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ISSN 1999-8872 • R30.00 (incl. VAT) • Vol. 3 • No. 1 • January 2010

AGGRESSIVE KIMBERLITE PROGRAMME PAYS OFF

Ngamiland exposes exciting base

Credit: Willem Smuts

metal results

Since Tsodilo Resources decided to acquire and staff-up its own drilling rig and geophysics unit in 2006, its exploration programme has grown and developed rapidly. An aggressive kimberlite exploration programme has developed into exciting base metal discoveries. ***DR WILLEM SMUTS*** visited the site in December 2009 to review developments in the field.

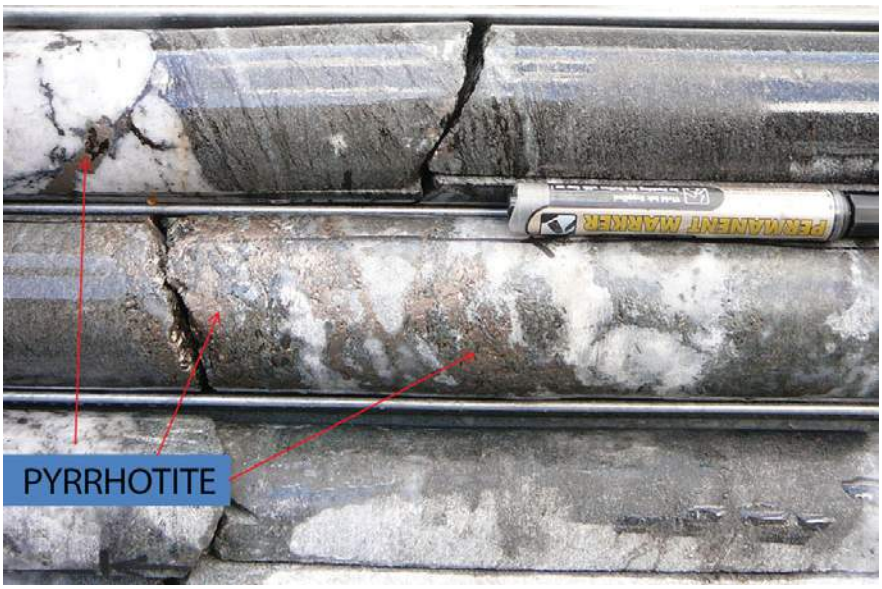
Flying over the Delta and neighbouring Ngamiland, you soon realise that it's pretty flat country out there but that you could easily get lost among ancient dunes and dense savannah scrub. For miles around, the only blip on the horizon is the Tsodilo Hills, from which the company gets its name. It is within sight of these hills that some very exciting base metal discoveries are being made under the blanket of Kalahari sand. These discoveries, albeit still at an early stage, certainly seem to be starting to rewrite the geological maps and textbooks for Southern Africa in a big way.

Regional setting

The geology in the study area is mostly unexposed with isolated outcrops, lithological information from boreholes and airborne geophysical data that have been used by previous workers to infer the geology underlying the Kalahari sediments. The main basement geological units are:

- **Phanerozoic:** The clastic (mainly sandstones) and volcanic (flood basalts) carboniferous to Jurassic Karoo sequences in the south-eastern part of the delta area.
- **Neoproterozoic:** Siliclastic and carbonate sequences of the Ghanzi Formation in the south-east and Damara rocks in the north-west.
- **Mesoproterozoic:** Metavolcanics and metarhyolites of the Kgwebe Formation in the south-east and granite-gneiss basement of the Kwando Complex in the central part. The Kwando Complex is not exposed; it is only recovered from borehole logs.
- **Palaeoproterozoic:** Granitic-gneiss basement of the Quangwadum Complex in the north-west.

The Mesoproterozoic Kgwebe

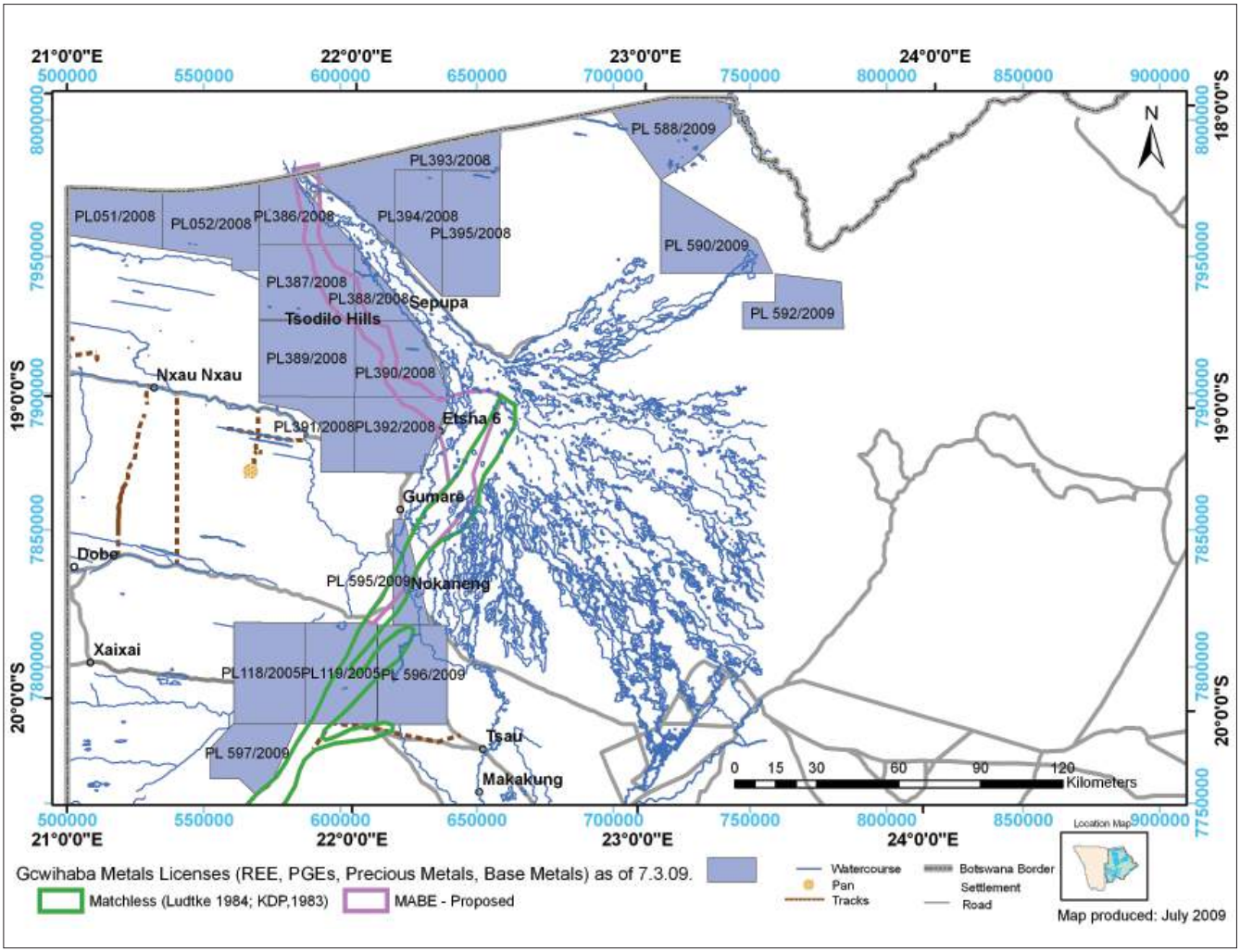


Credit: Willem Smuts

Credit: Willem Smuts

ABOVE Massive pyrrhotite associated with carbonates and quartz veining
OPPOSITE Drill crew getting ready to catch the next core-run on borehole L9680/6. Since commissioning in July 2006, the Atlas Copco CT14 mounted on an IVECO 6 x 6-truck has worked out perfectly for Tsodilo, according to James Bruchs

BELOW Gcwihaba metals licences relative to the Okavango Delta. The matchless and matchless amphibolite belt extension (MABE) as proposed by De Wit (2009) is shown



Credit: Tsodilo

Formation and the Neoproterozoic Ghanzi Formation rocks form what is known as the Ghanzi-Chobe Fold Belt in the south-eastern part of the delta, with the Kgwebe appearing at the core of the anticlines.

Targeting the Gcwihaba licences

The metals prospecting licences are located in the north-western part of Botswana and can be divided into three main areas:

- the area bordering the panhandle portion of the Okavango Delta (the panhandle prospect)
- the area south-west of the Okavango Delta (the Nokaneng prospect)
- the area northeast of the Okavango Delta (the Lenyant/Kwando prospect).

The southern part of panhandle prospect was an obvious target as the mineralisation encountered through soil sampling was significantly elevated. The northern part of the licence area was targeted purely based on the structural fabric as interpreted from the aeromagnetic data, while magnetic anomalies were targeted in the middle section.

> The Damara Belt is largely hidden beneath younger sediments in Ngamiland

The Nokaneng prospect primarily targets what is believed to be an extension of the matchless amphibolite in Namibia, which hosts significant copper mineralisation. The Lenyanti/Kwando prospect is a continuation of targeting circular magnetic intrusions in the hope that they may host mineralisation as discovered in the southern part of the panhandle prospect.

The Damara Belt is largely hidden beneath younger sediments in Ngamiland, such that knowledge of much of the geological and tectonic evolution relies on observations of the well-exposed lithological correlatives in Namibia. The Damara Belt is known as the inland branch of the Damara Orogeny in Namibia, formed during a high-angle collision of the Kalahari and Congo cratons, with the Kalahari subducting northwards below the Congo Craton. The belt is estimated to have evolved within a period spanning from 580 Ma to 505 Ma. The aeromagnetic data shows that the Damara structural trend is deflected from a northeast

BELOW Location of the drill sites on an aeromag image: The sites were placed at the edge of a highly magnetic body in the north-west part of the map
BOTTOM Location of the drill sites on a VTEM resistivity cross-section: The sites were placed approximately 1 200 m apart targeting an electrical conductor (deep blue zone). The conductor dips steeply at L9680/10 as compared to L9680/6

to a north to north-west trend in the area around the panhandle prospect. This deflection, supported by Tsodilo drill results, indicates that this area is

This area is part of the lufilian arc structure

part of the lufilian arc structure. The lufilian arc hosts the world's largest copper-nickel-cobalt deposits in both Zambia and the Democratic Republic of Congo.

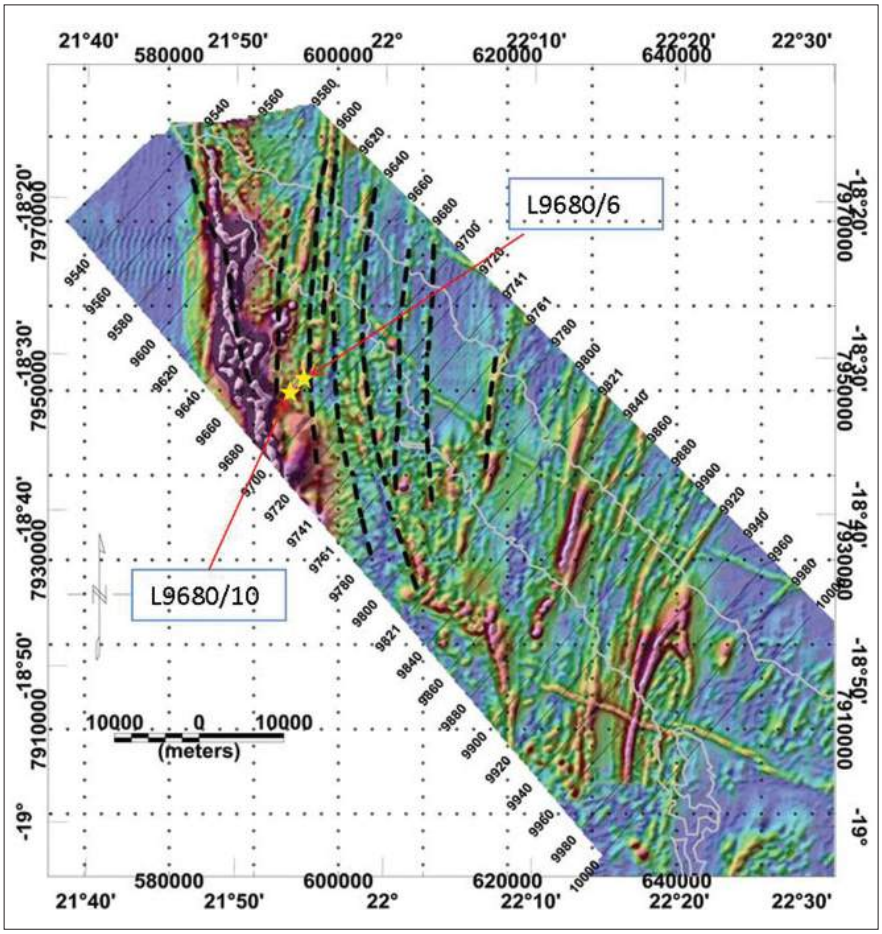
The working front

Tsodilo drilling efforts have mainly concentrated in the panhandle prospect in licence areas PL386/2008, PL387/2008, PL388/2008 and Pl390/2008. This is primarily because of the availability of the airborne time domain electromagnetic data, which is very important for locating conductive sulphide-bearing structures.

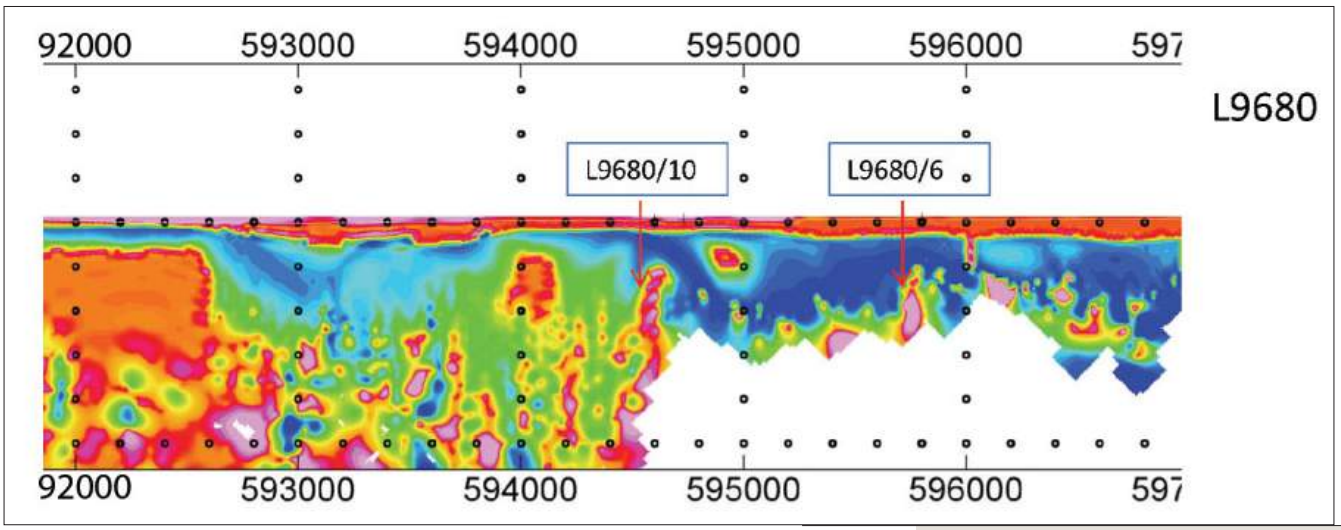
The drilling results can be summarised as follows:

- 44 holes were drilled in the metal licences since 2008
- total depth = 8 148.3 m
- 21 holes drilled in 2009, totalling 3 795 m
- target selection based on magnetic anomalies in 2008
- target selection based on the use of airborne electromagnetic and magnetic data sets in 2009
- 31 holes encountered significant sulphide mineralisation
- major sulphides: pyrite, pyrrhotite and minor chalcopyrite
- pyrite concentrated towards the southern portion of the lower panhandle prospect with lesser amounts of pyrrhotite and chalcopyrite
- pyrrhotite concentrated towards the northern portion of the lower panhandle prospect (in most holes, pyrite concentrated in top sections and pyrrhotite below).

James Bruchs, CEO and president of Tsodilo Resources, says, "We can say that the combined use of airborne electromagnetic and magnetic data sets has been very successful in



Credit: Tsodilo



Credit: Tsodilo

BELOW Drill operator Diketso Ramotswetla waiting for his crew to return to the hole

Credit: Willem Smuts

Credit: Willem Smuts

Credit: Willem Smuts

ABOVE Eddie Mostert, a Southern African drilling veteran, has been in charge of Tsodilo drilling operations since the company first decided to acquire its own rig in 2006

LEFT Prof. David Reid (UCT), James Bruchs (CEO Tsodilo Resources) and Dr Iuma Martinez (GIS consultant) comparing drill results with the GIS model in Tsodilo's well-appointed core storage at the Maun International Airport. See more details on the GIS modelling elsewhere in this issue

drilling sulphide-bearing targets."

Through the use of airborne electromagnetic data, Tsodilo has been able to delineate a belt-bearing carbonaceous black shales and meta-pelites within the Damara rocks in north-western Botswana. It is within this belt that the company encounters good sulphide mineralisation within the shales and the meta-pelites.

Drill cores inspected at Tsodilo's core shed in Maun and at the drill site

ABOUT TSODILO RESOURCES

Gcwihaba, a 100%-owned subsidiary of Tsodilo Resources (TSX-V: TXD), has been granted 18 prospecting licences for metals covering an area of some 13 400 km². The prospecting licences are located within the nascent Okavango Rift structure, which is part of the East African Rift System. The Okavango Rift System takes advantage of the pre-existing structures of the north-east trending Neo-Proterozoic Pan African Orogenic Belt, known as the Damara Belt.

The venture into metals exploration by Tsodilo came as an offshoot of kimberlite exploration in the southern part of the Panhandle Prospect in early 2008. It was by chance that sulphide mineralisation was discovered while following up on circular magnetic anomalies, which were interpreted then to be likely kimberlites. Metal prospecting licences were then applied for and subsequently granted by the Botswana government in December 2008.

Late in 2009, Tsodilo appointed Dr Michiel 'Mike' de Wit to its board of directors as a non-executive director. Dr De Wit has extensive experience in the diamond industry, having begun his career as an exploration geologist for the Geological Survey in South Africa prior to joining De Beers, for whom he worked for 29 years. Dr De Wit managed various exploration programmes for De Beers in Africa, which led to a number of kimberlite discoveries. Prior to his most recent appointment as president and CEO of BRC Diamond Corporation, he was general manager for De Beers in the Democratic Republic of the Congo (DRC), and prior to that, he was responsible for all exploration programmes for De Beers in Africa. In addition to MSc degrees in geophysics and sedimentology from the universities of Pretoria and Reading (UK), Dr De Wit holds a PhD from the University of Cape Town where he focused on the alluvial diamond distribution of western South Africa. He brings some 33 years of exploration experience to the company. Dr De Wit is currently consulting to the company, focusing on Tsodilo's current kimberlite exploration projects, identifying and evaluating new diamond properties for acquisition in Botswana, and on increasing the existing exploration efforts on the company's prospective base and precious metals projects.

Credit: Willem Smuts

Dr Mike de Wit, non-executive director of Tsodilo, at the core shed

bear strong similarities to those of the nickel-cobalt-copper deposits of the Kalumbila Project in Zambia. Here, the mineralisation is found within the pyrrhotite-pyrite-bearing carbonaceous shales. These shales have been correlated to the ore shale of the Zambian Copperbelt. The abundance of pyrrhotite in the northern part of our lower panhandle prospect is particularly promising since this sulphide mineralisation is often associated with economic nickel and cobalt deposits.

Spending the money where it matters

Tsodilo Resources is one of those exploration juniors that go quietly about their business, spending shareholders' money where it matters most – in the ground. Since commissioning a company drill rig in July 2006, Tsodilo has completed 22 000 m worth of coring.

"The Atlas Copco CT14 mounted on one of our IVECO 6 x 6s has worked out perfectly for us," says James Bruchs.

Eddie Mostert, drilling operations manager, explains, "We drill 18 hours a day, seven days a week, and we service the rig in the off-hours to ensure that it is operating at full capacity during the drilling hours. Our drill rig is one of our exploration tools, as such we are not so preoccupied by metres per day as a contractor would be. This allows us the ability to keep our machine running like new."

> These shales have been correlated to the ore shale of the Zambian Copperbelt

"We are very pleased with the operation of the CT14 and are currently looking at purchasing another or similar model," adds Bruchs. "We plan to start assaying samples in early 2010 to facilitate focused drilling. Our targets are therefore aimed at carbonaceous shales/meta-pelites and magnetic possible IOCG type deposits.

"To this end, we have an ongoing high-resolution (20 m line spacing) ground magnetic survey in our lower panhandle prospect to reveal and better resolve the basement structure as well as possible igneous intrusions. We have so far completed just over 3 170 line kilometres of magnetic data acquisition and preliminary data results indeed show that we are able to map the basement fabric and igneous intrusions better," Bruchs concludes. 3S

GIS-BASED SPATIAL SELECTION RULES AND PROXIMITY ANALYSES

Possible copperbelt in Botswana

GIS-based spatial selection rules and proximity analyses associated with base metal sulphides drilled near the xaudom group ironstone anomaly, which aim to assist exploration-drilling activities associated with possible Zambian Copperbelt-like, IOCG or other mineralisation type targets in NW Ngamiland, Botswana, have been developed by Dr Iúma Martinez for Tsodilo Resources.

One component of the base metal exploration strategy involves the development and implementation of GIS-based filtering techniques to aid the identification of the more promising base metal sulphide targets. This methodology involves the definition of spatially constrained selection rules based on proximal analyses of the current drilling results or field observations to date. While the approach draws from previous base metal exploration programme experiences, it is also both site-specific and empirical in nature.

The relationships between the distributions of base metal sulphide-rich cores drilled to date, and a range of geophysical exploration datasets, are examined and used to define a series of favourable target zones. The different zones are then considered in an integrated manner to identify the more interesting targets as suggested by anomalies in the structurally enhanced aeromagnetic data.

"Among the variables considered in the target selection filtering process are the distribution of conductors identified from VTEM data, possible faults and fault junctions, ironstone lithology and other lithology – conductor relationships," explains Dr Martinez.

Several factors suggest that the source of sulphides associated with the magnetic anomaly feature identified by the Department of the Geological Survey (DGS) of Botswana as the xaudum

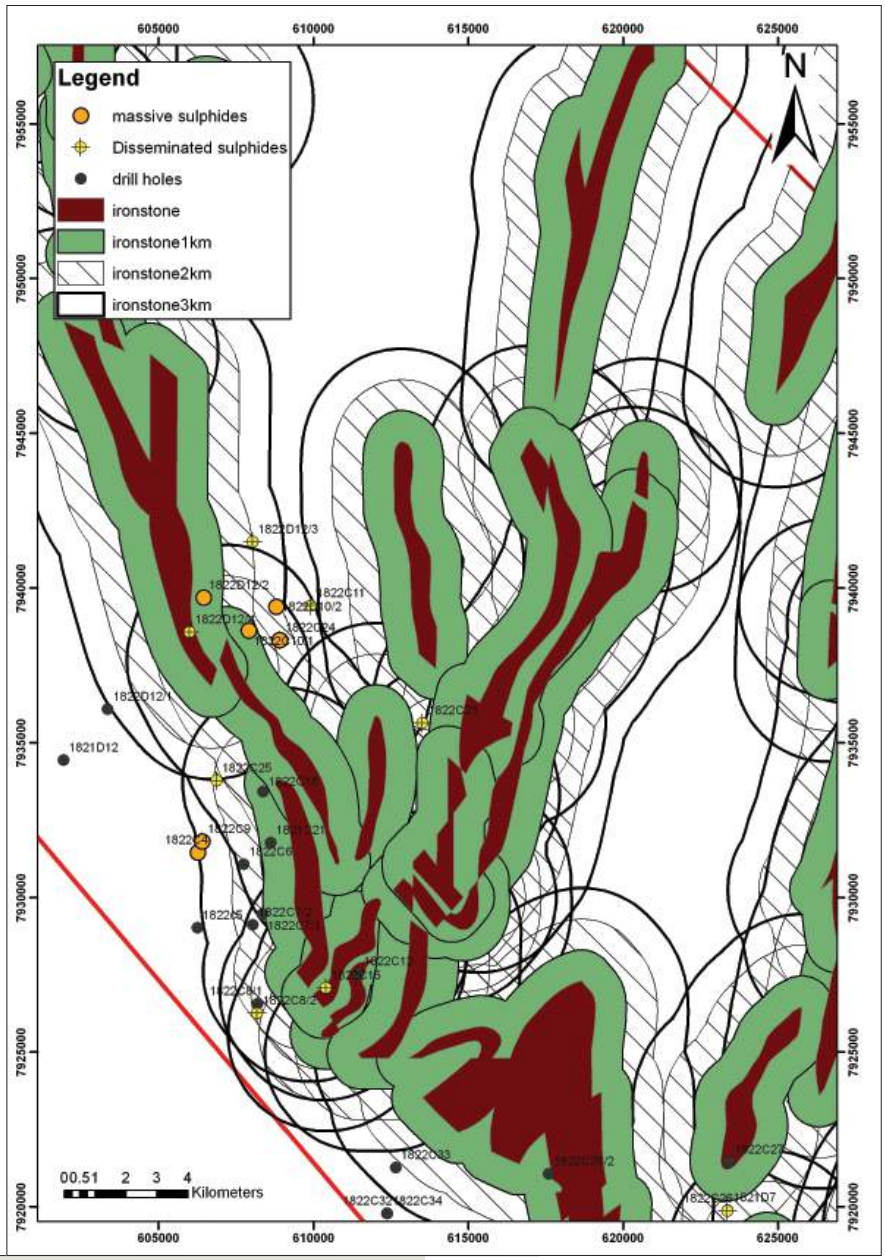
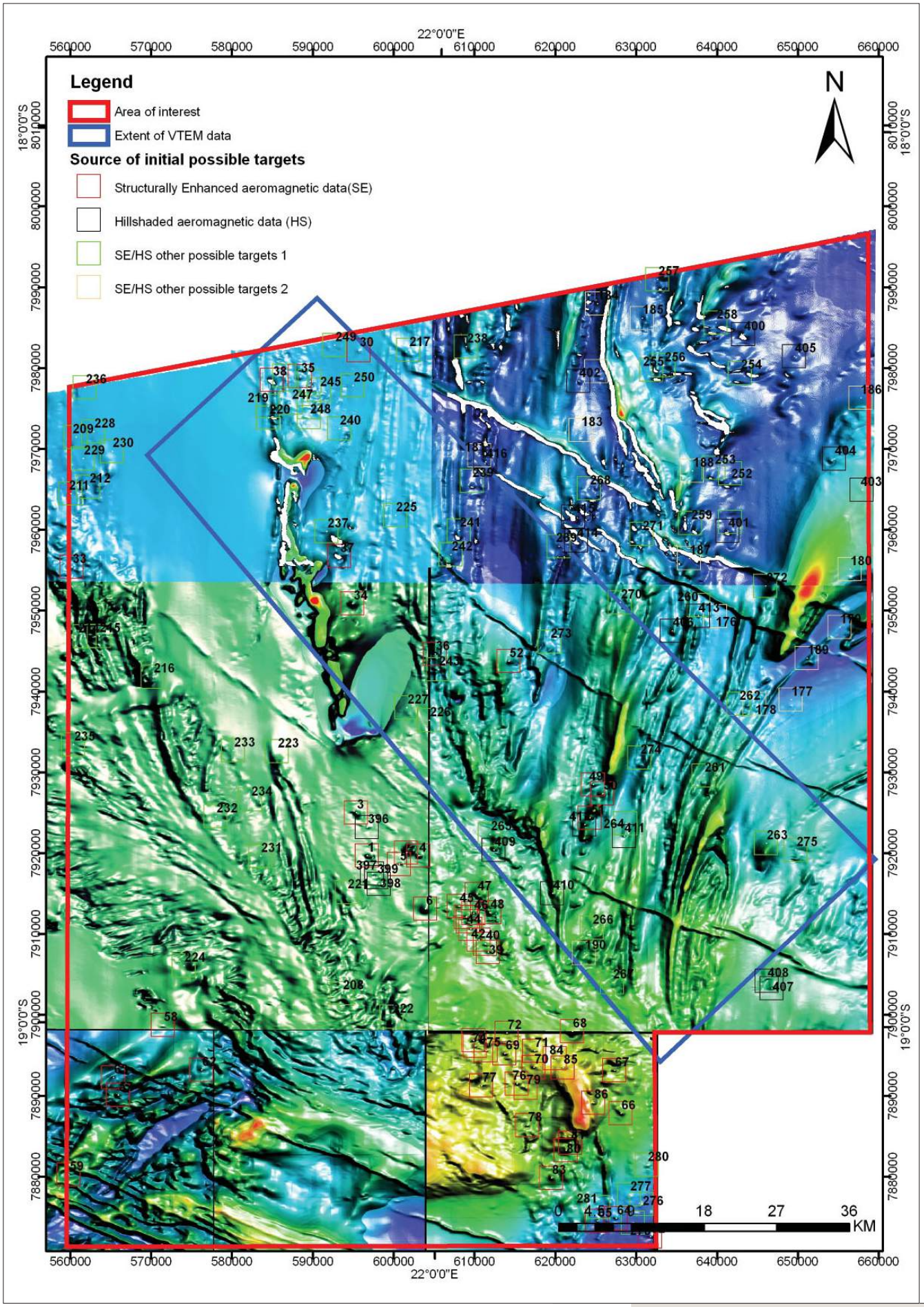


FIGURE 1 (RIGHT)
Possible targets over structurally enhanced (SE) aeromagnetic data image. The initial targets are determined by identifying magnetic anomalies in the south-east and hillshaded (HS) images

FIGURE 2 (LEFT)
Drilled massive and disseminated sulphides relative to 1, 2 and 3 km buffer zones created around the ironstone lithology as recognised by the Department of the Geological Survey (DGS) of Botswana near the Xaudom Ironstone anomaly (NW Ngamiland)


Legend
Area of interest
Extent of VTEM data
Source of initial possible targets
Structurally Enhanced aeromagnetic data(SE)
Hillshaded aeromagnetic data (HS)
SE/HS other possible targets 1
SE/HS other possible targets 2
N
22°0'0"E
18°0'0"S
19°0'0"S
560000
570000
580000
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18
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36
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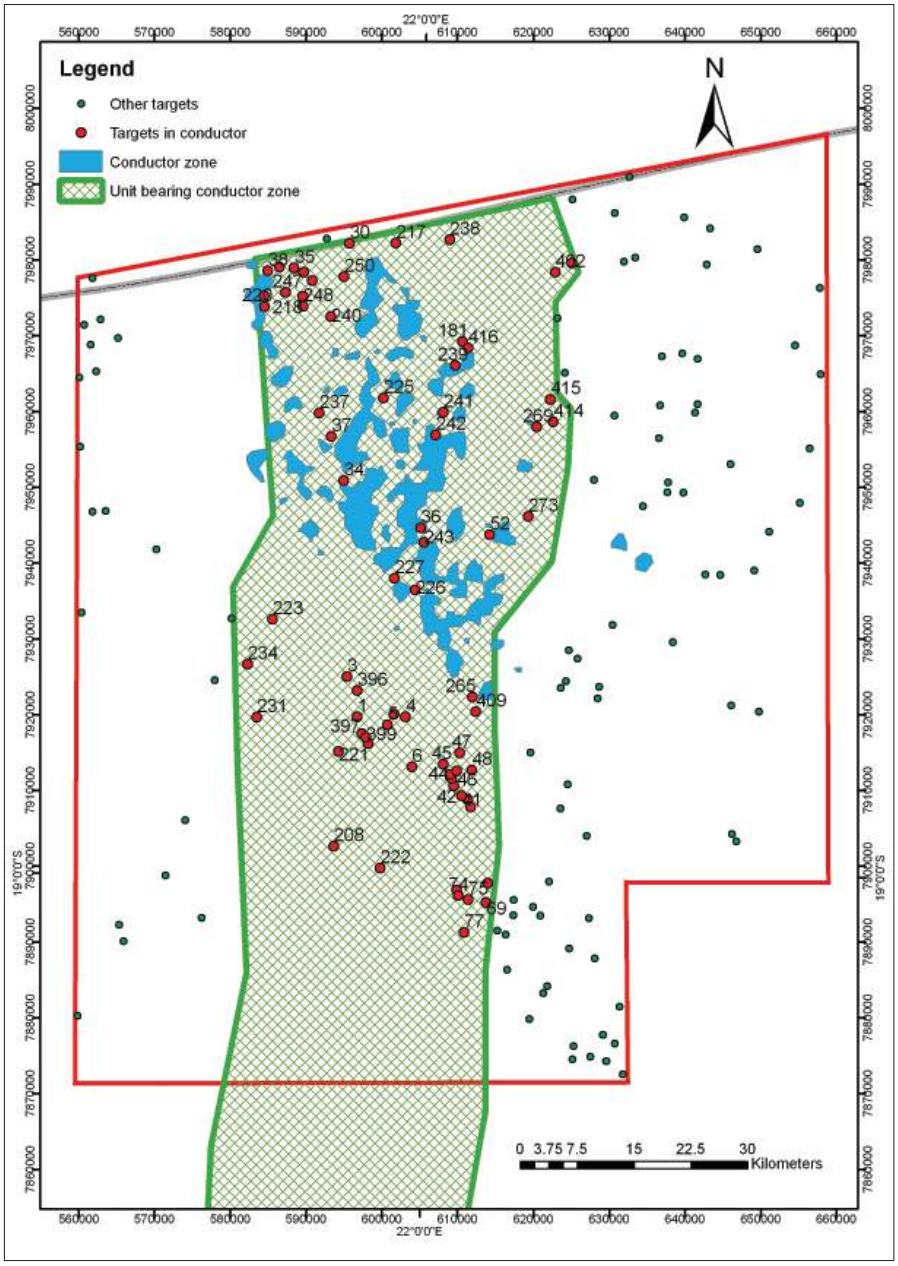
FIGURE 4
Possible targets within conductor zones identified from VTEM data and within lithological unit bearing conductor



group ironstone in north-western Ngamiland may represent an extension of Zambian copperbelt-like mineralisation in Pan African Basement of north-west Botswana. This is based on strong lithological similarities with the black shales encountered in the Kalumbila Co-Ni-Cu prospect, which is regarded as part of the Zambian Copperbelt of the lufilian arc.

The resources estimated for the Kiwara Project in the Kalumbila deposit are ~3.04 Mt at 0.67 wt % Ni, 0.2 wt % Co and 0.11 wt % Cu. If the similarities are true, then the drilled sulphides near the xaudom anomaly may represent a comparable highly prospective Co-Ni-Cu deposit. In addition to the abundance of magnetite, the detected Cu-Co concentrations, abundance of sulphides in cores, the uranium potential of the region, detected Au and other factors, the lithotectonic basement trends suggest that the xaudom ironstone feature lines up regionally with the lufilian arc structures. All of these factors favour a Zambian copperbelt-like source for the mineralisation.

The regional (several N-S, NE-SE trending fault systems) and local structural controls such as the proximity to favourable zones along crustal scale fractures such as the Mwembezhi shear zone and the Gumare fault, which represents a major regional thrust fault,

These factors favour a Zambian copperbelt-like source for the mineralisation

place the xaudom anomaly in a geological setting highly favourable for structurally controlled mineralisation. Other structural features in the area are a distinct fault junction immediately south of the Xaudum ironstone anomaly and lithotectonic Pan-African basement trend features that may suggest regional shearing east of the anomaly.

While some of these structural controls and other aspects mentioned above are also encountered in the iron oxide-copper-gold (IOCG) systems described by earlier authors, at this point the lithological evidence continues to favour a Zambian copperbelt-like source. Further field evidence is required before the Xaudum ironstone anomaly can be considered as a possible hydrothermal, iron oxide body. These regularly occur as planar features often tens of kilometres long and may be misidentified as banded iron formations. On this aspect, what remains to be done is drilling in the area to determine if other characteristics such as round-pebble hydrothermal brecciation, i.e. the Kasumbalesa tabular body of Zambia/DRC, dyke-like magnetite and/or hematite veins, as well as tabular, conformable iron-oxide bodies of hydrothermal origin, i.e. Congolese deposits at Luiswishi, Shituru and Kamoya, are present.

Preliminary work on the geochemistry and mineralogy by University of Cape Town researchers, Mojaki and Reid, points to a hydrothermal IOCG-type body rather than a MAB

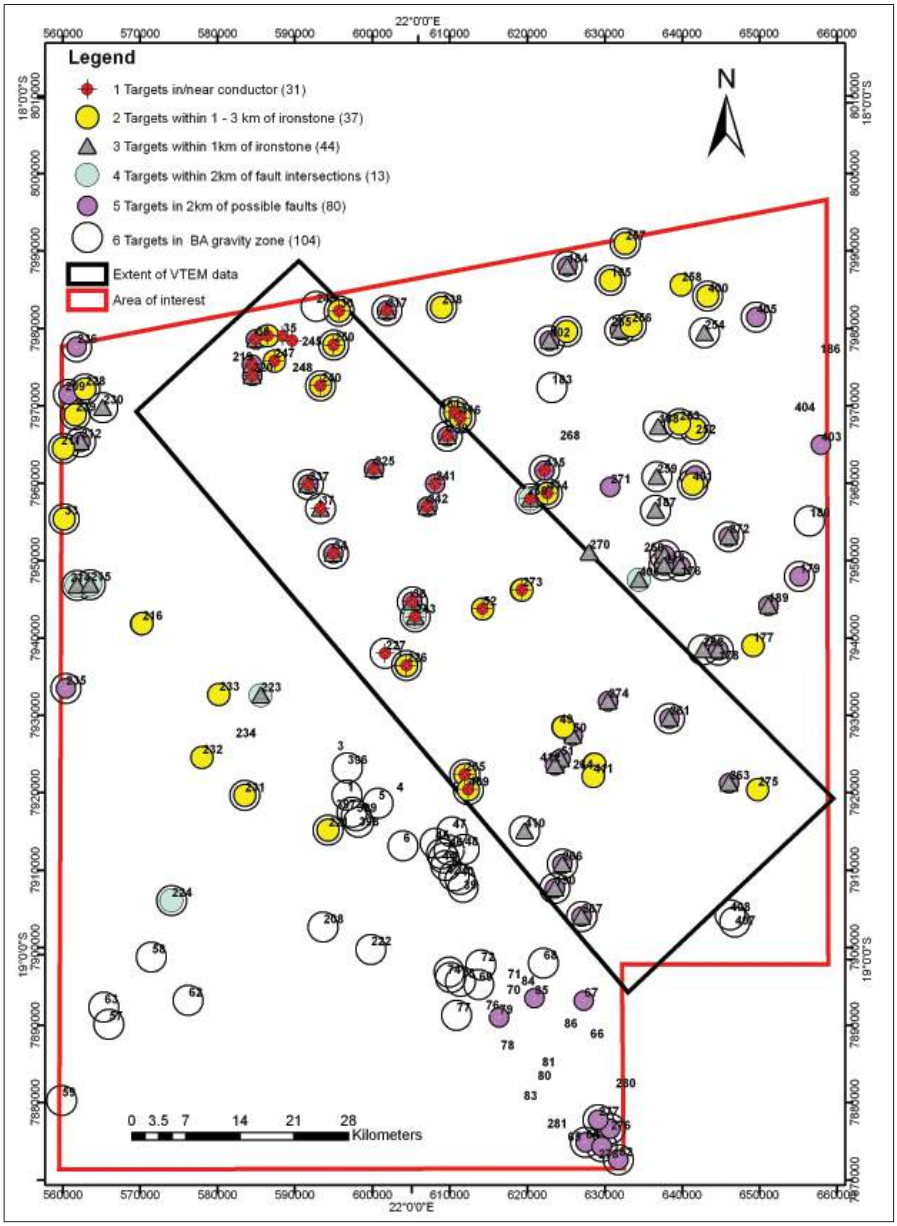
type source. While the source of the drilled sulphides remains to be better constrained, a very exciting picture appears to be emerging in terms of base metal exploration potential. The next step is to verify that the abundance of sulphides encompasses not only pyrite but also significant amounts of sulphide minerals of high economic potential, i.e. those rich in Cu, Ni, Co and Au. The preliminary investigations suggest that this may be the case.

As the sulphides are derived in close proximity to what has been interpreted by the Geological Survey of Botswana as a huge ironstone feature (xaudom ironstone), it was decided to establish the preliminary rules for the selection model by considering variables relevant to an IOCG-type deposit that have been monitored to date in the drilling area. The experiences drawn from typical ICOG and other deposit types reflect that the actual

A very exciting picture appears to be emerging in terms of base metal exploration potential

occurrence of copper sulphides relative to ironstone bodies is around, and not within, these bodies, e.g. Kombat Mine in Namibia. Furthermore, the VTEM data reveals that most of the sulphides are within, or closely associated with, conductors. The trend of the conductive zones correlate well with that of the basement fabric as mapped from aeromagnetic data. This may be applied to prioritise samples

FIGURE 8
Summary of analyses based on the different proximity selection criteria



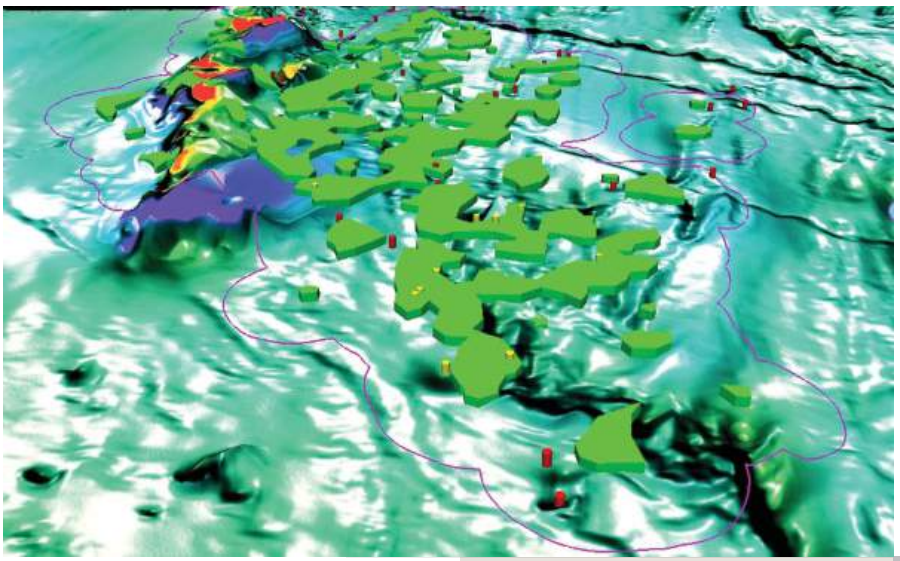


FIGURE 9
A 3-D schematic view of structurally enhanced aeromagnetic data created using ERDAS® Imagine Virtual GIS ® and ER Mapper ® near the xaudom ironstone anomaly. Also shown are the drilled sulphides (yellow) relative to a conductive unit (green) and the targets (red) within a 3 km buffer zone around the conductive unit

beyond the VTEM data coverage. These are some of the key factors that have been employed to contextualise the proximal analysis conducted.

The end result of this preliminary set of comparisons is a map of possibly favourable target zones based on the intersection of the relationships between proximity to interpreted faults, fault junctions, BA gravity anomaly, VTEM conductors and lithologies carrying conductors, as well as ironstone occurrences as defined by the disseminated and massive sulphide cores drilled in the area to date. The analyses of the current drilling results presented the following set of preliminary selection rules for prioritising base metal sulphide targets as identified by magnetic anomalies, such as dipoles, on structurally enhanced aeromagnetic data imagery:

1. lie within conductor zones identified from VTEM data
2. lie within lithological unit-bearing conductor
3. lie within 1 to 3 km of ironstone occurrences and within ferruginous quartzite
4. lie within 1 km of ironstone occurrences
5. lie within 1 km of possible fault or fault junction occurrences
6. lie within 2 km of possible faults
7. lie within – 4.3 km and 6.3 km with reference to the BA gravity value.

A trial test of the proximity criteria described above has been applied to several possible targets and offered to the field team for consideration. The preliminary results of applying these concepts in the current area of exploration are summarised in the selected figures 1 to 9. While several researchers have postulated that the copper mineralisation encountered in the greater lufilian arc probably extends into north-western Ngamiland (Ghanzi-Chobe Belt of Botswana), significant overburden has obscured the understanding of how this area fits into the regional geological puzzle. The selection rules described above are in essence generic and independent of the source of mineralisation. As such, they are useful exploration tools particularly in an area where the nature of the deposit is likely of multi-origin and/or still under scrutiny. 35

The end result of this preliminary set of comparisons is a map of possibly favourable target zones