Geological Society of Zimbabwe

Field Excursion Guide-

Mistress Mine, Zimbabwe

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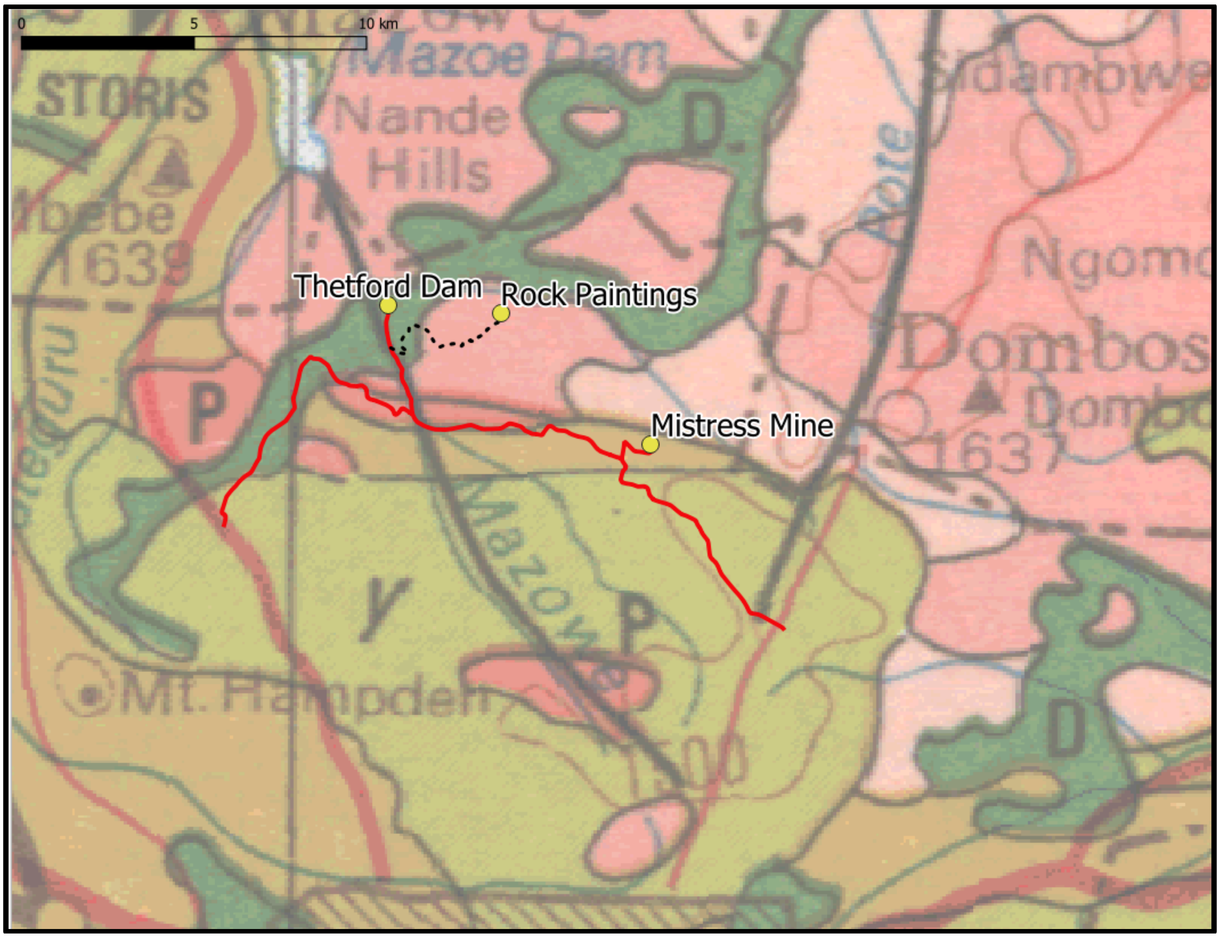
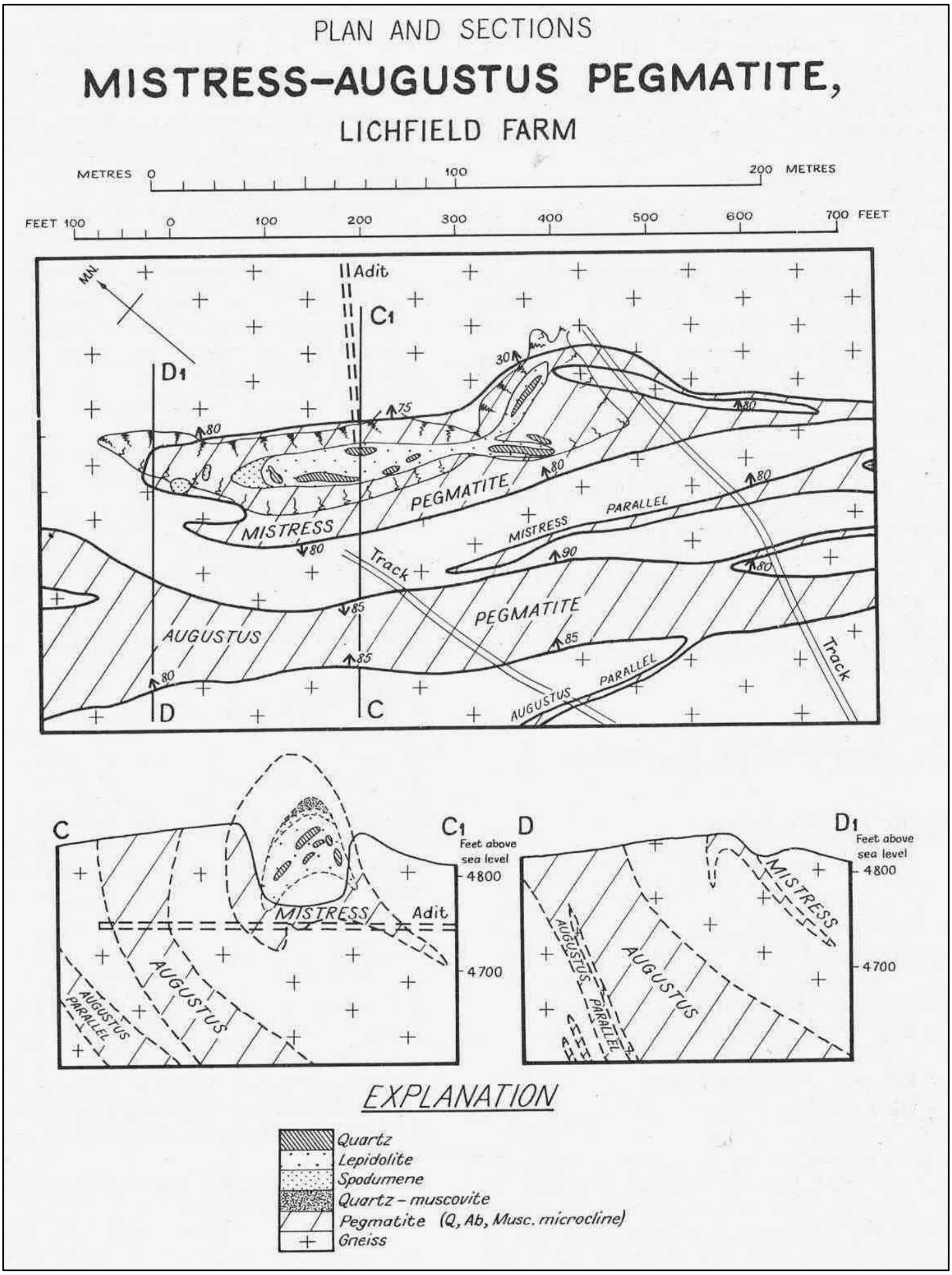


GEOLOGY OF THE MISTRESS AND AUGUSTUS PEGMATITES



Regional Setting

The Harare Greenstone Belt is a complex assemblage of typical metamorphosed Archaean volcanic and sedimentary rocks, the stratigraphy of which is outlined in Bulletin 94 of the Zimbabwe Geological Survey (Baldock, 1991).

Bulawayan Supergroup

Passaford Formation – Epiclastic and volcanogenic deposits

Mount Hamden Formation – Peltitic carbonaceous shales, iron-formation and limestone

Arcturus Formation – Basalt, komatiitic basalts and komatiites and minor iron-formation

Belingwean Supergroup (?)

Iron Mask Formation – Felsic to intermediate volcanic rocks and minor sediments including stromatolitic limestone.

The Mistress and Augustus pegmatites are located within a WNW trending segment of the Iron Mask Formation along the northern margin of The Harare Greenstone Belt and the southwestern edge of the Chinamora Igneous Complex (Baldock, 1991). It lies within a porphyritic hornblende granodiorite/tonalite gneiss. To the south, this gneiss is in contact with a metamorphosed assemblage of intermediate to felsic pyroclastic rocks, and further south with mafic volcanic rocks of the Arcturus Formation.

Although outcrop is poor to the north, Robertson (1964) describes a gradational diminution of the hornblende content of the granodiorite/tonalite with a commensurate increase in quartz and feldspar to produce a typical granitic gneiss. He also mentions that the hornblende and plagioclase megacrysts are aligned and produce a marked foliation. His petrographic descriptions record that microcline commonly replaces plagioclase with myrmekitic textures in places, and elsewhere that the microcline shows large areas of optical continuity, which he suggested was due to potash metasomatism.

Snowden mapped the Chinamora Igneous Complex in its entirety in the early 70s. He distinguished 45 different granitic types, which were later assigned to three main groups of old gneisses, gneissic granites and late granites (Snowden and Snowden, 1979). Of these only the last is considered to be relevant to the many pegmatites in the area, of which the Mistress and Augustus bodies have been the most productive. There is a strong spatial link between the 2.60 – 2.54 Ga Chilimanzi potash granites throughout the Archaean in Zimbabwe and a likely genetic link in that the fluids that produced the pegmatites are probably late-stage accumulations following the crystallisation of these large-volume, sheet-like bodies. All of these granites are remelts of earlier continental crust, which allowed for the concentration of the unusual elements commonly found in pegmatites.

History and Production

The Mistress claims were registered in 1936 for lithium and the Augustus in 1930. The first production of beryl and lithium was in1953 and for microlite three years later. Since 1965 there has been intermittent production of quartz and feldspar for abrasives and as a filler in tile cement. The production figures for all products to 1986 are tabulated below.

Period	Mineral	Mass (t)
1953 – 1969	Beryl	174.81
1975 – 1986	Beryl	40.80
1956 – 1971	Microlite	26.63
1975 – 1985	Microlite	5.26
1954 – 1957	Lepidolite	1245
1961 – 1965	Lepidolite	164
1969, 1971	Lepidolite	181
1956	Spodumene	80
1985 – 1986	Spodumene	273
1965 – 1975, 1979 – 1985	Quartz	3505
1965 – 1984, 1986	Feldspar	9155

The need for beryllium in nuclear reactors prompted the UKAEA (United Kingdom Atomic Energy Authority) to assess all of the beryl producers in the country and to explore a number of these. In 1960 they drilled eight inclined holes through the Mistress pegmatite and drove an adit from the north underneath the Mistress and into the Augustus Pegmatite. This showed that the Mistress terminated not far from the pit floor whereas the width of the Augustus body appeared to be increasing in depth.

Pegmatite Geology and Features of the Mistress Pegmatite

Descriptions of the two pegmatites include those of Branscombe and Hawkes (1962) of the UKAEA, Martin (1963) and Robertson (1964). Derived from these, were the excursion guide for the Granite ’71 Symposium held in Harare, and the descriptions of S Kalbskopf and E Muchemwa in Baldock (1991).

The two pegmatites are part of a swarm that extends within the hornblende granodiorite over 13 km in an easterly direction with most hosted by the pyroclastic rocks of the Iron Mask Formation with fewer in the basalts of the Arcturus Formation.

Most of these bodies are narrow dykes and the Augustus has an outcrop length of 700 m. Its average width is around 30 m and the depth exceeds 50 m. This pegmatite is poorly zoned and relatively fine grained. It contains beryl, spodumene and microlite – the last in possibly economic quantities. In the early 1960s the pegmatite was being quarried for road metal, which caused Martin (1963) to “question the wisdom of using potential microlite ore as ballast”, as seven of the UKAEA holes averaged 0.67 kg/t of microlite with a range of 0.27 to 1.73 kg/t. Currently only the feldspar is being mined.

The Mistress Pegmatite is smaller than the Augustus and Branscombe and Hawkes (1962) identified five well defined zones:

Zone	Width (m)	Mineralogy
Border Zone	< 0.15	Albite, quartz and trace muscovite
Wall and Outer Intermediate Zone	3 – 17	Albite, cleavelandite, quartz, muscovite microcline and micro-perthite
Intermediate Zone	< 3	Quartz, spodumene
Inner Intermediate Zone	< 3	Albite, lepidolite and quartz
Core Zone	<10	White quartz

Robertson (1964) subsequently investigated the Inner Intermediate Zone in some detail and summarized his findings in the Granite ’71 Excursion Guidebook (Morrison and Wilson, 1971) as follows:

Unit 1. Lepidolite cockade unit.
A two-fold unit consisting of an early violet-coloured lepidolite which grades into a later, rhythmically banded albite-lepidolite cockade unit. This unit has been considerably broken up and injected by Unit 2.

Unit 2. Plagioclase-quartz injection unit.
This unit consists of coarse, bladed cleavelandite (a coarse variety of albite), fine-grained, sugary albite, and very coarse-grained, grey quartz. It cuts into, and is often found surrounding Unit 1.

Unit 3. Fine-grained albite-quartz unit. This is a micropegmatite of very fine-grained albite and quartz veined with sericite and is of very limited extent. It is only found with, and appears to be later than, Unit 2. The relationship to later units is uncertain.

Unit 4. Silvery lepidolite unit. Lenticular bodies of dense, silver-grey lepidolite occur between Unit 2 and the Core, and there is some evidence of overlap between Units 2 and 4.

Unit 5. The Core. The Core consists of white, fractured, translucent quartz parted by clay seams, and it is not intrusive into the other units.

These units will be focus of the excursion.

The “cockade” unit described by Robertson is one or two metres wide and consists of rhythmically banded concentrations of medium-grained, granular albite and lepidolite of variable proportions. Each layer is a few centimetres thick with the purple layers containing more lepidolite and the whitish bands more albite with gradational layer boundaries. He also noted a decrease in lepidolite over the whole unit with a commensurate increase in the albite content.

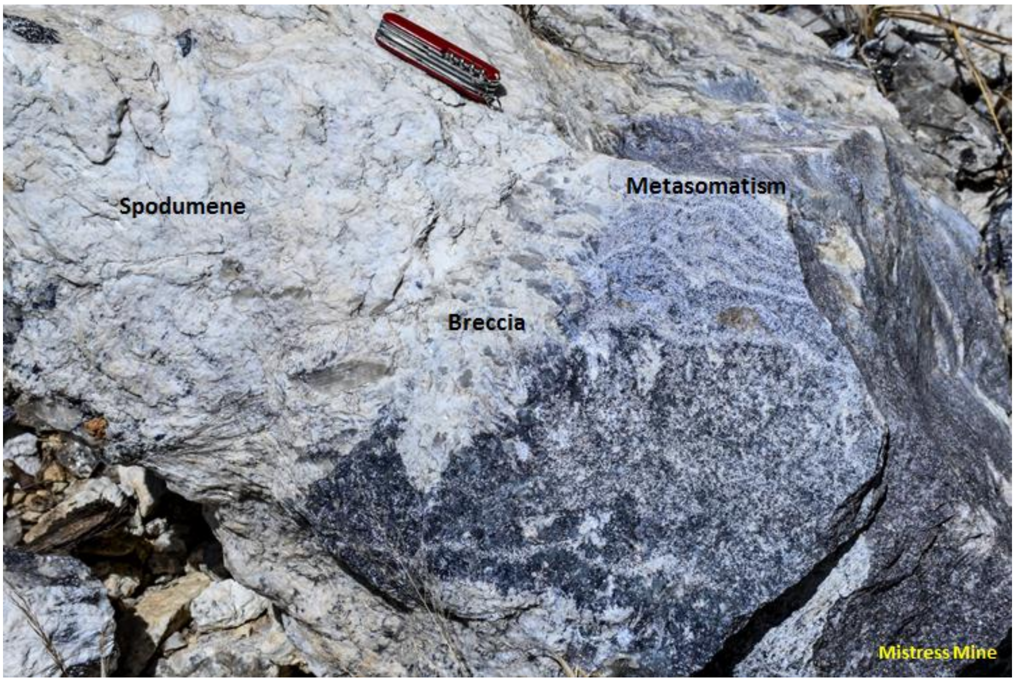


Figure 1 Mistress Mine – Alternating lepidolite-rich and albite-rich bands

All exposures of these units display fold-like, concentric layering, which commonly rests upon a core of coarse quartz-lepidolite breccia (Unit 2). Robertson interpreted these "as concentric, concretionary growth…with further deformation being caused by the brecciation of Unit 1 and the forceful injection of Unit 2." Similar banding occurs at Bikita (and in my experience is common in many pegmatites) and was interpreted by Martin (in Wilson, 1961) to be the result of fluctuating fluid compositions (excesses of lithium or sodium) and that their folded nature "was occasioned by slight movement of the superincumbent mass of pegmatite…" For the layering this is a plausible explanation for some exposures, and in particular that shown in the photograph from Bikita below right. However, for the origin of the folded nature of the banding I would propose alternative interpretations. Firstly the substrate is not planar and the banding tends to parallel the uneven substrate. This is well exemplified by the cockade structures shown in the two photographs below.

Figure 2 Cockade Structure – Hydrothermal Sulphides (left), Bikita Pegmatite (right)

Cockade ore is defined in the AGI Glossary of Geology (Bates and Jackson, 1987) as open-space vein filling in which ore and gangue minerals are deposited in successive comb-like crusts around rock fragments, e.g. around vein breccia fragments.

My second objection is that there is no evidence of foliation within what, at Mistress at least, could be described as tight to almost isoclinal shapes. My interpretation is that the banding is caused by diffusional replacement of pre-existing pegmatite triggered by multiple injections of pegmatitic fluid in a similar, but hotter process, to that which produced liesegang banding.

Figure 3 Liesegang Banding in sandstone (left), similar pattern at Mistress (right)

Above the layered unit at some localities is a zone of oriented tabular, white crystals that could be spodumene or cleavelandite; in places it is conformable with the layering and elsewhere appears cut across it.

Robertson’s conclusion that the banding was the result of a “concentric concretionary growth” was in line with Martin’s earlier interpretation of the Bikita lamination. But he also noted another significant observation that ‘further deformation…[was] caused by…brecciation…and the forceful injection of Unit 2.” My own observations from Bikita, Arcadia and Mistress indicate that breccias are a common feature in pegmatites and that “forceful injection” of successive pulses of fluids under high pressure is the most likely cause.

References

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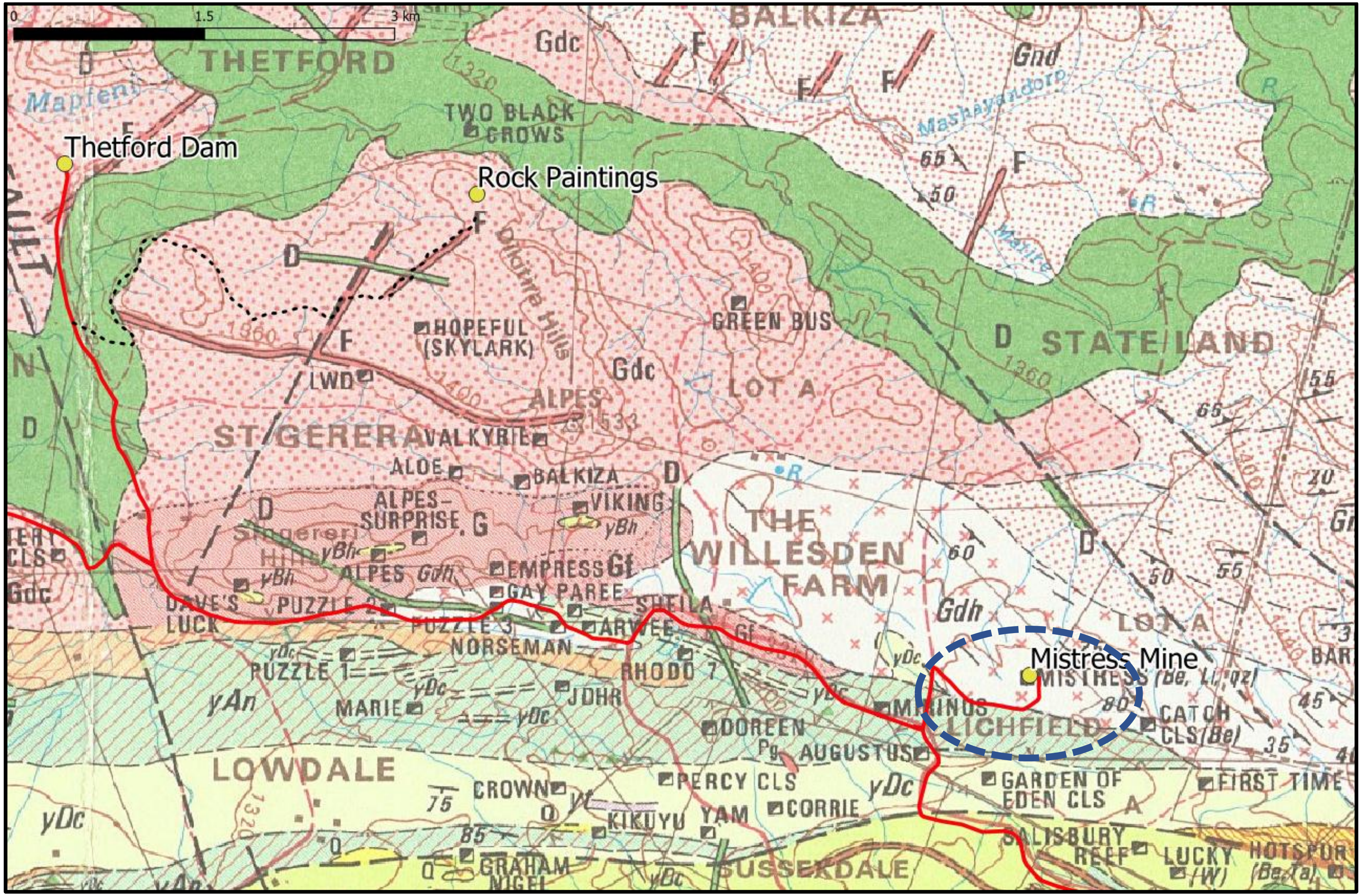

Figure 4 Baldock, J.W. 1991. Zim. Geol. Surv. Bull. 94.

Key to Geological Map

Various Ages

	Q	Quartz vein
	F	Felsite
	Pg	Pegmatite
	E, Es	Epidote, epidote schist
MASHONALAND SUITE	D, Do	Dolerite, olivine dolerite
MANYIKA SUITE	Hx, H	Differentiated gabbro, Harare Gabbro

Archaean Granites

G	Granite
Gf	Fine-grained granite
Gc	Coarse-grained granite
Gp	Porphyritic granite
mG	Microgranite porphyry
Gl	Leucogranite
Gb	Biotite-rich granite
Gd	Granodiorite
Gdf	Fine-grained granodiorite
Gdc	Coarse-grained granodiorite
Gdp	Porphyritic granodiorite
Gdt	Leuco-granodiorite / tonalite
Gdh Gh	Hornblende granodiorite altered to hornblende granite
M	Diorite (unfoliated)
Gth	Hornblende tonalite
Gm	Tonalite to granite, massive to banded migmatite
Gmg	Migmatitic granite gneiss
Gnm	Migmatitic gneiss
Gnh	Gneissic hornblende granodiorite
Gd	Gneissic granodiorite
Gnd	Granodiorite gneiss
Gdp	Porphyritic granodiorite gneiss
Gdx	Xenolithic granodiorite gneiss
Gdh	Hornblende granodiorite / tonalite gneiss
Gnl	Leuco-tonalite / granodiorite gneiss
Gdt	Granodiorite / tonalite gneiss
Gn	Granitoid gneiss

Archaean Bulawayan

yAn	Meta-andesite
yF, yDc	Metafelsite, metadacite
yq	Quartzite (metasandstones)
yqa	Meta-arenite /volcaniclastics
yl	Limestone
yfc	Metachert
yi	Iron-formation (oxide and sulphide facies)
yp	Phyllite (meta-argillite)
yB	METABASALT

Name	Formula	Type	Description	SG	% Li_2O	Hardness	Streak
Petalite	Li $AlSi_4O_{10}$	Feldpathoid - lithium aluminium phyllosilicate	Colourless, Convert to spodumene and qtz c heat & pressure	2.42	4.50%	6-6.5	colourless
Lepidolite	$K(Li,Al,Rb)_3(Al,Si)4O_{10}(F,OH)_2$	Mica	Purple-pink, botryoidal	2.84	7.70%	2.5-3	white
Spodumene	$LiAl(SiO_3)_2$	Pyroxene	Lithium extracted with acid	3.15	8.03%	6.5-7	white
Eucryptite	$LiAlSiO_4$	Silicate	Alteration product of spodumene, granular-massive	2.67	11.86%	6.5	white
Amblygonite	$(Li,Na)AlPO_4(F,OH)$	fluorophosphate	Looks like feldspar but higher density and diagnostic flame test	3.04	7.40%	5.5-6	white
Zinnwaldite	$KLiFeAl(AlSi_3)O_{10}(OH,F)_2$	Hydrated Fluoride (in siderophyllite - polylithionite series)	Mica with a variety of colours	2.9-3.1	low	3.5-4.0	white
Microlite	$(Na,Ca)2Ta_2O_6(O,OH,F)$	Oxide of pyrochlore supergroup	Pale-yellow, reddish-brown, or black isometric mineral composed of sodium calcium tantalum oxide	4.2-6.4	N/A	5-5.5	light yellow
Tantalite - Columbite	$(Fe, Mn)(Ta,Nb)_2O_6$	Coltan or "columbite-tantalite" Group	Dull black to brown mineral	Tantalite 8.0+ Columbite 5.3–7.3	N/A	6-6.5	Brownish-red to black
Bismuth - native	Bi	Metal	Good cleavage with striations	9.78	N/A	2.25	Silver - white
Bismutite	$Bi_2(CO_3)O_2$	Bismuth Carbinate Mineral	Yellow to brown, greenish, green-grey, grey or black typically occurs as earthy to fibrous masses	6.7-7.4	N/A	2.5-3.5	Grey
Epidote	$Ca_2Al_2(Fe^{3+};Al)(SiO_4)(Si_2O_7)O(OH)$	Silicate	Usually yellowish-green prismatic with striations, fibrous, massive	3.3-3.6	N/A	6-7	Greyish white
Monazite	$(Ce,La,Th)PO_4$	Phosphate	Reddish brown, brown, pale yellow, pink, green, gray, prismatic or wedge-shaped crystals	4.6-5.7	N/A	5.0-5.5	White
Cassiterite	SnO_2	Oxide	Dark variable colours, pyramidic, prismatic, radially fibrous botryoidal crusts and concretionary masses; coarse to fine granular, massive	6.98–7.1	N/A	6-7	White to brownish
Garnet	$X_3Y_2(SiO_4)_3$ [X=(Ca, Mg, Fe, Mn)$^{2+}$ Y=(Al, Fe, Cr)$^{3+}$]	Silicate	Any colour - chombic dodecahedron or cubic crystals	3.1-4.3	N/A	6.5-7.5	White
Ilmenite	$FeTiO_3$	Oxide	Iron-black, granular to massive and lamellar	4.70-4.79	N/A	5-6	Black
Beryl	$Be_3Al_2Si_6O_{18}$	Silicate	Prismatic to tabular hexagonal crystals in a variety of colours	2.76	N/A	7.5-8	White
Albite	$NaAlSi_3O_8$	Plagiocalse Feldspar	White to grey, perfect cleavage	2.60-2.65	N/A	6-6.5	White
Microcline	$NaAlSi_3O_8$	Alkali Feldspar	Clear, white, pale-yellow, brick-red, or green often with cross-hatch twinning	2.5-2.6	N/A	6-6.5	White