ASEG-PESA 2015
Geophysics and Geology together for Discovery
24th International Geophysical Conference and Exhibition
15–18 February 2015 Perth, Western Australia

Geophysical Responses over the Cannington Ag-Zn-Pb Deposit-Queensland

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SUMMARY

The Cannington deposit is a high grade Ag-Zn-Pb deposit found in 1990 by BHP Minerals drilling an isolated 1,000 nT aeromagnetic feature. Following the discovery of Cannington, numerous airborne, ground and borehole surveys have been carried out which overall, provided some assistance at better defining the ore system but did not lead to the discovery of new major deposit in the area.

While Cannington possessed a clear magnetic response, the presence of a thick conductive cover made the use of EM and electrical techniques challenging. BHP used Cannington as a test ground for a variety of new techniques including a ground SQUID EM sensor, modified airborne EM technology (higher power and lower base frequency) and over 10 years after discovery, the first ever Falcon airborne gravity gradiometer survey in Australia.

Key words: aeromagnetics, Cannington, minerals discovery.

INTRODUCTION

The Cannington orebody is located 200 km SE of Mt. Isa (QLD), Fig. 1, and has been in production since 1997. The deposit had a total resource of 43.8 million metric tones (pre-mining) grading 11.6 percent lead, 4.4 percent zinc, and 538 ppm silver (Walters et al. 2002) and is currently the largest producer of silver in the world. Cannington was discovered by BHP-Utah Minerals International (BHP) in 1990 during the testing of a distinctive aeromagnetic feature defined in the course of a multi-year exploration program aimed at finding Broken Hill-type (BHT) analogues in the Eastern Succession of the Proterozoic Mt Isa Inlier (Walters et al. 2002).

The Cannington deposit does not outcrop but is covered by a veneer of Cretaceous mudstones with a thickness varying from a few 10s to over 100 meters. This layer impeded the use of mapping and geochemistry and so following the discovery of Cannington, a series of geophysical surveys were carried out so as to ascertain apart from magnetics what techniques might be used to find similar deposits. Some of the work was performed shortly after the discovery, whereas other surveys were carried out over a decade later.

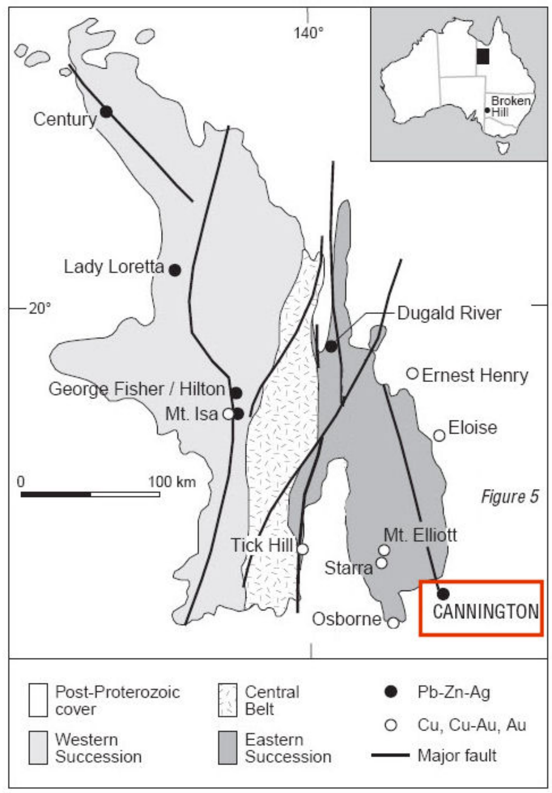

Figure 1: Location of Cannington (from Walters et al. 2002).

DISCOVERY

Geologists within both BHP Minerals and Utah Development Corp. (Utah) recognized in the mid-1980s the prospectivity of the Eastern Succession following the release of new research on the Broken Hill deposit in the early 1980s. With the purchase of Utah by BHP from General Electric in 1984, the two exploration groups were merged and the new group continued active exploration in the Eastern Succession. During this time, due to the lack of outcrop over much of the area aeromagnetics was a primary tool to map and target potential deposits. Moving loop TEM was the preferred follow up technique. In 1988, BHP discovered the Eloise deposit located approximately 100 km north of Cannington (Brescianini et al. 1992). Eloise was a Cu-Au system in high grade metamorphic rocks. While the tonnage and grade were too low to be economic for BHP, its discovery validated the geophysical approach being used to explore the terrain and hence was an important milestone in the subsequent discovery of Cannington.

Following the discovery of Eloise, BHP undertook a major aeromagnetic survey program that extended well south of Eloise and covered the Cannington deposit. The Cannington feature was deemed significantly anomalous to warrant immediate drill testing.

GEOLOGY

While the search for another Broken Hill deposit initiated the exploration programs by BHP and Utah, the Cannington deposit has sufficient differences that it is considered not to be an exact analogue but more as having a strong affinity with the BHT model. Major differences include the very high silver grades and the locally abundant magnetite in Cannington which resulted in a 1,000 nT anomaly over the deposit, features not observed in the Broken Hill deposit. The deposit geology is outlined in Fig. 2.

The description of the geology of Cannington is taken from Walters et al. 2002. *"Economic mineralization is hosted by siliceous and Fe-Ca-Mn-F-rich lithologies with zonation between silver-lead and zinc-dominant ore lenses. The deposit has experienced a complex history of metamorphism, post metamorphic hydrothermal events, and repeated ductile and brittle deformation. In addition to economic ore lenses, the Cannington deposit is characterized by significant volumes of subeconomic mineralization and alteration that define a large and coherent system envelope with a north-south strike extent of 1,800 m and a maximum (structurally repeated) thickness of 200 to 300 m, extending to depths of over 600 m below surface. Fresh sulfide minerals subcrop at the basement unconformity and part of the deposit was removed by pre-Cretaceous erosion. The northwest-trending Trepell fault zone (Fig. 3) is a late brittle structure that divides the deposit into northern and southern zones."*

In terms of mineralization, while the overall mineralogy is very complex due to the long history of metamorphic processes, the dominant economic minerals are galena (Ag + Pb) and sphalerite (Zn). Magnetite is an important gangue mineral and it distribution is outlined in Figs. 2 and 3 (cross section through L4700). Pyrite and pyrrhotite are locally abundant as well. There is a significant difference in the mineral endowment between the Northern and Southern Zones; the Northern Zone with 9.1 Mt @ 8.9% Pb, 3.0% Zn and 371 g/t Ag whereas the Southern Zone had 34.7 Mt @ 12.4% Zn, 4.9% Pb and 582 g/t Ag (Walters et al. 2002).

PETROPHYSICS

In an effort to both better understand the nature of the Cannington deposit as a minerals resource and aid in exploration for other Cannington style deposits, a considerable effort was made to establish a representative suite of physical properties for the Cannington deposit. The emphasis was placed on the magnetic susceptibility and density of the ore and host rocks; the electrical conductivity was also examined.

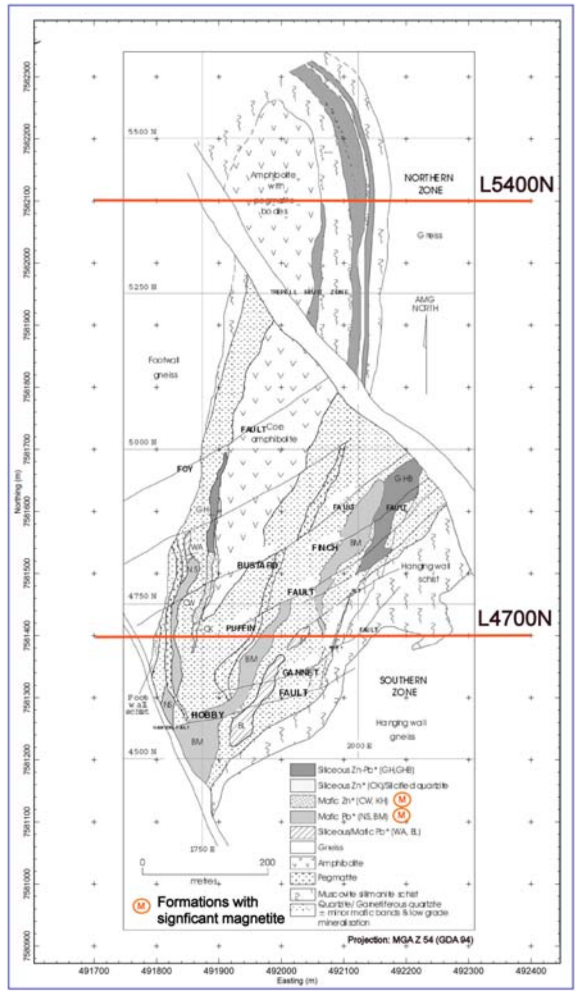

Figure 2: Geology of the Cannington deposit; sections L4700N and L5400N shown and formations with significant magnetite (from Christensen 2001 after Bailey 1998)

A summary of several campaigns of measurements is shown in Table 1. For the density and susceptibility there were numerous (100s) samples measured but the data base for the conductivity was far more limited. Figs. 4 and 5 show cross plots of the contained Ag vs. the density and magnetic susceptibility. There is a good correlation between Ag and density but no a clear relationship with magnetic susceptibility. The conductivity results show that several formations are quite conductive but the rest are resistive. The overlying Cretaceous mudstone unit is quite conductive as well, with estimates of 2-4 ohm-m. While IP-resistivity has been used as an exploration technique at Cannington, no core measurements of chargeability have been made.

GEOPHYSICAL SURVEYS

Geophysics played a key role in the discovery of Cannington. As well, the site was then used for a series of trials of new airborne, ground and borehole techniques that went into the next decade after discovery. This included tests of a new version of the Geotem airborne EM system in 1993 (25 Hz 3 msec pulse and then in 1995 (25 Hz 4 msec). This last configuration became the new standard for Geotem which is still used today.

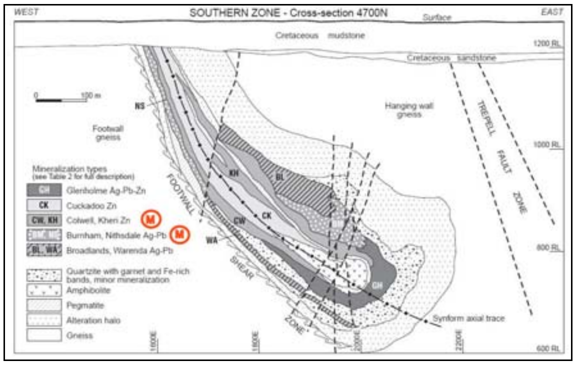

Figure 3: Geological section through Southern zone along 4700N magnetic units highlighted-(refer to Fig. 2).

Table 1

Ore Type	Ag g/T	Pb %	Zn %	Density gm/cc	Mag Sus 10^{-5} SI	Conductivity ohm-m n= # of samples
COLWELL	51	1.08	4.20	3.34	0.0822	1186 (n=1)
CUCKADOO	78	2.47	7.38	2.95	0.0006	NA
WARENDA	85	2.57	1.39	2.91	0.0027	NA
INVERAVON	91	2.73	1.92	2.92	0.0006	NA
KHERI	92	3.04	4.64	3.42	0.0822	0.0006 (n=2)
BROADLANDS	234	5.84	1.94	3.16	0.0038	12,220 (n=8)
GLENHOLME	462	10.32	7.57	3.21	0.0004	932 (n=4)
NITHSDALE	598	12.2	2.67	3.52	0.1500	NA
BURNHAM	620	12.69	3.20	3.20	0.0601	0.0024 (n=7)

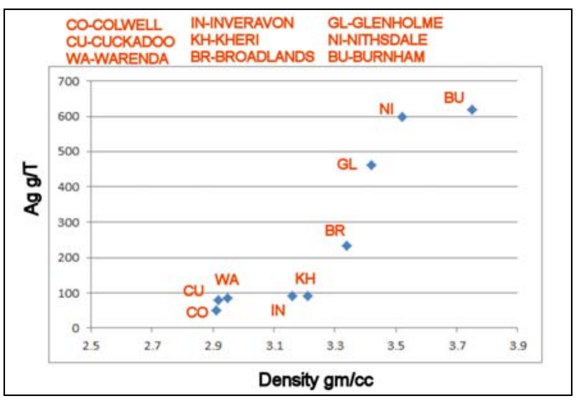

Figure 4: Cross plot of Ag and density for the various ore types.

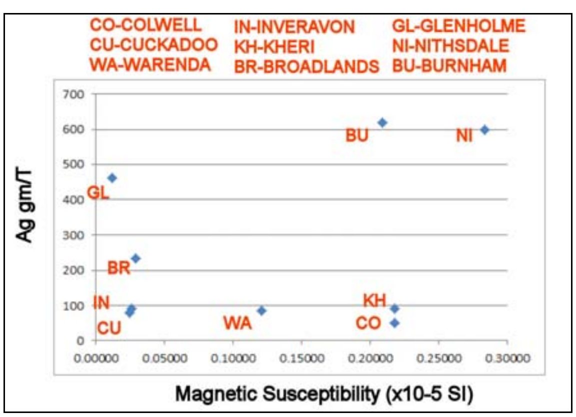

Figure 5: Cross plot of Ag and magnetic susceptibility for the various ore types.

In 2000, the first work with the Falcon airborne gravity In 2000, the first work with the Falcon airborne gravity radiometer system was carried out over Cannington (Christensen et al. 2001). A high temperature ground based SQUID sensor was trialed in 1993. Numerous trials of IP techniques were also carried out, including the MIMDAS system in 2005 (Busuttil 2006). A seismic reflection survey was carried out in 2002 (Velseis 2003).

Airborne Surveys

Airborne magnetic results were critical to the discovery of Cannington. Subsequent surveys focused on EM and later airborne gravity gradiometry in an effort to develop alternate means to define economic targets below the thick cover of very conductive surface material. The TMI-RTP result (BHP 1991) over the Cannington area is shown in Fig. 6. The magnetic response of the geological section shown in Fig. 3 has been modeled (Fig. 7), using susceptibilities listed in Table 1. The overall shape is similar to the observed anomaly, but the amplitude is less than half. This suggests that there is a strong and apparently variable remanence present in the system. BHP supported a number of studies examining this (i.e. Fullagar 2003, Fullagar and Pears 2007). In Fig. 8, images of the Falcon gD (Christensen et al. 2001) and Geotem 25 Hz dB/dt Z Ch 11-6.3 msec (BHP 1995).

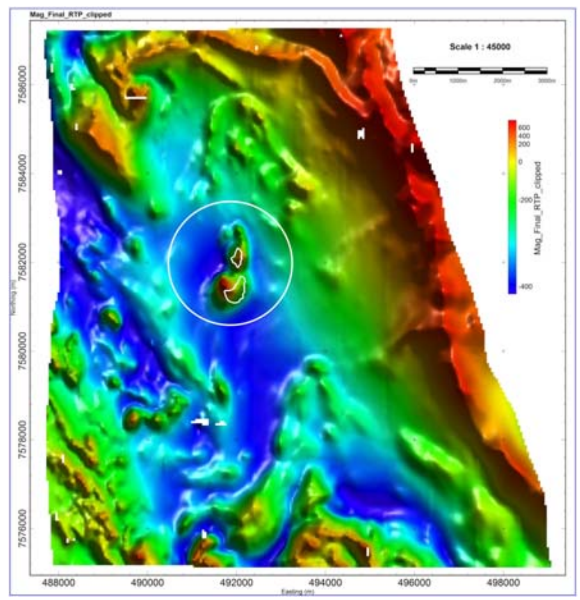

Figure 6: TMI-RTP over the Cannington deposit (Northern and Southern zones outlined in white).

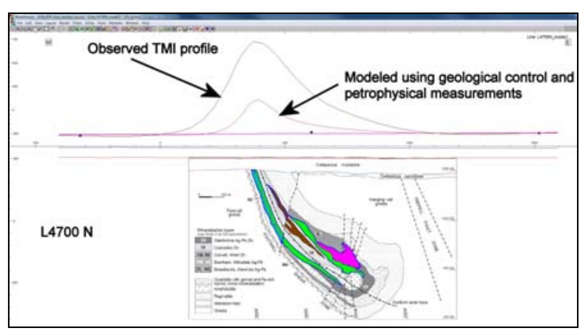

Figure 7: PB Model Vision Pro model of magnetic response along L4700N- (refer to Fig. 2).

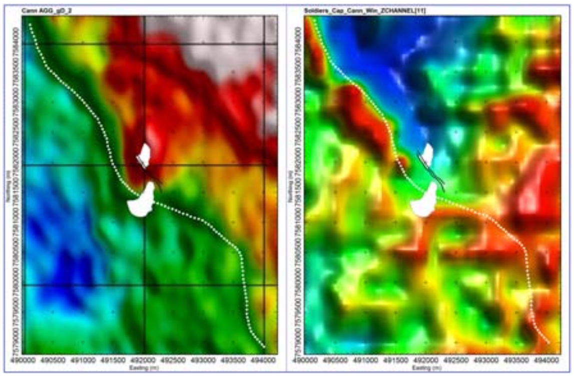

Figure 8: Falcon gD (left) and Geotem 25 Hz dB/dt Z Ch 11 (6.3 msec). Cannington Northern and Southern zones are highlighted as is a NW-SE trending low (dashed white line). The Trepell fault is in black.

The Falcon survey shows the strong gravity high associated with the Northern zone, which merges with a much larger high to the north and northeast. A distinct sinusoidal gravity low trending NW-SE is outlined on both images. On the EM image this gravity low appears to at least in part, follow a gradient in the EM response. The mapped Trepell Fault lies to the NE of this feature.

Ground Surveys

EM and IP-resistivity have been the major types of ground surveys undertaken over the deposit. Fig. 9 shows the inverted resistivity and chargeability results acquired in 1991 for L5400N. The strong shallow resistivity low is quite apparent as is a clear chargeability feature.

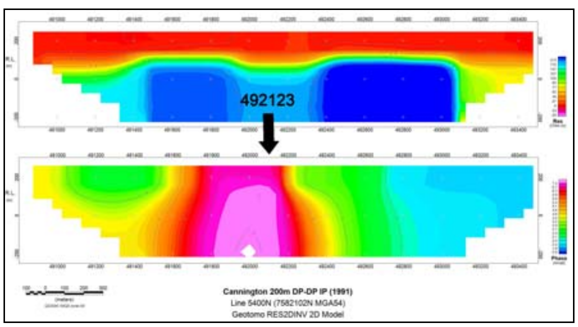

Figure 9: L 5400N-inverted resistivity and IP data-(refer Fig. 2).

Fig. 10 shows an inverted TEM line for L5400N. While there is a 'dip' in the DC resistivity at the same location as the TEM feature, the chargeability high sits slightly to the west.

CONCLUSIONS

The Cannington deposit shows strong geophysical responses and it was the clear and isolated magnetic response that was directly responsible for its discovery. While numerous other geophysical systems and processing approaches have been applied over the deposit, none of this work resulted in a major new discovery in the area of Cannington. However, for BHP Exploration, the geophysical test work was a critical part of the group's development of new technologies during the period 1990-early 2000 which produced systems and approaches still considered 'state-of-the-art' 25 years after the initial discovery.

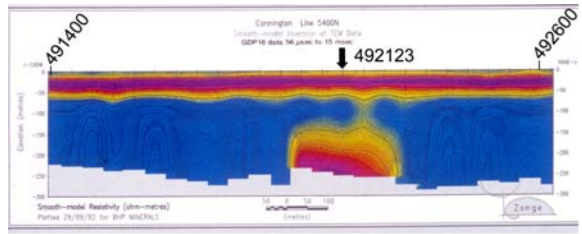

Figure 10: Inverted TEM data for L5400N-(refer Fig. 2).

ACKNOWLEDGMENTS

The authors' acknowledgment the assistance of BHPBilliton Pty. Ltd. in providing access to the non-public domain data presented here. One author (KEW) wishes to thank Doug Price for providing useful background information on the discovery.

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