FALCON™, BHP Billiton's Airborne Gravity Gradiometer
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The BHP Billiton FALCON™ airborne gravity gradiometer is a breakthrough technology in the mineral resources industry. It is the first airborne system with the ability to detect gravity targets related to ore deposits and to collect high-resolution gravity data sets covering large areas that will provide new insights into buried geology and structure.

This capability has already been demonstrated over a number of known gravity targets associated with ore deposits, and FALCON™ has already discovered new diamondiferous kimberlite pipes at the EKATI™ project in northwest Canada.

There are currently two systems flying in Africa and the Americas with two more on order, the first to be deployed in Australia during 2002. BHP Billiton's business goal is share the benefits of FALCON™ through alliances and joint ventures and create new opportunities for the discovery of major deposits.

The Technology

FALCON™ resulted from a collaborative project between BHP Exploration and BHP Research to identify new reconnaissance technologies capable of seeing buried deposits in areas adjacent to known mineral provinces. Airborne gravity was identified, but in the 1980's there were no known technologies capable of meeting the stringent resolution and operational requirements of mineral surveying.

Technology developed for the US Navy in the 1970s by Bell Aerospace (now Lockheed Martin), became available for commercial application at the end of the "cold war". BHP Billiton entered into an exclusivity agreement with Lockheed Martin to develop instrumentation for deployment in a survey aircraft. After an extensive feasibility study, construction of two instruments commenced in 1996. The first system flew in 1997 and was deployed on survey work in 1999. The second instrument followed in 2000. BHP Billiton researchers developed all data processing and analysis software. The total cost of the project was A$30 million.

The Lockheed Martin gravity gradiometer has accelerometers with tangential sensing axes mounted on a slowly rotating wheel and measures differential curvature gradients. These non-intuitive components are transformed into the more common vertical gravity (Gz) and vertical gravity gradient (Gzz) during data processing to form maps.

The aircraft also records high-resolution magnetics, radiometrics and GPS location data. A laser scanner continuously records terrain clearance that is used to derive an accurate digital terrain model for removal of the topographic response from the gravity data.

The gradiometer has proved to be remarkably immune to turbulence and is able to effectively record data within the normal safety constraints of survey flying with few operational problems.

Target Detection

A variety of different targets have been flown since FALCON™ was first deployed. These include base metal deposits, iron ore deposits and kimberlite pipes. The size, density contrast and depth of the target determine the amplitude and dimensions of the associated gravity anomaly. The flying height and the system noise, from residual accelerations in the instrument remaining after data processing, set the fundamental limitation of the gradiometer.

Figure 1 shows a plot of vertical gravity gradient (Gzz) response versus the average gravity anomaly width for a variety of deposit types. Where there is FALCON™ data the actual anomaly characteristics are plotted. In other cases the values have been taken from published gravity data. The bands inside the axes show the schematic limits of detection determined by the flying height and the system performance.

Mapping Capability

The ability of FALCON™ to map bedrock geology is demonstrated by data collected for the EKATI™ project in northwest Canada. Figure 2 shows a map of the vertical gradient of gravity over an area 65 kilometres east west by 35 kilometres north south. The various bedrock units are clearly distinguishable in the data. Perhaps more surprising, dolerite dyke swarms are also clearly visible. Many of the dark circular responses are due to gravity lows over known kimberlite pipes.

Conclusion

The BHP Billiton FALCON™ airborne gravity gradiometer represents a new era in airborne reconnaissance exploration and will change our perception of gravity as an exploration tool forever. It is the result of a sustained effort to identify an appropriate technology and a well-managed research and development project to adapt it to the required application. BHP Billiton has a ten-year exclusivity agreement with Lockheed Martin over the technology and is actively seeking to create new opportunities by making the system available to the industry through innovative commercial arrangements.

Acknowledgement

FALCON™ is the result of the efforts of a number of people who worked on the FALCON™ project team over a number of years backed by BHP Billiton to project completion. Their efforts are acknowledged along with the permission of BHP

Billiton to present this paper.

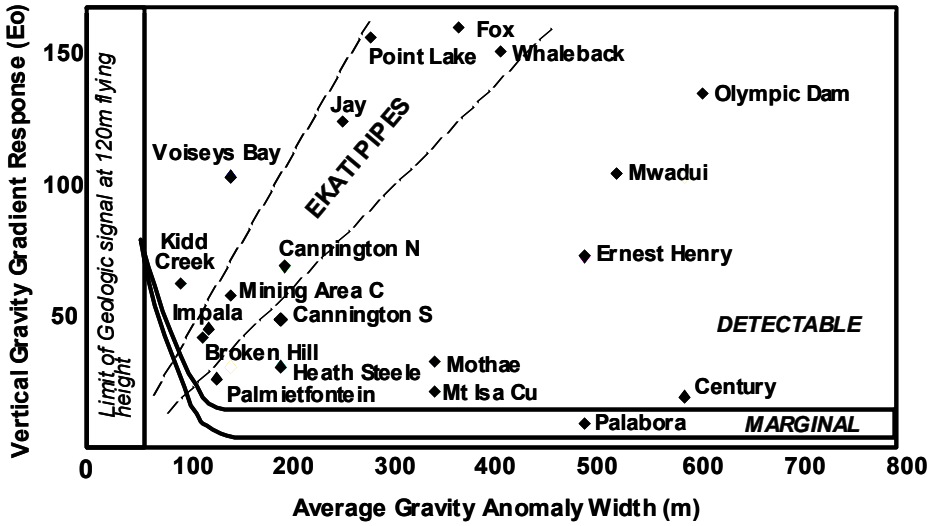

Figure 1. Deposit detection capabilities.

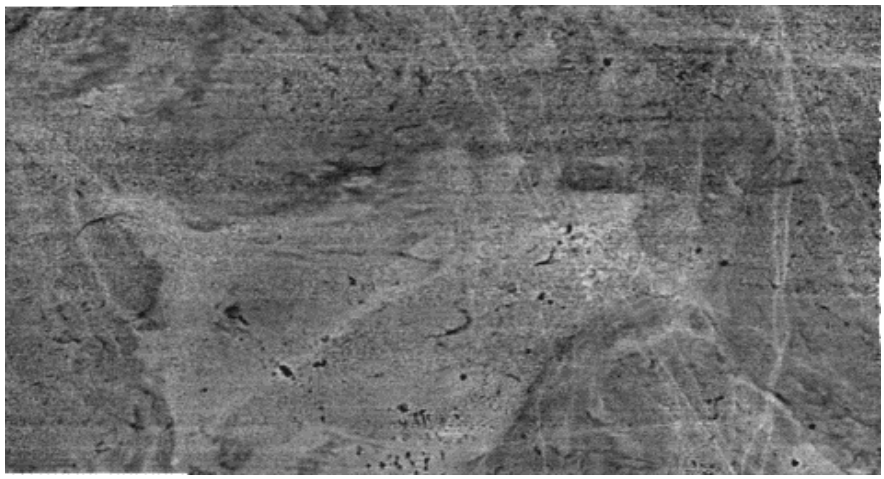

Figure 2. Vertical gravity gradient, EKATI^{TM} survey showing geological units, dykes and kimberlite pipes. The area is 65 km by 35 km.