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Optimizing the exploration of hydrothermally enriched calcium carbonate bearing faults using geophysical methods: Implications to resource estimation

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A study to find geophysical techniques that can optimize the exploration of hydrothermally enriched carbonate bearing fault zones near Marble Hall in Limpopo, South Africa was conducted by the Council for Geoscience in 2012. Hydrothermal origin calcite and sulphides in the country rocks is possibly due to the diorite intrusion in the vicinity of Marble Hall [1]. Ground magnetics; frequency domain electromagnetics, electrical resistivity tomography (ERT) and radiometrics were assessed. The fault and fracture system having a control on the carbonate enrichment processes were rapidly mapped by the magnetics method. CaCO3 enriched ore bodies appear as sharp and distinct high to very high resistivity zones with drill holes BH19F and BH19EF correlating strongly with the ERT results in contrast to the surrounding low resistivity serpentinized dolomites and dolomitized shales. Analysis of the borehole assays indicate that CO3 enrichment is associated with near zero K oxide percentages. There is a direct relationship between radiometric K % and Th (ppm) results and laboratory measured depletion in K oxide percentage and this warrant more research and calibration techniques. Terrain conductivity and radiometrics show coherent patterns in zones suspected to be enriched with carbonates though it is not possible to say whether these areas are within fault or fracture systems without reference to magnetics or ERT. In general the carbonate enriched faults are associated with intense magnetic fabric patterns possibly indicating deformation both on a localized and regional scale, inflexion points towards decreasing terrain conductivity, coinciding sharp and localized low K % and low Th (ppm) assays as well as medium to very high resistivity adjacent to or cut by faults and pyrite bearing fractures. The interpreted magnetic shear/deformation zones could be indicative of hydrothermal fluid flow channels and are confirmed by a 2D magnetic model. The ERT method proved most effective in mapping the carbonate enriched fault zones and has the advantage of providing high resolution lateral and depth subsurface information. Thus ore body characteristics may be deduced from the ERT results. Generation of 3D images of the subsurface is possible with ERT for parallel lines. However the method suffers slow deployment and is therefore recommended as a follow up on delineated magnetics, terrain conductivity and radiometric anomalies as the later have rapid coverage. With more sampling and borehole information for calibration purposes, the radiometric method has potential of becoming a quick, cheap and effective method based on K % as the boreholes are also sampled for their K oxide percentage. The strong correlation between magnetic modelling, results of the inversion of ERT data, sample drillhole logs and assay CaCO3 percentages provides a simple basis for resource estimation. This is based on assuming that a quick magnetic survey is run over the entire mineral rights area. This is then followed by modelling 2D or 3D to establish shear zone volume constrained by depth extent obtained from test boreholes and or resistivity. Coupled with a few more test holes, lab assaying and ERT lines for interpolation/extrapolation between drill holes the CaCO3 resource can be estimated at a very much lower cost.

References

[1] Graham, I.T., de Waal, S.A, and Marshal, B. (2004) Late-magmatic calcite-pyrrhotite-chalcopyrite mineralisation associated with magmatically-evolved diorite, Marble Hall, South Africa: South African Journal of Geology 107, 545-558.