MACGREGOR MEMORIAL LECTURE FIELDTRIP:

SHAMVA GREENSTONE BELT, SATURDAY 18 MAY 2019

Hielke Jelsma (PhD, FGSSA, Pr Nat Sci), Principal Geologist, Anglo American: A.M. Macgregor's (1951) Gregarious Batholiths and a Tripartite Subdivision of the Greenstone Belt Stratigraphy: Exploring our current Understanding of the Geological Evolution and Mineral Endowment of the Zimbabwe Craton.

A.M. Macgregor (1888-1961) is remembered for his enormous contribution to geology. His maps changed the course of geological thinking in southern Africa and impacted on the discovery of mineral deposits and our understanding of mineral endowment.

His passion for geology and determination in mapping and documenting field observations is to be continued, which is *the* cornerstone of investigations in our field.

During this one-day field trip we will:

- Explore the extraordinary geology of the Shamva greenstone belt with classic outcrop localities along the Mazowe River.
- Discuss three deposit styles: magmatic-hosted Ni-Cu, epigenetic gold and VHMS Cu-Pb-Zn.
- Discuss our understanding of the greenstone belt stratigraphy and of the basement terrain, following on from the Macgregor Memorial Lecture.

Itinerary

Depart from University of Zimbabwe Geology Department at 06:30 hrs.

Stop 1. 31.457°E, -17.569°S. Rutope Ultramafic Complex with Tipparary Ni-Cu Claims.

Stop 2. 31.543°E, -17.382°S. Lower Shamvaian Group volcaniclastic sediments and porphyries.

Stop 3. 31.585°E, -17.316°S Lower Shamvaian Group rocks east of Shamva (Ashkirk claims).

Stop 4. 31.60105°E, -17.26753°S. Upper Shamvaian Group rocks along Mazowe River transect.

Stop 5. 31.84513°E, -17.15078°S. Upper Bulawayan Group rocks along Mazowe River transect.

Expected total distance = 300 km. Outcrops are a short walk from the vehicles.

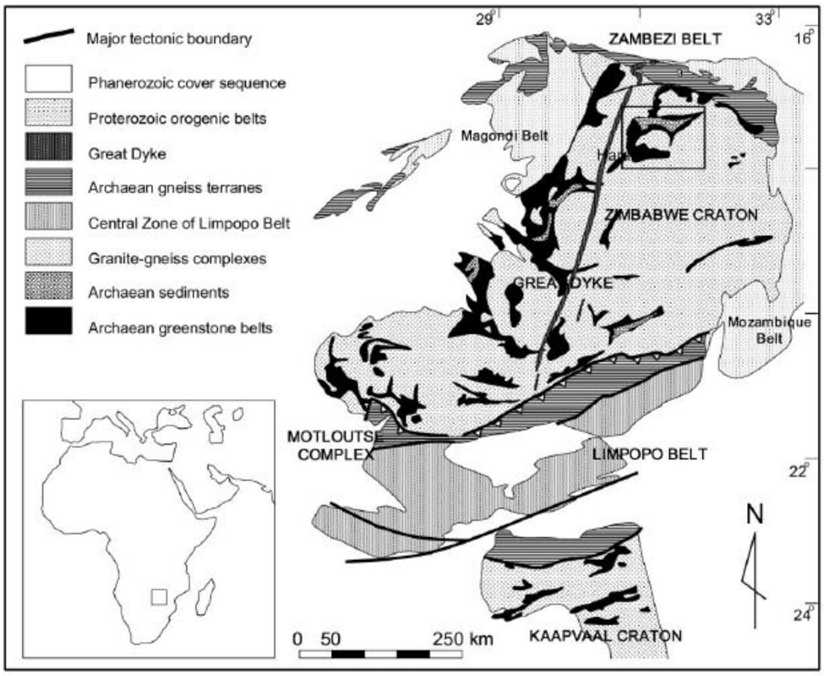


Fig. 1. General geology of the Southern Africa craton, surrounding Archean high-grade gneiss and Proterozoic terranes. Inset shows the location of the Harare-Shamva greenstone belt (after Brandl and de Wit [1997], Blenkinsop et al. [1997], Treloar and Blenkinsop [1995], and own data).

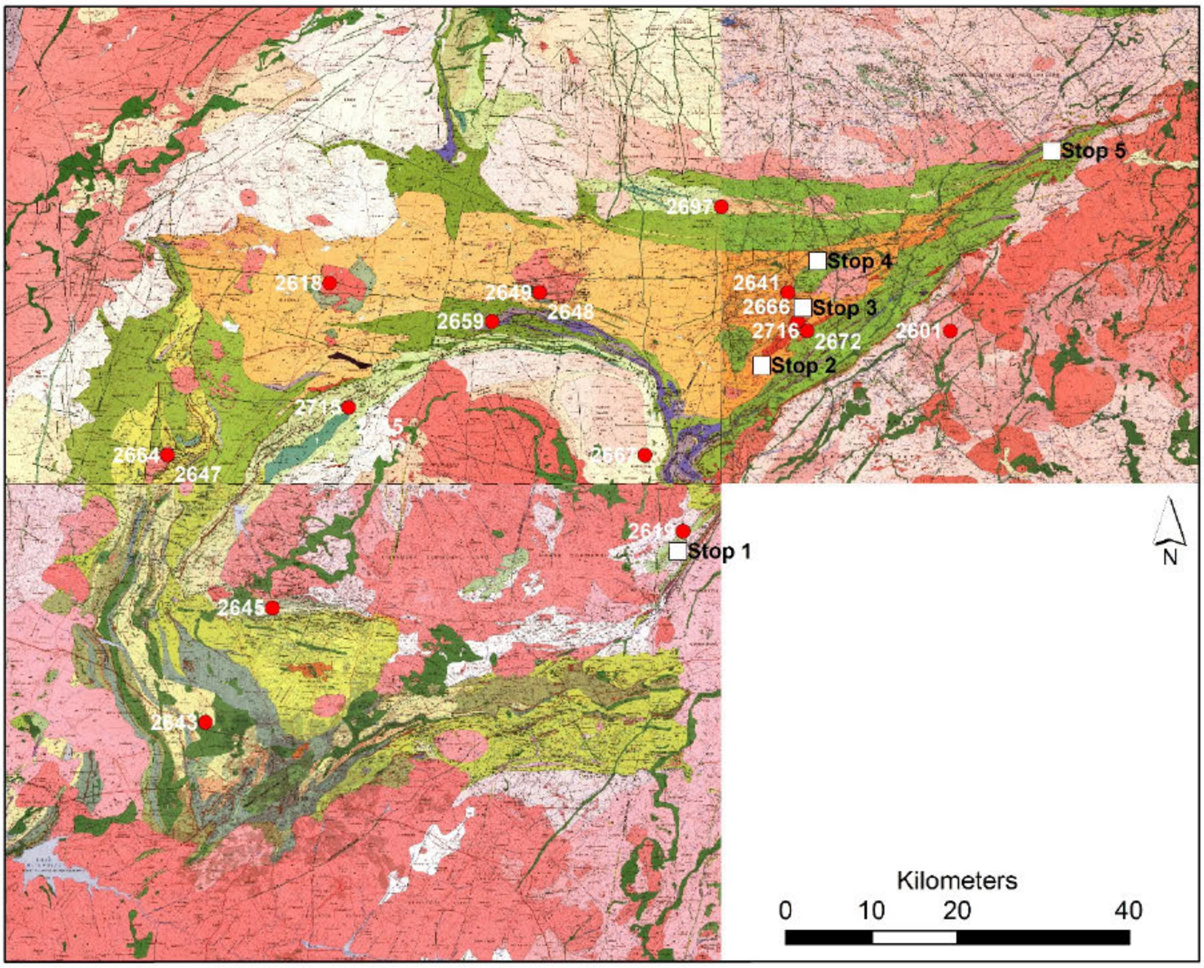


Fig. 2. Geological survey Harare, Bindura and Shamva map sheets, with superimposed crystallization ages for units dated and referred to in text, and field stop localities (Stops 1-5).

INTRODUCTION

The Bindura-Shamva greenstone belt forms part of the Harare-Shamva greenstone belt wrapped around the Chinamora batholith. Other bordering batholiths are Murehwa (southeast), Madziwa (northeast) and Chiweshe (northwest). The belt comprises Upper Bulawayan Supergroup greenstones and associated Shamvaian Supergroup sediments. The greenstones were mapped and described by Stidolph (1977) in Geological Survey Bulletin No. 78, but changes have been made to the subdivision of formations. Although the greenstone belt lithologies have been metamorphosed to greenschist-amphibolite facies grade, the prefix "meta-" is not here used.

Stratigraphy

Along the southern margin of the greenstone belt, the basal succession of the greenstone belt is represented by the Iron Mask Formation, which occurs as an arc around and structurally overlies the Chinamora batholith. The Iron Mask Formation comprises mainly calc-alkaline rhyodacitic volcanic rocks with intercalated ironstone and chert horizons. The overlying Arcturus Formation is a volcanic pile of up to 6 km thick of pillowed and massive tholeiitic basalts. Intercalated are komatiitic basalts, ultramafic schists, and serpentinites, which host the **Trojan Ni-Cu deposit**, ironstone, chert and marble, and thin horizons of felsic volcaniclastic and pelitic sediments. The base of the Arcturus Formation is commonly interpreted as either a shear zone or an unconformity (Jelsma et al. 1993; Wilson et al. 1995; Ridley et al. 1997; Jelsma and Dirks 2000) and is overlain by a thin quartzitic horizon. The Arcturus Formation is overlain by graphitic argillites (Mount Hampden Formation) and felsic volcanics and volcaniclastic sediments (Passaford Formation).

Along the northern margin of the greenstone belt, the basal succession of the greenstone belt is represented by the Thebus Formation (previously not recognized within the Shamva greenstone belt). The Thebus Formation occurs as an arc around and structurally overlies the Madziwa batholith and is well exposed within the Mount Darwin greenstone belt further north; within the Shamva belt this formation occurs within the northern flank, but only as a thin sliver near the eastern tip. Other exposures occur at Dikitira hills within the central part of the Madziwa batholith (roof of batholith?). The Thebus Formation comprises mostly andesitic volcanic and volcaniclastic (tuffaceous) rocks, but also less and more evolved (basaltic, dacitic-rhyolitic) varieties. Intercalated are horizons of ironstone, chert, ferruginous quartzite and marble. The Thebus Formation hosts the **Maramba VHMS Cu-Pb-Zn Prospect.** The overlying Mungari Formation is an up to 3km thick monotonous pile of pillowed and massive basalt flows. The Mungari Formation is overlain by quartz and feldspar porphyries, tuffs and agglomerates (rhyolites, dacites) of the Maparu Formation. On the basis of sheared contact relationships, and identical rock types, the overlying Nyamwanga Formation north of Shamva may be regarded as the structurally stacked equivalent of the Mungari and Maparu formations. Both the Mungari and the Maparu formations taper towards the eastern part of the greenstone belt.

For both flanks, geochemistry shows that the mafic volcanics are characterized by flat extended REE patterns (limited crustal contamination) and MORB-normalized REE patterns similar to present-day ocean-island, intracontinental or initial rift tholeiitic basalts, whereas the calcalkaline felsic volcanics show fractionated REE abundance patterns and marked depletion of Nb-Ta, a feature often taken as indicative of island-arc processes. The bimodal magmatism may be explained through deposition within an island-arc or continental-arc setting.

The above lithologies are part of the Upper Bulawayan Supergroup. To the northeast of Shamva town, the contact between the Upper Bulawayan Supergroup and the overlying Shamvaian Supergroup is unconformable (Jelsma et al. 1993), but elsewhere it is commonly tectonized (Jelsma and Dirks 2000).

The Shamvaian Supergroup is a predominantly coarse-grained fluvial-deltaic sedimentary association composed of polymict conglomerates, grits, coarse- to fine-grained arenites, siltstones and mudstones, but in places it also contains intercalations of intermediate to felsic volcaniclastic and reworked epiclastic sediments (Lower Shamvaian or Tsambe Formation), such as seen at **Shamva Au Mine**. Shamvaian Supergroup sediments have been intruded by several plutons and small stocks.

The Shamvaian stratigraphy resembles a drowning sequence for an alluvial fan or braided delta (from a stream-flow dominated setting through a flood-type environment, the downslope part of a fan, to a high velocity turbiditic environment). The dominance of sediment deposited as sheets rather than forming channelled deposits on the Shamvaian alluvial fans may lie in the absence of vegetation in the Archaean, favouring unconfined sediment transport (Hofmann et al. 2001). The tectonic setting has been equated to that of modern foreland and forearc successions and formed during compressional or transtensional tectonics associated with accretionary processes (Hofmann et al. 2002; Hofmann et al. 2004).

Structure

Although the overall structure of the Bindura-Shamva section of the greenstone belt appears synformal, we now have evidence that such an interpretation is an oversimplification. Firstly, the stratigraphy of the Upper Bulawayan greenstones along the northern flank of the belt is different from the stratigraphy along the southern flank (Stidolph 1977; Jelsma et al. 1996). Whereas the northern flank is characterized by tholeiitic volcanics with intercalated rhyodacitic volcanics, and volcaniclastic sediments, the southern flank comprises tholeiitic and komatiitic volcanics and numerous intercalations of ironstones, cherts, pelites, and limestones.

Secondly, structural-metamorphic data within the Harare-Shamva greenstone belt show an early generation of amphibolite-grade structures (D1) involving anastomosing, largely layer-parallel shear zones with shallow mineral lineations, which have been strongly silicified and infiltrated by iron-sulphides (Dirks and Jelsma 1997). These shears appear to have accommodated imbricate stacking of a pre-existing stratigraphy (for example south of Bindura, cf. Dirks and Jelsma, 1996), tectonically modifying continuity and original contacts.

Thirdly, no large-scale synform exists within the Shamvaian sediments in the core of the belt. A prominent D1 layer-parallel mylonite zone separates Shamvaian sediments, which young to the north, from basalts of the Mungari Formation, which young to the south and, as for the Brinkburn shear zone to the south, truncates the trends of primary layering in the footwall and hanging wall. This break is clearly seen north of Shamva town where a tightly folded ENE trending sedimentary sequence is structurally overlain by E-W trending mafic schists that young to the south. Foliation trajectories and younging indicators within the Shamvaian sediments show complex folds and shear zones. In places, however, stratigraphic contacts are preserved such as north of Panmure inlier where mafic volcanics are unconformably overlain by Shamvaian sediments, but along strike this unconformable contact is cut by a shear zone. A tectonic break within the Shamvaian sediments is defined by a 50-100 m wide chlorite-actinolite schist horizon with a top-to-the-west shear component (Wolley shear zone). This zone can be traced within the Shamvaian, over a distance of more than 50 km.

Large-scale fold geometries within the Shamvaian sediments mostly represent disharmonic structures on a layering, which generally dips and youngs to the north. The fold structures have highly variable styles and wavelengths (λ), ranging from mesoscopic, tight to isoclinal, noncylindrical folds with $\lambda <$ 100 m close to the contacts with the volcanics to macroscopic, open to tight, near-cylindrical folds with λ = 1-2 km within the core of the greenstone belt. Felsic volcanics and volcaniclastic sediments occur as tectonic megalenses, bound by shear zones and infolded with the sediments (Jelsma and Dirks 2000). L1 linear fabrics (mineral elongation lineations, X axes of strain markers, and boudin necks) and F1 folds in all Upper Bulawayan and Shamvaian lithologies plunge generally at shallow to moderate angles to the west or east.

The mafic volcanics of the southern flank (Arcturus Formation) structurally overlie gneisses of the Murehwa batholith in the east and felsic-intermediate volcanics of the Iron Mask Formation in the west. Although these contacts were regarded by Jelsma (1993) as possible tectonized unconformities, they are best interpreted as major D1 shear zones (Riverbend and Brinkburn shear zones) considering the intensity of deformation features (such as planar and linear fabrics, disharmonic and sheath folds, grain shape fabrics, S-C fabrics, and truncation of bedding).

D2 structures involved the rise of TTG granite-gneiss domes such as the Chinamora batholith, and infolding of the greenstone sequences, giving rise to what appears like a dome-and-basin configuration. This event resulted in the formation of shear zones marginal to the domes, with strain and lineation patterns that are typical around ballooning diapirs (Jelsma et al. 1993), and a normal, dome-side-up sense of shear (for example south of Bindura, southeast of Shamva), localised recumbent folding and a pervasive amphibolite facies contact metamorphic overprint, which occurred at about 2.62 Ga (Van Dijk and Kater, 1996). This event may have been preceded or may have been accompanied by oblique reverse movements or strike-slip movements within the greenstone belt. This D2 event is often associated with epigenetic gold mineralization (for example at Bindura and Mazowe, Vinyu et al. 1996).

D1 and D2 structures are truncated by a complex array of greenschist facies shears (D3), which are associated with duplex geometries (such as at Freda-Rebecca and Mazowe mines, Iron Mask Dam road cutting, Murehwa-Mutawatawa road cutting). This event is accompanied and post-dated by the emplacement of the classical "post-tectonic" Chilimanzi-type monzogranites

In general, the D1-D3 structures can be explained with a model involving stacking of thick crustal slices with second-order imbrication of the greenstone stratigraphy, resulting in crustal thickening (35 km), large-scale crustal melting and transient diapirism (Dirks and Jelsma 1997).

On the basis of the structures described, the greenstone belt can be divided into two separate blocks. Both the southern (footwall) block and the northern (hanging wall) block include internally stacked, mafic-felsic greenstone stratigraphies. The volcanics of the southern block are capped by Shamvaian sediments that are tectonically overlain by the inverted northern block. D1 lineation directions in both blocks are the same, indicating continuity in deformation style.

Age constraints

For the northern block the only data available are for a rhyolitic tuff of the Maparu Formation which gave a SHRIMP zircon age of 2697 ± 9 Ma (Wilson et al. 1995).

For the southern block the Iron Mask volcanics comprise rock assemblages dated using TIMS zircon at 2715 ± 15 Ma (Jelsma et al. 1996) and using SHRIMP zircon at 2715 ± 7 Ma (Nesbitt et al. 2000; Bindura) and at 2645 ± 4 Ma (Wilson et al. 1995; Harare). The younger age is similar to the SHRIMP age for the Passaford volcanics of 2643 ± 8 Ma (Wilson et al. 1995), which, together with geochemical data (Tomschi, 1987), suggests that the intermediate-felsic volcanics of the two formations within the Harare Sequence were related and that the Passaford Formation is the structurally stacked equivalent of the Iron Mask Formation in this area, as was previously proposed by Tomschi (1987), and the two have been referred to as the Harare Sequence (Wilson et al. 1995). The underlying Mount Hampden Formation might represent the deeper, downslope part of a Shamvaian Supergroup (foreland?) basin.

Felsic volcanics intercalated with the structurally overlying Arcturus Formation have a Pb-Pb whole rock age of 2659 ± 38 Ma (Taylor et al. 1991). Toward the structural top of the greenstone pile, subvolcanic high-level porphyries associated with Shamvaian volcaniclastic sediments have been dated using TIMS zircon at 2672 ± 12 Ma (Jelsma et al. 1996). Redating the zircon population using SHRIMP yielded an older age of 2716 ± 4 Ma for a selected population of zircons. The latter age, however, is in conflict with existing relative and absolute age data (general stratigraphy based on age data and field relations including younging indicators) for the greenstone sequence and most likely reflects an inherited component in the zircon population of the sample. Although more data are required, the ages available for the felsic volcanics suggest the existence of at least two separate tectonostratigraphic sequences, one at 2715-2672 Ma and the other at 2645-2643 Ma.

The mafic volcanics and sediments interlayered with the felsic volcanics have not been directly dated. For the Shamvaian sediments, Dougherty-Page (1994) obtained clast zircon (Kober) ages in the range of 3.2-2.7 Ga, indicating the proximity of mid-Archean felsic crust during deposition.

A younger age bracket is given by the U-Pb zircon ages of gneisses within the Chinamora batholith and of late syn-tectonic to post-tectonic plutons of intermediate to felsic composition, which intruded the various greenstone belt lithologies and cut D1 fabrics.

All batholiths show a widespread development of syn-tectonic tonalites, granodiorites and granites which have been assigned to the Wedza Suite (Jelsma 1993; Wilson et al. 1995). Within the Chinamora batholith, the gneissic granites (tonalites to syeno-granites) occur near the outer margin (Becker et al. 2000). These granitoids show a wide variation in intensity of fabrics and include banded, mixed migmatitic rocks. Their age of emplacement and crystallization must be younger than 2643 Ma (which is the age of extrusion of felsic volcanics in the greenstone belt), but older than ~2601 Ma (which is the crystallization age of the porphyritic granites). The TIMS zircon age of the Chinamora gneiss (2667 ± 4 Ma, Jelsma et al. 1996) may either represent a mixed magmatic/inherited age (D2/M2) that is too old, or represent a truly magmatic, pre-tectonic (pre-D1/M1) age.

Late syn-tectonic granitoids include relatively early diorite, monzonite or tonalite phases and later granodiorite and granite phases and intruded the greenstone belt at all levels. The internal Bindura and Mazowe plutons have ages of 2648 and 2647 Ma, respectively (TIMS - Jelsma et al. 1996 and Vinyu et al. 1996; SHRIMP - Nesbitt et al. 2000), which are within error of the Passaford Formation felsic volcanics age (2643 ± 8 Ma, SHRIMP, and the Harare Sequence Iron Mask volcanics) and the main

Mineral ages on unoriented M2 garnet (U-Pb) and hornblende (Ar-Ar) grains from the margin of the Shamva greenstone belt near the Murehwa batholith show that the M2 contact metamorphic overprint in this area occurred between 2621 and 2566 Ma (van Dijk and Kater, 1996; Dirks and Jelsma, 1998).

Amongst the youngest granites are the largely tabular ca. 2.6 Ga Chilimanzi (Razi, Pfungwe) Suite (monzo)granites which have a large areal extent, marking crustal relaxation and heralding the onset of cratonization. This is followed by intrusion of the Great Dyke and its satellite dykes at 2575 Ma (Armstrong and Wilson 2000; Wingate 2000).

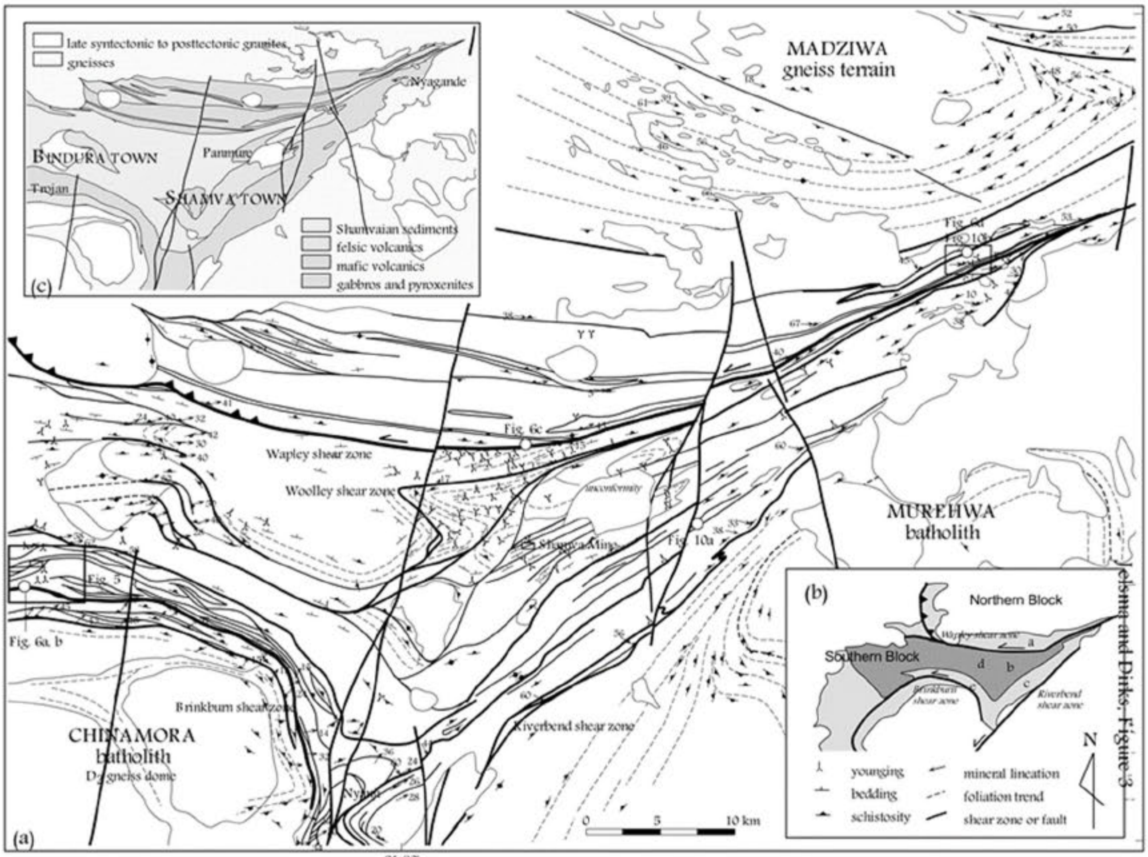
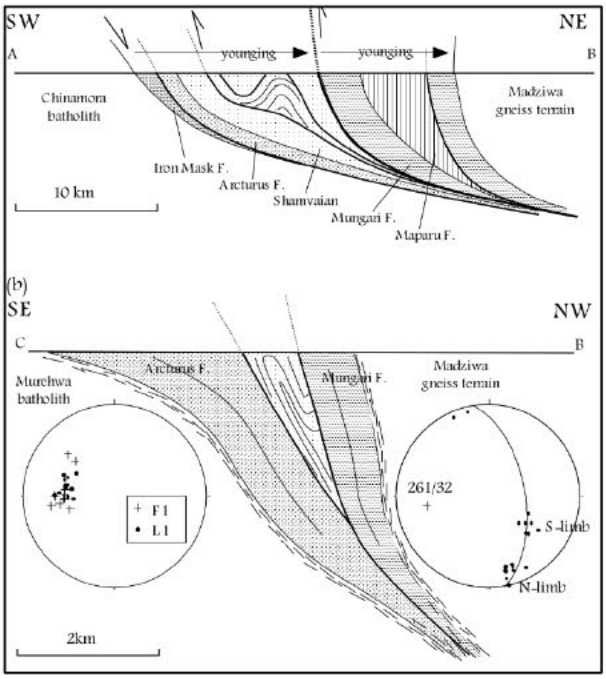


Fig. 3. (a) Structural compilation map of the Bindura-Shamva section of the greenstone belt (based on detailed field studies by former B.Sc. Honors students in 1984 and 1994-1997 (C. Makuni, R. Manyanga, J. Mariga, A. Mashingaidze, W. Mbalaka, T. Paji, and R. Simango); J. Orpen, personal communication, 1997; Stidolph (1977), Chimimba (1987), Baglow (1992), and own data, as well as remote sensing lineament analysis, i.e. aerial photos and SPOT satellite images). Shown are anastomosing networks of D_1 shear zones, the D_2 contact shear zone around the Chinamora batholith, foliation trajectories, lineation data, and younging indicators. (b) Summary map showing the two tectonic blocks and the five stereoplot domains presented in Figure 4. (c) Summary map showing the distribution of the main lithologies (Jelsma and Dirks 2000).

Fig. 4. Schematic cross sections through the Bindura-Shamva section of the greenstone belt along section lines A-B and B-C shown in Figure 2. (a) Cross section through the central part of the greenstone belt (after Figure 2 of Dirks and Jelsma [1998a]). (b) Cross section through the NE extension of the greenstone belt. The lineations on either side of the boundary shear zone are parallel and plunge shallowly to the west (see text). Note the inferred listric nature of the shear zones, which is based on field data.



Stop 1. Rutope Ultramafic Complex with Tipparary Ni-Cu Claims (31.457°E, -17.569°S)

The first (short) stop is located to the east of the tar road approximately 60 km NE of Harare and 30 km southwest of Shamva, where the road crosses the southern tip of the Bindura-Shamva greenstone belt. The contact with the Murehwa Batholith to the east is referred to as the Umwindsi shear zone, along which migmatites and synkinematic granulite grade mineral assemblages are found. The greenstone belt comprises intermediate volcanics that have been correlated with the 2715 Ma (Jelsma et al. 1996; Nesbitt et al. 2000) Iron Mask Formation, as well as amphibolites and ironstones and intruded by the ***Rutope Ultramafic Complex***. The complex hosts the Tipparary claim that has been explored for polymetallic Ni-Cu mineralization. Polymetallic mineralization in Zimbabwe is associated with ultramafic lavas within greenstone belts or in closely associated intrusions, especially those of Bulawayan age, such as seen at Trojan, Empress, Shangani (2733 Ma), Epoch (2740 Ma) and Madziwa and at Hunter's Road (2746 Ma) and Damba (Prendergast and Wingate 2013). These deposits comprise a variety of deposit styles which are found in intra-cratonic rifts, rifted continental margins, as well as back-arc settings. They are hosted by peridotites, pyroxenites, or varieties of gabbros emplaced at mid-crustal levels in layered complexes; or at mid- to shallow crustal levels as feeder systems and lava flows related to flood basalts or basin-related volcanism, encompassing komatiite and picrite varieties. The deposits include (a) stratiform (semi)massive or disseminated, (b) disseminated and net-textured reef-type, (c) magmatic-hydrothermal or (d) tectonically remobilized vein-type mineralization (e.g. Trojan Mine). Base metals are typically contained by pyrrhotite, pentlandite, and chalcopyrite. The metal source is the magma, with possible contributions from crustal contaminants; concentration is a product of metal partitioning during melt immiscibility and gravitational and/or fluid dynamic segregation. The S source may be related to the primary magma as well as contamination by crustal sources, including S-bearing sediments, which are usually found in the settings referred to above.

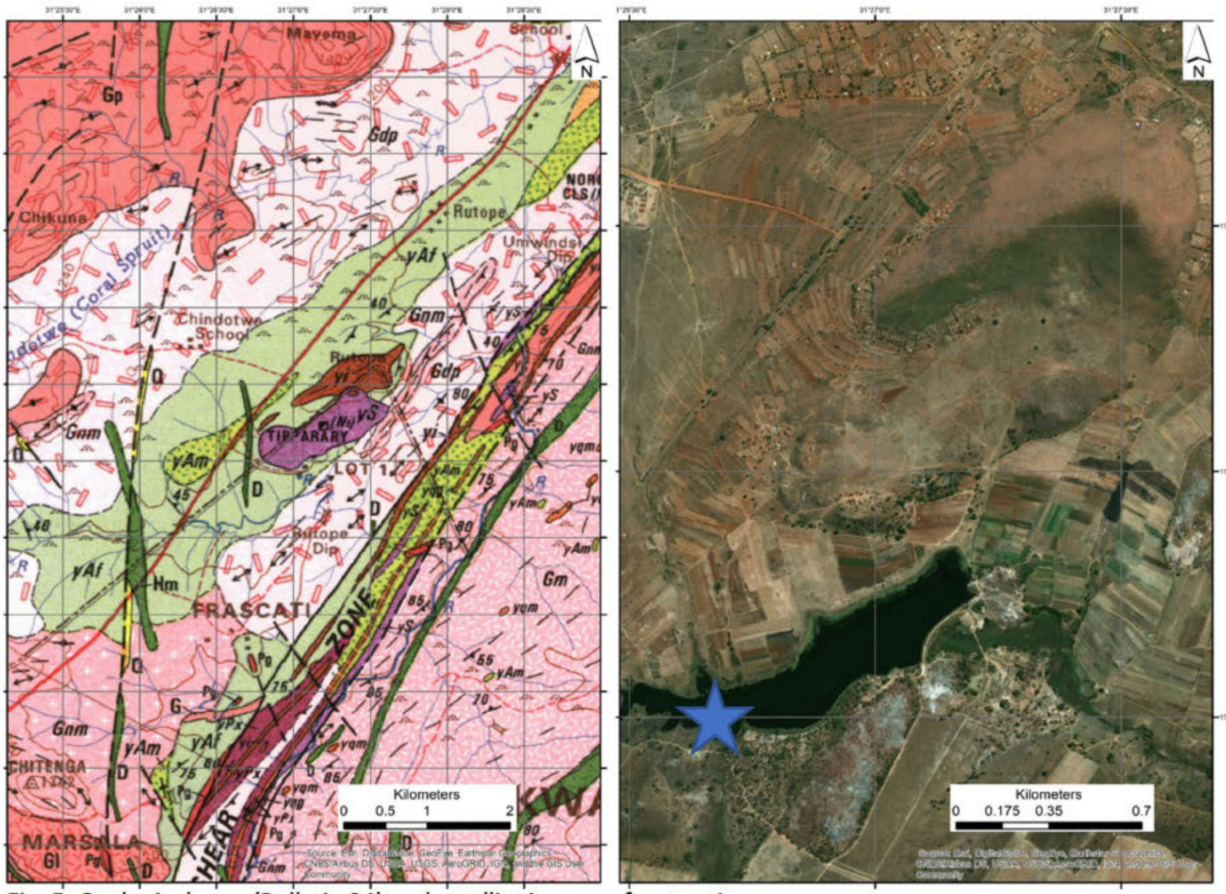


Fig. 5. Geological map (Bulletin 94) and satellite imagery for stop 1.

Stop 2. Lower Shamvaian Group volcaniclastic sediments and porphyries (31.543°E, -17.382°S)

Stidolph (1977) subdivided the Shamvaian Group into two lithostratigraphic units, (1) the Lower Shamvaian consisting of volcaniclastic and reworked epiclastic sediments, and (2) the Upper Shamvaian consisting of a coarse-grained siliciclastic association characterized by the presence of granitic detritus. Hofmann et al. (2001) differentiated three tectonostratigraphic units, termed the Tsambe, Pote, and Mazowe Formations that are separated from each other by shear zones. The units differ in lithofacies and/or composition from each other. The Tsambe Formation is equivalent to the Lower Shamvaian of Stidolph (1977) and is restricted to the southern part of the Shamvaian outcrop.

South of Shamva Mine, the Tsambe Formation volcaniclastic sediments are well exposed as a >1 km wide unit, locally intruded by small bodies of feldspar porphyry. The tuffs are greenish grey to dark grey in colour and are andesitic in composition, containing hornblende and plagioclase. The spatially and probably genetically associated porphyries are similar in appearance and composition and like many tuffs characterized by 1-5mm sized plagioclase and hornblende phenocrysts set against a dark grey matrix. In outcrop the porphyry lacks banding and commonly contains amphibolite xenocrysts. The age of intrusion of the porphyries is constrained by a U-Pb zircon TIMS age of 2672 ± 12 Ma (Jelsma et al. 1996). Two <u>short stops</u> to view the volcaniclastic rocks and porphyry (two small hillocks to E of road).

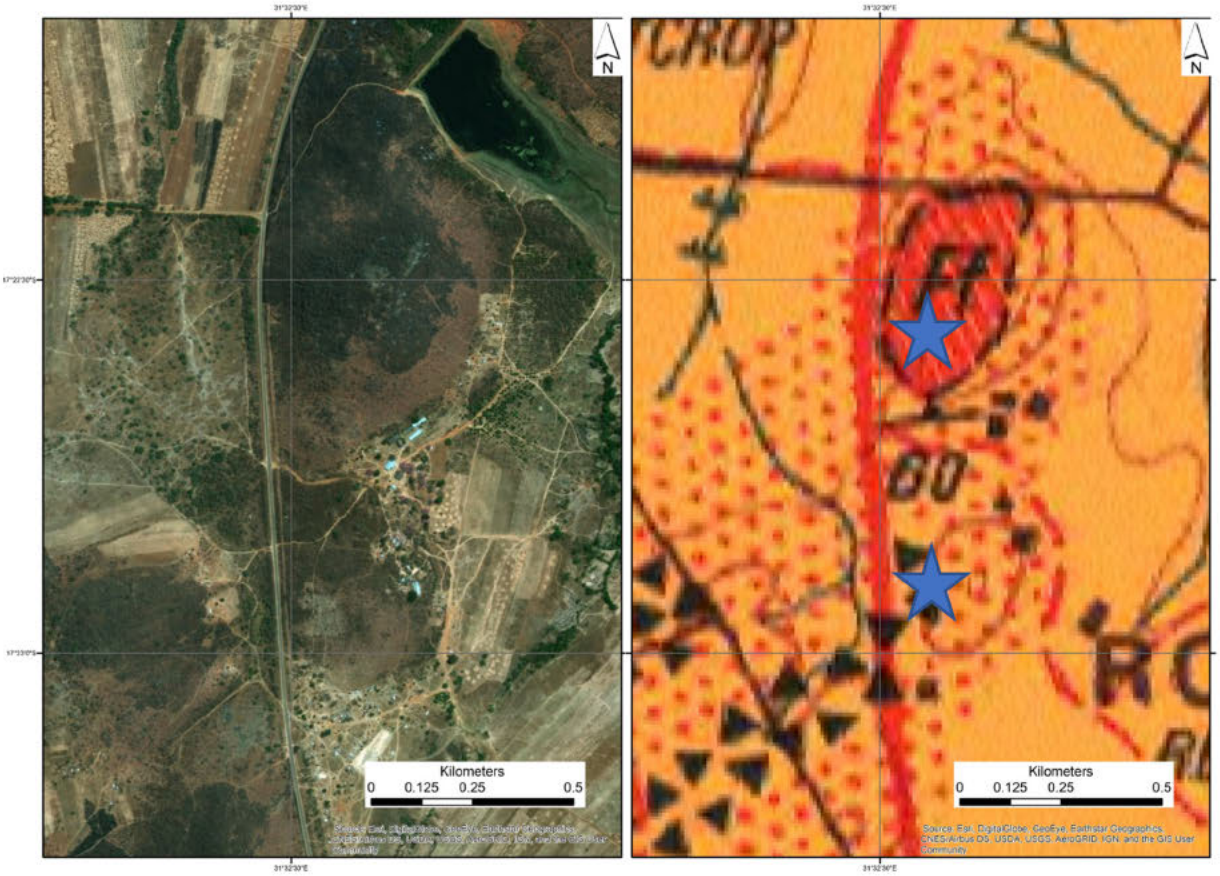


Fig. 6. Geological map (Bulletin 78) and satellite imagery for stop 2

Stop 3. Shamvaian Group rocks east of Shamva (Ashkirk claims, 31.585°E, -17.316°S)

Host rocks at Shamva Mine are pyritiferous felsic volcaniclastic and reworked epiclastic sediments of the Tsambe Formation, locally intruded by small bodies of feldspar porphyry. These rocks occur as part of a tightly to isoclinally folded and faulted/sheared sequence. Most of the ore channels are situated along the main Shamva shear trend, extending from the Danton and Electra claims to the west of Shamva Mine to the main workings on Shamva hill and to the Ashkirk claim to the east.

Farther to the east and west, the Shamvaian Group sediments have been intruded by the Cadogan, Bindura and Glendale plutons, which comprise rocks of diorite, monzonite to granodiorite composition that have been dated using U-Pb zircon TIMS method at 2649 ± 6 Ma (Jelsma et al. 1996) and using SHRIMP at 2648 ± 6 Ma (Nesbitt et al. 2000).

Mineralization is thought to be epigenetic (structurally-controlled) associated with shear zones such as Wolley, Wapley and Shamva and the emplacement of felsic plutons. The ages of the mineralization are identical to those reported from other mesothermal gold deposits. The Pb and Nd isotopic signatures are compatible with a direct mantle or a short crustal residence time for the protoliths to the host intrusions (Vinyu et al. 1996). The origin of the gold could have been metamorphic and/or magmatic. The time frame around 2.65 Ga represents a period of significant crustal growth through addition of mantle-derived magma, deformation and metamorphism.

A brief stop to discuss the gold mineralization at Shamva.

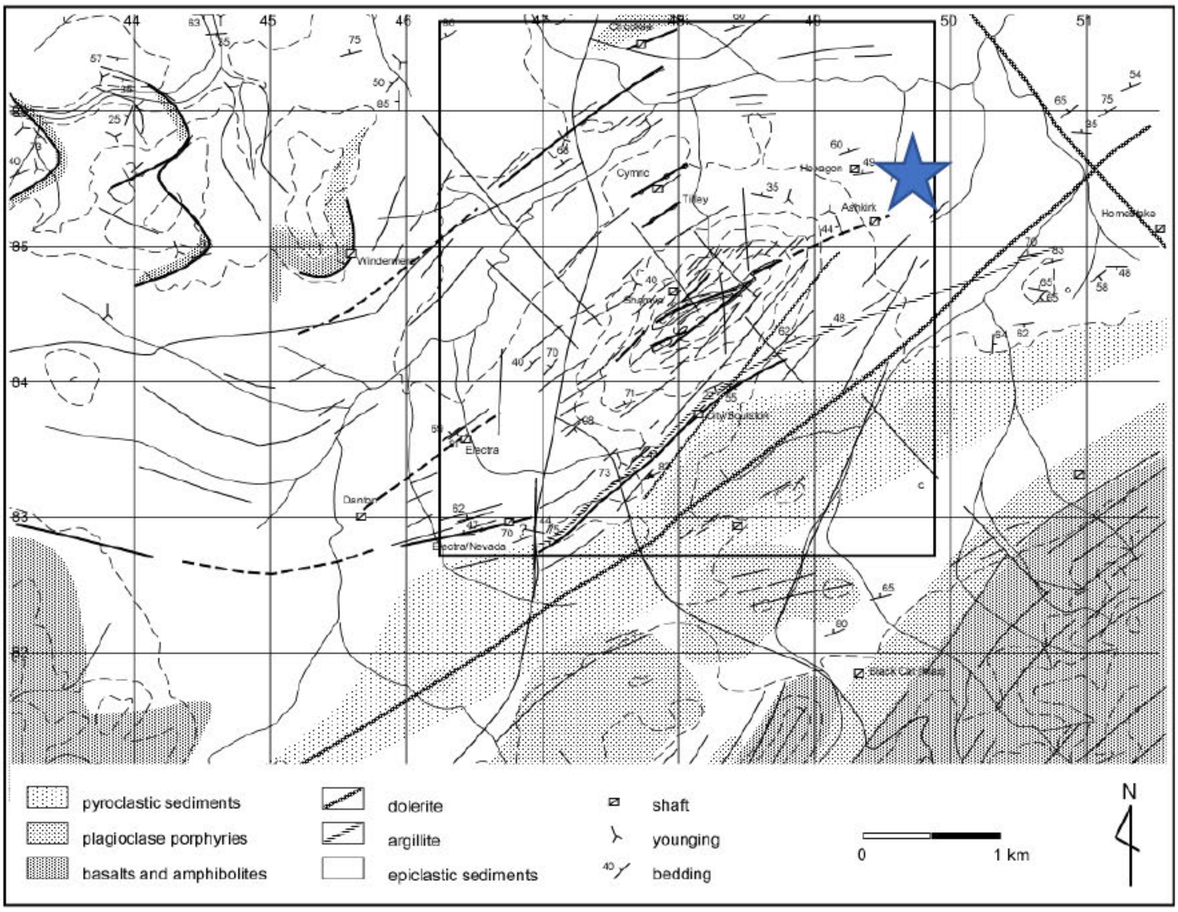


Fig. 7. Geology of the area around Shamva gold mine, showing the main lithologies, lineaments as deduced from airphoto and SPOT interpretation and the distribution of gold deposits. UTM grid.

Stop 4: Upper Shamvaian Group clastic sediments

Ten kilometres NE of Shamva, the Mazowe River transects the contact between the Upper Bulawayan Group Arcturus Formation and sediments belonging to the Shamvaian Group. The Bulawayan greenstones occur as an erosional window in the centre of an antiformal structure (Panmure Inlier) surrounded by younger sediments. We will walk a cross-section through part of the steeply northward dipping northern limb of this antiform, and investigate intrusive relationships in the Bulawayan greenstones, the contact with the Shamvaian sediments, and the stratigraphy of the lower part of the Shamvaian Group, which is referred to as the Pote Formation (Hofmann et al. 2001). The Arcturus Formation comprises massive and pillowed basalts as well as komatiitic basalt varieties. Pillow lavas can be seen that are intruded by several generations of mafic dykes. In places the basalts preserve spinifex textures typical of hot, high MgO magmas such as komatiites.

When following the Mazowe River upstream for about 400m, a sudden change in rock type can be observed. Basal conglomerate rests on fine-grained, structureless basaltic rock. The contact is sharp and remarkably planar for at least 50m. Within a few decimetres of the contact, basalt is more strongly foliated and contains minor anastomosing shear zones. The amount of displacement along the contact (if any) is difficult to assess. The absence of mylonites is suggestive of a slightly deformed conformable contact. The conglomerate is polymict with clasts mostly of granitoid composition, but also including basalt, chert, quartzite, felsite, ironstone and porphyry. The clasts are rounded to well-rounded and range from spherical to ellipsoidal to oblate in shape. The matrix consists of granule-bearing, coarse- to very coarse-grained sand.

Walking upstream from the contact, gradual changes can be observed in the composition and sedimentary structures preserved in the sediments. The number of pebbles and their size decreases, as the proportion of finer sand increases. The sandy units show sedimentary structures such as cross-bedding and fluidisation structures.

The Wolley shear zone is a ~40 m thick unit of sheared sediment. It is characterized by foliated mudstone/shale thinly intercalated with beds of siltstone and sandstone. Strong deformation resulted in disruption and boudinage of the sandstone beds. Narrow quartz veins are deformed together with the surrounding sediment. The lower contact of this unit is not exposed. The upper contact seems to be gradational as indicated by the occurrence of less disrupted tabular sandstone beds intercalated with mudstone.

Thin to thick beds of normally graded sandstone intercalated with shale form the >>200 m thick upper part of the section and are attributed to the Mazowe Formation (Hofmann et al. 2001). Beds are tabular with a sharp to slightly erosive base (≤4 cm erosional relief) and commonly show Bouma T_{abde} and T_{bde} sequences. Massive to horizontally laminated, medium-grained sandstone, partly containing mudstone intraclasts up to 1 cm across, occurs at the base. This grades upwards into massive, horizontally laminated and/or current ripple-laminated, fine-grained sandstone which, in turn, is overlain by massive to laminated mudstone.

The Pote and Mazowe Formations represent the Upper Shamvaian of Stidolph (1977). The Pote Formation forms most of the central part of the Shamvaian outcrop, whereas the Mazowe Formation is restricted to a 1-3 km wide unit in the northern part of the outcrop. The southern contact of the Mazowe Formation is termed the Wolley shear zone. Along the northern contact with Bulawayan volcanics occurs a several tens of metres wide schistose zone termed the Wapley shear zone (Jelsma and Dirks 2000; Fig. 7.2).

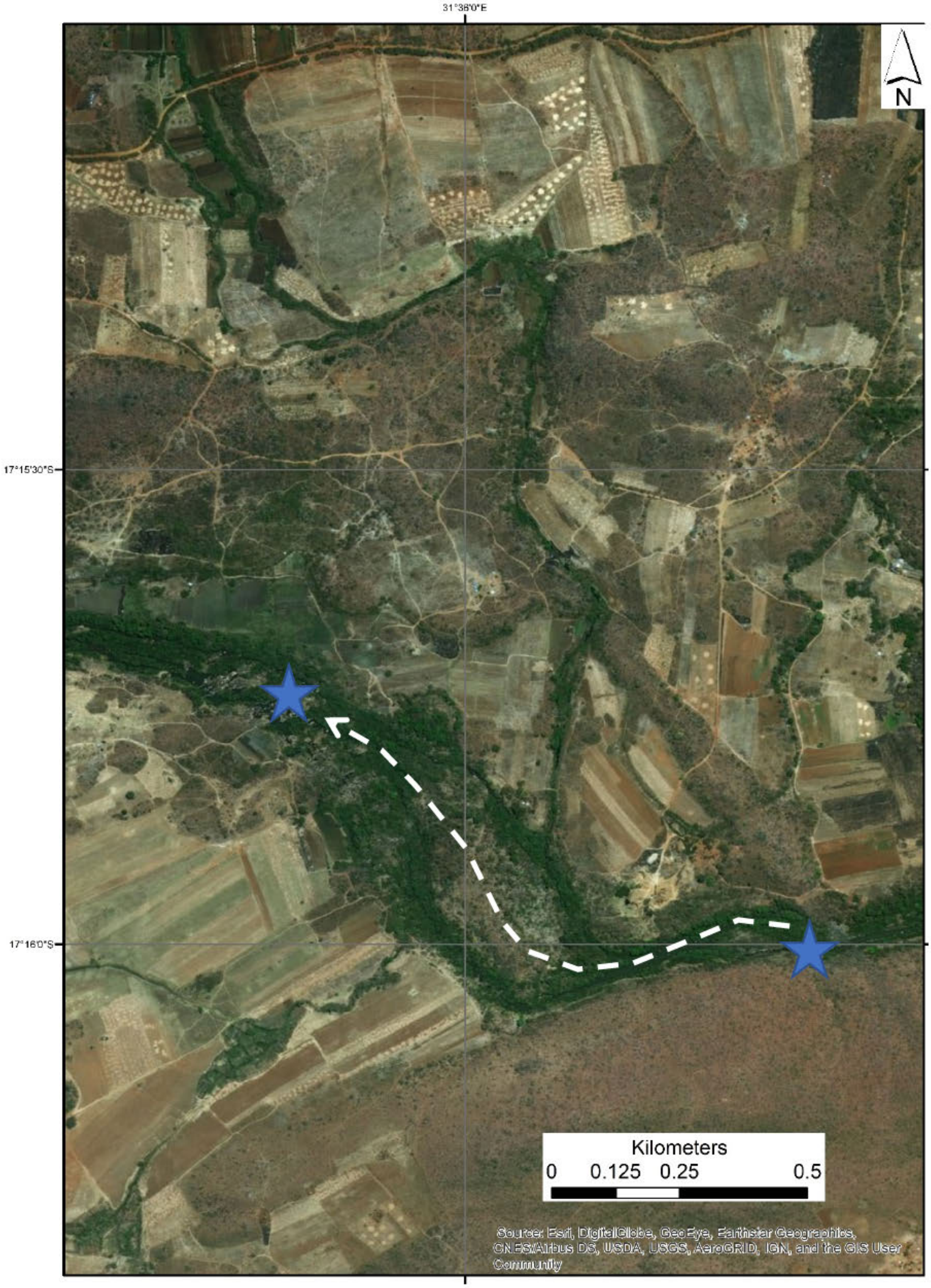


Fig. 8. Mazowe River section at Hippo Valley Estate.

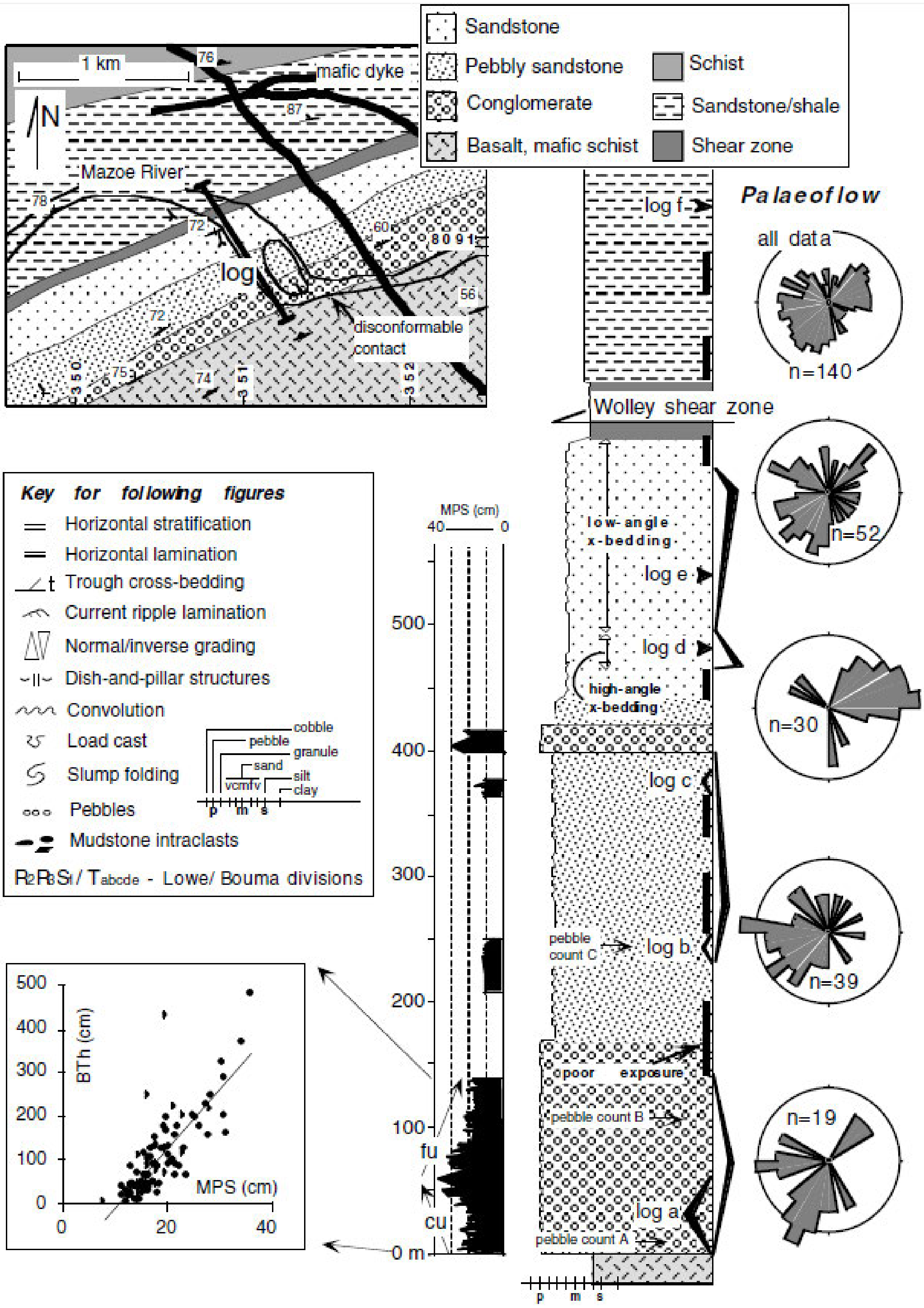


Fig. 9. Simplified geological map and graphic log of the Mazowe River section. Palaeoflow diagrams and a plot of maximum particle size (MPS) vs bed thickness (BTh) are shown (Hoffman et al. 2001).

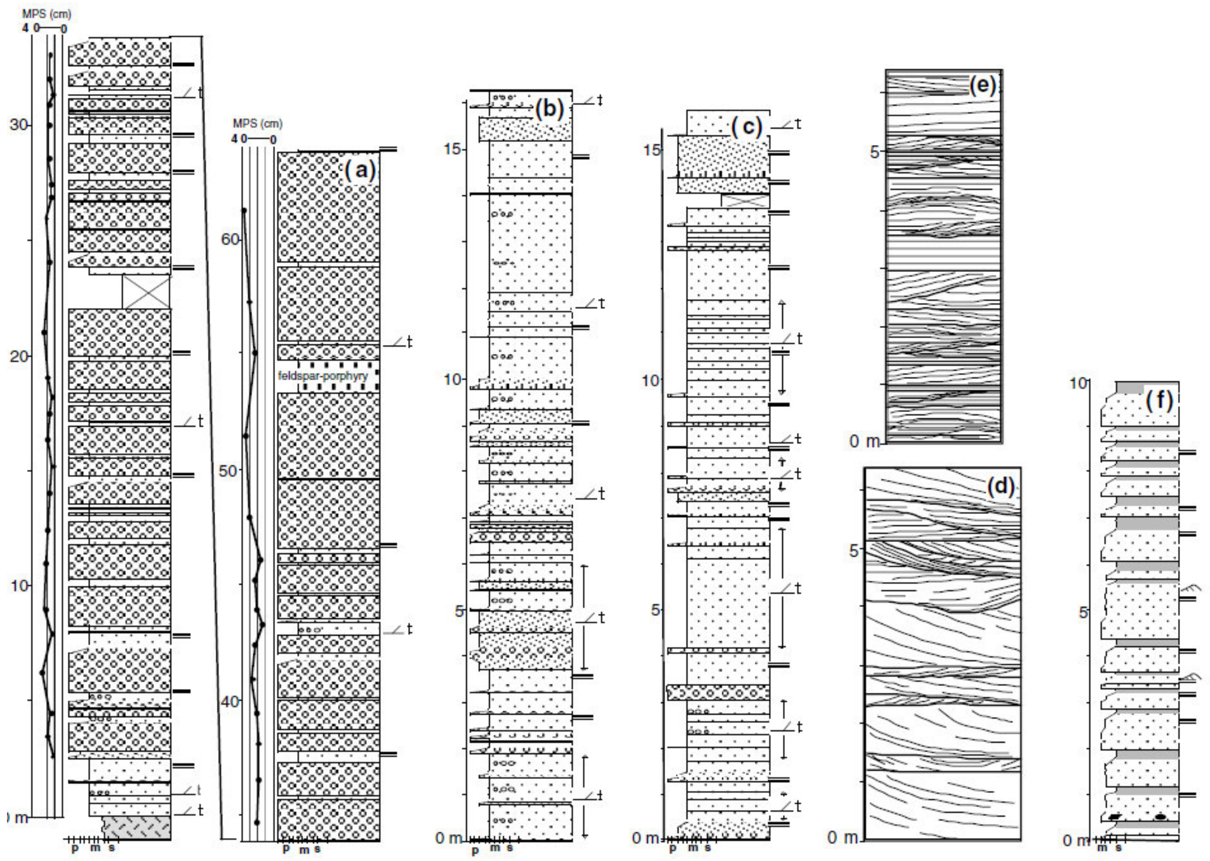


Fig. 10. Representative graphic logs of different lithological units of the Mazowe River section (Hofmann et al. 2001).

Stop 5. Bulawayan Group stratigraphy along Mazowe River

Nyagande primary school is located 45 km NE of Shamva (gravel road). At this locality the greenstone belt has tapered to a width of <5 km and the rocks are variably strained, flattened and, in places, boudinaged. Directly north of Nyagande School, the Mazowe River cuts a gorge through the northern limb of the syncline. The lithologies within this limb dip 70-80° to the NW and are overturned, younging to the SE.

From S to N the following rock types can be mapped, which have been deformed and metamorphosed:

a. Fine-grained poorly sorted clastic greywackes of the Shamvaian Group.
b. Massive basalts composed (Nyamwanga Formation, or Mungari Formation?).
c. Andesite tuffs and agglomerates exposed in a small stone quarry.
d. Rhyodacite tuffs with mm-sized rounded quartz phenocrysts (Maparu Formation).
e. Pillowed basalts with well-preserved structures. Although the pillows are strongly flattened during deformation and metamorphism, the original outline can still be used to determine the direction in which this sequence is younging (Mungari Formation).
f. Talc-tremolite schists.
g. Well-banded cherts, with locally preserved sedimentary structures such as cross-bedding, parallel laminations and ripple marks (Thebus Formation).
h. Spotted rocks, referred to as dalmationite (cordierite-anthophyllite hornfels).
i. Intermediate- to felsic schists, which are the host rock to the Maramba Prospect and of volcanic origin (Thebus Formation).

The Maramba Prospect occurs over a strike length of 3km to the east of the Mazowe River, within felsic-intermediate schists of volcanic origin (andalusite-sericite, hornblende-biotite, cordierite-orthoamphibole-biotite schists), biotite schists, quartzofeldspathic paragneiss, volcanic breccias, marbles and calcsilicates and ironstones. Garnet forms porphyroblasts which are syn- to post-tectonic with respect to foliation development, and which can form zones of semi-continuous adjoining crystals. The rocks show a moderate to penetrative foliation with dip angles ranging from 45-90° N. Strain is typically inhomogeneous. The early D1 foliation is a shear fabric as indicated by S-C fabrics, shear bands, asymmetric porphyroclasts, and duplex-like geometries. The volcanic pile, mineralization and structure have been intruded by post-tectonic granites and pegmatites.

The prospect was explored by Falconbridge in 1996 and 1997 using soil sampling and HLEM surveying, followed by trenching and drilling. Trenches were dug (1m deep and 1m wide, 25m in length) perpendicular to the strike of the mineralization (and foliation), across HLEM conductor axes and anomalous Cu-Pb-Zn anomalies from soil sampling. The trenches show a malachite- and azurite-bearing gossan of oxidized massive sulphides with a maximum thickness of about 14m. The zone of mineralization pinches and swells, as a result of flattening and boudinaging. In general, the mineralization appears to become less pervasive in a westerly direction, yet the zone of anthophyllite-cummingtonite alteration continues for another 6 km to the west, across the Mazowe River.

The sulphide mineralization is mostly of remobilized vein type. The major ore minerals present are pyrrhotite, sphalerite, galena, pyrite, chalcopyrite and magnetite. Ten holes were drilled and sampled for assaying, petrography and geochemistry (Danda, 1997). Host rocks are andesites, although komatiitic basalts, basaltic andesites and dacites occur as well. Most samples have Fe_2O_3+MgO values between 8-16%, indicating subseafloor alteration. In general, the drill hole intersects are disappointing both in width and grade, with Mar97-03, 3.05m @ 2.49% Cu, 0.70% Zn and Mar97-04, 0.60m @ 2.17% Cu, 1.42% Zn, 1.67% Pb. Trench data give Cu values of up to 14m at 3.4% showing likely occurrence of supergene enrichment.

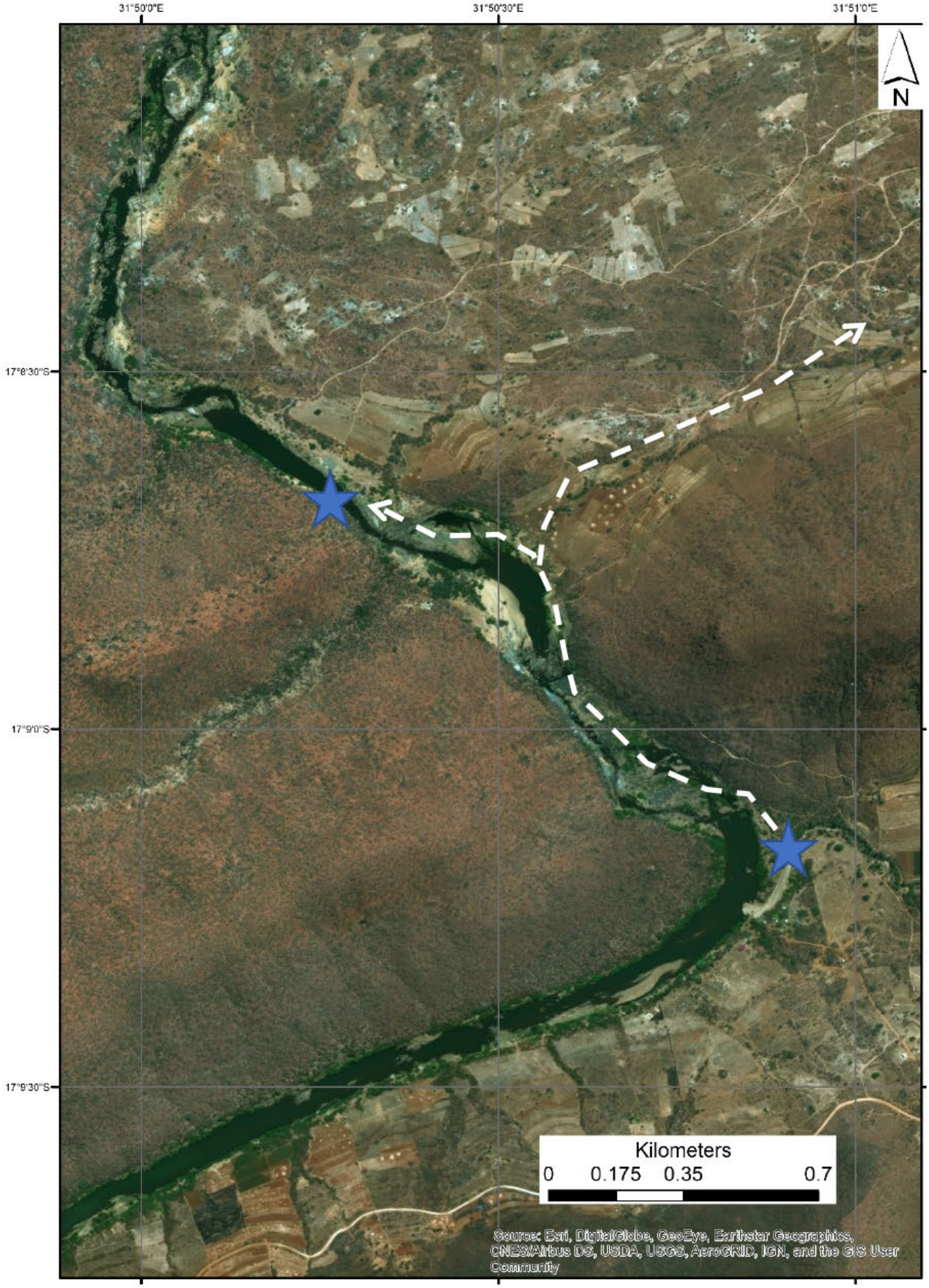


Fig. 11. Mazowe River section at Sunungukai / Nyagande Pools.

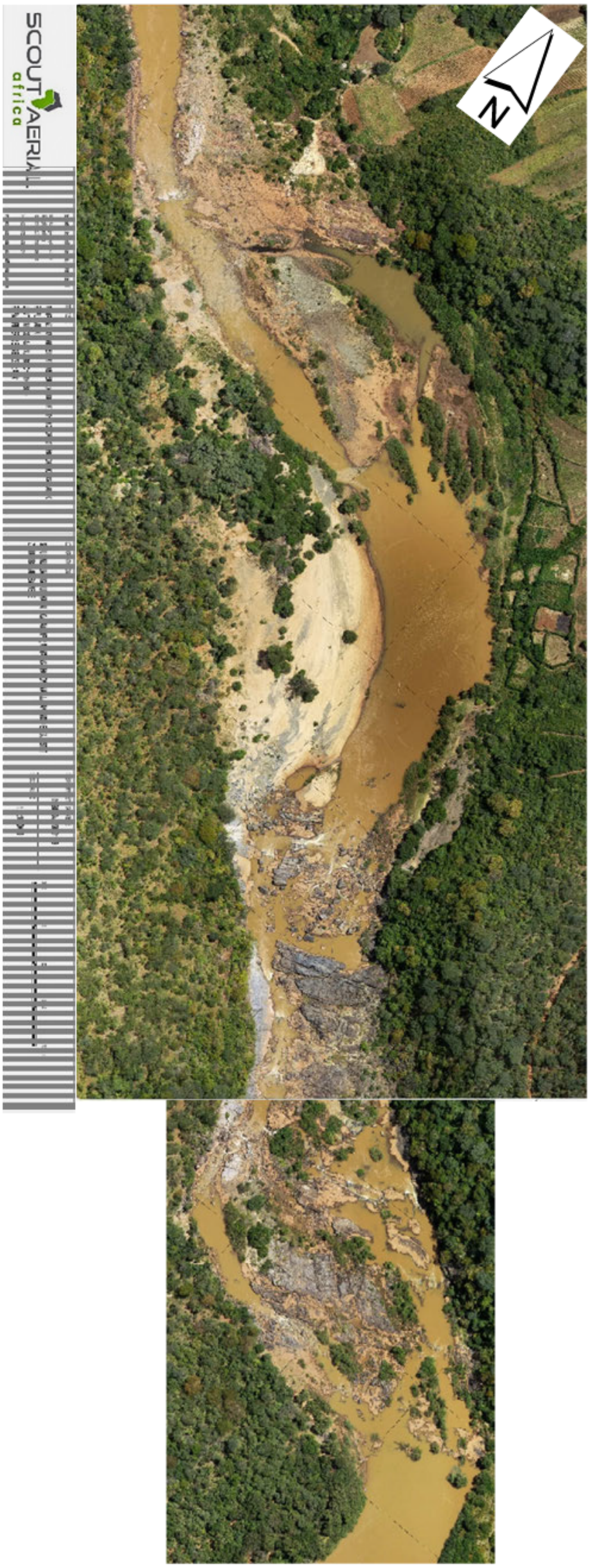


Fig. 12. Drone imagery over the Mazowe River section at Sunungukai / Nyagande Pools (courtesy A. Martin).

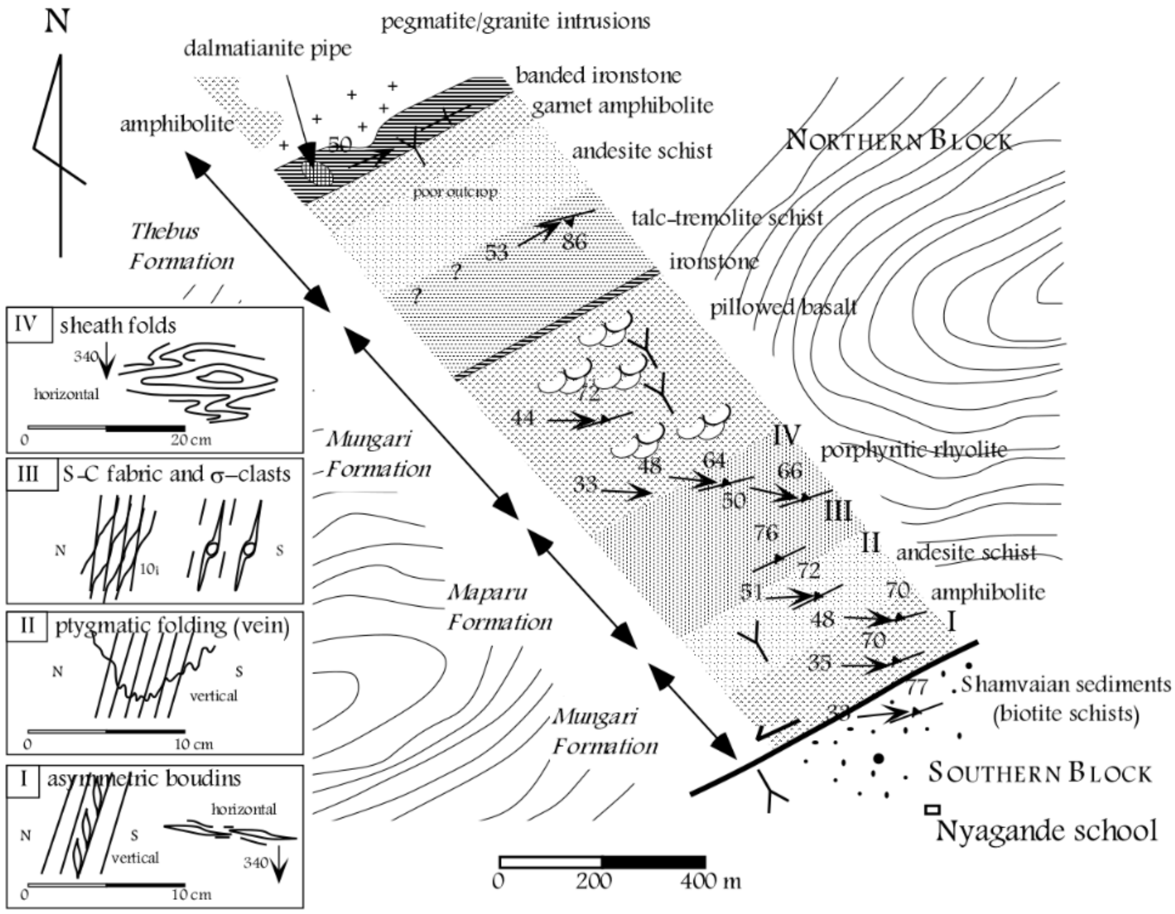


Fig. 13. Detailed N-S river traverse along the Mazowe River, through the northern flank of the Shamva greenstone belt, Nyagande area. Note the lithological variation, overturned bedding and shear zone at the contact between the northern and southern blocks. Contour lines indicate 20m vertical interval contours (Jelsma and Dirks 2000).

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