Identifying the competence of delineating the subsurface extension of Eppawala apatite deposit using magnetic survey

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Abstract— Host rock of the Eppawala apatite deposit is suggested to be a carbonatite in origin, which has been intruded and altered over the geological time. The high apatite/phosphate occurrences are demarcated by hillocks revealing the weather resist character of apatite formations.

One of the associated minerals of apatite is magnetite, and a high concentration of magnetite has been observed at the fringe of the apatite occurrences within the carbonatite host. The same character is a common phenomenon in many rock-phosphate deposits throughout the world.

A magnetic survey has been conducted to identify the magnetite concentrations at the fringe of the apatite deposit selecting two specific areas of interest within the deposit. The collected magnetic intensity data were corrected for diurnal variations and resultant anomalies were extracted. In this the anomalous area in deposit was marked as positive and negative anomalies. To remove overlapping 3D analytical signal maps were constructed and it shows the exact anomalous area in the study site.

Anomaly and the 3D analytical signal reveal that the magnetic survey technique is reliably applicable to identify magnetite and it can be indirectly apply to demarcate apatite body.

***Keywords*—**3D analytical signal, apatite deposit, magnetite, magnetic anomaly, magnetic survey

I. Introduction

Mineral exploration is one of the main target areas in exploration Geophysics. Quantifying the known mineral reserves and identifying hidden resources is an integral part of the development of the national mineral wealth that generates revenues to the national economy.

Eppawala apatite occurrences are one of the major non-metallic mineral rescores that has not been fully explored with its resource extension and economic potential. Magnetic method is a very successful approach for exploring of mineral deposits with magnetic signature, which is a measurement of magnetic minerals of the host body. Ferrous mineral content of rocks produces an induced field due to the influence of the Earth's geomagnetic field. The vector sum of two fields; induced and the Earth magnetic field makes the magnetic anomaly [1].

This method is commonly used for mineral exploration in many countries though Sri Lanka is yet to apply the same in detail. Despite few attempts on iron-ore deposits, this method has never been applied for identifying any other mineral commodity such as apatite. Instead, identifying the subsurface extension of mineral deposits is largely based on surface mapping assisted by drill-holes, which is costly and time consuming [3]. This is an attempt to assess the applicability of geophysical techniques, particularly magnetic method, in demarcating apatite extension in selected area within Eppawala deposit.

Apatite usually occurs along with magnetite and the cooling history of the geothermal (or carbonatite) emplacement produce zonation in apatite and magnetite minerals [4]. The co-existence of apatite and magnetite is a common feature of the phosphate deposits. In general high magnetite concentration is observed at the rims of the deposit as a result of zonation [2]. To test the applicability of magnetometer surveys in screening apatite occurrences, Eppawala phosphate deposit was selected as a pioneer project.

A. Materials and methods

GSM-19 portable high-sensitive magnetometer system was used to conduct the survey. The rowing component of the system, which is integrated with a GPS (Global Positioning System) receiver, was deployed in the field for raw data acquisition while a base station is maintained at a fixed point in the vicinity of the survey to identify the time dependent variations of the total magnetic field within the survey area.

B. Survey Planning

Two survey plots were considered for this study where phosphate mining has been carried out. In southern study site, the mining process has already completed, and the fringe of the mine consists of apatite bearing host rock. Northern study site is presently in operation and opencast mining is conducted

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with heavy equipment. The terrain conditions of this site is not permitted to acquire raw data along parallel lines, which is preferable a norm in a magnetic survey, hence data were collected in a random manner. Base magnetometer was installed in the noiseless area within the survey site at the close proximity.

II. RESULT AND DISCUSSION

A. Review Stage

The Northern study site magnetic anomaly map (Figure 1) revealed that the mined area (B) has no any significant natural anomaly. There were two clear anomalies, but they were manmade objects viz; a metal crusher and a metal building. In untouched area there was a very clear magnetic anomaly spread over the area.

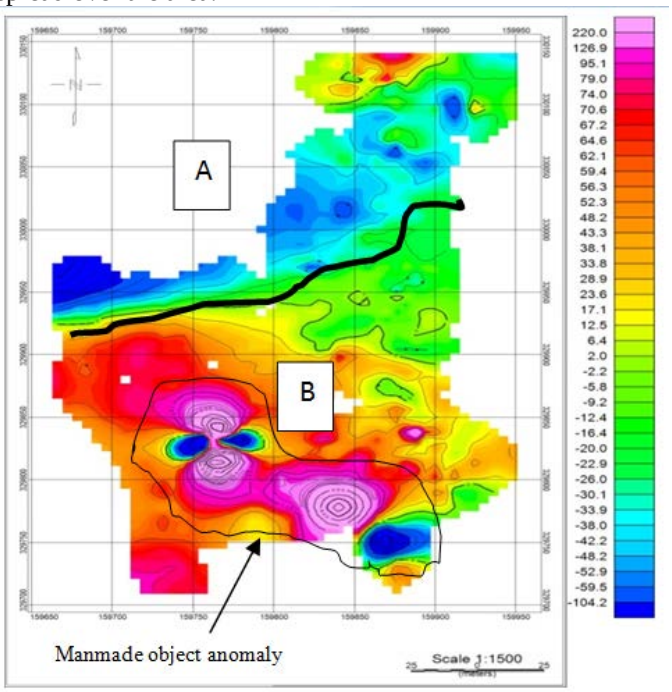

Fig. 1 Magnetic anomaly map of Northern study site: A- un-mined area, B- mined area.

Magnetic anomaly over the southern site (Figure 2) revealed that there are some spheres like anomaly signatures in the mined area. These anomalies correspond to isolated apatite host rock that spread over the mining site. As of the Northern study site, un- mined area of the Sothern study site reveal interesting anomalies over the body.

When considering the Earth magnetic pole, the magnetic North pole is aligned nearly with the geological South Pole. When an object in which ferrous is present is placed, the edge of the object located towards the magnetic North will be induced as negative whereas the other edge will be induced as a positive. This is the reason for forming high negative and positive anomalies. When these ferrous include objects are placed as a sheet like feature, the edges which presumably the fringes of the deposit induced whereas the central part was magnetically quite compared to the fringes. The isolated magnetite intrusions always give the bell shape anomalous magnetic signature that is comparable to the signature of a buried sphere.

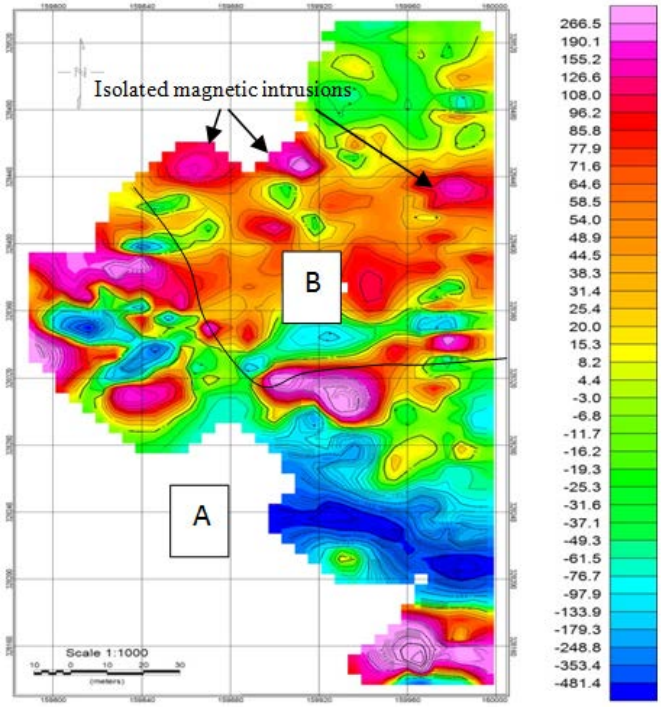

Fig. 2 Magnetic anomaly map of Southern study site: A- un-mined area, B- mined area

In some cases anomalies may have been cancelled out due to close coincidence of positive and negative shoulders of the anomaly. To eliminate this and extract anomalous area, 3D analytical signal were used, as it is a measure of magnetic strength in three orthogonal directions. It gives only positive values and it can be used to extract anomalous area.

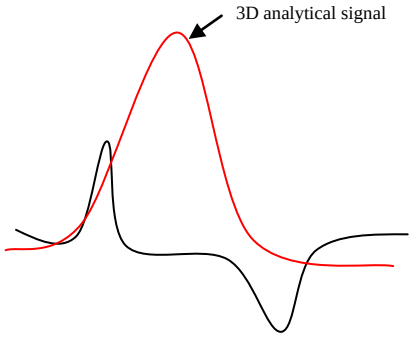

Fig. 3 3D analytical signal formation

Figure 4 and 5 shows the 3D analytical signal maps of the Northern and the Southern deposits. These figures give exact anomalous area in the study site. Figure 4 implies that there are some magnetite intrusions at Southern mining site which has been abandoned years ago indicating that there are some apatite - rich carbonatite remains in the subsurface though not fully exploited. Northern deposit also has some potion of magnetite rich apatite. But it is smaller than that compared with the Southern site. Figure 5 implies that the currently mining area is not rich in apatite.

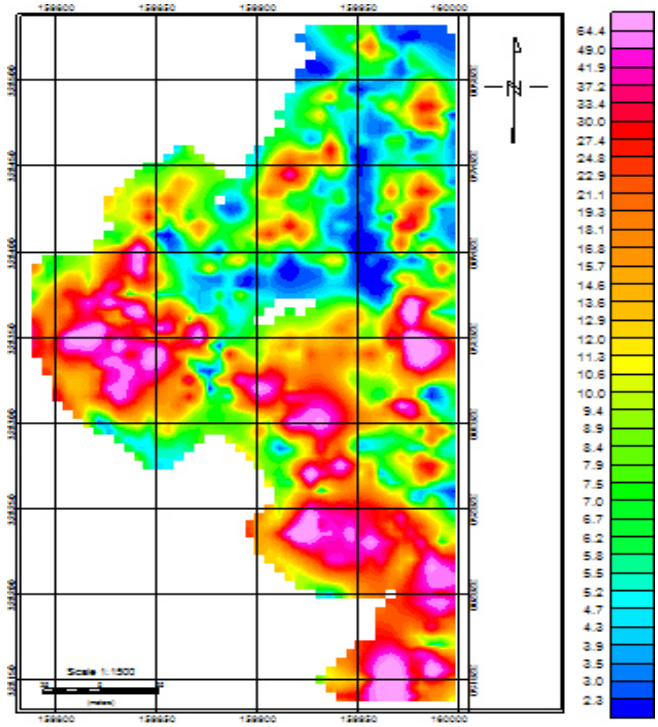

Fig. 4 3D analytical signal map of Southern study site

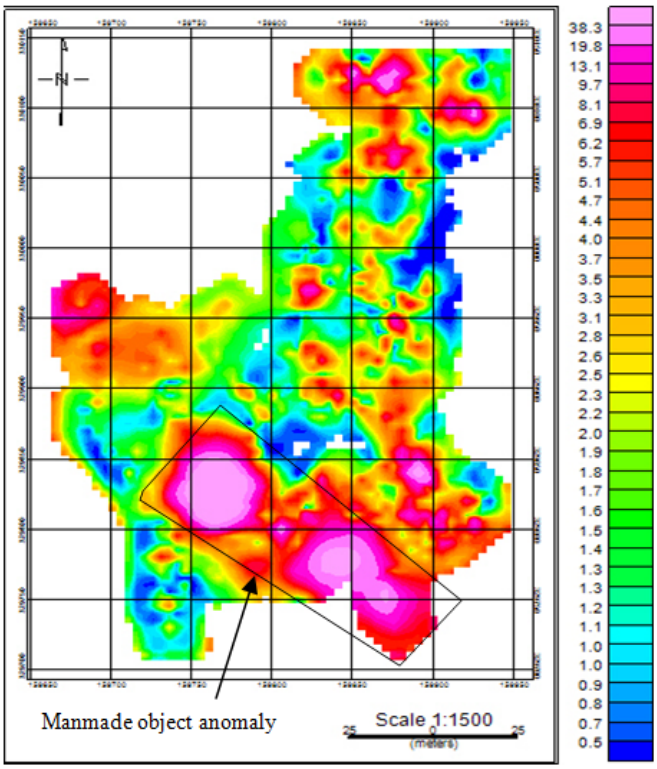

Fig. 5 3D analytical signal map of Northern study site

III. CONCLUSION

Magnetometer survey can be successfully employed to demarcate apatite occurrences when they co-exist with magnetite mineral.

Anomaly map can be used to get rough idea about shapes of the apatite ore.

3D analytical signal technique enables one to demarcate the periphery of the apatite occurrence with possible subsurface extension. Subsequently it would be possible to roughly estimate the monetary value of the apatite ore.

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