BRITISH GEOLOGICAL SURVEY
Overseas Directorate

A regional drainage geochemical exploration survey of the country between Rushinga and Nyamapanda, north-east Zimbabwe

P. N. Dunkley

Report MP/87/16
British Geological Survey
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SUMMARY AND RECOMMENDATIONS

During the period 1982-86 a team of geologists from the British Geological Survey carried out a programme of regional geological mapping and geochemical exploration in collaboration with the Zimbabwe Geological Survey under a Technical Co-operation agreement. This report describes the working methods and results of a stream sediment geochemical exploration survey of the Rushinga - Nyamapanda area of north-east Zimbabwe, which formed part of this programme. The results of the survey are presented in a series of geochemical maps which are held on open file at the offices of the Zimbabwe Geological Survey and the British Geological Survey, and which should be consulted in conjunction with this report.

The ground covers an area of 8 000 km^2 and is underlain by the northeastern corner of the Rhodesian craton and the junction of the Zambezi and Mocambique orogenic belts. The Archaean craton occupies approximately two thirds of the area, in the south and west, and consists of three contrasting terrains. Migmatitic gneisses form the northern and eastern craton margin, and contain the oldest known metamorphic sequences in northeastern Zimbabwe (3.0 -3.1 Ga). The migmatitic gneiss terrain is separated from a late Archaean volcano-plutonic complex, termed the Greenstone-Grey Gneiss Terrain, by a major Archaean tectonic break. Granitic rocks of the Mutoko Intrusive Suite occupy the south-west corner of the area and intrude the Granite-Grey Gneiss Terrain.

A sequence of Proterozoic paragneisses and migmatites structurally overlies the northern and eastern margins of the Archaean craton. Together with tectonic slivers of cratonic-type gneiss, these sequences form the Marginal Gneiss Terrain. The interface between the Craton and the Marginal Gneiss Terrain is almost totally occupied by a tabular-shaped quartz monzonite-monzodiorite batholith, the Basal Rushinga Intrusive Complex, that records an early Pan-African intrusive age (c. 830 Ma). In the northernmost part of the area high grade metamorphic rocks of the Zambezi Allocthonous Terrain, consisting of leucomigmatites and mafic gneisses with granulite remnants, have been thrust over the Marginal Gneiss Terrain.

Basic sheet-like intrusions of Proterozoic age ('Mashonaland Dolerite') cross-cut terrain boundaries, and in addition basic and felsic dykes and small felsic stocks belonging to the Rukore Intrusive Suite, of Mesozoic age (post-Karoo), occur in the northeastern part of the area.

A total of 12438 stream sediment samples was collected during the survey, giving an average density of 1.55 samples per km^2. The - 80 mesh fraction was analysed for Cu, Pb, Zn, Co, Ni, Mn and Li by atomic absorption spectrophotometry following digestion with hot concentrated hydrochloric acid, and for As, Ba, Sn, Ta and W by X-ray fluorescence spectrometry. Analytical precision was monitored by the replicate analysis of samples, and by the regular analysis of standard samples.

Results were analysed statistically and geochemical maps were plotted by computer at a scale of 1:100 000 as transparent overlays complementary to the published geological map sheets for Rushinga-Sutswe and Nyamapanda. The analytical data for each element is presented in a series of single element maps, which illustrate element concentration by means of proportional symbols, and provide a rapid and visual means of assessing concentration ranges and broad variations related to lithology.

Geochemical anomalies are portrayed on multi-element anomaly maps. Because of difficulties in portraying 12 elements on a single plot, the anomalies are

split into two element associations, and each is presented separately. During interpretation the influences of lithology on stream sediment chemistry were accounted for by classifying the analytical results into groups according to the dominant drainage basin lithology at each sample site. For each element and lithological grouping, graphs of log-concentration plotted against cumulative frequency on a probability scale were used to determine threshold values (T), above which concentrations are considered to be anomalous. Anomalous values (AV) were then standardised to produced standard anomaly values (SAV) that are directly comparable regardless of the element, concentration range, background lithology and map sheet.

The formula used for standardisation is: $SAV = ((AV - T)/T)100$.

A total of 44 geochemical anomalies are listed and briefly described at the end of the report, and recommendations are made for further investigation of these. In particular, three anomalies, or groups of anomalies, are considered to merit detailed attention.

A Ni-Co anomaly, associated with an ultramafic body, to the south-east of Bunda and north-east of Nyanza in the Pfungwe Communal Land is by far the most striking anomaly discovered by the survey. This should be given the highest priority in follow-up work, which should include detailed soil and rock geochemical surveys, geological mapping, and ground geophysical surveys.

A broad As and minor W and Cu anomaly in the vicinity of the Southern Cross Mine, Ball Mine and Four Mile prospect should be investigated in more detail, specifically with reference to low-grade gold mineralisation. Initially a detailed soil geochemical survey should be undertaken, preceded by orientation work to ascertain the best sampling and analytical procedures.

The survey has discovered several groups of Pb-Zn with minor Ba and Cu anomalies within the Marginal Gneiss Terrain, often in close proximity to intrusions of the Rukore Suite. Mineralisation of this style was previously unknown within the region, and these anomalies should therefore be examined in more detail, with particular consideration being given to the possibility of silver being present.

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A REGIONAL DRAINAGE GEOCHEMICAL EXPLORATION SURVEY OF THE COUNTRY BETWEEN RUSHINGA AND NYAMAPANDA, NORTH-EAST ZIMBABWE.

INTRODUCTION

This report describes the working methods and results of a regional drainage geochemical exploration survey of the country between Rushinga and Nyamapanda in north-east Zimbabwe. The survey was undertaken as part of a regional geological mapping and mineral reconnaissance project carried out during the period 1982-86 by staff of the British Geological Survey (BGS) and Zimbabwe Geological Survey (ZGS), under a technical co-operation agreement funded by the Overseas Development Administration of the United Kingdom and the Ministry of Mines of Zimbabwe. The report is complementary to a series of geochemical maps held on open file at the offices of the BGS and ZGS.

THE AREA

The ground covered by the survey extends from the international border with Mocambique southwards to latitude $17^{o}15'$S and westwards to longitude 32^{o}E, and has an area of approximately 8 000 km^2.

Access

Access to the area is by metalled road, both to Rushinga in the west and Nyamapanda in the east (Fig. 1). Much of the area is within a days drive from Harare. Numerous motorable dirt tracks are present in the southwest of the area in contrast with the sparsely populated northern and eastern districts.

Topography and drainage

Most of the area has an elevation of between 600 and 900 m, although in the north-east and extreme north the ground falls to below 600 m, and in the south-west it rises above 900 m in a number of places reaching a maximum of 1367 m in the peak of Mitowe (Fig. 2). Topography varies from a distinctive dwala or bornhardt landscape developed upon granite terrain in the south-west, through gently undulating to featureless ground typical of much of the central gneissic terrain, to more disected ground in the north-east. Differential relief of more than 100 m is unusual except in the bornhardt topography of the south-west, and upon folded layered sequences of meta-sedimentary rocks in the north-east.

Drainage is dominated by the Mazowe, Nyadire and Mudzi rivers which flow northeastwards across the area, although the extreme north-west is drained by the Ruya and the extreme south-east by the Ruenya. Only the Mazowe and Nyadire are perenial, although even these dry out in periods of drought, as was the case during much of the present survey.

Climate and vegetation

The climate of the area is characterised by a dry season from May to October, during which little rain falls, and a wet season from November to April when

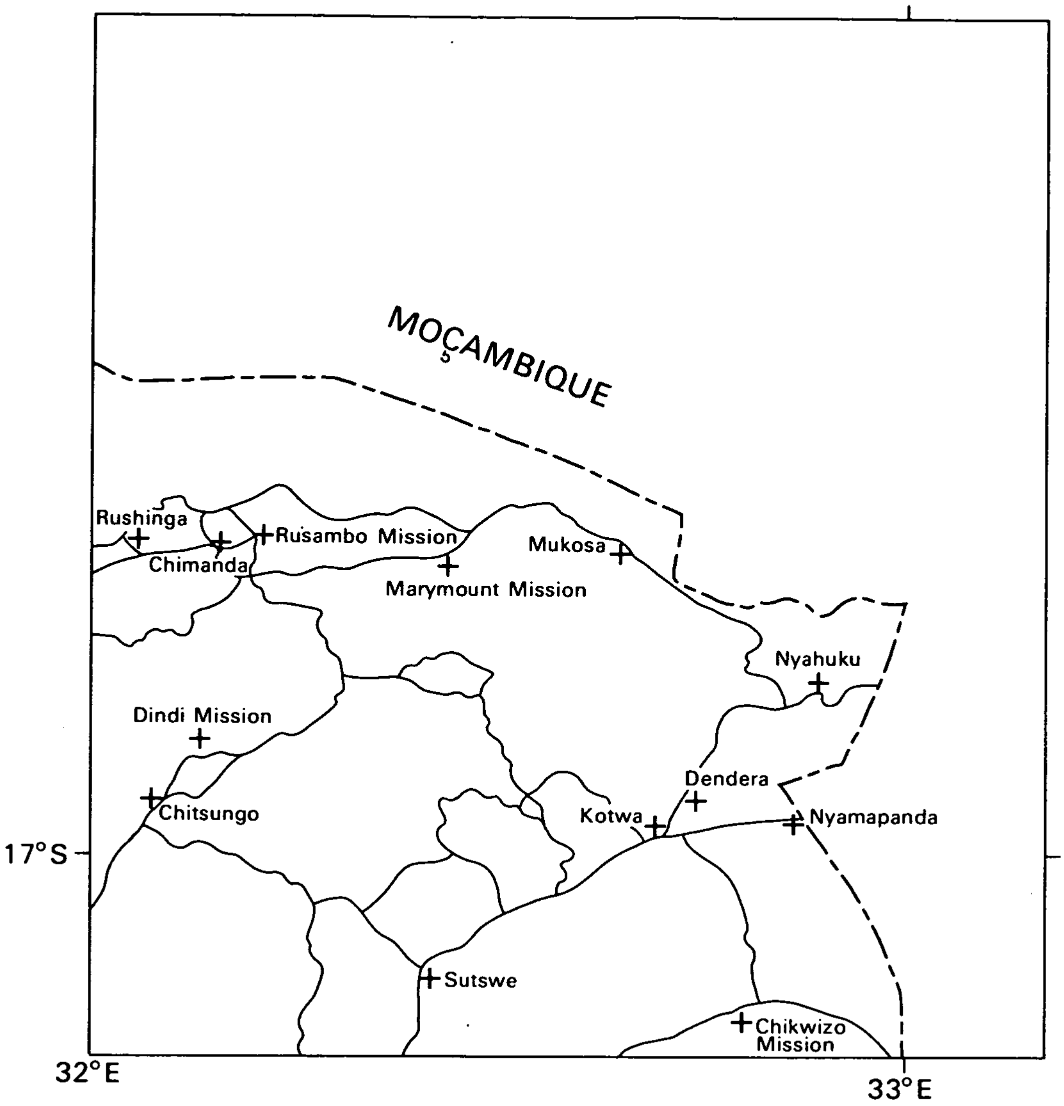

Figure 1: Roads and settlements of the area.

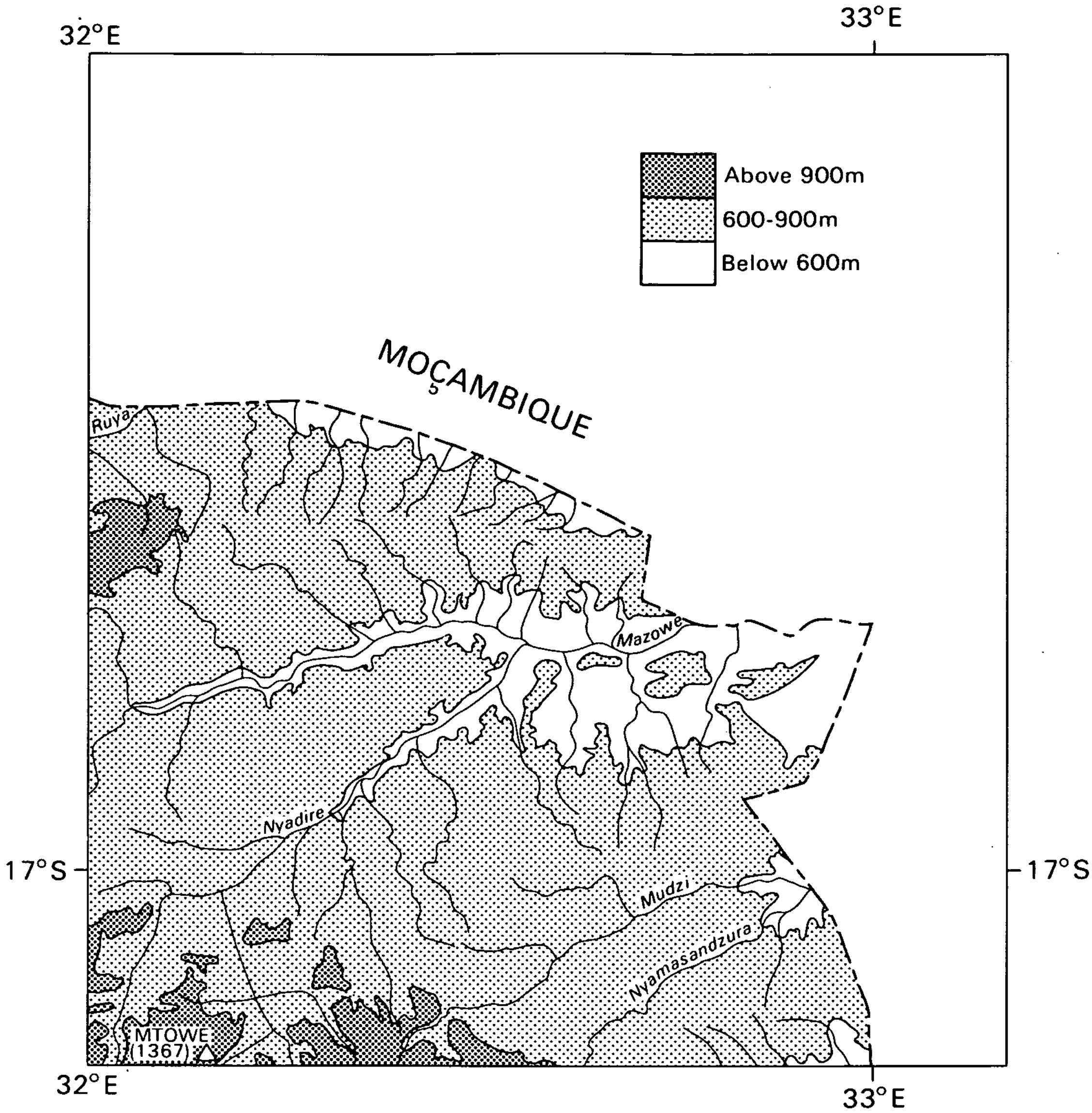

Figure 2: Relief and drainage of the area.

rainfall is intermittant but heavy. Mean annual rainfall varies between 350 and 950 mm, with greatest amounts falling on the higher ground in the south-west of the area. Data for Mtoko, the nearest weather station with complete records, are presented in appendix 1 and illustrate the marked seasonal nature of the rainfall.

The hottest part of the year is from September to April, with mean maximum monthly shade temperatures in the range 25 to 29° C, and the coolest period is from May to August with mean maximum maximum temperatures of 21 to 25° C. However temperatures in direct sunlight and in the lower ground in the north and north-east of the area are considerably higher.

Vegetation is varied but is dominated by woodland including the species Brachystegia spiciformis (Msasa), B. boehmii (Mfuti) and Julbernardia globiflora (Mnondo). Colophosphermum mopane (Mopane) and Adansonia digitata (Baobab) are prolific, particularly in the hotter and drier parts of the area, and Acacia sp. is widespread and very common in secondary bush developed upon previously cleared and cultivated ground.

Soils

The soils of the area are mostly fersiallitic (Thompson and Purves, 1978). These are moderately leached soils in which the dominant clay mineral is kaolinite, and in which there are appreciable amounts of free sesqui oxides of iron and aluminium, and usually reserves of weatherable minerals. Over granitic rocks these fersiallitic soils consist mainly of moderately shallow, greyish brown, coarse sands and sandy loams overlying sandy loams (type 5G of Thompson and Purves op. cit.). Over siliceous gneisses and schists they are moderately deep, brown to reddish brown, fine to medium grained sandy loams, overlying sandy clays (type 5P of Thompson and Purves op. cit.). Over greenstone belts and basic and ultra-basic intrusive rocks they consist of moderately deep to deep reddish brown granular clays (type 5E of Thompson and Purves op. cit.).

In the north-east of the area, particularly in and adjacent to the valley of the Mazowe River, siallitic soils are developed. These are relatively unleached with illite group minerals predominating over other clays. They are moderately shallow, brown to reddish brown, fine to medium-grained loamy sands overlying sandy loams and sandy clay loams (type 4P of Thompson and Purves op. cit.).

Lithosols are widely distributed in rugged hilly ground. They are very shallow soils formed over weathering rock. In the rugged granitic terrain of the south-west of the area there are extensive pavements and steep hillsides of bare rock.

GEOLOGY

The country between Rushinga and Nyamapanda exposes the northeastern corner of the Rhodesian craton and the junction of the Zambezi and Mocambique orogenic belts. The geology of the area is extremely complicated and is described by Barton et al. (in press), whose account forms the basis of the following summary.

Major structural rock units or terrains form the principal geological sub-divisions (Fig. 3). The Archaean craton in the south and west consists of

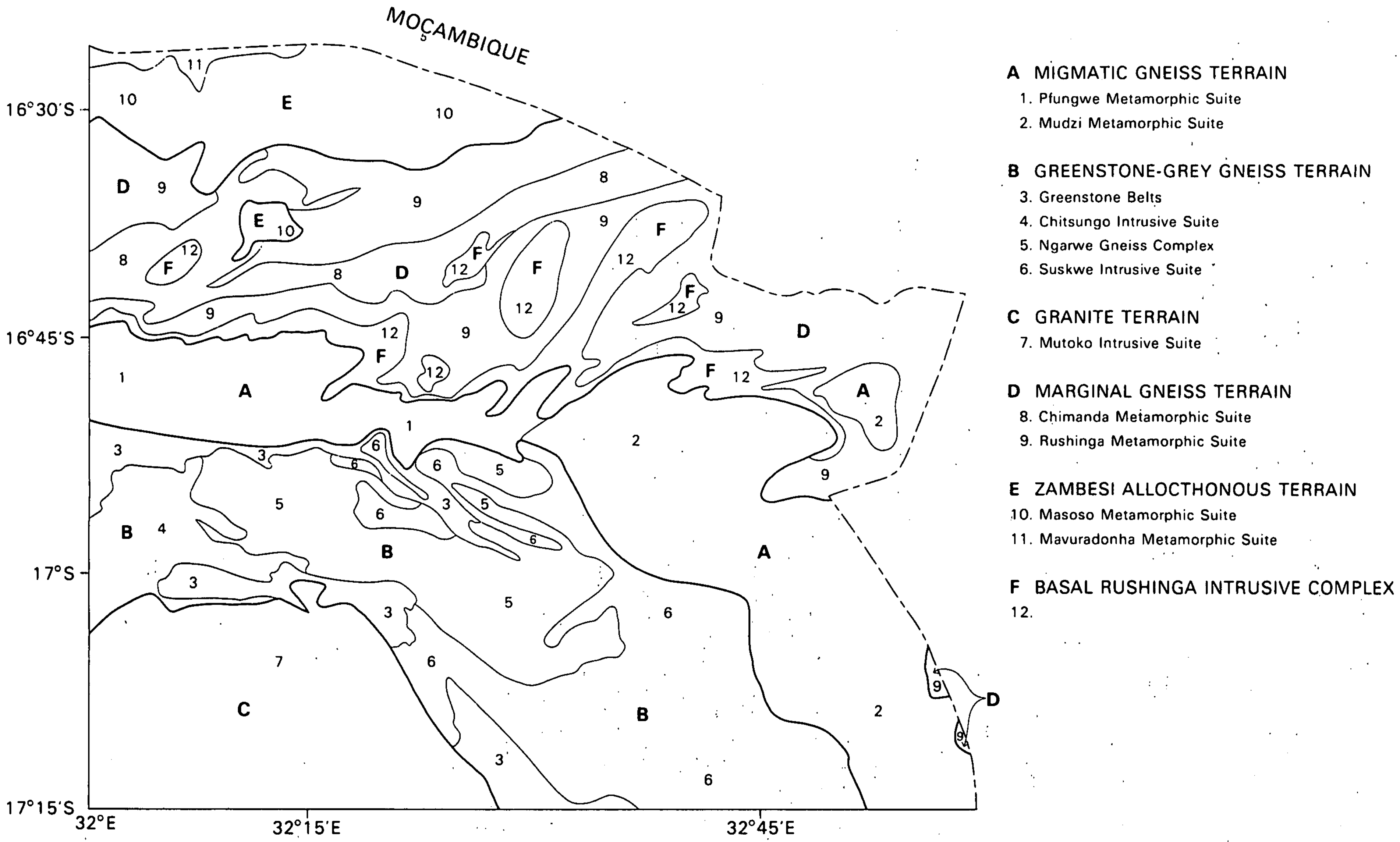

Figure 3: Simplified geological map of the area.

three contrasting terrains (Table 1). The Migmatitic Gneiss Terrain forms the northern and eastern craton margin, and contains the oldest known metamorphic sequences in northeastern Zimbabwe (3.0-3.1 Ga). This terrain is separated from a late Archaean volcano-plutonic complex, termed The Greenstone-Grey Gneiss Terrain, by a major Archaean tectonic break. The Granite Terrain forms part of a large batholith that was emplaced into the Greenstone-Grey Gneiss Terrain during the late Archaean.

A sequence of Proterozoic paragneisses and migmatites structurally overlies the northern and eastern margins of the Archaean craton. Together with tectonic slivers of cratonic-type gneiss, these sequences form the Marginal Gneiss Terrain. The interface between the Craton and the Marginal Gneiss Terrain is almost totally occupied by a tabular-shaped grantoid batholith, the Basal Rushinga Intrusive Complex, that records an early Pan-African intrusive age (c. 830 Ma).

The structurally uppermost terrain, the Zambezi Allochthonous Terrain, comprises a sequences of high-grade metamorphic rocks (garnet-granulite). Fabrics within this terrain are of early Pan-African age. The basal surface of the allochthonous terrain is considered to be a major translational fault.

Basic sheet-like intrusions of Proterozoic age ('Mashonaland Dolerite') cross-cut terrain boundaries, and in addition basic and felsic dykes and small felsic stocks belonging to the Rukore Intrusive Suite, of Mesozoic age (post-Karoo), occur in the northeastern part of the area.

The Migmatitic Gneiss Terrain

The Migmatitic Gneiss Terrain is subdivided into two metamorphic suites. The Pfungwe Metamorphic Suite occupies the western part of the terrain and includes a compositionally layered biotite and hornblende-rich migmatite complex and leucocratic gneisses of possible supracrustal-type. The Mudzi Metamorphic Suite occupies the eastern part of the terrain and consists of massive gneisses of more orthogneissic aspect. Both suites contain hypersthene granulite remnants of mafic to felsic composition. Such granulites preserve fabrics that pre-date the principal migmatitic event. Rb:Sr whole rock ages of c. 3.0 Ga have been obtained from granulites within the Mudzi Suite. Both suites also contain sheet-like intrusions of tonalite-trondhjemite composition, one of which (the Mapangisa tonalite) has an apparent age of c. 3.1 Ga. Bodies of augen granite-gneiss are developed close to the interface with the Marginal Gneiss Terrain, and the whole Migmatitic Gneiss Terrain was extensively deformed during the Pan-African orogeny.

The Greenstone-Grey Gneiss Terrain

This terrain consists of metavolcanic sequences of basaltic to dacite composition (greenstone belts) and deformed intrusive phases of trondhjemitic or tonalitic granitoid (grey gneiss). The two types of sequence are often separated by intrusive or sheared intrusive contacts. Two greenstone belts occur within the area and are divided into a number of tectonic units. The Dindi greenstone belt contains dacitic and basaltic metavolcanic rocks and includes sequences that are structurally inverted. The Mataki-Makaha greenstone belt consists of a compositionally varied sequence of bimodal dacitic and basaltic/basaltic andesite metavolcanic rocks with phyllonites, banded iron-formations, calc-silicate rocks and ultramafites.

The Dindi greenstone belt is in part underlain, and in part folded beneath the Chitsungo Intrusive Suite, a distinctive assemblage of coarse tonalite and granodiorite gneisses. The Chitsungo suite is interpreted as a sub-volcanic intrusive complex intruded into the base of the greenstones. The Chitsungo Suite is in turn underlain and intruded by trondhjemitic gneisses of the Ngarwe Gneiss Complex. The principal trondhjemite component is an orthogneiss that shows evidence of multiple phase injection and shearing during intrusion, and represents the deepest exposed level of the Greenstone-Grey Gneiss Terrain. A folded horizon of migmatitic amphibolite that exhibits intense ductile deformation also forms part of the Ngarwe complex.

The Suskwe Intrusive Suite is the youngest component of the Greenstone-Grey Gneiss Terrain. It consists of a number of deformed plutons of tonalite, trondhjemite, granodiorite and granite composition. In addition, a sheet-like body of porphyroblastic granodiorite gneiss occupies much of the southern part of the terrain and forms a relatively late intrusive phase. Field relations show that Suskwe suite intrusions were emplaced after both greenstones and some grey gneiss sequences were penetratively deformed.

The Granite Terrain

The Granite Terrain consists of a number of Archaean granitoid phases which together comprise the Mutoko Intrusive Suite. Biotite granite is the main component of the Mutoko Suite, and lesser amounts of biotite granodiorite and quartz-diorite are also present. Primary igneous layering defined by both megacryst alignment and xenolith trains is folded by structures related to emplacement in a regime of tectonic stress.

Proterozoic basic and ultrabasic intrusions are widely distributed throughout the Archaean terrains where they occur as dykes, sills and fracture-filled networks. In the craton they are virtually undeformed but towards the north and east the effects of Pan-African deformation and metamorphism become intense. They include microgabbro and gabbro-norite of Manyika-type, which are post dated by volumetrically more important sub-ophitic microgabbros of Mashonaland-type (Mashonaland dolerite of other areas).

The Marginal Gneiss Terrain

This terrain consists of two lithostratigraphic components, the Chimanda Metamorphic Suite and the Rushinga Metamorphic Suite, that together form a belt 20 km wide around the craton margin.

The Chimanda Metamorphic Suite consists of a number of tectonically-bounded gneissic slivers that occur near the base of the central and western Marginal Gneiss Terrain. Chimanda suite gneisses are either quartzo-feldspathic or biotite-rich in composition and contain a mylonitic foliation that has been superimposed on earlier fabrics.

The Rushinga Metamorphic Suite is the main component of the Marginal Gneiss Terrain and consists of a sequence of Proterozoic paragneisses and migmatites that contain polyphase structural and metamorphic fabrics of Pan-African age. The Rushinga suite consists of layered quartzose, micaceous and feldspathic gneisses and schists, with thick metaquartzite and marble units. The entire suite has been metamorphosed at kyanite or sillimanite grade, and nowhere is it possible to distinguish with certainty clastic grains.

The Zambezi Allochthonous Terrain

The Zambezi Allochthonous Terrain includes the uppermost exposed structural units in the Zambezi orogenic belt and overthrusts the Marginal Gneiss Terrain. A bimodal suite of microcline-rich leucomigmatite and striped mafic gneiss together make up The Masoso Metamorphic Suite, forming the terrain base and structural roof to the Rushinga suite. In the west of the area mafic gneisses contain pods of coarse garnet-granulite, whereas amphibolite facies assemblages occur in Masoso suite sequences elsewhere. Mafic horizons contain lithologies that exhibit tectonically reduced grain-size fabrics, and are interpreted as zones of regional translation.

The Mavuradonha Metamorphic Suite crops out in the extreme north-west of the area and is composed of scapolitised metagabbro and mafic granulite. The sole to the suite is schistose, and contains tectonic inclusions of meta-pyroxenite, garnet-granulite, and a large, lenticular-shaped carbonate body. The carbonate occurrence includes rare-earth-enriched magnetite-apatite rocks.

The Basal Rushinga Intrusive Complex

The Basal Rushinga Intrusive Complex is a tabular-shaped granitoid batholith emplaced along the Marginal Gneiss-Migmatitic Gneiss Terrain interface. The complex has a quartz-monzonite to quartz-monzodiorite composition, and individual plutons contain a variably developed gneissic fabric and a unidirectional mineral lineation. Structural geometry is consistent with a single folded sheet at least 0.5-1 km thick and more than 100 km in strike length. Rb:Sr whole rock ages indicate that emplacement and cooling occurred during an early Pan-African event (c. 830 Ma), at approximately the same time as crystallisation of sequences within the allochthonous Masoso suite.

Pan-African tectono-thermal events

Pan-African tectono-thermal events are related in broad terms to emplacement of the Zambezi Allochthonous Terrain with formation of associated high-pressure metamorphic fabrics, and to emplacement of the Basal Rushinga Intrusive Complex with associated folding and backthrust deformation, and formation of high-temperature migmatites. Radiometric age data suggest that both events were broadly synchronous (c. 830 Ma). In the extreme west of the area the orientation of mineral lineations suggests that underthrusting of the Marginal Gneiss Terrain and Archaean craton below the Zambezi allochthon was toward the north or northeast. The high-pressure metamorphic assemblages garnet-orthopyroxene in allochthonous granulites, and kyanite in Rushinga Suite gneisses are only preserved in the western sequences. Further east, sillimanite grade metamorphism together with complex patterns of deformation that include interference structures, folds with NE-SW axes, and translational fault surfaces inclined south or southeast all occur in spatial association with the Basal Rushinga Intrusive Complex. There, both Pan-African and Archaean terrains have been turned on edge and locally translated toward the northwest or north. Late Pan-African isotopic events dated at c. 660 Ma and c. 470 Ma are also recorded in Rb-rich lithologies, but these have not been correlated with mesoscopic fabrics or structures.

The Rukore Intrusive Suite

The youngest rocks in the area belong to the the Rukore Intrusive Suite which consists principally of NW-SE trending dykes of Mesozoic (post-Karoo) age that cross the northeastern gneissic terrains. Dyke compositions include basalt, olivine basalt, rare picrite and phonolite, together with aphyric and porphyritic microgranite. Stocks of porphyritic microgranite and associated rhyolite sheets, and two small isolated nepheline syenite plugs also form part of the intrusive suite.

Table 1: Summary of terrains and rock units, and of tectono-thermal events

Rukore Intrusive Suite	
ZAMBESI ALLOCTHONOUS TERRAIN	Tectono-thermal event c.830 ma.
Masoso Metamorphic Suite Mavuradonha Metamorphic Suite	
MARGINAL GNEISS TERRAIN	
Basal Rushinga Intrusive Complex Rushinga Metamorphic suite Chimanda Metamorphic Suite	
	Intrusion of basic and ultrabasic sheets, including Mashonaland-type and Manyika-type dolerites and microgabbros. c.1830±230 ma.
GRANITE TERRAIN	
Mutoko Intrusive Suite	
GREENSTONE - GREY GNEISS TERRAIN	Deformation and migmatisation c.2600 ma.
Suskwe Intrusive suite	Deformation pre-c.2600 ma.
Greenstone belts Ngarwe Gneiss Complex Chitsungo Intrusive Suite	
MIGMATITIC GNEISS TERRAIN	Pfunzi orogenic event c.3000 ma. (granulite formation)
Mudzi Metamorphic Suite Pfungwe Metamorphic Suite	

GEOCHEMICAL ORIENTATION SURVEY

At the beginning of the project, in late 1982, a geochemical orientation survey was conducted by J. Ridgway of the BGS (Ridgway, 1983). The purpose of this orientation survey was to determine:

a) The best sediment size fraction to sample.

b) The analytical methods most suitable for detecting known types of mineralisation.

c) The density of sample spacing required to give the highest probability of locating mineral deposits of the type known to exist in the area, taking financial and time constraints into consideration.

Four areas of mineralisation were examined during the orientation work. These are:

1. Ball Mine - Four Mile Prospect area: Scheelite with accessory Mo-Cu-Au mineralisation in veinlets and shears within gneisses of the Pfungwe suite, close to the contact with the Dindi greenstone belt.

2. Benson Mine: Pegmatites containing Be-Ta-Nb-Sn-Li-Cs mineralisation.

3. T.O.T. Claims, Chikwizo: Quartz vein containing weak Pb-Cu-Zn mineralisation.

4. Olympus-Umbrella mines area, Makaha: Greenstone-hosted Au-Cu mineralisation in quartz veins and shears.

The orientation survey indicated that the best anomaly to background contrast could be obtained by analysing the -100 mesh size fraction of the stream sediments. However, sieving to this size was found to be too time consuming and at many sites it was not possible to obtain sufficient sample. The -80 mesh size fraction was found to give acceptable anomaly to background contrast and sieving was much faster, and this size fraction was therefore chosen for the main survey.

It was decided to analyse the samples for Cu, Pb, Zn, Co, Ni, Mn, and Li by atomic absorbtion spectrophotometry, following digestion by hot concentrated hydrochloric acid, and to determine As, Sn, Ba, Pb, Ta and Ni by X-ray fluorescence spectrometry.

The orientation survey indicated that the mineral deposits under study could be detected at distances of 1 to 3 km, although this may have been affected by contamination caused by earlier working.

SAMPLING PROGRAMME

A total of 12438 samples was collected from the area, which is equivalent to an average sampling density of 1.55 samples per km^2.

Sample position and numbering.

At the beginning of the survey the positions of sample sites were determined and marked on 1:50 000 topographical maps, and each map was allocated a set of 1000 consecutively numbered sample envelopes. Prior to the sampling of a particular map area the sample envelopes were shuffled, and were subsequently drawn randomly for use in the field on a daily basis. On completion of the sampling programme the samples were reordered consecutively prior to submission to the laboratory for analysis. The randomisation of sample numbers in this manner was taken as a precaution in case of changes in analytical precision or introduction of analytical bias within the laboratory. Thus, for example, if bias was introduced for a short period during the analytical programme it would not affect all the samples from any one particular area or drainage basin.

Organisation of sampling teams

For most of the survey 4 sample teams were employed and each was managed by a geologist engaged upon geological mapping. Each geologist and respective sampling team were responsible for mapping and sampling of particular 1:50 000 map sheets, and they generally worked from the northern to the southern boundary of the area during the course of the survey, covering a strip of country corresponding to the width of a 1:50 000 topographic map. On a daily basis sampling teams were provided with the localities of 20-30 samples to be collected. These localities were marked on 'working maps' and after collection the sites and sample numbers were copied to 'clean maps'. Sampling traverses were numbered and the traverse routes recorded on maps.

Each sampling team was composed of 3 men. These included a team leader who was responsible for the location of sample sites and for recording information pertaining to sample registration, and two samplers who actually collected the samples.

Sample collection

During the course of the survey all drainage channels were dry, thus enabling samples to be sieved on site.

Samples were made up of sediment taken at several different positions in the stream bed within a radius of up to about 5 metres, and at least 6 positions were sampled at each locality. Only the central or active parts of channels were sampled so as to avoid local material collapsed from banks. Samples were taken from just below the surface by scraping off the top layer with a plastic dust pan and using a plastic jug to scoop up the sample from below. The sediment was sieved through a stack of 3 wooden sieves with plastic meshes of sizes 10, 60 and 80 mesh. The -80 mesh fraction was collected in a wooden bowl at the base of the stack and then transferred to randomly selected pre-numbered sample envelopes (Kraft soil sample bags). Sample packets were usually filled to about two-thirds capacity, corresponding to a mass of about 100 grams.

Information, recorded on sample registration forms at the site of collection, included:

- Sample number
- Map sheet number, e.g. 1732A1
- Sample type (in this case drainage sample)
- Grid reference
- Name of sampler
- Date
- Traverse number
- Description of channel morphology, including depth, width, cross profile shape and description of sediment (ie. sandy or bouldery etc.)
- Description of unusual rock types found in float

In addition, traverse numbers were recorded on sample packets at the time of collection.

Samples were taken to the Geological Survey offices in Harare at the end of each month, where they were sorted and stored in consecutive order prior to submission to the laboratory for analysis.

CHEMICAL ANALYSIS OF SAMPLES

The chemical analysis of samples was undertaken at the Institute of Mining Research, University of Zimbabwe.

Samples were submitted to the laboratory in batches of about 150. They were analysed for Cu, Pb, Zn, Co, Ni, Mn and Li by atomic absorption spectrophotometry (AAS) following digestion with hot concentrated hydrochloric acid for a period of 1 hour, and for As, Ba, Pb, Ni, Sn, Ta and W by X-ray fluorescence spectrometry (XRF).

Precision of the AAS analytical method was monitored by the regular analysis of control samples. Three 'known' control samples, designated BGS1, BGS2 and BGS3 were inserted into each analytical batch by the laboratory, and another three 'hidden' controls, designated A, B and C, were submitted to the laboratory under the guise of routine samples. During the analysis of the first 10 batches of samples the control samples were analysed routinely and the mean, standard deviation and coefficient of variation was calculated for each element, the values of which are given in appendix 2. Precision was set at mean$\pm$2SD and for the remainder of the survey the control samples were analysed routinely and results were plotted on precision monitoring charts of the type presented in appendix 3. Using this method only 1 in 22 determinations should fall outside mean$\pm$2SD, and fewer than 1 in 370 outside mean$\pm$3SD. Departures from these limits would indicate the introduction of unacceptable errors or bias.

Precision of the AAS analytical programme was also monitored by the method of Thompson and Howarth (1973), which takes into account the variation of precision with concentration. In this method precision is defined as twice the coefficient of variation expressed as a percentage (SDx200/mean), and may be examined for conformity to an arbitrary level by use of a precision chart such as that shown in appendix 4. Throughout the course of the analytical programme samples were re-analysed routinely and replicate analyses plotted on such charts.

Precision for the AAS analysis was generally good, except for Pb at low concentrations (below 10 ppm). At higher concentrations however, the precision for Pb was acceptable.

Precision of the XRF analytical method was monitored by the regular analysis of international rock standards and of 'in house' control stream sediment samples, the results of which are summarised in appendix 2. Although the XRF analytical precision for control samples appears to be acceptable a number of samples gave exceptionally high results (in the percent range) for all, or several elements. As some of these abnormal results were for elements that generally behave in a geochemically incoherent manner with respect to one another (for example exceptionally high Ni and Ta in the same sample) they were discarded from the data set. Similarly, for a number of the XRF analytical batches all the elements for all samples were reported as having zero concentration, which is highly unlikely, especially for elements such as Ni and Ba which normally occur in concentrations well above their detection limits. Finally, the Ta values for samples from the area of the Vumaninga 50 000 sheet (1732B2) are either very low or abnormally high, as can be seen from the Nyamapanda single element concentration map for that element. Such spurious results throw doubt on the reliability of the XRF data set as a whole, and in particular the tantalum analyses should be treated with considerable scepticism.

Detection limits for both the AAS and XRF analytical methods are presented in table 2. Detection limit is here defined as twice the standard deviation at zero concentration, and was calculated by regression of the means against the differences of duplicate analytical results (Thompson and Howarth, 1978).

Table 2: Analytical detection limits

Element	Det. Limit
Cu	1 ppm
Pb	9 ppm
Zn	3 ppm
Co	3 ppm
Ni	2 ppm
Mn	26 ppm
Li	1 ppm
Sn	4 ppm
W	4 ppm
Ta	5 ppm
Ba	54 ppm
As	10 ppm

ACQUISITION OF DATA

Four data subsets were compiled during the course of the survey, and these were eventually merged to form a single data set for interpretation and the generation of geochemical maps. A printed copy of the merged data set is held on open file at the Geological Survey office in Harare and copies can also be obtained on magnetic diskette from BGS headquarters on request.

The four data subsets are as follows:

1. AAS analytical results. These were entered into the project's Cifer 1880 microcomputer in Harare.

2. XRF analyses were recorded on the PDP11 computer at IMR and on completion of the analytical programme the results were forwarded on magnetic tape to BGS headquarters in the U.K. Approximately 10% of the samples, or their analytical results, were mislaid in the XRF laboratory, and absent data values (-1) were therefore assigned to these samples and were not taken into account during subsequent statistical analysis. The elements Ni and Pb were analysed by both the XRF and AAS methods, but because of the loss of so many XRF analyses and the general uncertainty over the quality of the XRF data, only the AAS analyses for these two elements were used in the interpretation.

3. Information on the geology of sample sites was taken from 1:50 000 manuscript geological maps, and each sample was given a two-tiered code denoting its underlying bedrock type and lithostratigraphic unit, as listed in appendix 5. This information, together with stream order at sample sites, was recorded on the project's microcomputer.

4. Grid references of sample sites were obtained by automated digitisation of sample locality maps at BGS headquarters. Important river courses and international boundaries were also digitised for automated plotting on the final geochemical maps.

INTERPRETATION AND PRESENTATION OF RESULTS

Each element is approximately log-normally distributed. This is borne out by the close similarity between the median and geometric mean values, as shown in the statistical summary presented in table 3, and by straight-line distributions produced in numerous log-probability plots during the interpretation, an example of which is shown in figure 4.

Table 3. Statistical summary of analytical results for the entire area

	Min Conc	Max Conc	Median	Arith Mean	Stand Dev	Geom Mean	Geom Mean (log)	Log Dev	N
Cu	*	260	19	23	17.9	18	1.250	0.331	12401
Pb	*	120	*	6	6.5	5	0.730	0.206	12401
Zn	6	741	42	55	38.8	46	1.661	0.258	12401
Co	*	100	10	11	6.3	10	0.983	0.265	12401
Ni	*	2920	17	22	39.6	16	1.199	0.366	12401
Mn	*	8120	560	650	392.1	550	2.741	0.255	12401
Li	*	30	4	5	2.9	4	0.617	0.250	12401
Sn	*	924	4	8	18.3	5	0.658	0.415	11151
W	*	479	5	13	24.2	6	0.781	0.505	11151
Ta	*	1970	5	18	46.3	7	0.850	0.528	11151
Ba	*	10458	565	578	356.9	440	2.644	0.407	11151
As	*	413	*	7	9.4	6	0.780	0.193	10954

* Below detection limit. Values below detection limit were set to half the detection limit prior to statistical analysis.

The results of the survey are presented in a series of maps, which include:

a) Single element concentration maps at 1:100 000 scale.
b) Multi-element anomaly maps at 1:100 000 scale.

Single element concentration maps

Single element concentration maps were produced at a scale of 1:100 000 as transparent overlays complementary to the geological map sheets for Rushinga-Sutswe and Nyamapanda. These illustrate the level of a particular element at each sample site by means of a line, of length directly proportional to concentration, extending from the sample point. In addition to presenting the raw data in a visual form, these maps provide a rapid means of assessing the overall results for each element by indicating the concentration range and broad variations related to lithology, as well as drawing attention to some of the more prominent anomalies.

In order to maintain general uniformity between the maps for each area and for each element, the background (median) level for each element is assigned a standard symbol size of 5 mm. For elements such as Pb, Sn, W and Ta the true median values are well below detection limits, and therefore the symbol sizes were standardised using a median value calculated only from values above detection; without doing this the maps would have been confused by a proliferation of very large symbol sizes representing the higher concentrations. For the other elements almost all analytical results are above detection and the true median is practically the same as that calculated using only values above detection. The maximum symbol size used on these maps is set at 20 cm, corresponding to 40 times background; a very limited number of Ni, Sn, and Ta analyses exceeded 40 times background and are therefore truncated at this level on their respective maps.

Multi-element anomaly maps

Multi-element anomaly maps were produced at a scale of 1:100 000 as transparent overlays complementary to the geological map sheets for Rushinga-Sutswe and Nyamapanda. Because of difficulties in portraying 12 elements on a single plot, the anomalies for each of the two map sheets are split into two element associations and presented separately, making a total of four anomaly maps for the entire area. The four multi-element anomaly maps are:

Anomaly map 1	Rushinga - Sutswe: Cu, Pb, Zn, Co, Ni, Mn, Ba, W and As.
Anomaly map 2	Rushinga - Sutswe: Sn, Ta, Li and W.
Anomaly map 3	Nyamapanda: Cu, Pb, Zn, Co, Ni, Mn, Ba, W and As.
Anomaly map 4	Nyamapanda: Sn, Ta, Li and W.

Lithological influences on stream sediment chemistry were accounted for by classifying the analytical results into groups according to the dominant drainage basin lithology at each sample site. The lithological classification used to subdivide the data was chosen in consultation with mapping geologists and is given in table 4, whilst sorting by computer was achieved using the codes listed in appendix 5.

Table 4. Classification used to group the data according to dominant lithological influence on sample sites.

Pfungwe Metamorphic Suite (PM)

Mudzi Metamorphic Suite (MM)

Greenstone belts
- Felsic volcanic rocks with minor phyllonite (GB1)
- Basaltic and andesitic volcanic rocks (GB2)

Chitsungo Intrusive Suite (CI)

Ngarwe Gneiss Complex (NC)

Suskwe Intrusive Suite
- Xenolithic Tonalite and Trondhjemite (SI1)
- Nyanza Granite, Granodiorite, Fine Granite and pegmatite (SI2)
- Porphyroblastic Gneiss (SI3)

Mutoko Intrusive Suite (MI)

Chimanda Metamorphic Suite (CM)

Rushinga Metamorphic Suite
- Metaquartzite with minor marble and anorthosite (RM1)
- Mica Schist (RM2)
- Gneiss (RM3)

Masoso Metamorphic Suite
- Leucogneiss (MO1)
- Striped Mafic Gneiss and Corona Textured Gabbro (MO2)

Basal Rushinga Intrusive Complex (RI)

Rukore Intrusive Suite (RK)

Mashonaland Dolerite and amphibolite sheets (DA)

For each element and lithological grouping, graphs of log-concentration plotted against cumulative frequency on a probability scale were used to determine threshold values (Sinclair, 1976), above which concentrations are considered to be anomalous (Fig. 4). Threshold values were identified at inflexion points at high concentrations, and background concentration taken at the 50th percentile (median) of the distribution. The practice, frequently adopted in the absence of well-defined inflexions in the log-concentration versus probability curves, of regarding the top 2.5% of high values as being anomalous was not followed; in the absence of such inflexions all values are considered to be sub-anomalous. Summary statistics for the data grouped according to influencing lithologies are given in appendix 6, and threshold and background values are presented in table 5.

Anomalous values, for each element and lithological group, were standardised by the method of Govett and Galanos (1974), thus resulting in anomaly magnitudes that are directly comparable regardless of element, concentration range, background lithology and map sheet.

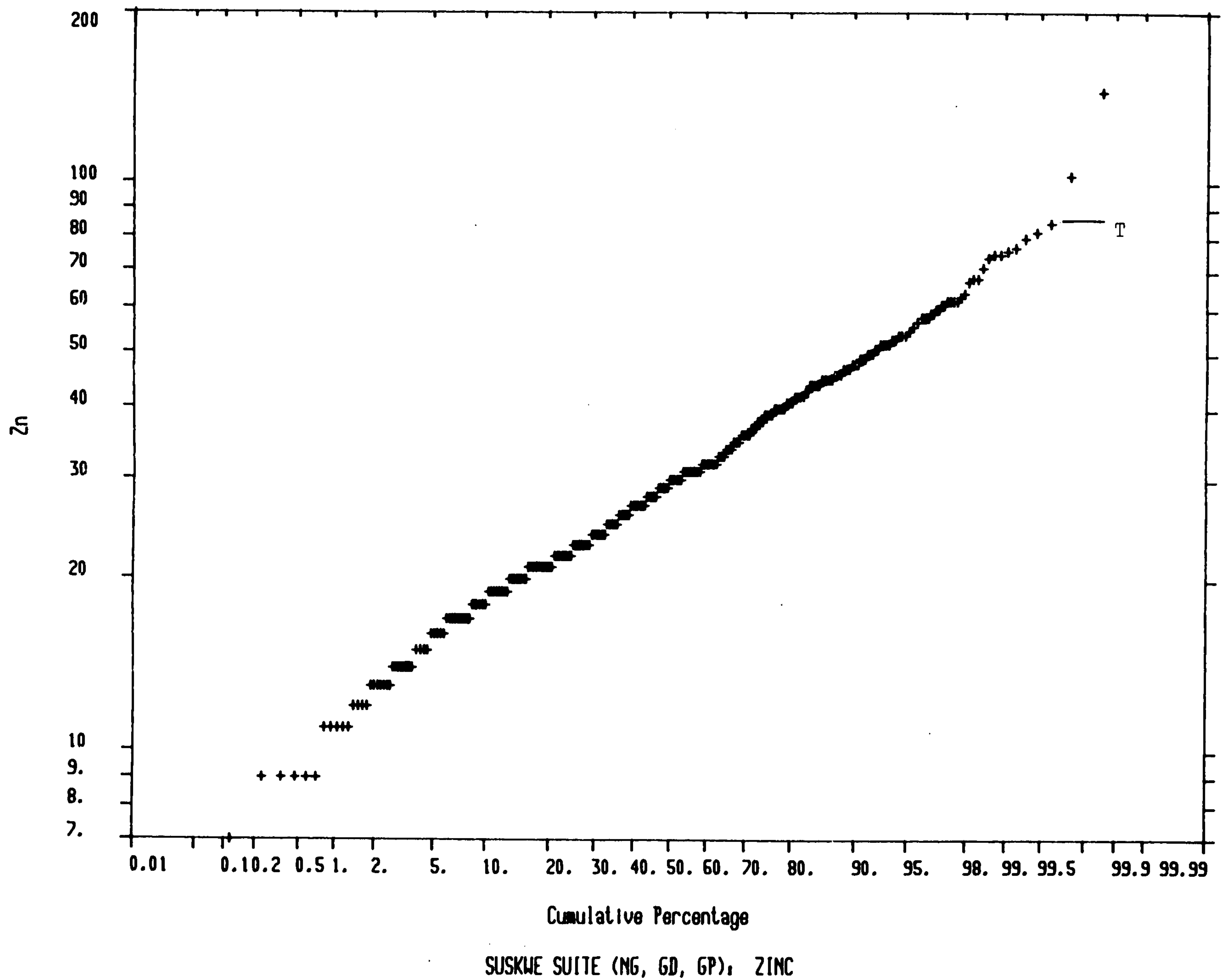

Figure 4: Example of a log probability plot. T = threshold (86 ppm).

The formula used for standardisation is:

$$\text{Standardised anomaly value} = \frac{(\text{Anomaly} - \text{Threshold})}{\text{Threshold}} * 100$$

Table 5. Threshold (upper) and background (lower) values in relation to lithological groups (see table 4 for explanation of letter codes).

Rock Group	Cu	Pb	Zn	Ba	Mn	Co	Ni	As	W	Sn	Ta	Li
PM	101	14	147	1365	1561	24	-	47	29	19	36	20
	24	*	40	577	510	11	28	*	*	*	*	5
MM	112	20	129	1940	1851	35	211	38	263	83	242	14
	18	*	43	610	500	11	22	*	*	*	*	3
GB1	46	15	61	1115	1001	32	65	19	82	39	130	12
	20	*	29	272	410	10	25	*	*	*	*	3
GB2	95	-	71	1160	1511	47	103	21	72	33	78	15
	33	*	36	210	630	16	38	*	5	*	*	4
CI	56	10	65	950	930	-	30	21	102	69	135	-
	9	*	24	367	320	6	8	*	10	*	*	3
NC	93	13	75	1830	1121	24	148	34	116	81	180	17
	13	*	31	441	360	7	12	*	*	*	*	4
SI1	78	18	82	1495	1390	-	70	22	69	59	174	-
	12	*	30	485	350	8	14	*	*	*	*	4
SI2	88	13	86	2490	1261	32	79	22	66	47	137	20
	12	*	29	502	320	6	10	*	*	*	*	4
SI3	79	-	63	1830	831	26	93	27	71	65	81	-
	12	*	30	506	330	7	13	*	*	*	*	3
MI	98	94	77	1510	2451	41	126	28	117	45	144	20
	12	16	32	562	510	7	8	*	4	*	*	4
CM	71	22	230	-	2031	33	72	31	37	29	32	18
	22	*	77	685	940	12	18	*	10	5	6	4

* Background values below detection limit.

Table 5 continued on next page.

Table 5 continued.

Rock Group	Cu	Pb	Zn	Ba	Mn	Co	Ni	As	W	Sn	Ta	Li
RM1	63	22	186	-	1970	43	72	80	99	87	451	20
	25	*	85	625	940	14	20	*	10	7	7	6
RM2	57	-	179	2905	1981	32	86	31	44	50	253	23
	26	*	80	686	850	15	24	*	10	7	7	6
RM3	69	31	271	1390	2131	-	-	33	104	53	137	19
	34	*	118	652	1170	18	28	*	12	8	7	5
MO1	56	21	162	1821	1481	27	39	23	66	21	88	-
	19	*	71	597	730	12	15	*	10	9	9	5
MO2	38	-	126	1190	1171	-	-	-	30	-	30	-
	19	*	60	566	650	11	14	*	9	8	9	5
RI	62	24	199	1765	2661	-	65	46	50	30	52	-
	17	*	99	673	1000	10	13	*	9	5	8	5
RK	-	21	-	-	-	-	-	-	-	-	-	-
	12	20	69	313	1020	15	10	*	*	*	*	3
DA	161	34	120	1455	1600	-	88	29	120	42	159	15
	30	*	41	500	610	12	18	*	*	*	*	4

GEOCHEMICAL ANOMALIES

Numerous anomalies occur throughout the area, although only the more important ones are described here. The grading of anomalies is somewhat subjective, and in the following section they are listed only in approximate order of importance. Many of the large single-sample Ta, Sn and W anomalies are given low priority and are described towards the end of the list, as there is some doubt over the validity of the analyses for these elements.

Anomaly 1.

The most striking anomaly discovered by the survey is a large Ni-Co anomaly centered on an unamed hill (42731352) situated 3 km south-east of Bunda and 2.5 km north-east of Nyanza in the Pfungwe Communal Land. The hill is composed of deeply weathered ultramafite which is interpreted as a xenolith within granodiorite of the Suskwe Intrusive Suite. Nickel concentrations in the stream sediments reach up to 2900 ppm over a background of 10 ppm, and are several orders of magnitude larger than values associated with ultramafic lithologies eleswhere in the region. Cobalt is moderately anomalous, whereas copper is anomalously low.

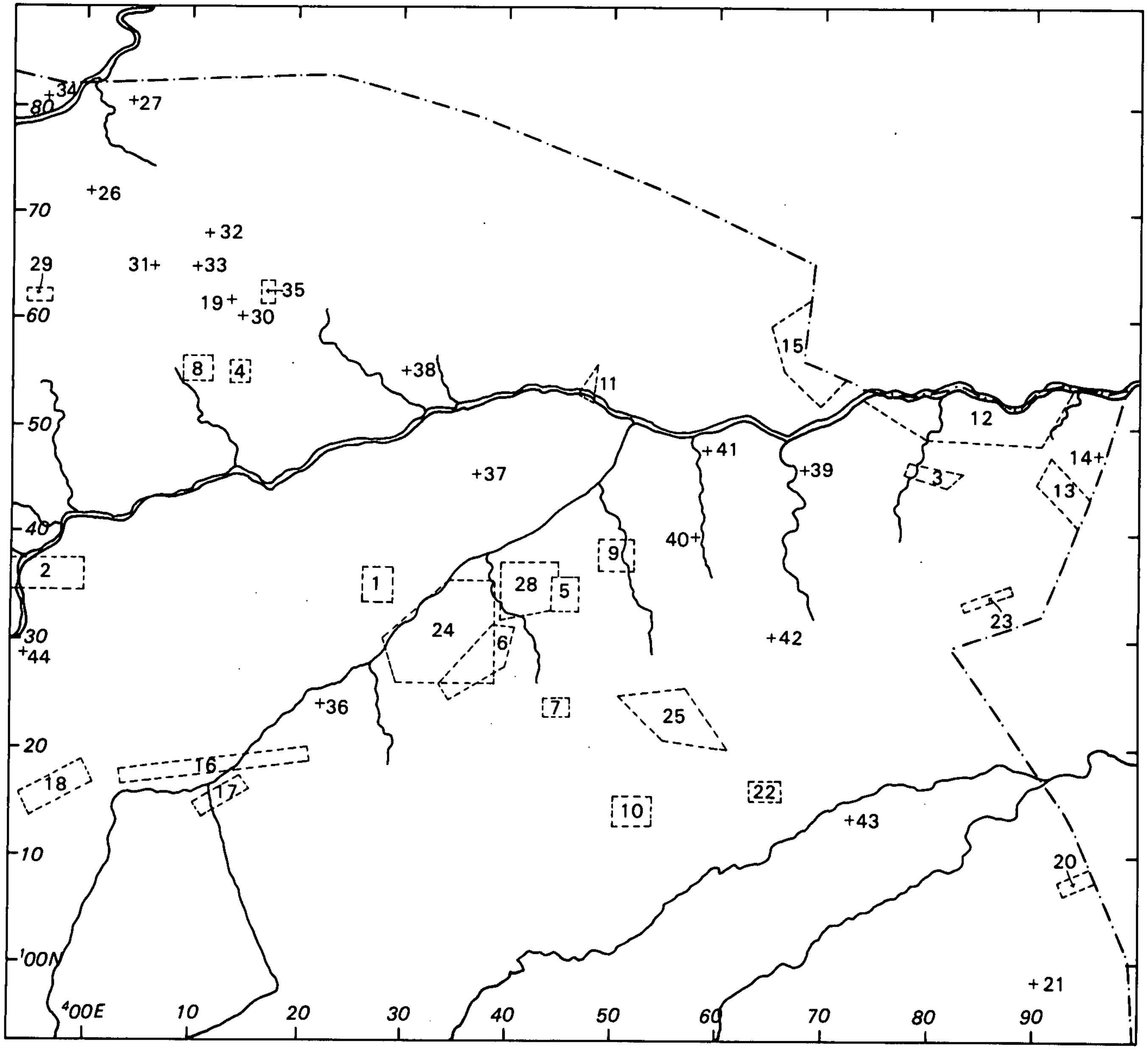

Figure 5: Distribution of geochemical anomalies.

Anomalous sites include:

Site	Grid Ref.	Ni	Co
4262	42870364	370	-
4907	42691363	370	-
4942	42801360	516	-
22336	42841344	192	-
22344	42691358	508	-
22346	42761354	1060	55
22350	42791353	199	-
22352	42691354	1677	69
22356	42851363	881	36
22368	42761358	2920	100
22370	42761358	904	44
	Threshold	79	32
	Background	10	6

Anomaly 2

A broad group of strong As and minor W and Cu anomalies occurs in the vicinity of the Southern Cross and Ball mines (39601375), and extends eastwards to Nyakaturi Dam (39941375). This corresponds to a known zone of scheelite mineralisation associated with the sheared contact between the gneisses of the Pfungwe Metamorphic Suite and volcanic rocks of the Dindi Greenstone Belt.

Anomalous sites include:

On Pfungwe Suite gneisses

Site	Grid Ref.	As	W
1493	39871367	98	-
1568	39921367	101	-
1747	39961372	-	57
1758	39711370	364	-
1783	39771368	385	-
22231	39611375	413	102
22249	39691374	115	-
	Threshold	47	29
	Background	bd	bd

bd = below detection limit

On basaltic greenstone

Site	Grid Ref.	As
1601	39481366	83
1780	39681365	227
22232	39611372	57
22236	39641370	40
	Threshold	21
	Background	bd

On felsic greenstone

Site	Grid Ref	As	Cu
1476	39941353	35	-
1549	39931360	-	61
1615	39641356	-	67
	Threshold	19	46
	Background	bd	20

Anomaly 3

A group of moderately high Pb-Zn and weak Cu anomalies occur over a strike-length of 2.5 km in streams draining into the Nyangombie River off the northern flanks of the Nyangwa Range (48251450). The anomaly is underlain by metaquartzites and gneisses of the Rushinga Metamorphic Suite that are intruded by basaltic and felsic dykes of the Rukore Suite.

Anomalous sites include:

Site	Grid Ref.	Cu	Pb	Zn
19022	48121453	-	40	-
19023	48141452	-	37	-
19055	48021453	-	58	-
19060	47981457	110	-	450
19061	47991457	105	-	-
19073	47961455	-	39	-
19078	48071454	-	45	275
19080	48091450	-	80	335
19081	48101449	-	63	-
19082	48101449	-	95	370
19083	48051456	-	52	-
19084	48041453	-	52	425
19085	48051451	-	56	335
	Threshold	69	31	271
	Background	34	bd	118

None of the samples from this anomalous zone were analysed by the XRF method, and therefore data for Ba and As are not available.

The source of the anomaly is uncertain. Generally the Rushinga Metamorphic Suite is characterised by high background levels of Zn and Pb, and many other anomalies occur upon the suite eleswhere in the survey area. It is thought that the intrusion of Rukore Suite may have played a role in remobilisation of these elements within the metasediments, since several anomalies appear in proximity to dykes, and elsewhere in the region minor Pb-Zn mineral occurrences are known to be associated with Rukore suite rocks.

Anomaly 4

A small group of strong Pb and Zn and weak Mn anomalies occurs about 2 km south-east of Katohwe Dam (41251572), situated to the north of Rusambo Mission. The anomaly occurs in streams draining Wadze Biotite Gneiss of the Chimanda Suite, and mica schists of the Rushinga Suite. A cursory follow-up survey failed to locate the source of the anomaly.

Anomalous sites include:

Site	Grid Ref.	Pb	Zn	Mn
924	41441556	85	-	-
22076	41481556	30	741	3110
22087	41491544	-	518	2325
22088	41401558	-	291	-
	Threshold	22	230	2031
	Background	bd	77	940

Anomaly 5

A group of moderatly strong Ni and minor Co anomalies occurs in the vicinity of the Ky Mine (44501345). The anomalies occur within streams underlain by Porphyroblastic Gneiss of the Suskwe Suite, although they probably originate from nearby ultramafic bodies.

Anomalous sites include:

4314	44651356	470	44
4759	44621354	363	38
12070	44621353	385	34
12098	44581359	185	-
12262	44411346	191	-
21819	44471348	155	36
21932	44581354	308	-
21939	44531347	180	-
21988	44491336	146	-
	Threshold	93	26
	Background	13	7

Anomaly 6

A widespread group of moderate to weak Cu, As and Ba anomalies occurs between 5 km and 15 km south-west of the Ky Mine. The anomalous sites are underlain by granodiorite of the Suskwe Suite, trodhjemitic injection gneiss of the Ngarwe Complex, and basaltic volcanic rocks of the Dindi Greenstone Belt.

Anomalous sites include:

On Suskwe Suite granodiorite

Site	Grid Ref.	Cu	As	Ba
4700	43481252	153	-	-
12065	43551252	126	-	3844
21923	43891307	-	30	-
21960	43781281	-	39	-
	Threshold	88	22	2490
	Background	12	bd	502

On Ngarwe Complex injection gneiss

Site	Grid Ref.	Cu	As	Ba
4832	44051311	-	85	-
4834	43911280	167	-	-
12353	43901314	113	-	-
21957	43871283	-	-	2218
21964	43931277	-	48	-
	Threshold	93	34	1830
	Background	13	bd	441

On basaltic greenstone

Site	Grid Ref.	Cu
4539	43751288	260
	Threshold	95
	Background	33

Anomaly 7

A small group of moderate to weak Cu, W and Ba anomalies occurs upon trondhjemitic injection gneiss of the Ngarwe Complex and porhyroblastic gneiss of the Suskwe Intrusive Suite, approximately 4 km south-east of Manyuchi Dam (44251274), to the south of Ky Mine.

Anomalous sites include:

On Suskwe Suite porphyroblastic gneiss

Site	Grid Ref.	Cu	W	Ba
12352	44411240	128	-	-
21868	44551242	102	272	-
21919	44551239	-	-	2445
21928	44451244	-	-	2314
21944	44561239	-	-	2300
	Threshold	79	71	1830
	Background	12	bd	506

On Ngarwe Complex injection gneiss

Site	Grid Ref.	Cu	W
12362	44481235	142	-
21872	44401237	-	207
21879	44491234	118	-
21920	44461237	110	-
	Threshold	93	116
	Background	13	bd

Anomaly 8

A small group of moderately high W anomalies occurs 6 km south-south-west of Rusambo Mission, upon metaquartzite and mica schist of the Rushinga Metamorphic Suite.

Anomalous sites include:

On metaquartzite

Site	Grid Ref.	W
22104	41011565	268
22110	41201558	177
22111	41011555	194
	Threshold	99
	Background	10

On mica schist

Site	Grid Ref.	W
22103	41141554	117
	Threshold	44
	Background	10

Anomaly 9

A group of weak Cu and W anomalies occurs within minor tributaries of the Kudzwe River, approximately 2.5 km west of Chingomuka Dam (45381372) in the Ngarwe Communal Land. The anomaly is underlain by gneisses of the Mudzi Suite.

Anomalous sites include:

Site	Grid Ref.	Cu	W
6782	45081382	153	-
6915	45141390	119	-
7051	45031374	142	-
7451	44961370	138	-
13277	45011397	115	-
21802	44931392	-	323
21821	44931372	-	306
21866	45081388	-	338
21871	45131387	-	431
	Threshold	112	263
	Background	18	bd

Anomaly 10

A group of weak W and associated Ba, As and Cu anomalies is situated approximately 4-5 km south-east of Katsande Dam (44731184) in the Ngarwe Communal Land. The anomalies are underlain by granodiorite of the Suskwe Suite, and trondhjemitic injection gneiss of the Ngarwe Complex.

Anomalous sites include:

On Suskwe Suite granodiorite

Site	Grid Ref.	W	Cu	Ba	As
7584	45111152	-	-	1627	242
8196	45291142	-	111	-	-
21833	45141141	121	-	-	-
21853	45181148	93	-	-	-
21874	45121139	115	-	-	-
	Threshold	66	88	1495	22
	Background	bd	12	485	bd

On Ngarwe Complex injection gneiss

Site	Grid Ref.	W
21839	45351149	160
21851	45351149	194
	Threshold	116
	Background	bd

Anomaly 11

A small group of moderate to weak Zn anomalies is situated adjacent to the Mazowe River, approximately 5 km north-west of its confluence with the Nyadire. The anomalies are underlain by quartz-monzonite/monzodiorite of the Basal Rushinga Intrusive Complex.

Anomalous sites include:

Site	Grid Ref.	Zn
6016	44791527	265
6038	44801539	280
6069	44831549	383
6481	44791539	256
13001	44721532	295
	Threshold	199
	Background	99

Anomaly 12

A number of widely scattered moderate to weak Cu, Pb, Zn and Ba anomalies occur in the northeastern corner of the area, extending in a broad zone along the southern side of the Mazowe River for about 20 km from its confluence with the Nyahuku River in the east (49441537) to the high-level road bridge in the west (47351525). The zone of anomalies occurs upon gneisses and meta-quartzites of the Rushinga Metamorphic Suite, that are in places intruded by felsic and basaltic dykes of the Rukore Suite.

Anomalous sites include:

On gneiss

Site	Grid Ref.	Cu	Zn	Ba
14261	48201499	-	-	1699
14357	48521521	-	-	1685
14412	48421519	-	-	1663
14454	48061499	87	-	-
14455	47691522	-	-	1872
14466	48421501	-	-	2468
14493	48081496	-	-	1501
15013	48861511	-	330	-
22342	47541521	-	340	-
	Threshold	69	271	1390
	Background	34	118	652

On metaquartzite

Site	Grid Ref.	Cu	Pb
14400	48121520	71	-
14403	48501525	-	44
14409	48441527	-	27
15005	48891490	-	32
	Threshold	63	22
	Background	25	bd

Anomaly 13

A group of sporadic and weak Pb anomalies and a single Ba anomaly occurs in the vicinity of Nyakadecha (49351427) in the Mkota Communal Land, upon gneisses and metaquartzites of the Rushinga Metamorphic Suite.

Anomalous sites include:

On gneiss

Site	Grid Ref.	Pb	Ba
8878	49281463	47	-
19107	49181462	38	-
19134	49411416	-	1851
	Threshold	31	1390
	Background	bd	652

On metaquartzite

Site	Grid Ref.	Pb
19100	49101448	25
19102	49101446	37
	Threshold	22
	Background	bd

Anomaly 14

A weak Cu-Zn anomaly occurs at two sample sites adjacent to the border with Mocambique about 7 km south-south-west of the Baobab Beacon (49891539). The anomaly appears to be related to secondary copper mineralisation (azurite and malachite) occuring in a fractured pegmatite within gneisses of the Rushinga Metamorphic Suite, which is exposed at the side of the road running along the border.

Anomalous sites are:

Site	Grid Ref.	Cu	Zn
8118	49641478	80	-
8175	49611475	-	345
	Threshold	69	271
	Background	34	118

Anomaly 15

A broad group of weak Pb, Mn, W, Sn and Ta anomalies occurs within streams draining the felsic intrusion of Rukore (46751574).

Anomalous sites include:

Site	Grid Ref.	Pb	Mn	W
13361	47161542	-	-	141
13371	47091538	-	-	142
13391	47081537	50	-	-
13398	47121538	-	2700	-
13399	47141536	-	2240	-
13492	46651599	35	-	-
13778	46741602	55	-	-
13795	46591593	45	-	-
13805	46801606	-	2500	-
	Threshold	31	2131	104
	Background	bd	1170	12

Anomaly 16

A broad zone of weak and sporadic W anomalies extends westwards from the eastern end of Bangauya (41901185) for a distance of 18 km. The anomalies are underlain by felsic and basaltic greenstones, and granitic rocks of the Mutoko, Chitsungo and Suskwe intrusive suites.

Anomalous sites include:

On felsic greenstone

Site	Grid Ref.	W
2474	40451171	119
2478	40431179	97
2523	40441176	128
10815	41271169	97
	Threshold	82
	Background	bd

On basaltic greenstone

Site	Grid Ref.	W
2495	40831181	92
2502	41041178	93
2957	41741189	105
10810	41101165	108
	Threshold	72
	Background	5

On Suskwe Intrusive Suite

Site	Grid Ref.	W
10579	41241184	87
10614	41441183	91
	Threshold	71
	Background	bd

On Chitsungo Intrusive Suite

Site	Grid Ref.	W
10526	41501194	131
	Threshold	102
	Background	10

On Mutoko intrusive Suite

Site	Grid Ref.	W
2982	41801196	149
	Threshold	117
	Background	4

Anomaly 17

A small group of Ba, Pb, As and Mn anomalies occur immediately to the south and east of the confluence between the Nyadire and Chitora rivers (41201166). These anomalies are underlain by volcanic rocks of the Mataki Greenstone Belt and at one site by granite of the Mutoko Intrusive Suite.

Anomalous sites include:

On felsic greenstone

Site	Grid Ref.	Pb	Mn	Ba
21949	41461161	-	-	2194
21978	41471162	-	1460	-
21998	41331157	20	-	-
22003	41551164	20	-	-
	Threshold	15	1001	1115
	Background	bd	410	272

On andesitic greenstone

Site	Grid Ref.	Ba	As
21963	41351164	2299	26
21968	41251161	1698	-
	Threshold	1160	21
	Background	228	bd

On granite

Site	Grid Ref.	Ba	As
21958	41151142	2321	37
	Threshold	1510	28
	Background	562	bd

Anomaly 18

A small group of weak to moderate Cu, Ni, Pb, Zn, Mn and As anomalies occurs to the south of Guyu Dam (39711184) in the Pfungwe Communal Land. These are underlain by trondhjemitic granodiorite of the Chitsungo Suite, granite of the Mutoko Suite, and Mashonaland Dolerite.

Anomalous sites include:

On Chitsungo Suite trondhjemitic granodiorite

Site	Grid Ref.	Cu	Ni	Pb	Mn	As
2107	39741162	-	37	-	-	-
2209	39851177	-	-	-	2280	-
2429	39461155	-	-	-	-	29
2432	39571154	94	-	-	-	-
2434	39751162	-	57	-	-	-
2437	39691152	63	-	-	-	25
2574	40041170	67	-	-	1600	-
22013	39811167	-	-	20	-	-
	Threshold	56	30	10	930	21
	Background	9	8	bd	320	bd

On Mutoko Suite granite

Site	Grid Ref.	Zn
2333	39641147	115
	Threshold	77
	Background	32

On Mashonaland Dolerite

Site	Grid ref.	Cu	Ba
2110	39651161	182	-
21962	39781172	-	2593
21966	39811177	-	1715
	Threshold	161	1455
	Background	30	500

Anomaly 19

A minor Cu-Ni-Co anomaly occurs upon leucomigmatite of the Masoso suite approximately 0.5 km east-north-east of Rusambo Mission.

Two sample sites are anomalous; these are:

Site	Grid Ref.	Cu	Ni	Co
190	41371618	153	86	34
22098	41391615	82	45	-
	Threshold	56	39	27
	Background	19	15	12

Anomaly 20

A group of weak Co, Zn and Mn anomalies is situated close to the border with Mocambique, approximately 5 km south-south-east of Karera Beacon and 4-5 km north-east of Kasoro Dam (49141048) in the Chikwizo Communal Land. The anomalies are underlain by leucocratic-mesocratic gneiss of the Mudzi Metamorphic Suite.

Anomalous sites include:

Site	Grid Ref.	Zn	Co	Mn
9223	49501083	134	49	2380
9944	49421078	-	41	-
9965	49511082	142	38	2285
22273	49311076	-	47	-
22274	49401077	-	43	2580
22275	49401079	-	-	2060
22295	49391077	-	-	2180
	Threshold	129	35	1851
	Background	43	11	500

Anomaly 21

Two Mn-Zn anomalies are situated about 2.5 km south-west of Nyamasa Dam (49181000) in the Chikwizo Communal Land. The anomalies occur within the Selkirk Claims and are underlain by gneisses of the Mudzi Metamorphic Suite.

The anomalous samples are:

Site	Grid Ref.	Zn	Mn
9475	49030982	194	2040
9820	49010984	-	6201
	Threshold	129	1851
	Background	43	500

Anomaly 22

A group of weak Mn anomalies is situated approximately 5 km south-east of Matowa in the Mudzi Communal Land, and is underlain by porphyroblastic gneiss of the Suskwe Intrusive Suite.

Anomalous sites include:

Site	Grid Ref.	Mn
8243	46461152	1140
8477	46531155	1020
21767	46471163	1220
21789	46501160	940
21796	46441168	1040
	Threshold	831
	Background	330

Anomaly 23

A group of weak Li anomalies occurs approximately 9 km north of Nyamapanda on the north-east side of the Situmba Range. The anomalies are underlain by gneisses and mica schists of the Rushinga Metamorphic Suite.

Anomalous sites include

On gneiss

Site	Grid Ref.	Li
8503	48551340	25
8511	48521338	20
8522	48371330	27
	Threshold	19
	Background	5

On mica schist

Site	Grid Ref.	Li
8513	48591340	25
8533	48621341	28
8643	48691340	24
	Threshold	23
	Background	6

Anomaly 24

A group of widely scattered Sn and minor Li anomalies occurs to the south of the Nyadire River between the Nyamereri and Nyagoko tributaries. The anomalies are underlain by gneisses of the Pfungwe Suite, granodiorite of the Suskwe Suite, and volcanic rocks of the Dindi Greenstone Belt.

Anomalous sites include:

On Pfungwe Suite gneisses

Site	Grid Ref.	Sn
4200	43631356	36
4352	43851353	78
	Threshold	19
	Background	bd

On Suskwe Suite granodiorite

Site	Grid Ref.	Sn
4409	43231268	102
4512	43611266	81
4641	43141303	161
4671	43691299	148
	Threshold	47
	Background	bd

On basaltic greenstone

Site	Grid Ref.	Sn	Li
4214	43761268	59	-
4539	43751288	56	-
4605	42921294	46	-
4868	42901305	-	25
	Threshold	33	15
	Background	bd	4

On felsic greenstone

Site	Grid Ref.	Sn	Li
4938	43101300	-	14
12181	42961314	68	-
	Threshold	39	12
	Background	bd	3

Anomaly 25

A widely scattered group of weak W, As, Ba and Cu anomalies extends southeastwards for a distance of approximately 10 km from Morosi Dam. The anomalies are underlain by gneisses of the Mudzi Suite, granodiorite of the Suskwe Suite, and trondhjemitic injection gneiss of the Ngarwe Complex.

Anomalous sites include:

On Mudzi Suite gneisses

Site	Grid Ref.	W	As	Ba
13318	45961216	-	85	-
21825	45831220	308	-	-
21948	45511248	-	-	2919
21954	45701231	-	-	2927
21969	45771227	-	-	2761
	Threshold	263	38	1940
	Background	bd	bd	610

On Suskwe Suite granodiorite

Site	Grid Ref.	Cu	W	Ba
7027	45131248	-	-	137
13325	45551213	-	-	31
13514	45341240	114	-	23
21959	45371236	-	83	36
	Threshold	88	66	22
	Background	12	bd	bd

On Ngarwe Complex injection gneiss

Site	Grid Ref.	W	Ba
21873	45891208	174	-
21965	45471238	-	2351
	Threshold	116	1830
	Background	bd	441

Anomaly 26

A single Ba anomaly occurs upon Striped Mafic Gneiss of the Masoso Suite at grid reference 40051722, approximately 3 km north-north-east of Mbungwe Dam in the Masoso Communal Land. The site (806) gave an analytical result of 9251 ppm over a threshold of 1190 ppm and background of 566 ppm.

Anomaly 27

A single Ba anomaly occurs at grid reference 40451806, approximately 3.5 km south-east of the confluence between the Mudzi and Ruya rivers in the Masoso Communal Land. The site (803) gave an analytical result of 10458 ppm Ba over a threshold of 1821 ppm and a background of 597 ppm.

Anomaly 28

A group of widespread but sporadic W, Sn and Ta anomalies occurs to the west and south-west of Ky Mine, upon gneisses of the Pfungwe and Suskwe suites.

Anomalous sites include:

On Pfungwe Suite

Site	Grid Ref.	W	Sn	Ta
12197	44311368	-	65	-
12248	44311361	-	25	-
21806	44401347	200	-	-
21829	44381371	270	-	368
21857	43871283	-	37	-
21921	44431368	47	-	-
	Threshold	29	19	36
	Background	bd	bd	bd

On Suskwe Suite

Site	Grid Ref.	W
21819	44461348	103
	Threshold	71
	Background	bd

Anomaly 29

A small group of moderate to strong W and weak Ta anomalies occurs between 1 and 2 km north-north-east of Rushinga township, upon metaquartzites and mica schists of the Rushinga Metamorphic Suite.

Anomalous sites include:

On mica schist

Site	Grid Ref.	W	Ta
22163	39571628	-	347
22164	39801623	-	442
22171	39621623	262	429
22206	39661629	85	-
	Threshold	44	253
	Background	10	7

On metaquartzite

Site	Grid Ref.	W
22154	39511619	382
	Threshold	99
	Background	10

Anomaly 30

A single W-Sn-Ta anomaly occurs at grid reference 41481604, approximately 2 km south-east of Rusambo Mission. The site (22108) is underlain by leuco-migmatite of the Masoso Suite, and gave analytical results of 479 ppm W over a threshold of 66 ppm and background of 10 ppm, 28 ppm Sn over a threshold of 21 ppm and a background of 9 ppm, and 560 ppm Ta over a threshold of 88 ppm and background of 9 ppm.

Anomaly 31

A single W-Ta anomaly occurs at grid reference 40661649, approximately 2.5 km south-south-east of Runwa Dam in the Masoso communal Land. The site (22138) is underlain by mica schists of the Rushinga Suite, and gave analytical results of 247 ppm W over a threshold of 44 ppm and background of 10 ppm, and 439 ppm Ta over a threshold of 253 ppm and a background of 7 ppm.

Anomaly 32

A single W anomaly is situated upon mica schists of the Rushinga Suite at grid reference 41191681, approximately 1 km south-east of Nahwa Dam in the Masoso Communal Land. The site (22170) gave an analytical result of 273 ppm W over a threshold of 44 ppm and a background of 10 ppm.

Anomaly 33

A single W anomaly occurs at grid reference 41061649, approximately 4 km north-west of Rusambo Mission. The site (22148) is underlain by metaquartzite of the Rushinga Suite and gave an analytical result of 419 ppm W over a threshold of 99 ppm and a background of 10 ppm.

Anomaly 34

A single W anomaly occurs at grid reference 39681807, approximately 5 km west-south-west of the confluence between the Mudzi and Ruya rivers in the Masoso Communal Land. The site (788) is underlain by leucomigmatite of the Masoso Suite and gave an analytical result of 204 ppm W over a threshold of 66 ppm and a background of 10 ppm.

Anomaly 35

A group of 3 Ta anomalies occurs 4 km east-north-east of Rusambo Mission, upon Striped Mafic Gneiss of the Masoso Suite.

The anomalous samples are:

Site	Grid Ref.	Ta
22114	41691616	86
22117	41711622	130
22159	41721631	254
	Threshold	30
	Background	9

Anomaly 36

A large single-site Sn-Ta anomaly is situated on the Nyagwapere River approximately 1.5 km upstream from its confluence with the Nydire, at grid reference 42241243. The site (12202) is underlain by trondhjemitic granodiorite of the Chitsungo Suite, and gave analytical results of 924 ppm Sn over a threshold of 69 ppm, and 1521 ppm Ta over a threshold of 135 ppm, with backgrounds below detection limit.

Anomaly 37

A single Sn anomaly occurs at grid reference 43671460, approximately 4 km north-east of Masunzwa in the Pfungwe Communal Land. The site (4710) is underlain by metaquartzites of the Rushinga Suite and gave an analytical result of 763 ppm Sn over a threshold of 87 ppm and background of 7 ppm.

Anomaly 38

A single-site W-Sn-Ta anomaly occurs at grid reference 43031551, approximately 1 km south-west of Chiromba in the Chimanda Communal Land. The site (3044) is underlain by leucocratic gneiss of the Chimanda Suite, and gave analytical results of 93 ppm W over a threshold of 37 ppm and background of 10 ppm, 37 ppm Sn over a threshold of 29 ppm and background of 5 ppm, and 73 ppm Ta over a threshold of 32 ppm and background of 6 ppm.

Anomaly 39

A small W-Sn anomaly occurs upon the Basal Rushinga Intrusive Complex, about 3 km south-south-east of the confluence between the Mazowe and Vombosi rivers in the Mkota Communal Land.

The anomalous sites are:

Site	Grid Ref.	W	Sn
7405	46791462	-	46
7433	46761462	212	-
	Threshold	50	30
	Background	9	5

Anomaly 40

A single Ta anomaly occurs at grid reference 45771400, approximately 9 km south of the confluence between the Mazowe and Nyadumbu rivers in the Mkota Communal Land. The site (7444) is underlain by leucomigmatite of the Mudzi Suite and gave an analytical result of 1951 ppm Ta over a threshold of 242 ppm and background of 5 ppm.

Anomaly 41

A single Ta anomaly occurs at grid reference 45841479, approximately 1.5 km south-south-east of the confluence between the Mazowe and Nyadumbu rivers in the Mkota Communal Land. The site (7441) is underlain by the Basal Rushinga Intrusive Complex and gave an analytical result of 1970 ppm Ta over a threshold of 52 ppm and background of 8 ppm.

Anomaly 42

A single Sn anomaly occurs at grid reference 46501305, approximately 6 km north-west of Dendera Mission in the Ngarwe Communal Land. The site (7468) is underlain by augen granite gneiss of the Mudzi Suite and gave an analytical result of 479 ppm Sn over a threshold of 83 ppm and a background of 4 ppm.

Anomaly 43

A single Sn-Ta anomaly occurs at grid reference 47281135, approximately 3 km east-south-east of the confluence between the Mudzi and Nyamuunga rivers in the Mudzi Communal Land. The site (8447) is underlain by gneisses of the Mudzi Suite, and gave analytical values of 890 ppm Sn over a threshold of 83 ppm, and 353 ppm Ta over a threshold of 242 ppm, with backgrounds below detection limits.

Anomaly 44

A single Sn anomaly is situated at grid reference 39411291, approximately 1.5 km north of Kakonde in the Pfungwe Communal Land. The site (1954) is underlain by felsic volcanic rocks of the Dindi Greenstone Belt and gave an analytical result of 159 ppm over a threshold of 39 ppm and background below detection.

RECOMMENDATIONS

The area is generally considered to be poorly prospective, although a number of the anomalies described in the previous section should be examined in more detail. The more important areas which merit further study are discussed in the following paragraphs. Anomalous areas should initially be investigated by further stream sediment surveys using higher sampling densities, and areas that continue to be of interest should subsequently be investigated by detailed soil geochemical surveys, geological mapping and rock geochemical surveys.

The Ni-Co anomaly to the south-east of Bunda (anomaly 1) is by far the most striking anomaly discovered by the survey and should be given the highest priority in follow-up surveys. The source of the anomaly has already been tightly constrained, so that further stream sediment surveys are considered unnecessary. The source area, a hill composed of heavily weathered ultramafic rocks, should therefore be investigated by soil and rock geochemical surveys and detailed geological mapping. Ground geophysical surveys should also be implemented, partly to help decide whether sulphide mineralisation is likely to exists beneath the zone of weathering, and partly to help elucidate the structure of the ultramafic body. With respect to the latter problem, Barton et al. suggest the body is a xenolith within granodiorite of the Suskwe Intrusive Suite, although the writer believes it is more likely that the body represents a later cross-cutting ultrabasic intrusion.

The broad As and minor W and Cu anomaly in the vicinity of the Southern Cross Mine, Ball Mine and Four Mile prospect (anomaly 2) should be investigated in more detail. The anomaly roughly coincides with a broad zone of mineralisation within sheared gneisses of the Pfungwe Suite close to the margin of the Dindi Greenstone Belt. Little is known about the geology of the Southern Cross Mine and the extent of the workings, although Went (1917) described the mineralisation as consisting of numerous small quartz stringers and veinlets containing gold and minor scheelite within gneisses, and reported an average grade of 5.46 g/t over a width of 27 m. Similar style mineralisation is exposed in the quarry at Ball Mine, which produced scheelite and minor amounts of gold, and accessory molybdenite, arsenopyrite and chalcopyrite occurs at both mines. In 1968 Lonrho Ltd. investigated the area under EPO 216. This survey was ostensibly for scheelite, although some gold assays were also carried out, and the zone of mineralisation was traced over a strike-length of more than 8 km. It is strongly recommended that the area be re-examined for low-grade gold mineralisation using detailed soil geochemical surveys. It is also suggested that this work be extended along strike to the west of the Mazowe (i.e. to the west of the present survey area). Initially orientation work should be undertaken to ascertain the best sample type for Au analysis. Gold should be determined routinely at the ppb level, and As, W, Cu and Mo should be analysed as pathfinder elements. The collection of heavy mineral concentrates from soils for Au and W analysis is also recommended, and these should preferably be obtained by automative separation techniques rather than traditional panning methods, in order to optomise precision.

A number of Pb-Zn anomalies, with or without anomalous Ba and Cu, have been discovered in the present survey in the Marginal Gneiss Terrain, often in close proximity to intrusions of the Rukore Suite. Several lines of evidence suggest that the anomalies may be related to intrusions of the Rukore Suite, although background levels of Zn are generally high within the Marginal Gneiss Terrain. For example several strongly anomalous sites within anomaly 3 are coincident with a gossanous felsite dyke containing pyrite. Furthermore, galena - barite mineralisation occurs at the margin of an altered dyke approximately 4.5 km east-north-east of Mukosa School (Kalbskopf, 1984), and there are also reports of a silver mine on the northern flanks of Rukore, on the Mocambique side of the border, which mined argentiferous galena. Mineralisation of this style has not previously been recognised within the region and it is therefore strongly recommended that the Pb-Zn-Ba-Cu anomalies associated with the Marginal Gneiss Terrain and Rukore Suite be investigated in more detail (eg. anomalies 3, 4, 11, 12 and 13). Follow-up surveys should include the determination of Ag, which was not analysed for in the present survey, as well as Pb, Zn, Cu, Ba, As and Mn.

A major problem encountered in the present survey concerns the reliability of the XRF analytical results for Ta, W and Sn. Many of the large anomalies for these elements may be spurious due to poor analyses. It is therefore recommended that at an early stage several of these anomalies are re-sampled in order to check the validity of the results from the present survey for these particular elements, before considering any detailed follow-up surveys over any of these anaomalies.

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APPENDIX 1: RAINFALL AND TEMPERATURE DATA FOR MTOKO.

RAINFALL

	1982	1983	1984	1985	MEAN*
JAN	171.6	96.2	95.2	327.0	169.4
FEB	141.4	87.0	90.9	194.4	141.5
MAR	32.6	9.7	18.7	185.9	90.9
APR	19.0	3.8	0.2	4.8	25.9
MAY	7.0	0.2	5.2	2.1	7.5
JUN	-	13.5	-	-	5.1
JUL	0.4	9.9	4.4	0.3	0.6
AUG	-	1.0	-	-	0.3
SEP	-	-	-	-	9.5
OCT	71.7	17.9	-	29.4	9.6
NOV	8.2	54.1	56.6	85.0	80.0
DEC	87.6	155.0	150.1	233.7	156.0
TOTAL	532.9	378.3	448.1	925.3	696.3

MEAN TEMPERATURE*

	MEAN MAX	MEAN MIN
JAN	26.4	17.1
FEB	26.3	17.0
MAR	26.4	15.7
APR	25.8	14.1
MAY	23.9	11.3
JUN	21.7	9.0
JUL	21.4	8.5
AUG	23.6	10.3
SEP	26.2	13.0
OCT	28.6	16.1
NOV	27.8	16.8
DEC	26.9	17.1
MEAN ANNUAL	25.4	13.8

*Mean rainfall and temperature based on records for previous 25 year period.

APPENDIX 2: ANALYTICAL PRECISION OF CONTROL SAMPLES

Values in ppm.

COPPER (AAS)

Sample	Mean	SD	CV	N
BGS-1	74.2	1.46	1.97	40
BGS-2	13.5	1.73	12.85	41
BGS-3	44.0	1.19	2.70	39
A	66.1	2.17	3.28	30
B	13.7	1.56	11.36	30
C	42.9	1.27	2.95	30

LEAD (AAS)

Sample	Mean	SD	CV	N
BGS-1	8.9	0.83	9.28	40
BGS-2	20.0	1.55	7.72	41
BGS-3	14.0	0.93	6.60	39
A	0.2	0.68	290.96	30
B	20.2	2.14	10.59	30
C	6.4	1.83	28.48	30

ZINC (AAS)

Sample	Mean	SD	CV	N
BGS-1	126.1	2.87	2.28	40
BGS-2	23.4	1.61	6.88	41
BGS-3	73.8	2.06	2.79	39
A	54.5	2.14	3.94	30
B	23.3	1.37	5.87	30
C	107.2	6.22	5.80	30

COBALT (AAS)

Sample	Mean	SD	CV	N
BGS-1	31.1	1.41	4.53	40
BGS-2	12.4	0.62	5.04	41
BGS-3	22.2	0.81	3.64	39
A	48.1	3.49	7.25	30
B	12.5	1.28	10.21	30
C	31.5	1.92	6.10	30

NICKEL (AAS)

Sample	Mean	SD	CV	N
BGS-1	75.1	2.95	3.92	40
BGS-2	12.4	1.16	9.35	41
BGS-3	43.9	2.67	6.08	39
A	61.1	4.08	6.68	30
B	12.1	1.45	12.00	30
C	37.9	2.30	6.07	30

MANGANESE (AAS)

Sample	Mean	SD	CV	N
BGS-1	1334.8	15.19	1.38	40
BGS-2	649.0	14.28	2.20	41
BGS-3	992.0	17.84	1.80	39
A	2096.0	71.65	3.42	30
B	679.3	25.99	3.82	30
C	1573.7	43.35	2.75	30

LITHIUM (AAS)

Sample	Mean	SD	CV	N
BGS-1	6.4	0.66	10.47	40
BGS-2	5.6	0.63	11.19	41
BGS-3	6.0	0.63	10.51	39
A	4.5	0.97	21.47	30
B	5.8	0.95	16.28	30
C	3.7	0.58	15.62	30

ARSENIC (XRF)

Sample	Mean		SD	CV	N
AGV-1	1.5	(0.8)	1.24	83.22	37
MA-N	13.4	(13)	1.48	11.08	37
ST-5	34.4		1.57	4.56	36
SV-6	3.7		2.08	56.68	36

BARIUM (XRF)

Sample	Mean		SD	CV	N
AGV-1	1274.5	(1200)	13.47	1.06	35
MA-N	63.6	(42)	7.97	12.53	35
ST-4	731.2		22.55	3.08	35
SV-6	789.2		9.05	1.15	35

TANTALUM (XRF)

Sample	Mean		SD	CV	N
AGV-1	2.6	(1.4)	4.50	172.40	35
MA-N	304.8	(306)	2.46	0.81	35
ST-4	252.9		8.41	3.33	35
SV-6	26.8		3.24	12.09	35

TIN (XRF)

Sample	Mean		SD	CV	N
AGV-1	6.1	(3.6)	3.00	49.10	35
MA-N	921.4	(1050)	0.65	0.07	35
ST-4	244.5		2.73	1.17	35
SV-6	71.1		2.93	4.12	35

TUNGSTEN (XRF)

Sample	Mean		SD	CV	N
AGV-1	4.5	(0.53)	2.43	5.90	35
MA-N	71.9	(70)	2.98	4.14	35
ST-4	22.3		2.23	9.99	35
SV-6	89.7		15.47	17.24	35

* Values in parenthesis for the international rock standards AGV-1 and MA-N are working values proposed or recommended by Govindaraju (1984).

List of AAS control samples:

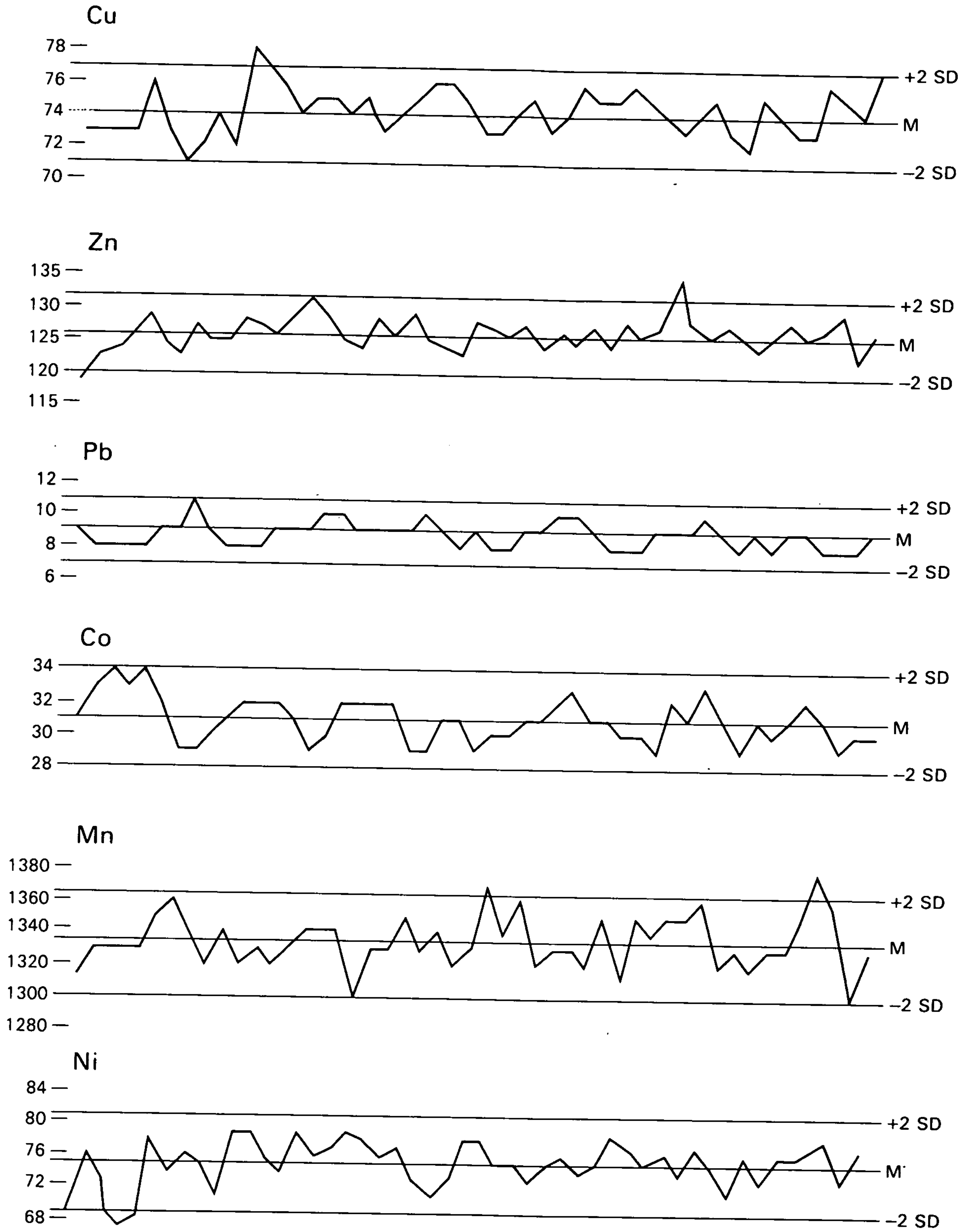
BGS-1, BGS-2, BGS-3: 'In house' stream sediment samples collected by the BGS Zimbabwe Project and provided to IMR for routine analysis in each analytical batch.

A, B, C: Stream sediment samples collected by the BGS Zimbabwe Project and submitted to the laboratory as 'hidden controls' under the guise of routinely collected samples. Controls BGS2 and B are splits of the same sample.

List of XRF control samples:

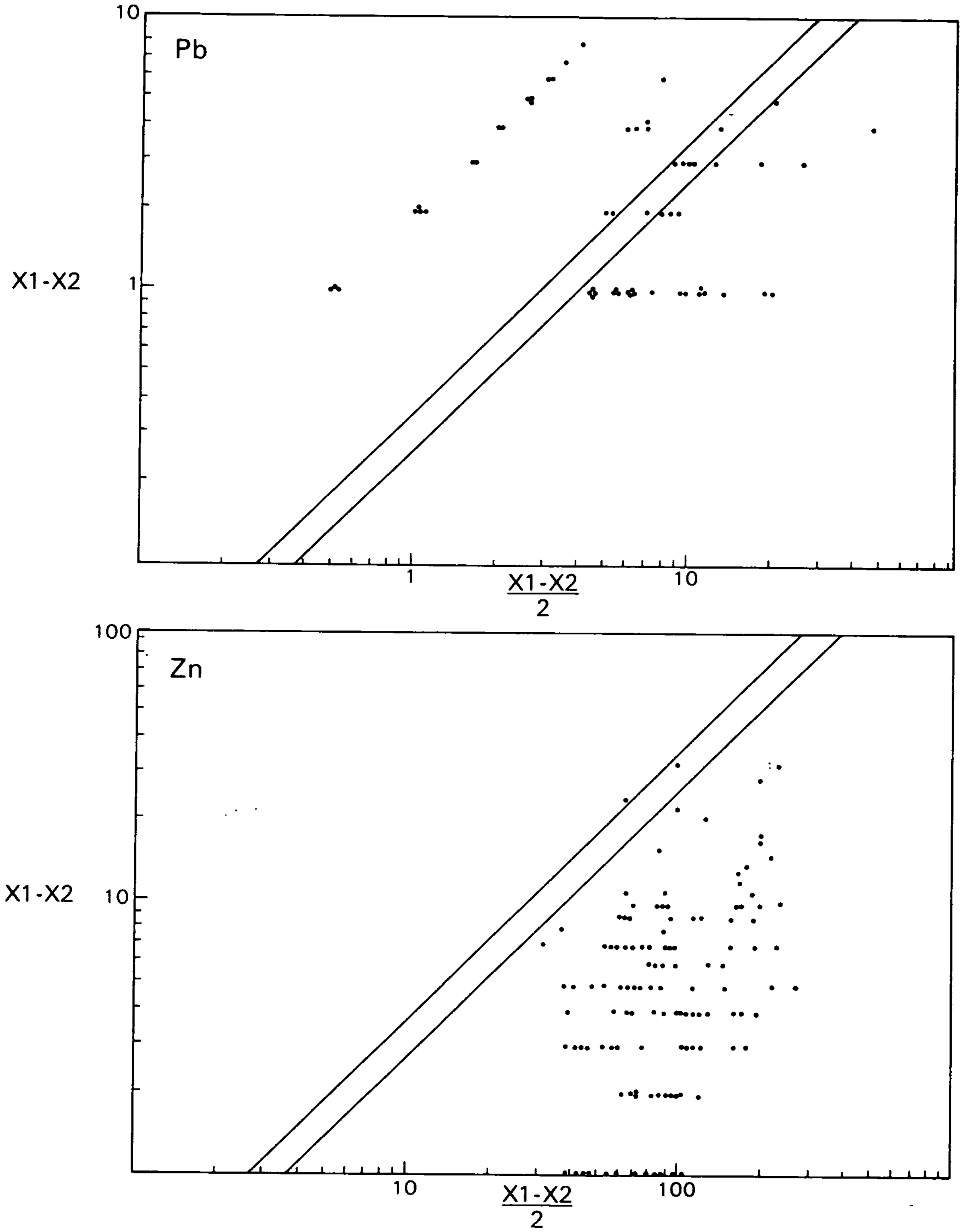
AGV-1: Andesite (USGS International rock standard).
MA-N: Granite (ARNT (France) International rock standard).
ST-5: Granite (Nottingham University standard).
ST-4: Stream sediment sample (BGS Zimbabwe Project).
ST-5: Stream sediment sample (BGS Zimbabwe Project).

APPENDIX 3.



Example of control charts, for control sample BGS-1, analytical batches 14-26.
SD = Standard deviation, M = Mean, calculated from 40 replicate analyses.

APPENDIX 4:



Examples of precision monitoring charts, for replicate determinations (X1 and X2) showing the 90th and 99th percentiles as a function of concentration for an arbitrary precision of 20%. In these examples the precision for Pb is unacceptable (i.e. greater than 20%), whilst that for Zn is acceptable.

APPENDIX 5: LITHOLOGICAL CODES FOR BEDROCK TYPE AT SAMPLE SITES.

MAIN UNIT	CODE	SUB UNIT	CODE
Pfungwe Metamorphic Suite	PM	Pfungwe Migmatite Complex	MC
		Leucogneiss	LG
		2-Mica Augen Gneiss	AG
Mudzi Metamorphic Suite	MM	Retrograde Granulite	RG
		Leuco/Mesocratic Gneiss	LG
		Mapingisa Xenolithic Tonalite	MT
		Porphyroblastic Granite Gneiss	PG
		Augen Granite Gneiss	AG
		Amphibolite	AM
		Ultrabasic Rocks	UB
Dindi Greenstone Belt	DG	Felsic Volcanics Rocks	FV
		Basaltic Volcanics Rocks	BV
Mataki - Makaha Greenstone Belts	MG	Felsic Volcanic Rocks with Phyllonite	FV
		Andesitic Volcanic Rocks with Phyllonite	AV
		Basaltic Volcanic Rocks with Phyllonite	BV
		Andesitic and Basaltic Volcanic Rocks	AB
		Basaltic Andesites	AB
		Phyllonite	PH
Chitsungo Intrusive Suite	CI	Trondhjemitic Granodiorite	TG
Ngarwe Gneiss Complex	NC	Trondhjemitic Injection Gneiss	TI
		Striped Migmatite	SM
		Amphibolite	AM
		Mashonaland Dolerite	MD
Suskwe Intrusive Suite	SI	Xenolithic Tonalite + Granodiorite	XT
		Trondhjemite	TJ
		Nyanza Granite	NG
		Massive - Foliated Granodiorite	GD
		Porphyroblastic Gneiss	PG
		Pegmatite + Fine Granite	GP
		Mashonaland Dolerite	MD
Mutoko Intrusive Suite	MI	Nyadire Intrusion Complex	NI
		Foliated Granite	FG
		Megacrystic Granite	MG
		Mashonaland Dolerite	MD

MAIN UNIT	CODE	SUB UNIT	CODE
Chimanda Metamorphic Suite	CM	Wadze Biotite Gneiss	WG
		Maguwo LeucoCratic Gneiss	ML
Rushinga Metamorphic Suite	RM	Metaquartzite	MQ
		Marble + Calc-silicate	MB
		Mica Schist	MS
		Gneiss	GN
		Amphibolite	AM
		Anorthosite	AN
Masoso Metamorphic Suite	MO	Leucomigmatite	LM
		Striped Mafic Gneiss	SG
		Corona Textured Gabbro	CG
Mavuradonha Metamorphic Suite	MV	Gungwa Metagabbro	GM
		Nyamasoto Biotite Gneiss	NB
Basal Rushinga Intrusive Complex	RI	Quartz Monzonite/Monzodiorite	QM
		Amphibole and Mica Schist	AM
Rukore Intrusive Suite	RK	Felsitic Rocks	KF

APPENDIX 6: STATISTICAL SUMMARY AND THRESHOLD VALUES FOR SAMPLES GROUPED ACCORDING TO DOMINANT LITHOLOGICAL INFLUENCE

PFUNGWE METAMORPHIC SUITE

Number of samples = 1116

Element	Min Conc	Max Conc	Median	Mean (Arith)	Stand Dev	Geom Mean	Log Dev	Threshold
Cu	4	115	24	27	15.9	24	0.244	101
Pb	*	20	*	1.5	2.1	1	0.398	14
Zn	16	205	40	45	20.3	41	0.161	147
Co	*	41	11	11	4.4	11	0.181	24
Ni	*	156	28	32	18.7	27	0.271	-
Mn	110	2650	510	557	259.5	506	0.190	1561
Li	1	25	5	6	3.0	5	0.219	20
Sn	*	78	*	3	5.3	2	0.507	19
W	*	270	*	5	12.8	2	0.533	29
Ta	*	368	*	4	13.2	2	0.588	36
Ba	*	1668	577	558	255.3	320	0.853	1365
As	*	413	*	6	28.3	2	0.522	47

MUDZI METAMORPHIC SUITE

Number of samples = 2149

Element	Min Conc	Max Conc	Median	Mean (Arith)	Stand Dev	Geom Mean	Log Dev	Threshold
Cu	2	153	18	23	16.1	19	0.265	112
Pb	*	23	*	1	1.9	1	0.278	20
Zn	15	210	43	47	18.7	44	0.158	129
Co	*	49	11	12	5.0	11	0.182	35
Ni	*	363	22	26	22.1	21	0.252	211
Mn	100	6201	500	552	288.9	505	0.176	1851
Li	*	18	3	4	1.9	3	0.215	14
Sn	*	890	*	7	25.6	2	0.643	83
W	*	468	*	14	34.9	3	0.778	263
Ta	*	1951	*	23	78.5	4	0.870	242
Ba	*	4346	610	606	364.3	338	0.837	1940
As	*	85	*	4	5.4	2	0.548	38

* Below detection limit (see table 4. for list of detection limits)

GREENSTONE BELTS: Felsic Volcanic Rocks and Phyllonites

Number of samples = 383

Element	Min Conc	Max Conc	Median	Mean (Arith)	Stand Dev	Geom Mean	Log Dev	Threshold
Cu	*	92	20	21	10.5	19	0.236	46
Pb	*	21	*	2	3.2	1	0.437	15
Zn	14	98	29	31	10.8	30	0.131	61
Co	*	53	10	11	5.5	10	0.218	32
Ni	2	70	25	26	13.6	22	0.278	65
Mn	110	2200	410	465	220.5	425	0.182	1001
Li	1	28	3	4	2.2	3	0.217	12
Sn	*	159	*	6	12.5	2	0.636	39
W	*	128	*	11	20.7	3	0.757	82
Ta	*	177	*	18	30.0	4	0.867	130
Ba	*	2194	272	311	255.5	157	0.831	1115
As	*	35	*	4	4.7	2	0.522	19

GREENSTONE BELTS: Basaltic and Andesitic Rocks

Number of samples = 217

Element	Min Conc	Max Conc	Median	Mean (Arith)	Stand Dev	Geom Mean	Log Dev	Threshold
Cu	2	260	33	38	25.5	31	0.296	95
Pb	*	11	*	1	2.1	1	0.324	-
Zn	15	110	36	37	12.1	35	0.137	71
Co	*	51	16	19	10.9	16	0.272	47
Ni	2	190	38	43	26.5	35	0.316	103
Mn	137	1840	630	713	347.3	635	0.212	1511
Li	1	25	4	5	3.1	4	0.225	15
Sn	*	59	*	6	11.1	2	0.668	33
W	*	108	5	12	20.7	3	0.724	72
Ta	*	129	*	13	24.1	3	0.819	78
Ba	*	2299	210	278	276.3	126	0.842	1160
As	*	227	*	7	31.0	2	0.574	21

CHITSUNGO INTRUSIVE SUITE

Number of samples = 433

Element	Min Conc	Max Conc	Median	Mean (Arith)	Stand Dev	Geom Mean	Log Dev	Threshold
Cu	3	100	9	12	11.2	10	0.265	56
Pb	*	20	*	1	1.8	1	0.246	10
Zn	11	76	24	26	8.9	25	0.134	65
Co	*	28	6	6	3.3	6	0.196	-
Ni	*	57	8	10	6.5	8	0.261	30
Mn	100	2280	320	354	179.4	324	0.174	930
Li	*	13	3	4	1.8	3	0.215	-
Sn	*	824	*	10	50.8	2	0.712	69
W	*	131	10	22	28.0	6	0.850	102
Ta	*	1521	*	26	85.7	4	0.901	135
Ba	*	2154	367	380	233.5	229	0.751	950
As	*	30	*	6	5.5	3	0.554	21

NGARWE GNEISS COMPLEX

Number of samples = 866

Element	Min Conc	Max Conc	Median	Mean (Arith)	Stand Dev	Geom Mean	Log Dev	Threshold
Cu	2	167	13	19	18.1	14	0.339	93
Pb	*	17	*	1	1.3	1	0.233	13
Zn	6	93	31	33	12.1	31	0.160	75
Co	*	39	7	8	4.4	7	0.239	24
Ni	2	360	12	18	21.8	12	0.351	148
Mn	60	1360	360	408	199.9	365	0.206	1121
Li	*	30	4	4	2.5	4	0.243	17
Sn	*	247	*	7	14.7	2	0.665	81
W	*	207	*	11	22.2	2	0.751	116
Ta	*	350	*	19	33.9	4	0.842	180
Ba	*	2429	441	493	370.3	231	0.923	1830
As	*	99	*	5	7.3	2	0.555	34

SUSKWE INTRUSIVE SUITE: Xenolithic Tonalite/Granodiorite and Trondhjemite

Number of samples = 769

Element	Min Conc	Max Conc	Median	Mean (Arith)	Stand Dev	Geom Mean	Log Dev	Threshold
Cu	1	116	12	16	14.4	12	0.353	78
Pb	*	28	*	2	3.5	1	0.495	18
Zn	7	117	30	32	14.4	29	0.181	82
Co	*	39	8	9	5.5	7	0.277	-
Ni	*	92	14	18	14.9	13	0.390	70
Mn	60	2330	350	404	228.9	354	0.220	1390
Li	1	20	4	5	2.7	4	0.232	-
Sn	*	125	*	8	13.2	2	0.720	59
W	*	195	*	9	16.9	2	0.732	69
Ta	*	285	*	22	34.9	4	0.907	174
Ba	*	2084	485	499	296.1	333	0.638	1495
As	*	1382	*	6	51.0	2	0.565	22

SUSKWE SUITE: Nyanaza Granite, Massive - Foliated Granodiorite, Pegmatite and Fine Granite.

Number of samples = 792

Element	Min Conc	Max Conc	Median	Mean (Arith)	Stand Dev	Geom Mean	Log Dev	Threshold
Cu	*	153	12	17	16.6	12	0.385	88
Pb	*	26	*	2	2.8	1	0.453	13
Zn	7	145	29	31	13.1	29	0.170	86
Co	*	100	6	8	7.1	6	0.309	32
Ni	*	2920	10	26	135.8	10	0.446	79
Mn	30	1630	320	379	218.3	328	0.234	1261
Li	*	24	4	5	2.6	4	0.230	20
Sn	*	161	*	7	13.7	2	0.694	47
W	*	121	*	8	14.6	2	0.707	66
Ta	*	189	*	16	25.1	3	0.835	137
Ba	*	3844	502	511	316.5	306	0.770	2490
As	*	137	*	4	7.2	2	0.543	22

SUSKWE INTRUSIVE SUITE: **Porphyroblastic Gneiss**

Number of samples = 342

Element	Min Conc	Max Conc	Median	Mean (Arith)	Stand Dev	Geom Mean	Log Dev	Threshold
Cu	1	128	12	18	16.5	13	0.387	79
Pb	*	20	*	2	2.7	1	0.424	-
Zn	13	71	30	31	10.6	30	0.143	63
Co	*	44	7	8	5.6	7	0.282	26
Ni	*	470	13	24	48.4	13	0.421	93
Mn	80	1240	330	378	208.6	329	0.229	831
Li	*	13	3	3	1.8	3	0.232	-
Sn	*	195	*	12	18.2	3	0.794	65
W	*	272	*	10	24.0	2	0.744	71
Ta	*	432	*	15	33.9	3	0.824	81
Ba	*	2445	506	509	336.4	234	0.986	1830
As	*	36	*	4	5.5	2	0.565	27

MUTOKO INTRUSIVE SUITE

Number of samples = 1154

Element	Min Conc	Max Conc	Median	Mean (Arith)	Stand Dev	Geom Mean	Log Dev	Threshold
Cu	1	160	12	22	23.6	13	0.456	98
Pb	*	120	16	19	13.4	13	0.440	94
Zn	6	120	32	35	14.7	32	0.181	77
Co	*	49	7	9	6.5	7	0.341	41
Ni	*	500	8	13	20.6	8	0.476	126
Mn	100	4000	510	602	378.7	516	0.239	2451
Li	*	27	4	5	3.2	4	0.262	20
Sn	*	60	*	7	10.7	2	0.699	45
W	*	149	4	18	26.7	4	0.853	117
Ta	*	244	*	22	32.3	4	0.915	144
Ba	*	2321	562	583	254.1	454	0.526	1510
As	*	44	*	5	5.6	2	0.557	28

CHIMANDA METAMORPHIC SUITE

Number of samples = 484

Element	Min Conc	Max Conc	Median	Mean (Arith)	Stand Dev	Geom Mean	Log Dev	Threshold
Cu	6	96	22	25	12.9	22	0.210	71
Pb	*	85	*	3	5.3	1	0.509	22
Zn	20	741	77	85	48.5	76	0.199	230
Co	3	42	12	14	5.6	13	0.170	33
Ni	*	88	18	22	13.1	18	0.256	72
Mn	320	3400	940	977	368.4	920	0.150	2031
Li	*	25	4	5	3.4	4	0.312	18
Sn	*	40	5	6	6.1	4	0.515	29
W	*	63	10	12	9.2	9	0.416	37
Ta	*	144	6	9	29.9	4	0.569	32
Ba	*	2242	685	743	351.3	551	0.642	-
As	*	133	4	7	10.2	3	0.630	31

RUSHINGA METAMORPHIC SUITE: Pricipally metaquartzite with minor marble and anorthosite

Number of samples = 952

Element	Min Conc	Max Conc	Median	Mean (Arith)	Stand Dev	Geom Mean	Log Dev	Threshold
Cu	5	80	25	27	12.2	24	0.213	63
Pb	*	44	*	4	4.7	2	0.550	22
Zn	7	233	85	88	34.5	81	0.189	186
Co	*	54	14	15	5.8	14	0.179	43
Ni	*	95	20	21	11.0	19	0.254	72
Mn	17	2855	940	970	332.2	908	0.172	1970
Li	*	23	6	6	3.4	5	0.255	20
Sn	*	763	7	10	28.3	5	0.499	87
W	*	419	10	15	26.5	8	0.529	99
Ta	*	1970	7	21	91.1	6	0.641	451
Ba	*	2750	625	678	337.6	486	0.644	-
As	*	192	*	7	12.1	2	0.632	80

RUSHINGA SUITE: Mica schist

Number of samples = 297

Element	Min Conc	Max Conc	Median	Mean (Arith)	Stand Dev	Geom Mean	Log Dev	Threshold
Cu	6	67	26	28	12.0	25	0.197	57
Pb	*	20	2	4	4.1	2	0.552	-
Zn	20	518	80	86	44.9	77	0.201	179
Co	3	38	15	15	5.2	15	0.155	32
Ni	*	118	24	25	13.4	22	0.253	86
Mn	*	2940	850	915	365.4	831	0.252	1981
Li	1	28	6	7	4.7	6	0.277	23
Sn	*	88	7	9	10.9	5	0.507	50
W	*	273	10	15	29.7	7	0.604	44
Ta	*	669	7	23	78.4	5	0.678	253
Ba	*	4717	686	754	467.8	512	0.690	2905
As	*	41	*	4	6.3	2	0.580	31

RUSHINGA METAMORPHIC SUITE: Gneiss

Number of samples = 581

Element	Min Conc	Max Conc	Median	Mean (Arith)	Stand Dev	Geom Mean	Log Dev	Threshold
Cu	7	110	34	36	14.4	33	0.183	69
Pb	*	95	*	8	10.6	3	0.625	31
Zn	38	450	118	130	57.0	120	0.174	271
Co	4	31	18	18	4.9	17	0.131	-
Ni	*	76	28	28	11.0	26	0.195	-
Mn	100	2850	1170	1201	336.0	1153	0.129	2131
Li	*	27	5	6	3.2	5	0.256	19
Sn	*	69	8	11	11.2	6	0.515	53
W	*	170	12	17	19.0	10	0.532	104
Ta	*	319	7	14	29.4	5	0.669	137
Ba	*	2468	652	687	323.0	467	0.722	1390
As	*	58	*	6	8.0	2	0.622	33

MASOSO METAMORPHIC SUITE: Leucogneiss

Number of samples = 540

Element	Min Conc	Max Conc	Median	Mean (Arith)	Stand Dev	Geom Mean	Log Dev	Threshold
Cu	5	153	19	21	10.4	19	0.179	56
Pb	*	40	*	3	3.1	2	0.447	21
Zn	30	259	71	78	29.5	73	0.155	162
Co	3	37	12	12	4.0	12	0.134	27
Ni	2	86	15	16	7.3	15	0.194	39
Mn	340	8120	730	771	380.7	733	0.126	1481
Li	1	19	5	6	2.3	5	0.175	-
Sn	*	42	9	9	5.0	8	0.338	21
W	*	479	10	13	25.6	9	0.415	66
Ta	*	560	9	14	38.4	8	0.415	88
Ba	*	10458	597	600	519.5	336	0.858	1821
As	*	46	2	5	6.0	2	0.585	23

MASOSO SUITE: Striped Mafic Gneiss and Corona Textured Gabbro

Number of samples = 156

Element	Min Conc	Max Conc	Median	Mean (Arith)	Stand Dev	Geom Mean	Log Dev	Threshold
Cu	7	41	19	20	6.6	19	0.150	38
Pb	*	15	*	2	2.3	1	0.437	-
Zn	15	263	60	66	31.4	60	0.186	126
Co	6	21	11	11	2.8	11	0.106	-
Ni	2	35	14	14	5.3	13	0.180	-
Mn	240	1280	650	674	199.6	645	0.132	1171
Li	*	12	5	5	2.0	5	0.195	-
Sn	*	23	8	8	4.6	6	0.384	-
W	*	40	9	10	7.0	7	0.408	30
Ta	*	130	9	16	52.6	7	0.490	30
Ba	*	9251	566	587	782.1	259	0.939	1190
As	*	19	*	1	4.9	1	0.573	-

BASAL RUSHINGA INTRUSIVE COMPLEX

Number of samples = 636

Element	Min Conc	Max Conc	Median	Mean (Arith)	Stand Dev	Geom Mean	Log Dev	Threshold
Cu	3	108	17	20	11.8	17	0.245	62
Pb	*	29	*	2	3.1	1	0.439	24
Zn	6	383	99	103	39.5	96	0.167	199
Co	*	36	10	11	5.6	10	0.250	-
Ni	*	97	13	16	11.8	12	0.389	65
Mn	140	4300	1000	1090	431.3	1017	0.162	2661
Li	*	19	5	5	2.8	5	0.255	-
Sn	*	50	5	6	5.6	4	0.493	30
W	*	212	9	11	13.0	6	0.543	50
Ta	*	160	8	11	12.3	6	0.528	52
Ba	*	2691	673	721	335.6	548	0.554	1765
As	*	75	*	6	7.7	2	0.607	46

DOLERITE AND AMPHIBOLITE SHEETS

Number of samples = 448

Element	Min Conc	Max Conc	Median	Mean (Arith)	Stand Dev	Geom Mean	Log Dev	Threshold
Cu	1	213	30	41	33.0	29	0.378	161
Pb	*	50	*	5	8.5	1	0.662	34
Zn	11	168	41	45	20.6	41	0.186	120
Co	*	37	12	13	6.8	12	0.248	-
Ni	*	370	18	24	25.6	17	0.351	88
Mn	*	1800	610	667	318.5	587	0.237	1600
Li	*	22	4	4	2.8	4	0.270	15
Sn	*	56	*	6	9.6	2	0.670	42
W	*	410	*	15	30.0	3	0.798	120
Ta	*	270	*	18	31.0	4	0.845	159
Ba	*	2593	500	531	350.0	276	0.873	1455
As	*	42	*	5	6.6	3	0.577	29

RUKORE INTRUSIVE SUITE

Number of samples = 4

Element	Min Conc	Max Conc	Median	Mean (Arith)	Stand Dev	Geom Mean	Log Dev	Threshold
Cu	11	25	12	16	5.5	15	0.139	-
Pb	20	45	20	26	10.8	24	0.152	21
Zn	56	110	69	82	20.9	79	0.113	-
Co	12	22	15	17	3.7	16	0.097	-
Ni	8	13	10	11	2.1	11	0.088	-
Mn	750	1685	1020	1179	343.5	1129	0.128	-
Li	3	5	3	4	0.8	4	0.093	-
Sn	*	8	*	2	3.3	0	1.267	-
W	*	51	*	16	20.9	1	1.725	-
Ta	*	49	*	20	20.7	1	1.790	-
Ba	*	831	313	375	297.0	31	2.023	-
As	*	10	*	3	4.3	0	1.299	-