OVERVIEW OF ZIMBABWE'S MINERAL RESOURCE POTENTIAL – TIP OF THE ICEBERG?

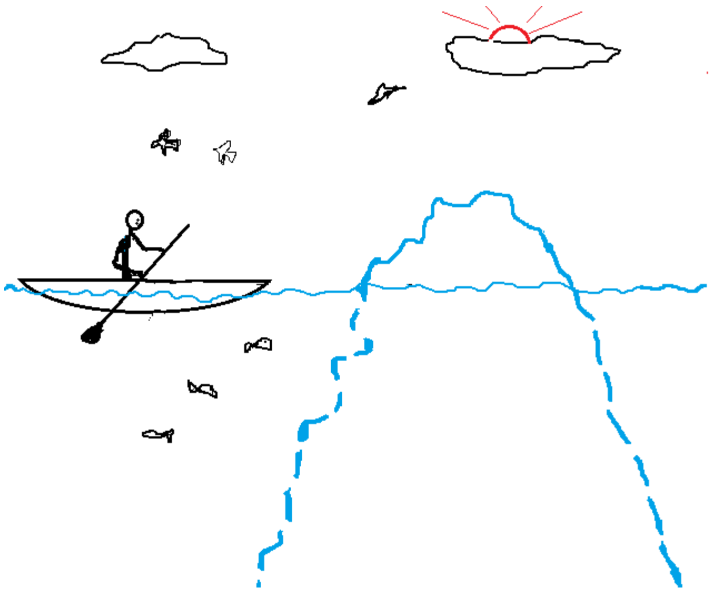
Forbes Mugumbate

Zimbabwe Geological Survey

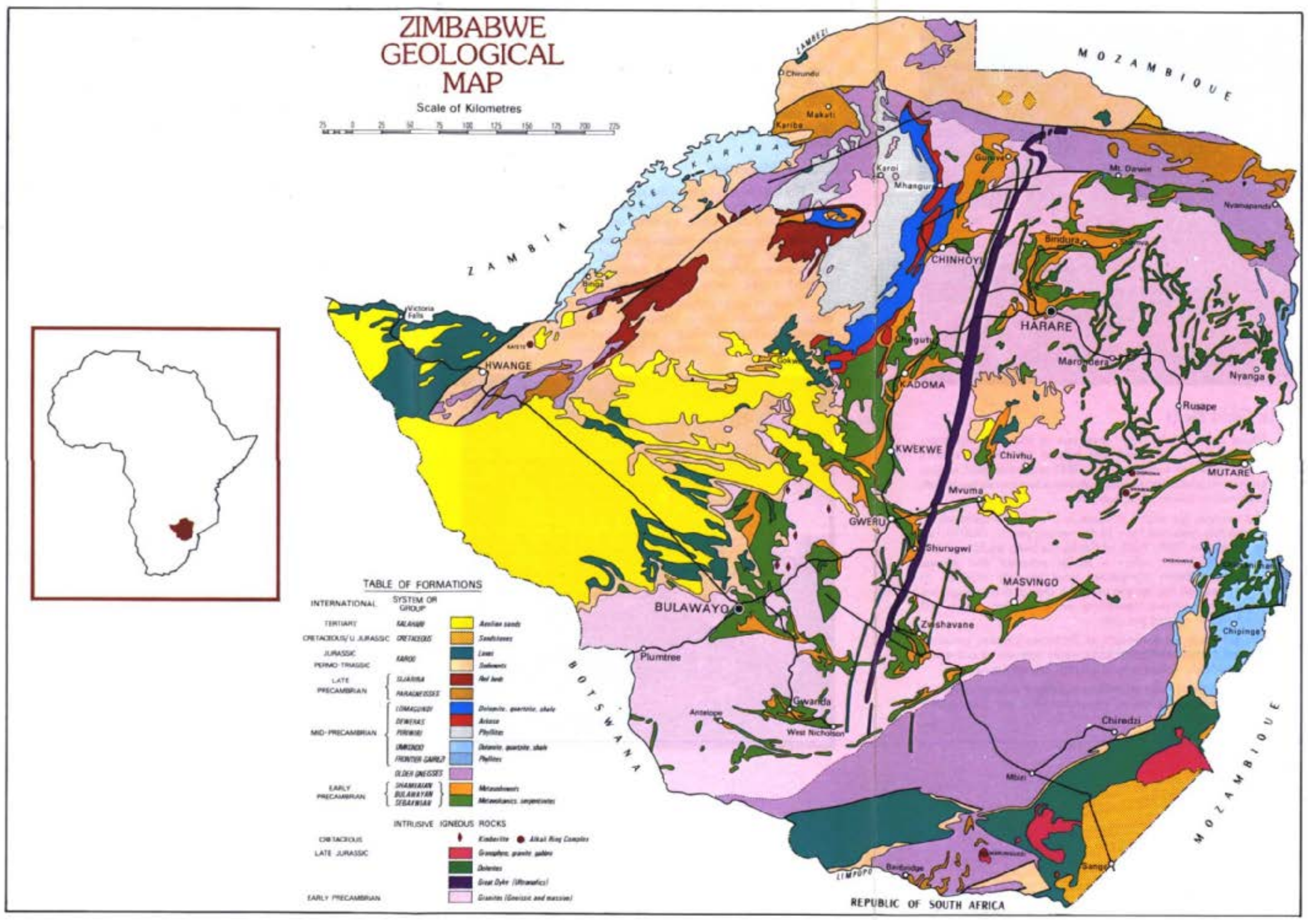
Introduction

Floating icebergs have a significant proportion of their mass below the surface of water.

This presentation to discuss how much available information tells us about state of our mineral resource – how big is the submerged portion of the iceberg?

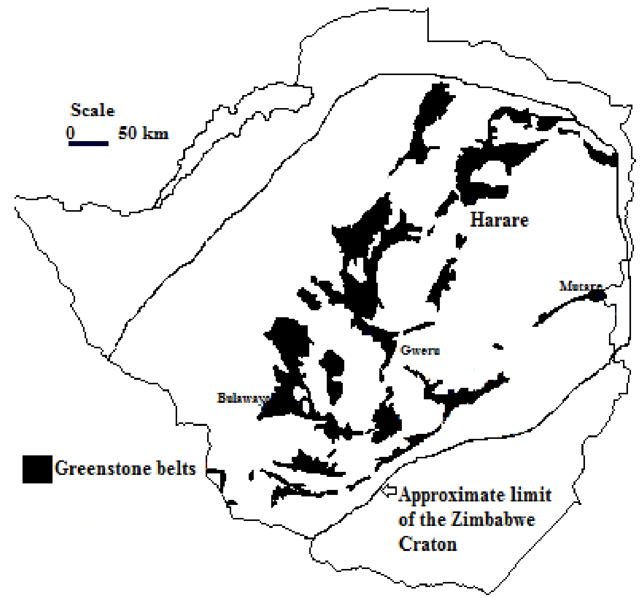


Brief Geology



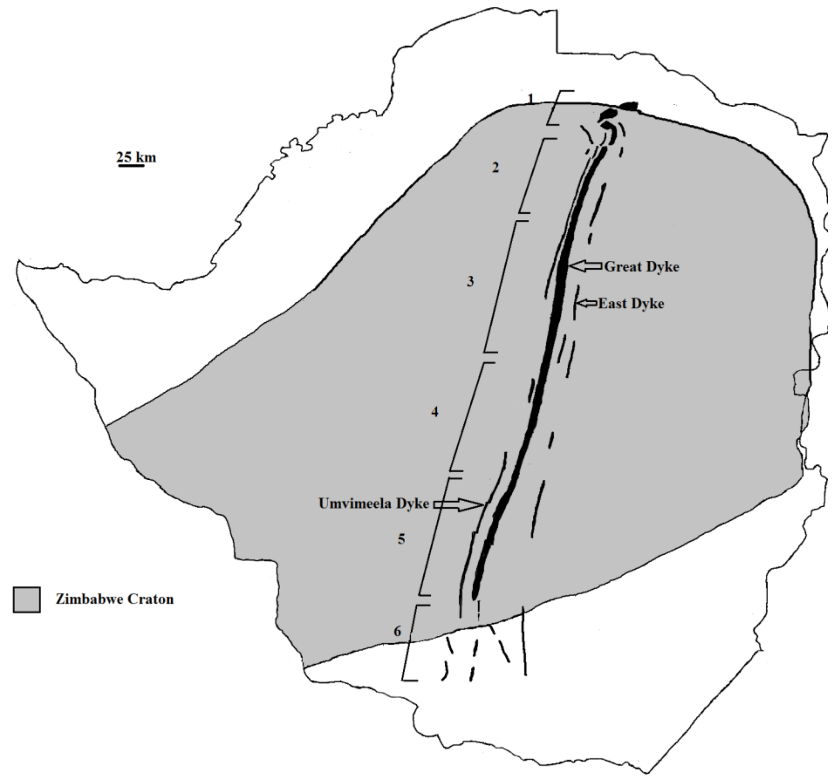
The Archaean

- The period before 2 550 million years ago. The period during which the foundations of the earth were laid down.
  - 7% of continents made up of the Archaean whereas about 60% of Zimbabwe's land surface comprises rocks of this important Era
  - granitic rocks locally enclosing remnants of volcano-sedimentary piles of Greenstone Belts.
  - Greenstone belts are renowned for their rich variety of mineral resources
    - Zimbabwe has many greenstone belts
    - Most productive in the world at 6kg Au / km2 compared to 1kg / km2 in other parts of the world



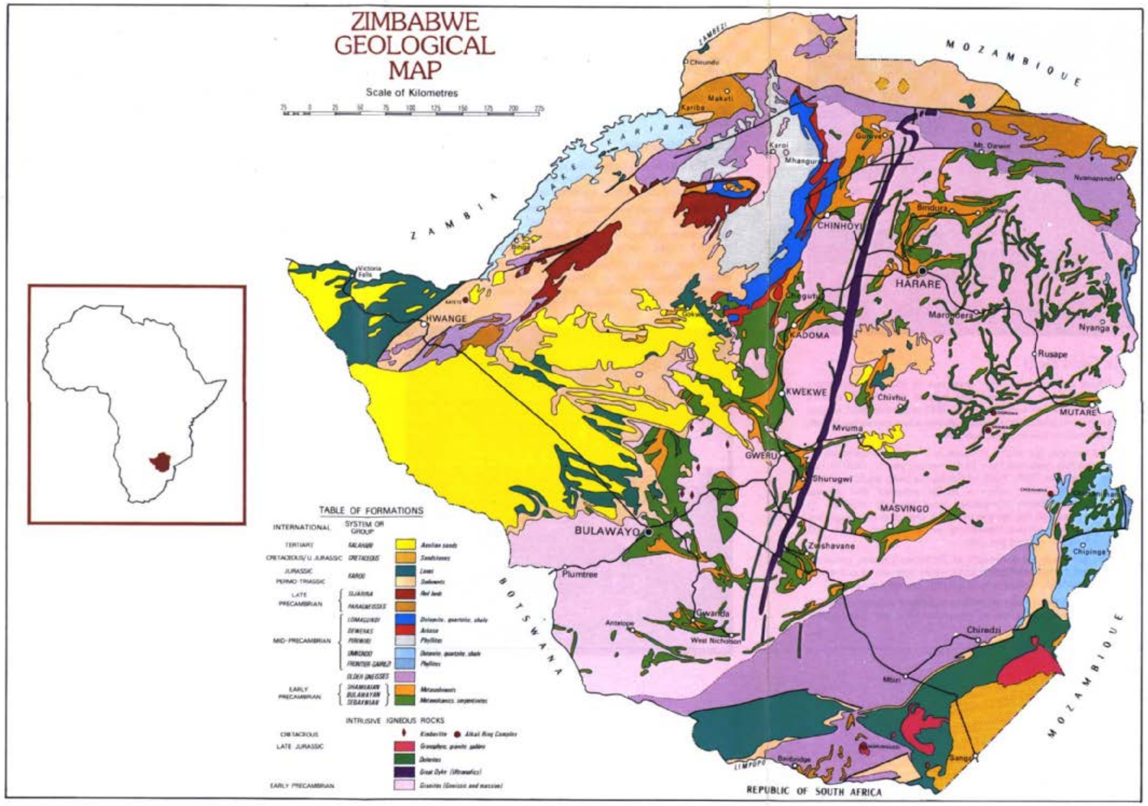
Great Dyke

- A body intruding nearly the whole N-S length of the Zimbabwe craton
- Marks the boundary between the Archaean and Proterozoic in Zimbabwe.
    - The Great Dyke hosts world-class reserves of platinum group metals and chrome ore.



Mobile belts

- Metamorphic belts surrounding the Craton:
  - the neo-Archaean Limpopo Mobile Belt to the south,
  - the palaeo-Proterozoic Magondi to the northwest, and
  - the neo-Proterozoic Zambezi Mobile Belt to the north and northeast.

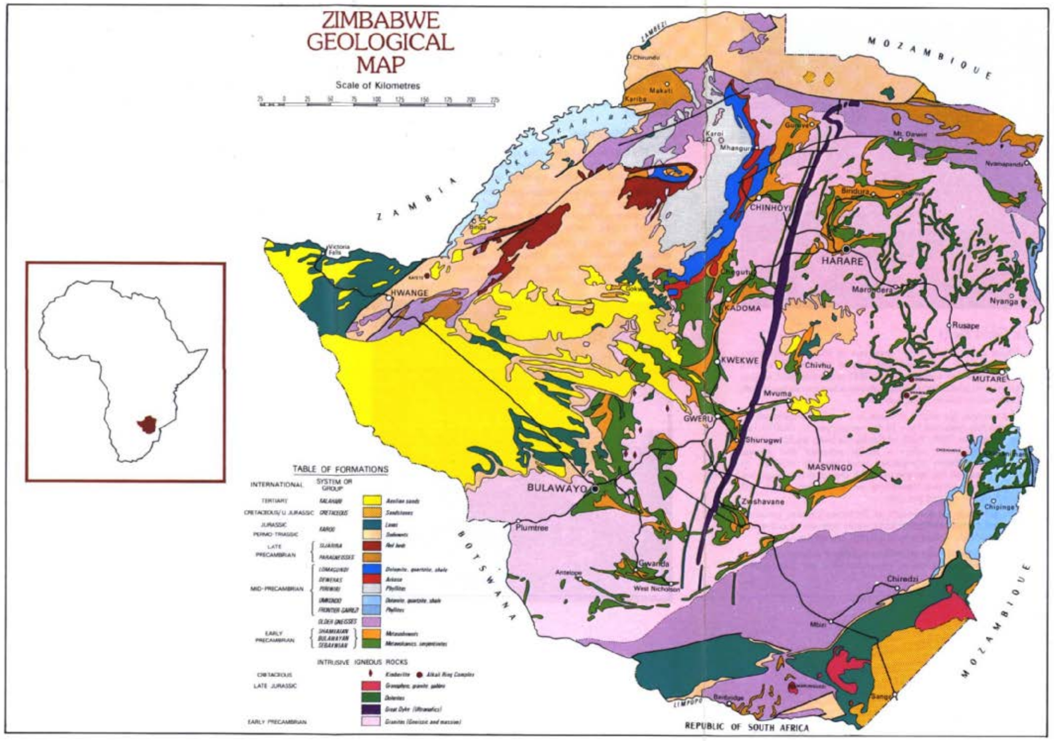


Proterozoic basins

Magondi Supergroup

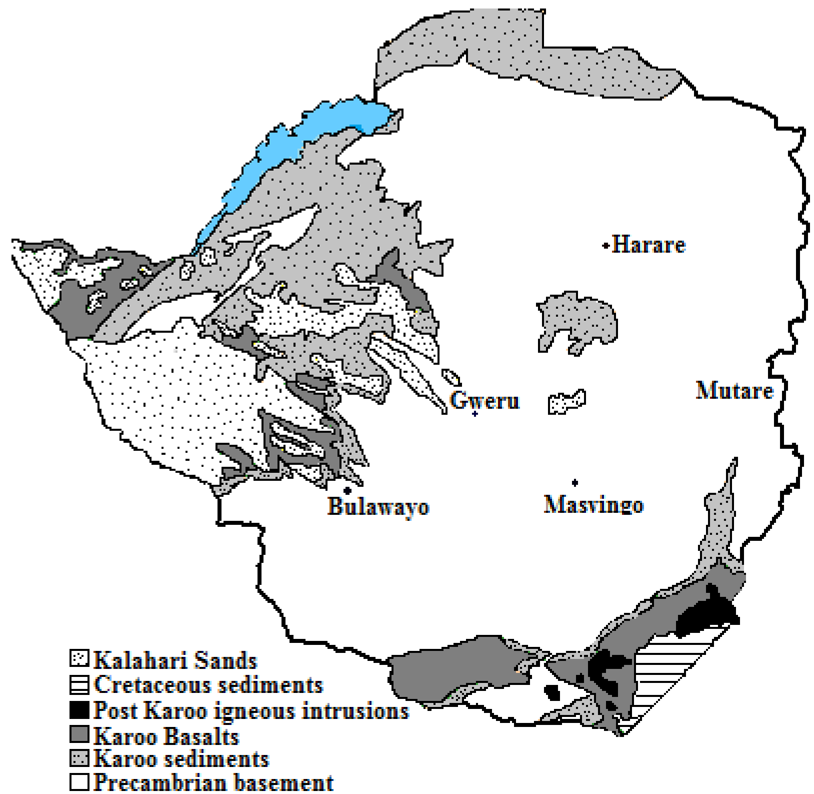
- Deweras (Cu, Au)
- Lomagundi (Cu, Mn, industrial minerals)
- Piriwiri (Au, Cu)

Umkondo Group (Cu, Au, Diamonds)



Karoo

- the Permian-Triassic-Jurassic sedimentary and basaltic rocks of the Karoo Supergroup
    - Huge resources of good quality coal and CBM



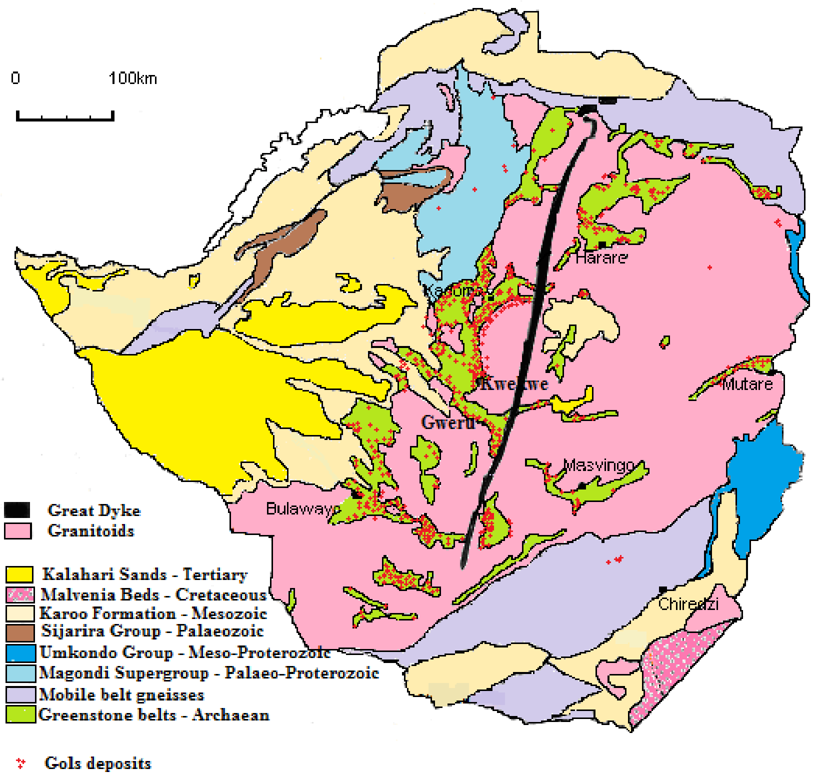
Outline of potential of major minerals

Gold

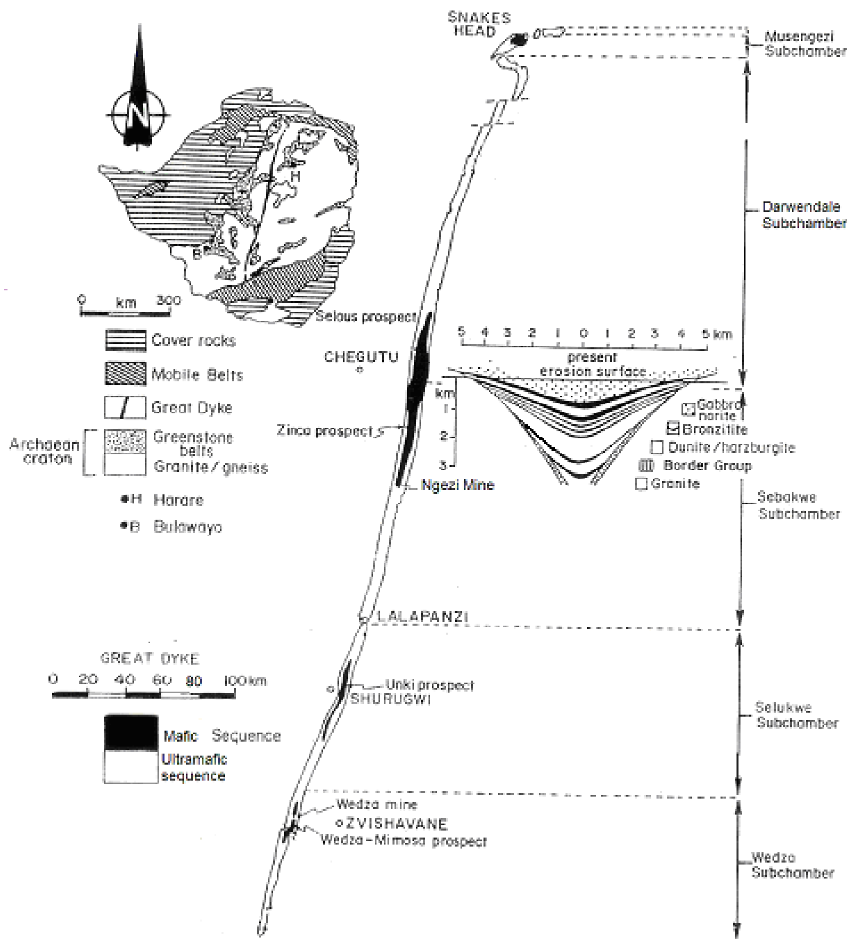
- >**6** 000 prospects recorded.
- Systematic mining ceased in the 1930's at most deposits
- >30 deposits produced >10t gold each
- >900 deposits produced >100kg each
- Highest production recorded 28.84t (1918)

- >90% deposits occur associated with Archaean greenstone belts and surrounding granitoids
    - Richest greenstone belts in the world

- Gold in the LMB
    - Renco-Ngundu area
- Gold in the Piriwiri –
    - D-Troop area
- Umkondo - a new gold province
    - Tarka Forest
- By-product e.g. Great Dyke
- Alluvial gold e.g. Mutare, Mazowe, Angwa, Umzingwane rivers
- Gold in dumps - >260t Au locked up in tailings (Solens Consultants, 2002)



Platinum Group Metals



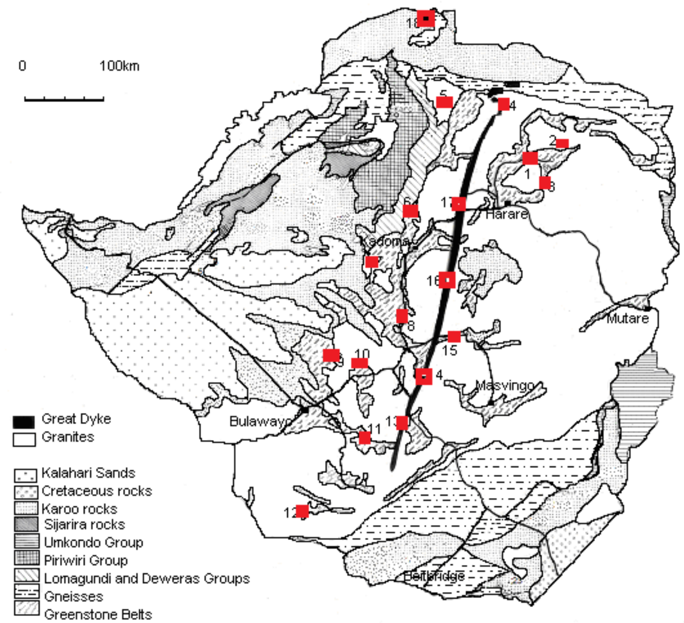
- Second largest resources in the world in the Main Sulphide Zone
  - Where the stratigraphy is capped by gabbro/norite
- Grade and thickness of ore body persist over large areas.
- Large resources locked up in oxidized parts of the MSZ
- Lower Sulphide Zone not investigated in detail.
- Potential outside the Great Dyke not investigated
  - Mhangura, Empress, other layered complexes??

Chromite

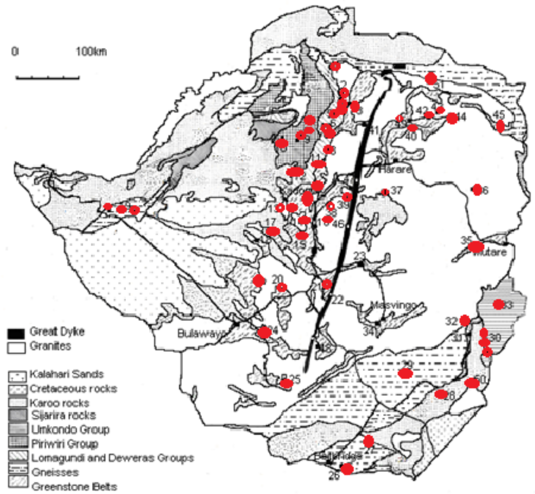
- Largest high grade chrome ore resources in the world in 11 narrow but persistent seams on the Great Dyke - > 3 billion tonnes
- Alluvial and eluvial deposits associated with the Great Dyke proving to be significant
  - Locally the concentration ranges from 3% to 35% of the soil.
- Significant resources in some Greenstone belts – Shurugwi, Belingwe, Mashava, greenstone remnants in the Great Dyke

Nickel

- The geology of Zimbabwe is highly conducive to nickel occurrences
- >30 deposits known
  - Komatiite-hosted nickel sulphides e.g. Trojan, Hunters Road, Shangani
  - Layered / Unlayered mafic intrusions e.g. Empress, Madziwa
  - Lateritic nickel deposits e.g. Horseshoe area 1 to >2% Ni over 300km2
  - Most ultramafic bodies contain high concentrations of Ni in laterites - phytomining potential?
  - Hydrothermal, shear zone deposits e.g. Noel



Copper



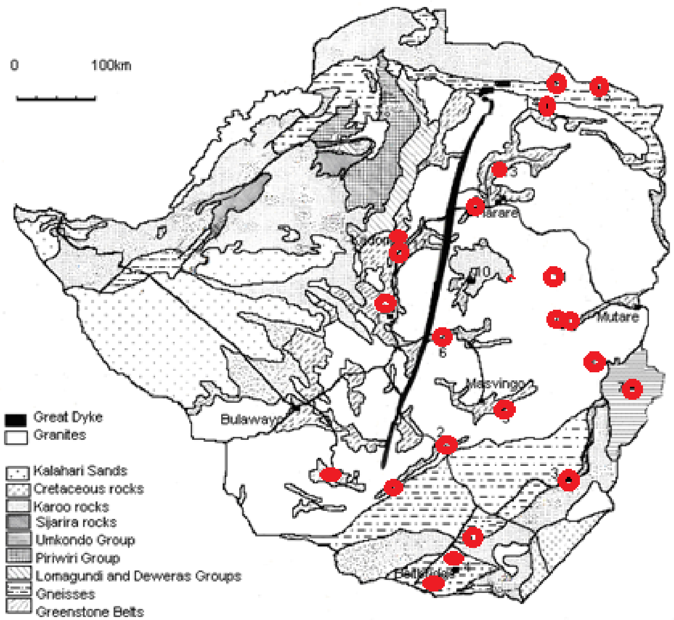
known copper provinces

- Deweras Group
  - finely disseminated bornite and chalcopyrite in arkosic sandstone in a zone stretching for over 150 km on the edge of the Magondi Basin, e.g. Mhangura, Shamrocke
- Piriwiri Group
  - the lead-copper-zinc deposits at Copper Queen and Copper King mines
  - 60km long Piriwiri Mineral Belt e.g. Gondia, Crescent, Northern Star, Montana and Wealth
- Piriwiri Group
  - e.g. Umkondo Mine.
- post-Karoo igneous complexes
  - copper-tungsten-molybdenum-gold, e.g. Hippo, P & O, Buona Fortuna and Mapani.
- Hydrothermal deposits
  - Considerable amount of copper produced from vein-type deposits, e.g. Inyati, Copper Duke

Copper

- Why is there no mining of copper despite the existence of so many deposits that have previously produced?
  - many of the smaller deposits were closed down in the 1970’s most likely as a result of the deteriorating security situation during the war of liberation.
  - Only the bigger deposits with robust infrastructure continued to operate
  - base metals need processing plants such as smelters and refineries = large capital inputs.
  - Thus many copper deposits have remained unexploited as they are too small to have own processing plants.
  - But why not exploit our experience in small-scale gold mining to exploit small copper deposits?
    - centralised facilities for processing the ore and concentrates,
    - Copper deposits generally clustered e.g. Mutandahwe, hydrothermal deposits around Kadoma

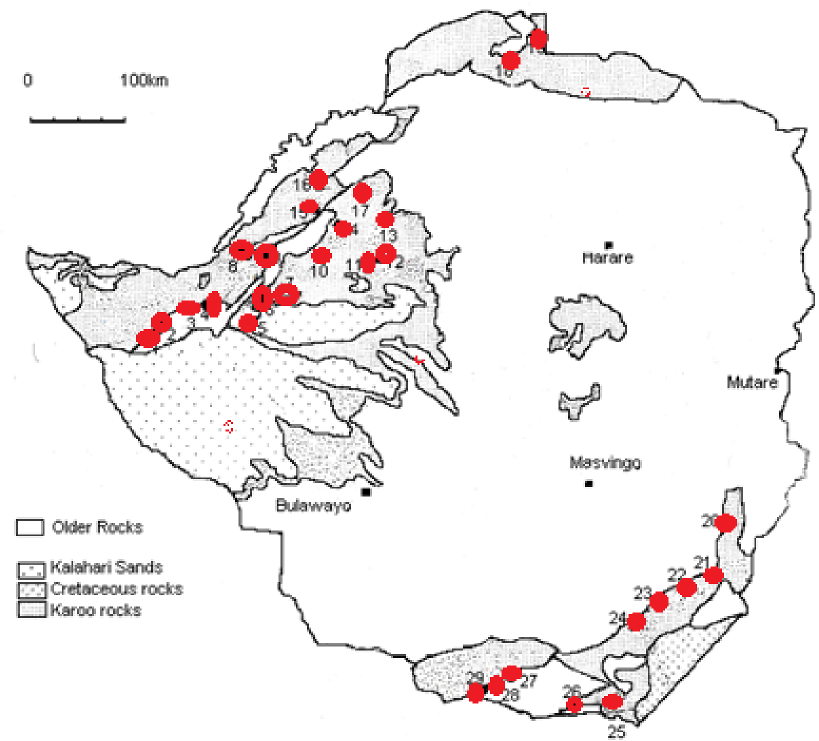
Iron ore



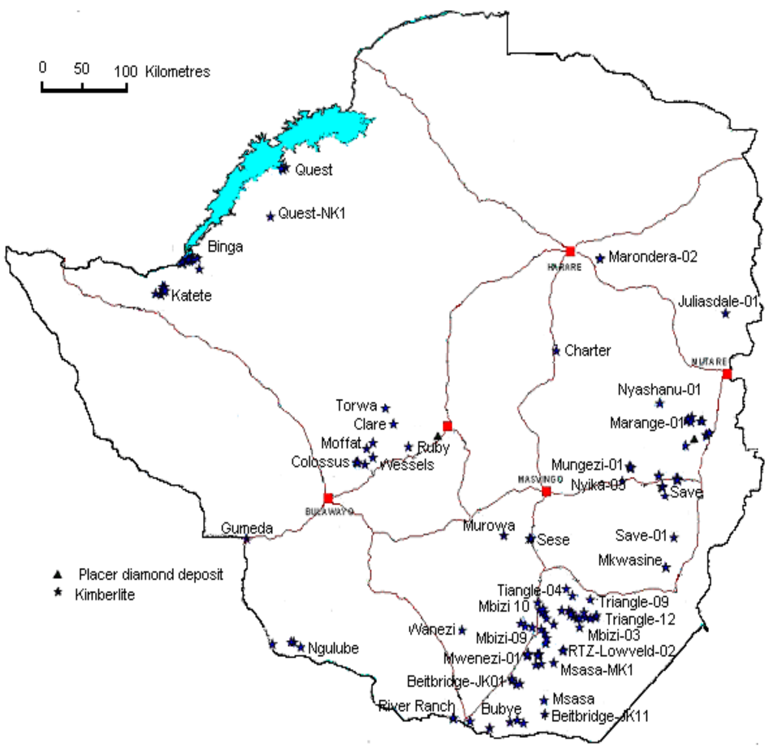
- Huge deposits associated with banded ironstone formations - >30 billion tonnes
  - Although much not DSO, the vast stretches of BIF contain on average 35-40% Fe. These may, with advance of technology, become important ore reserves.
- Other significant deposits
  - Iron Formations in the Limpopo Mobile Belt e.g Mongula and Manyoka
  - Magnetite deposits associated with carbonatites e.g. Gungwa
  - Vanadium-magnetite horizons in some layered igneous complexes, e.g. Chuatsa
  - Magnetite horizons in the Umkondo sediments

Coal and CBM

- >25 billion tonnes coal resources in Lower Karoo of the mid Zambezi Basin and the Save-Limpopo basin.
- Some areas associated with CBM
  - Conservative estimates for the Lupane area indicates gas resources far in excess of 100 000 million m^3.

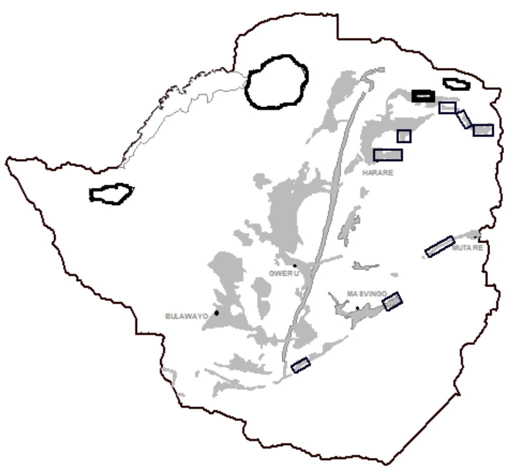


Diamonds



- Economic kimberlites are most commonly found in ancient cratons.
- >200 kimberlites have been discovered in Zimbabwe
- Murowa and River Ranch
- Palaeo-placer deposits at Marange and Chimanimani
  - extent of mineralization not elucidated.

Pegmatite minerals



- Economic pegmatites in Zimbabwe generally classified into greenstone belt and metamorphic belt pegmatites
- Sources of Ta, Nb, Sn, Li, Cs, Be, W, gemstones
- World-class pegmatite deposits at Bikita, Kamativi, Sandawana, Beryl Rose, Benson and Bepe
- With a reserve of 12 million tonnes, Bikita is the largest petalite deposit in the world. Also world's largest caesium deposit.
- The poorly explored Sandawana pegmatite field covers >100km2 of emerald and Ta rich aplites and pegmatites
- Beryl Rose contains over 100 Sn-Ta-Be pegmatites over a stretch of 24km

Possible nature of the submerged portion of the ‘iceberg’

Resources / Reserves

- The country’s laws do not compel companies to delineate certain resources before mining
  - resources at many mineral deposits are not known.
  - Majority of mines operate at zero reserves or usually only calculate reserves a few months ahead of production.
  - Small-scale producers who dominate the industry do not have capacity to delineate reserves.
  - However many mines have been intermittently worked for nearly 100 years on this basis without being exhausted. This suggests that there are substantial mineral resources at many deposits, most of which have only been sporadically worked.

Political and economic challenges

- Different political situations at various stages of the development of the country have hindered modern and comprehensive exploration.
  - International sanctions before independence
  - 1970s mining companies drastically reduced exploration efforts as a result of insecurity caused by the war of independence.
  - Immediately after independence, the socialist rhetoric made companies to adopt a wait and see attitude
  - New challenges of the late 1990s to present
  - Systematic green-field exploration in Zimbabwe has virtually stopped

Thus the country not adequately subjected to the usage of modern technology such as high resolution geophysics and geochemistry, remote sensing, and manipulation of large datasets in Geographical Information Systems (GIS) that have contributed immensely to the discovery of mineral deposits in other countries.

Mid-1980s exploration window

- Significant systematic exploration only resumed a few years after independence when the economy was liberalized
- During this period that lasted about ten years, an influx of mining companies with requisite capital, technology and innovative ideas resulted in recognition of world-class mineral deposits
  - e.g Ayrshire, Connemara, Eureka, Giant, Freda-Rebecca, Indarama, Isabella, Pickstone, Royal Family, Turkey, and Vubachikwe, previously considered to be small deposits.
  - New discoveries were also made at Maligreen, Ipanema and Hungwe gold deposits.
  - This period also coincides with the discovery of Kanyemba uranium deposit and the commissioning of the Hartley Platinum mine.

However this positive trend took a plunge from year 2000 when the country faced new economic and political challenges

This window clearly demonstrates that given an environment that encourages exploration, this country has unlimited opportunities for mineral discoveries.

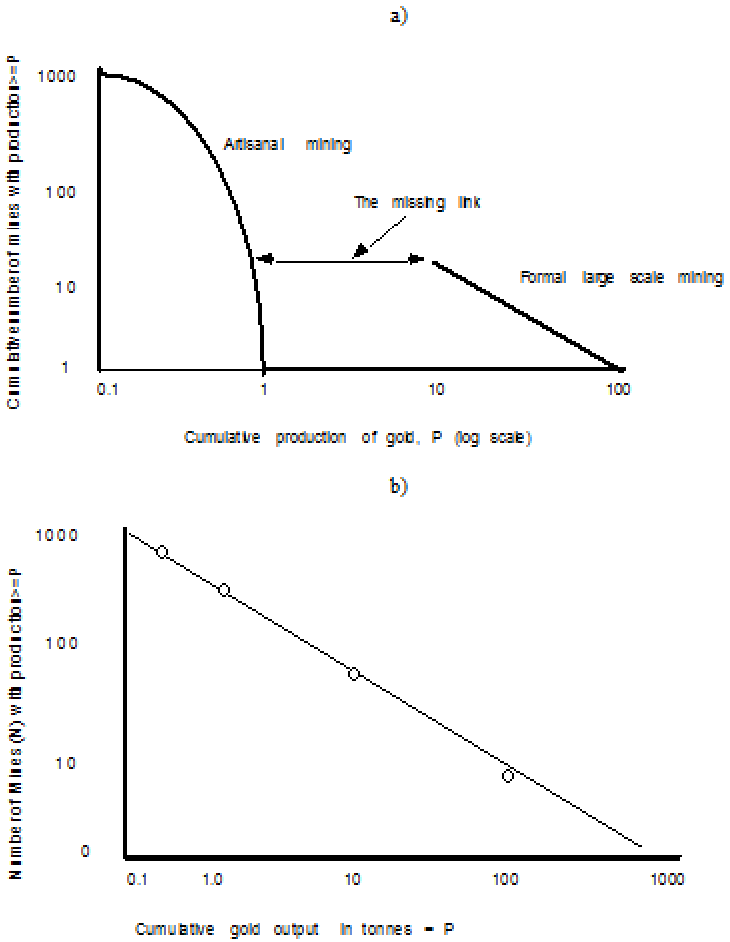
Small-scale mining areas

- Small scale mining areas often point to possible significant mineralization
- However the partitioning of ore bodies by small-scale mining claims belonging to different owners present challenges to modern scientific exploration.
- The potential of these areas remain obscured although consolidation of some of these claims has occasionally led to major mineral discoveries, e.g. the Vubachikwe deposit
- Most so-called small mines are sitting on large deposits – nearly all of Zimbabwe's large mines were initially operated as small mines
- Opportunities to re-examine the hundreds of small mines

•

Skewed structure

- The structure of the mining industry in Zimbabwe is highly skewed
- There is a gap between hundreds of small scale mines and a few large mines.
- The apparent missing link bridging the two groups simply indicates that there are many small mines with potential to develop into medium and large-scale.
- Small-scale mines need assistance and investment to unlock potential



“The person claiming that no further attention is to be paid to old mines and their surroundings is guilty of misinformation” (Martin, 1975).

Abandoned workings

- There are hundreds of abandoned mines majority of them last worked in the 1930s, with only a few having been mined to significant depths
- Most of these have never been scientifically investigated.
- Technical data on many of these dormant workings is clearly suggestive of the need for further investigations
- Thus with hundreds of old mines dotted across the country, opportunities for re-discovering some of them as large deposits are enormous

For every ore body that outcrops, there will be many that do not

Buried ore bodies

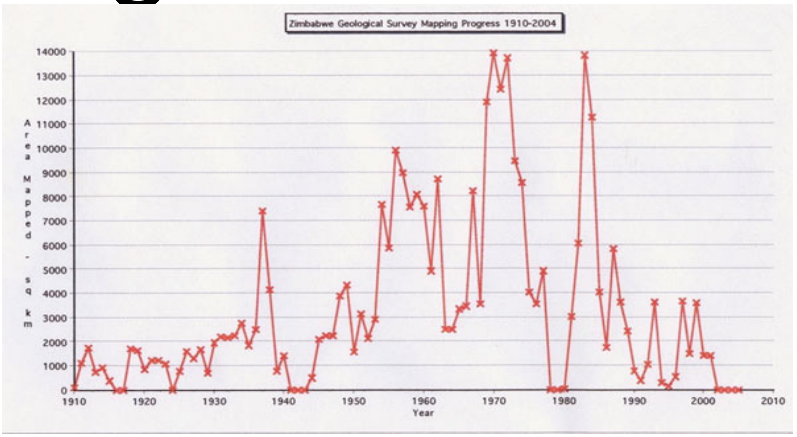
- The Ancients were efficient at searching for outcropping ore bodies.
- Exploration in the last 100 years has been mostly biased at rediscovering the Ancients' mines
- Buried ore bodies are likely to be under cultivated areas. The ore bodies in these environments are expected to be in the form of shear zones mineralised with sulphides and less quartz veining, and thus susceptible to deep weathering.
- High resolution geophysics and geochemistry will likely detect concealed mineralised shear zones, e.g. Maligreen.

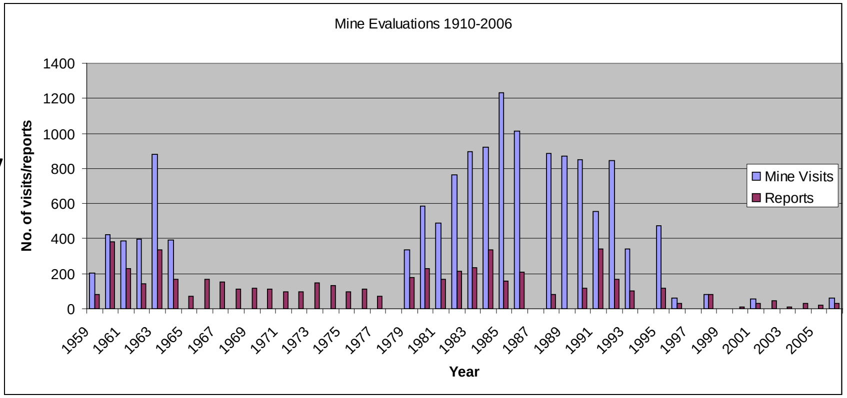
Non traditional exploration targets

- Large areas that traditionally have not been considered for mineral exploration simply because they do not have a glaring history of mining are proving to be valuable. These include:
  - Minor greenstone belts such as Mount Darwin (Ruia and Mukaradzi), Dindi (Ball mine area), Makaha (Chipenguli Hill), Mutare-Odzi (Penhalonga), Beatrice (Beatrice-Roma) , Felixburg and Lower Gwanda (Antelope and Legion areas)
  - Limpopo Mobile Zone (Ngundu area)
  - Umkondo basins (Tarka Forest gold, Marange and Chimanimani placer diamonds)
  - Granite terrains (Inyati mine)

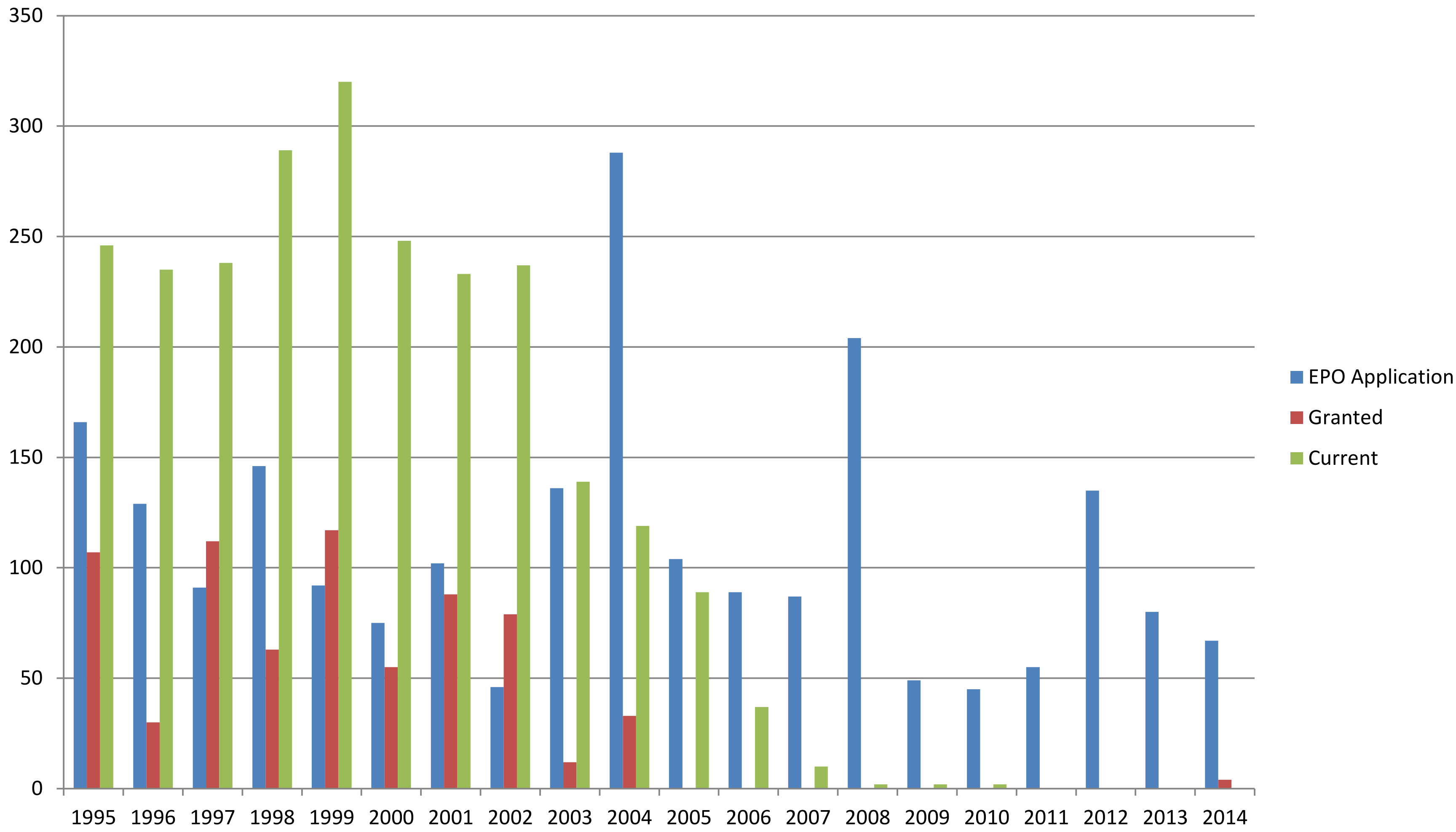
Declining geo-data generation

- Mineral occurrences are revealed through systematic exploration and regional geological mapping
- Production of new geological information has drastically declined
- much of the country was mapped more than 40 years ago before advent of modern mapping technology and deep understanding of geological structures and processes
- Also, although there have been a lot of new mineral discoveries, many of these have not been systematically described and recorded by the Geological Survey
- Thus the geological potential of Zimbabwe remains largely unrealized





Declining Exploration



“….geological phenomena have no respect for political boundaries….”

Geological Extrapolation and Research

- Zimbabwe has similar Archaean geology to some great mineral producers e.g. Australia and Canada.
- LIP and super continents studies are not only suggesting dichrous evolution of these geological provinces, but that some of them formed as a unit in space and time and later separated, and thus should share many similarities including mineral potential
- The Archaean crust developed as a super-continent that eventually broke into smaller cratons
  - e.g. on the basis of tectonic, age and lithostratigraphic similarities, the Zimbabwe craton and the Slave craton of Canada are projected to have been linked during the late Archaean
  - Also palaeomagnetic and age data of dykes from the Zimbabwe craton and Yilgarn craton of Australia suggest a connection between the two cratons during cratonization at 2.7-2.6 Ga to form a super-craton known as Zimgarn
  - This would in turn infer a much bigger super-craton comprising the Zimgarn and the Slave craton.

Geological evidence therefore suggests that there should be no differences in the nature and sizes of mineral deposits in Zimbabwe and these “partners”

- known mineral provinces in cratons with which the Zimbabwe craton formed super-cratons before the break could therefore be sought for in the Zimbabwe craton
  - e.g. Tropicana gold deposit on the periphery of the Yilgarn craton in Western Australia mirrors the Renco Mine in Zimbabwe in that both deposits occur within 15km of the edge of an Archaean craton in Archaean granulites
  - Similarity in age, tectonic settings, and petrogenesis to the komatiites of the Yilgarn craton suggests an enhanced prospectivity for magmatic nickel sulfide deposits associated to komatiitic sequences in the Zimbabwe craton
    - So conceptual targeting models for Yilgarn's nickel sulfide deposits can be adopted for Zimbabwe

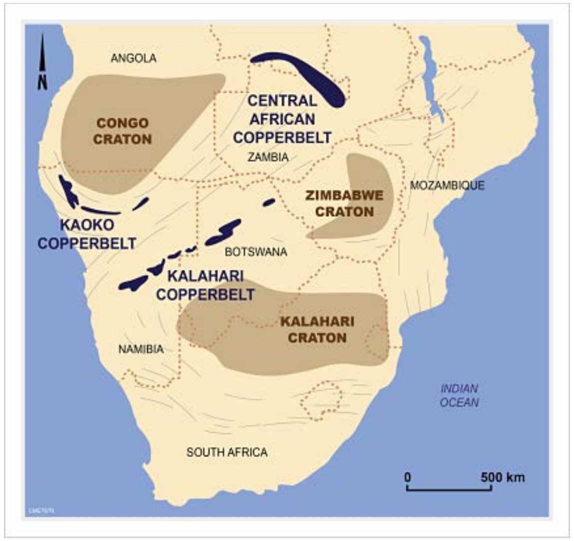
Uncovering Proterozoic mineral wealth!!

- Much of Zimbabwe's mineral wealth comes from the Archaean yet most of the giant mineral deposits elsewhere come from the Proterozoic
- Giant mineral deposits were likely formed by geological processes at orogenic boundaries such as the late Proterozoic Pan African along which the Gondwana amalgamated
- A study of African metallogenesis showed that >30% of minerals occur in the Pan African
- Despite this, historical EPO maps show that the Zambezi belt has been little explored

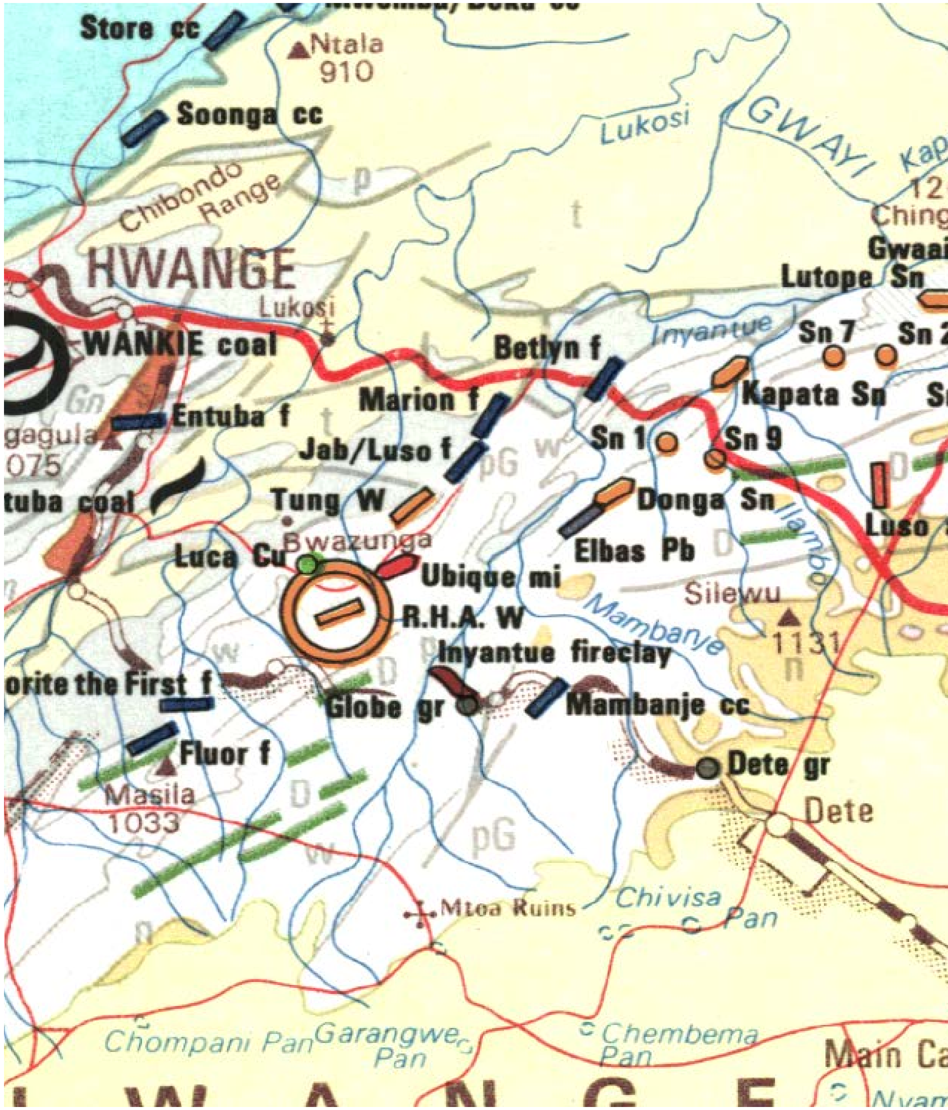
Does the Kalahari Mineral belt extend into Zimbabwe??

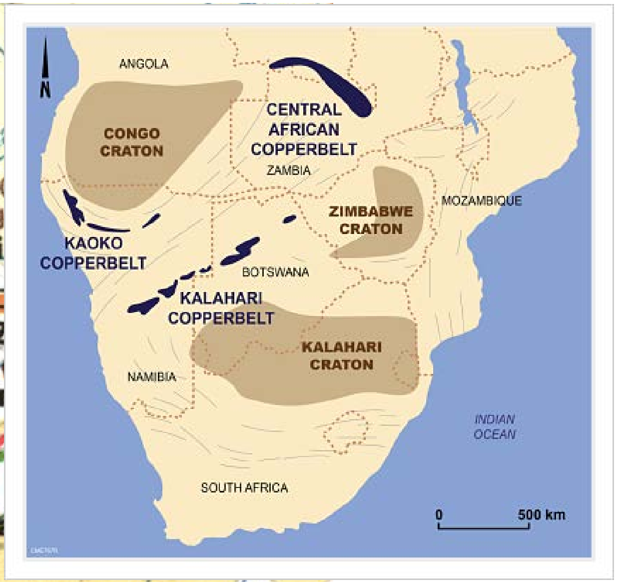
Kalahari Copperbelt

- A mineral belt recently defined as stretching discontinuously for 800km from central Namibia into northwestern Botswana
- reputed to contain some of Southern Africa's richest copper deposits.
- similar age to, and has similar styles of copper mineralisation as the famous Central African Copperbelt
- The Klein Aub underground mine operated between 1966 and 1987, producing around 5.5 million tonnes at 2% Cu and 50 g/t Ag.



Can the Kalahari belt be projected into Zimbabwe?

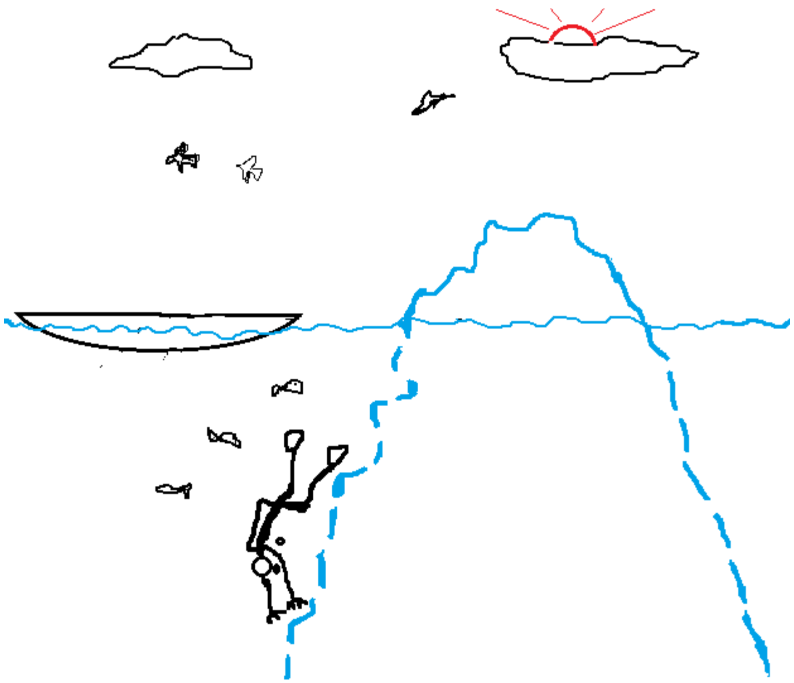




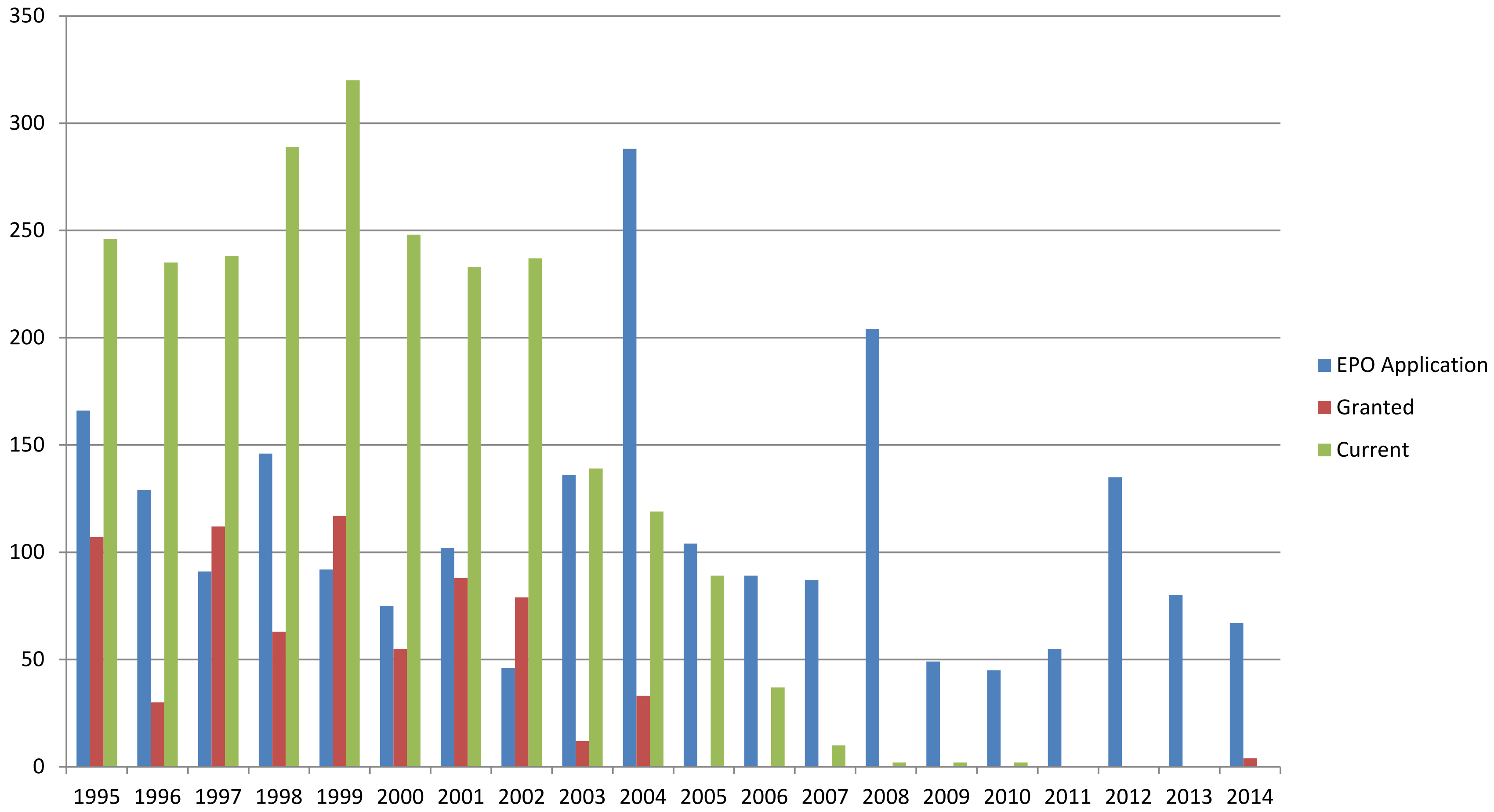
Concluding Remarks

- Just like the tip of the iceberg, Zimbabwe’s known mineral resources are therefore undisputedly representing a tiny part of the possible resource.
- That the country remains under-explored despite the overwhelming mineral potential has more to do with policy issues than geological limitations.

In the same way appreciation of the full size of an iceberg can only be achieved by probing the protruding tip below the surface of water, realization of the full mineral resource of the country will be accomplished by comprehensive exploration and research.



Systematic exploration has virtually stopped.



‘Water flows to areas of less resistance’ Ian Saunders

Policy intervention and research are necessary to promote exploration to reveal the nature of the mineral ‘iceberg’.

Thank You