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Geological and geophysical characteristics of massive sulphide deposits: A case study of the Lirhanda massive sulphide deposit of Western Kenya

E. Dindi [a, *], J.B.J. Maneno [b]

[a] Department of Geology, University of Nairobi, P.O Box 30197, Nairobi, Kenya
[b] Building and Civil Engineering Dept., Technical University of Mombasa, P.O Box 90420, Mombasa, Kenya

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ABSTRACT

An integrated geophysical ground survey was conducted on an airborne electromagnetic (EM) anomaly located in Kakamega forest of Western Kenya. The purpose of the study was to establish the existence of massive sulphides and identify suitable optimal geophysical method(s) for the investigation of similar anomalies. The study was also expected to provide information on the geological and geophysical characteristics of the deposit.

Field work involved electromagnetic methods: Vertical Loop (VLEM), Horizontal Loop (HLEM), TURAM EM and potential field methods: gravity and magnetics. Geochemical sampling was carried out concurrently with the geophysical survey.

All the geophysical methods used yielded good responses. Several conductors conforming to the strike of the geology were identified. TURAM EM provided a higher resolution of the conductors compared to VLEM and HLEM. The conductors were found to be associated with positive gravity anomalies supporting the presence of bodies of higher density than the horst rock. Only the western section (west of 625W) of the grid is associated with strong magnetic anomalies. East of 625W strong EM and gravity anomalies persist but magnetic anomalies are weak. This may reflect variation in the mineral composition of the conductors from magnetic to non-magnetic. Geochemical data indicates strong copper anomalies (upto 300 ppm) over sections of the grid and relatively strong zinc (upto 200 ppm) and lead (upto 100 ppm) anomalies. There is a positive correlation between the location of the conductors as predicted by TURAM EM and the copper and zinc anomalies.

A test drill hole proposed on the basis of the geophysical results of this study struck massive sulphides at a depth of 30m still within the weathered rock zone. Unfortunately, the drilling was stopped before the sulphides could be penetrated. The drill core revealed massive sulphide rich in pyrite and pyrrhotite.

An attempt has been made to compare characteristics of the Lirhanda massive sulphide deposit with those of better documented massive sulphides. Despite the fact that very little is known about Lirhanda, there are several similarities on the characteristics compared. These include evidence of back arc regional environment, calc-alkaline volcanic associations, conformity of anomalies to the structural trend of the host rock, proximity of synvolcanic rift, dispersive anomalies of copper and zinc in soils, presence of gossan and association of the deposit with strong EM anomalies.

1. Introduction

The geology of Western Kenya (Fig. 1) consists of rocks of the Nyanzian and Kavirondian systems. These are bound to the east by rocks of the Mozambique Mobile Belt (MMB). Rocks of the Nyanzian System include volcanics (rhyolites, andesites, andesitic tuffs and basalts) and sedimentary rocks (slates, greywackes and conglomerates). The two systems are separated by a major unconformity with Kavirondian System being the younger one. The region is recognized as a greenstone belt (Barongo, 1983; Ichang'i, 1990; Ichang'i and MacLean, 1991; Ichang'i, 1993) and often referred to

* Corresponding author.
E-mail addresses: edwin.dindi@uonbi.ac.ke (E. Dindi), jmaneno@tum.ac.ke (J.B.J. Maneno).

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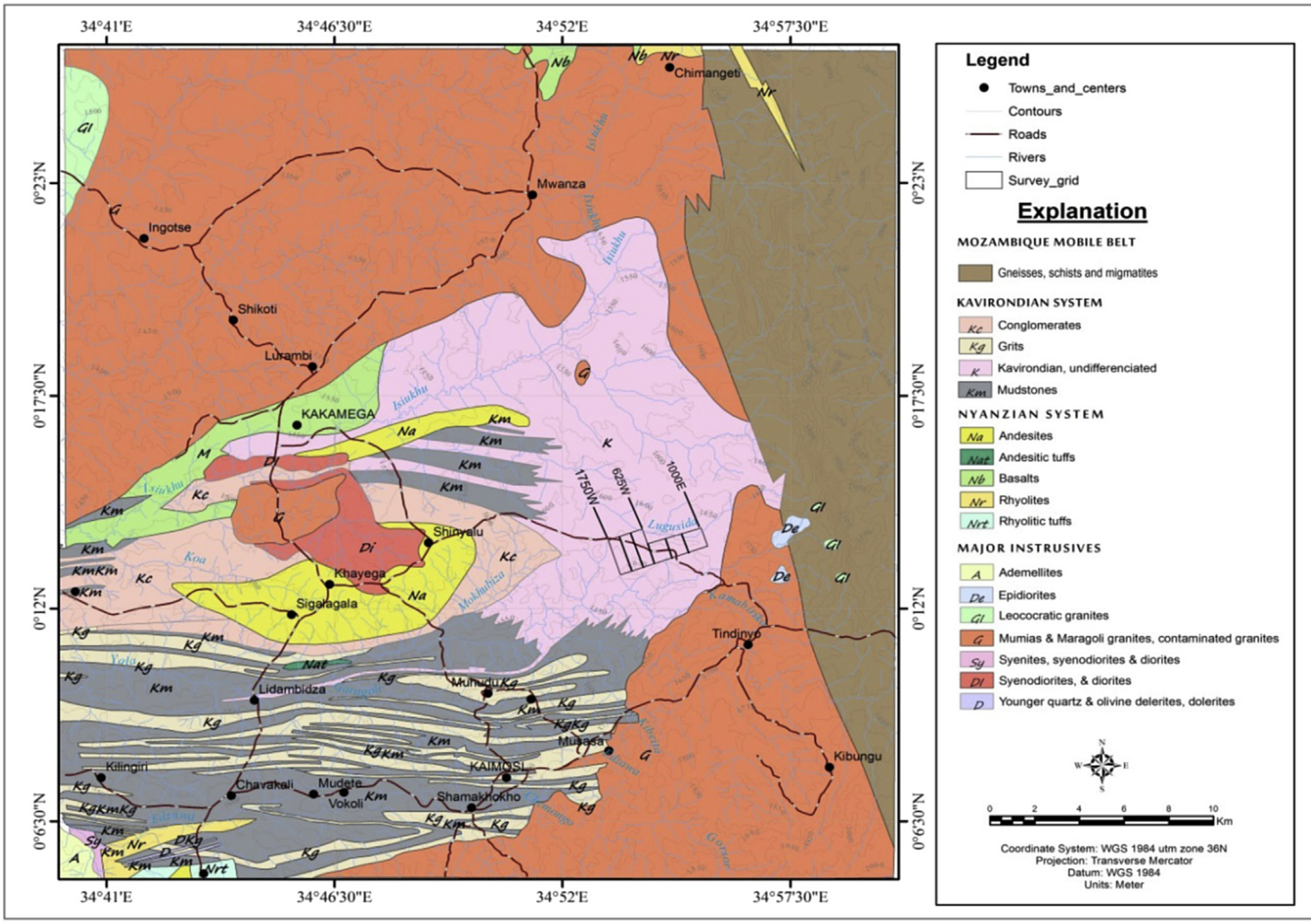

Fig. 1. Geological map of the study area with location of the survey grid indicated.

as the Nyanza Greenstone Belt (Schülter, 1997). It is known to have experienced conditions that were conducive to the accumulation of massive sulphide deposits. These are conditions of submarine volcanic environment near sea floor where the immediate host can be either volcanics or sedimentary (Galley et al. (2007). Indeed several occurrences of massive sulphides and kimberlitic pipes have been reported (Barongo, 1983: Ichang'i, 1990) suggesting existence of thinner crust and vent sites through which fluids might have migrated for accumulation of massive sulphides.

Several integrated geophysical fieldwork initiatives were undertaken especially from the late seventies in the effort to understand the occurrence and distribution of massive sulphides within the Nyanza greenstone belt. One such initiative was an airborne electromagnetic survey over five areas in western Kenya (Hetu, 1978). Data from the survey revealed several electromagnetic targets most of which were discarded during the initial screening on account of them being of cultural origins. The remaining targets were assigned a priority rating for ground follow-up (Macharia and Barongo,1982). The ground follow-up led to the attribution of the airborne electromagnetic anomalies to three possible sources: kimberlitic pipes, graphite bodies or massive sulphide bodies. Barongo (1983) conducted a follow-up investigation on probable kimberlitic pipes and identified horizontal loop EM (with in-phase anomalies of upto 40%), magnetics (with residual total field anomalies of upto 500 nT) and resistivity (with resistivities of 3–15 Ohmm) as the geophysical methods offering good response and results. Test drilling confirmed the presence of kimberlites in three of the four anomalies investigated.

This study details the results of the ground follow-up investigations conducted on one of the high priority targets for massive sulphides. The study involved geological, geophysical and geochemical investigations and established it to be a massive sulphides deposit here referred to as the Lirhanda massive sulphide deposit. The geophysical methods used for the ground follow-up included Horizontal and Vertical Loop Electromagnetics (HLEM and VLEM), TURAM Electromagnetics (TURAM EM), gravity and magnetics. The basis for the selection of these methods is the well-known fact that massive sulphide deposits typically have strong geophysical contrasts with the host rock arising from the substantial differences in physical and chemical properties between them. (Thomas et al., 2000). Such properties include density, magnetic susceptibility and electrical resistance.

2. Purpose of study

Several studies have been conducted on geological and geophysical characteristics of massive sulphide deposits in various parts of the world (Lydon, 1984; Bishop and Lewis, 1992; Salisbury et al., 1996; Gimmell et al., 1998; McIntosh et al., 1999; van Staal et al., 2003; Ford et al., 2006 and Morgan, 2012). Although western Kenya is known to be underlain by such deposits, very little has been written about the characteristics of massive sulphides in that environment. The purpose of this study was to (a) establish the existence of massive sulphide deposits at the locality and if present