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Discussion on: Geophysical case history of the discovery of the Agvas Teñidas East massive sulphide deposit, SW Spain

by J.D. Hopgood and N. Hungerford, *Exploration Geophysics* **25** (1994), 1-17

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I would like to thank the authors of "Geophysical Case History of the Discovery of the Aguas Teñidas East Massive Sulphide Deposit, SW Spain" (Vol 25, No. 1 March 1994) for citing my contribution to this discovery.

However, it is evident that they have based their re-construction of events on incomplete records, especially as neither author was involved in the discovery. The value of any case history depends upon its accuracy in order that lessons may be learnt from it, despite what one might have wished to have occurred.

I regret to say that the article contains several important inaccuracies, plus the implication that I failed to interpret the TEM anomaly and was not aware of current-gathering effects. The shallow "TEM-Geology" target shown in their Fig. 5 is not my interpretation.

In particular, I would like to correct the mistaken opinion that downhole TEM was crucial to the discovery. In fact, the DHTEM only served to confirm the anomaly seen from surface and was used to persuade management to drill another deeper hole (AE-3) which intersected mineralisation and was the "discovery" hole.

The Anguas Teñidas area was selected on geological grounds, especially as the nearby, but unrelated, Anguas Teñidas copper mine had produced 0.5Mt of high grade copper ore in the last century. Trial Max-Min profiles gave a good response over the old mine, suggesting that E< methods might be more cost-effective than the widely accepted regional gravity approach as used at Neves-Corvo.

An INPUT survey, flown over the entire licence block, had produced numerous shallow Channel 1-3 anomalies in the Aguas Teñidas East area, but Max-Min follow-up did not locate any significant conductors.

A strong INPUT anomaly near another old pyrite mine at Confesionarios, several kilometres away, was tested with Crone DEEPEM and simple vector interpretation gave a drill target at approx. 200m depth. The first hole did not intersect but DHTEM confirmed the anomaly and the second hole was stepped back, intersecting a blind barren pyrite body at a vertical depth of about 200m. The first hole had passed within about 25m of the body.

This "technical success" confirmed the cost-effectiveness of the TEM method for locating massive sulphide bodies and it was seen that current gathering could displace the anomaly. It also demonstrated that aiming at the top of the target with subsequent deflection upwards of the hole would lead to inevitable "misses". At this time it was decided to use the EM-37 and the PLATE model for future work.

Large loop EM-37 profiling was then carried out on 200 m line spacings along the geological trend at Aguas Teñidas, including the old mine. A complex linear assemblage of anomalies was interpreted by the contractor with time constants of 1-2ms and depths from 100 to 200+ metres. One of these linear features ran through the old mine, but the highest time constants were observed in the Aguas Teñidas East area. The anomaly trends were seen to shift position by about 200 m depending on which side the transmitter loop was placed.

Numerous gossans relating to presumed Roman workings were known in this area, and shallow targets were anticipated by the geological team.

Gravity surveys over this area on 100 x 50 and 200 x 25m grids did not produce any anomalies, near surface density variations giving a "noise" envelope of about 0.2mGal. A broad ill-defined "high" of 0.3mGal was observed and attributed to geological structure.

A gradient array IP/R survey (AB=2000m) did not reveal the anticipated shallow mineralisation, but instead disclosed a single, smooth, symmetrical chargeability anomaly (25mV/V) in an otherwise low background (<5mV/V), consistent with a deep chargeable source. Resistivity values were uniformly around 400Ohm-m.

Dipole-dipole profiling (a=200m) confirmed a deep (200+ m) source for the IP anomaly, and finite element modelling gave a 200m wide by 50 m thick target at about 250m depth. This alone would have been sufficient for a discovery.

The EM-37 data was then revised and modelled using the Geonics Plate approximation, still constrained by the geologists' insistence on steep dips (later renamed schistosity!) The anomaly was seen as a crossover in the Z-component just outside the loop, implying a vertical dip, but also as a maximum in the Z-component just inside the loop, implying a sub-horizontal dip. The best fits were obtained with plate of great depth extent (effectively monopoles) at depths of approx. 250m. Thus no dip information was forthcoming, but the strike extent of more than 1000m and the high time constant suggested that a conductive body of significant size was present.

A drilling recommendation was made, but the first holes AE-1 and AE-2 (along strike), aimed at the shallowest of the possible targets, failed to intersect any mineralisation.

In view of the cost of drilling further 500 m holes, the target was downgraded and the discovery would not have been made were it not for the efforts of the Project Geologist, Heniz Gröpper who, 5 months later, finally obtained permission for another attempt. This time, the possible effects of current gathering in enhancing the anomaly, making it appear shallower, were taken into account and hole AE-3 was stepped back and steepened to aim for a target around 300 m vertical depth. An intersection of 17 metres of massive sulphides was made at a vertical depth of 315 m which was the discovery hole.

The subsequent drilling program delineated a shallow-dipping ribbon-like body of massive sulphides, of dimensions 1000 x 200 m approx. The shape of the sulphide body accounted for the law gravity anoamly (0.3 mGal) and the lack of a true dipolar inductive EM response. However, the observed exponential decays with time constants of 2-2.5 ms and the observed host resistivity of 4000 Ohm-m indicate that both galvanic and inductive mechanisms contributed to the essentially monopole anomaly observed on the surface. Use of a plate model of large depth extent was not an unreasonable simulation of a monopolar, horizontal prism.

In this age of ubiquitous PC's it is perhaps amusing to recollect that a special trip to Head Office had to be made to justify the purchase of a desktop machine only! No budget for software existed and the author is grateful for the PLATE program in HP BASIC given to him by the Ontario Geological Survey.