT/04	Diameter (in/cm)		Type	DD
Xcoordinate	592209	Ycoordinate	7489162	Collar Elevation (mamsl)	
Inclination	-60 degrees	Date Start	28/10/2006	Date Finish	31/10/2006

Depth (m)				
From	To	Lithology	Susceptibility	Vis. Log
0.00	6.20	Tricone		
6.20	11.60	Weathered tuffisitic kimberlite breccia		
11.60	29.50	Fresh tuffisitic kimberlite breccia		
29.50	34.10	Pink granite		
34.10	34.70	Dolerite (dyke?)		
34.70	39.00	Pink granite		
39.00	39.70	Hypabyssal kimberlite		
39.70	41.95	Granite, sheared		
41.95	43.47	Hypabyssal kimberlite		
43.47	44.60	Mafic intrusion		
44.60	46.90	Hypabyssal kimberlite		
46.90	47.80	Brecciated shear zone rock with mylonitised zones.		
47.80	52.45	Dolerite (dyke?)		
52.45	68.90	Mafic rock with pink feldspar inclusions		
68.90	80.60	Granite with dominant pink feldspar		
80.60	95.25	Gneissic granite, grey with pink feldspar zones		
95.25	97.42	Dolerite (dyke?)		
97.42	101.60	Gneissic granite with predominantly pink feldspar zones		
		E.O.H = 101.60m		

Appendix 2 K4GT05

Borehole Number	K4/GT/05	Diameter (in/cm)		Type	DD
Xcoordinate	592153	Ycoordinate	7489064	Collar Elevation (mamsl)	
Inclination	-50 degrees	Date Start	29/11/2006	Date Finish	2006/02/12

Depth (m)				
From	To	Lithology	Susceptibility	Vis. Log
0.00	12.50	Tricone (hypabyssal kimberlite breccia)		
12.50	24.40	Hypabyssal kimberlite breccia		
24.40	37.58	Pink granite with intrusive kimberlite veins		
37.58	45.50	Gneissic granite with pink granite zones		
45.50	50.20	Pink granite		
50.20	101.40	Pinkish-grey gneissic granite		
		EOH = 101.40m		

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	Appendix 2 K5GT01						
Borehole Number		K5/GT/01	Diameter (in/cm)			Type	DD
Xcoordinate	591379	Ycoordinate		7490527	Collar Elevation (mamsl)		
Inclination	-50 degrees	Date Start		2006/07/11	Date Finish	13/11/2006	

Depth (m)		Lithology	Susceptibility	Vis. Log
From	To			
0.00	5.00	Tricone (hypabyssal kimberlite breccia)		
5.00	9.80	Hypabyssal kimberlite breccia		
9.80	24.95	Pink gneissic granite		
24.95	33.90	Amphibolitic gneiss with pink granitic patches		
33.90	48.74	Pink gneissic granite, coarse towards the bottom		
48.74	49.78	Dolerite dyke		
49.78	59.26	Coarse pink granite		
59.26	73.80	Pinkish-grey gneissic granite		
73.80	76.25	Coarse pink granite		
76.25	84.83	Pinkish-grey gneissic granite		
84.83	86.90	Pinkish-whitish grey coarse granite		
86.90	92.50	Pinkish-grey gneissic granite		
		EOH = 92.50m		

	Appendix 2 K5GT02						
Borehole Number		K5/GT/02	Diameter (in/cm)			Type	DD
Xcoordinate	591428	Ycoordinate		7490574	Collar Elevation (mamsl)		
Inclination	-50 degrees	Date Start		13/11/2006	Date Finish	15/11/2006	

Depth (m)				
From	To	Lithology	Susceptibility	Vis. Log
0.00	1.50	Tricone (Calcretised kimberlite breccia with granite inclusions)		
1.50	5.40	Calcretised kimberlite breccia with granite inclusions (contact breccia), especially towards the bottom		
5.40	8.10	Calcretised gneissic pink granite		
8.10	15.20	Dolerite dyke		
15.20	30.00	Pinkish-grey gneissic granite		
30.00	32.78	Dolerite dyke		
32.78	33.83	Pink granite		
33.83	91.00	Dolerite (dyke/sill?)		
		EOH = 91.00m		

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	Appendix 2 K5GT03						
Borehole Number		K5/GT/03	Diameter (in/cm)			Type	DD
Xcoordinate	591376	Ycoordinate		7490619	Collar Elevation (mamsl)		
Inclination	-60 degrees	Date Start		16/11/2006	Date Finish	17/11/2006	

Depth (m)				
From	To	Lithology	Susceptibility	Vis. Log
0.00	3.90	Calcretised kimberlite breccia with doleritic xenoliths		
3.90	7.32	Calcretised kimberlite breccia with large doleritic xenoliths		
7.32	19.10	Weathered dolerite (dyke/sill?)		
19.10	92.40	Dolerite (dyke/sill?), fresh		
		EOH = 92.40m		

	Appendix 2 K5GT04							
Borehole Number		K5/GT/04	Diameter (in/cm)			Type	DD	
Xcoordinate	591325	Ycoordinate		7490564	Collar Elevation (mamsl)			
Inclination	-50 degrees	Date Start		13/11/2006	Date Finish		16/11/2006	

Depth (m)				
From	To	Lithology	Susceptibility	Vis. Log
0.00	0.70	Calcretised kimberlite (highly weathered)		
0.70	25.85	Kimberlite breccia with abundant granitic, amphibolitic/doleritic inclusions		
25.85	35.70	Pink gneissic granite		
35.70	66.00	Grey gneiss with pink granitic patches		
66.00	67.40	Pink granite		
67.40	85.57	Greyish-pink gneissic granite		
85.57	91.20	Amphibolitic gneiss with whitish granite patches		
		EOH = 91.20m		

	Appendix 2 K5GT05						
Borehole Number		K5/GT/05	Diameter (in/cm)			Type	DD
Xcoordinate	591419	Ycoordinate		7490557	Collar Elevation (mamsl)		
Inclination	-60 degrees	Date Start		28/11/2006	Date Finish		29/11/2006

Depth (m)				
From	To	Lithology	Susceptibility	Vis. Log
0.00	6.20	Tricone		
6.20	9.05	Grey gneissic granite with pink granite and kimberlite (contact zone)		
9.05	16.50	Pink granite with stockwork of veins		
16.50	56.86	Pink gneissic granite, massive and granular in places, especially at the bottom		
56.86	83.40	Dolerite dyke		
		EOH = 83.40m		

	Appendix 2 K6GT01						
Borehole Number		K6/GT/0	Diameter (in/cm)			Type	DD
Xcoordinate	591168	Ycoordinate		7490891	Collar Elevation (mamsl)		
Inclination	-50 degrees	Date Start		2006/04/11	Date Finish	2006/07/11	

Depth (m)				
From	To	Lithology	Susceptibility	Vis. Log
0.00	12.00	Tricone (hypabyssal kimberlite, mined out and backfilled)		
12.00	32.10	Banded grey gneissic granite		
32.10	40.70	Sheared gneissic granite with pink feldspar patches		
40.70	45.20	Dark green sheared mafic rock (intrusive?)		
45.20	60.80	Unsheared mafic rock (dolerite intrusive?)		
60.80	64.60	Dark green sheared mafic rock (intrusive?)		
64.60	90.00	Whitish grey gneissic granite with pink feldspar		
		E.O.H = 90.00m		

Appendix 2 K6GT02

Borehole Number	K6/GT/02	**Diameter (in/cm)**		**Type**	DD
Xcoordinate	591169	**Ycoordinate**	7490894	**Collar Elevation (mamsl)**	
Inclination	-50 degrees	**Date Start**	2006/08/11	**Date Finish**	2006/04/11

Depth (m)				
From	**To**	**Lithology**	**Susceptibility**	**Vis. Log**
0.00	6.20	Tricone (hypabyssal kimberlite)		
6.20	14.30	Weathered hypabyssal kimberlite		
14.30	31.80	Amphibolitic gneiss with pink granitic inclusions in places		
31.80	33.35	Mafic intrusion		
33.35	89.70	Gneissic granite with pink feldspar patches		
89.70	95.70	Pink gneissic granite		
95.70	101.70	Gneissic granite with alternatic pink feldspar patches and grey amphibolitic patches		
		EOH = 101.70m		

	Appendix 2 K6GT03							
Borehole Number		K6/GT/03	Diameter (in/cm)			Type	DD	
Xcoordinate	591164	Ycoordinate		7490880	Collar Elevation (mamsl)			
Inclination	-50 degrees	Date Start		2006/11/11	Date Finish		13/11/2006	

Depth (m)				
From	To	Lithology	Susceptibility	Vis. Log
0.00	3.70	Tricone (weathered hypabyssal kimberlite)		
3.70	4.90	Gneissic granite (xenolith/inclusion?)		
4.90	11.74	Weathered hypabyssal kimberlite		
11.74	34.38	Fresh hypabyssal kimberlite with granite xenolith towards the bottom		
34.38	48.50	Gneissic granite with pink felspar patches		
48.50	58.84	Hypabyssal kimberlite breccia		
58.84	59.70	Dark grey granite inclusion		
59.70	95.00	Hypabyssal kimberlite		
95.00	101.70	Dark grey gneissic granite with pink feldspar patches		
		EOH = 101.70m		

	Appendix 2 K6GT04						
Borehole Number		K6/GT/04	Diameter (in/cm)			Type	DD
Xcoordinate	591163	Ycoordinate		7490890	Collar Elevation (mamsl)		
Inclination	-50 degrees	Date Start		17/11/2006	Date Finish	27/11/2006	

Depth (m)				
From	To	Lithology	Susceptibility	Vis. Log
0.00	0.90	Tricone (hypabyssal kimberlite)		
0.90	14.70	Weathered hypabyssal kimberlite		
14.70	17.05	Fresh hypabyssal kimberlite		
17.05	18.30	Grey gneiss		
18.30	19.47	Pink granite		
19.47	68.80	Grey gneissic granite with pink granitic patches		
68.80	73.70	Younger grey fine grained intrusive granite		
73.70	75.00	Pink coarse granite		
75.00	86.60	Grey sheared mafic rock with pink granitic inclusions, intensely sheared at the bottom		
86.60	89.34	Dolerite dyke		
89.34	91.45	Grey sheared mafic rock with pink granitic inclusions		
91.45	101.40	Pinkish grey granite with a stockwork of fractures and sheraed in places		
		EOH = 101.40m		

Appendix 3 Failure Codes for UCS Tests

CLASSIFICATION OF ROCK SPECIMEN FAILURE MODE INFLUENCED / NOT INFLUENCED BY DISCONTINUITIES DURING COMPRESSION TESTING

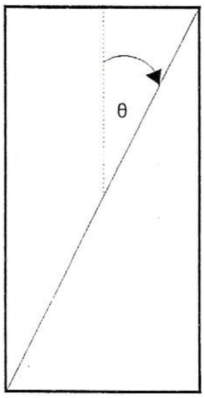
FAILURE NOT INFLUENCED BY DISCONTINUITIES (INTACT)

TYPE CODE	DESCRIPTION OF SUBCODES	
	A	B
X	PARTIAL CONE DEVELOPMENT	COMPLETE CONE DEVELOPMENT

FAILURE INFLUENCED BY DISCONTINUITIES

TYPE CODE	DESCRIPTION OF SUBCODES	
	A	B
	FAILURE PARTIALLY ON DISCONTINUITY	FAILURE COMPLETELY ON DISCONTINUITY
1	AT 0-10° TO AXIS	AT 0-10° TO AXIS
2	AT 11-20° TO AXIS	AT 11-20° TO AXIS
3	AT 21-30° TO AXIS	AT 21-30° TO AXIS
4	AT 31-40° TO AXIS	AT 31-40° TO AXIS
5	AT 41-50° TO AXIS	AT 41-50° TO AXIS
6	AT 51-70° TO AXIS	AT 51-70° TO AXIS
7	AT 71-90° TO AXIS	AT 71-90° TO AXIS

Example: Failure Type 3B: Failure completely on a discontinuity with an orientation of between 21° and 30° to the specimen axis.



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Appendix 3
RESULTS OF UNIAXIAL COMPRESSION TESTS

ROCKLAB
DIVISION OF SOILLAB (PTY) LTD
Tel: 012 481 3894
Fax: 012 481 3812
E-mail: Chenj@rocklab.co.za

Client: OHMS (Pty) Ltd. Sampling Site: Diamond Ex - Lerala - Botswana

6-Dec-06

SPECIMEN PARTICULARS			SPECIMEN DIMENSIONS					SPECIMEN TEST RESULTS			
Rocklab Specimen No 2868-	Sample No.	Rock Type	Diameter mm	Height mm	Ratio of Height to Diameter	Mass g	Density g/cm³	Failure Load kN	Strength (UCS) MPa	Failure Code	Note
UCS-01	1	Kimberlite Breccia	61.1	172.0	2.8	1378.0	2.73	219.7	74.9	XA	
UCS-02	2	Kimberlite Breccia	60.9	171.8	2.8	1392.1	2.79	193.2	66.4	4A	
UCS-03	3	Kimberlite Breccia	60.8	175.0	2.9	1423.1	2.80	433.6	149.5	XA	
UCS-11	11	Granitic Gneiss	47.4	110.9	2.3	527.5	2.69	454.1	257.0	XA	
UCS-12a	12	Granitic Gneiss	47.4	114.7	2.4	549.4	2.72	421.7	239.5	XA	
UCS-12b			47.3	119.4	2.5	573.8	2.73	463.0	263.4	XB	
UCS-13a	13	Granitic Gneiss	47.4	118.7	2.5	555.0	2.65	280.3	158.6	2A	
UCS-13b			47.5	118.5	2.5	554.9	2.64	362.1	204.3	XB	
UCS-22	22	Foliated Gneiss	60.9	159.6	2.6	1239.2	2.66	516.1	177.1	XB	
UCS-23	23	Foliated Gneiss	47.4	124.8	2.6	584.6	2.65	532.1	301.4	XB	
UCS-24a	24	Foliated Gneiss	47.5	125.7	2.6	593.7	2.66	471.2	265.5	XA	
UCS-24b			47.6	114.7	2.4	543.3	2.66	489.7	274.9	XB	
UCS-25a	25	Foliated Gneiss	47.7	128.1	2.7	605.8	2.64	511.5	286.1	XB	
UCS-25b			47.6	127.2	2.7	603.6	2.67	492.8	277.1	XB	
UCS-27	27	Granitic Gneiss	47.3	128.6	2.7	594.7	2.63	561.5	319.0	XB	
UCS-28a	28	Granitic Gneiss	47.6	128.0	2.7	610.2	2.68	427.6	240.6	XB	
UCS-28b			47.6	126.2	2.6	595.3	2.65	355.5	199.6	XB	
UCS-29	29	Granitic Gneiss	47.6	132.1	2.8	644.8	2.75	479.6	270.0	XB	
UCS-33	33	Kimberlite Breccia	60.8	163.5	2.7	1295.7	2.73	285.6	98.5	XB	
UCS-34	34	Kimberlite Breccia	60.7	147.1	2.4	1159.8	2.73	263.1	91.0	XB	
UCS-35	35	Kimberlite Breccia	61.3	162.0	2.6	1355.4	2.84	152.9	51.8	2B	
UCS-36	36	Pink Granitic Gneiss	47.1	107.7	2.3	489.3	2.61	328.9	188.8	XB	
UCS-37a	37	Pink Granitic Gneiss	47.3	118.3	2.5	541.3	2.61	252.8	144.1	2A	
UCS-37b			47.3	121.1	2.6	553.5	2.61	176.7	100.8	XB	
UCS-40	40	Granitic Gneiss	44.8	132.5	3.0	546.3	2.62	195.6	124.4	2A	
UCS-41	41	Granitic Gneiss	44.8	130.6	2.9	538.6	2.62	292.9	186.2	XB	
UCS-42	42	Granitic Gneiss	44.8	128.6	2.9	527.3	2.61	185.3	117.8	1B	
UCS-45	45	Kimberlite	61.0	166.3	2.7	1415.5	2.91	230.2	78.8	1A	
UCS-46a	46	Kimberlite	44.9	121.9	2.7	546.1	2.83	194.0	122.4	XB	
UCS-46b			45.0	121.3	2.7	546.8	2.84	240.5	151.3	XA	
UCS-47a	47	Kimberlite	44.9	113.6	2.5	505.6	2.81	183.0	115.6	XB	
UCS-47b			44.9	113.2	2.5	504.7	2.81	196.4	123.9	XA	
UCS-48	48	Dolerite Dyke	44.5	120.1	2.7	531.8	2.85	314.8	202.2	XA	
UCS-50a	50	Dolerite Dyke	44.0	115.4	2.6	518.8	2.95	359.0	235.7	XB	
UCS-50b			44.6	69.9	1.6	435.7	3.99	369.3	236.6	XB	
UCS-51a	51	Dolerite Dyke	44.5	126.5	2.8	562.5	2.86	112.0	72.0	3B	
UCS-51b			44.4	122.6	2.8	546.2	2.88	153.3	99.1	3B	
UCS-52	52	Kimberlite Breccia	61.0	169.8	2.8	1319.5	2.66	355.3	121.5	XA	
UCS-53a	53	Foliated Gneiss	47.4	120.4	2.5	580.2	2.73	565.7	320.3	XB	
UCS-53b			47.4	118.8	2.5	565.4	2.70	515.0	291.7	XB	
UCS-54	54	Dolerite Dyke	44.1	97.7	2.2	435.3	2.92	378.2	248.1	XA	
UCS-55a	55	Dolerite Dyke	44.4	91.5	2.1	436.9	3.08	244.8	158.0	1B	
UCS-55b			44.4	124.7	2.8	596.6	3.09	153.1	98.9	1B	

Note: All tests were conducted according to ISRM Specifications.

DIVISION OF SOILLAB (PTY) LTD
Tel: 012 481 3894
Fax: 012 481 3812
E-mail: Chenj@rocklab.co.za

RESULTS OF BASE FRICTION ANGLE TESTS OF ROCKS
BASED ON DIRECT SHEAR TESTS ON SAW-CUT ROCK SURFACE

Client: OHMS   Sampling Location: Diamond Ex - Lerala - Botswana   15-Jun-07

ROCKLAB Specimen No 2974-	Sample ID	Rock Type	Shear Area (mm²)	Shear Cycle No	Hor. Force (kN)	Vert. Force (kN)	Dil. Angle (°)	Normal Stress (MPa)	Shear Stress (MPa)	Angle or App. Angle (°)	Base Friction Angle (°)	Note
BFA-04	4	Kimberlite Breccia	2919	1	0.68	1.2	0.0	0.42	0.23	29.1		
			2919	2	0.89	1.6	0.0	0.55	0.30	29.1	29.2	
			2919	3	1.74	3.1	0.0	1.06	0.60	29.3		
BFA-05	5	Dyke	2930	1	1.04	1.2	0.0	0.42	0.35	40.4		
			2930	2	1.35	1.6	0.0	0.55	0.46	40.2	40.4	
			2930	3	2.67	3.1	0.0	1.06	0.91	40.7		
BFA-09	9	F Gneiss	1783	1	0.71	1.2	0.0	0.68	0.40	30.2		
			1783	2	0.93	1.6	0.0	0.90	0.52	30.2	30.3	
			1783	3	1.82	3.1	0.0	1.74	1.02	30.4		
BFA-10	10	F Gneiss	1743	1	1.05	1.2	0.0	0.70	0.60	40.7		
			1743	2	1.39	1.6	0.0	0.92	0.80	41.0	40.8	
			1743	3	2.67	3.1	0.0	1.78	1.53	40.7		
BFA-11	11	F Gneiss	1762	1	0.91	1.2	0.0	0.69	0.52	36.7		
			1762	2	1.19	1.6	0.0	0.91	0.68	36.6	37.1	
			1762	3	2.41	3.1	0.0	1.76	1.37	37.9		
BFA-12	12	Kimberlite Breccia	2948	1	0.56	1.2	0.0	0.41	0.19	24.7		
			2948	2	0.73	1.6	0.0	0.54	0.25	24.5	24.7	
			2948	3	1.45	3.1	0.0	1.05	0.49	25.1		
BFA-13	13	Dark Gneiss	1780	1	1.00	1.2	0.0	0.69	0.56	39.3		
			1780	2	1.35	1.6	0.0	0.90	0.76	40.2	40.1	
			1780	3	2.67	3.1	0.0	1.74	1.50	40.7		
BFA-14	14	Dark Gneiss	1780	1	0.95	1.2	0.0	0.69	0.53	37.9		
			1780	2	1.25	1.6	0.0	0.90	0.70	38.0	37.9	
			1780	3	2.41	3.1	0.0	1.74	1.35	37.9		
BFA-15	15	Dark Gneiss	1784	1	0.87	1.2	0.0	0.68	0.49	35.5		
			1784	2	1.12	1.6	0.0	0.90	0.63	35.0	35.3	
			1784	3	2.21	3.1	0.0	1.74	1.24	35.5		
BFA-16	16	Pink Gneiss	1783	1	1.01	1.2	0.0	0.68	0.57	39.6		
			1783	2	1.35	1.6	0.0	0.90	0.76	40.2	40.2	
			1783	3	2.69	3.1	0.0	1.74	1.51	40.9		
BFA-17	17	Pink Gneiss	1783	1	0.79	1.2	0.0	0.68	0.44	32.9		
			1783	2	1.02	1.6	0.0	0.90	0.57	32.5	32.8	
			1783	3	2.01	3.1	0.0	1.74	1.13	33.0		
BFA-18	18	Pink Gneiss	1787	1	0.86	1.2	0.0	0.68	0.48	35.2		
			1787	2	1.15	1.6	0.0	0.90	0.64	35.7	35.5	
			1787	3	2.21	3.1	0.0	1.73	1.24	35.5		
BFA-19	19	Pink Gneiss	1780	1	0.82	1.2	0.0	0.69	0.46	33.9		
			1780	2	1.08	1.6	0.0	0.90	0.61	34.0	34.3	
			1780	3	2.16	3.1	0.0	1.74	1.21	34.9		
BFA-20	20	Pink Granite	1780	1	0.69	1.2	0.0	0.69	0.39	29.5		
			1780	2	0.91	1.6	0.0	0.90	0.51	29.6	29.5	
			1780	3	1.75	3.1	0.0	1.74	0.98	29.4		

Note:

Appendix 5 Joint roughness coefficient (JRC) and Joint wall compressive strength (JCS)

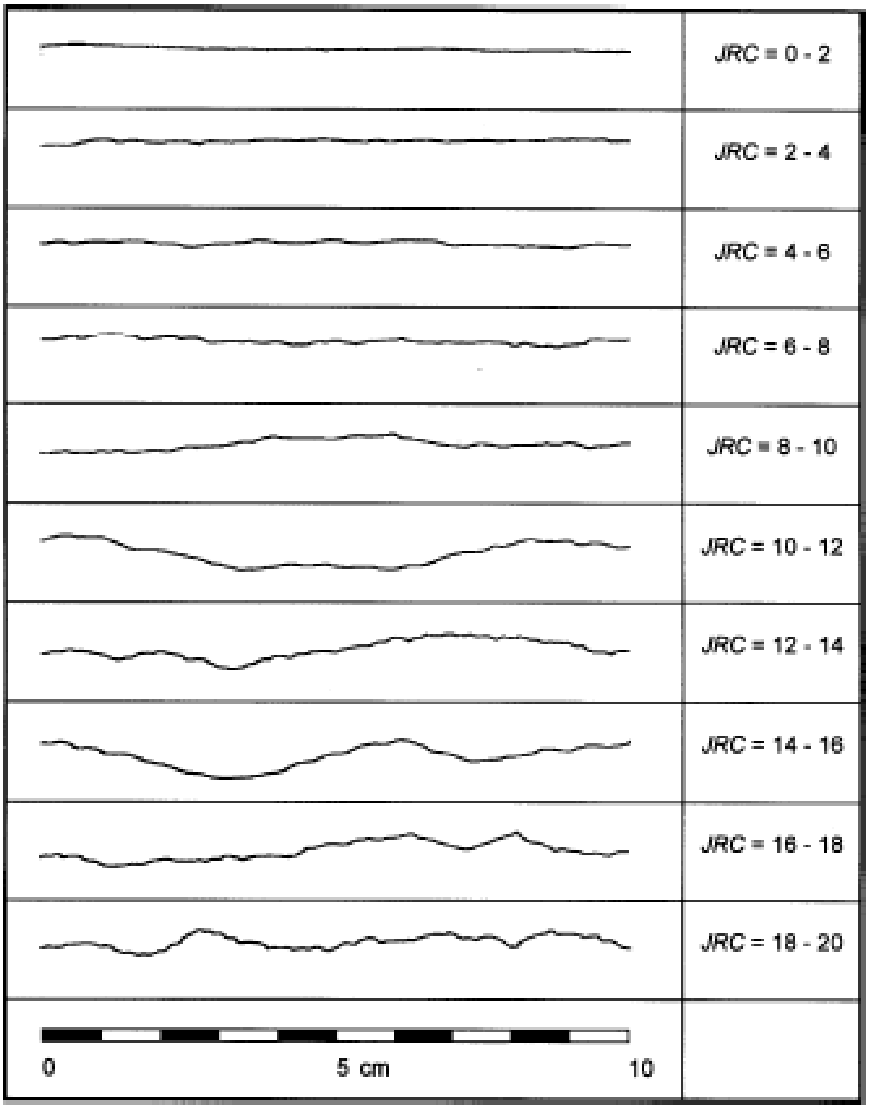

Figure 1: Roughness profiles and corresponding JRC values (After Barton and Choubey 1977).

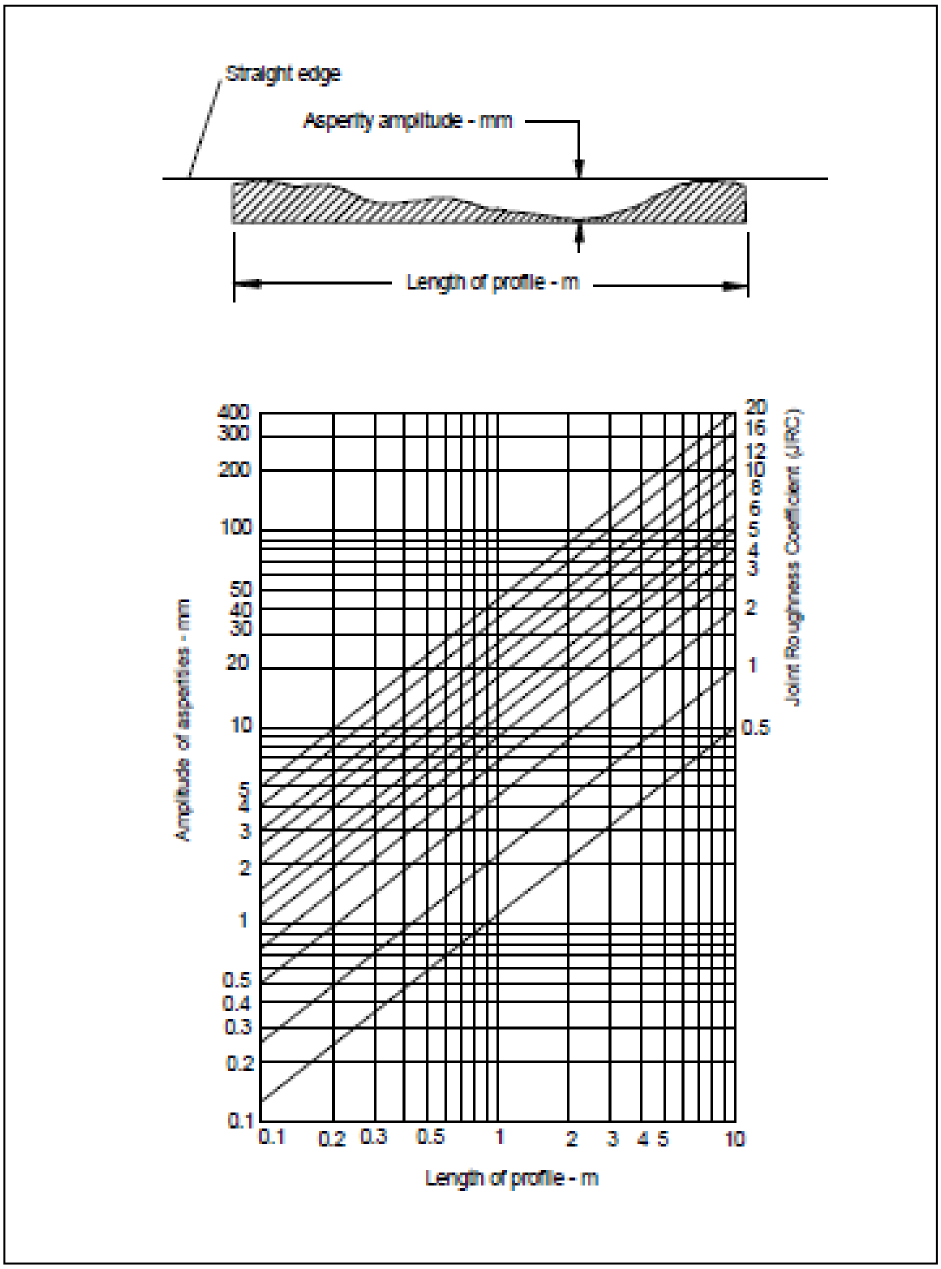

Figure 2: Alternative method for estimating *JRC* from measurements of surface roughness amplitude from a straight edge (Barton 1982).

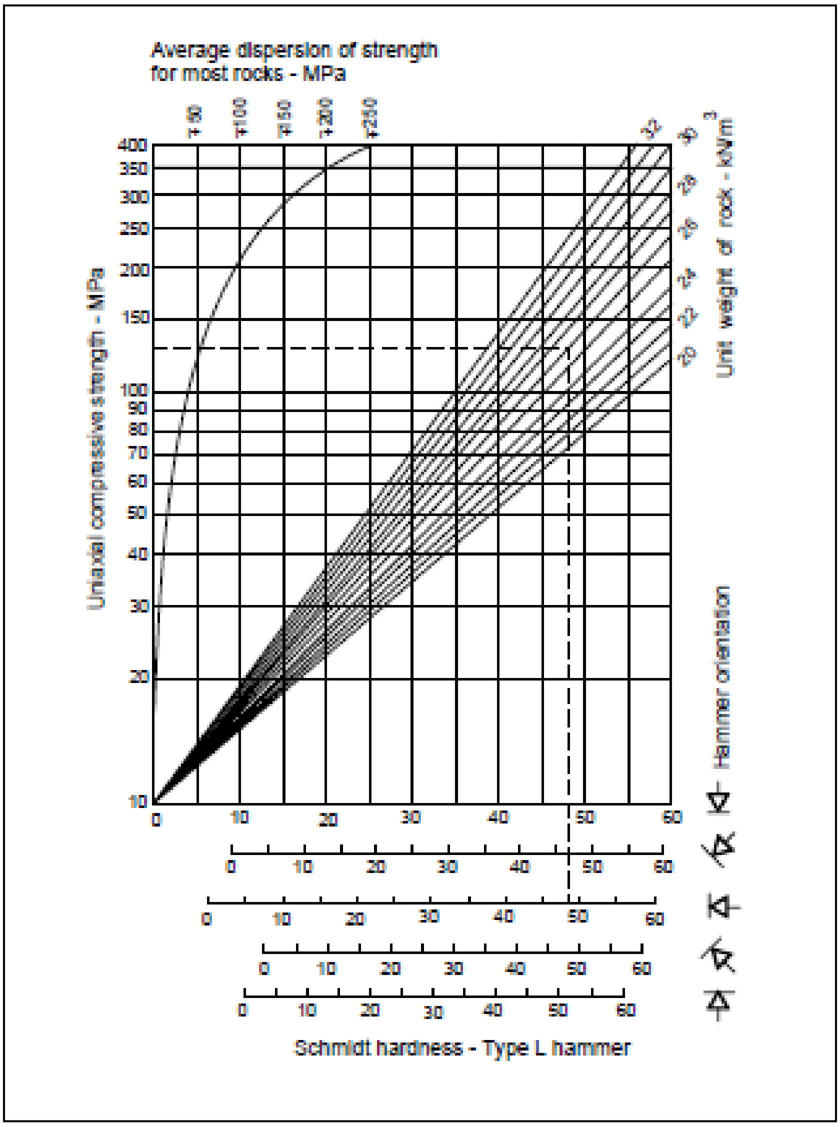

Figure 3: Estimate of joint wall compressive strength from Schmidt hardness. (Deere and Miller 1966)

Barton shear failure criterion

Input parameters:

Basic friction angle (PHIB) - degrees	29
Joint roughness coefficient (JRC)	16.9
Joint compressive strength (JCS)	96
Minimum normal stress (SIGNMIN)	0.360

Normal stress (SIGN) MPa	Shear strength (TAU) MPa	dTAU / dSIGN (DTDS)	Friction angle (PHI) degrees	Cohesive strength (COH) MPa
0.360	0.989	1.652	58.82	0.394
0.720	1.538	1.423	54.91	0.513
1.440	2.476	1.213	50.49	0.730
2.880	4.073	1.030	45.85	1.107
5.759	6.779	0.872	41.07	1.760
11.518	11.344	0.733	36.22	2.907
23.036	18.973	0.609	31.33	4.953
46.073	31.533	0.496	26.40	8.666

Cell formulae:

```
SIGNMIN = 10^(LOG(JCS)-((70-PHIB)/JRC))
    TAU = SIGN*TAN((PHIB+JRC*LOG(JCS/SIGN))*PI()/180)

   DTDS = TAN((JRC*LOG(JCS/SIGN)+PHIB)*PI()/180)-(JRC/LN(10))
          *(TAN((JRC*LOG(JCS/SIGN)+PHIB)*PI()/180)^2+1)*PI()/180

    PHI = ATAN(DTDS)*180/PI()
    COH = TAU-SIGN*DTDS
```

Figure 4: Printout of spreadsheet cells and formulae used to calculate shear strength, instantaneous friction angle and instantaneous cohesion for a range of normal stresses. (Barton 1973)

RESULTS OF TRIAXIAL COMPRESSIVE STRENGTH TESTS

DIVISION OF SOILLAB (PTY) LTD
Tel: 012 481 3894
Fax: 012 481 3812
E-mail: Chenj@rocklab.co.za

Client: OHMS

Samping Site: DiamondEx - Lerala - Botswana

27-Mar-07

SPECIMEN PARTICULARS						SPECIMEN DIMENSIONS					SPECIMEN TEST RESULTS						
Rocklab Specimen No 2868-	Sample No.	Borehole No.	Depth from (m)	Depth to (m)	Rock Type	Diameter mm	Height mm	Ratio of Height to Diameter	Mass g	Density g/cm³	Confining Pressure δ_3 MPa	Failure Load P kN	Strength (TCS) δ_1 MPa	Peak Cohesion Mpa	Friction Angle (°)	Failure Mode	Note
TCS-4a						61.9	129.9	2.1	908.6	2.32	10.0	147.1	48.9	14.0	74.0	XA	
TCS-4b						62.0	120.6	1.9	753.2	2.07	20.0	252.6	83.8			XA	
TCS-07a						61.5	131.7	2.1	947.2	2.42	10.0	183.7	61.8			XA	
TCS-09a						62.5	81.6	1.3	516.5	2.06	5.0	103.2	33.6			1B	
TCS-09b						62.0	117.6	1.9	765.2	2.16	10.0	117.1	38.8	28.4	39.4	1B	
TCS-09c						62.2	116.0	1.9	739.9	2.10	15.0	127.1	41.8			1B	
TCS-09d						61.8	124.9	2.0	803.8	2.15	20.0	103.5	34.5			1B	

Note: All tests were conducted accoridng to the ISRM Specification.
1 - Specimen was failed on laminated plane.

Appendix 7 Geomechanics Classification

Parameter			Ranges of Values						
1	Strength of Intact rock material	Point load strength index	>10 MPa	4-10 MPa	2-4 MPa	1-2 MPa	For this low range – uniaxial compressive test is preferred		
		Uniaxial compressive strength	>250 MPa	100-250 MPa	50-100 MPa	25-50MPa	5-25 MPa	1-5 MPa	<1 MPa
	Rating		15	12	7	4	2	1	0
2	Drill core quality *RQD*		90%-100%	75%-90%	50%-75%	25%-50%	<25%		
	Rating		20	17	13	8	3		
3	Spacing of joints (Js)		>2m	0.6-2m	200-600mm	60-200mm	<60mm		
	Rating		20	15	10	8	5		
4	Condition of joints (Jc)		Very rough surface Not continuous No separation Weathered wall Rock	Slightly rough Surfaces Separation <1mm Slightly weathered Walls	Slightly rough Surfaces Separation <1mm Highly weathered Walls	Slickensided surfaces, or Gouge<5mm thick, or Separation 1-5mm continuous	Soft gouge >5mm thick, or Separation >5mm continuous		
	Rating		30	25	20	10	0		
5	Groundwater (Jw)	Inflow per 10m Tunnel length (l/min)	None	10	10-25	25-125	>125		
		Joint water pressure/major principal stress	0	0.0 – 0.1	0.1-0.2	0.2-0.5	>0.5		
		General Conditions	Completely dry	Damp	Wet	Dripping	Flowing		
	Rating		15	10	7	4	0		
6	Strike and dip orientations of joints*		Very favourable	Favourable	Fair	Unfavourable	Very unfavourable		
	Rating		0	-2	-5	-10	-12		

Rock Type	Parameter	Measurement Description	Rating
Granitic Gneiss	UCS	189MPa	12
	RQD	90%	18
	Js	0,6m – 1,5m	13
	Jc	Slightly rough surfaces Separation <1mm Slightly weathered walls	22
	Jw	Damp	10
Granitic Gneiss	**RMR**		**75**
Kimberlite	UCS	113MPa	11
	RQD	78%	16
	Js	200mm – 600mm	10
	Jc	Slickenside - Slightly rough surfaces Separation 1 - 5mm Highly weathered walls	12
	Jw	Damp	10
Kimberlite	**RMR**		**59**

Rock Type	**Parameter**	**Measurement** **Description**	**Rating**
Kimberlite Breccia	UCS	78MPa	7
	RQD	82%	17
	Js	200mm – 600mm	10
	Jc	Slickenside - Slightly rough surfaces Separation 1 - 5mm Highly weathered walls	12
	Jw	Damp	10
Kimberlite Breccia	**RMR**		**56**
Dolerite Dyke	UCS	211MPa	13
	RQD	72%	15
	Js	200mm – 600mm	10
	Jc	Slickenside urfaces Separation 1 - 5mm Highly weathered walls	10
	Jw	Damp	10
Dolerite Dyke	**RMR**		**58**

Appendix 8 Mining Rock Mass Classification

Parameter		Range of Values										
1	*RQD*	100-97		96-84	83-71	70-56	55-44	43-31	30-17	16-4	3-0	
	Rating (= *RQD* x 15/100)	15		14	12	10	8	6	4	2	0	
2	*UCS* (MPa)	185	184-165	164-145	144-125	124-105	104-85	84-65	64- 45	44-25	24-5	4-0
	Rating	20	18	16	14	12	10	8	6	4	2	0
3	Joint Spacing	Refer Figure 1										
	Rating	25						0				
4	Joint Condition Including Groundwater	Refer Table 1										
	Rating	40						0				

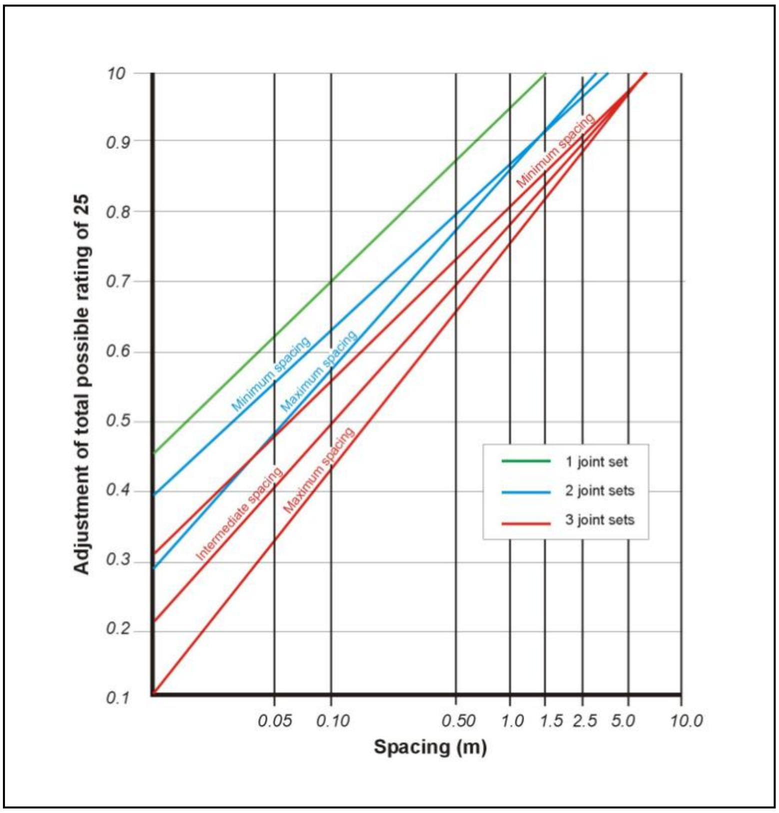

Figure 1 Graph for determination of joint spacing rating

Table 1 Adjustments for Joint Condition and Groundwater

Parameter	Description		Dry Condition	Wet Conditions: Moist	Wet Conditions: Moderate pressure 25-125 1/mm	Wet Conditions: Severe Pressure >125 1/min
A Joint Expression (large scale irregularities)	Wavy	Multi-Directional	100	100	100	95
	Wavy	Uni-Directional	95 90	95 90	90 85	80 75
	Curved		89 80	85 75	80 70	70 60
	Straight		79 70	74 65	60	40
B Joint Expression (small scale irregularities or roughness	Very rough		100	100	95	90
	Striated or rough		99 85	99 85	80	70
	Smooth		84 60	80 55	60	50
	Polished		59 50	50 40	30	20
C Joint Wall Alteration Zone	Stronger than wall rock		100	100	100	100
	No alteration		100	100	100	100
	Weaker than wall rock		75	70	65	60
D Joint Filling	No fill – surface staining only		100	100	100	100
	Non softening and sheared material (clay or talc free	Coarse Sheared	95	90	70	50
		Medium Sheared	90	85	65	45
		Fine Sheared	85	80	60	40
	Soft sheared material (eg talc)	Coarse Sheared	70	65	40	20
		Medium Sheared	65	60	35	15
		Fine Sheared	60	55	30	10
	Gouge thickness <amplitude of irregularity		40	30	10	
	Gouge thickness <amplitude of irregularity		20	10	Flowing material 5	

Table 2 Weathering Adjustment (Laubscher 1993)

Rate of weathering and adjustments (%)					
Description of weathering extent	**6 months**	**1 year**	**2 years**	**3 years**	**4 + years**
Fresh	100	100	100	100	100
Slightly	88	90	92	94	96
Moderately	82	84	86	88	90
Highly	70	72	74	76	78
Completely	54	56	58	60	62
Residual soil	30	32	34	36	38

Table 3 Adjustments to MRMR due to joint orientation (Laubscher 1993)

Number of joints defining the block	**Adjustment (%) Number of faces inclined away from the vertical**				
	70	75	80	85	90
3	3	-	2	-	-
4	4	3	-	2	-
5	5	4	3	2	1
6	6	5	4	3	2 or 1

Table 4 Adjustments for Blasting Effects (Laubscher 1993)

Excavation Technique	**Adjustment (%)**
Boring	100
Smooth wall blasting	97
Good conventional blasting	94
Poor blasting	80

Rock Type	**Parameter**	**Measurement Description**	**Rating**
Granitic Gneiss	RQD	90%	14
	UCS	189MPa	19
	Js	Joints spaced maximum 0.6m apart ; 3 joint sets	18
	Jcw	Curved ; Striated – rough ; Moist ; No alteration ; Non softening sheared material – medium sheared (40 * 0.8 *0 .85 * 1.0 * 0.85)	23
	MRMR		**74**
	Weathering	Fresh	1
	Jo	5 joints defining the block ; 1 face inclined away from the vertical	0.9
	Stress	Surface mining – Concave pit	1
	Blasting	Good conventional blasting	0.94
Granitic Gneiss	**Adjusted MRMR**		**63**
Kimberlite	RQD	78%	12
	UCS	113MPa	12
	Js	Joints spaced maximum 0.4m apart ; 3 joint sets	16
	Jcw	Curved ; Smooth ; Moist ; No alteration ; Soft sheared material – coarse sheared (40 * 0.75 * 0.80 * 1.0 * 0.65)	16
	MRMR		**56**
	Weathering	Highly weathered in 6 months	0.7
	Jo	5 joints defining the block ; 1 face inclined away from the vertical	0.9
	Stress	Surface mining – Concave pit	1
	Blasting	Good conventional blasting	0.94
Kimberlite	**Adjusted MRMR**		**33**

Rock Type	Parameter	Measurement Description	Rating
Kimberlite Breccia	RQD	82%	13
	UCS	78MPa	8
	Js	Joints spaced maximum 0.4m apart ; 3 joint sets	16
	Jcw	Curved ; Smooth ; Moist ; No alteration ; Soft sheared material – coarse sheared (40 * 0.75 * 0.80 * 1.0 * 0.65)	16
	MRMR		**53**
	Weathering	Highly weathered in 6 months	0.7
	Jo	5 joints defining the block ; 1 face inclined away from the vertical	0.9
	Stress	Surface mining – Concave pit	1
	Blasting	Good conventional blasting	0.94
Kimberlite Breccia	**Adjusted MRMR**		**31**
Dolerite Dyke	RQD	72%	11
	UCS	211MPa	20
	Js	Joints spaced maximum 0.3m apart ; 3 joint sets	13
	Jcw	Curved ; Smooth ; Moist ; No alteration ; Soft sheared material – medium sheared (40 * 0.75 * 0.80 * 1.0 * 0.60)	14
	MRMR		**58**
	Weathering	Fresh	1
	Jo	5 joints defining the block ; 1 face inclined away from the vertical	0.9
	Stress	Surface mining – Concave pit	1
	Blasting	Good conventional blasting	0.94
Dolerite Dyke	**Adjusted MRMR**		**49**