ZAMBIA: EXPLORATION POTENTIAL FOR IRON OXIDE COPPER–GOLD DEPOSITS AND A RE-EVALUATION OF THE COPPERBELT

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ABSTRACT

The Zambezi Joint Venture between Equinox and Anglo American has established an extensive tenement holding within one of the world's great metallogenic provinces, the Zambian Copperbelt. This region has had only very limited exploration over the last 25 years and has not been tested by modern exploration techniques and philosophies. Anglo American throught the Zambezi Joint Venture, is funding a major exploration program in Zambia, currently operated by Equinox. The Equinox team with its focus on Iron Oxide Copper-Gold concepts and through a re-evaluation of the Zambian Copperbelt is generating highly prospective targets which is the subject of a major ongoing exploration program in Zambia.

INTRODUCTION

The Equinox team (Equinox Resources NL) has considerable expertise in exploration for iron oxide copper–gold deposits of the Ernest Henry or Olympic Dam type. The company is currently exploring for such deposits in the Gawler and Curnamona Cratons of South Australia and the Cloncurry region of northwestern Queensland. Equinox is now expanding this strategy to explore internationally for iron oxide Cu–Au deposits and is developing programs in southern Africa and northern Sweden. A review of the Proterozoic geology and potential for iron oxide Cu–Au in southern Africa highlighted the prospectivity of the Kibaran Belt of Zambia and the Democratic Republic of Congo (Congo). This paper will focus on Equinox's activities in Zambia and as the company has only been actively exploring the region for about 12 months the results presented here should be considered preliminary.

Iron oxide Cu–Au exploration model

The exploration model being applied by Equinox has been developed by the team through its involvement in the Ernest Henry discovery in Queensland and through research on Olympic Dam in South Australia. The exploration target is essentially Proterozoic iron deposits with variable concentrations of copper, gold, cobalt and uranium. These deposits are typically related to fractionated granite suites and are associated with structures active at the time of granite emplacement. The host rock is commonly quartzofeldspathic, the critical factor probably being the competency of the host rock and its ability to fracture and focus dilation during deformation. As magnetite is commonly present, magnetic techniques provide key exploration tools.

Zambezi Joint Venture

The Zambezi Joint Venture, formed in mid-1996, combines the African operating expertise and financial capabilities of Anglo American with the exploration skills of Equinox for iron oxide Cu–Au mineralisation. Equinox is operating the first two stages of a substantial exploration effort, the initial US$12.5 million to be funded by Anglo American. Although the area of interest of the Zambezi Joint Venture covers southern Africa, the program is initially concentrating its efforts on Zambia.

ZAMBIA — EXPLORATION FOCUS

Iron oxide Cu–Au is the primary exploration focus of Equinox in Zambia. The Cu–Co mineralisation of the Zambian Copperbelt has previously been considered syngenetic, although the deposits exhibit some features in common with iron oxide Cu–Au deposits. The controls on mineralisation in the Copperbelt are being re-evaluated, representing a second style of priority exploration target in Zambia.

Zambian Copperbelt — a major copper producer

The Zambian Copperbelt is one of the world's great copper provinces and is currently the subject of a major resurgence of interest by explorers and miners as a result of the end of socialist rule and the privatisation of the major copper producing mines of ZCCM. Development of the Copperbelt commenced in the 1930s and up to 1990 mining had produced 1122 Mt of ore grading 2.7% Cu, producing over 25 Mt of copper metal. Zambia currently produces approximately 300 000 t of copper per year, down from its peak annual production of 750 000 t in 1970. There are currently five mines operating on the Zambian Copperbelt. Total Copperbelt reserves are estimated to be in excess of 2000 Mt with a grade of 2.5% Cu. The key attraction of Zambia to Equinox is that, notwithstanding the country's major producer status, there has been virtually no regional exploration undertaken in Zambia since the early 1970s. This indicates that Zambia has outstanding exploration

potential, untapped by modern exploration philosophy and techniques.

Equinox — extensive tenement holdings

Equinox has established an extensive land position in Zambia. The Zambezi Joint Venture has now been granted eight exploration tenements covering a total area of approximately 50 050 km^2 with an additional 14 000 km^2 under application. These tenements include numerous copper, gold, iron and uranium occurrences indicating regional prospectivity for iron oxide copper–gold mineralisation and several cover extensions of the host sequence to the Zambian Copperbelt.

REGIONAL GEOLOGICAL SETTING

Tectonics

The geology of Zambia is dominated by the northeast-trending Kibaran Mobile Belt (KMB) which separates the Archaean Congo Craton to the northwest from the Kalahari and Zimbabwe Cratons to the southeast. The KMB was probably initiated in the Palaeoproterozoic (ca 1800 Ma), but is dominated by Neoproterozoic rocks and structures. Repeated periods of extension (1150 Ma and 850 Ma), continental rifting and sedimentation, followed by crustal shortening (550 to 450 Ma), greenschist to amphibolite facies metamorphism and syn- to late-orogenic granite intrusion have all been recognised in the overall sequence.

There are two main groups of structures in the Lufillian Arc (which includes the Copperbelt), which were active during both extension and compression.

- east–west to northwest–southeast faults
  — extensional rifts during deposition of the Katangan Supergroup;
  — thrust/fold development during north to northeast shortening; and
- north–south to northeast–southwest faults
  — transfer faults during extension; with
  — strike slip and tear faults during compression.

The importance of the interaction of different generations of structures in localising mineralisation has not been emphasised in previous studies of the Copperbelt.

Granitoids

Three main groupings of granitoids have been recognised:

- Irumide granitoids (1400 Ma to 1100 Ma);
- Nchanga and Mkushi granites (Copperbelt area) and Lusaka granites (900 Ma to 800 Ma); and
- Hook granite suite (570 Ma to 530 Ma) — magnetic data suggest that this suite is more widespread than previously recognised.

The Hook granite suite is considered a potential source of mineralising fluids for iron oxide Cu–Au style mineralisation. Magnetic studies indicate that granites of this age may underlie the Copperbelt.

Stratigraphy

The Meso- to Neoproterozoic Katanga Supergroup overlies an Palaeoproterozoic basement complex of granites, gneisses and schists (Lufubu and Muva Groups). The Katanga Supergroup is composed of the basal Lower Roan sedimentary rocks (850 Ma to 800 Ma), Upper Roan and Kundelungu (750 Ma to 500 Ma) sequences. Although most of the deposits in the Copperbelt are hosted by the Lower Roan, the position within the stratigraphy varies substantially between deposits and mineralisation in the Congo Copperbelt is probably higher in the Roan sequence. Some workers have suggested that it extends up into the Kundelungu. There is evidence of a significant deformational event at 640 Ma, suggesting that stratigraphic relationships may not be as simple as previously thought.

Iron oxide copper–gold prospects

Iron oxide Cu–Au targets in Zambia have been identified primarily through the integration of aeromagnetic interpretation and a compilation of results from previous explorers (mostly pre-1975). Intense magnetic anomalies related to structures associated with granitic intrusive phases, in particular the Hook granite, represent priority targets. In a number of areas anomalous copper and/or gold occurrences have been reported from iron oxide concentrations, and in some target areas is associated with magnetic anomalies. Priority iron oxide Cu–Au target areas are summarised as follows.

- **Lufwanyama.** Lufwanyama (Figure 1) covers a poorly exposed basement dome which is flanked by the target Lower Roan sequence, 40 km south of the Copperbelt. Aeromagnetic data suggest that at least part of the granites in this dome may be intrusive into the Katanga Supergroup. A detailed interpretation of the Lufwanyama area has delineated a number of priority magnetic and geochemical targets.

- **Chongwe.** The Chongwe tenement (Figure 1), east of Lusaka, contains a series of copper, gold and iron occurrences. An interpretation of the aeromagnetic data has delineated several targets for evaluation.
- **Kafue Park / Itezhi–Tezhi.** Geological targets identified in the Kafue Park / Itezhi–Tezhi region (Figure 1) are consistent with the iron oxide Cu–Au model. Priority targets are the numerous iron

occurrences and alteration zones associated with the Hook granite, some of which are anomalous in copper–gold–uranium. Intense alteration associated with structures in the region includes the hematite–magnetite–Kspar–epidote–scapolite–sulphide assemblage and a number of ironstone breccias have been mapped.

- **Kabompo.** Kabompo, in northwestern Zambia (Figure 1), covers a series of granitic domes flanked by a sequence considered equivalent to the Lower Roan. Magnetic and radiometric data clearly define the trace of the Lower Roan equivalent, which is the host to numerous copper–cobalt, gold, uranium and iron occurrences. Copper mineralisation associated with magnetite has been reported from numerous prospects, including Chililamawombo (with a drillhole intersection of 9.4 m of 1.2% Cu), Kalaba (trench with 9 m of 2.8% Cu and 0.7% Co); and Mujimbeji (with a drillhole intersection of 3.8 m of 2.9% Cu, 0.2% Mo and 0.2% Ni).

- **Kasanka / Serenje.** The Kasanka / Serenje region (Figure 1) was identified as prospective for iron oxide Cu–Au during a regional aeromagnetic study of Zambia. The magnetic pattern is indicative of previously unrecognised granite intrusions into the Katanga sequence, associated with major structures. A search of previous exploration data identified a number of gold occurrences in the region, some associated with magnetic ironstones.

A further 3 new tenement applications have been lodged by the Zambezi Joint Venture at **Mukombo, Muchinshi** and **Kapiri Mposhi** (Figure 1).

ZAMBIAN COPPERBELT — A RE-EVALUATION

Geological concepts regarding the major Cu–Co concentrations of the Zambian Copperbelt have, since the mid-1960s, been dominated by syngenetic models. These models have been developed by numerous workers, primarily resulting from the observation that most of the mineralisation occurs within the basal Lower Roan sequence flanking basement domes. While Equinox is not prepared to discount this syngenetic concept, observations by the Equinox team in Zambia suggest that the importance of structure has largely been ignored by previous workers on the Copperbelt. For this reason the company has focused its efforts on re-evaluating the Copperbelt from a structural perspective in order to generate exploration targets untested by previous explorers.

Important features of the Zambian Copperbelt deposits include host stratigraphy, structure and granitic intrusions.

- **Host stratigraphy.** Most of the copper deposits are hosted by fine-grained sedimentary rocks of the Lower Roan. However, some mineralisation occurs within the Upper Roan and even higher within the sequence (Figures 1 and 2). In detail, mineralisation in the Zambian Copperbelt occurs at various stratigraphic positions within the Lower Roan, and the internal stratigraphy of this unit is highly variable. Mineralisation also occurs in the basement granites, gneisses and schists.

- **Structure.** In some Copperbelt deposits a moderate to strong layer-parallel foliation is developed within the mineralised sequence and is commonly most intense at the basement contact and in the ore zones. Shallow north-dipping shear zones are associated with overturned folds at Nchanga and indicate top block south movement directions. Interpretation of aeromagnetic data for the Copperbelt region has identified fault sets that may be related to the extensional phase of deformation that produced the Katanga basins. In particular, the east–west structures appear to have controlled basin development, these structures having been reactivated during subsequent compression. Structures cutting areas previously mapped as basement within the Kafue Anticline may be associated with slices of the prospective Lower Roan sequence, defining targets for further evaluation.

- **Granites.** Although dating information is sparse, most of the granites in the Kafue Anticline pre-date the Katanga Supergroup. At Nchanga the Lower Roan unconformably overlies the Nchanga granite, although the strongly sheared basement contact at Baluba is more typical. Equinox's interpretation of aeromagnetic data suggests that the Copperbelt region is overprinted by a thermal event of Hook granite age.

Detailed aeromagnetic surveys have recently been flown by Equinox over about 27 000 km^2 of the Copperbelt region, including coverage of most of the mines. The detailed interpretation of this dataset that is underway is critical to the unraveling of the structural framework of the Copperbelt.

Equinox has pegged most of the Copperbelt region that was not covered by ZCCM mining leases. The Zambezi JV tenements in this region include the **Kitwe, Luanshya South** and **Lufwanyama** properties (Figures 1 and 2) which cover areas previously mapped as Lower Roan. Particularly prospective is the 50 km section of the target zone between Mufulira and Ndola (partly along the Congo border), which includes a small copper deposit at Ndola West (3 Mt at 1.5% Cu) and a significant prospect at Ngala (including a drillhole intersection of 7.5 m of 4.8% Cu). The basement dome at Lufwanyama, to the south of the Copperbelt, is prospective for both iron oxide Cu–Au

and for Copperbelt-style mineralisation. Similarly, Kabompo (Figure 1) is prospective for both styles of mineralisation. The sequence at **Kabompo** has been mapped as equivalent to the Lower Roan at the Copperbelt, although it has perhaps stronger similarities with the mineralised sequence in the Congo Copperbelt.

Equinox Exploration Activities

Equinox, as operator of the Zambezi Joint Venture, has established a base in Kitwe and currently has a field team of 12 people, including 6 geologists, employed in Zambia. The field program commenced at the start of the dry season in April 1997 and will be completed by the commencement of the wet season in December. Activities to date include:

- flying of aeromagnetic and radiometric surveys (65 000 line km);
- acquisition of additional aeromagnetic data (approximately 40 000 line km);
- interpretation of aeromagnetic data and target definition;
- flying of SPECTREM (Anglo-proprietary airborne EM system) (35 000 line km);
- compilation of previous exploration data;
- geological mapping of priority regions; and
- geochemical sampling of target areas.

This program is complemented with field work evaluating all granted tenement areas, including RAB and RC drilling of some priority targets.

CONCLUSIONS

Equinox has established an extensive tenement holding within one of the world's great metallogenic provinces, the Zambian Copperbelt. This region has had only very limited exploration over the last 25 years and has not been tested by modern exploration techniques and philosophies. Anglo American is funding a major exploration program in Zambia, currently operated by Equinox, through the Zambezi Joint Venture. Although this program is at a relatively early stage, the Equinox team, with its focus on iron oxide Cu–Au concepts and through a re-evaluation of the Copperbelt, is generating highly prospective exploration targets that have not been tested by previous exploration.

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Figure 1. Locality map showing ion oxide Cu–Au prospects of the Zambezi Joint Venture (Equinox–Anglo American) in the geological setting in Zambia. Mineralisation occurrences are also shown.

Figure 2.