REPUBLIC OF BOTSWANA

MINISTRY OF MINERAL RESOURCES,
GREEN TECHNOLOGY AND ENERGY SECURITY

Botswana Mineral **Projects and Prospects**

BOTSWANA
GEOSCIENCE
INSTITUTE

Excellence in Geoscience

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Introduction

1.1 BGI Mandate

The Botswana Geoscience Institute (BGI) was established through an Act of Parliament passed in 2014. Its purpose is to undertake research in the field of geosciences and provide specialised geoscientific services; empower the Institute to be the custodian of geoscience information; promote the search for, and exploration of any mineral in Botswana; and to act as an advisory body in respect of geohazards and other incidental matters.

1.2 History of Exploration and Mining

Botswana's exploration and mining has been historically dominated by diamonds and to lesser extent base metals. Most of Botswana's diamond production is of gem quality, resulting in the country's position as the world's leading producer of diamond by value.

Copper, gold, nickel, and soda ash production also has held significant, though smaller, roles in the economy. Base metal mining experienced a slum in 2015, however exploration for Cu-Ag deposits has intensified in western part of Botswana. Growth is expected from the copper/ silver discoveries in the Kalahari Copper Belt (KCB).

The Botswana government granted Khoemacau Copper Mining Company a mining licence for a 3.6 Mtpa underground mine production and is anticipated to start production in 2021. Within the KCB, several exploration companies have advanced exploration to prefeasibility stage and these include. Tshukudu Metals Exploration-Mining Company.

2 Precompetitive Data: National Coverage of Geological and Geophysical Surveys

Approximately 25% of Botswana land area, narrow eastern strip and Ghanzi ridge, is covered by Pre-Kalahari Geological Formations where all of the mines in Botswana have been discovered.

Notwithstanding extensive cover of the Quaternary Kalahari Deposits, the unexposed 75% Pre-Kalahari Geology rocks in Botswana are potential metallogenic provinces with unexplored and untapped mineral potential that can drive diversification from diamonds.

2.1 Geological Mapping Coverage

In recognition of this potential, Botswana Government has since independence, embarked on aggressive nationwide geological and geophysical mapping resulting in 90% of the land area covered in high resolution aeromagnetic and relatively high-resolution gravity survey in the northern part, central and Molopo Farms areas. Geological mapping covered 48 % of the country. Currently, 45% of the country is covered by 37% of 1: 125 000 scale and 8% of 1: 250 000 scale geological maps.

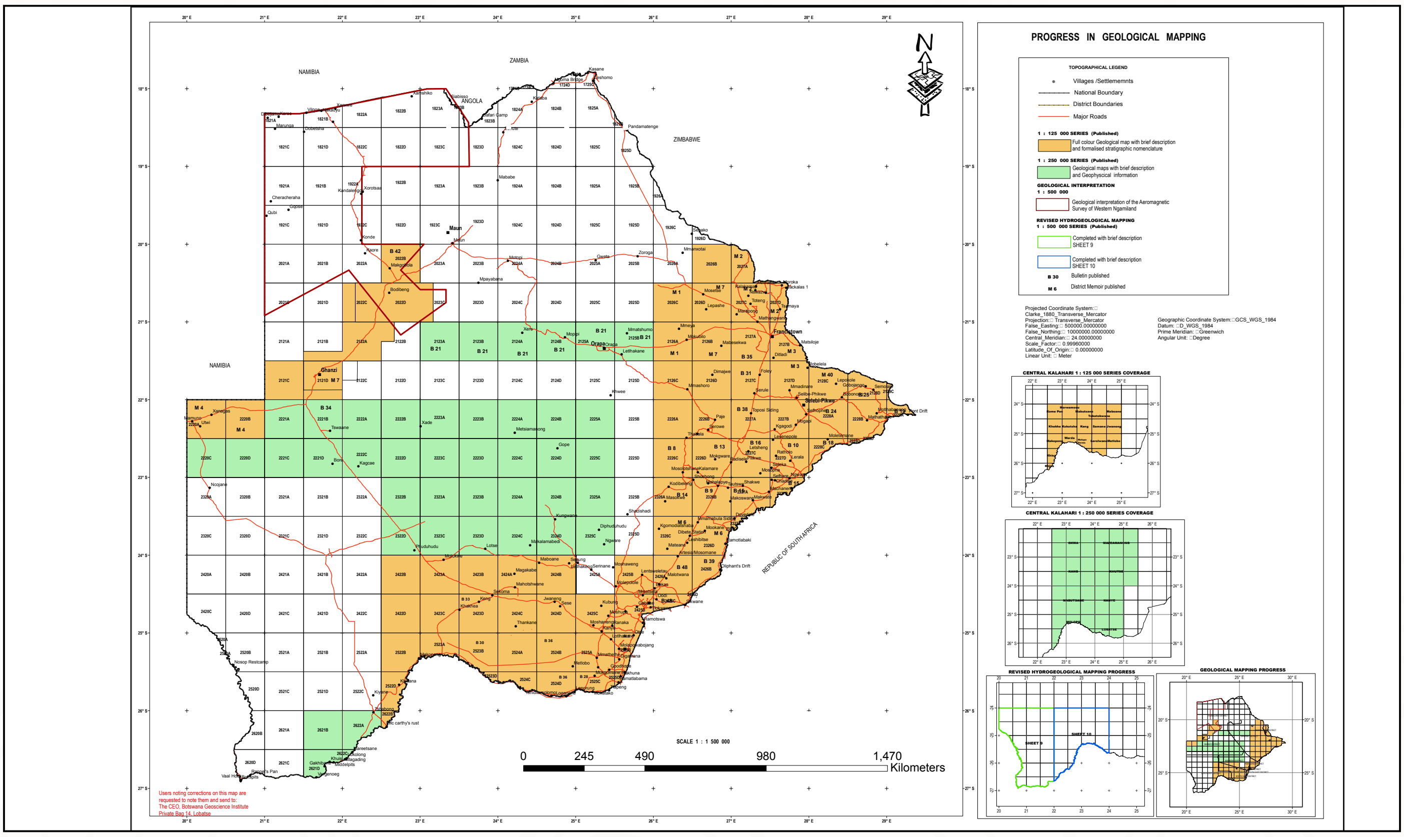
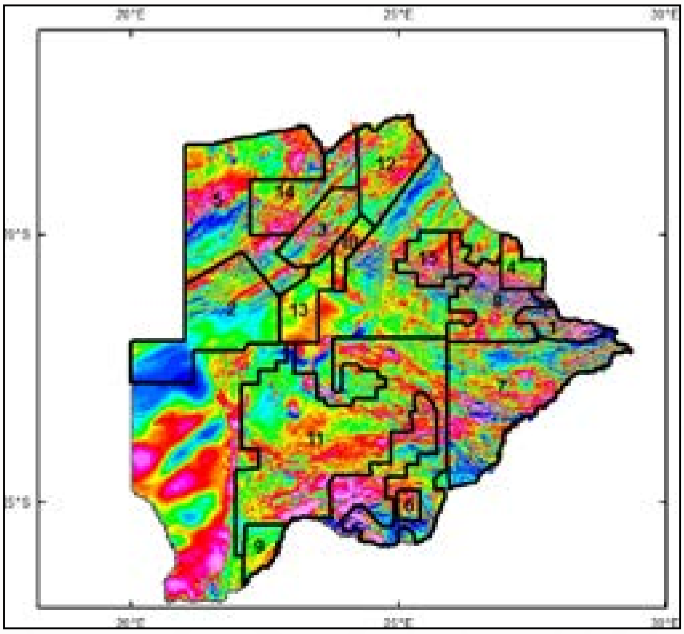


Figure 1 : Progress in Geological Mapping as at June 2011

2.2 Geophysics Data

Botswana Government has, between 1989 and 2003, conducted geophysical surveys totalling 1, 834, 545 line kilometres (line-km).



	Survey Name	Year Flown	Line Kilometer
1	Magogaphate	1989	22,686
2	Ghanzi - Chobe	1994	166,211
3	Maun	1995	20,442
4	Northeast Botswana	1996	33,654
5	Ngamiland	1997	281,494
6	Kanye	1997	9,564
7	Limpopo	1998	261,416
8	Francistown	1998	118,228
9	Tsabong	1999	29,543
10	Boteti	2001	23,260
11	Central Kalahari	2002	507,941
12	Chobe	2003	82,112
13	Deception Pan	2003	43,396
14	Okavango	2003	187,193
15	Makgadikgadi	2003	47,406

Figure 2 : Government Funded Geophysical Surveys

In 2011, the Government of Botswana funded a tie-line survey totalling 75000 line kilometres to merge all existing aeromagnetic surveys into seamless dataset to facilitate easy data manipulation and interpretation.

A 1: 1 000 000 Total intensity Magnetic Map of the country was produced based on Government and private sector data that comprised 2, 167, 297 line-km from 70 (seventy) individual aeromagnetic surveys.

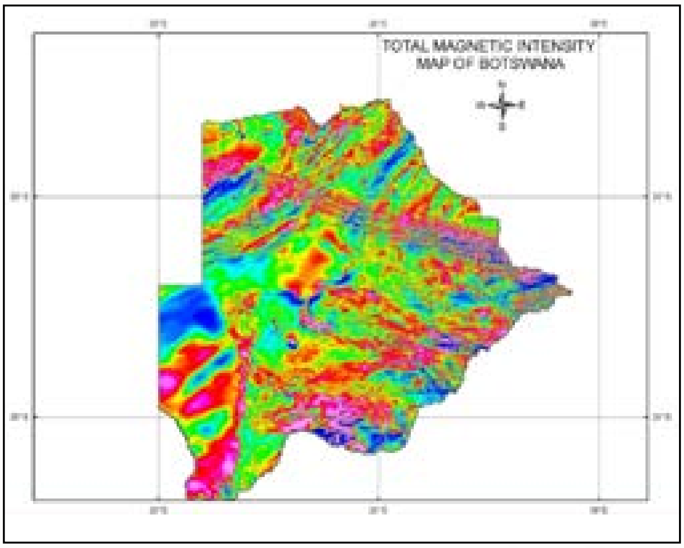


Figure 3 : Total Magnetic Intensity Map of Botswana 2011

2.2.2 Gravity Surveys

In addition to the aeromagnetic surveys, the Government of Botswana embarked on national gravity data acquisition which started in 1972 to 1978 with a total 3265 stations. From 1978 to 1999 Government continued to acquire more gravity points through various projects including mineral and groundwater projects. Of significance was the helicopter supported gravity data acquisition and processing in Northern Botswana where a total of 4003 data points were acquired as well as establishment of gravity base stations through out the country to be within 200km of each other. In parallel to government surveys, private sector also acquired a number of gravity surveys such as the Anglo American Central Kalahari Project which was also helicopter support with total of 2195 stations and many more. The database has a total of about 25000 gravity stations.

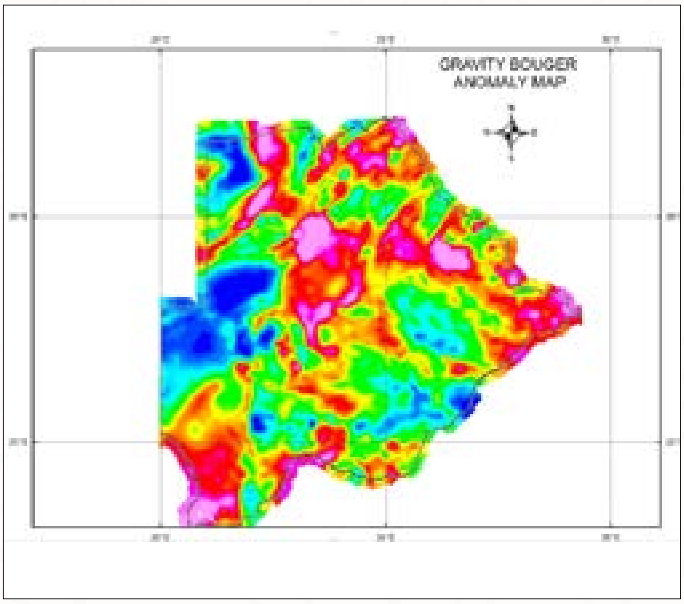


Figure 4 : Gravity Bouger Anomaly Map

2.2.3 Radiometric Data

Airborne radiometric survey have been carried out in eastern Botswana (where there is very little cover of Kalahari Tertiary Deposits (sands and calcretes) in conjunction with the airborne magnetic survey.

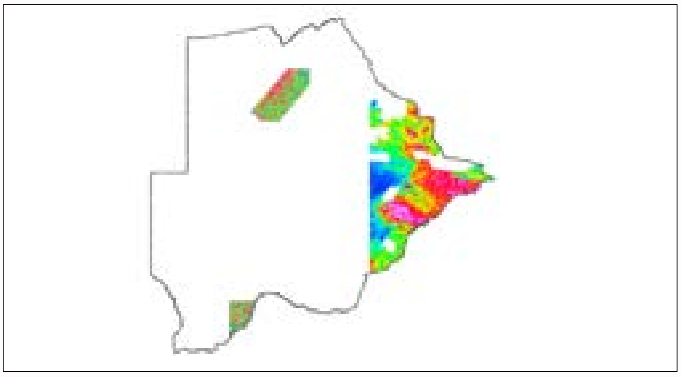


Figure 5: Radiometric Data Coverage

2.3 Geochemical Data

Department of Geological surveys, Botswana, undertook regional soil geochemistry sampling of North West Ngamiland and Molopo farm areas. The map below shows area covered by the NW geochemical survey.

2.3.1 North West Nickel Distribution

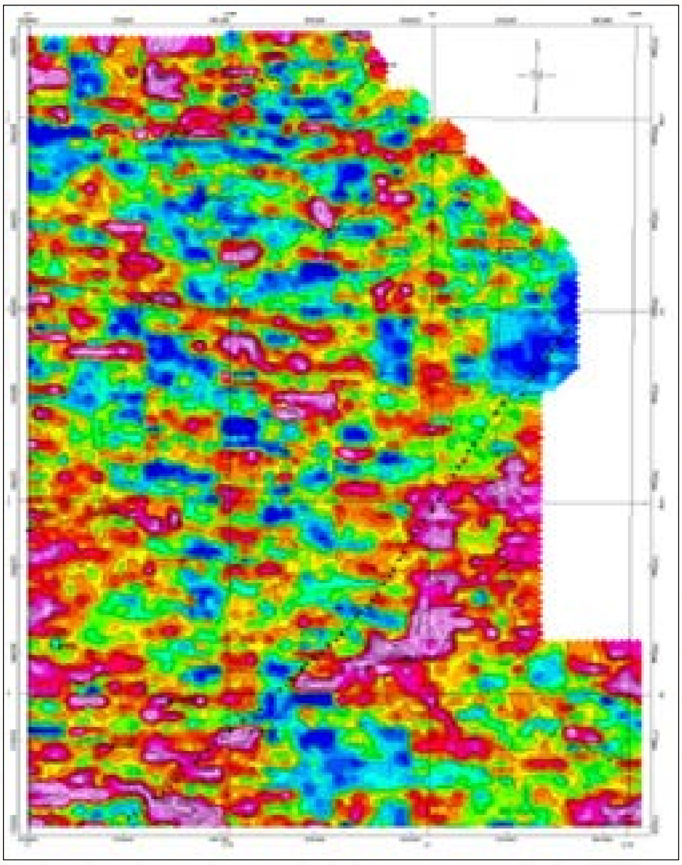
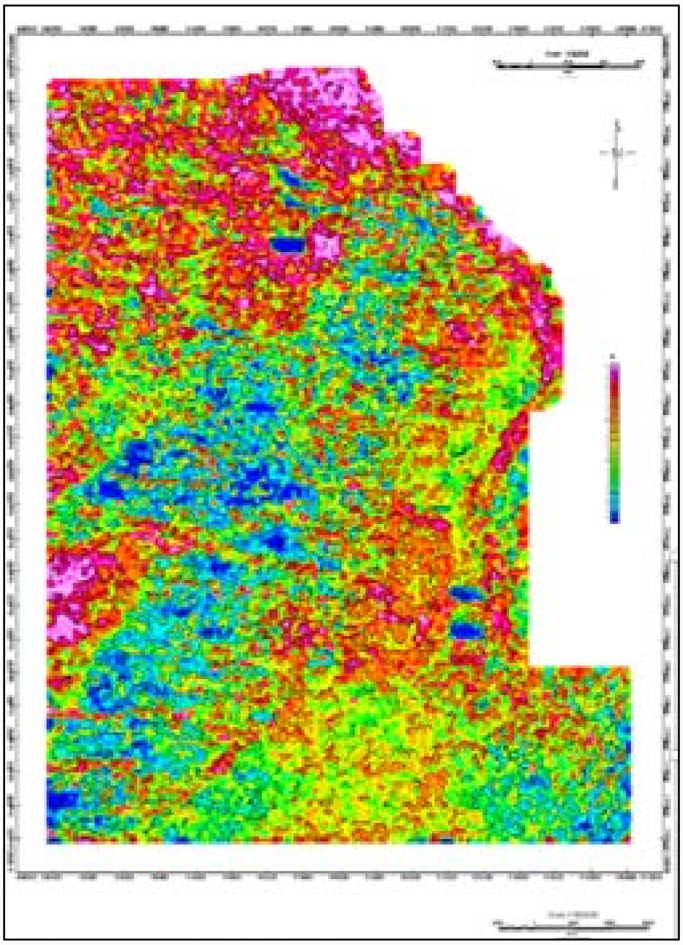


Figure 6: Nickel concentration distribution pattern



Geochemical Zone	Area km²	Mg (ppm) minimum	Mg (ppm) maximum	Mg Mean ppm	Background (mean + std dev)
Xhwihaba-Ipopeng	16956	0	2260	502	920
Xhwihaba West	338	120	2000	970	1555
Aha Hills Ring	854	44	2540	1233	1856
Dobe North	386	140	2480	1056	1626
Xhwihaba East	582	98	2000	1102	1584
Zeniwe South	710	40	2160	1494	2036
Zeniwe North	294	60	2280	1122	1533
Makakung-Nokaneng	2175	40	2140	963	1604
Qunibe	894	140	2000	1011	1392
Sepopa	1798	20	2160	968	1490
Shakawe	389	60	2000	859	1303
Tsau	1498	0	2000	305	639
Gabba	1727	0	2000	455	933

Figure 7: Magnesium concentration distribution pattern

2.4 Borehole Data

Borehole information for both exploration and water borehole is available and covers the whole country. Exploration companies are expected to submit all borehole data for future references. Core from exploration boreholes is stored in the three core sheds, at Kang, Molapowabojang and Lobatse. Exploration borehole location map is shown in Figure 8.

2.5 Updating of the National Geological Map

The above data set are currently being used on the current project of detailed mapping of Botswana which is meant to update the National Geology map of Botswana.

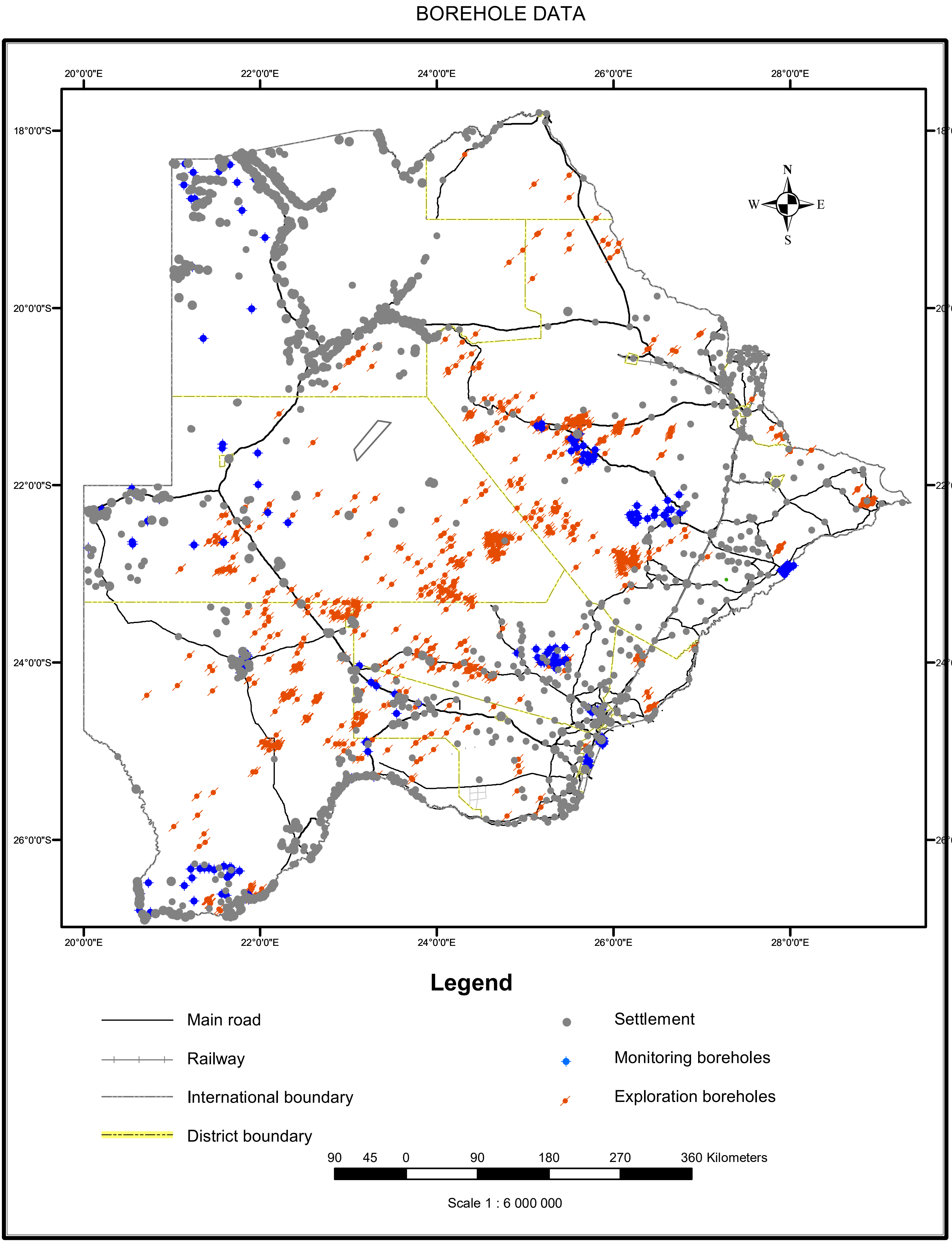


Figure 8: Exploration Borehole Location Map

2.6 Pre-Kalahari Geology Map

To promote mineral exploration, geophysics data collected by the government was augmented with data collected by the private sector (to cover 90% of Botswana land area) to conduct an interpretation of the Pre-Kalahari Geology. The Government has now embarked on a project (2020-2021) to update this National Map.

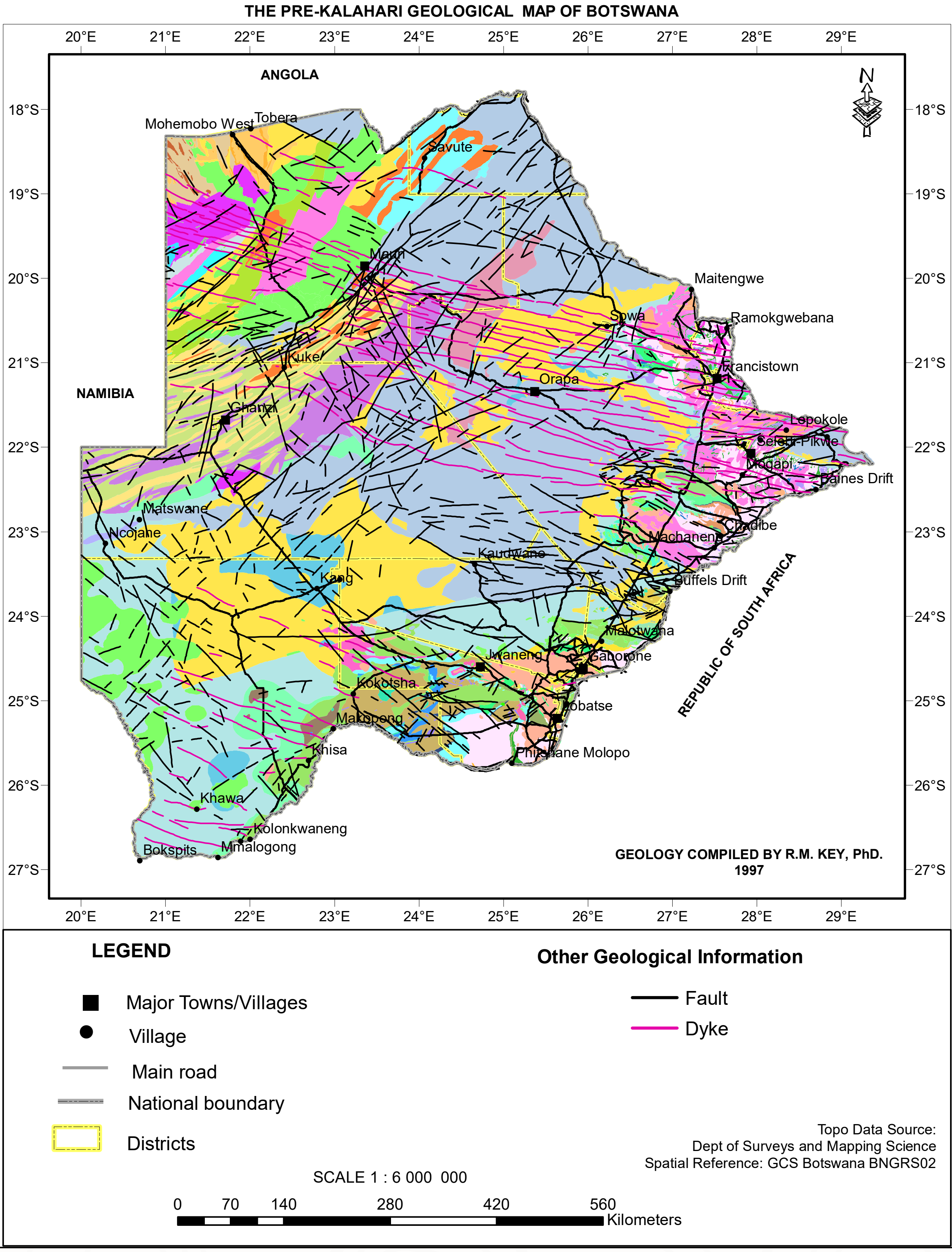


Figure 9: Pre Kalahari Geology Map

3 Botswana Mineral Potential: By Commodity and Geological Provinces

3.1 Coal

Botswana has considerable coal deposits that have been previously estimated at 212 billion tons (Mostly hypothetical and Speculative categories). The coal occurs in various coalfields which are, Pandamatenga, Eastern (Dukwi, Foley and Sese), Tuli, Morupule and Moijabana, Mmamabula, South Eastern (Dutlwe and Letlhakeng) as shown on figure 10. Coal deposits remain largely unexploited, currently there are only two coal mines.

The two mines are Morupule Coal Mine in eastern Botswana which produces about 1.5 million tonnes per year and Masama coal project in south-western Botswana. The Masama Coal Project has a coal resource of about 380 million tonnes (Mt) and it is currently under developed by Minergy Coal. There are other mining licenses issued to Jindal in the Mmamabula coalfield and African Energy around Sese/Foley coalfield but there are not yet developed.

Preliminary results from an on-going study that seeks to classify coal resources according to their quality and quantity has revealed that Botswana coal resources are mostly Sub-Bituminous and has been estimated to have about 28.2 Billion tonnes (Bt) including measured, indicated and inferred resources from various Competent Person's Report (CPR) of different reporting standards. Figures 10 below shows the distribution of various coalfields.

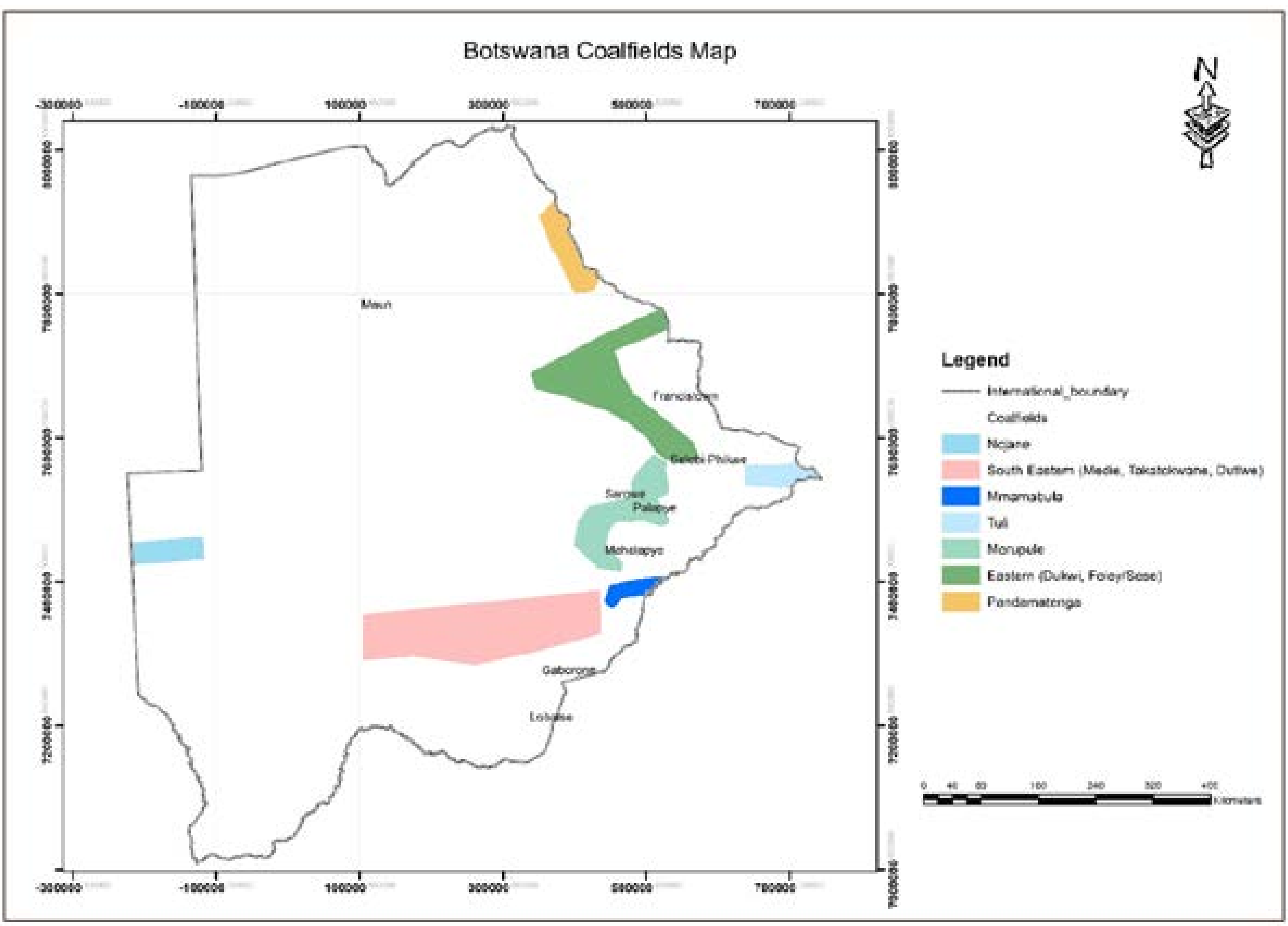


Figure 10: Coalfields map

3.2 Coal Resource Estimation

The tables below show coal resource estimation, which is currently ongoing. The data that is used is from previous, current exploration reports and other reliable data sources which are compliant with International Reporting Standards. Only reports that are compliant with international reporting standards for coal resource estimation, (JORC, SAMREC, NI 43-101, etc) are used as data sources.

Table 1: Coal resource estimation

Coalfields	BGI Report			Total (Mt)
	Identified (Mt)			
	Demonstrated		Infered	
	Measured	Indicated		
Mmamabula	5,560.67	1,159.20	3,693.00	10,413.77
Dukwi	TBC	508.00	414.00	922.00
Foley / Sese	651.00	1,714.00	2,653.00	5,018.00
Morupule	2,518.21	694.25	3,903.17	7,115.63
Masama	12.71	73.21	304.01	389.93
Dutlwe / Letlhakeng	TBC	424.50	2,654.00	3,078.50
Mmamantswe	978.00	265.00	TBC	1,243.00
Total (Mt)	**9,720.59**	**4,838.16**	**13,622.08**	**28,180.83**

Location	Tonnage (Mt)	Relative Density	CV (MJ / Kg)	Mois-ture (%)	Raw Ash(%)	Volatile Matter (%)	Fixed Carbon (%)	Total Sulphur (%)	Classification (Coal Rank)
Mmamabula	**10,413.77**	TBC	22.51	5.48	21.80	23.71	50.39	2.13	Sub-Bituminuos
Dukwi	922.00	TBC	19.95	6.44	27.41	22.33	43.83	0.35	Sub-Bituminuos
Foley / Sese	5,018.00	TBC	TBC	TBC	TBC	TBC	TBC	TBC	
Morupule	7,115.63	TBC	19.20	3.99	37.16	23.19	TBC	1.69	
Masama	389.93	TBC	21.60	4.83	24.3	25.9	45	2.26	Sub-Bituminuos
Dutlwe / Letlhakeng	3,078.50	TBC	17.81	7.41	35.11	TBC	TBC	1.88	
Mmamantswe	1,243.00	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC

4 Opportunities for Diamonds, Base and precious metals

4.1 Diamonds and Kimberlite Fields

Large number of Kimberlite pipes are distributed on several fields across the country. The map below shows occurrence of kimberlite fields in relation to structural provinces and tectonic units. Some of these Kimberlites are of high economic importance to Botswana due to production of diamonds. New discovery of Kimberlites continues to date most notably at the Tsabong kimberlite fields.

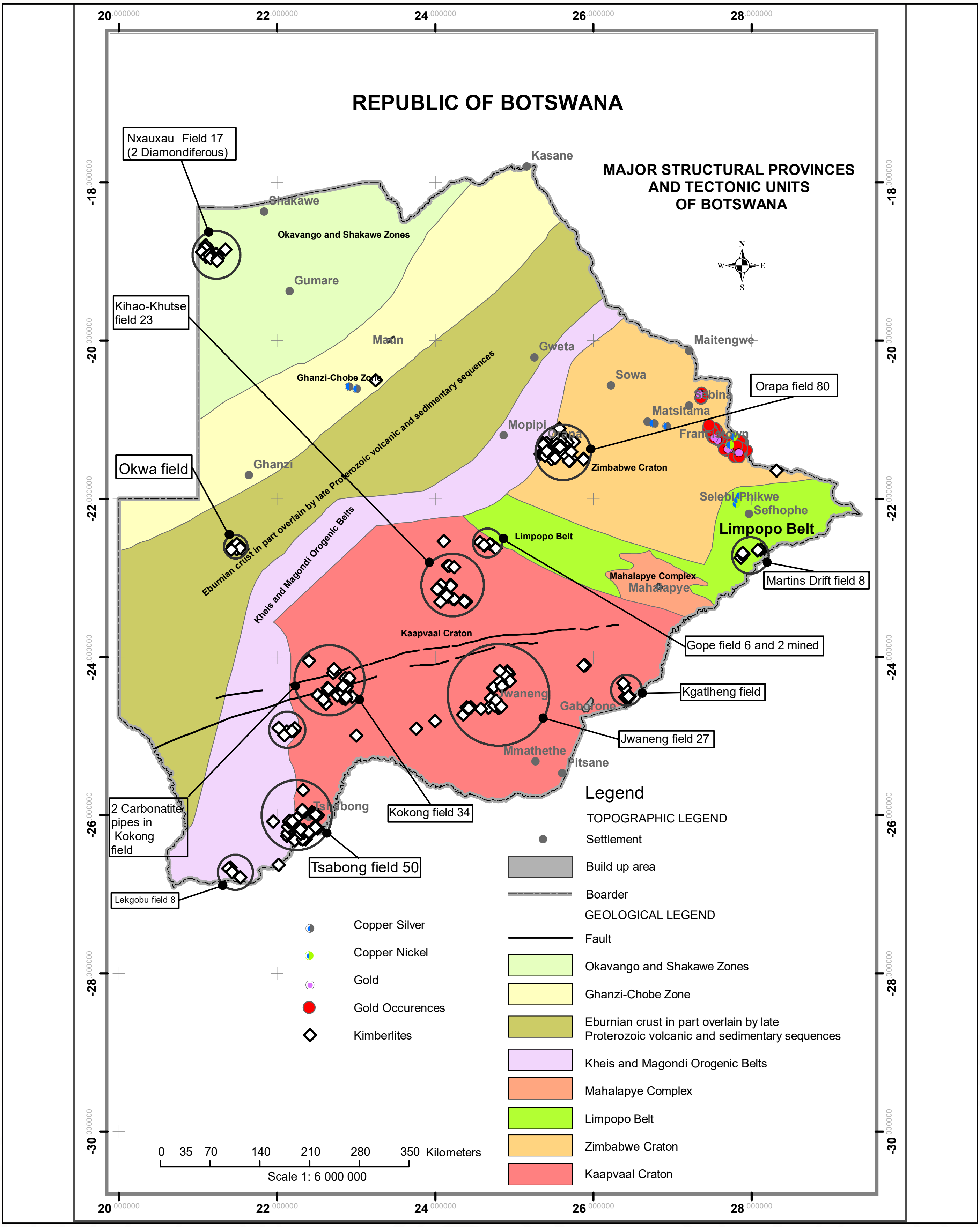


Figure 11: Map showing occurrence of kimberlite fields in relation to structural provinces and tectonic units

Table 3: showing Kimberlite fields and the number of kimberlites

Kimberlite Field	No of Kimberlites
Jwaneng	27
Orapa	80
Martins Drift	8
Gope	6
Kokong	34
Nxauxau	17
Kihao-Khutse	23
Okwa	8
Lekgodu	8
Tsabong	50

4.2 Geological Districts of Botswana

Botswana is mostly covered by recent sediment (Kalahari beds and the Karoo Sequence) with limited exposure in western side of the country. The country is sitting on stable cratonic regions being the Kapvaal Craton in the south and the Zimbabwean Craton in the north.

The Limpopo mobile belt separates these cratons. However there are other orogenic belts to the west of the two major cratons, namely the Kheis Magondi belt, the Kalahari Copper Belt (Ghanzi/Chobe) and the Damara Orogenic belt. The map below shows the cratonic terranes, the Kapvaal and Zimbabwe craton (Archaean) and the early Proterozoic mobile belts (Kheis Magondi, Ghanzi Chobe) and the late Proterozoic belt, the Damara Orogenic belt.

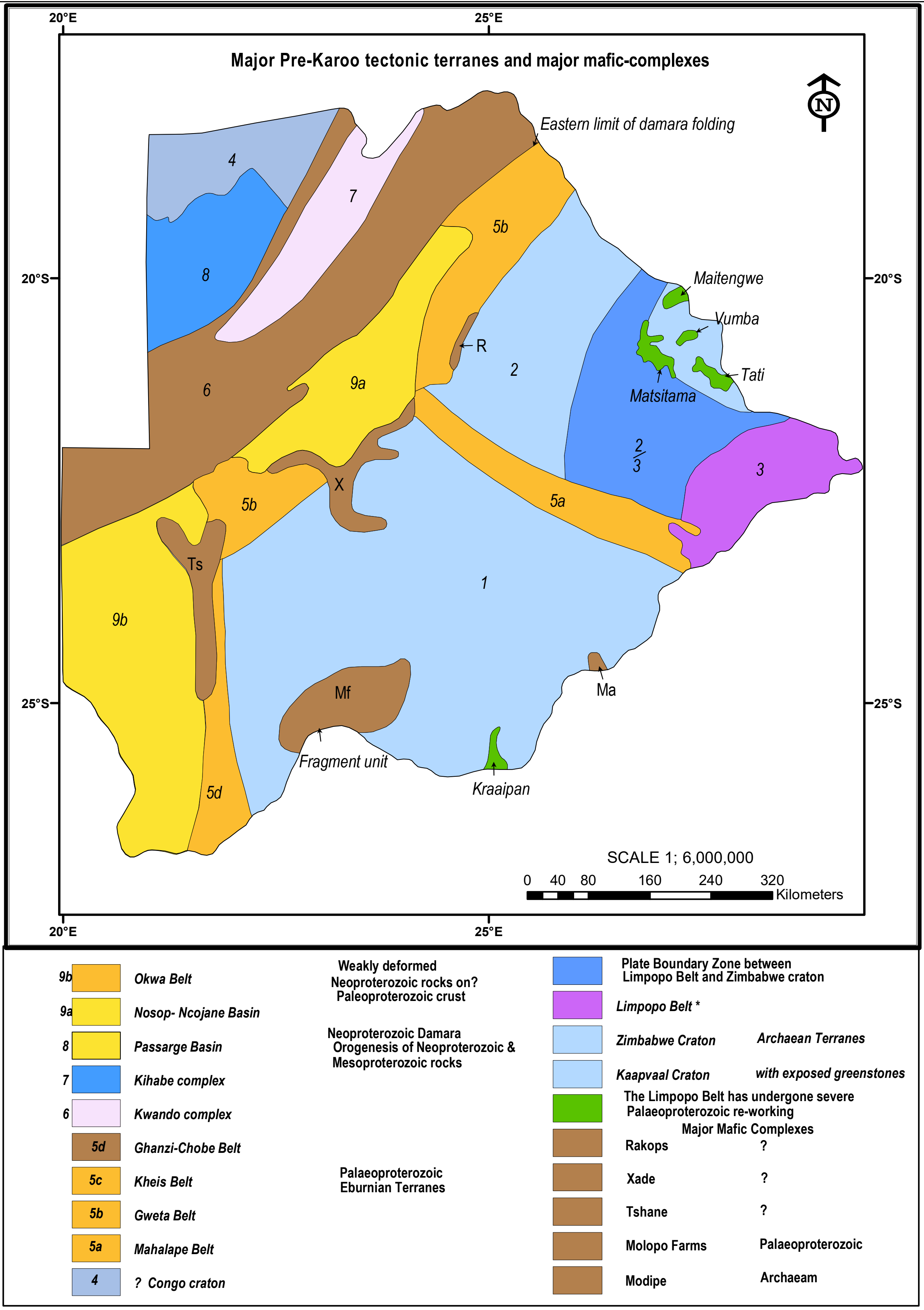


Figure 12: Map showing Metallogenic provinces

Table 4: Showing relation of geology and mineral occurrence in the above map.

Tectonic Terranes	Age	Mineral Potential
Passage Basin	Early Proterozoic	
Kihabe Complex	Late Proterozoic	Copper, Silver, Lead, Zinc, Cobalt, Germanium and Vanadium
Kwando Complex	Late Proterozoic	Iron and Copper
Ghanzi-Chobe Belt	Late Proterozoic	Copper and Silver.
Okwa belt	Early Proterozoic	
Nossop-Ncojane Basin	Early Proterozoic	
Kheis-Magondi Belt	Early Proterozoic	
Gweta Belt	Early Proterozoic	
Mahalapye Belt	Early Proterozoic	
Limpopo Mobile Belt	Archaean	Nickel and Copper
Tati Schist belt	Archaean	Nickel, Copper and Gold
Vumba Schist belt	Archaean	Nickel, Copper and Gold
Maitengwe Schist belt	Archaean	Nickel, Copper and Gold
Matsitama Schist belt	Archaean	Copper, Gold traces
Kraaipan	Archaean	Iron and Gold
Zimbabwe Craton	Archaean	Nickel, Copper and Gold
Kaapval Craton	Archaean	Silver, Gold Iron and Manganese
Major Mafic Complexes		
Rakops	Early Proterozoic	
Xade	Early Proterozoic	
Tshane	Early Proterozoic	
Molopo Farms	Early Proterozoic	Gold, Iron, traces of PGE, REE potential carbonatites
Modipe	Archaean	

4.2.1 Geological Provinces: Molopo Farms Complex

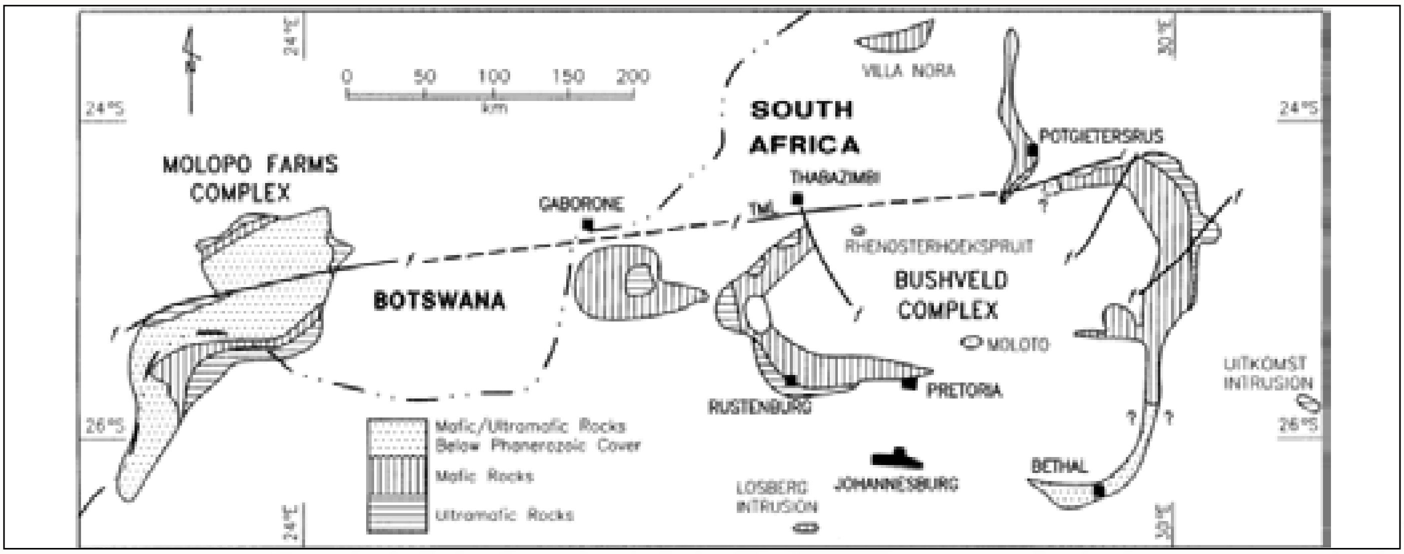


Figure 13: Map showing. Molopo farms complex Geology

In 2006, The Botswana Government commissioned a study to assess mineral potential of Molopo Farms in southern Botswana. The project area spreads from Mabule in the East extending to Khisane in the west and to Takatokwane in the North.

The project identified 29 Potential sites for Precious and Base Metals (Cu (Copper), PGE (Platinum group Elements), Au (Gold), Ni (Nickel), Fe (Iron) and Rare Earths in Carbonatites in Mabutsane) and Coal located +/- 150m below ground. The 29 sites are still a subject of interest for private sector exploration.

a) Mabutsane Area: Gold, nickel-copper and copper-lead –zinc deposits (Mapeo, 1989) within the amphibolites and schists of the Kraaipan group, however the economic deposits have not been proven.

b) Phitshane Area: Banded Iron Formations of the Kraaipan group are potential sites for Iron ore (Aldiss, 1985).

c) There are currently 32 Prospecting Licences in the area for various mineral commodities listed below:

i. Energy Metals – 1
ii. Precious Stones -5
iii. Precious and Base Metals – 15
iv. Industrial Minerals - 11

4.2.2 Geological Provinces: Kalahari Copper Belt

The Kalahari Copperbelt (KCB) is late Mesoproterozoic to Neoproterozoic belt that extends from Namibia into Botswana and hosts strata bound sediment-hosted Cu–Ag districts.

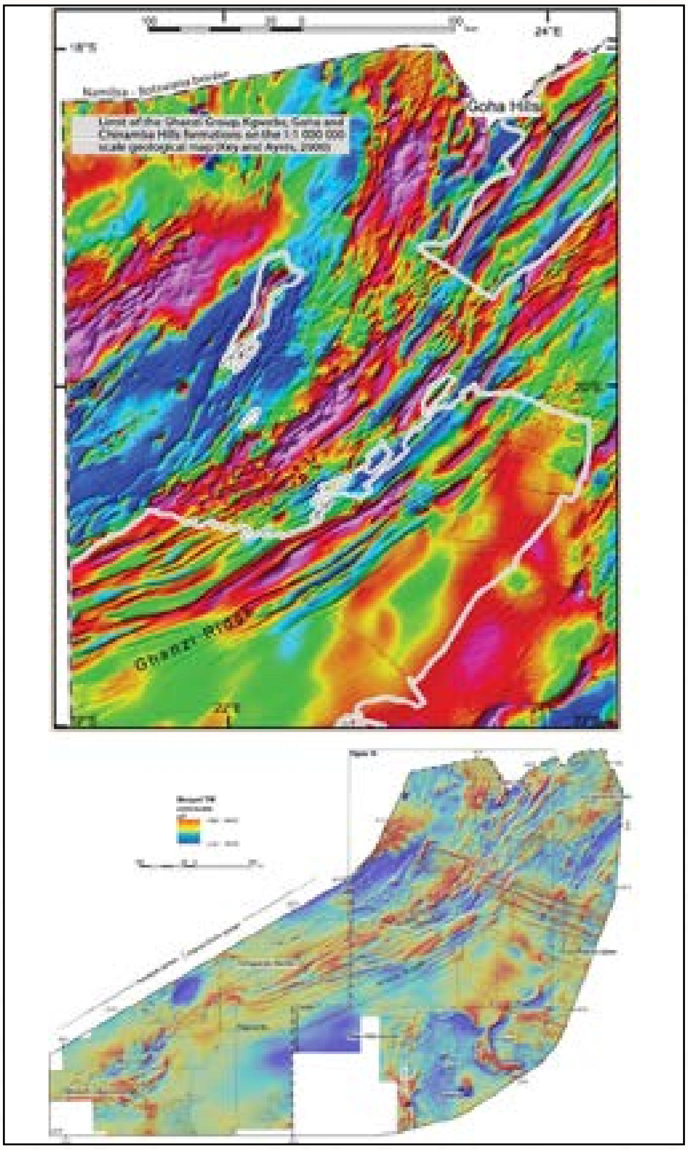


Figure 14: Kalahari Copper Belt

4.3 Rare Earths

Rare Earths in Botswana remain largely unexplored despite occurrence of numerous granitic rocks in Botswana. Lusty et al. 2012 of British Geological Survey, assessed the potential for REE mineralization in the Precambrian igneous rocks in Botswana.

The focus area for the study was the Semarule Syenites, Mahalapye and Mokgware Granites, Moshambe, Timbale, Domboshaba Granites and Kalakamate Monzonite shown in figure 16.

The total REE (TREE) of the above sampled areas varied highly and ranged from <10 to >2000 ppm, with the highest values obtained from the Semarule syenites, Mahalapye Granites and Domboshaba Granites. The same reports also indicates that, two samples from Semarule Syenite have highest concentrations of Lithium.

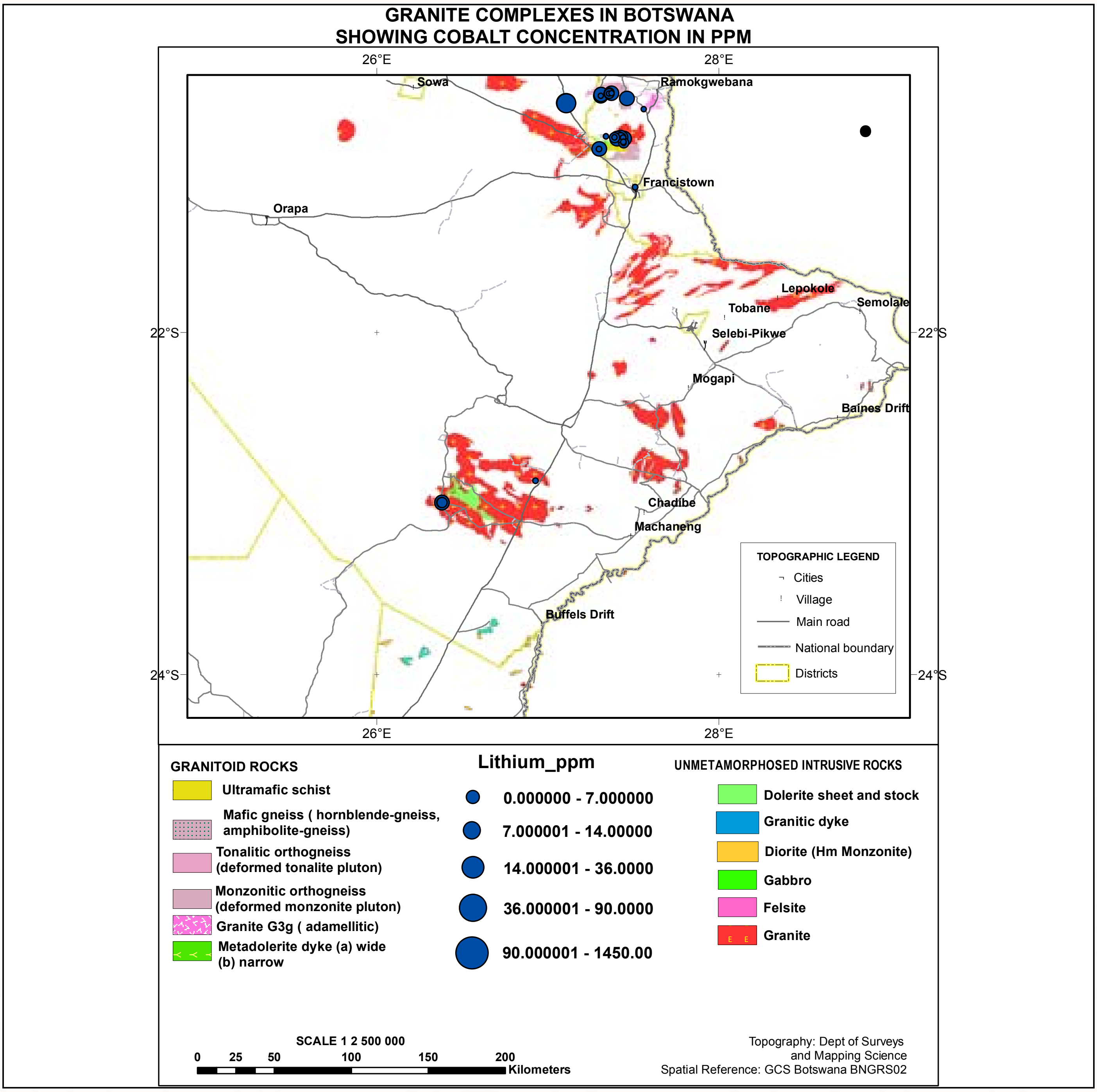


Figure 15: Granitic Complexes of Botswana showing battery metals concentration results from BGS Sampling Points

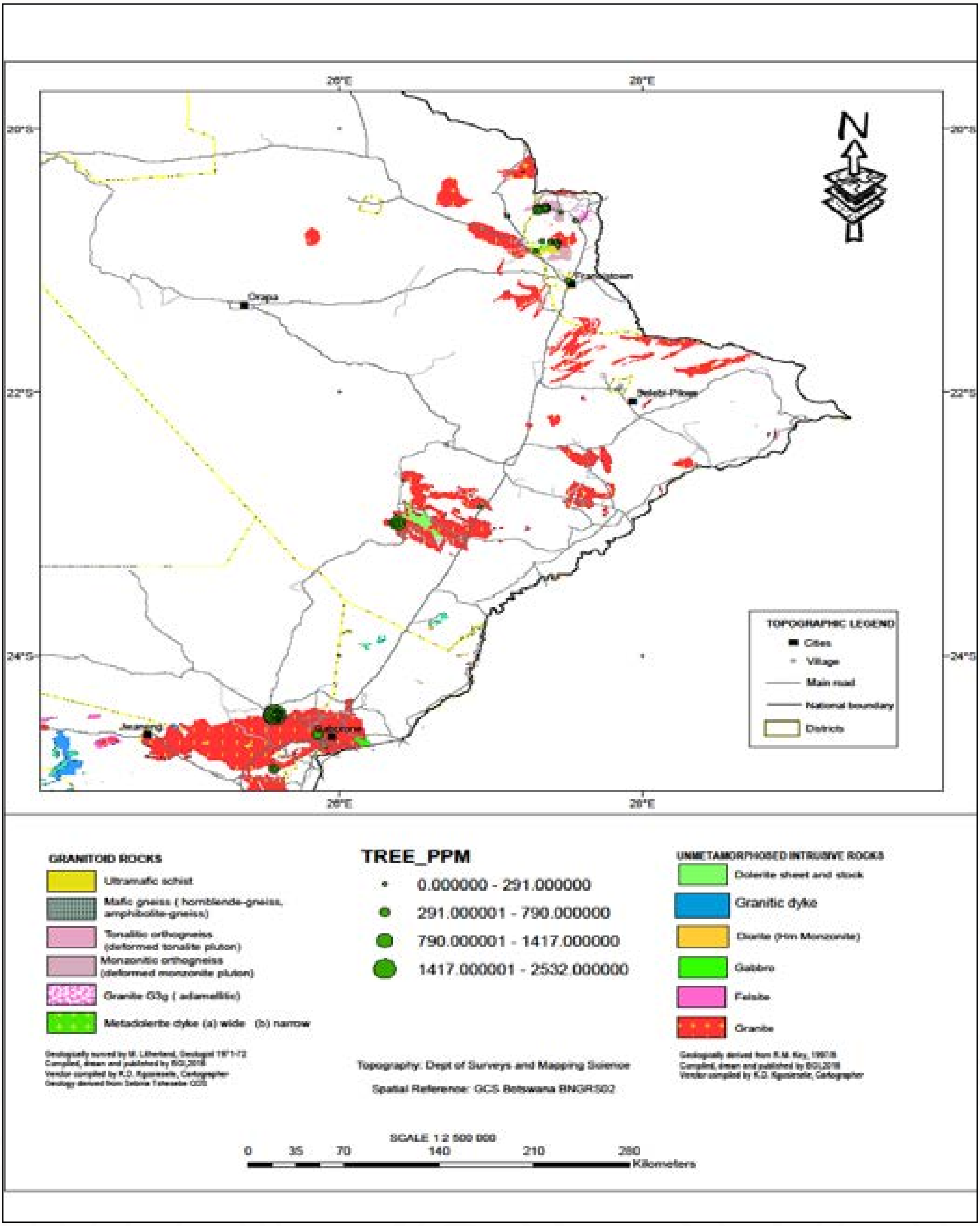


Figure 16: Granitic Complexes of Botswana showing REE concentration results from BGS Sampling Points

4.4 Industrial Minerals and Construction Aggregates

4.4.1 Slates

Botswana has a significant volume of different types of slate by different colours. These slates have good strength and durability for use as flooring material and are resistant to cracks, scratches, breaks and chips. The southern and part of the eastern part of Botswana has well exposed slate deposits which has not yet been tapped for industrial purpose.

Figure 17: Dipotsana slate is grey in colour when it is fresh, but it weathers reddish-brown depending on the period it took in contact with the fluids which results in oxidation of the top most surface of the slate.

4.4.2 Aggregate for roads and building Construction

The geology of Botswana plays a significant part in the country's economy. The basement rocks of the Kaapvaal-Zimbabwe craton extend into Botswana whilst in the east and southeast, metamorphic rocks of Archaean age are dominant.

All these rocks which are predominantly non-metallic minerals constitute to natural construction and building aggregate (See industrial minerals map of Botswana).

In Botswana, construction aggregate occur as granular materials suitable for use either on their own or with the addition of cement, lime or a bituminous binder in construction. Important applications include concrete, manufactured sand, mortar, road stone, asphalt, railway ballast, drainage courses and bulk fill.

Figure 18: Coarse to medium grained found both in the eastern and southern Botswana, the material qualify for road and building construction. Further crushing of these rocks, using cone crushers produces manufactured sand, which is suitable for construction buildings.

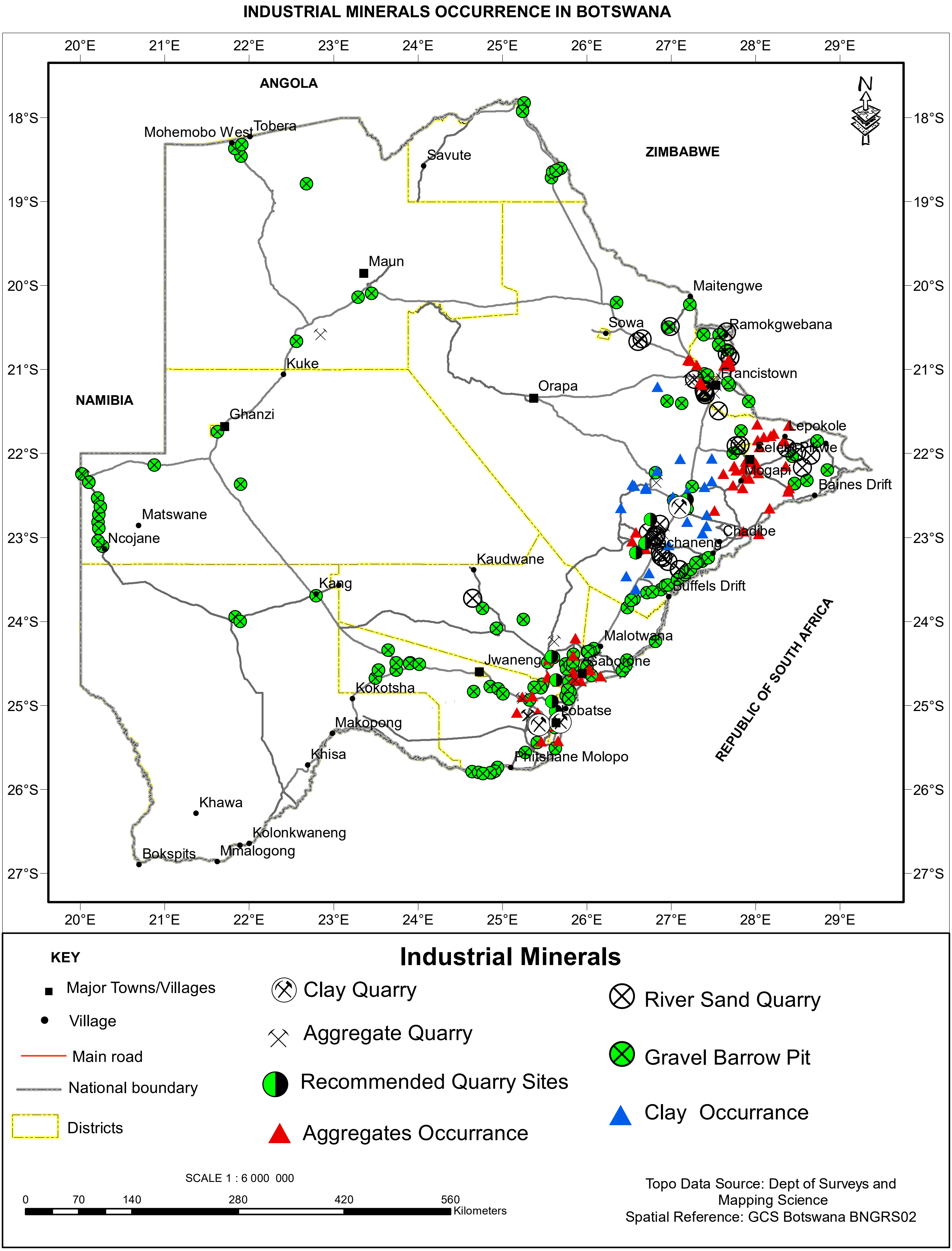


Figure 19: Industrial Minerals Map

4.4.3 Ornamental Stones

Botswana government has recently embarked on the identification and assessment of granites as ornamental stones.

The results has shown vast amount of potential for ornamental stones in the Southern and North-eastern Botswana, with good strength and different shades of colours (See Industrial minerals map of Botswana).

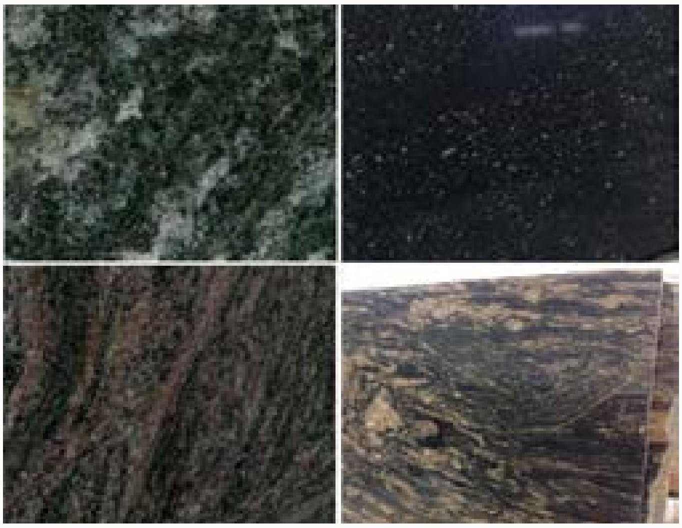


Figure 20: Some of the granites (ornamental stones) similar to those found in the Greater Gaborone and North eastern Botswana, showing different shades of colours and textures.

4.4.4 Clay Deposits

Clay in Botswana is associated with Karoo Sediments of the Ecca group widely spread throughout the country. Clay is mined at Makoro, Lobatse and Dipotsana for brick production.

(See industrial minerals map of Botswana).

Figure 21: Clay deposits in Botswana is used mostly for brick making. Small portion of it is used in pottery, of which most of it is exported to neighbouring countries.

Botswana imports about 100% of its cement from neighbouring countries after the closure of Matsiloje cement plant. Currently the government is evaluating limestone deposits in the country that are sufficient to sustain a cement plant in order to reduce the import of cement. Two areas have been assessed in terms of both quality and quantity. These areas are Gasita and Letlhakeng in the southern part of the country.

4.4.5.1 Gasita Calcrete Deposit

The Ngopilo hill, Moletsane and Segeng areas are situated on the Gasita area. Gasita is a small village in the Southern District about 65km Southwest of Kanye. Ngopilo hill forms a gentle dune rising towards the southwest of Ngopilo Pan.

In the assessment of the Ngopilo Hill, Moletsane and Segeng calcrete deposits, 10 boreholes were drilled at Ngopilo, 9 boreholes at Moletsane Pan and 13 boreholes at Segeng Pan The three calcrete deposits have average thickness ranging from 1.7m to 4.1m which qualified to be cement grade as per South African Bureau of Standards (SABS) for cement manufacturing.

The Ngopilo, Segeng and Moletsane deposit each have a total calcrete resource estimation of 991024, 446 591 and 336 016 tonnes respectively, which brings the Gasita deposit to have a total calcrete resource of 1,773,631tonnes.

4.4.5.2 Letlhakeng Calcrete Deposit

The area under investigation is located in Kweneng District, southeast of Letlhakeng village about 75 km Northwest of Molepolole.

The area lies at the confluence of Gaotlhobogwe and Letlhakeng rivers. The area is divided by the fossil valley that is defined by a very low topography, whereas the target area is mostly topographic high in both sides of the fossil valley. Topography of the area can be described as undulating with the altitude ranging from 1070m and can reach altitude of about 1090m. This area is within the vicinity of the Letlhakeng village hence makes it an ideal area for future mining development as the infrastructures like roads and necessary utilities are within reach with ease.

Resource assessment was carried out in Letlhakeng including drilling of fifty-three boreholes with the deepest boreholes of 30m. Drilling was informed by positive results from detailed surface sampling. The results were positive since they qualified as per South African Bureau of Standards (SABS) for cement manufacturing.

During drilling most of the boreholes drilled intersected calcrete with various thickness ranging from 3m to 18m. Drilling was conducted in order to calculate the resource and to check the quality of the calcrete with depth and 888 samples were from drill core was analysed and over 65% of the samples qualified as per SABS. The preliminary resource estimation of Letlhakeng calcrete deposit is approximately 139,000 million tonnes (Mt).

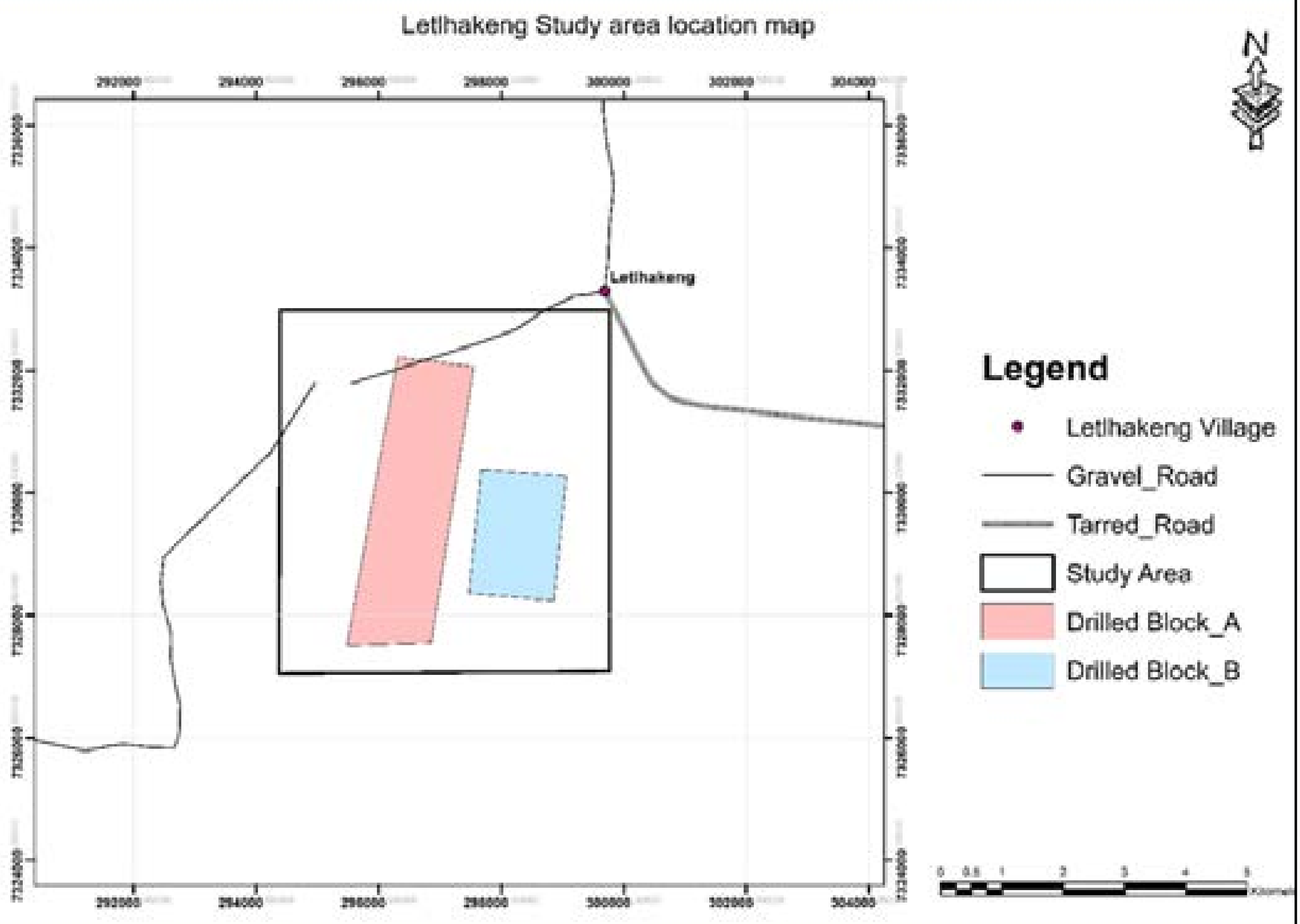


Figure 22: Location of the study area and topographic elevation from ASTER DEM.

Maitengwe Greenstone Belt

The main objective of this literature review was to combine data sets in the area and reinterpret in order to check if the area has mineral prospective targets to be considered for drilling.

Regional Geology

The geology of the area is covered by the Archaean Zimbabwe Craton which can be subdivided into Francistown Granite- Greenstone Complex, Mosetse Complex and Motloutse Complex. The Francistown Granite- Greenstone Complex is made up of the Greenstone belts Maitengwe, Vumba, Matsitama and Tati) which are mainly made of volcanic rocks metamorphosed in the greenschist and lower amphibolite facies. These greenstone belts are intruded by voluminous tonalites, followed by late- tectonic granodiorites, monzonites and granites.
The Maitengwe Greenstone Belt is found in the North-Eastern part of Botswana near Maitengwe village. The area is relatively flat with no or limited outcrops. It covers an area of approximately 484 Sq. Km. The proposed area can be accessed from Francistown through a tarred road via Tutume and Nkange village. There are also other motorable tracks.

The Mosetse Complex Consists of sediment-dominated supracrustal sequences which experienced higher grades metamorphism and gneissosity. Granitoids including tonalites, granodiorites and granites which are thought to be syn-tectonic.

Amphibolite sheets were observed within granitoid gneisses. Motloutse Complex consists of meta-sedimentary and para-gneissic rocks of the same protolith types to those in the Mosetse Complex. The rock units are of granitic composition and composed of migmatitic and megacrystic varieties (Carney, 1994).

Local Geology

Three sequences of meta-sedimentary and meta-volcanic rocks are present in the area namely:

The Mpapho Banded Ironstone Formation
This formation consist of units of quartzo-feldspathic rocks, serpentinite and amphibolite which are intercalated with banded ironstones. Banded ironstones are generally finely laminated to bedded silica bands with varying amount of iron oxides.

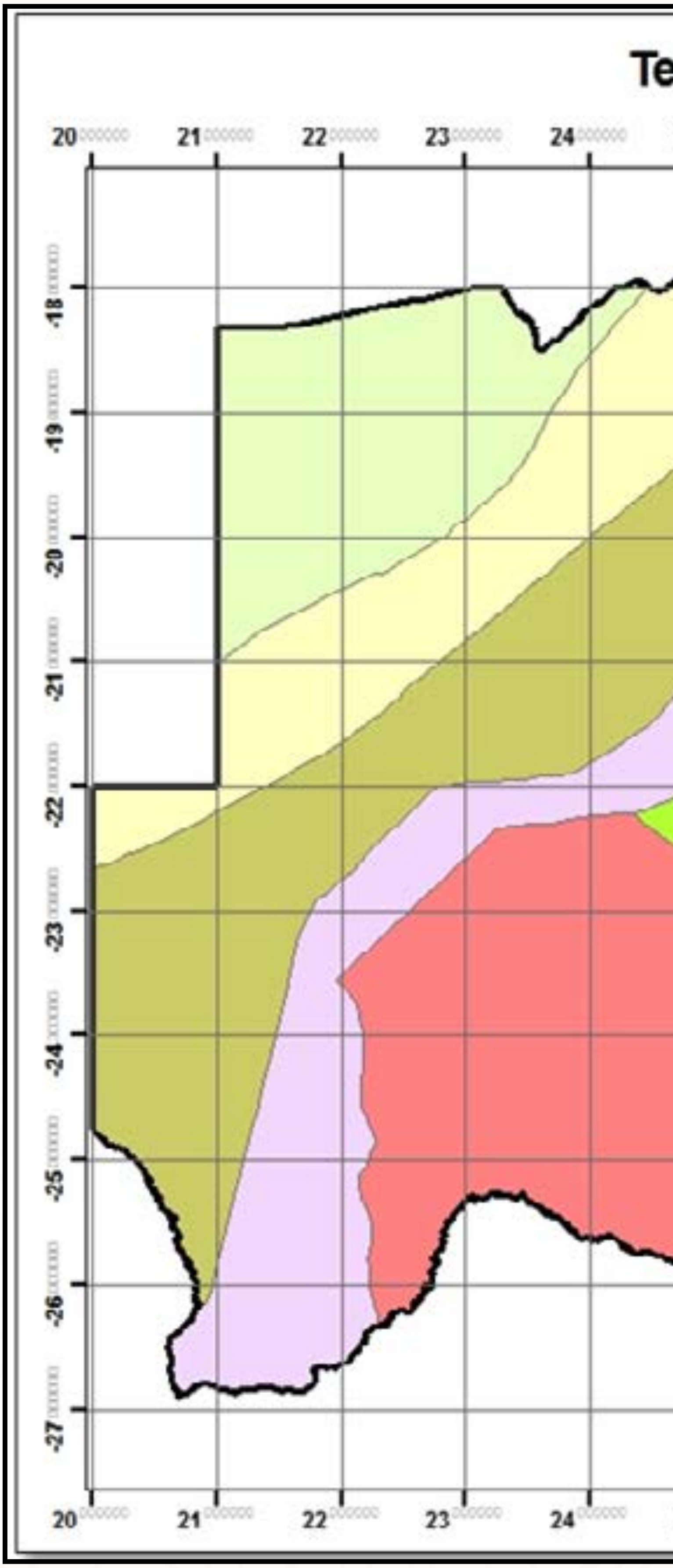
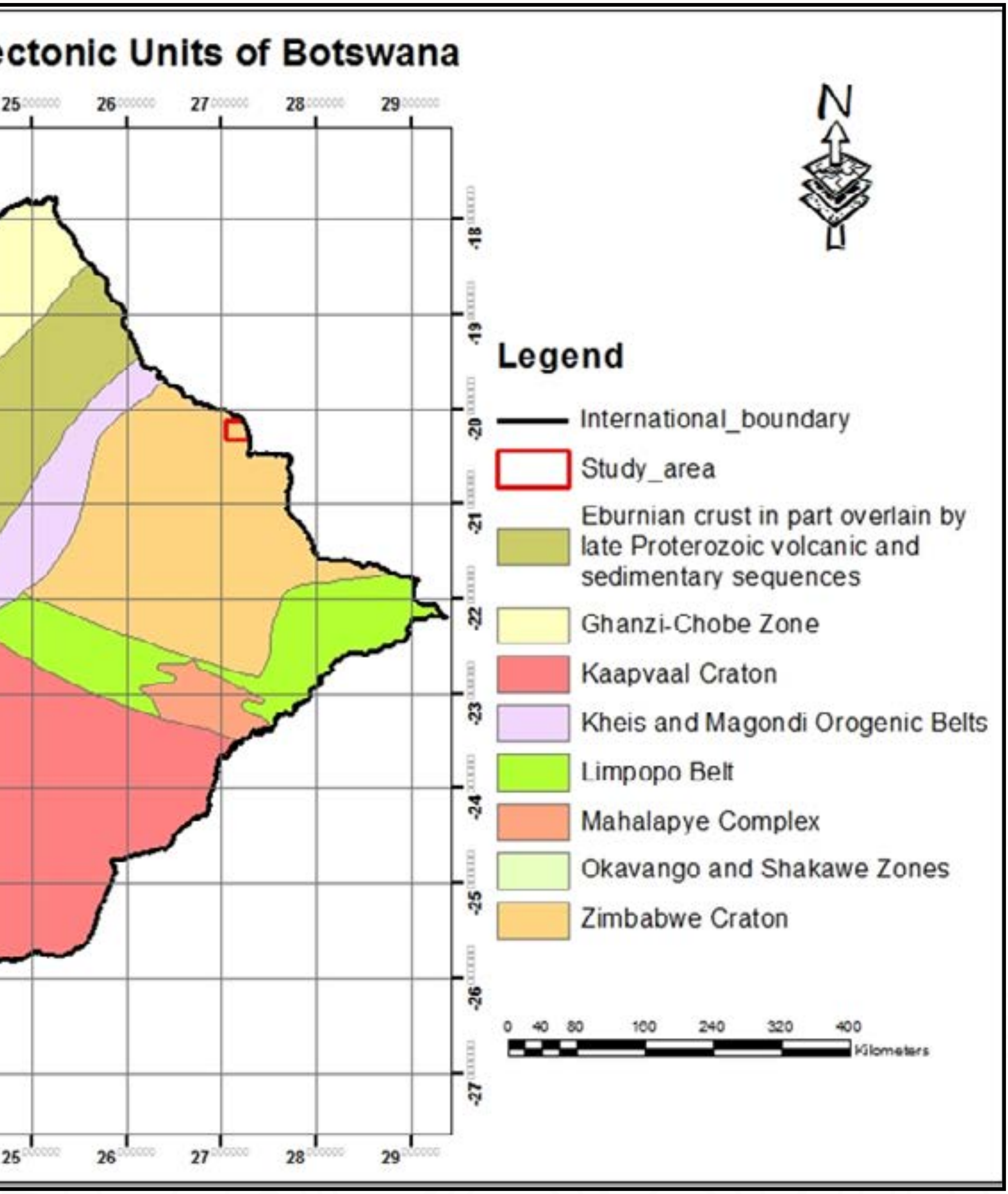


Figure 23: Regional Geology and major tectonic units of Botswana in relation to Maitengwe Study Area


ctonic Units of Botswana
25
26
27
28
29
-18
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-20
-21
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-23
-24
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-26
-27
N
Legend
International_boundary
Study_area
Eburnian crust in part overlain by late Proterozoic volcanic and sedimentary sequences
Ghanzi-Chobe Zone
Kaapvaal Craton
Kheis and Magondi Orogenic Belts
Limpopo Belt
Mahalapye Complex
Okavango and Shakawe Zones
Zimbabwe Craton
0 40 80 160 240 320 400
Kilometers

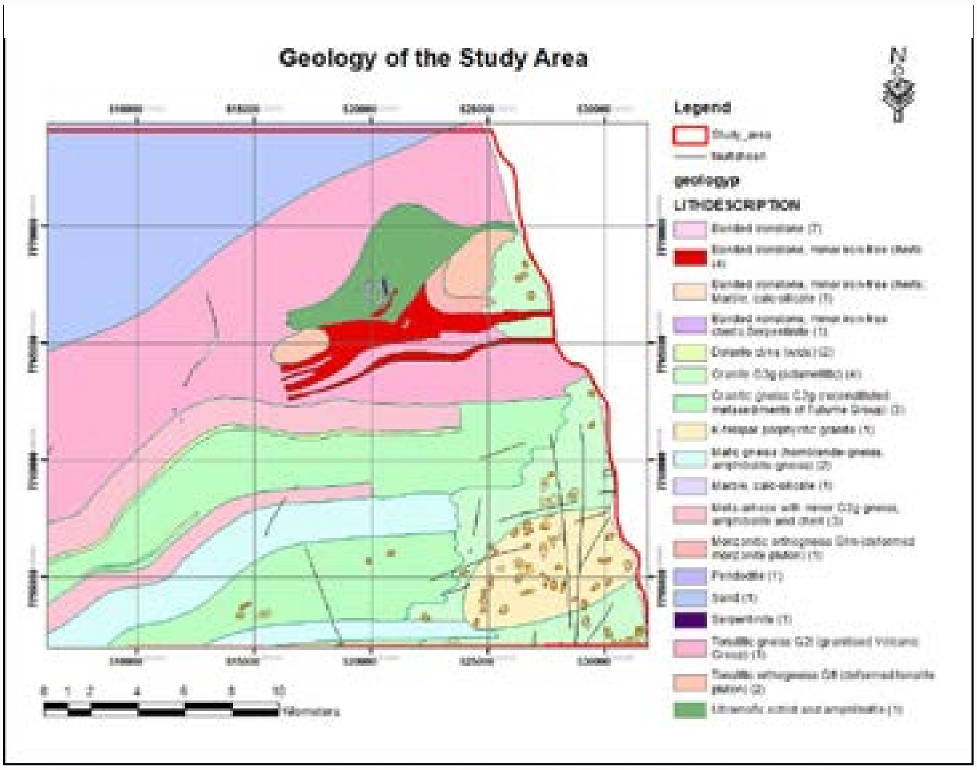

Figure 24: Local Geology around the Maitengwe Study Area

The Mazuwe Amphibolite

There are three types of amphibolites; the grey to black, granular amphibolite weakly foliated with some sparse felsic mineral probably feldspars; the gray to grayish green medium to coarse grained massive variety with quartz/ carbonate alteration; and the extensively foliated tremolite/ actinolite (ultramafic) schist.

The Sokwane Quartz - Sericite Schist

Band Ironstone outcrops show Interbanded quartzite with siliceous banded ironstone. The outcrop exhibits numerous fractures infilled by quartz veinlets and enriched iron oxides (hematite and magnetite). Drill hole intersected quartz sericite schist dipping to the north at a very high angles (Chatupa, 2000) see the figure 24.

A number of studies have been done and the results show that previous work was not detailed as only few boreholes were drilled to the maximum depth of 200m. The boreholes were terminated within the hydrothermally altered lithological units showing both proximal and distal alteration mineral assemblages. The geochemistry survey line spacing was very large as it was 500m apart.

The results from geochemical analysis indicate that only a few trace elements were analyzed, therefore it became more important to analyze more trace element as their association can be used as pathfinders. Previous geochemistry analysis show presence of both gold and copper mineralization (Chatupa, 2000).

The mineralization is controlled by structures like shear zones, faults and lithological contacts but from the previous work there was no structural interpretation conducted in this area.

From the work done in this area, it has been established that, the Arhean Greenstone Belts mostly consisting of felsic intrusions (quartz feldspar porphyry) are possible gold bearing rocks the main source being hydrothermal fluids. Further investigations should focus on:

- High strain deformation zones; generally major breaks of 100 km's
- in length and several km's in width, simple shear zones which are conduits for Au-bearing fluids.
- Smaller scale splay faults; generally oblique (low angle), dilational zones of enhanced permeability which occur within and outside major deformation zones.
- Lithological contacts which are conduits for gold bearing fluids.

Economic Potential of Magondi Orogenic Belt in Botswana

The Magondi Supergroup is mainly metasedimentary succession with minor mafic and intermediate to felsic metavolcanics which is found in the early Proterozoic Magondi Mobile Belt of Western Zimbabwe, extending south west into Botswana. It is subdivided into the Dewaras, Lomagondi and Priwiri groups, which were deposited between 2.1 02.0 Ga.

In addition to the above, lithologies of the Dete-Kamativi Inliers of North West Zimbabwe are aslo part of the Magondi super group. The Magondi Supergroup was deformed into a thin and thick-skinned fold thrust belt and metarmophosed from greenschist to granulite facies during the C2.0-1.8 Ga, Magondi Orogeny, and was also affected by the irumide and Pan African Zambezi orogenisis. The Deweras group unconformably overlies the granite green-greenstone terrane of the archaen Zimbabwean craton. The Deweras group is inturn unconformably overlain by the Lomagondi group.

The Magondi Belt has proved to be highly economically important in Zimbabwe. There is evidence that it extends southwards into Botswana, where it is believed to be covered by karoo sediments. Therefore there is a need to know the extent of this belt in Botswana and determine its economic importance if there is any.

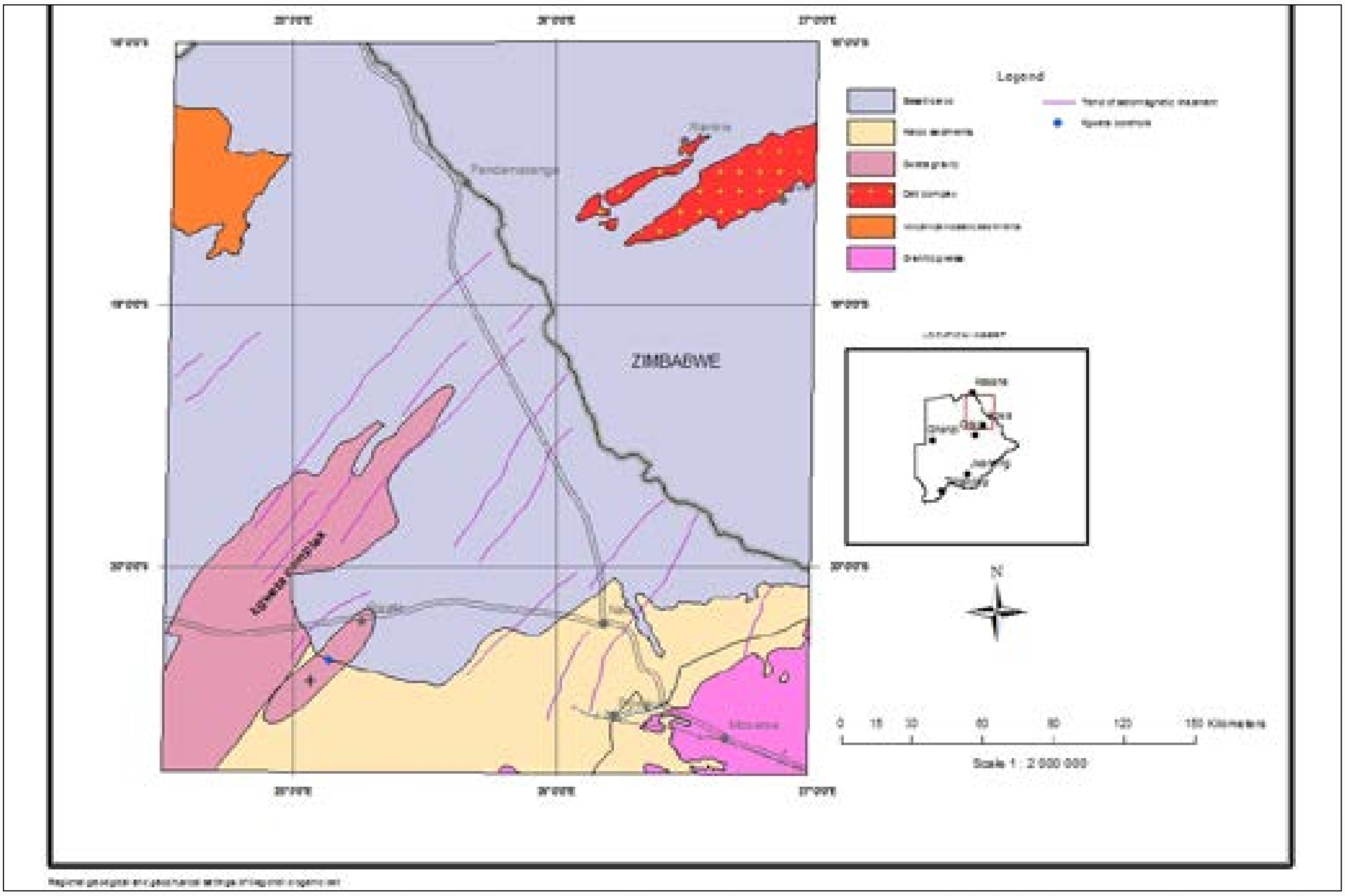

Figure 25: Regional Geology and Geophysical Setting of Magondi Oregenic belt

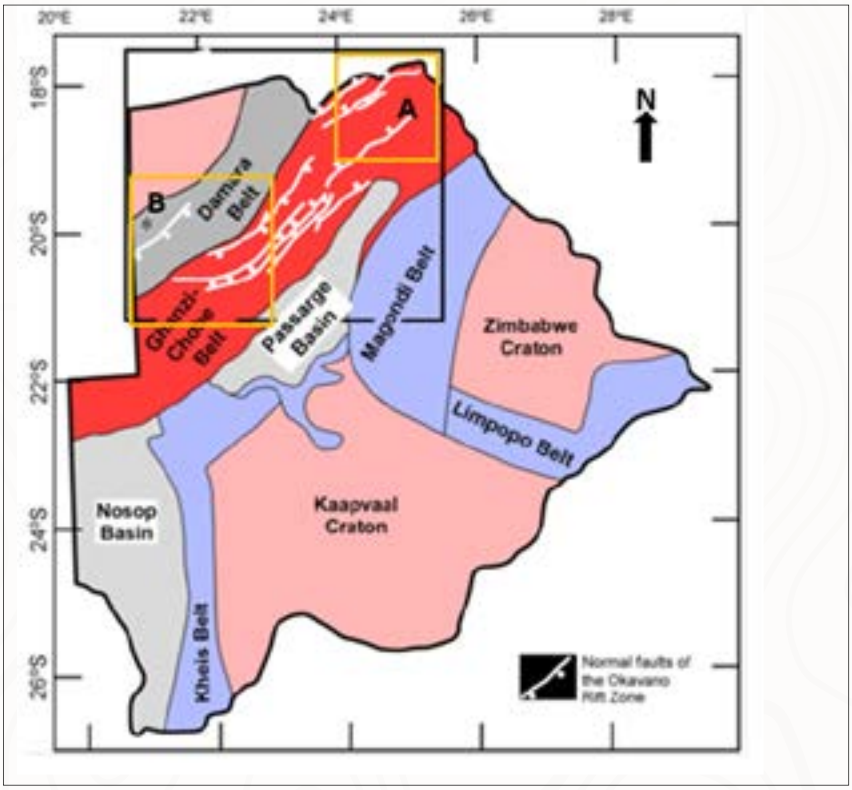

Figure 26: The spatial extent of Archean cratons and Proterozoic orogenic belt. White line represent the fault system of the Okavango Rift Zone. Modified after Singletary et al. (2003) and Begg et al. (2009)

Assessment of mineral potential of the Lesoma (ne) and Etsha-West (NW) areas.

Areas of interest in this study, fall within the Damara tectonic belt (Figure 26). The Damara tectonic belt is a complex domain of Proterozoic rocks that were deformed and metamorphosed during the Pan-African orogeny, occurring in Latest Proterozoic and earliest Phanerozoic time, between about 630 and 500 Ma (e.g. Miller 1983a).

The orogeny is interpreted by many workers as the closure of a rift, or series of rifts, which had accumulated sedimentary and volcanic rocks of the Damara Sequence (SACS 1980). Derivation of this Damara infill is primarily from an Eburnian (2000 Ma) source (Hawkesworth and others 1986).

Other components of the orogenic belt include syn- to post- Pan-African granites, and basement inliers of diverse lithology with ages ranging between 1730 and 1060 Ma (Cahen and others 1984).

The extension of the Damara Belt in Botswana contains a succession of volcanic and sedimentary rocks, metamorphites and granitoids with at least some components of the latter two consisting of Kibaran-age basement reworked during the Pan-African orogeny (Figure 26).

Mineral Accounts

Botswana is an implementing partner to the Wealth Accounting and Valuation of Ecosystem Services (WAVES) - a global partnership led by the World Bank that aims to promote sustainable development by mainstreaming natural capital in development planning and national economic accounting systems, based on the System of Environmental-Economic Accounting (SEEA). The WAVES global partnership brings together a broad coalition of governments, UN agencies, non-government organizations and academics for this purpose.

The Government of Botswana through BGI undertakes mineral accounting under this partnership National Mineral Accounting under this global partnership, carried out by the Government of Botswana (GoB) and the World Bank.

Mineral Accounts provides information on five commodities being diamonds, coal, copper-nickel, soda ash and gold.

The information from the mineral accounts is of critical importance to Botswana's economy and the national balance sheet. Mining in Botswana, continues to be the largest contributor to Gross Domestic Product (GDP), generating the majority of export earnings, and making major contribution to government fiscal revenues.

Mineral accounts are intended to ensure that appropriate decisions are taken regarding the investment of mineral revenues to provide for future economic growth. The objectives of mineral accounting are;

- Quantifying the major physical trends in resource stocks for major minerals;
- Quantifying the major monetary trends in resource stocks for major minerals;
- Estimating the rent generated by each of the major minerals;
- Producing estimates of national mineral wealth;
- Producing estimates of mineral depletion;

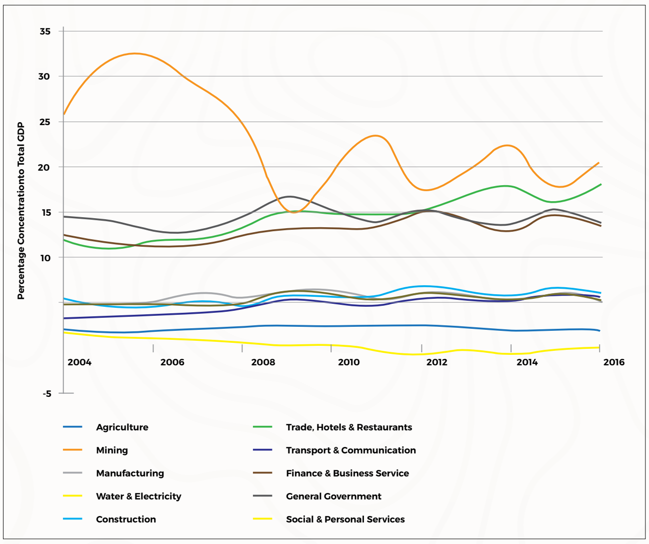

Figure 27: Contribution of Gross Value Added to GDP by kind of Economic Activity (Statistics Botswana 2017)

The mining sector has long been the dominant sector of Botswana's economy. It continues to be the largest contributor to GDP, government revenues and form majority of Botswana's export earnings. (See figure 27) The mining sector has been the second best after the general government in creation of employment (See figure below), except in 2016 where it was surpassed by manufacturing, trade hotels & restaurants, banks, insurance and business services.

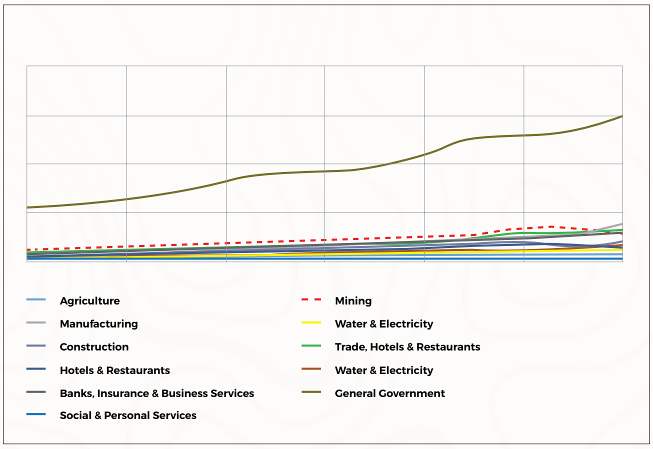

Figure 28: Compensation of Employees by Industry (Statistics Botswana (2017)

This observation can be attributed to BCL mine closure. It is therefore important to sustain the whole value chain of mining starting from exploration in order to help sustain employment.

Mineral accounts have emerged as a useful tool of measuring natural capital (Resource Value and Resource Rents). The mineral asset value is used to track its macroeconomic management to ensure long-term sustainability. Countries like Botswana, which are more contingent on mineral resources, should be on a sustainable path if the mineral asset value is converted to other forms such as produced, human and financial capital.

Mineral accounts measures this value, addresses policy and computes the depletion component of rent that is used as an input for the calculation of the Adjusted Net National Savings (ANNS).

The depletion component of mineral consumption takes into account the lifetime of our mineral resources and the produced annual rents according to the following formula:

$$Depletion = \frac{RR}{(1+r)^n}$$

Where: RR = annual resource rent, r = chosen discount rate, and n = lifetime of mineral deposit (to exhaustion). The depletion component gets larger as the remaining lifetime of the deposit gets shorter. In aggregate, the lifespans of Botswana's mines (notably diamond mines) are relatively long, while the depletion component is relatively small see the figure below.

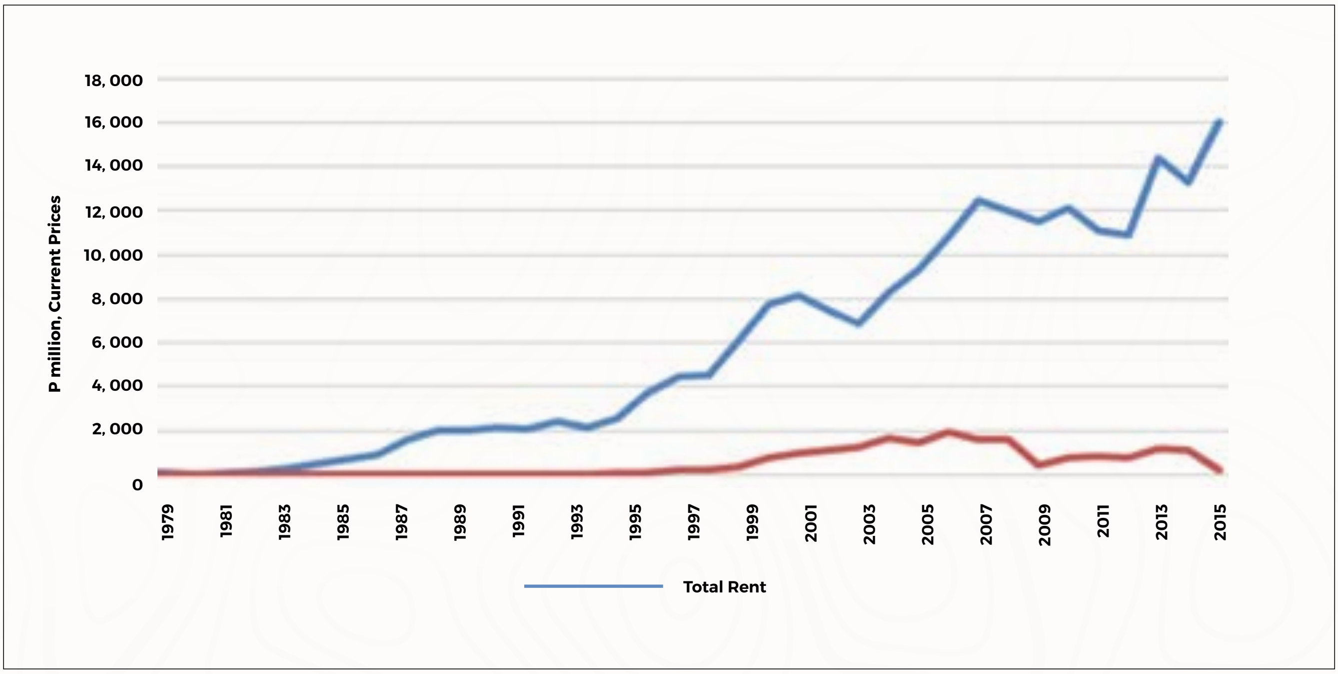

Figure 29: Depletion Components of rent (Economic Accounting of Mineral Resources 2016/17)

In line with the above mentioned, the policy recommendations for mineral resource sector development were as follows;

- A need to look beyond diamond mining alone in order to improve diversification.
- The mining sector to take advantage of growth potential in Coal and Copper - Nickel and monetize it for the benefit of the government.
- Maximize mining sector revenue from downstream activities.
- Research to unleash investment areas and appropriate decision making in mining.

For Further information , Contact

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