Comparing Seismic And Magnetic Responses To Copper Gold Deposits Under Different Cover Sequences

Okan Evans Onojasun

Abstract: Appropriate application of geophysical techniques is required to effectively explore through the cover sequences that will allow the discovery of deep seated orebodies within the 1-3km depth range. Whilst potential field methods that are traditionally used for Cu-Au exploration seems effective, they lack the expected resolution required to detect deeper mineral deposits under >500 m cover. Seismic reflection techniques offers a distinct advantage over all other geophysical techniques because of its ability to penetrate deeper into the subsurface without losing its resolution. We present in this report modelling results from magnetic and seismic responses to Cu-Au deposits when located within 100-1000m depth range. In the case of magnetic modelling, we apply upward continuation filters which calculate the potential field that would have been recorded at (100m, 250m, 500m and 1000 m) levels by filtering away shallow anomalies from the initial data. For seismic modelling, simple but realistic geological model with varying cover thicknesses (100m, 250m, 500m and 1000m) were created, and then populate these models with petrophysical data. Simulated synthetic seismic responses from the models was processed using basic processing flows to obtained depth migrated images. Results show that for shower depths (0-100m), good correlation exist between the magnetic and the seismic responses. From 100-250m depth cover, though we can still see some magnetic anomalies within the target zone, its effectiveness decreases with depths whereas seismic responses was maintain within the depth range. From 500m to 1000m magnetic response becomes spear or fuzzy as much useful information is practically missed out. Similarly, high resolution power of seismic was ably demonstrated as the depth of even 2km did not degrade its resolution. Thus, both magnetic and seismic methods are very useful for shallow investigation but at greater depth, seismic method appears to be a more valid exploration tool to find Cu-Au deposits.

Key Words: Cu-Au deposits, exploration, magnetic method, resolution, seismic method

1 Introduction

Frankly speaking, mineral explorers would want to discover ore as close to the surface as possible. However, this is not always the case as the 'easy and near surface' discoveries have largely been made, while new discoveries are likely covered by thick sequences of sediments with weak geophysical and geochemical signatures; thus are difficult to target, drill or analyse. Potential field geophysical methods that are typically used to detect the major structures that lead to the location of prospective targets have low spatial resolution at depth, and are limited to directly detecting shallow targets hence another method is required. The seismic method is considered the most powerful geophysical tool for detailed mapping at depth and is frequently used in the petroleum industry. Though early application of seismic for mineral exploration was generally expensive with some discouraging results, nevertheless, recent application of seismic reflection surveys holds future promise for explorers especially in the delineation of ore-bodies and for mine planning in exceptionally complex hard rock environments (Drummond et al 2000, Duweke et al 2002, Pretorius et al 2000, Robert et al 1983, Salisbury, 1997; Juhlin et al, 2003). Further research work has also shown that seismic reflection method has the capability to produce images of amazing quality as well as locate small and high grade deep seated orebodies without degrading its resolution (Malemir et al 2012, 2014; Ehrig, 2013).

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2. Survey Area

Gawler Craton (Figure 1), the oldest and largest geological province located within the western and northern parts of South Australia is a Precambrian crystalline basement crustal block cratonised ca. 1550-1450 Ma. Prior to 1550 Ma, the craton comprised a number of active Proterozoic orogenic belts extending back in time to at least 2450 Ma (Parker, 1990, Hand, et al 2007, Fraser, et al 2010. In and around the Gawler Ranges, the volcanic and older rocks were intruded by Hiltaba Suite granites which are closely associated with formation of the giant Olympic Dam orebody. They are typically covered by a thick 10-1000m younger sedimentary sequences and volcanic rocks; thus, making the region extremely difficult and costly to explore (Daly, et al., 1998, Parker, 1993, Vassallo and Wilson, 2002). Although relatively undeformed, the Gawler Range Volcanic, which extend from the centre of the craton to its eastern margin, represent a major period of crustal deformation ca. 1590 Ma which heralded the final consolidation and stabilization of the craton as it is seen today. Metals were mobilised from mantle and crustal sources and redeposited in the upper crust to form a variety of mineral deposits, including the supergiant Olympic Dam Iron Oxide Copper Gold (IOCG) deposit and other deposits with similar characteristics (e.g. Carrapateena, Prominent Hill and the recent Hillside discovery). Economic copper-gold mineralization is thought to be a later feature in the regional development of these deposits (Barton, & Johnson 2004, Williams & Skirrow 2000). IOCG deposits within the craton are characterized by extensive hematite-magnetite (iron) alteration and brecciation, and typically comprise disseminated to massive chalcopyrite, chalcocite and bonite copper mineralisation with associated gold.

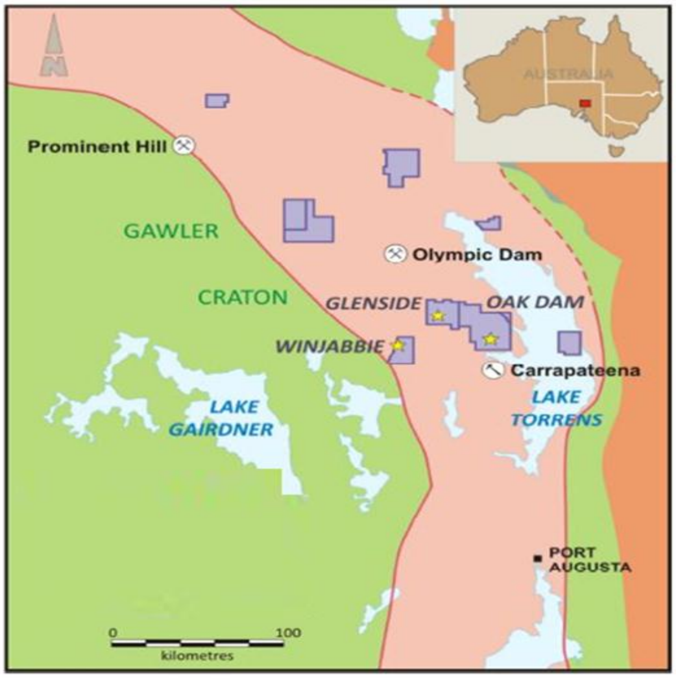


Figure 1: *A physico-chemical model (Sato and Mooney, 1960)*

3. Materials and Methods

The main objective of this study is to demonstrate the magnetic and seismic responses to IOCG deposit at deeper level. We hypothesize that magnetic method lack the lateral and depth resolution needed to image deep seated mineral deposit (greater than 500m depth) while seismic method will maintained its resolution at such depth. To test the first hypothesis, initial residual magnetics of Hillside camp was plotted on Oasis Montag software. We then apply upward continuation filters which calculate the potential field that would have been recorded at higher level from the source. The aim of applying this filter was to test the magnetic responses when potential field at higher levels (100m, 250m, 500m and 1000 m) filters away shallow anomalies from the initial data. The next step was to test the second hypothesis by modelling seismic responses over the geological model. The production of realistic geological model for synthetic data analysis is of utmost importance, and thus emphasis is placed on the accuracy and realism of input parameters. In this case, models have been designed with strong correlation to geological interpretations made from seismic surveys conducted in the past. Rex Minerals provided an interpreted geological cross-section, representative of the Cu-Au exploration area, derived from previous drill-holes data. The geological model used for this experiment is shown in Figure. As was the case with magnetic forward modelling, we also vary the depths cover from 100m, 250m, 500m and 1000m respectively. The ideal was to demonstrate seismic resolution being maintained with depth as oppose to potential (magnetic) method.

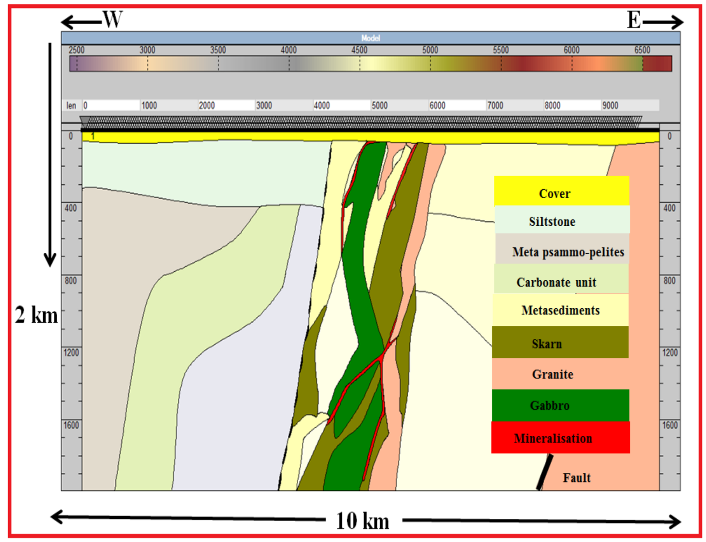
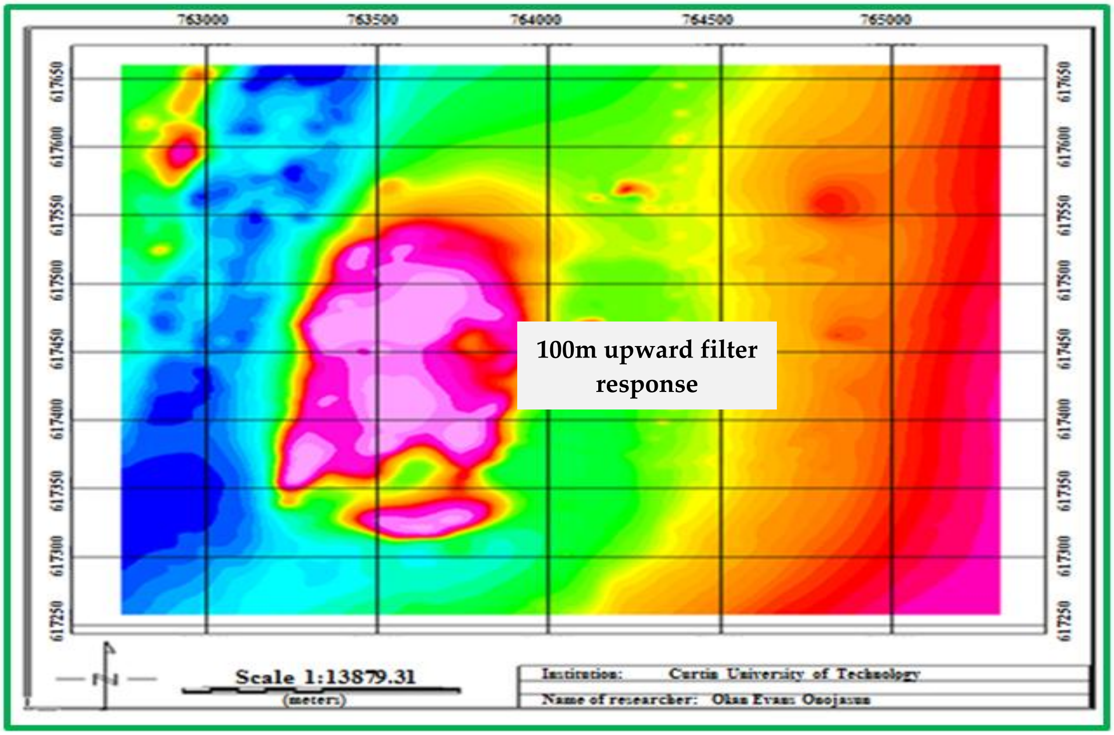


Figure 2: *Synthetic geological model with incorporated lithological units used for modelling.*

4 Results

Results from the upward continuation filtering illustrating the changes in anomaly character with increasing observation to magnetic source distance are shown in Figures 3-4 while results from seismic modelling are shown in Figures (5-6). For shower depths (0-100m), good correlation exist between the magnetics and the seismic responses. From 100-250m depth cover, though we can still see some anomalies within the target zone its effectiveness decreases with depths as useful deposits may have been missed by the absence of detectable magnetic responses whereas seismic responses at same depth maintain resolution. From 500m to 1000m magnetic response becomes spear or fuzzy. Much useful information is practically missed out when compared with the previous responses. High resolution power of seismic was ably displaced as the depths of even 2km did not degrade its resolution. Reflection around the edges of intrusion was noticeable in all cases but the individualised structures within the intrusive package and the mineralisation zones cannot be image due to the almost vertical nature of the intrusive structure. We can also see some artefacts which might be due to processing error and also the nature of the angle. Overall resolution was maintained with depth.



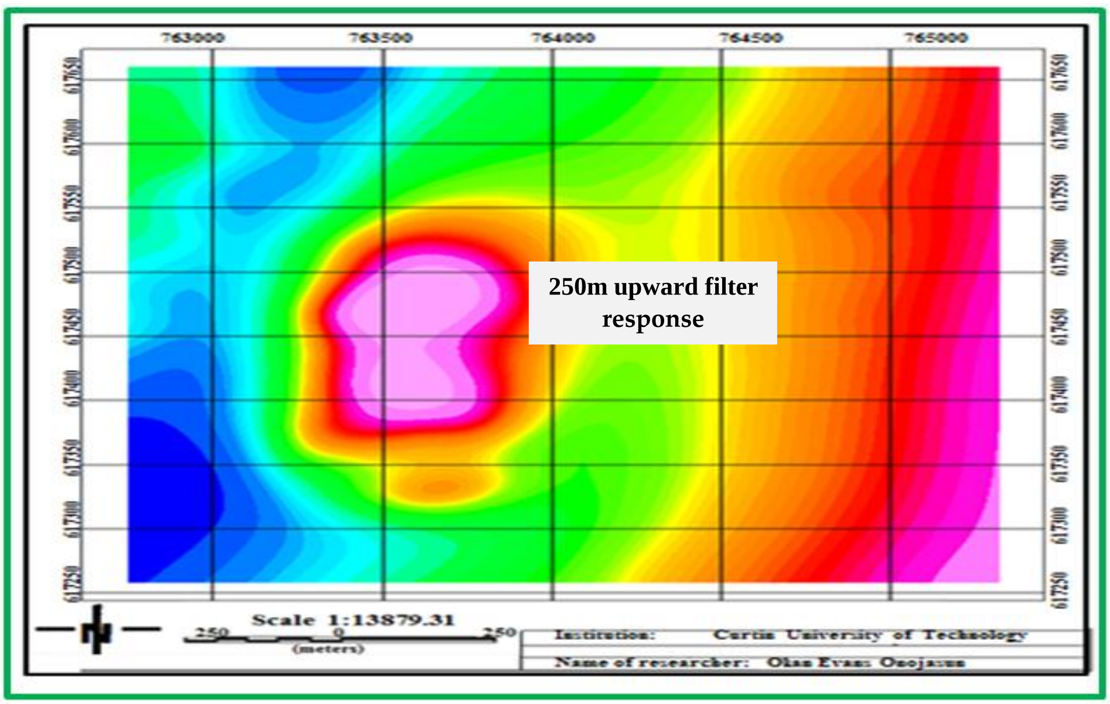


Figure 3: *Magnetic responses; Top) 100m upward continuation filter response, Buttom) response due to 250 upward continuation filter.*

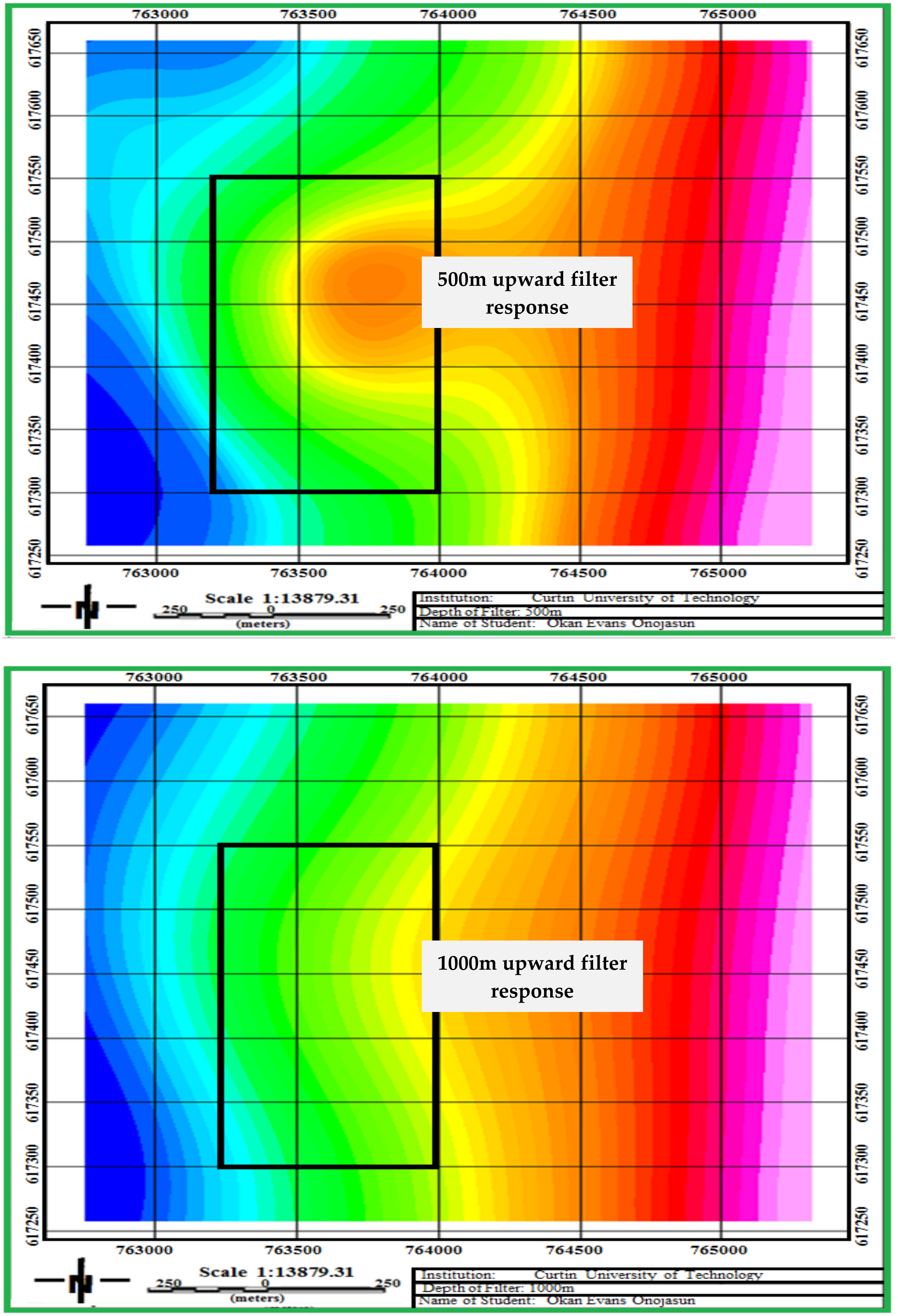


Figure 4: *Magnetic responses; Top) 500m upward continuation filter response, Buttom) response due to 1000m upward continuation filter. Magnetic responses are not feasible at these depths. No response was observed further*

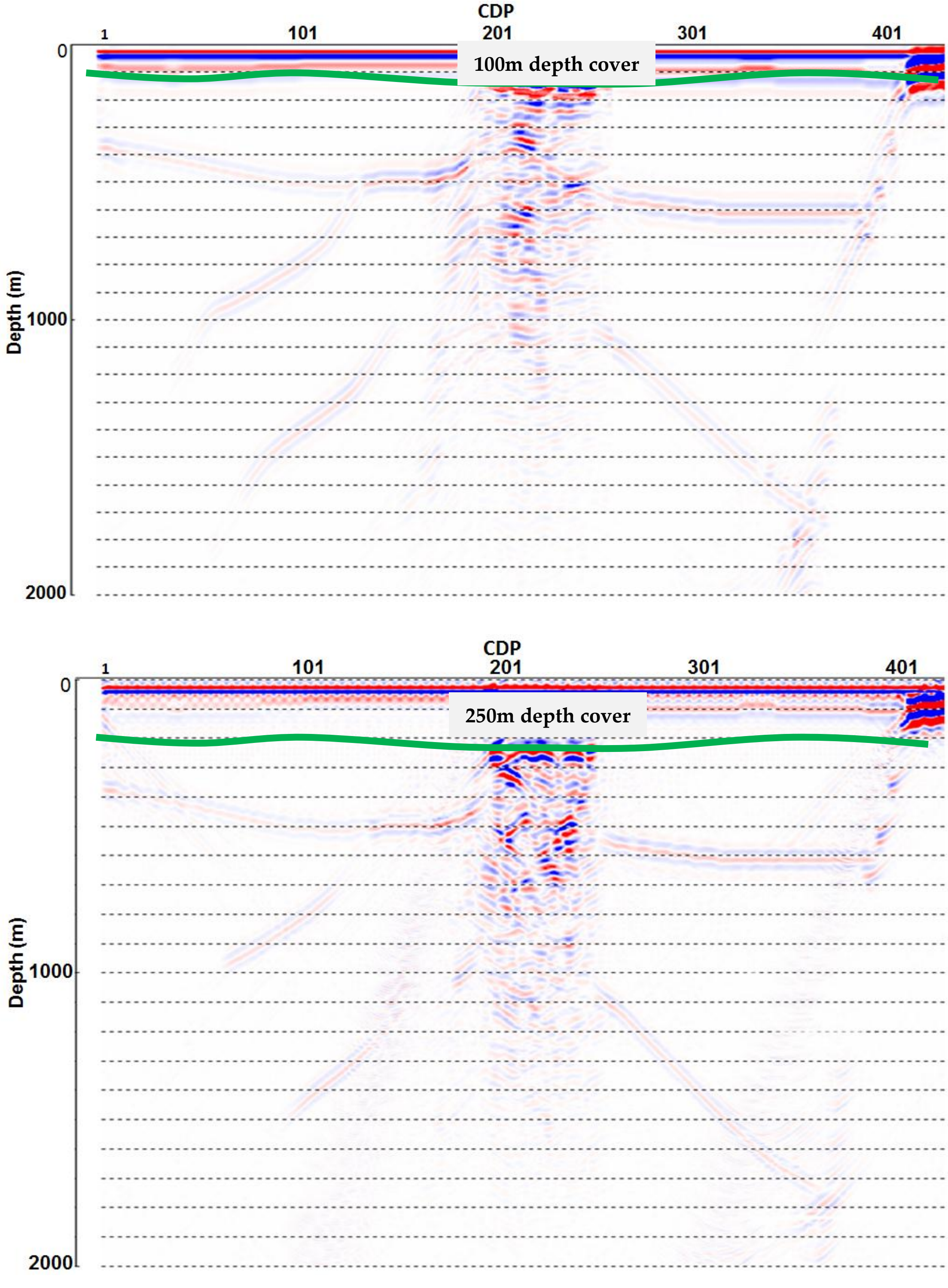


Figure 5: *Noise free depth migrated section with 80 m source and 40 m receivers spacing; Top) 100m depth cover, Buttom) 250m cover*

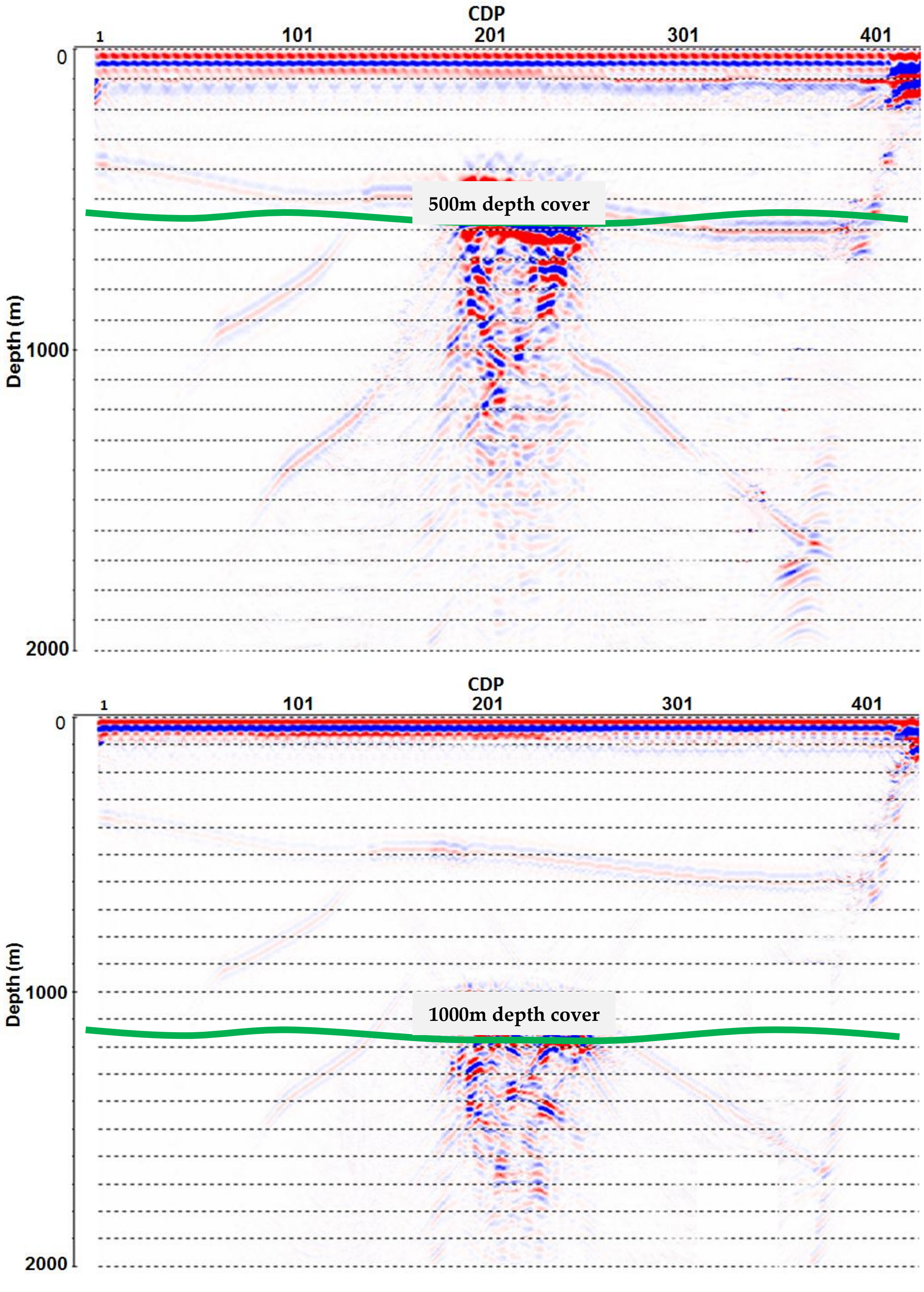


Figure 6: *Noise free depth migrated section with 80 m source and 40 m receivers spacing; Top) 500m depth cover, button) 1000m cover*

6. Conclusion

This study has demonstrated that magnetic and seismic methods are very effective for shallow investigation as good correlation exist between both responses up to 250m cover. However, from 500m to 1000m magnetic responses becomes spear or fuzzy as useful information was practically missed out which implies that magnetic method though very effective, lacks the needed resolution to confidently detect deeper mineral deposits under >500 m cover. Seismic method on the other hand was able to detect the intrusive structures hosting the deposits up to 2km depth without degrading its resolution which suggest that it is a more viable tool needed to explore deep seated ore-bodies in the Gawler craton

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