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SUMMARY

GEOPHYSICS IN THE ZAMBIAN ENVIRONMENT

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This summary is supplementary to the GEOPHYSICS section by Garlick and Gane published in "The Geology of the Northern Rhodesian Copperbelt", edited by Mendelsohn in 1961 and now being reprinted.

An increase in the amount and variety of geophysical investigations in Zambia during the last decade has been accelerated by projects sponsored by the Zambian Government, the United Nations, and by mining and exploration groups. The revision of the Mines and Minerals Act has resulted in an influx of experts from many countries who brought fresh ideas and techniques to the search for viable deposits in Zambia.

Although the results of many surveys are still being studied and ground checking is far from complete, some local environmental effects on geophysical methods can be recognized and others suspected in the plateau areas where deep weathering is ubiquitous, and especially in western Zambia, where the weathered zone has been covered by a veneer of Kalahari sand. The present seasonal rainfall pattern may have persisted since the development of the Mid-Tertiary and subsequent peneplanes which are characterized by forested interfluves alternating with low-lying and usually swampy grass covered vallyes called "dambos". From November to March thunderstorms are common, but much of the precipitation is absorbed with a minimum of surface runoff. From April to October most of the absorbed water percolates downward and dry winds carry evaporated and transpired moisture to the west. Since peneplanation the amount of runoff has decreased and downward percolation has increased so that chemical decomposition has exceeded physical erosion, and the permanent water table is at maximum depth in December or January and a minimum in June or July. The development of sesquioxide concentrations in residual clays, and of ferricrete, silcrete, or calcrete layers in the overlying Kalahari sand, has produced a number of horizontal layers with differing resistivities according to the varying amount and direction of percolating water at different seasons.

This accumulative increase in total thickness of decomposed bedrock accompanied by chemical development of horizontal zones of different resistivity, and further complicated by the variable annual rate of percolation of water through the regolith and into the fluctuating zone of complete saturation has produced a continually varying environment which is a major factor in evaluating geophysical data.

Evaporation and percolation combine to produce a highly resistive surface layer on the interfluves during the dry season, and the application of saline solutions or water does not uniformly compensate for the varying thickness of this layer between electrodes or stations in S-P, E-M and I-P surveys. S-P methods produce useful results when the water table is low and when rainfall has added sufficient interstitial water to provide uniformly good contacts between the electrodes and bedrock, but the effect of decomposing sulphides is not detectable when the water

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table is high enough to dilute the electrolyte and dissipate the energy produced. Ground E-M methods are as likely to detect near-surface channels with weakly ionic solutions as disseminated conductive minerals in bedrock formations.

I-P methods have detected known disseminated sulphide deposits where the weathered zone is thin, but surveys with normal spacings were ineffective at the Kalengwa deposit which was detected with 15 metre stations and the current electrode at fractions of the distance between potential electrodes. With judicious selection of electrode spacing, the effects of horizontal conductors are minimized and the I-P technique is an effective follow-up method.

Inductive energization for surveys utilizing aircraft to position loops of wire, are not apt to be successful in Zambia because the energized wire will be in close contact with damp ground in dambos and will be draped in trees 15 to 30 metres above dry ground across interfluves.

Three small deposits of disseminated sulphides were used to test helicopter borne E-M systems. Over two deeply weathered deposits there was no reaction from either McPhar's F-400 or Scintrex's HEM-701 systems. Over a less deeply weathered deposit, both systems recorded almost identical anomalies slightly downdip from the shallowest sulphides and nearly coincident with the unweathered base of an overlying amphibolite. The HEM-701 system recorded E-M and magnetic anomalies coincident with the top of the amphibolite, which was less precisely indicated by the F-400 system. The former system produced fewer other anomalies than the latter.

Shallow conductors are probably responsible for many anomalies recorded by the Barringer INPUT method which produced six channel anomalies over formations with moderate sulphide content of considerable strike length. A number of INPUT anomalies have been followed by ground I-P and diamond drilling, which have indicated technical successes.

Deep weathering may concentrate resistant magnetic minerals and thus accentuate magnetic anomalies over certain rock types and simplify structural interpretation. Weathering of other formations produces slabs of ironstone in surficial layers. Although most slabs appear to be hemathite or limonite, some are highly polarized, perhaps due to lightning, and may produce single station anomalies of several hundred gammas. Because of the erratic distribution of such slabs, interpretation of surface observations may result in spurious correlations.

Differential weathering simplifies interpretation of gravimetric surveys, because of the unformly low specific gravity of the regolith and because the variation of regolith thickness is dependent on the composition of the bedrock. The Bouguer gravity measured over deeply weathered carbonate rocks will be lower than that over adjacent slightly weathered quartzite, granite-gneiss, shale or schist.

Within calculatable limits, gravity surveys can be eleminatory for replacement and secondarily enriched sulphide deposits which occur in or below the weathered zone. This effect is dependent on the contrast in specific gravity between mineralization and country rock, and on the size, shape, and attitude of the body in relation to its depth.

Apart from the direct discovery of ore, an important geophysical objective is the mapping of buried geological contacts.

The Zambian Geological Survey are supervising an airborne magnetometer and spectrometer survey of the Barotse Plain, an area of some 50 000 square miles along both sides of the swampy Zambezi floodplain where recent alluvium and Kalahari sand may conceal basic intrusives and are underlain in part by Karoo sediments and lavas which in turn may overlie both Katanga and Pre-Katanga rocks. It is understood that the aircraft is flying at constant elevation above sea level and that both analogue and digital recorders are being used. Electronic filtering and computer interpretative techniques should reveal the locations of basic intrusions worth investigating for a variety of minerals. The presence of marine Cretaceous or Karoo rocks and possible petroleum accumulations might be inferred, and, if the basin is shallow, the paleotopography may indicate areas in which deposits of base metal ores in Katanga system rocks might be sought.

On and west of the Copperbelt, the mapping of the Pre-Katangan topography has not been successful except at shallow depths although seismic, gravity and both ground and airborne magnetic methods have been used. The Katangan rocks are generally less metamorphosed than "Basement" rocks and have similar geophysical characteristics, but the interpretation of survey results is complicated locally by the effects of amphibolites which vary in size and shape and are irregularly distributed in rocks overlying the Lower Roan ore horizons. The magnetic effects of amphibolites are often recognizable but they very considerably within a single deposit.

In central and eastern Zambia, amphibolitic and more basic rocks may be accompanied by sulphide deposits containing economic amounts of nickel or copper. Geological Survey staff are also supervising an airborne magnetometer-spectrometer survey of a triangular area between the Luangwa valley and the Malawi and Mozambique frontiers. Karroo rocks outcrop along the Luangwa Valley and overlap metamorphosed Pre-Cambrian rocks which are known to include amphibolites and basic rock types as well as pegmatites and possibly carbonatites. The area includes moderately rugged and gently rolling topography, the rock is not deeply weathered, and the aircraft will fly at a constant altitude above the ground surface for maximum resolution of magnetic bodies.

Further improvements in both ground and airborne electrical methods, such as the Magnetic I-P technique recently announced by Scintrex, should minimize the effects of the weathered zone. The development of successful down hole methods could increase the value of diamond drilling, and is likely to be a valuable tool for increasing the future mineral potential of Zambia.