Geological Society of Zimbabwe

Dorowa – Shawa Field Guide

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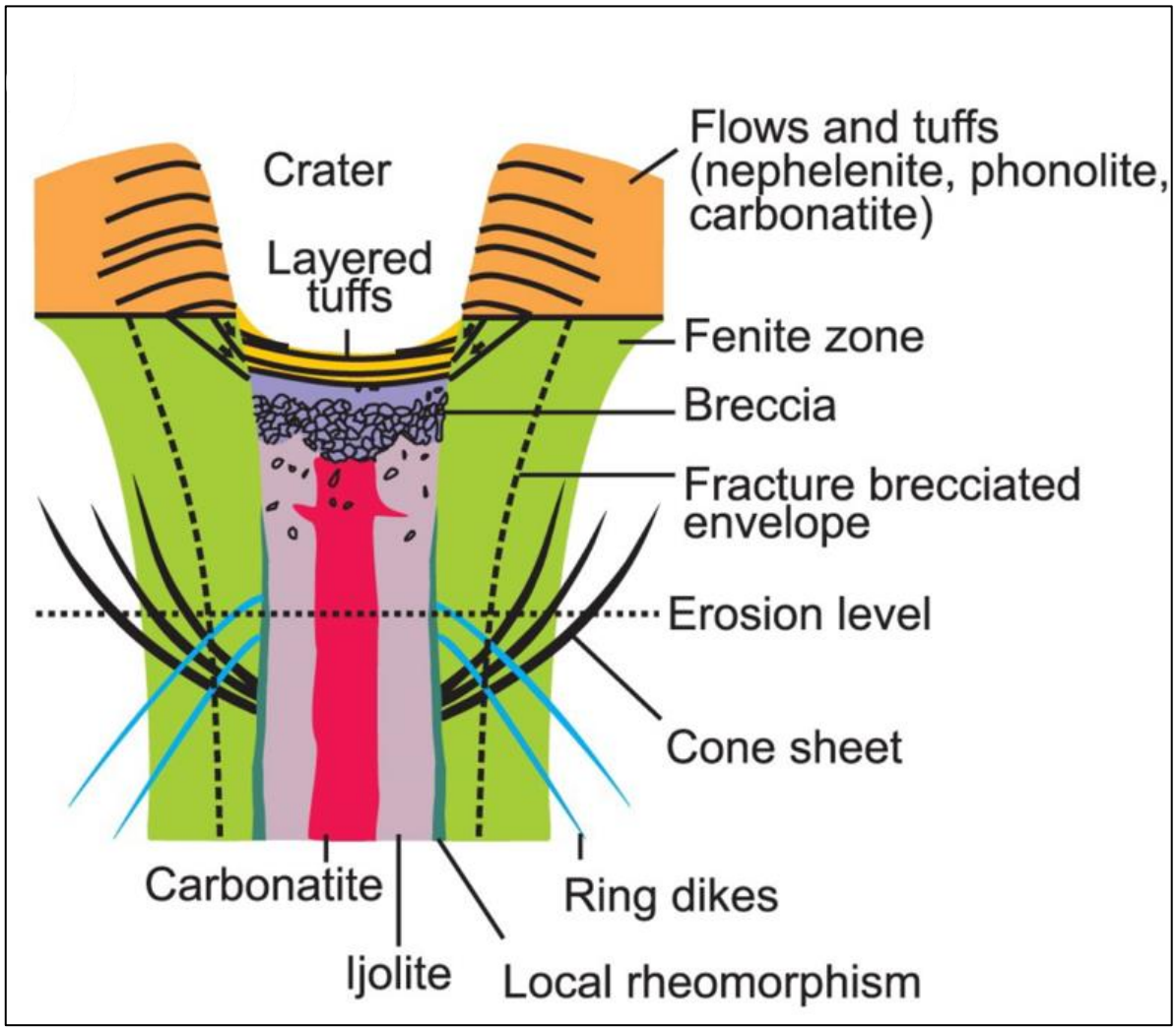
ALKALI RING COMPLEXES

Alkali Ring Complexes are roughly cylindrical, sub-volcanic intrusive bodies with distinctive alkaline lithologies including carbonatite. Although the carbonatites were once thought to be metamorphosed sedimentary rocks, they are now accepted as magmatic and originating from very low degrees of partial melting of the mantle. The magmas are highly alkaline with minimal silica, and charged with volatiles, mainly water and carbon dioxide. This chemistry controls the mineralogy which is dominated by soda, potash and calcic minerals with very minor to no quartz. The magmas have very low viscosities, which readily allows for differentiation and layering, and the high volatile content results in widespread veining and metasomatism. In addition, there is abundant evidence of numerous pulses of injection of both magmas and volatiles of variable compositions.

Most alkaline complexes were emplaced in continental extensional settings and range in age from Archean to recent – the oldest at 3007 Ma is in Greenland and the Ol Doinyo Lengai volcano in Tanzania is currently active.



The alkaline silicate rocks are commonly associated with carbonatites, but carbonatites also occur as discrete pipes, sills, and dykes – including cone sheets, ring dykes and radial dykes.

Alkaline-carbonatite complexes are the main sources of rare earth elements (REE) and Nb, and host significant deposits of apatite, vermiculite, Cu, Ti, fluorite, Th, U, zircon, and Fe.

Rock Types

The lithologies in these complexes are dominated by feldspathoids and alkali-rich pyroxenes and include the following:

Carbonatite: Igneous rock containing more than 50% carbonate minerals

Fenite: Metasomatic rock consisting of alkali feldspar, sodic pyroxene and sodic amphibole

Foyaite: K-feldspar-rich nepheline syenite containing < 10% pyroxene, hornblende and biotite

Ijolite: Igneous rock consisting of nepheline and subhedral augite

Jacupirangite: Igneous – essentially a pyroxenite consisting of augite with minor nepheline and accessory biotite, magnetite, apatite, perovskite and melanite garnet.

Juvite: Igneous rock consists of orthoclase, plagioclase and pyroxene with minor nepheline (as phenocrysts) and accessory sphene.

Nepheline syenite: Plutonic rock consisting of nepheline and alkali feldspar. The rocks are mostly pale in colour and similar to granite but without the quartz.

Phonolite: The fine-grained extrusive equivalent of nepheline syenite.

Melteigite: An intrusive igneous rock containing nepheline and alkali pyroxene (aegirine or aegerine-augite). With decreasing mafic mineral content and increasing nepheline, melteigites pass into ijolites and then urtites. All three rocks type are essentially feldspar-free, undersaturated syenites.

Phoscorite: Plutonic ultramafic rock comprising magnetite, apatite, forsterite, diopside and phlogopite.

Pulaskite: Medium to coarse grained with rounded microcline augen in a groundmass of albite, aegirine, amphibole, microcline with minor biotite and nepheline.

Sövite: medium-to-coarse-grained calcite-carbonatite with accessory amphibole, biotite, magnetite, pyrite, pyrochlore and fluorite.

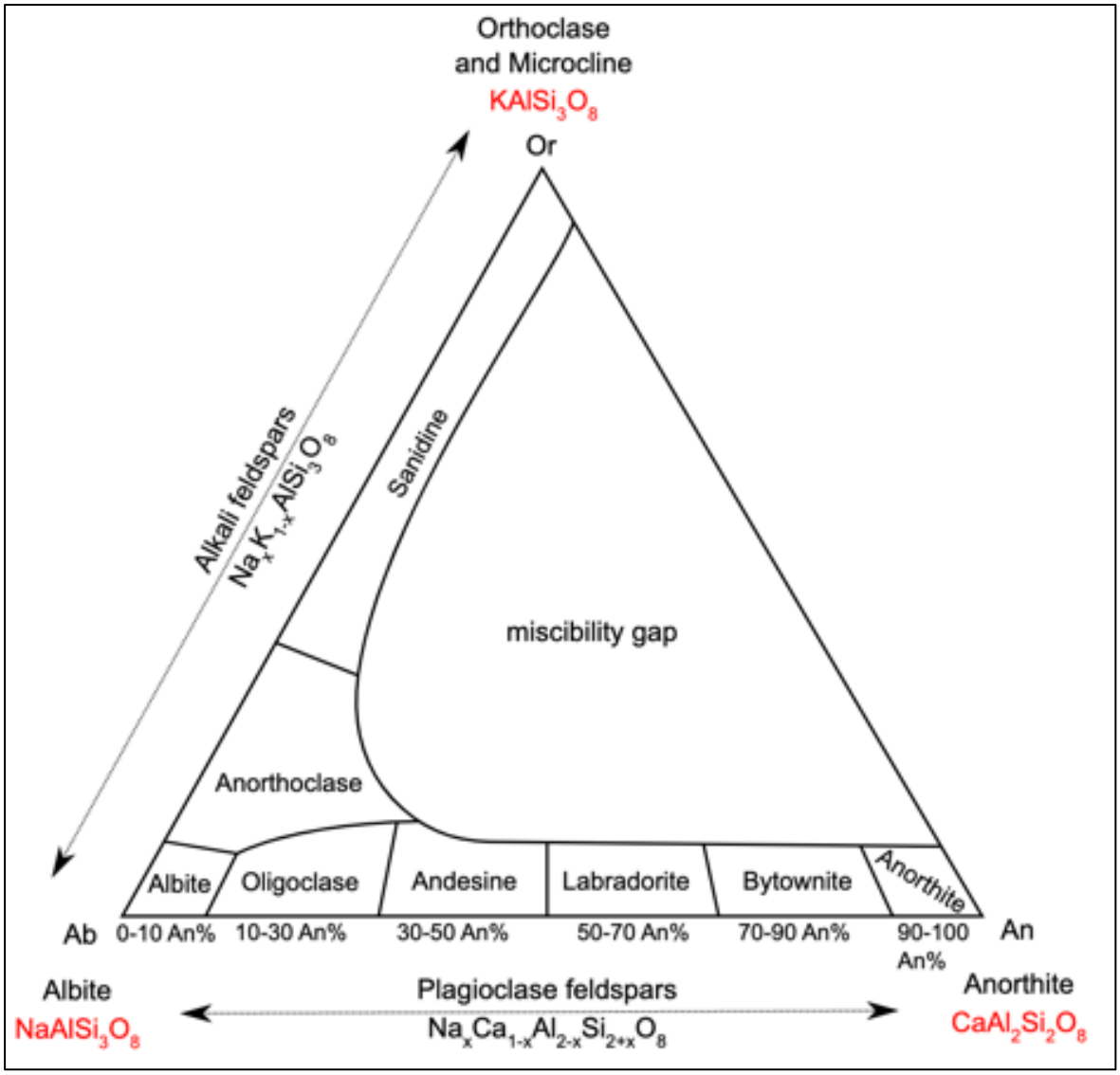
Beforsite: medium-to-coarse-grained variety of dolomite-carbonatite with accessory amphibole, biotite, magnetite, pyrite, pyrochlore and fluorite.

Minerals

Aegirine-augite: $NaFe3+[Si_2O_6]$ pyroxenes – a chemical series in which Ca replaces Na, and Mg and Al replace Fe. Common in alkaline igneous rocks, such as syenites

Apatite: $Ca_5(PO_4)_3(F,Cl,OH)$

Feldspar: K, Na, Ca alumino-silicates



Feldspathoids: minerals which resemble feldspars but have a lower silica content and higher K, Na, and/or Ca. They occur in alkaline igneous rocks with no primary quartz.

Arfvedsonite: soda-rich amphibole $[Na][Na_2][(Fe_2+)4Fe_3+][(OH)_2|Si_8O_{22}]$

Bastnäsite: Rare earth carbonate $(La, Ce, Y)CO_3F$

Biotite: Phyllosilicate $K(Mg,Fe)_3(AlSi_3O_{10})(F,OH)_2$

Fergusonite: Rare Earth niobate $REENbO_4$

Monazite: REE Phosphate (Ce,La,Th)PO4

Nepheline: Tectosilicate, feldspathoid $(Na,K)AlSiO_4$

Phlogopite: Phyllosilicate $KMg_3(AlSi_3O_{10})(F,OH)_2$

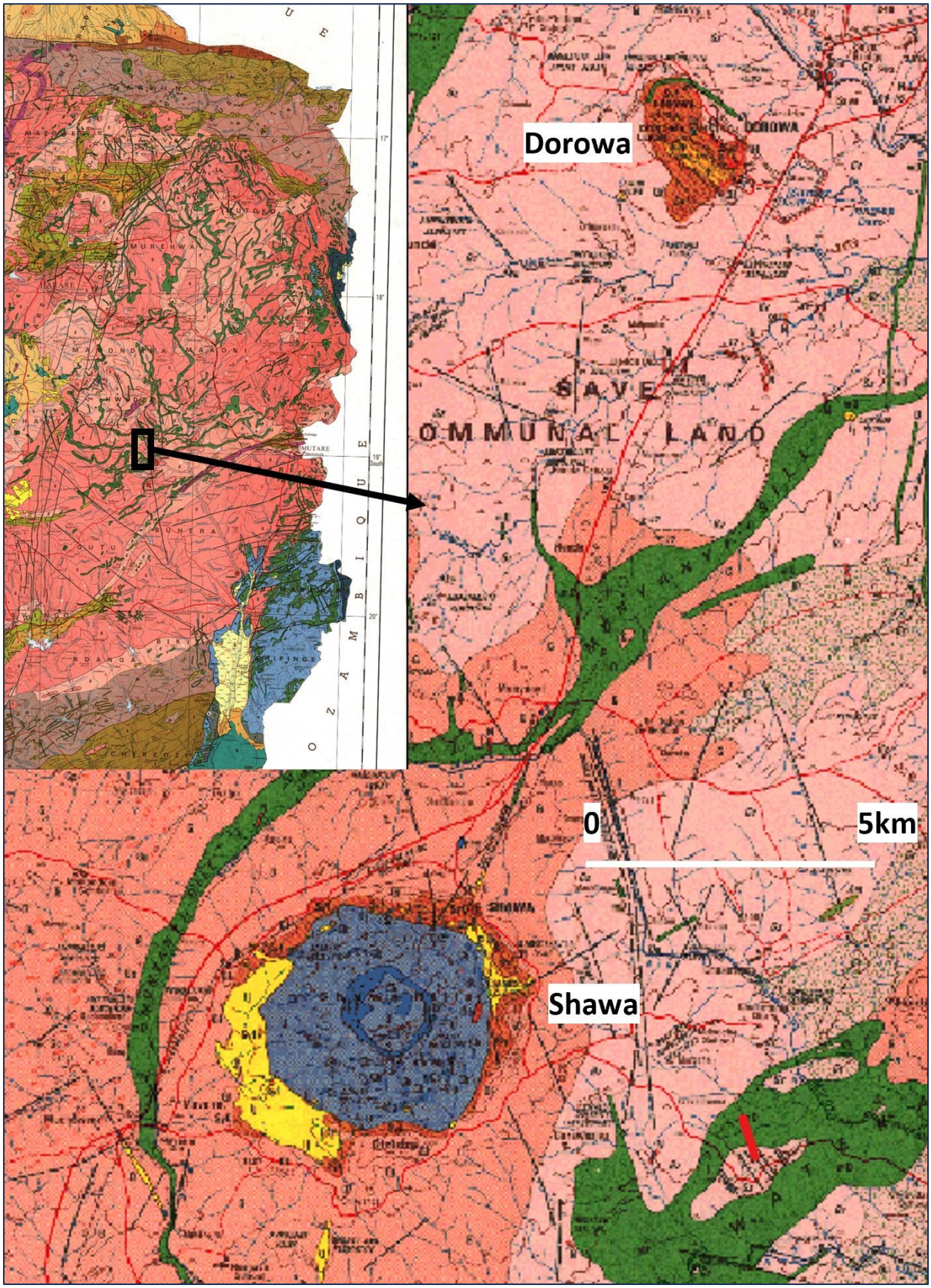
Pyrochlore: Oxide mineral $(Na,Ca)_2Nb_2O_6(OH,F)$

Riebeckite: Na-rich amphibole $Na_2(Fe_2+3Fe_{3+2})Si_8O_{22}(OH)_2$

Vermiculite: Phyllosilicate $(MgFe_2+Fe_3+)_3[(AlSi)_4O_{10}](OH)_2.4H_2O$

Xenotime: Phosphate YPO_4

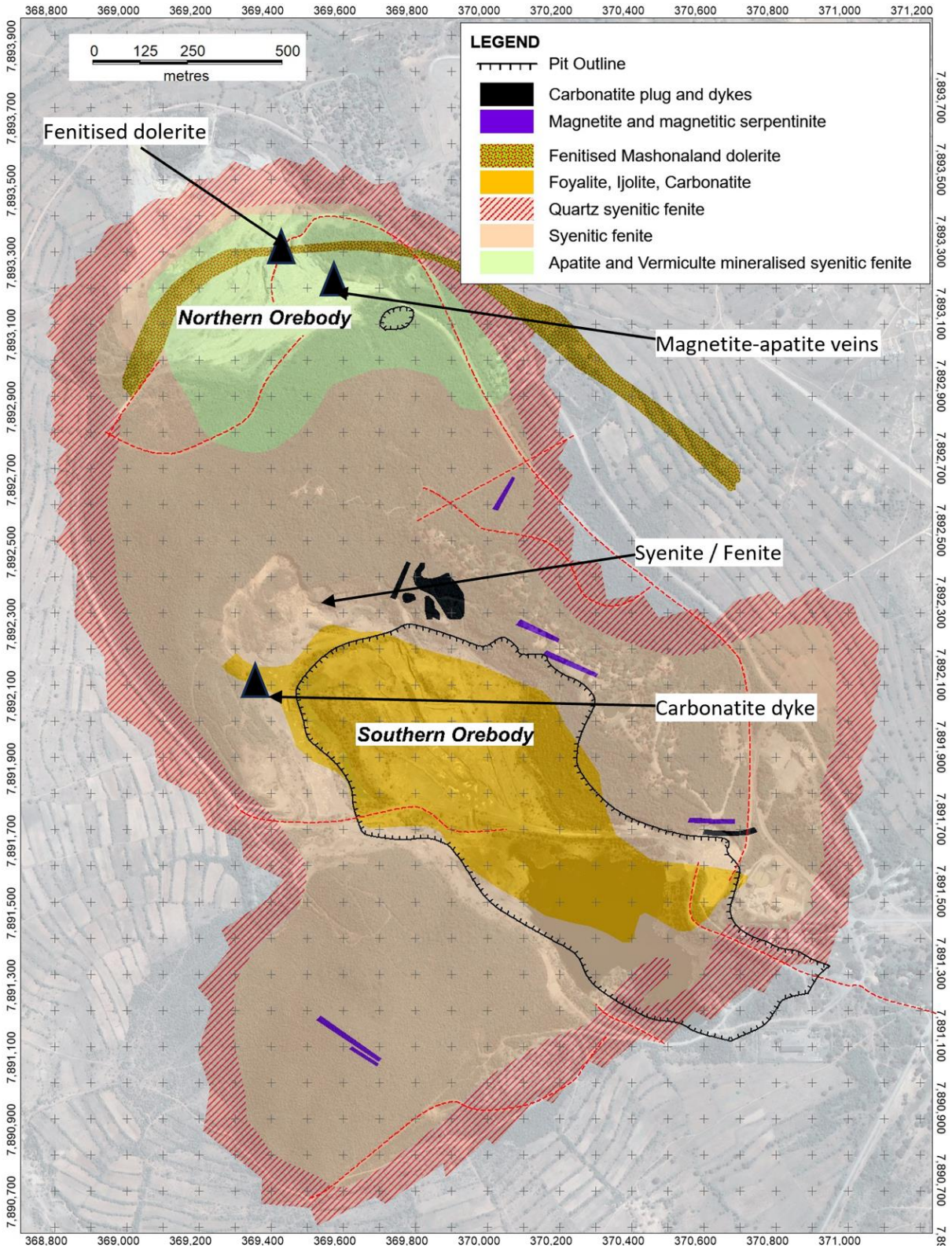
Dorowa – Shawa Regional Geological Setting



DOROWA

The Dorowa hills rise 160 m above the surrounding plains. They represent a 209±16Ma-old Alkali Ring Complex (Rb/Sr, Nicholaysen, 1962) which consists of foyaite and ijolite plugs and dykes of carbonatite, syenite and fenitised syenite as well as magnetite-dykes and magnetitic serpentinite. The emplacement of the complex induced in-situ metasomatism (fenitisation) of the intruded granitic country rocks.

Dorowa Geology Map



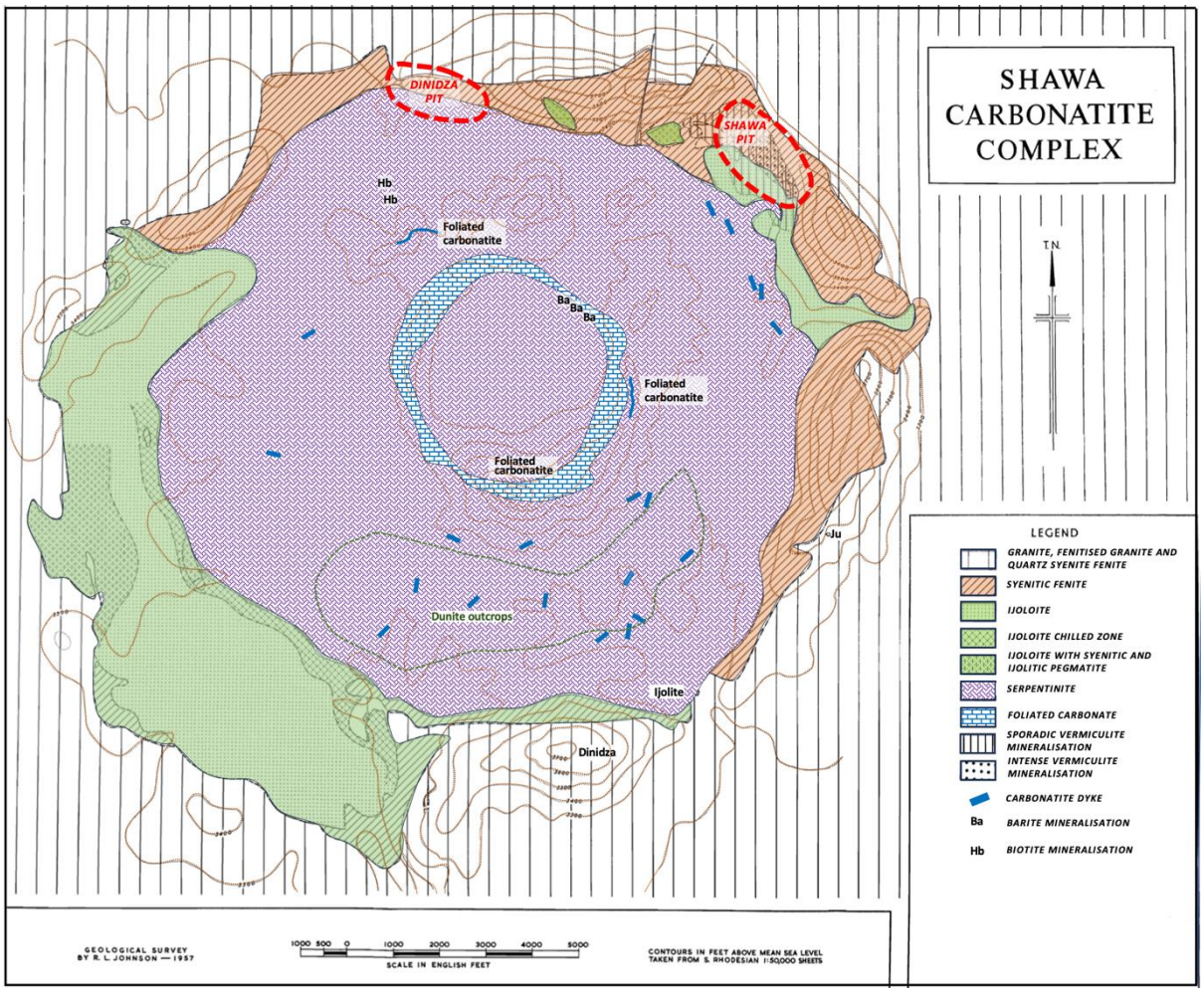
The carbonatites are dominated by the sovite variety (calcite-rich) over the beforsite variety (dolomite-rich)

SHAWA

The Shawa complex has a diameter of approximately 5 km and an area of just under 29 km². It displays a classical ring structure with positive topographic features forming two circular ranges of hills, one around the rim and a smaller central range.

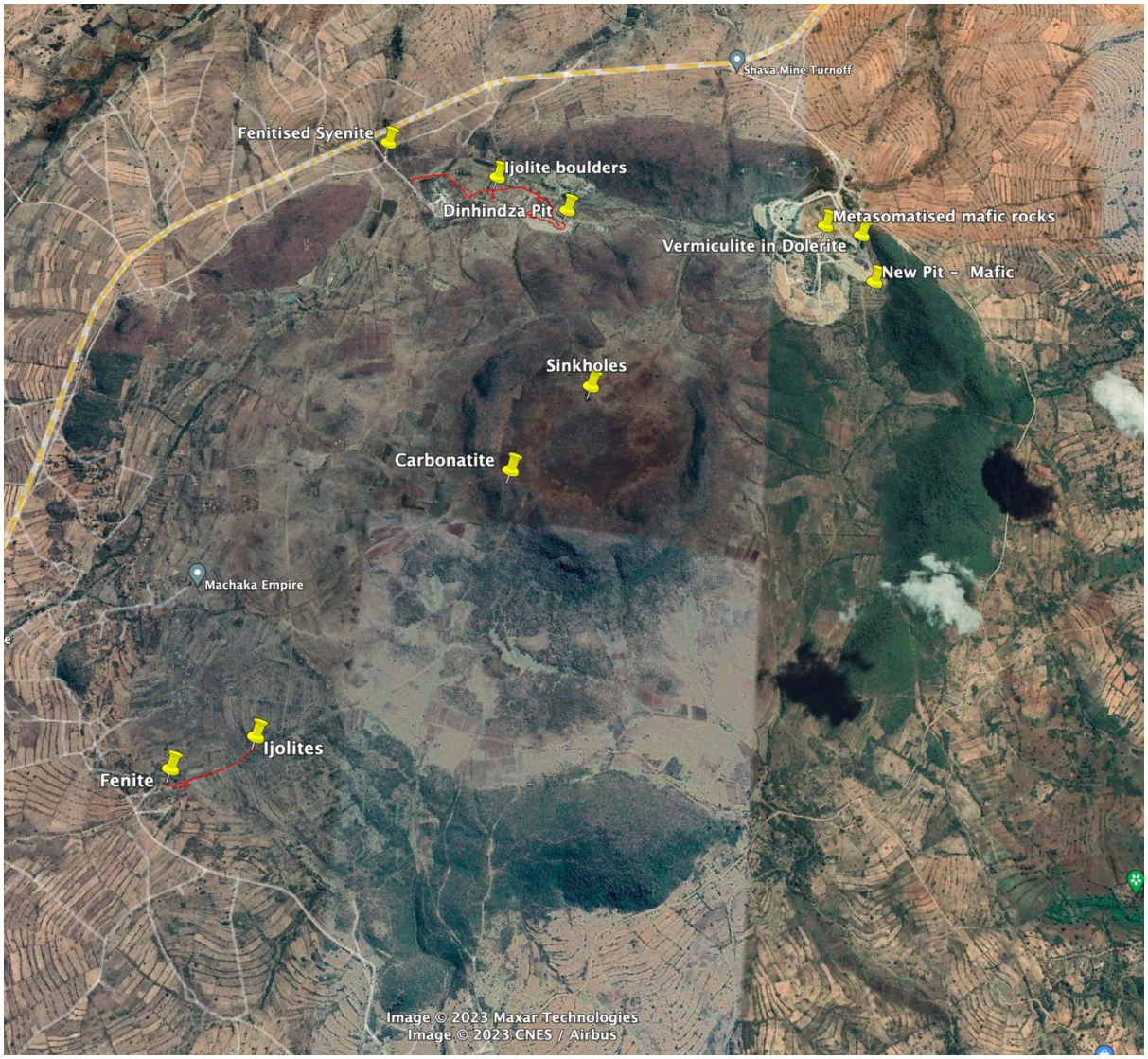
The dominant lithology is serpentinised dunite, partly surrounded by arcuate bodies of ijolite encircled by an irregular zone of fenite grading outwards into the granitic country rocks. Within the serpentinite-dunite is a ring dyke of carbonatite. The carbonatite and fenite zones form positive topographic features whereas much of the central area of ultramafic rocks is relatively flat.

Shawa Geology Map



The only economic mineral currently exploited at Shawa is vermiculite which has formed from the metasomatism (hydration) of biotite and phlogopite within the syenitic fenite and ijolite. The potential for rare earth elements is being investigated.

The field trip will attempt to cover the main lithologies and also the metasomatism which is widespread in both complexes, and which provides evidence for the processes involved in the formation of these unusual intrusions. Potential stops are shown on the Google Earth image below.


Shava Mine Turnoff
Fenitised Syenite
Ijolite boulders
Dinhindza Pit
Metasomatised mafic rocks
Vermiculite in Dolerite
New Pit – Mafic
Sinkholes
Carbonatite
Machaka Empire
Ijolites
Fenite
Image © 2023 Maxar Technologies
Image © 2023 CNES / Airbus

Rock examples of the Dorowa and Shawa complexes

Ijolite

A series of plutonic rocks containing **nepheline** and 30% to 60% mafic minerals, generally clinopyroxene, and including sphene and apatite.

Syenite

- A coarsely crystalline plutonic intermediate rock consisting chiefly of alkali feldspar with less than 5% quartz and/or feldspathoid.
- Clinopyroxene, hornblende, biotite mica, or olivine may be present in minor proportions.

Fenite

- A high-temperature metasomatic rock characterised by the presence of alkali feldspar, sodic amphibole and sodic pyroxene.
- Fenites occur as zoned aureoles around alkaline igneous complexes, including carbonatites, forming in a wide range of host lithologies. They occur on the metre to kilometre scale.

Carbonatite is a type of intrusive or extrusive igneous rock defined by mineralogic composition consisting of greater than 50% carbonate minerals.

- Beforsite when carbonate is dolomite
- Sovite when carbonate is calcite

Foyaite

- A nepheline-syenite with predominant orthoclase and a trachytic texture.
- They contain <10% ferromagnesian minerals (pyroxene, hornblende and biotite