High resolution aeromagnetic mapping of "loss-of-ground" features at platinum and coal mines in South Africa

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Abstract: High-resolution aeromagnetic surveys now constitute an essential mapping tool in the delineation of steeply dipping loss-of-ground features within the lease areas of South African platinum and coal mines. The mapping targets comprise dykes, sills and mafic intrusions or replacement bodies, which are often of limited width or diameter and carry only trace concentrations (<1%) of accessory magnetite. While dykes of varying geological ages are common to both mining areas, each is characterised by a loss of-ground feature which is unique to that particular geological terrane. "Pothole slump structures" in flatly dipping Bushveld platiniferous reefs are often spatially associated with iron-rich-ultramafic pegmatoid (IRUP) replacement bodies which subcrop below thin overburden cover as 20 m to over 300 in diameter magnetic features. Vertical displacements in coal seams at Karoo coal mines are usually associated with sill-breakthrough features, in which otherwise conformable sills suddenly break upwards into the hanging wall and then return to their normal elevations. The near-vertical breakthrough zone constitutes the magnetic mapping target. "Ultra" high-resolution surveys are those flown with flight-line separations of 25 m to 100 m and sensor terrain clearances of 10 m to 35 m. Pioneering work in 1979 by the Geophysical Department of the Johannesburg Consolidated Investment Company (JCI) led to the first surveys of this type in Southern Africa, airborne survey parameters being based on modelling of ground magnetic and palaeomagneticn data. Initial mapping predictions were confirmed from field aeromagnetic mapping results. While such surveys have been flown in RSA for the past 25 years, incremental technological advances including rapid sampling magnetometers and GPS real-time navigation, plus directly measured horizontal and vertical gradient data, now allow for the acquisition of airborne data having a spatial mapping resolution which approaches that of ground surveys. An added benefit is the near-absence of surface geological and cultural magnetic noise features which degrade many ground surveys. The mine-planning benefits and limitations of high-resolution aeromagnetic surveys are demonstrated via examples taken from platinum mines in the Rustenburg area of the Western Bushveld, and from coal mines in the Witbank and "Eastern Transvaal" coalfields of Mpumulanga Province. Benefits mainly pertain to the rapid cost-effective mapping of weakly magnetic IRUP, dyke and sill features, exemplified by the coal-mine case of 2 m thick dykes carrying less than 0.5% magnetite: target subcrop positions are mapped to better than 10 m precision on mine plans and can be classified as to dip geometry. Limitations relate mainly to the observation that not all platinum mine and coalfield loss-of-ground features are magnetic, and coalfield interpretation problems in correctly identifying and interpreting certain sill-breakthrough features. Historical and recent palaeomagnetic sampling of Bushveld and Karoo stratigraphic and intrusive units indicates the dominant role of remanent rather than induced magnetisation, which has significant implications for dip modelling of magnetic anomalies. Koenigsberger ratios range from 1 to over 40, with dykes, IRUP replacement bodies and many stratigraphic units showing either positive or reversed polarities. Case histories illustrate the by now essential roles of

image processing and other magnetic data enhancement techniques in the loss-of-ground target delineation phase and emphasise the importance of acquiring representative palaeomagnetic data as an aid in the final quantitative interpretation phase. The latter yields estimates of depth, width and dip for the intrusive bodies, such that their plan-position intersections with underground levels can often be confidently predicted.

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