ASEG-PESA 2013
'THE EUREKA MOMENT'
11-14 AUGUST 2013 • MELBOURNE, AUSTRALIA

Airborne Magnetic and Radiometric Geophysical Mapping in South and Central Range Mountains, Papua Indonesia.

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SUMMARY

The Center for Geological Survey (CGS) of Geological Agency, Indonesia, known as Pusat Survei Geologi, commissioned an airborne magnetic and radiometric survey covering the Indonesian Papuan Central Highlands Region and the southern side of the highlands during 2010 and 2011. The survey was funded by the State Revenue and Expenditure of the Ministry of Energy and Mineral Resources of The Republic of Indonesia and covered an area of 156,964 square kilometres. Geological mapping in this area is recognised as being difficult predominately due to the extreme terrain and weather. The objective of the survey was to map the surface geology as well as sub-surface geology, identify and map the structure of the region, to model new geophysical data along with previously collected ground gravity data, and integrate all the results with the previously known geology. The expected outcome would be a better understanding of the geology and structure in the region and an increase in mineral and oil and gas exploration for Indonesia. The survey consisted of a helicopter based magnetic and radiometric survey in the Central Highlands Region at 500 m spacing totalling 20,045 km and a fixed-wing aircraft based magnetic and radiometric survey over the south side of the highlands at 1,000 m spacing totalling 155,530 km. The results highlighted and extended the geological, structural, and tectonic evolution knowledge of the region and identified areas for further mineral and oil and gas exploration. The modelling of the magnetic and gravity data supported the interpretation and added further information to the depth analysis of the data.

Key words: Papua, Airborne, Magnetics, Radiometric, Indonesia

INTRODUCTION

In 2010 and 2011 the Center for Geological Survey (CGS) (Pusat Survei Geologi), Indonesia awarded a contract to PT Intan Angkasa Air Service JV GPX Surveys Pty Ltd to fly an airborne magnetic and radiometric survey in Papua, Indonesia over the Central Highlands Region and the southern side of the highlands.

Ground gravity surveys had previously been conducted by CGS in cooperation with Australian Bureau of Mineral Resources (BMR) (now Geoscience Australia) over a number of periods during 1979-1982, and further work was completed in 2007 by CGS. However, previous geological mapping had been difficult and limited, due to the mountainous regions, the swampy low lands and the extreme weather conditions. It had been compiled using aerial photography, ground mapping and gravity data.

The survey consisted of a total of 155,530 line km covering an area of approximately 156,964 square kilometres. (Figure 1) All data was processed in Indonesia and CGS began the interpretation phase which included structural interpretation, geological analysis and modelling of the geophysical data.

The results show more detailed mapping of the geology and structure of the region than previously known. Also the data and interpretation show new areas of interest for mineral and oil and gas exploration and have resulted in CGS flying further surveys in 2012 in Maluku and Kai island regions of Indonesia.

Figure 1. Survey Location (outlined in red)

METHOD AND RESULTS

The airborne magnetic and radiometric survey was flown with a Piper PA-31 fixed-winged aircraft and a series of Hughes MD500 and Bell 212 helicopters. The fixed-wing aircraft flew the low land areas with traverse lines North-South at 1,000 metre spacing and tie lies east-west at 10,000 metre spacing. The survey was conducted at a flying height of 100 metres. A total of 155,530 km fixed-wing and 20,045km of helicopter survey was completed over 2010 and 2011.

Geologically, the low lying area in the southern side of the highlands form a part of the Arafura Platform that is included inside the North Australian Continent (Dow, et al, 1986). This area is covered by alluvial sediments and in most part is swampy in nature. Regional geology shows that it is covered by thick Pre-Tertiary to Quarternary sediments (Dow, et al, 1986, Sukamto, et al, 1996).

The tectonic process of two major plates, Australian Continent from the south and the Pacific Plate from the northeast formed the Papua Central Ranges, with the Pre-Tertiary sediments outcropping. Drillhole data has shown that the Pre-Tertiary sediments underlay this area. The previous gravity and the new magnetic data also highlight the occurrence of the basement undulation in the direction of north to south.

With the newly acquired magnetic data, Total Magnetic Intensity (TMI) (Figure 2), Reduction to the Pole (RTP) and other images were produced as part of the project and were a basis for the regional interpretation.

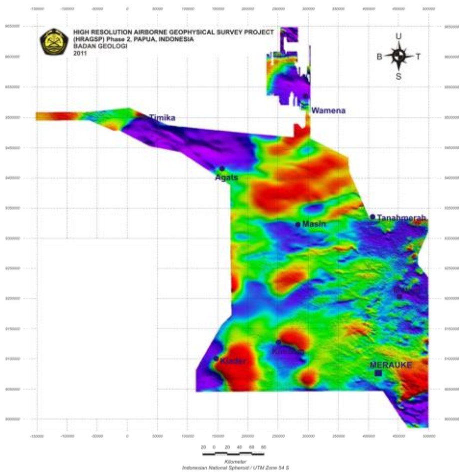

Figure 2. TMI Image of Survey Area

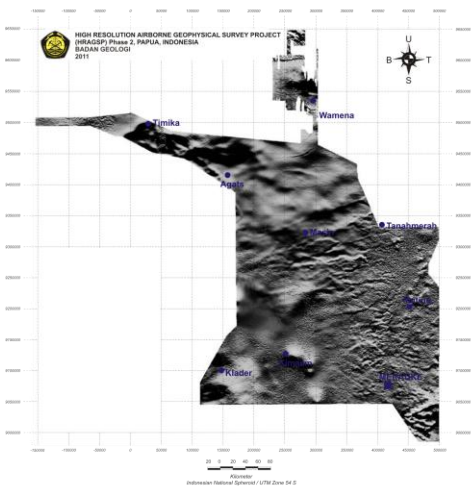

Figure 3. TMI First Vertical Derivative Image of Survey Area

A number of the enhancements were applied to the magnetic data such as First Vertical Derivative (1VD) (Figure 3) analytical signal and second vertical derivative (2vd) to assist in delineating the more high frequency information in the data set. The different images and filters applied to the data helped map basement geology, delineate intra-sedimentary structure, and map distinct lithology off-sets and the structural lineaments that were associated with these off-sets. The information gained from the magnetic data showed detail that was not visible at surface or found in the limited drill holes in the area. The data further defined the contact boundaries of basins including Arafura, Sahul and Akimeugah basins and their structural relationship with each other.

Initially regional structural information has been interpreted using the derivative enhancements (Figure 3 and 7). The added structural information at a regional scale especially in the low lands has been significant.

The newly acquired magnetic data was modelled with the gravity data to quantify the interpretation and look at the data and geology in cross section. The previous gravity data had mapped the Australian Continental Crust, whilst the newly acquired magnetic data also mapped the Pre-Tertiary rocks as well (Figure 4).

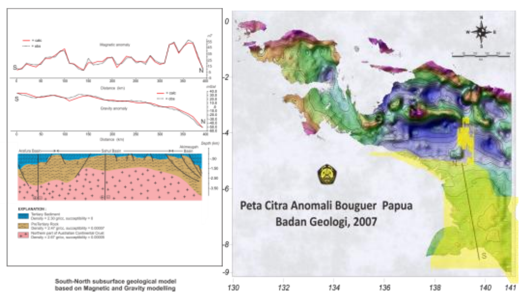

Figure 4. Model of the magnetic and gravity data with location of the line profile, overlaying the gravity Bouguer map of Papua.

The interpretation of the magnetic data is ongoing and the work done to date has only just scratched the surface. The interpretation has been completed at a regional scale however the magnetic data has the resolution to be interpreted in more detail.

The radiometric data showed the difference in the lithology at surface in the central highlands compared to the southern lowlands. Many of the river channels were Potassium rich to the west due to the weathering of the highlands and the subsequence alluvial deposition of the sediments. In the east region of the low lands the radiometric response changes to a relative high uranium and thorium response with the alluvial channel showing the potassium highs. The uranium and thorium response could be due to the make-up of the swampy plains and the rivers reflecting the alluvial deposition of the weather material from the north. The change in the surface deposition/geology noted in the radiometric data is also reflected in magnetic data along a large NE-SW trending structure (Figure 5).

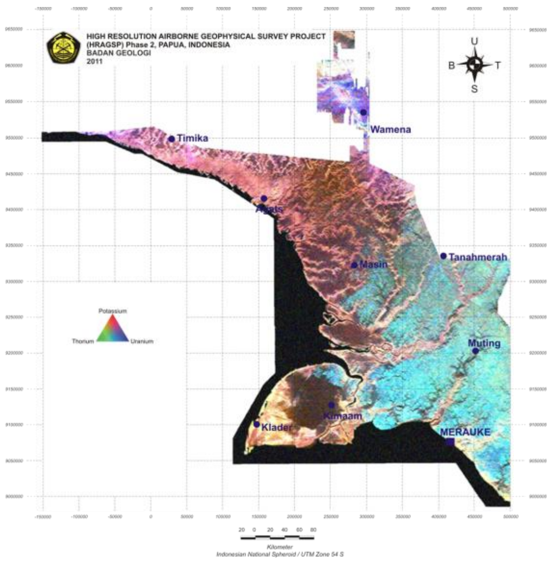

Figure 5. Radiometric Ternary Image of Survey Area

The interpretation results to date (Figure 7) show a greater understanding of the structural geology especially in the low lands. Previous mapped geology in the region was sparse (Figure 6) especially in the survey area. In the highlands, the structural information together with the radiometric mapping, has indicated that the area has a high prospectivity for mineral exploration especially similar styles to Grasberg. Further data is required to fully understand the structural picture in the highland region. The knowledge of the intra-sedimentary structural within the basins and the mapped basement topography has allowed the modelling to show the thickness of the sediments within the basement and therefore demonstrate areas of high prospectively for oil and gas deposits.

Further work is required as part of the interpretation to fully map the basement depth, structure and subsequent sedimentary thickness.

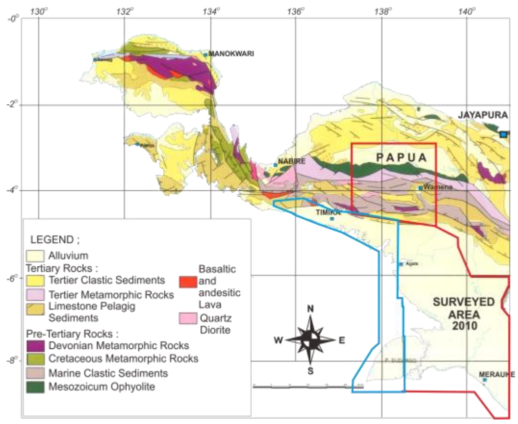

Figure 6. Previously Mapped Geology

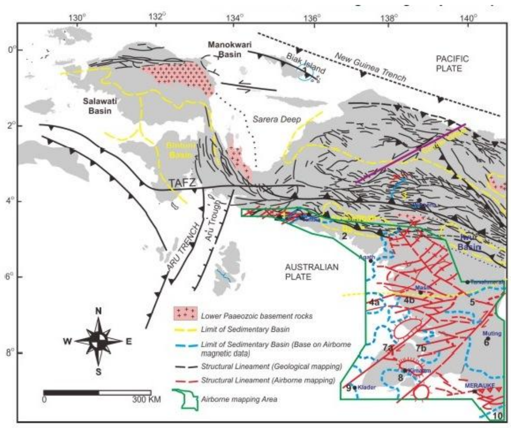

Figure 7. Preliminary Regional Structural Interpretation

CONCLUSIONS

The advantages of the airborne magnetic and radiometric survey to map the geology in regions with difficult access and harsh conditions, is immense. The results to date have unlocked geological knowledge that would have taken decades to map on the ground. The airborne survey was not without issue however, with weather being the main issue. Cloud, wind and rain were the survey's constant nemesis.

The interpretation process has only begun with a look at the data from a regional prospective. Further integration of the known geology is required, together with the quantitative analysis of the data. Depth analysis and where possible field verification can only add further benefit to the value of the data and the validity of the interpretation.

The airborne geophysical surveys, from a government perspective, has aided in the development of exploration for both minerals and oil & gas and generate a better understanding of the geology that can bring forth investment in one's country.

ACKNOWLEDGMENTS

This project would not have been possible without the support of The Head Of Centre for Geological Survey, Mrs. Sam Permanadewi, she inspired us greatly to work in this project. We also wish to express our gratitude to Committing Officer of this project, Mr. Edy Slameto for his partisipation and coordination in supporting the fund and facilities of the project. The support and help of many individuals and organizations are also gratefully acknowledged.

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