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TSODILO RESOURCES

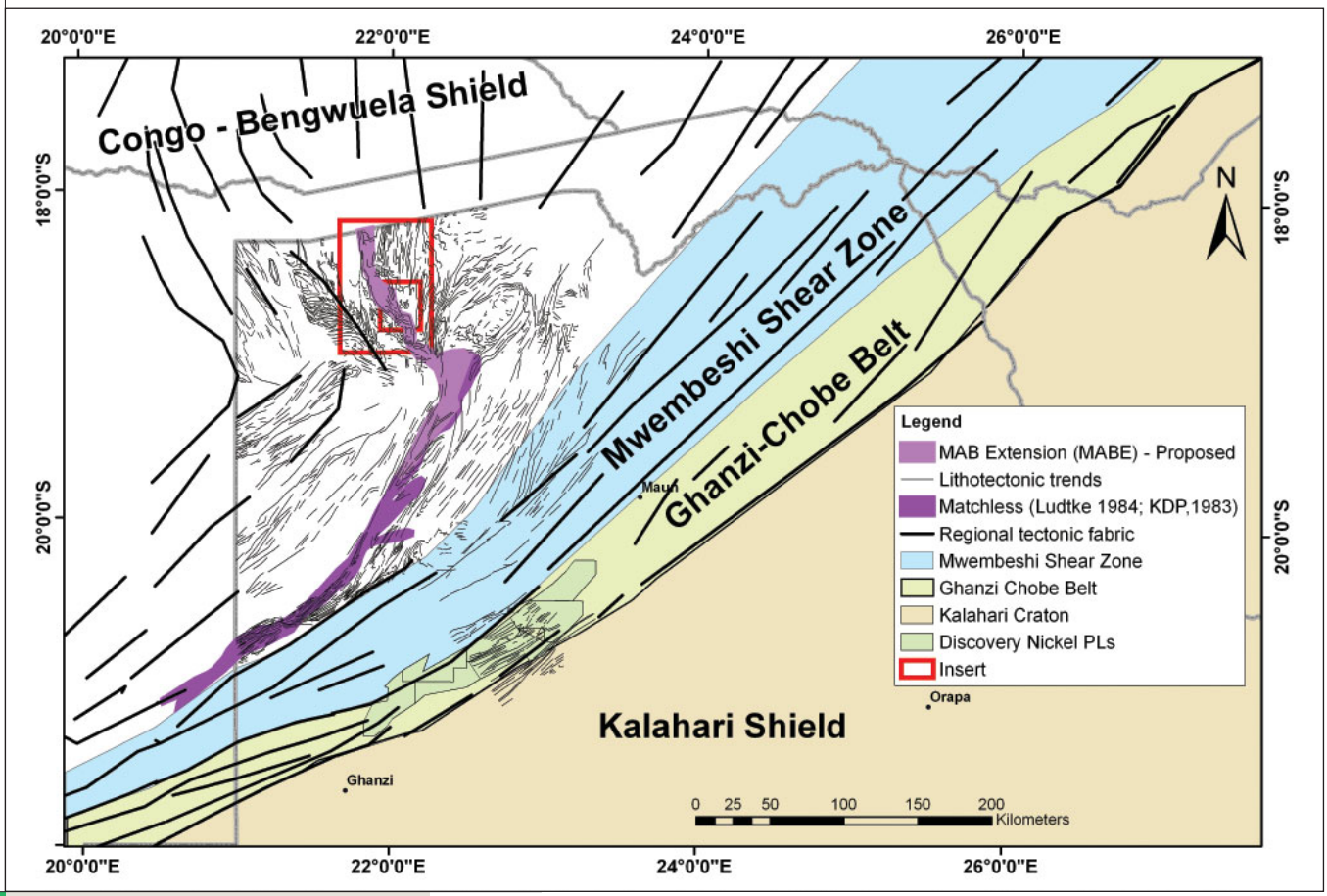
Copper Belt extends to Botswana

The Lufilian Arc, better known as the Zambian Copper Belt (>25 million tonnes of copper produced in Zambia), and its extension into Katanga (DRC), is a major source of mineral wealth that has captured the minds of exploration geologists and mining magnates ever since the discovery of this huge metallogenic province revealed its copper, cobalt and uranium riches, more than 80 years ago.

While the origins of the metals are still a subject of much debate, its relationship of the mineralisation to Pan-African (Neoproterozoic) age tectonics has been recognised from early days. Recent work has confirmed that these ore deposits were generated from deep sources during north-directed thrusting and concomitant regional-scale fluid flow through basement rocks with precipitation from these pregnant fluids at structural traps within the overlying sediments, such as the carbonates and graphitic shales of the Kalumbila Co-Ni-Cu deposits. Where did all this copper, nickel and cobalt (60% of the world's cobalt is contained in the Lufilian Arc) come from?

The big picture

Structural geologists have been speculating for decades about the western extension of the Lufilian Arc – a fold and thrust belt – as it curves sharply southwest before it is buried by younger rocks. Some favour a subsurface connection to the West-Congolian Belt in Angola and Gabon, while others truncate the Zambian Belt by the northeast trending Kibaran tectonic structures. Many geologists, however, have suggested that the belt is better linked to the northeast trending Damaran Belt, and in particular its sulphides-rich Matchless Amphibolite Belt (MAB,



Tony Rorke

OPPOSITE Litho-tectonic trends in Pan African basement in NW Ngamiland showing the possible entry point and trajectory of the Matchless Amphibolite Belt Extension (MABE)
BELOW Regional tectonic fabrics mapped from the total aeromagnetic intensity data for southern Africa. MSZ = Mwembeshi Shear Zone; GCB = Ghanzi-Chobe Belt. Red insert outline refers to MABE entry point

comprising mineralised meta-ophiolites) that marks a Neoproterozoic suture zone between the Kalahari and Congo-Tanzania-Bengwuela shields, and formed at the peak of collision-related metamorphism in the Damara-Lufilian-Zambezi orogen at ca. 550 Ma.

We think she was a black smoker

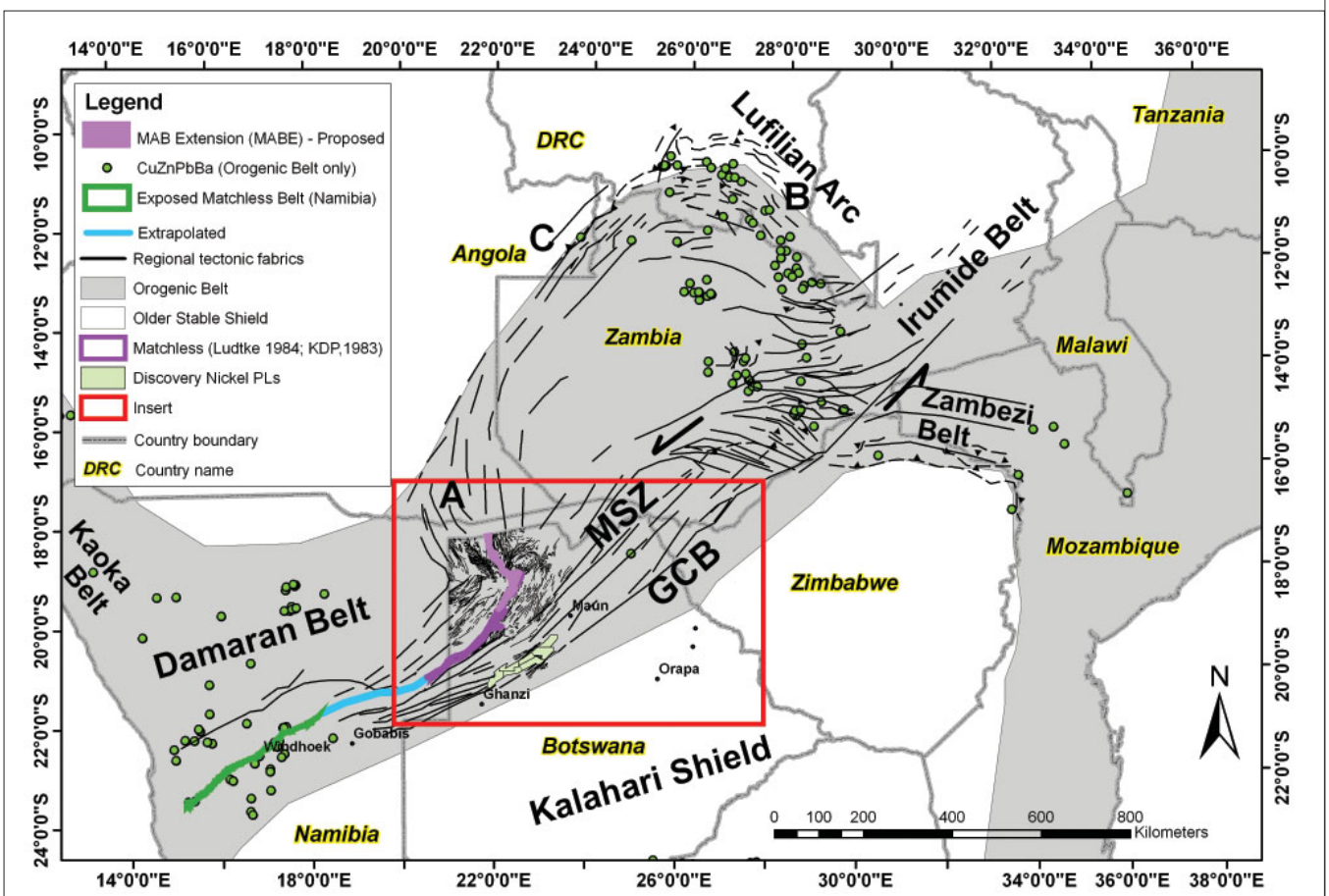
For the first time, this study conclusively shows this to be the most likely correlation. Could it be that, therefore, the copper was tectonically recycled from hydrothermal, black smoker-type sulphide deposits that formed originally in the basaltic pillow lavas, which are associated with gabbros, and ultramafic rocks, all exposed in the extensive Namibian Matchless Belt? Cu-Co mineralisation along this Matchless Belt has been known for more than a century. We have followed the northwest extension of the Matchless Belt with new and existing magnetic surveys data into central Botswana where it abruptly bends to the northwest. Here, the tectonic structures of the Damaran Belt also bifurcate. Firstly, a northeast-trending branch follows the Mwembeshi Shear Zone (MSZ), which separates the Ghanzi-Chobe Belt (a Mesoproterozoic calc-alkaline Andean-like belt with the newly discovered copper deposits close to the bifurcation, flanking the Kalahari Shield) from the Congo-Bengwuela Shield, and from there continues into the Irumbide/Zambezi Belt. High P/T grade ophiolitic rocks (including eclogites) in the Zambezi Belt suggest that the suture zone follows the general trend of this MSZ. Secondly, a northwest trending branch that contains the continuation of the MAB comprises a series of en echelon shears and NW-SE striking fold axis. This branch is likely rooted in a continental transfer zone between the suture zone flanking the MSZ to the south and the higher crustal level Lufilian Arc to the north. In this model, the MAB rocks are tectonically emplaced northwards, and the source of the mineral enriched fluids lies in the suture zone from where they were squeezed out and transferred to structural and stratigraphy traps at higher levels, along thrust duplexes and the vertical transfer fault zone.

A similar transfer zone may directly underlie the Zambian-DRC Copper Belt of the Lufilian Arc, since all its major deposits follow linear NW-SE trending lineaments.

Newly discovered

The newly discovered NW trending branch that links the Damaran Belt to

Tony Rorke



the Lufilian Arc should therefore provide ideal sites for structural controlled copper-cobalt mineralisation.

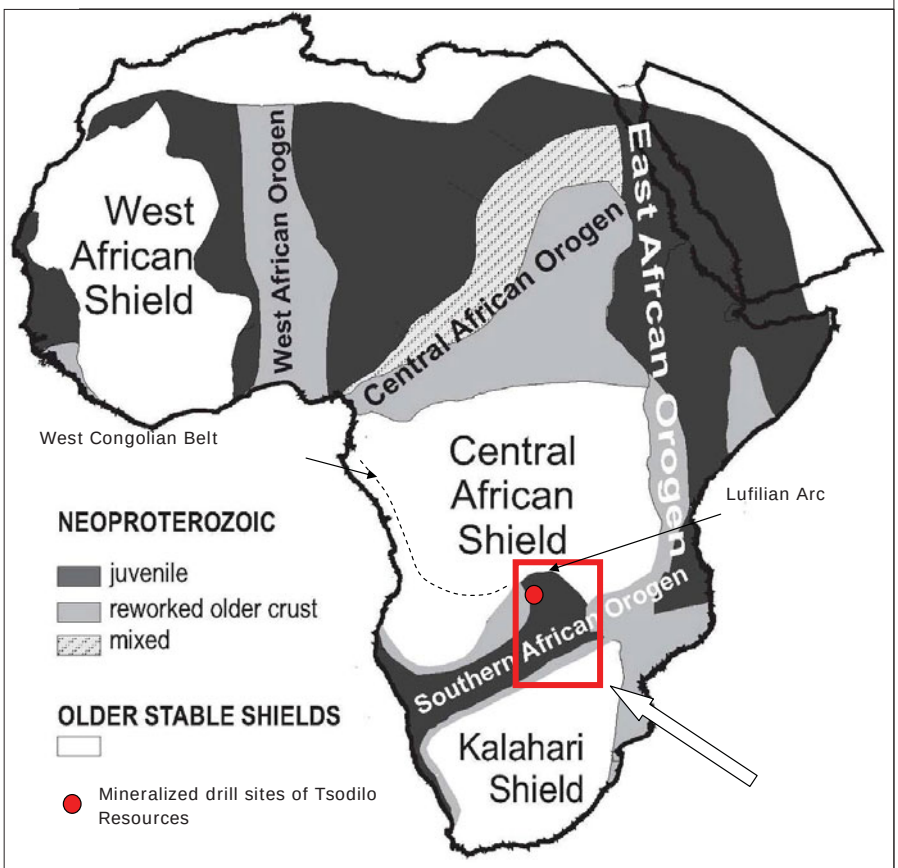
Tsodilo Resources has drilled 25 deep DDH into large and extensive magnetic anomalies within this NE trending transfer zone.

The first occurs at 1822C10, with average magnetic amplitude of 100 nanoteslas measuring some 2 by 2,3 km. Every drill hole that penetrated into this anomaly, beneath the 20 to 120 m thick Kalahari cover sequence, intersected concentrated and disseminated mineralised zones –sulphides – varying in thickness from 5 mm to 5 m. Rock types of various compositions, ranging from white carbonates interlayered with black graphite-rich shales, to metabasalts, gabbros and serpentinites, and to granitic gneiss and paragneiss basement are all invariably mineralised.

All rocks are intensely but heterogeneously deformed, showing strong cleavages and mylonites mineralised with syn- to post-tectonic sulphides, ranging from massive deformed layers to late vein mineralisation. Work on the petrography and chemistry of these rocks is still in progress and will be reported in future issues of **Inside Mining**. These cores typically contain Co values of up to 6996 ± 913 ppm as measured by handheld XRF (a Thermo Niton XL3t-500).

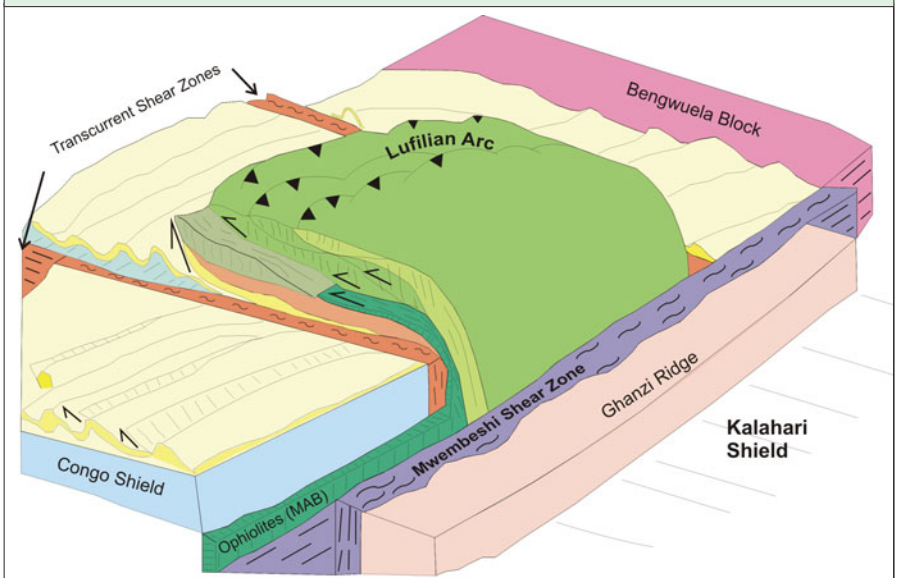
The assemblages of rocks from the different holes resemble a shallow carbonate-black shale sequence, overlain by tectonically emplaced ophiolite-rocks. We surmise that the ophiolites were rooted in the Matchless-Mwembeshi Suture Zone before they were emplaced northwards onto the foreland shallow marine sediment that covered the Congo-Bengwuela basement, and subsequently deformed in late transfer fault within which Tsodilo Resources located a large mineralised zone.

The polymetallic nature of mineralisation and the presence of cobalt, copper, nickel and platinum-group elements throughout the Lufilian Arc, implicates the mafic-ultramafic igneous rocks of the suture zone as a source of



The Structural Model

Schematic 3D interpretation of the link between regional thrust structures of the Lufilian Arc and a major Pan African suture zone in which ophiolitic rocks of the Matchless Belt-type are rooted, and from which the sulphide ores of the copper-cobalt belts may have been derived following extensive fluid fluxing during Pan African deformation. Note that the thrust panels are guided by two inferred transcurrent shear zones in the basement. Outside of these, the foreland basin sediments are folded and thrust to a lesser extent. Copper deposits of the Lufilian Arc are believed to align in the cover thrusts along the northerly transcurrent shear (not shown for clarity). Also not shown are the tectonic structures of other tectonic regimes such as the Kibaran Belt.



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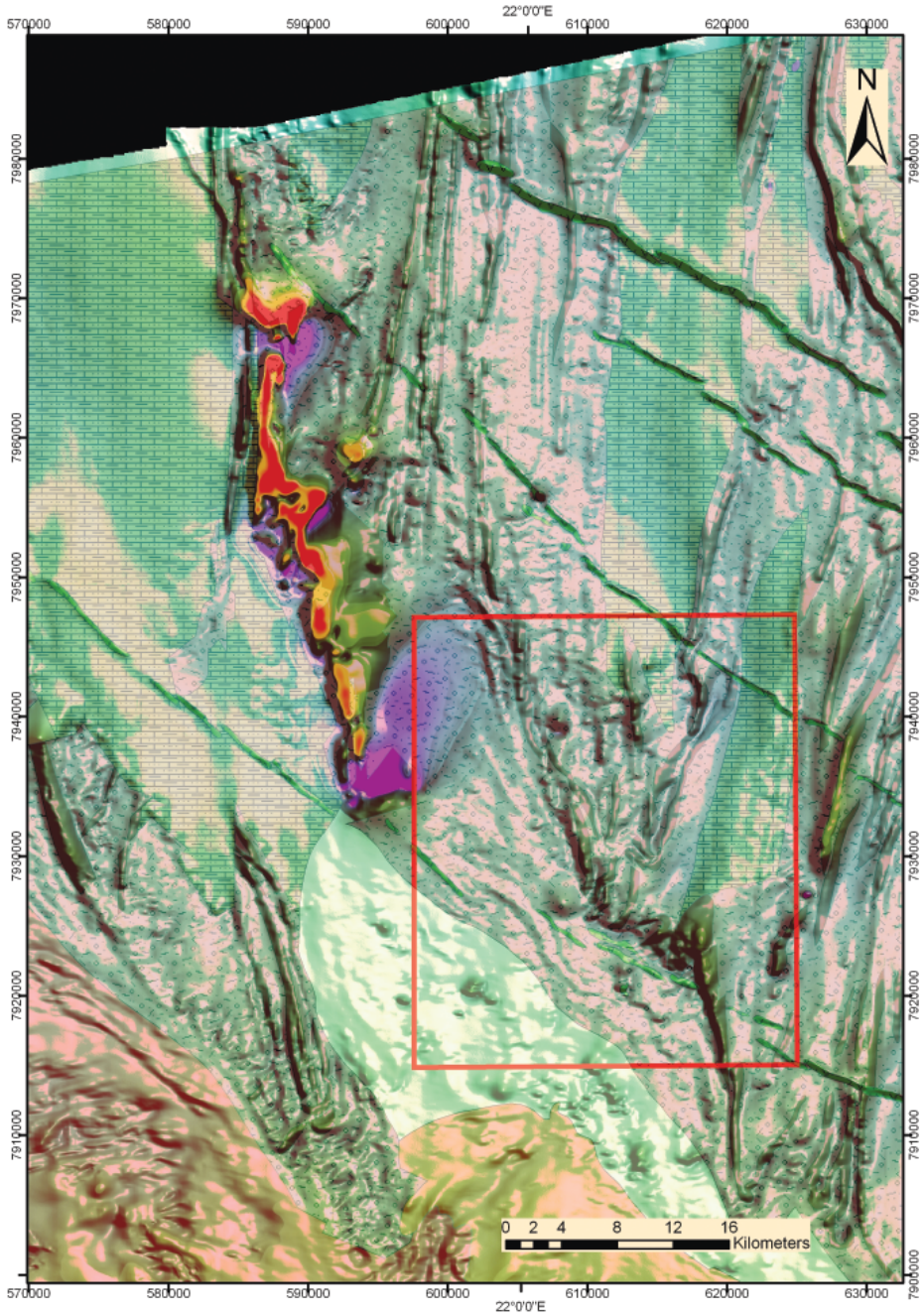
BELOW Structurally enhanced aeromagnetic data image overlain by regional geology (60% transparent). The red outline indicates the current drilling location

TABLE 1 Cu, Co, Ni, Cr and Ag values (ppm) as measured in cores by handheld XRF (Thermo Niton XL3t-500)

Index	Cu	Cu	Ni	Ni	Co	Co	Fe	Cr	Cr	Ag	Ag
		Error		Error		Error			Error		Error
19	-77	68	485	283	-2396	2470	2028669	-787	131	26	14
20	392	59	-204	132	6996	913	549866	-482	79	22	10
21	125	20	72	34	47	44	3460	-68	22	7	5
22	3203	124	374	121	-781	884	613833	-384	85	13	9
23	-1	1 4	38	32	109	106	25079	192	36	1	4



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Appendix Figure 2 Structurally enhanced aeromagnetics data image overlain by geology (60% transparent). The outline shows the location of the current drilling site shown in text figure 10.

the metals. Furthermore, the extensive carbonaceous, graphitic-rich shales are indicative of metamorphism and migration of hydrocarbons that often aid in early development of secondary porosity important for mineralisation of sulphides from migrating ore fluids (60% of the known copper-cobalt in Zambia is concentrated in dark shales).

It's a new play!

In view of these newly discovered extensions to the Zambian copper-cobalt fields, and the mafic-ultramafic rocks of the Matchless-Mwembeshi Belt, as well as the marked similarities that characterise all major Proterozoic polymetallic stratiform deposits in Africa, Australia and North America, the new finding of Tsodilo Resources in northwest Botswana has a rich potential for an extensive new base metal field. When good science and new technologies are brought together in fresh ways it often leads to exiting new discoveries – make sure to get the next issues of **Inside Mining** to learn more about Tsodilo's journey in Nagmailand. 3S

Adapted from the original text by Maarten de Wit, chartered geologist of the geological society, London, UK.