Geological Society
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Department of Geology
University of Zimbabwe

Intraplate Magmatism and Tectonics of southern Africa

Conference Fieldtrip Guide:

Alkaline igneous rocks of SE Zimbabwe

3-7 September, 1997

Department of Geology
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FT-5: Alkaline igneous rocks of southeastern Zimbabwe.

Itinerary in brief

Day 1 Wednesday 3rd September, 1997:

Departure at 7.30 am for flight Harare-Beitbridge

- River Ranch Diamond Mine, Beitbridge
- Marangudzi Alkaline Complex, Beitbridge

Spend the night at Lion & Elephants

Day 2 Thursday 4th September, 1997:

- Mutandahwe Alkaline Complex , Chiredzi

Spend the night at the Tambuti Lodge, Chiredzi

Day 3 Friday 5th September, 1997:

- Chishanya Complex
- Bikita Pegmatite

Spend the night at the Lodge of the Ancient City, Mashvingo

Day 4 Saturday 6th September, 1997:

- visit to Great Zimbabwe (early morning visit; optional)
- Shawa Carbonatite Complex

Spend the night in Mutare

Day 5 Sunday 7th September, 1997:

- visit to Dorowa Mine
- Return to Harare via Great Zimbabwe

Excursion guide: Alkaline igneous rocks of southeastern Zimbabwe.

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Wednesday 3rd September, 1997

STOP1. River Ranch Mine

Introduction

River Ranch, situated 13 km west of Beitbridge, is Zimbabwe's only producing full-scale diamond mine, but its opening has triggered a major exploration boom for the mineral and numerous discoveries of kimberlites, many potentially or proven to be diamondiferous, have been made.

The mine is owned and operated by Auridiam Zimbabwe (Pvt.) Ltd., a subsidiary of Auridiam Consolidated of Australia, but it was discovered in 1974 by Kimberlitic Searches Ltd., a local exploration arm of the diamond giant De Beers. KSL held diamond propecting orders and claims until 1991 but they had disagreements with the Zimbabwean government over developing the site and particularly over marketing the diamonds and their claims were revoked by the Ministry of Mines. Auridiam then won a tender bid for the site and began work. (Russell, 1994).

Economics

The mine has exceeded production expectations of 300,000 carats per annum and is now approaching the 0.5 million mark - see Figure 1, which shows Zimbabwe's production since 1990, all River Ranch's. The measured resource of the mine is an estimated 17.5 million tonnes of ore with an operating life of 12 years (Anon., 1995). The major shareholder, the American Redaurum Red Lake Mines Ltd., estimates the mining cost per tonne to be US$7 (Holloway, 1993).

About 60% of the diamonds mined are of cuttable gem quality - indicating both a higher than normal proportion of coarse stones and above average quality. A significant number of stones are over 10 carats and one of 28ct sold for more than US$110,000. (Holloway, 1993). Diamonds are sold to direct dealers in Antwerp, Belgium via the Minerals Marketing Corporation of Zimbabwe.

The mine will be open cast to 150m, with no feasibility studies yet done to decide if a future underground mine could be operated. (Anon., 1995).

Development

A trial mine was opened in 1992 using rotary diamond pan plant separation technology. Up to 800 tonnes a day were milled. Phase two, in 1994 and 1995, increased capacity to 2000-3000 tonnes a day and used a dense medium separation process, which uses cyclones containing ferrosilicone and water. Full production commenced at the end of 1995, using the same technology as phase two but with an enhanced capacity of up to 1.5 million tonnes per annum. (Anon., 1995).

Geology

The River Ranch deposit (Fig. 2) is one kimberlite, 500m by 100m in size, in a cluster of three. They are intrusive into high grade paragneissic rocks of the Central Zone of the Limpopo Mobile Belt and have themselves been intruded by Karoo dolerite dykes. They are high level diatreme kimberlites, mainly tuffisitic facies kimberlites and kimberlite breccias, passing down into hypabyssal facies.

Itinerary

The mine will organise a programme, including a visit to surface geology of the main pit.

References

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Holloway, J. 1993. Zimbabwe- the diamond story. Zim. Min. World, Sept. 93, 3-4
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STOP 2. Marangudzi

The Marangudzi Complex (Fig. 3) is situated 80km ENE of Beitbridge, centred at 22° 00' S and 30°37' E. It covers an area of nearly 80km^2 and is well exposed. The complex is a spectacular example of an acid-basic-alkaline complex. Since it was first mapped for the Ph.D. studies of Gifford (1961) and Rees (1960), it has attracted several workers who studied its age, mineral chemistry, petrography and petrogenesis.

Rock Types

Large volumes of gabbroic material fill the central part of the complex and also most of the adjacent and contemporaneous Madawula Complex to the south-east. These rocks were the subject of paper by Hossein & Henderson (1977), following a Manchester University Ph.D. (Hossein, 1970). They are mesocumulates and orthocumulates and consist of plagioclase (An ±80), augite (with orthopyroxene exsolution lamellae) and olivine. Accessories include minor biotite, orthopyroxene, alkali feldspar, hornblende, magnetite and apatite. The gabbros were the first rocks in the complex to crystallise, from a high-Al basaltic magma transitional between alkali and tholeiitic types, based on clinopyroxene compositions.

The silica oversaturated rocks at Marangudzi are dominantly quartz syenites, although the outer ring is granitic in parts, with up to 30% quartz. They form ring dykes and crop out as well-vegetated kopjes. The quartz syenites are varying mixtures of alkali feldspar, quartz and hornblende. The more quartz-rich varieties are coarse grained, while the others are medium to coarse grained. The microgranite minor intrusions are red coloured if they contain amphibole, otherwise aplitic. Flow banding of rectangular alkali feldspar crystals in the quartz syenites are commonly parallel to the sides of the ring complex, along with mafic xenolith trains and dark irregular schlieren (Broderick, 1979).

The silica undersaturated rocks in order of crystallisation are nepheline monzonite, pulaskite, foyaites and juvite. Nepheline monzonite, mapped as biotite foyaite by Rees and contaminated foyaite by Gifford, is a medium to coarse grained rock consisting of alkali feldspar, nepheline, plagioclase, biotite and ferrohastingsitic amphibole.

Pulaskite, in hand specimen, contains no visible nepheline and comprises potassium feldspar and hastingsite, usual with a coarse grain size. In some places it is banded by a concentration of the amphibole. It is a resistant rock and forms prominent arcuate ridges.

Foyaites are medium to coarse grained rocks of alkali felspar, hastingsite and nepheline. They usually have little or no plagioclase and have orientated tabular alkali feldspars. Xenoliths are common, including various syenites and gabbro.

Juvite forms the last of the intrusions of magma and occurs as a circular outcrop at the top of Marangudzi Hill. It is a nepheline syenite with pseudoleucite crystals, some euhedral, others rounded and more altered, of about 3 to 5cm in diameter.

Minor intrusions occur as a radial dyke swarm. They are of a variety of compositions and different types cut different units of the complex. Dykes of dolerite and micrógranitic composition cut the outer quartz syenite, gabbro and the basement rocks, trachytes and phonolites extend into the quartz syenites and pseudoleucite and porphyritic phonolites cut all the rocks except for the juvite, which has a few lamprophyric dykes.

Age

Early work giving a range of ages for the Marangudzi rocks by K-Ar of 186-195 Ma (Gough et al., 1964, recalculated) was superseded by Rb-Sr ages of 186±3 Ma for a suite of 26 rocks (Foland & Henderson, 1976). More recently, accurate Ar-Ar ages of 178±0.1 Ma were obtained by Landoll et al. (1989). In this last study, only 8 out of 11 samples gave the reported age, with the other 3 giving slightly older ages, believed by the authors to be due to 40Ar gain from late-stage magmatic fluids or fluids derived from country rocks hydrothermally.

Pseudoleucites

One of the impressive features of the Marangudzi complex is the preponderance of pseudoleucite bearing rocks. Pseudoleucites are complex intergrowths of nepheline and alkali feldspar (usually sanidine), typically in pseudomorphs of leucite icosotetrahedra. Fine examples of this morphology are seen in the juvites on top of Marangudzi Hill and in the phonolites radiating out from the centre of the complex.

Leucites of the same sodium-rich composition as pseudoleucites are unknown in nature. For example the Marangudzi pseudoleucites contain up to 9% Na_2O, whereas the maximum in natural leucites is about 2%. Hence, if pseudoleucites are derived from leucite crystals, some ionic substitution of Na for K is probably needed, either in the late or post magmatic stage. Alternatively, pseudoleucites may have been derived from K-rich analcite, which shares leuciteís crystal habit.

Henderson (1965) reported higher Rb and lower Ba and Sr values in Marangudzi pseudoleucites compared to their groundmasses, which he showed could have been due to derivation from either an original leucite or analcite. This is because the ionic arrangement of leucite and analcite is such as to allow Rb into the structure, but exclude Sr and Ba, in contrast to other minerals such as potassium feldspars.

A nepheline monzonite with a fingerprint texture (a vermicular intergrowth of nepheline and alkali feldspar, which has been called pseudoleucite) was reported by Rees (1961) from the western part of the nepheline monzonite ring. It resembles similar intergrowths seen in other intrusions such as Kaminak Lake, Canada and may represent cotectic nepheline-alkali feldspar crystallisation.

Another related texture is a nepheline-plagioclase intergrowth seen in Marangudzi pulaskites (Henderson & Gibb, 1972). Such textures had previously been ascribed to metasomatic replacement of plagioclase by nepheline, but was here interpreted as a late stage magmatic resorption of plagioclase and replacement by nepheline. A similar texture from the foyaites is shown in Figure 4.

Petrogenesis - Crossing the Syenite Divide

Comagmatic acid-basic-alkaline intrusive complexes in theory shouldnít exist! A basic magma can either evolve to an acid or an alkaline composition, due to the thermal divide in the kalsilite-nepheline-silica system. However, several of these intrusions are known and a branching evolution of the magma to both acidic and alkaline compositions can be explained either by contamination or by crystal fractionation.

In the Marangudzi complex all of the rock types are believed to have derived from the same basic parent magma. Foland & Henderson (1976), showed that the ages and initial Sr isotope ratios of a range of rocks from the complex were indistinguishable (at 186Ma and 0.7077 respectively). The initial Sr isotope ratios suggested that contamination was minimal, given the large difference in ratios between the complex and the Limpopo Mobile Belt rocks into which it intrudes (on average 0.75 at the time of intrusion). If a single magma was involved which subsequently fractionated to the quartz and nepheline syenites, it may have been controlled by crystal fractionation, probably by biotite and hastingsite crystallisation.

Later, high precision Sr and Nd isotope data showed some differences between the quartz and nepheline syenites, giving rise to the possibility of different parent magmas (Landoll et al., 1989), but their almost identical ages imply otherwise and support the comagmatic argument. However Landollís work on Nd isotopes showed that the quartz syenites are somewhat crustally contaminated, so whether crystal fractionation or contamination was the driving force behind branching evolution remains to be fully resolved. Perhaps it is time to collect and analyse a more comprehensive set of samples rather than re-run those collected nearly forty years ago!

ITINERARY

A track 0.8 km ~~east~~ west of Madawulo School leads northwards into the complex.

LOCALITY 1. 1.5 km after the turn-off is an outcrop of the outer quartz syenite at 582572.
LOCALITY 2. 4km after the turn-off and about 50m before the stream crossing is in gabbro with minor intrusives, including pseudoleucite phonolite, 610560.
LOCALITY 3. on the hillside, 620555, is in foyaite with minor intrusives including pseudoleucite and porphyritic phonolites, passing into nepheline monzonites on the northern slopes.
Having driven to 625558,
LOCALITY 4. at the base of the next ridge is the next stop, in pulaskite at 625555.
LOCALITY 5. at the top of Marangudzi Hill, 638551, is of juvite. This locality will be included if there is time to climb the hill, if not float will be examined or the stream which leaves the game fence at 637560 will be followed.

References

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Thursday 4th September, 1997

STOP3. Mutandahwe

The Mutandahwe Complex is a syenitic ring complex centred on the hill of Mutandahwe and cut by a major river, the Save, in the south-east of Zimbabwe, north of Gona-re-Zhou National Park. The complex is about 6km in diameter and covers an area of 45km^2. Earlier intrusions of syenite, particularly nordmarkites, and extrusions of felsites and basalts are cut by a later series of granites. A number of brecciated, xenolith-rich, assimilated and hybrid rocks are seen on the edge of the intrusion. The country rocks are Karoo basalts, in which copper/tungsten mineralisation is found in veins and shears connected with the intrusion of the Complex. Minor fluorite/molybdenum mineralisation is seen in the extrusives of the Complex. A detailed map on a scale of 1:50 000 (Choe & Choe, 1987) will be provided on the excursion, whilst Figure 5 summarises the geology of the area.

Rock Types

Karoo basalts in the vicinity of Mutandahwe are of the Upper Series and generally contain no olivine. They are some 3000m thick, fine grained and amygdaloidal with porphyritic and non-porphyritic varieties. Some andesitic ash bands and dolerite sills are seen in the succession. Mineralogically, the porphyritic basalts contain andesitic plagioclase, augite and dark brown glass. Porphyritic varieties include a glomeroporphyritic phenocrysts of tabular feldspar and another with small rounded clinopyroxenes.

The Chiwonje Complex to the south of Mutandahwe, consists of intrusions of granites, a northerly off shoot of the extensive mass of granophyric rocks of the Main Granophyre. The Chironje granites have less than 5% mafic constituents, a small amount of plagioclase, large amounts of microperthite and moderate amounts of quartz. A typical analysis for the Gombi granite, exposed in the Save and Gombe rivers, contains 33% quartz, 53% perthite, 13% plagioclase and 1% biotite (Cox et al., 1965).

Late stage granites of the Mutandahwe Complex itself - the Sabi, Masunji, Loupangwan and Monkey Hill granites are more plagioclase-rich but otherwise resemble the Chironje Granites. The Sabi granite differs in the texture of quartz, with hexagonal bipyramids representing an early phase, unlike the usual interstitial quartz of the other granites.

Extrusive rocks of the Mutandahwe Complex vary in appearance and composition. They range from the basalts described by Cox et al. (1965), which are highly contaminated rocks with abundant xenocrysts of quartz and feldspar and xenoliths of syenite, felsite and basalt, to acid felsites with rhyolite-like flow banding (Wilson, 1973) and some agglomerate/igneous breccia units.

Most of the Mutandahwe Complex consists of syenites, dominantly a pink coloured nordmarkite, i.e., an alkali syenite with 5-8% quartz and with perthite as the dominant feldspar. Coarse and fine grained varieties occur as a series of ring dykes and roof sheets, with the coarser ones more resistant to weathering and forming ridges. They are believed to be later than the finer syenites. The syenites are composed largely of subhedral to euhedral feldspars and variable amounts of hornblende, more in the fine grained rocks.

Hybrid Rocks

Hybrid rocks and intrusion breccias are most common along the Save River in the south and south-west of the complex. They are quartz-bearing syenitic rocks and have assimilated earlier rocks, especially basalts but also other syenites and even rhyolites. Xenoliths of all sizes, from centimeters to several metres, are abundant and may form up to 80% of the rock. They may be unaffected or be rounded and altered by magmatic erosion and reaction. Where xenoliths have been almost completely digested the resulting syenite is porphyritic but ghosts of the original rock may remain.

Several generations of syenite are present and these show remobilisation and mutual assimilation, but usually included material is more mafic than the host rock. The hybrid rocks are usually in the form of ring dykes but they are cut by numerous small dykes of more acid composition.

Economic Geology

Ancient workings have been found around Mutandahwe Hill in quartz-copper carbonate veins and old smelting sites are common, often giving rise to false soil geochemical anomolies. This century there have been several small scale copper and tungten mines in and around the complex, the largest being Cobra/P&O (543 tonnes Cu & 243 tonnes W), Mopani (203 tonnes Cu & 151 tonnes W), Hippo (451 tonnes W) and Buona Fortuna (36 tonnes W). These larger mines are confined to within 4 km of the contact with the syenites and are hosted in sheared Karoo basalt. Gossans and quartz-carbonate veins are the surface expression of the reefs. Tungten and copper mineralisation is believed to be hydrothermally derived and assocaited with the intrusion of the Mutandahwe Complex. Ore minerals include chalcocite, chalcopyrite, wolframite, scheelite, cobaltite, bismuthinite, sphalerite, galena, silver and gold. Gangue is quartz, carbonates (calcite, ankerite and siderite) and fluorite. Despite extensive exploration activities in the 1980's, no currently economic deposits exist, although Buona Fortuna has been looked at for tungten, fluorite and rare earths.

In the extrusive rocks of the complex is the Lazeno deposit. This is hosted by a vent breccia/agglomerate with angular clasts of aplitic syenite. Mineralisation occurs in the matrix and in joint fillings and comprises fluorite, molybdenite, pyrrhotite, sphalerite, chalcopyrite and scheelite. It was also assessed in the 1980's by the Zimbabwe Mining Development Corporation, and found to be 150 m by 30 m in size with mineralisation to a depth of at least 100m. However, it was not considered economic to mine at that time.

ITINERARY

STOP 3a. Buona Fortuna Mine

Turn off after bridge 22, on the road around the north side of Mutandahwe Hill. The mine is situated on the northern edge of the complex.

LOCALITY 1. is the tips of the now defunct mine, 762195, where unaltered and undeformed basalt occurs with more altered and deformed basalt and vein material containing copper sulphides, scheelite and ankeritic and calcitic carbonate.
LOCALITY 2. on the track to the south of the mine tips, 761195, is an outcrop of sheared basalt, caused by forceful intrusion of the complex.
LOCALITY 3. on the hillside further south, 758195, is in coarse grained syenite with various intrusive features and mafic crystal segregations.

STOP 3b. Central Part of the Complex

2.8km from the Buona Fortuna turn-off is a track leading S into the complex.

LOCALITY 4. is in volcanic breccias and flow banded felsites of the extrusive phase, at 740198.
LOCALITY 5. is in the stream bed at 735185, where fine grained Masunji Granite and coarse grained Monkey Hill Granite crop out.

STOP 3c. Save River Section

3.5km after the previous turn-off a track follows a small hill round to Hippo Mine. When the track heads south at 700201, leave the vehicles and walk east down to the Save River. A traverse will be made from country rock basalts through felsite with abundant basalt xenoliths into the main complex. Here a number of granites, syenites and hybrid rocks will be examined, including spectacular intrusion breccias and a host of intrusive relationships.

STOP 3d. Gombe River

If there is time we will look at outcrops of the Chironje (Gombi) Granite in the Gombe River, 695215, close to Hippo Mine.

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Friday 5th September, 1997

STOP 4. Chishanya

Of all the alkaline igneous bodies in south-eastern Zimbabwe, Chishanya (Fig. 6) has the highest proportion of carbonatite and has been extensively explored as a carbonate resource. It occurs in the Save river valley, 25km north of Birchenough Bridge. The complex has two main intrusive centres and consists of a series of sheets of carbonatite, melteigite and foyaite intruding fenitised granite basement. Following a brief report by Swift (1952), the most comprehensive work on Chishanya is by Bowen in his M.Phil thesis (1977), which is summarised in the Geological Society of South Africa's Mineral Deposits Volume (Bowen, 1986).

Geology

The Chishanya intrusion has been dated at 127±4 Ma by a single K-Ar analysis in biotite, which would make it considerably younger than Dorowa or Shawa, to which otherwise it is comparable in terms of rock types and location. Much of the complex is situated between two NNE trending faults, marked by sheared granite and quartz veining. The complex consists of sheets of carbonatite and melteigite, vaguely concentric aroung Chishanya and Baradanga Hills but otherwise randomly orientated, an unusual feature for carbonatite intrusions.

Chishanya has attracted interest as a potential source of calcium carbonate, phosphate and base metals but is sub-economic for all of these at present. Exposure is poor of most rock types except the carbonatites which led to an over-estimation of the amount of carbonate rocks in early mapping and prospecting.

Carbonatites vary from pure white s˚vites to highly ferruginous beforsites. The latter contain more accessory minerals. Ferruginous carbonates often contain octahedral magnetite crystals in clusters giving rise to jagged outcrops, and magnetite may form up to 70% of the rock. Pyrite also occurs but is oxidised at the surface so is not seen in outcrop. Phlogopite and aegirine are other accessory minerals, and apatite occurs in microcrystalline stringers and lenses. Local quartz veining and replacement textures are present.

Melteigites are dark green to black, aegirine-nepheline rocks with accessory biotite, olivine, phlogopite, apatite, magnetite and pyrite. Aegirine (or sometimes aegirine-augite) is the dominant mineral, with subhedral, clear nepheline forming up to 30% of the rock. Some samples contain highly altered sodic microcline which may mean that the melteigites are of metasomatic origin (Swift, 1952), but their field relations intimately associated with carbonatites as composite dykes suggests that they are igneous (Bowen, 1986).

Other igneous rocks of the complex include a distinctive body of foyaite seen on Chishanya Hill and a suite of nepheline-bearing dyke rocks. The granitic country rocks are extensively fenitised, up to 5km away. Their distribution is related more to the regional fracture pattern than to the outcrops of carbonatite and melteigite and unaltered granite can be seen in places close to the centre of the complex. Finally, a sedimentary rock, a conglomerate containing all of the Chishanya rocks crops out on the slopes of Baradanga between 600 and 650m, representing an earlier erosion surface.

ITINERARY

The visit will comprise a walk up the SW ridge of Baradanga, from the road at 161265 to the summit at 170271. On this traverse the fenites, carbonatites, melteigites and conglomerate will be seen. Magnetite and apatite-rich rocks are common in this area and the field relations of the different units can be studied.

For the group remaining at Chishanya for the day, it is suggested that a traverse around Chishanya Hill to the foyaite outcrop at 148265 and back over the hill is undertaken.

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STOP 5. **Bikita**

We stray a little off the alkaline rocks theme to visit a classic geological locality en route to our hotel, the Bikita Pegmatite, source however of large quantities of two alkali metals lithium and caesium. Bikita Mine (Figs 7, 8) is 65 km east of Masvingo, where a series of 2.6Ma lithium and beryllium pegmatites cut the eastern end of the Masvingo (Fort Victoria) Greenstone Belt and basement granites. Currently, Bikita is mined for four minerals: petalite, a spodumene-quartz intergrowth (SQI), pollucite and feldspar. Business is booming with production expected to top 50 000 tonnes this year.

Geology

The pegmatites generally strike north-south with a relatively flat (15-45°) easterly dip. Wall rocks are basaltic greenstones which have been weathered to soft, green clays. Hanging-wall alteration and metasomatism have produced black tourmalines on the top contacts in Bikita Quarry. The pegmatites were first mined in 1911 for tin and later for tantalum and beryl, but not until the 1950's for lithium. Since then lithium has been the major ore, in the form of petalite, spodumene, amblygonite, eucryptite and lepidolite. The mineral bikitaite, a hydrated spodumene, was first discovered at the mine and named after it (Daltry, 1994). Two main quarries are exploited: Bikita and Al Hayat.

Bikita Quarry

Bikita Quarry was the source of large quantities of lepidolite but now is the main source of petalite. Several adits have been cut into the east face of the quarry to assess future reserves. The quarry shows a strong zonation in its minerals, as described in the table below, after Marsh (1982).

Zone	Mineralogy	Thickness (m)
HANGINGWALL GREENSTONE	Tourmaline -quartz veins	0.1-0.5
BORDER ZONE	Quartz-plagioclase selvedge	0.01-0.2
UPPER WALL ZONE	Muscovite-zinnwaldite band Feldspar zone	0.3-0.4
UPPER INTERMEDIATE ZONE	Petalite zone Spodumene-quartz zone Pollucite zone	2-20 3-12 5-10
CORE ZONE	Quartz shell Feldspathic lepidolite core	5 up to 20
LOWER INTERMEDIATE ZONE	Cobble zone (spherical lepidolite in quartz-albite) Feldspathic lepidolite zone	 5-15 5-20
LOWER WALL ZONE	Feldspar-beryl zone Spotted Dog zone (feldspar-lepidolite)	2-5 2-5
FOOTWALL GREENSTONE		

Al Hayat Quarry

Al Hayat is separated from the Bikita Quarry by a cross cutting shear zone. On the upper benches petalite is the main mineral, with spodumene-quartz on the lower level. Pollucite also occurs in a characteristic lepidolite-veined habit.

Minerals

For those rusty on lithium and caesium minerals here is a quick guide to those found at Bikita:

Mineral	Formula	Colour & Habit
AMBLYGONITE	$LiAlPO_4(F,OH)$	white, waxy lustre, two cleavages, elephant skin weathering
BIKITAITE	$LiAlSi_2O_6$ H2O	cream to colourless, skeletal and prismatic crystals
EUCRYPTITE	$LiAlSiO_4$	hard to tell from quartz, but fluoresces pink
LEPIDOLITE	$KliAl2Si_3O_{10}(OH,F)_2$	lilac, micaceous
PETALITE	$LiAlSi_4O_{10}$	clear, well developed 001 cleavage
POLLUCITE	$Cs_2Al_4Si9O_{24}(OH)_2$	white, weak cubic cleavage, occurs with thin lepidolite veins
SPODUMENE	$LiAlSi_4O_{10}$	white, prismatic, 90∞ cleavage
ZINNWALDITE	$KLiFeAlSi_3O_{10}(OH,F)$	grey-brown to pale lilac, micaceous

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Saturday 6th September, 1997 & Sunday 7th September, 1997

Geology and geochemistry of the Buhera Carbonatite Complexes and associated nephelinitic magmatism

No detailed 'Itinerary of stops' is provided for the visits to the Dorowa and Shawa Carbonatite Complexes and associated alkaline intrusions on days 4 & 5: the number and nature of stops will largely be dictated by access, time, and quarrying activity in the Dorowa Pit. An overview of the general geological relationships is provided below followed by an outline of the features which will be illustrated in the stops. These will be selected to provide material for (hopefully) lively debate on outcrop!

General Geology

The Dorowa and Shawa carbonatites (Fig. 9) intrude Precambrian basement gneisses in south-eastern Zimbabwe and are associated with silica-undersaturated intrusives which occur as small plugs of olivine ijolite (Zwibi and Chikomo plugs) and a regional swarm of fine-grained nephelinitic dykes.

The geology of the Dorowa and Shawa complexes has been described by Johnson (1961, 1966) and Lee (1973). The only published age information on these rocks is the Rb-Sr date of 205 ±32Ma for biotite from ijolite in the Shawa Complex by Nicolaysen et al. (1962; recalculated).

STOP 6. Shawa

Shawa is a circular plug-like intrusion some 5.5 km in diameter composed largely of serpentinised dunite/olivinite surrounded by arcuate zones of ijolitic (nepheline - aegirine-augite) rocks on the south-western and north-eastern sides. Metasomatic rocks (fenites) with syenitic mineral assemblages occur at the contacts between the intrusion and the gneissic basement country rocks. Dolomitic carbonatite occurs as a steeply inclined ring dyke 1.6 km in diameter in the centre of the dunite plug. Late stage hydrothermal alteration of the ijolite body in the north-east has given rise to the development of mica, now altered to vermiculite.

Although largely serpentinised, outcrops of very fresh dunite occur in the southern part of the plug and are composed almost exclusively of coarse, polygonal aggregates of highly magnesian (Fo>80) olivine along with minor and variable amounts (usually as bands) of magnetite and spinel. The occurrence of magnetite with magnesian olivine is unusual but is a feature of the ultramafic associated with the carbonatites of the Turiy Mis, Russia, where the olivine-rich ultramafics are termed 'olivinites' rather than dunites because of the occurrence of magnetite.

The dolomite carbonatite ('beforsite') ring dyke varies from 30-400m in width and is built of several periods of carbonatite intrusion as evidenced by cross-cutting relationships between different phases of the generally well-foliated carbonatite types in the dyke. Numerous small dykes cut the serpentinite with no apparent preferred orientation. Accessory minerals in the carbonatites are magnetite, phlogopite and apatite.

Ijolitic rocks occur as two bodies on the outer contact of the serpentinite plug: a larger arcuate body along the western margin and a smaller, and more irregular patch in the north-east. The ijolite in the western body becomes finer-grained towards the inner contact with the serpentinite which Johnson (1961) regarded as a 'chill-zone'. In thin section the Shawa ijolites show no igneous features and new unpublished geochemical and isotopic data (Harmer and C.A. Lee) suggest that these rocks represent high-grade fenites rather than an igneous component of the Complex. Ijolites produced by extensive fenitisation have been described from Spitskop (Harmer, 1992), Iivaara (Kramm, 1994) and Dorowa (Johnson, 1961).

ITINERARY

STOP 6b. Shawa Complex

LOCALITY 1. outcrops of the fresh dunite/olivinite containing veinlets and disseminated magnetite
LOCALITY 2. ijolites of the western body
LOCALITY 3. vermiculite mineralisation in altered ijolites in the north-eastern body
LOCALITY 4. the dolomite-carbonate ring dyke

STOP 6b. Hande River

Short traverse up the Hande River to view the several nephelinitic dykes of the regional dyke swarm

STOP 6c. Chikomo Olivine Ijolite Plug (Time permitting)

STOP 7. Dorowa

The Dorowa Complex is essentially composed of a huge area of fenitised basement rocks approximately 3 km by 1.5 km in extent in which a relatively small amount of carbonatite occurs as several thin dykes and a small plug.

Fenite assemblages range from quartz syenitic through quartz-free syenitic ('pulaskitic') to nepheline syenitic and ijolitic. The high-grade, nepheline-bearing fenites were mapped as three NE-SW trending patches in the southern part of the fenite complex Johnson (1961). Petrographic features of the Dorowa fenites were documented by Lee (1973). In the lower grade (quartz syenite) fenites aegirine is seen replacing quartz along grain margins and is also seen lining joints in the gneiss. Original feldspars are preserved and the biotite of the gneiss exhibit reaction rims of potash feldspar and aegirine. The syenitic fenites are composed of feldspar and pyroxene with the transition into these medium-grade fenites being marked by the total disappearance of quartz. Feldspars consist of microcline remnants from the gneisses surrounded by mosaics of clear sodic plagioclase crystals having perthitic cores; pyroxenes are aegirine-augite and occur as aggregates of radiating crystals and in veins with apatite and sometimes perthite. Fenites mapped as ìpulaskiticî by Johnson (1961) are coarse-grained, grey-pink rocks composed of perthite, aegirine-augite and minor nepheline in which the original gneiss feldspar is no longer recognisable. Apatite, calcite and zeolite are accessory minerals. Acmite content of the aegirine-augite increases from ±25% in the quartz syenite fenites, to 35-50% in the syenites and 55% in the 'pulaskitic' fenites (Lee, 1973). In the highest grade fenites feldspar is subordinate or absent. These 'ijolitic' fenites are generally medium-grained although coarse pegmatoidal patches are sometimes seen. Relationships between these and the 'pulaskitic' fenites are complex and Lee (1973) notes occurrences where sharp contacts occur suggesting that a degree of mobilisation and rheomorphism of the fenites may have occurred.

The largest carbonatite body is plug-like, 100x150m in size, and composed of calcite-carbonatite containing a substantial band of dolomite carbonatite. The dolomitic carbonatite is coarse-grained, brown-weathering and well-foliated. A phase of the carbonatite contains large, 3-5cm diameter crystals of clear dolomite set in a fine-grained, highly foliated groundmass of brown-weathering dolomitic carbonatite; individual macrocrysts are rimmed by overgrowths of iron-rich carbonate. This was originally referred to as a 'porphyritic beforsite' by Johnson (1961). The macrocrysts have irregular, fractured outlines and are clearly not phenocrysts - instead, these large crystals are thought to represent grains from an early cumulate entrained and disrupted by the emplacement of the carbonatite plug. Calcitic carbonatites occur as small, fine-grained dykelets (the alvikites of Johnson, 1966). Both carbonatite compositions cut all types of fenite and their emplacement to the current erosion level clearly post-dates the peak of the metasomatism.

It is inconceivable that the large volume of fenites, and the intense and pervasive nature of the metasomatism, could have been produced by fluids associated with the small bodies of carbonatite currently exposed: it would rather appear that at the current erosion level the Complex is positioned close to and over a substantial body of carbonatite at depth. The central parts of the complex are currently quarried for phosphate which is contained in a swarm of magnetite-apatite sheets which intrude the fenites. These sheets are typically 20-50cm in width, and are commonly zoned with coarse magnetite grains concentrated towards the cores of each sheet. In the central parts of the Dorowa Minerals pit the density of these sheets are such that the spacing between sheets is typically less than 1m. The material in the sheets presumably also represents P_2O_5 - $FeO.Fe_2O_3$ enriched fluids released from the buried carbonatite body.

Nephelinites

Ijolitic silicate assemblages interpreted as having metasomatic origins have been described from both the Dorowa and Shawa Complexes. Clearly magmatic intrusions of nephelinitic/ijolitic character are also found in this area: a regional swarm of nephelinitic dykes are well exposed in several of the river courses whereas two small circular plugs of olivine-bearing ijolite, termed Zwibe and Chikomo, occur in close proximity to Dorowa.

Zwibe and Chikomo Plugs

Both these plugs are small, less than 100-150m in diameter. The Zwibe plug occurs less than 1km to the west of the southern edge of the Dorowa fenites whereas Chikomo lies some 4.5km to the south-south east. Zwibe has no positive relief whereas Chikomo forms a low hill. Both plugs are composed of coarse-grained ijolite in which forsteritic olivine occurs with aegirine-augite, nepheline and biotite with minor amphibole, apatite and titano-magnetite.

Dykes

Dykes of fine-grained, generally porphyritic nephelinite are commonly seen cutting the basement gneisses and Proterozoic dolerites of the Mashonaland Suite in most of the river beds between the Dorowa and Shawa complexes and are particularly well exposed along the Hande River.

Nepheline and aegirine-augite are the most common phenocryst phases while coarse apatite is commonly found as a phenocryst phase in some dykes.

ITINERARY

STOP 7a. Dorowa Complex in the Quarry pit of Dorowa Minerals

LOCALITY 1. examples of the different fenites;
LOCALITY 2. phosphate - magnetite sheets cutting fenites;
LOCALITY 3. carbonatite plug with iporphyritic beforsiteî

STOP 7b. Zwibe Ijolite plug

Differentiated ijolite intrusion into basement gneisses close to outer margin of the Dorowa fenites.

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Kramm, 1994.
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Acknowledgements

The following sources for some of the figures are acknowledged:

Fig. 2: Kitshoff (1996) - Auridiam Zimbabwe (Pvt.) Ltd.
Fig. 3: Foland et al. (1989) - Journal of Geophysical Research
Fig. 5: Choe & Choe (1982) - Zimbabwe Geological Survey
Fig. 6: Bird (1986) - Geological Society of South Africa
Fig. 7: Sutton (1987) - Bikita Minerals (Pvt.) Ltd.
Fig. 8: Anon. (1986) - Chamber of Mines Journal (Zimbabwe)
Fig. 9: Johnson (1961) - Geological Society of South Africa

Special thanks to Auridiam Zimbabwe (Pvt.) Ltd, Bikita Minerals (Pvt.) Ltd and Dorowa Minerals (Pvt.) Ltd. for permission to visit their mines. Also to Tim Nutt & Associates for developing costs of Figure 4 and to Lodge of the Ancient City for accommodation during a reconnaissance trip in March 1997.

Fig.1. Zimbabwe Diamond Production 1990-1996

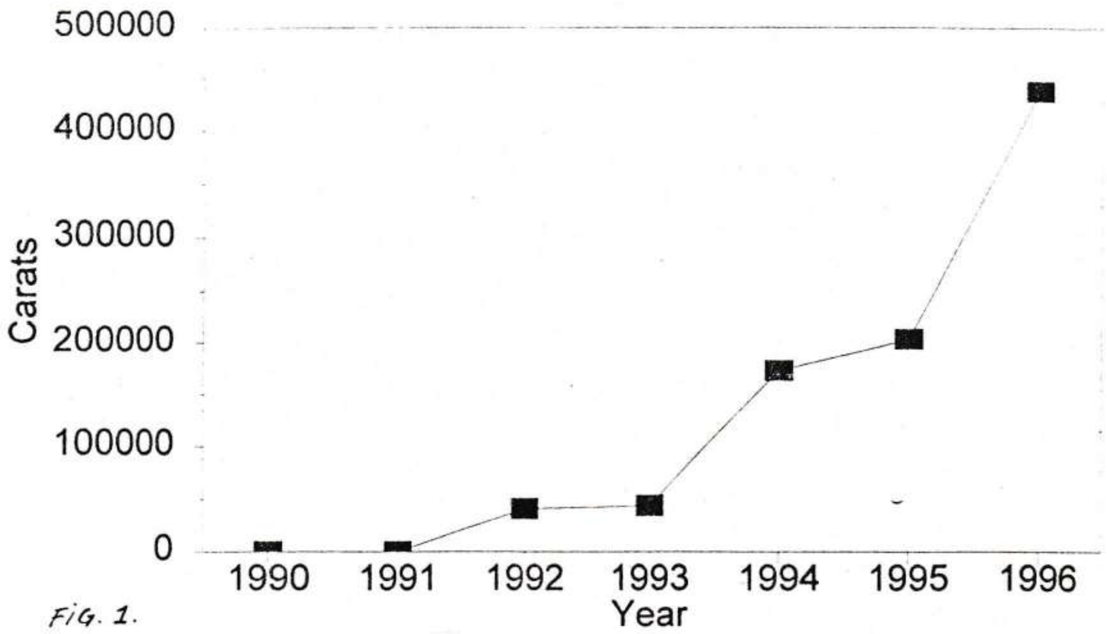

Fig. 1.

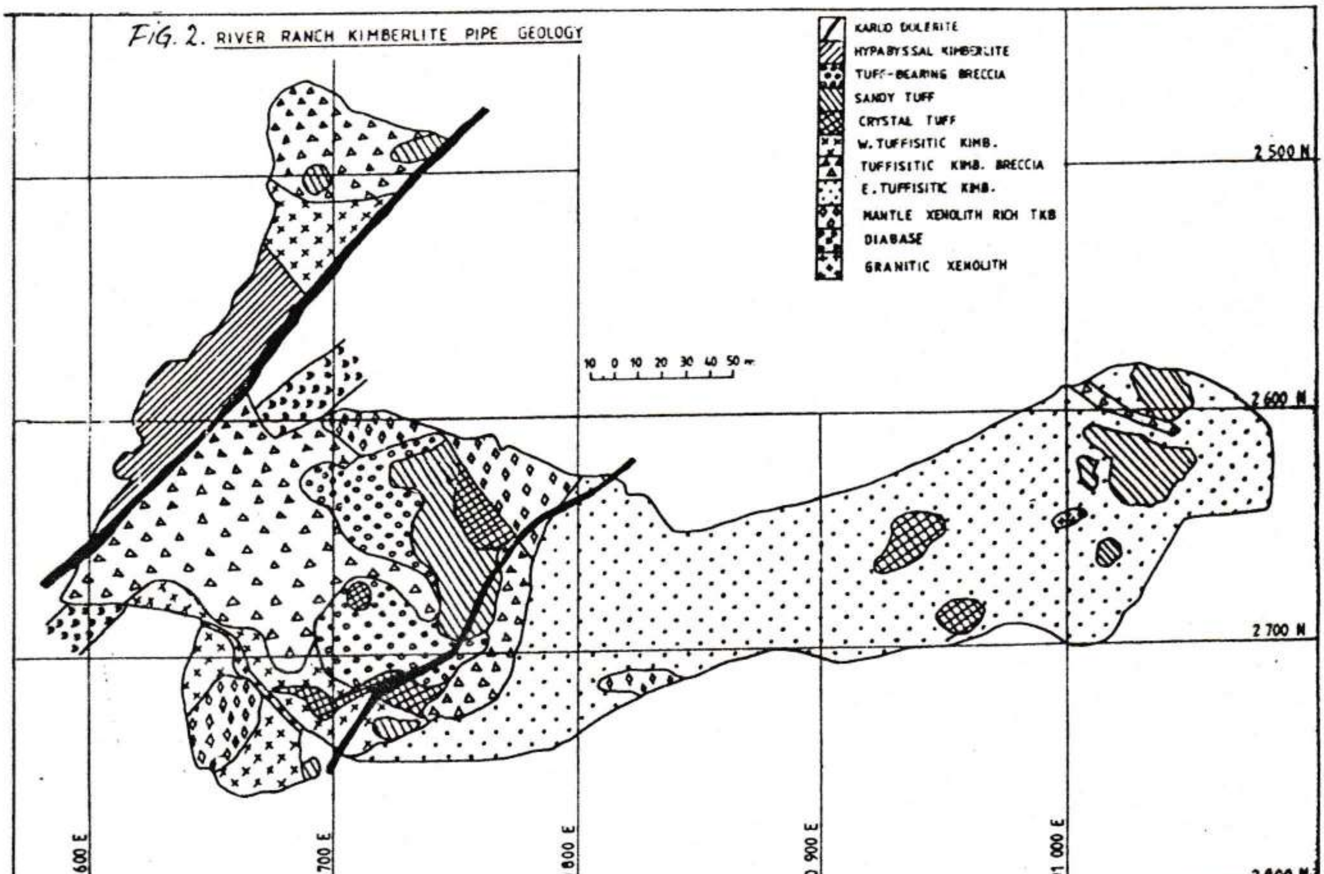

Fig. 2. RIVER RANCH KIMBERLITE PIPE GEOLOGY

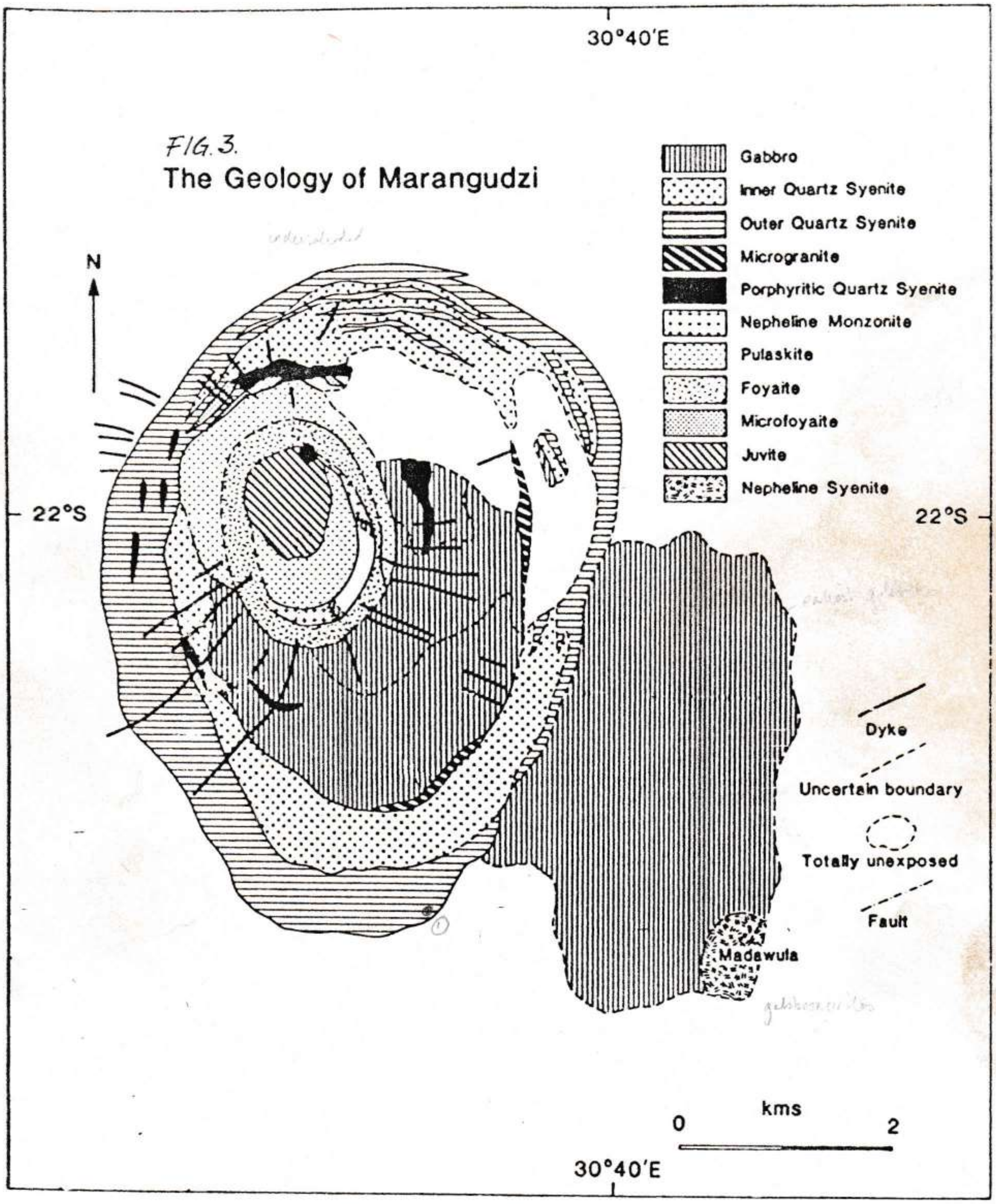

FIG. 3.
The Geology of Marangudzi

Fig. 4.

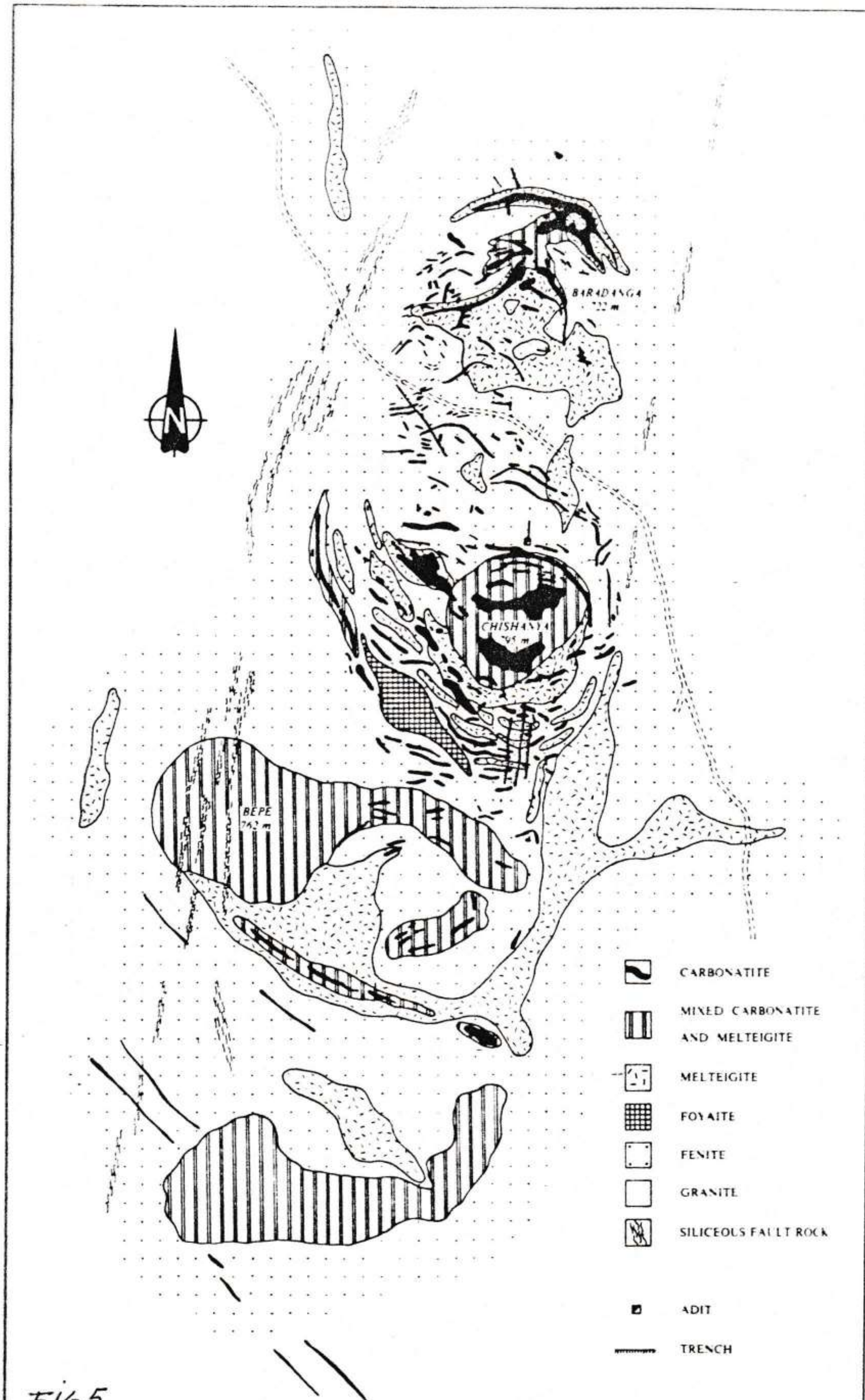

FIG. 5.

Geological map of the Chishanya Complex

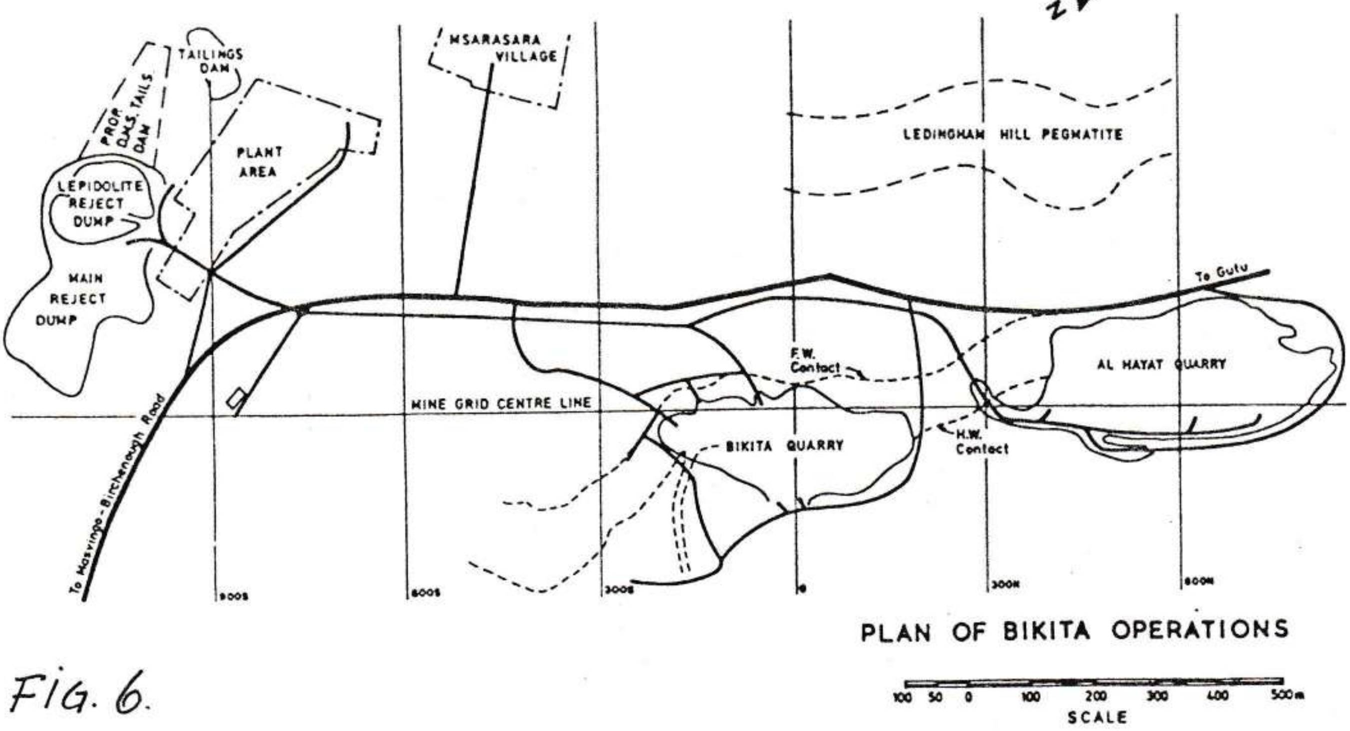
TAILINGS DAM
PROP. D.M.S. TAILS DAM
MSARASARA VILLAGE
PLANT AREA
LEPIDOLITE REJECT DUMP
MAIN REJECT DUMP
LEDINGHAM HILL PEGMATITE
To Gutu
F.W. Contact
AL HAYAT QUARRY
MINE GRID CENTRE LINE
BIKITA QUARRY
H.W. Contact
To Masvingo - Birchenough Road
900S
600S
300S
300N
600N
PLAN OF BIKITA OPERATIONS
100 50 0 100 200 300 400 500m
SCALE

FIG. 6.

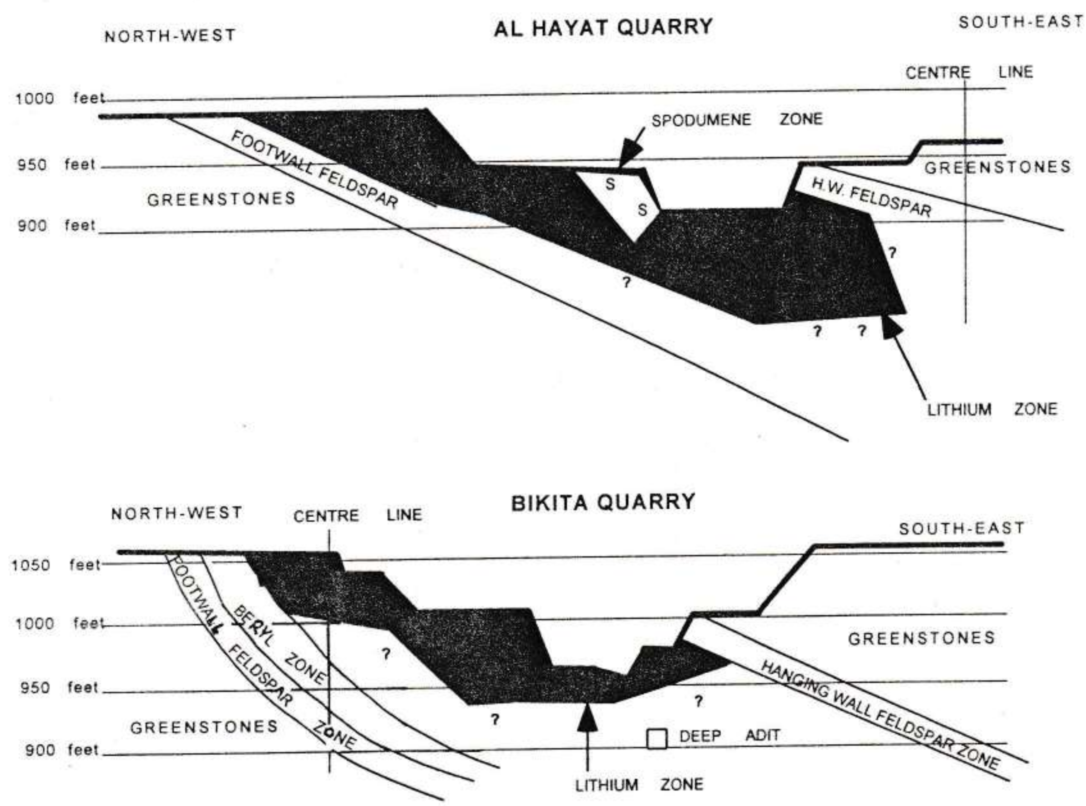
NORTH-WEST
AL HAYAT QUARRY
SOUTH-EAST
CENTRE LINE
1000 feet
SPODUMENE ZONE
950 feet
FOOTWALL FELDSPAR
S
S
GREENSTONES
H.W. FELDSPAR
900 feet
GREENSTONES
?
?
? ?
LITHIUM ZONE
NORTH-WEST
CENTRE LINE
BIKITA QUARRY
SOUTH-EAST
1050 feet
1000 feet
FOOTWALL FELDSPAR ZONE
BERYL ZONE
GREENSTONES
?
950 feet
HANGING WALL FELDSPAR ZONE
?
?
GREENSTONES
DEEP ADIT
900 feet
LITHIUM ZONE

FIG. 7.

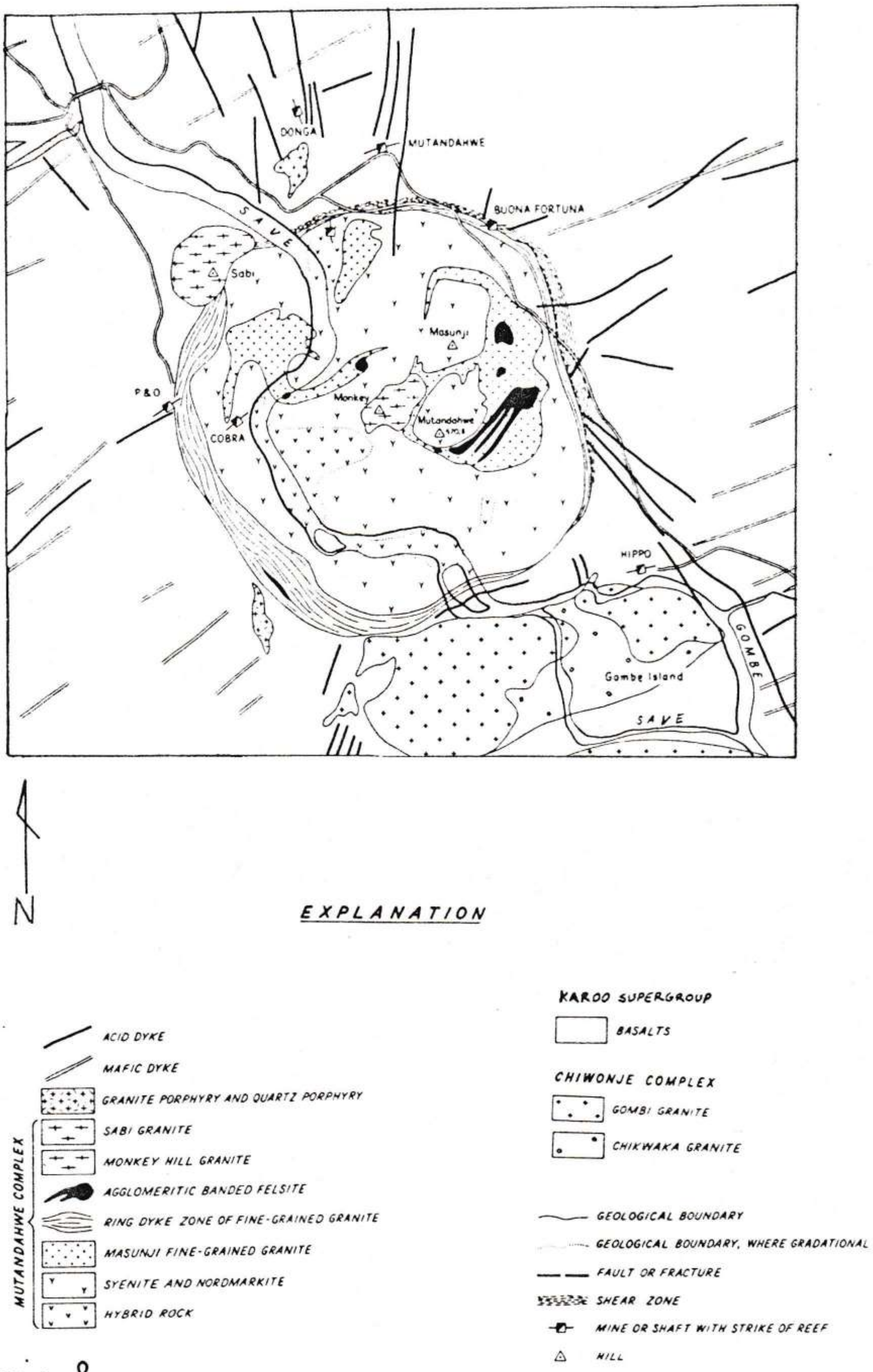
DONGA
MUTANDAHWE
BUONA FORTUNA
SAVE
Sabi
Masunji
Monkey
Mutandahwe
P&O
COBRA
HIPPO
GOMBE
Gombe Island
SAVE
N
EXPLANATION
ACID DYKE
MAFIC DYKE
GRANITE PORPHYRY AND QUARTZ PORPHYRY
MUTANDAHWE COMPLEX
SABI GRANITE
MONKEY HILL GRANITE
AGGLOMERITIC BANDED FELSITE
RING DYKE ZONE OF FINE-GRAINED GRANITE
MASUNJI FINE-GRAINED GRANITE
SYENITE AND NORDMARKITE
HYBRID ROCK
KAROO SUPERGROUP
BASALTS
CHIWONJE COMPLEX
GOMBI GRANITE
CHIKWAKA GRANITE
GEOLOGICAL BOUNDARY
GEOLOGICAL BOUNDARY, WHERE GRADATIONAL
FAULT OR FRACTURE
SHEAR ZONE
MINE OR SHAFT WITH STRIKE OF REEF
HILL

FIG. 8.

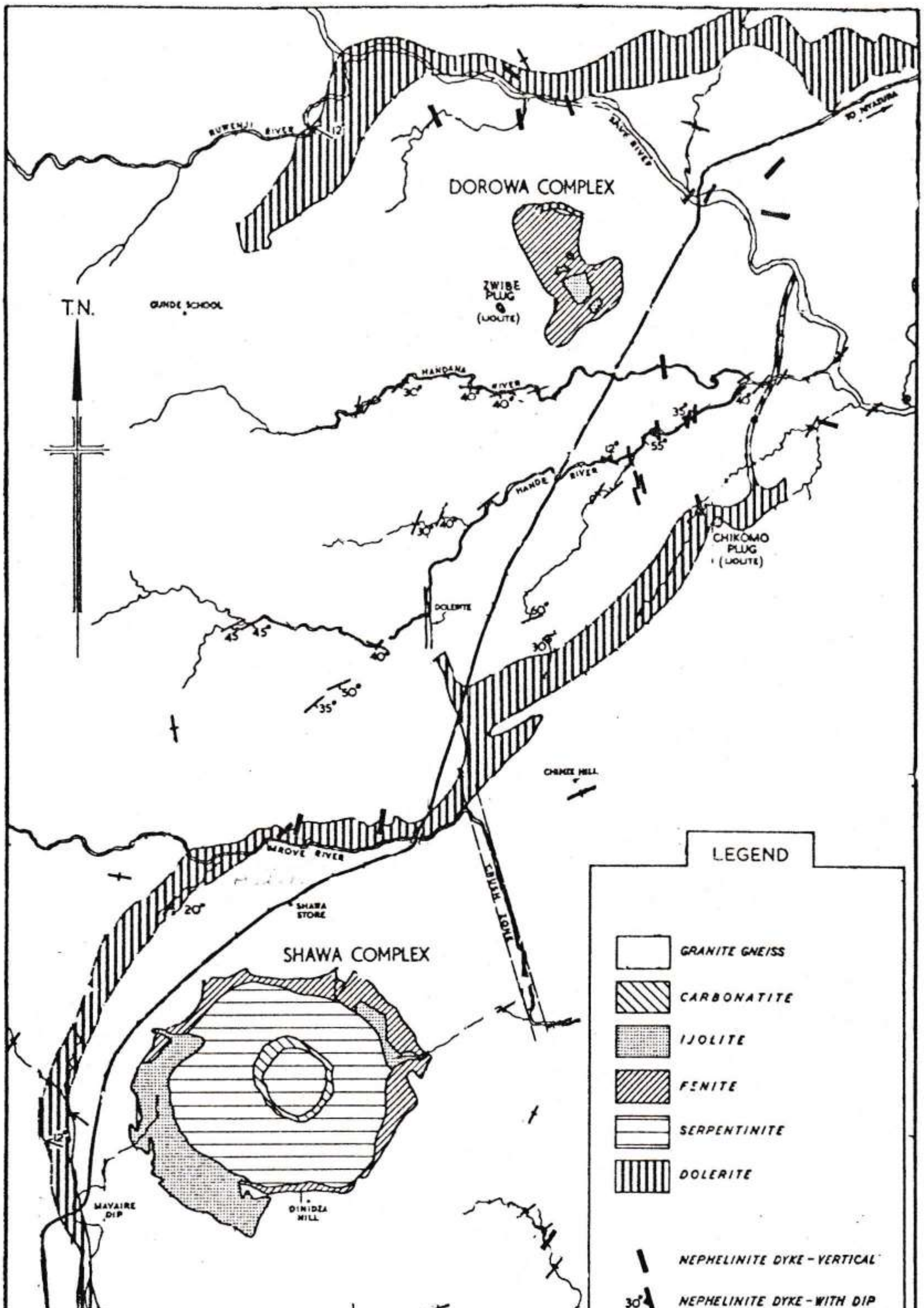
DOROWA COMPLEX
ZWIBE PLUG
(IJOLITE)
T.N.
CHIKOMO PLUG
(IJOLITE)
DOLERITE
SHAWA COMPLEX
SHAWA STORE
MROVE RIVER
MAYAIRE DIP
DINIDZA HILL
NESHAVA SCHOOL
SHEAR ZONE
LEGEND
GRANITE GNEISS
CARBONATITE
IJOLITE
FENITE
SERPENTINITE
DOLERITE
NEPHELINITE DYKE - VERTICAL
NEPHELINITE DYKE - WITH DIP
FOLIATION - VERTICAL
FOLIATION - WITH DIP
DIP OF DOLERITE-GNEISS CONTACT
GEOLOGICAL BOUNDARY
GEOLOGICAL BOUNDARY -POSITION UNCERTAIN
ROAD (POSITION SOUTH OF MROVE RIVER VERY APPROXIMATE)
0
1
2
SCALE IN KM

FIG. 9