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Identifying potential mineralisation targets through airborne geophysics – The Western Papua New Guinea Case study

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SUMMARY

Over the last few years exploration activity in Papua New Guinea (PNG) has declined to alarming lows that the Mineral Resources Authority (MRA) has introduced initiatives to acquire new geo-scientific datasets to enhance exploration in the country. One such initiative has been the 30,000 plus line kilometre airborne magnetic and radiometric survey over the western part of the country. The airborne survey was strategically located between the large Ok Tedi porphyry copper-gold mine and the advanced Frieda River porphyry copper-molybdenum prospect. The airborne datasets were acquired at a north-south line spacing of 500m with a Tie-line spacing of 5km and at nominal terrain clearance of 100m.

The main aim of the airborne geophysical survey was to identify magnetic and radiometric anomalies that may be further investigated for their mineral potential. Preliminary results of the airborne survey show large deep-seated NW-trending fault systems cross-cut by north-east trending transfer structures that may have contributed to mineral deposition in the region. Several magnetic and radiometric anomalies located within the periphery of existing prospects also have the potential to substantially increase resource values, while isolated anomalies may indicate new targets for further exploration.

While this paper highlights some of the interesting magnetic and radiometric features defined from the WPAGS, the release of the datasets now ensures investors have an extra layer of information to build on the mineral potential of the surveyed area. It is anticipated that the results from the survey will not only boost interest to explore in the area, but also drive exploration activities in the area to new heights, hopefully resulting in the identification of new mineral prospects.

Key words: Aeromagnetic, anomalies, structures, prospects.

INTRODUCTION

The central cordillera of the New Guinea mainland is host to a number of world-class mineral deposits. These include the giant Grasberg porphyry copper-gold mine (>1000Mt) in Papua Province of Indonesia, the gold-rich Ok Tedi porphyry copper (900Mt) project and the Porgera gold mine in Papua New Guinea (Fig. 1) The zone also hosts potentially large deposits such as the Frieda porphyry copper-gold, Yanderra porphyry copper-molybdenum and Wafi-Golpu porphyry copper-gold project. The discovery of all these mineral prospects make this central zone a highly prospective province for mineral exploration. It was with that conviction that a large airborne geophysical survey was flown for the Mineral Resources Authority, in an area between Ok Tedi and Frieda River, with the hope of identifying magnetic and radiometric anomalies, which could be further investigated as mineral prospects.
In this paper we discuss preliminary results of this survey, and how the datasets may be used to identify more mineral prospects within the survey area. Firstly we identify magnetic and radiometric anomalies similar to responses due to the Ok Tedi and Frieda River mineralisations. Then we use the ratio of Th/K (eg, Markandeluyu et al., 2013) to identify targets that may be potential porphyry targets for further geological investigations.

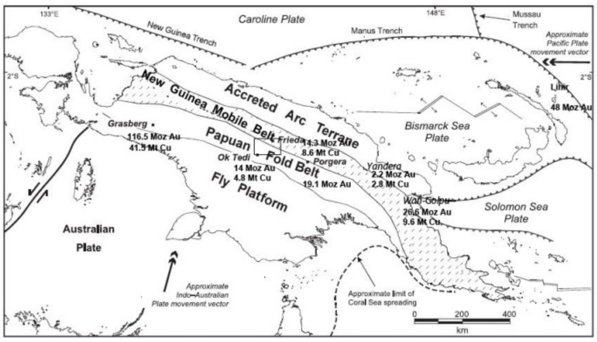

Figure 1. Large mineral deposits within the New Guinea Mobile Belt. Rectangle outlines airborne survey area boundary.

GEOLOGICAL SETTING AND MINERALISATION

Tectonic Setting

The Island of New Guinea which encompasses Irian Jaya to the west and Papua New Guinea to the east, comprises of late Cretaceous-Palaeogene intraoceanic island arc complexes of the Pacific geology lying north of the mainland while its southern margins comprises Mesozoic-Cainozoic shelf sediments overlying a Palaeozoic crystalline basement of the Australian continent (Pigram and Davies, 1987). Major deformation in the Tertiary due to the Oblique convergence of the northward-moving Australian Plate and the west-northwest-moving Pacific Plate, induced tectonism, related metamorphism, ophiolite obduction and uplift (Dow, 1977). Ongoing collisions resulted in developments of several microplates at the margins of the Australian Plate and the Pacific Plate. These microplates, also referred to as accreted tectonostratigraphic composite terranes (allochthonous) occupy the northern portion of the island while the southern part remains autochthonous of the Australian craton (Davies, 2009). Offshore features of these plate boundaries are marked by spreading ridges, deep-sea trenches and transform faults while those onshore are indicated by thrust, extensional, and strike-slip faults and folds (Davies, 2009).

Regional Geology

The Western PNG border geophysical surveyed area is located within the northern and southern flanks of the Blucher Range and Mianmin 1:250 000 geological sheets respectively (Fig.2). The area is within the New Guinea Thrust Belt and within the Central Cordillera of the New Guinea Mainland. The New Guinea Thrust Belt is a major foreland thrust belt (Rogerson et al, 1987b) bounded by the Torricelli and Finisterre terranes to the north, the Aure Fold Belt to the east and the Papuan Fold Belt to the south (Rogerson, et al., 1987b) and continues west into West Papua as the Tahin Fault (Davies, 1911).

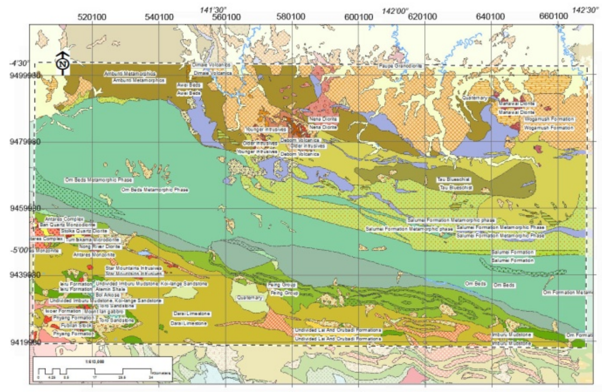

Figure 2. Geology of the survey area. Boundary of the survey area is marked by dashed boundary.

The New Guinea Thrust Belt represents crustal-scale thrust faults such as the Lagaip, Fiak-Leonard Schultz and Bundi Faults which are E-W system of anastomosing low-angle faults and are hosts to fragments of obducted oceanic crust (Sheppard and Cranfield, 2012). The belt is characterised by late Miocene, sub-horizontal to shallowly north-dipping, stacked thrust sheets of regionally metamorphosed and strongly cleaved Triassic to Eocene fine-grained sedimentary rocks and minor volcanic rocks (Sheppard and Cranfield, 2012). Predominantly low-grade metasedimentary rocks occupies the northern flank of the central range of the belt and are the hosts to the extensive Maramuni Arc magmatism, while a northern zone of medium grade metamorphic rocks probably related to the Tasman Orogen, forms the low mountain ranges surrounded by the Sepik Plain and the host to the Sepik magmatism (Sheppard and Cranfield, 2012).

Mineralisation

Mineralisation with notable deposits and prospects in the New Guinea Thrust Belt includes the lateritic Ramu nickel-cobalt mine, intrusion-related gold and copper mineralisation such as Frieda River (copper and gold), Yandera (copper, molybdenum and gold) and Kainantu (gold). A significant number of alluvial gold deposits (Jimi Valley, Simbai areas and foot hills of central cordillera and across South Sepik region), including sub-economic volcanic-hosted massive sulfide (VHMS) mineralisation also occur in this region.

Two main intrusion events are responsible for gold and copper mineralisation within the belt. The older Sepik Event (30-20 Ma) is the hosts to mostly small to medium size deposits, with some high grade gold occurrences being present, but most of the prospect remains under-explored, with only limited drilling of targets. The younger Maramuni Event (<17 Ma) represents the main period of magmatism and related mineralisation on Mainland Papua New Guinea and forms a 40-60km-wide belt of intrusions stretching for 750 km from the Indonesian - PNG border to the Wau district south of the Huon Gulf (Sheppard and Cranfield, 2012), and sporadically into the offshore Papua Islands (e.g. Woodlark Island). Mineralisation related to intrusions of intermediate composition of the Maramuni Event occurs along the whole length of the belt (Sheppard and Cranfield, 2012). Much of the Cu-Au mineralisation in this region maybe associated with Pliocene intrusions that overprinted the earlier Miocene intrusions (Rogerson and Williamson, 1986).

AIRBORNE GEOPHYSICS

In 2015 GPX Surveys Limited acquired over 30,700 line km of airborne magnetic and radiometric data over the western part of Papua New Guinea, in an encompassed by coordinates 4.5 – 5.25 degrees south and 141.02 – 142.51 degrees east. The survey area links two very prominent Papua New Guinea mining projects, the huge Ok Tedi porphyry copper-gold mine on the south-western flanks of the survey area, and the Frieda River copper-gold-molybdenum project on the northern flanks. Outside of the survey area, there is the giant Freeport copper-gold project in Indonesia's Papua Province to the west, and to the east, a host of other large mineral projects such as Porgera (Au), Ramu (Ni-Co) and Hidden Valley (Au) mines, and the advanced Wafi-Golpu (Cu-Au) project. Indeed the survey area is strategically located in an area that has the potential to host another major discovery. Hence acquiring the airborne magnetic and radiometric data was aimed at driving the exploration activities within this part of the country.

Magnetic Signature

The magnetic signature (Figure 2) of the survey area is characterised by a three broad magnetic features; a broad intermediate magnetic response mostly in the central area; a highly magnetic zone to the south and a zone of intermediate magnetic basement with highly textured magnetic signature to the north. All magnetic structures are orientated in a NW-SE trend except at the eastern central part of the survey area where there is a east-west orientation in the magnetic structure.

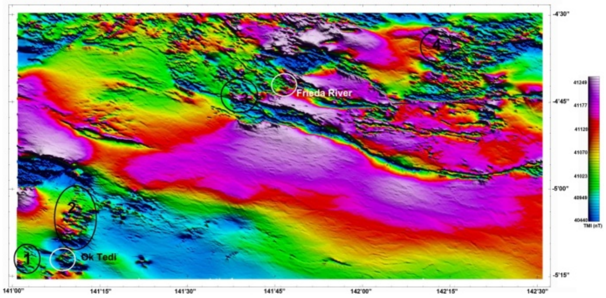

Figure 3. Reduced-to-equator total magnetic map of the survey area, showing locations of Ok Tedi porphyry copper-gold mine and the Frieda River porphyry copper-gold prospect.

The total magnetic intensity image of the area shows quite a few magnetic anomalies which appear to be associated with a major shear and cross-cutting transfer faults. These anomalies may be targeted for further exploration. This is especially so for the southern area between latitudes -5' and -5'15" and longitude 141' and 141'30". The numerous magnetic anomalies, attributed to dioritic intrusions, lie within a northeast-trending structures, the Ok Tedi transfer (Hill et. al., 2002) and terminated to the north by the Muller anticline, The Muller anticline also appears to have some controlling effects on other magnetic, which appear parallel to the Muller anticline.

Radiometric signature

The radiometric signature of the survey area is represented by the RGB ternary image in Figure 3. The image shows a clear distinction between the metamorphic rocks of the north to the clastic units (uranite-rich) of the south. The ternary image of the central corridor suggest a geological which probably has a good mixture of the three main radioelements, given that it is more lighter in colour composition.

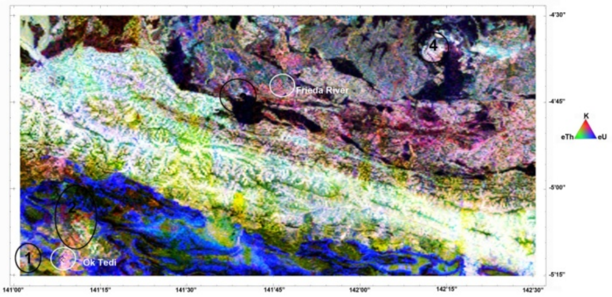

Figure 4. RGB ternary image of the Western PNG airborne radiometric dataset, displaying more ultramafics to the north compared to carbonates of the south.

Discussion

The magnetic anomalies which are manifested by the Ok Tedi and Frieda River porphyry copper systems appear to be part of several magnetic anomalies that appear to have been formed within some sort of structural limits (Figure 3). The Ok Tedi signatures suggest a north-south structural alignment whereas the Frieda River anomalies appear to have been formed around a circular structure. The many magnetic "blobs" signatures in both areas suggest that there had been numerous magmatic intrusions within the structural confines of the Ok Tedi transfer and around the boundary of a large perhaps plutonic intrusion (for Fried River). Both mineral prospects are characterised by ternary radiometric signature ofeten associated with felsic intrusions, a common trait of many porphyry copper deposits.

In order to determine the possibility of finding other porphyry intrusions within the survey area we have used the ratio of thorium to potassium (Figure 5) on applied that on to the targets identified from the magnetic and radiometrics (Figure 3 – 4). Figure 5 shows that Ok Tedi and Frieda River porphyries have pronounced low Th/K signature within high Th/K surrounds. The low Th/k ratio indicates elevated potassic alteration, which often occurs during mineralisation. The surrounding high Th/K may suggest very little dilution of thorite contained in the surrounding host rock.

By applying the Th/K ratio over the target magnetic and radiometric signatures, we find that two of the four anomalies display high Th/K ratios (1 & 4) while the other two display low ratios (2 & 3) similar to those displayed by Ok Tedi and Frieda River anomalies. When we look at the ternary radiometric signatures of these low Th/K anomalies, the similarity with the existing mineral prospects is not so obvious. Perhaps only anomaly 2 comes close to displaying ternary radiometric signature similar to Ok Tedi and Frieda River.

The intrusive units which give rise to the magnetic response marked as Target 4 register high contents of all three radiometric channels. Their corresponding Th/K ratio, however, suggest very little advanced potassic alteration. This has significant bearing on the mineral prospectivity of these intrusive units, suggesting perhaps, that they may not be host to any porphyry mineralisation.

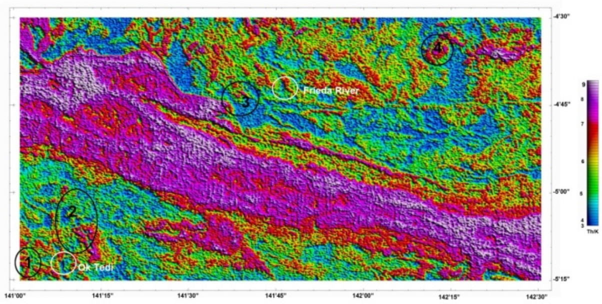

Figure 5. Ratio of Th/K used to define areas of enhanced potassic alteration patterns.

Target 3 displays elevated response from all three elements, and is interesting because the response appears to be located on the boundary with an ultramfic unit, suggesting that the resulting radiometric signature may be in response to alteration due to metamorphism. There are some parts of the anomaly that display advanced potassic alteration, and hence may be host to potential mineralisation.

Target 2 displays radiometric signatures associated with felsic intrusions, with Th/K ratio of the northern part of the anomaly, suggesting enhance potassic alteration. This anomaly may be an extension of the Ok Tedi porphyry system and therefore requires further geological investigations.

Target 1, just to the southwest of Ok Tedi has all the characteristics of an intrusive body, and its proximity to the Ok Tedi porphyry system, makes it a highly prospective target for a mineral deposit. Its high Th/K ratio, however, suggest very little potassic alteration, indicating that it may not be a good candidate for a porphyry deposit.

Some magnetic anomalies are not visible from the radiometric datasets. This is especially so for those to the east of the Ok Tedi porphyry deposit. This implies that these magnetic sources are quite deeply buried within the carbonate sequence that their alteration patterns cannot be reliably determined using the Th/K ratio. In such areas the Th/K ratio remain quite high, suggesting very little potassic alteration activity.

CONCLUSIONS

The high resolution airborne magnetic data shows a distinct character for the known deposit of Ok Tedi and Frieda River. Similar characterisitics, when the entire survey has been interpreted, can be seen in other areas of the survey area. The magnetic data also highlights the structure in the area typically NW-SE except for the central block that has a E-W orientation. The radiometric data, which is showing the surface expression, combined with the magnetic data is achieving its goal of identifying furture prospects and extending the prospectivity around know deposits. It has added to the regioal geological story and allowed more detailed mapping in areas that are difficult to access.

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