KEMESS SOUTH MAGNETIC MODELING.

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INTRODUCTION

Magnetic data in the vicinity of the Kemess South Mine in the Yukon has been analyzed and modeled in order to try to explain the origin of the observed anomaly correlating with the mine.

Mining was by open pit, which commenced around 1998 and the mine closed in 2011, after which the pit partially flooded. A DIGHEM survey was flown in August 2002 and a ZTEM survey was flown in October 2014 (after the pit closed). (These dates are important in the subsequent analysis).

The geology of the Kemess South Mine is shown in Figure 1 (Duuring et al., 2008). Porphyry-style Cu–Au–Mo mineralization is mainly hosted by the tabular, SW-plunging, 199.6±0.6-Ma Maple Leaf granodiorite, which intrudes tightly folded, SW dipping, Permian Asitka Group siltstone and limestone and homogeneous Triassic Takla Group basalt. The supergene-altered granodiorite (brown) and the hypogene-altered granodiorite (pink) host most of the mineralization. These units are faulted off to the north, but appear to extend south for some distance (although there is a lack of drill control to the south). The outline of the ultimate open pit is shown on the plan and the depth of the pit is shown on the sections (albeit rather faint black lines). The mineralized zone is underlain by the Takla Group basalt (green).

A 3D model of the mineralized zone was generated from the geological sections and plan (Figure 2). Based on limited data, this volume is not well constrained: the southern boundary was truncated approximately 400 m south of the southern boundary of the ultimate open pit.

MAGNETIC SUSCEPTIBILITY

Many holes were drilled into the ore body, but the core from only a few were logged with magnetic susceptibility. These are shown in Figure 3a. Figure 3b shows the average susceptibilities over portions of the holes for a number of representative holes. The susceptibility database did not contain any explanations of the units: however, apparently a KT-9 instrument was used, which measures in units x 10-3 SI, so these units have been adopted.

Based on the three drill holes which tested the main portion of the ore body, the average susceptibility of the ore zone is relatively low, approximately 5x10-3 SI (or 0.005 SI). These holes penetrated the underlying Takla Group basalt, where the average susceptibility is much higher, approximately 50x10-3 SI (0.05 SI). Within a group of holes near the east end of the ore zone, several also partly penetrated the Takla, with representative susceptibility of 43x10-3 SI (0.043 SI).

Based on this data it appears that the ore zone has low susceptibility, while the underlying Takla Group basalt is comparatively magnetic.

Note that this drill core susceptibility data was obtained late and was not available for much of the analysis.

Miner Deposita

Fig. 2 Geological map and sections for Kemess South: (*i*) the simplified geological plan shows the distribution of major rock types and structures. Note the position of the north–south cross section line (*N–S*), the east–west long-section line (*W–E*), and the logged diamond drill hole, KS-04-03 (Fig. 4). The granodiorite demonstrates a sharp tectonic contact with Permian Asitka Group siltstone but an irregular intrusive contact with Triassic Takla Group rocks. These rocks are unconformably overlain by Toodoggone Formation conglomerate, volcaniclastic, and epiclastic rocks. (*ii*) The west–east long section through the mine stratigraphy demonstrates the truncation of the moderately SW-plunging tabular granodiorite and Takla Group basalt by the North Block fault. The mine stratigraphy and E–W striking North Block fault are displaced by NE- to NW-trending normal faults (e.g., the 10180 fault). (*iii*) The simplified south–north cross section demonstrates the truncation of the shallowly dipping granodiorite and overlying Toodoggone Formation rocks by the North Block fault

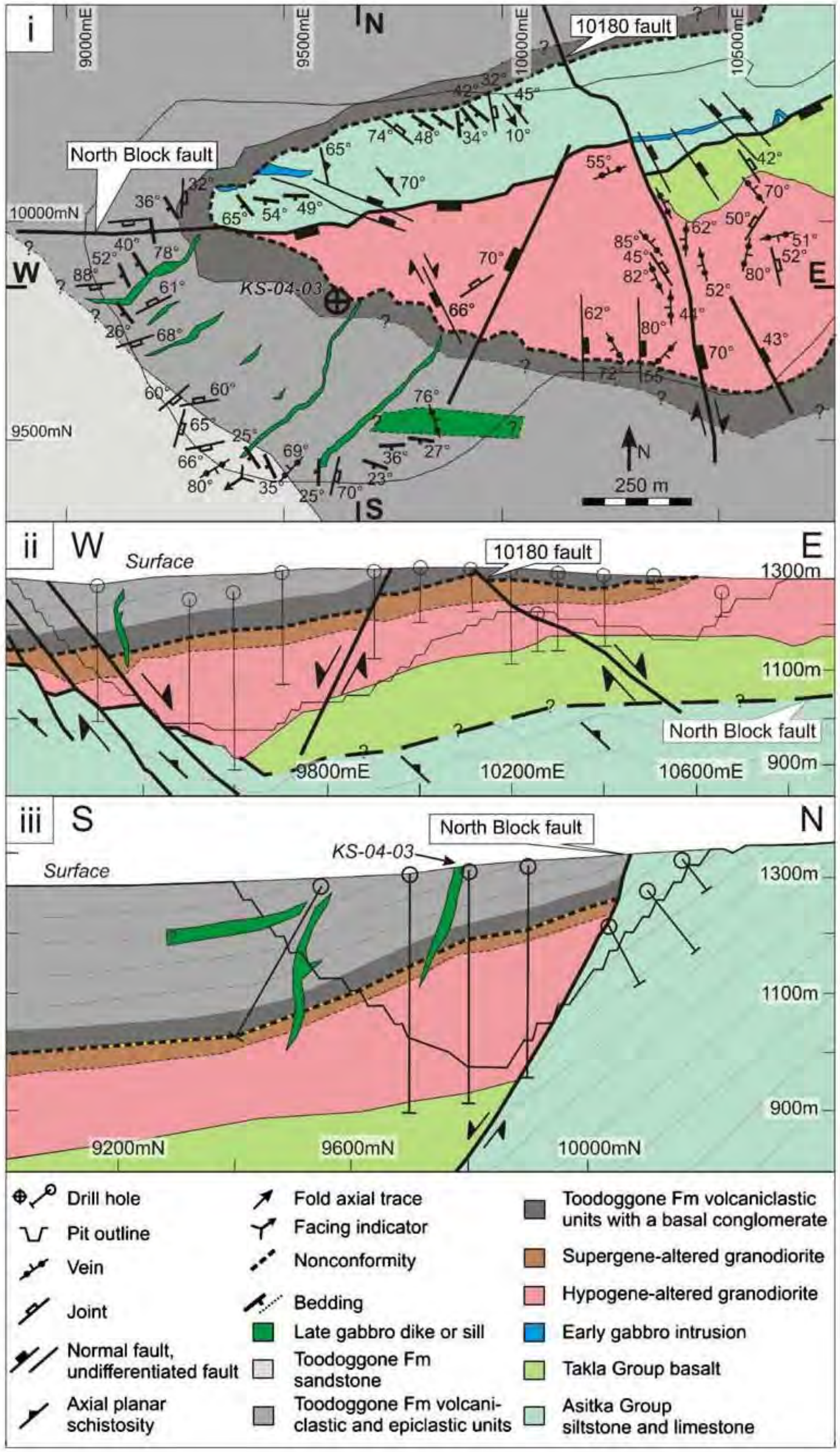


Figure 1: Kemess South geology (after Duuring et al., 2008).

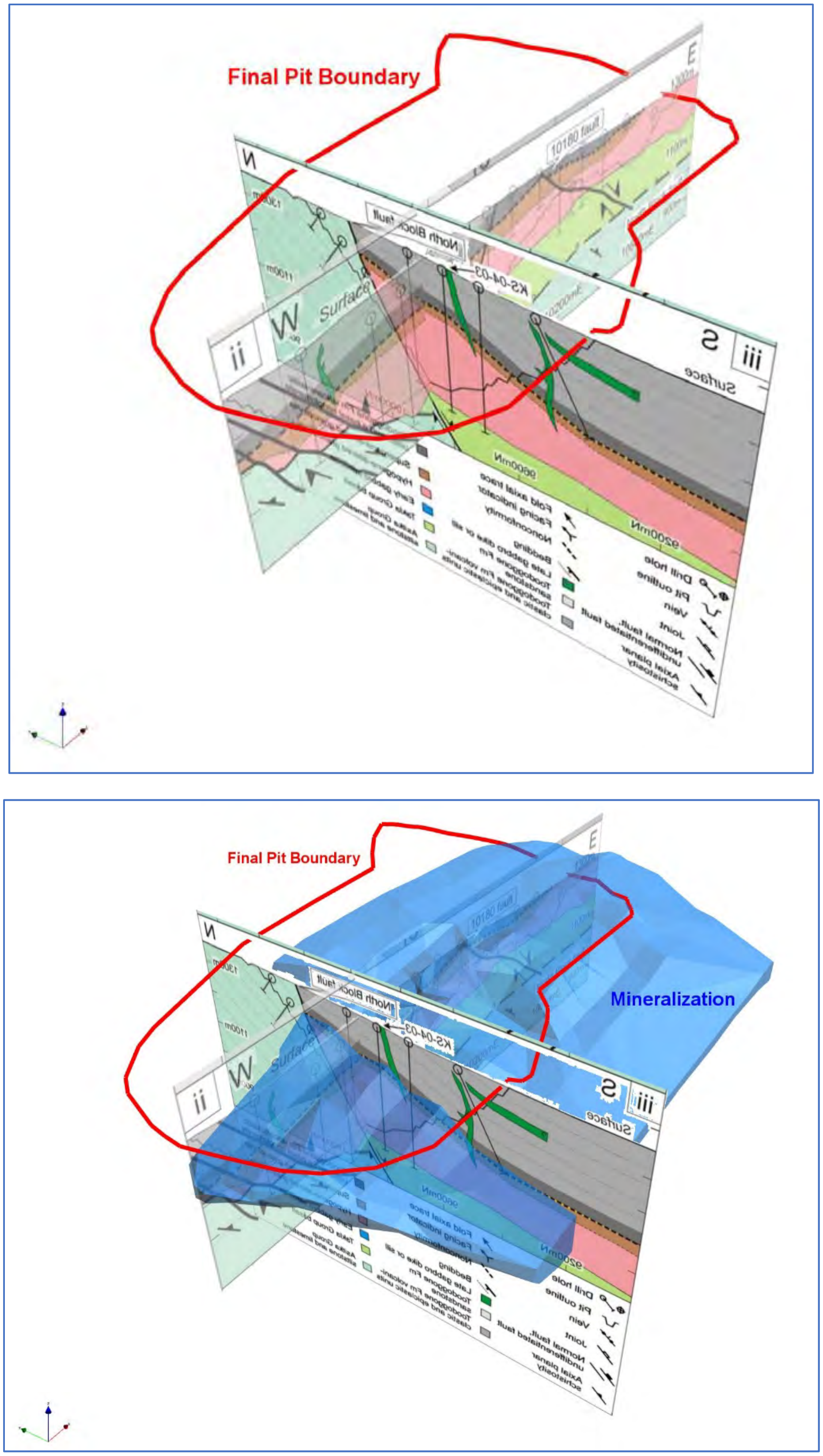


Figure 2: 3D view of geology (top) and mineralization (bottom), looking NE.

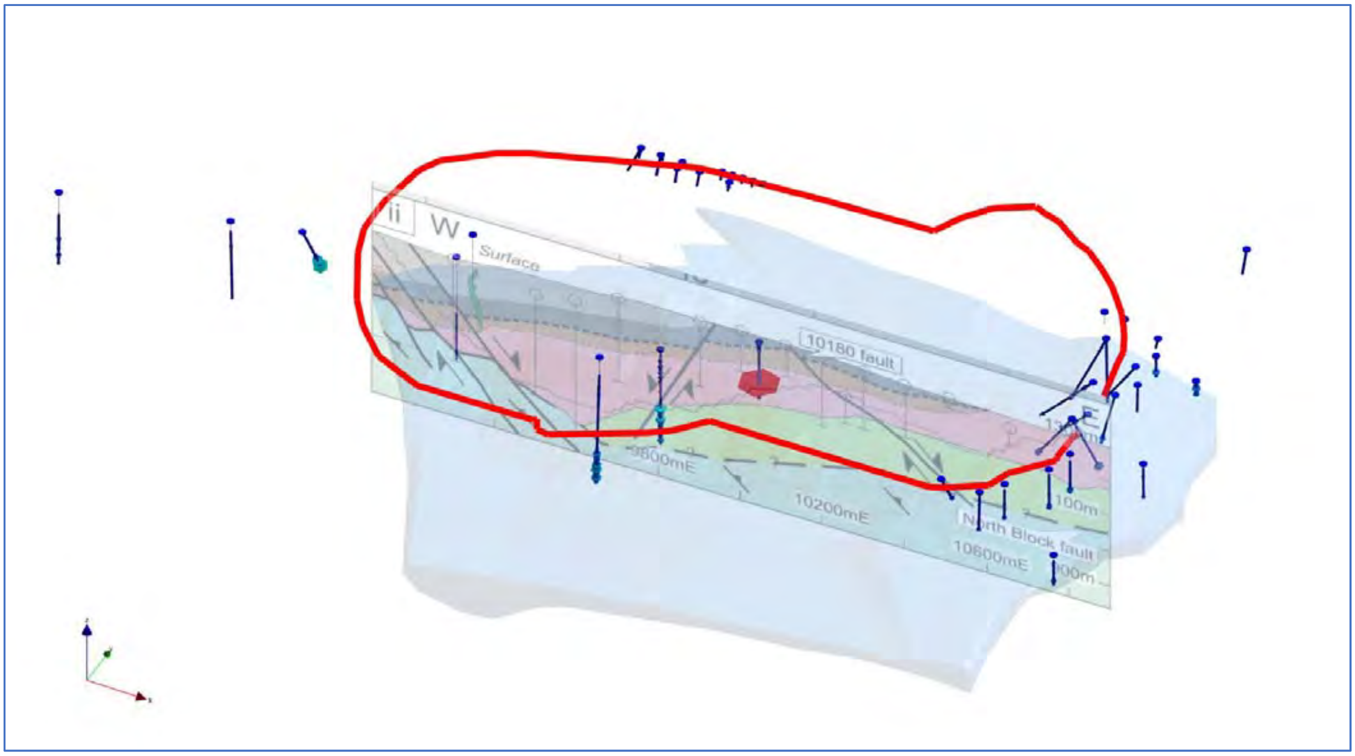


Figure 3a: Magnetic susceptibility measurements in drill holes within and close to open pit (looking NNW).

The susceptibilities are shown as a Rose diagram down the hole colored and sized by amplitude.

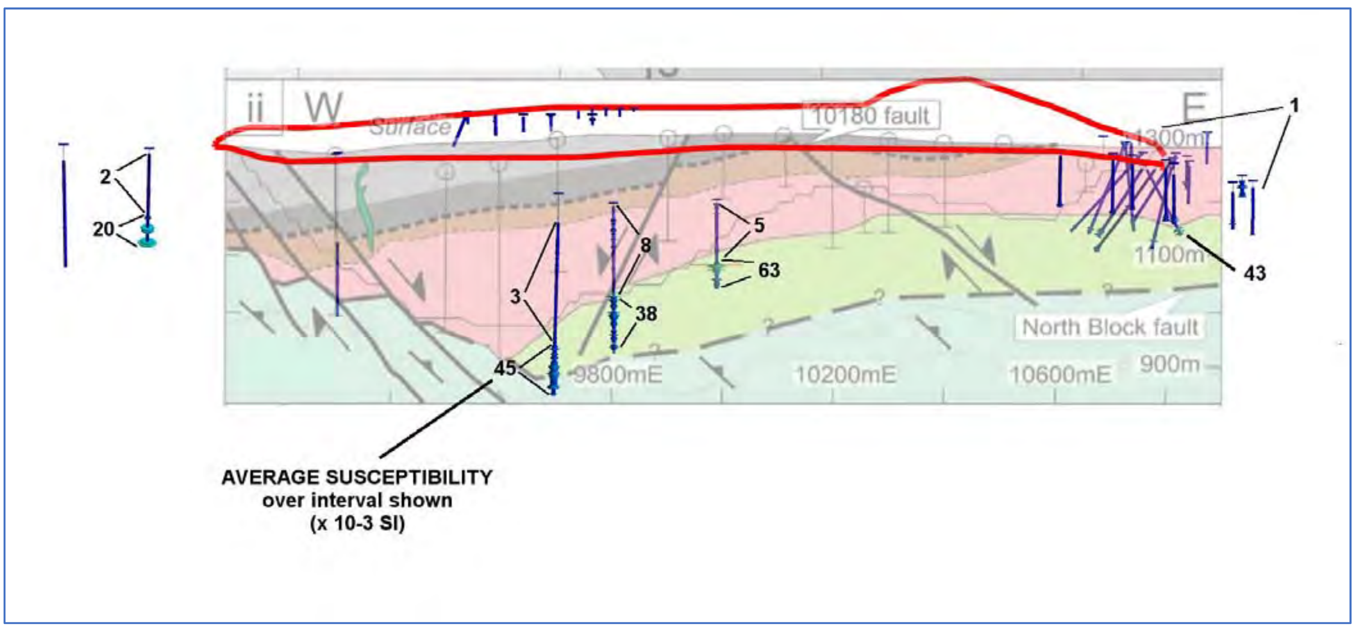
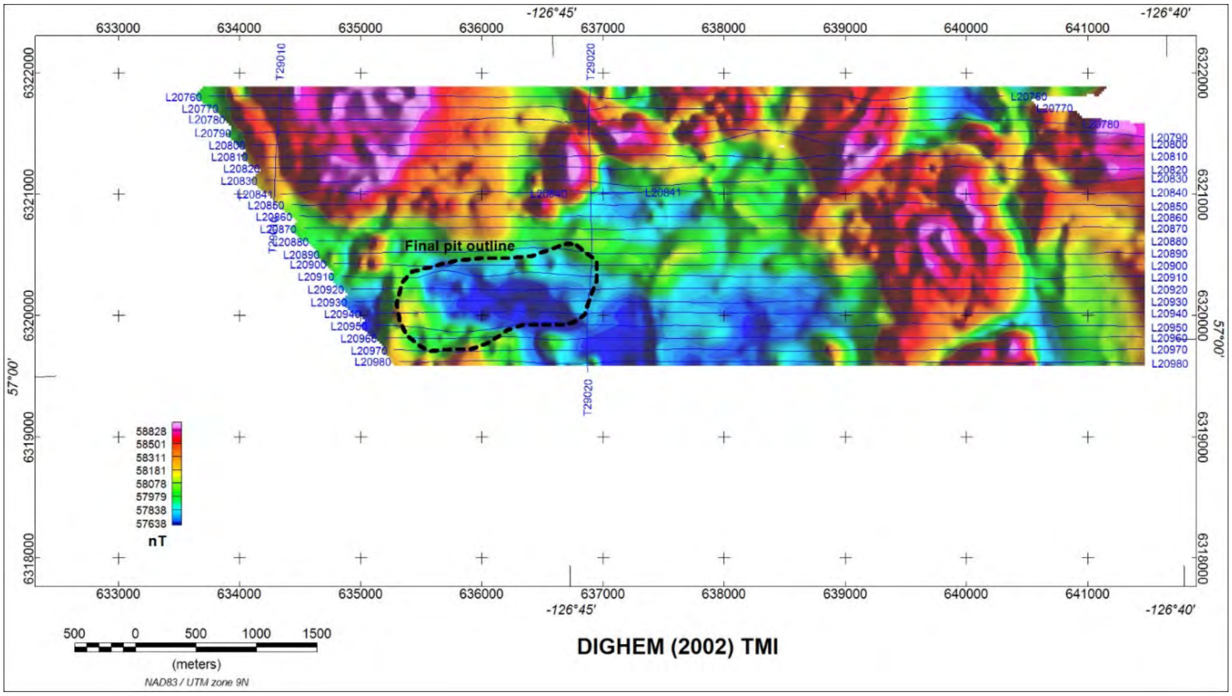


Figure 3b: Average susceptibilities in selected drill holes (looking North).

DIGHEM SURVEY

The TMI and RTP (Reduced to Pole) data from the 2002 DIGHEM survey covering the Kemess South area is shown in Figure 4. The Kemess South Mine lies close to the southwest corner of the survey, which provides little "background" to the west and south. The final pit outline is shown and it is clear that a relative negative anomaly (blue) correlates with the general area of mineralization. Two other similar (but weaker) negative anomalies are visible east of the mine (most clearly defined on the RTP image).



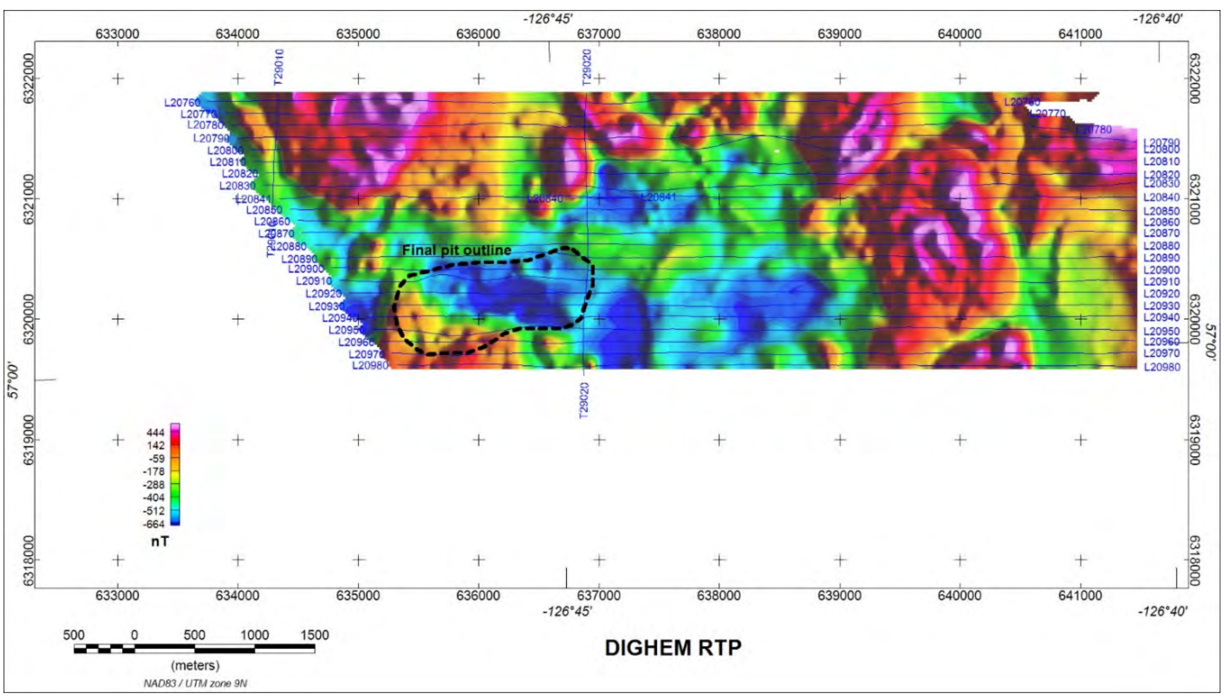


Figure 4: DIGHEM (2002) magnetic images: TMI (top) and Reduced to Pole – RTP (bottom).

At issue is whether the negative anomaly correlating with the mine is due to (1) negative remanent magnetization, (2) destruction of magnetite and magnetic pyrrhotite by hydrothermal alteration, (3) some other explanation.

A forward model of the ore zone with susceptibility contrast of -0.03 SI is shown in Figure 5. The “background” or host rock susceptibility is guesstimated to have average susceptibility of 0.03 SI, so using a contrast of -0.03 for the ore zone effectively means that it has a true susceptibility of zero. This represents total destruction of magnetic minerals by alteration. The top left panel shows a plan view of the ore zone with three representative fight lines, 20910, 20930 and 20950. Line 20930 lies close to the Duuring E-W geological cross section shown in Figure 1 and so has the best control on the ore zone geometry. The other panels show the observed (black) and model (red) magnetic profiles in the top, with a cross section below showing the ore zone.

There is a poor match between the observed and model profiles, so hydrothermal alteration destroying the magnetic minerals in the ore zone does not appear a viable option.

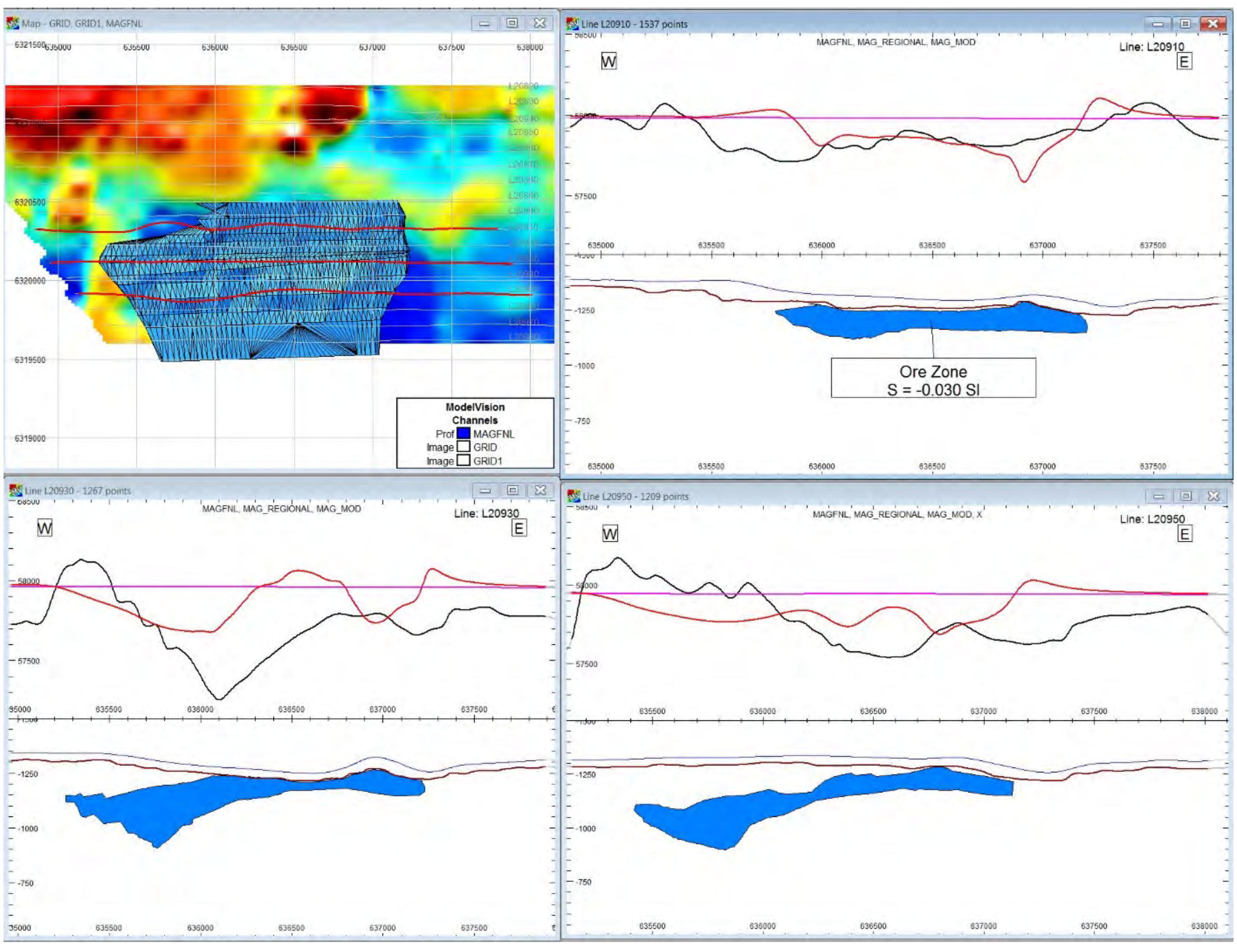


Figure 5: DIGHEM. Forward model of ore zone with sus -0.03 SI.

Next, the possibility of negative remanent magnetization was explored. The susceptibility of the ore zone was fixed at 0.005 SI (the approximate value of the ore zone shown in Figure 3b) and the remanent intensity, inclination and declination allowed to “float” during inversion. The result of this inversion is shown in Figure 6.

The final remanence parameters of the body area shown in the upper right panel. For reference the present Earth parameters are Incl=75 deg, Decl=19 deg.

There is some correspondence between observed and modeled profiles (particularly on the central Line 20930) but overall the correlation is not convincing. It does not appear that negative remanence of the ore zone can satisfactorily explain the observed negative anomaly.

Of course, it is possible that this representation of the ore body does not truly represent the geology and it actually has a different shape. Alternatively, the ore zone may not have uniform magnetic susceptibility and/or remanence and more complex geometries could explain the observed anomalies.

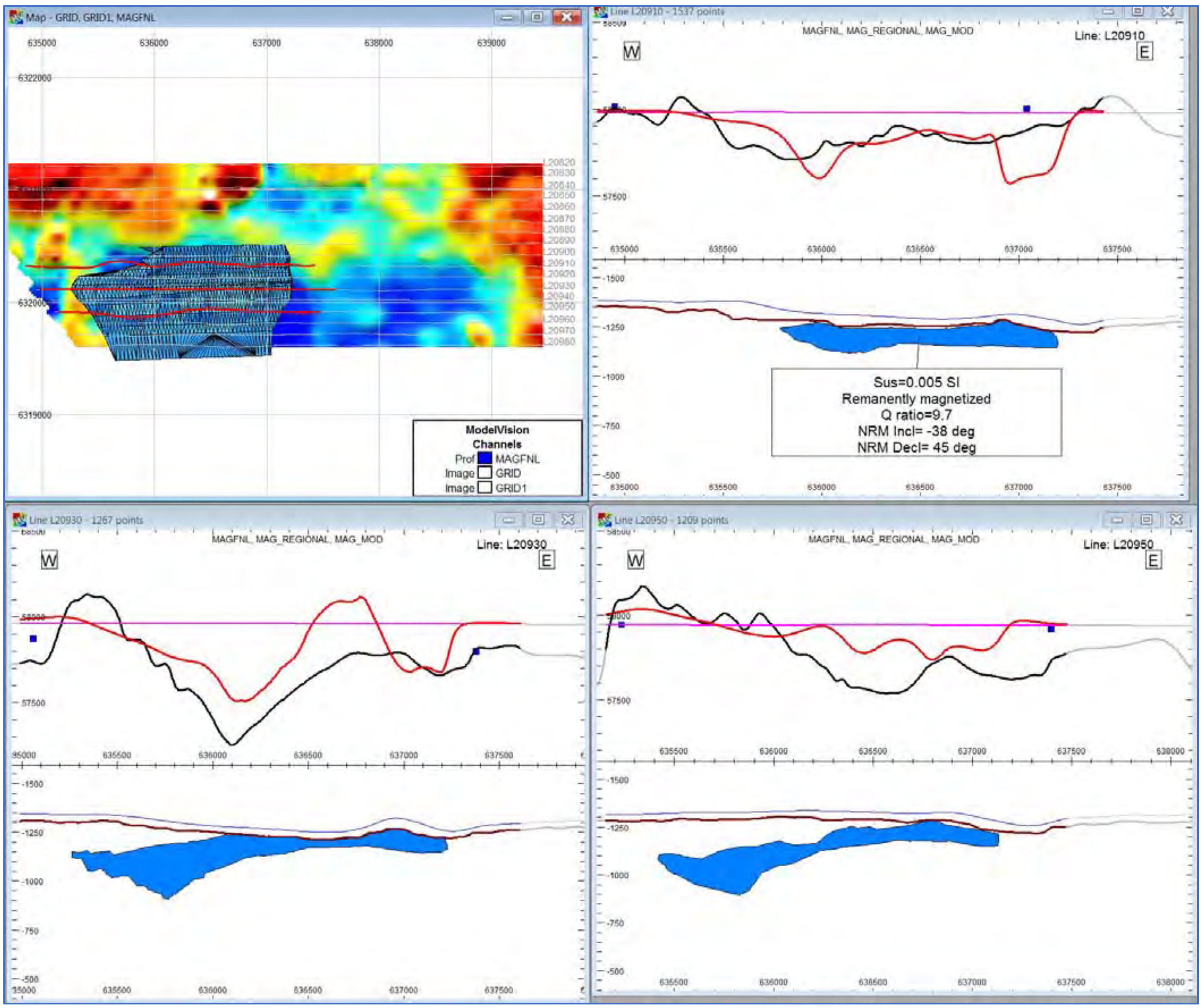


Figure 6: DIGHEM. Remanently magnetized inversion model.

Whilst analyzing the magnetics, a strong correlation between the magnetics and topography was noted. Figure 7 shows the calculated magnetic profiles for a uniform earth with susceptibility 0.03 SI. The upper surface of this uniform earth is the DEM calculated from the DIGHEM survey. With this relatively magnetic earth, even small topographic variations produce significant magnetic anomalies. Strong correlation with the observed magnetic profiles is evident.

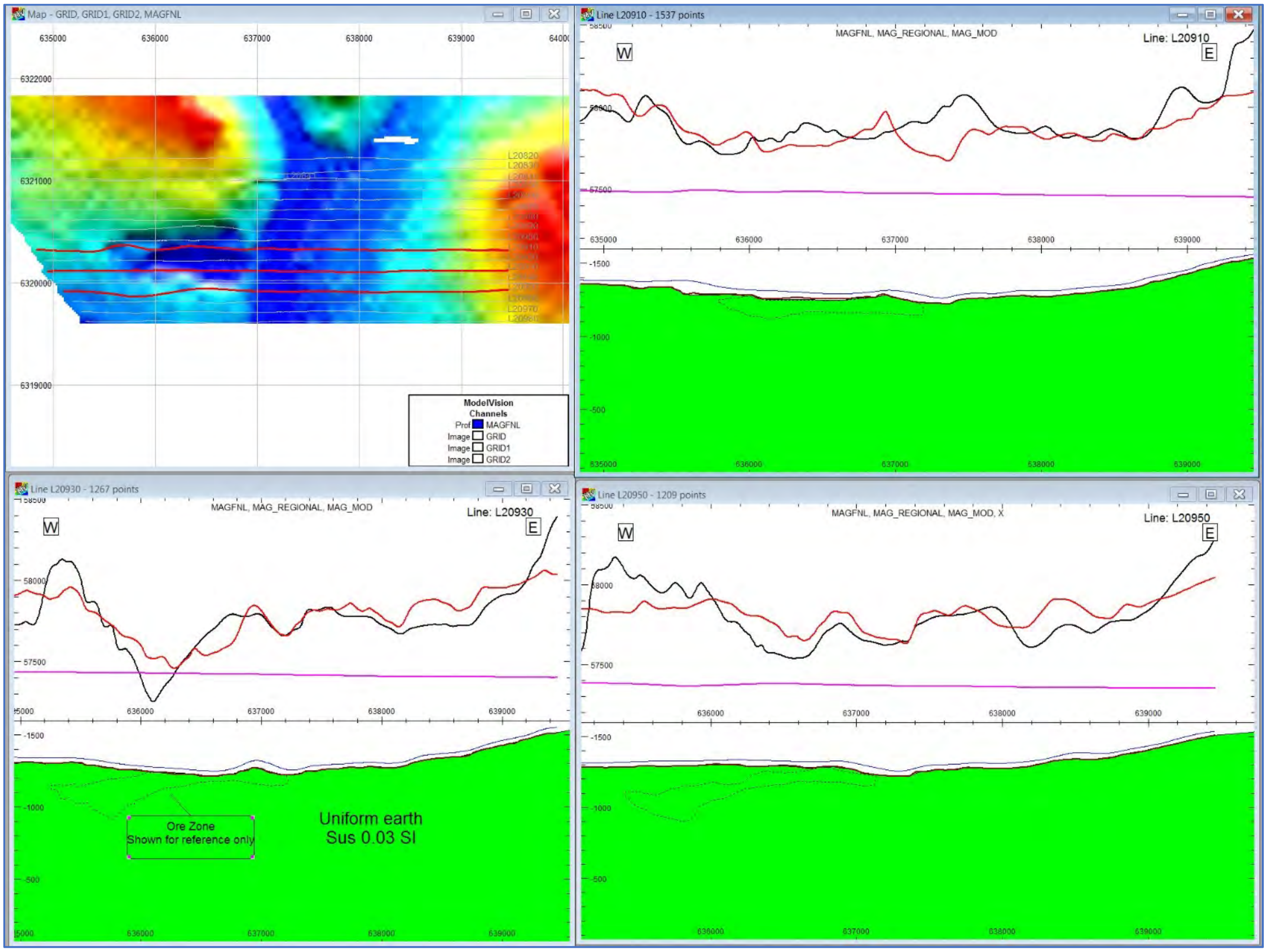


Figure 7: DIGHEM. Response of a uniform earth with sus 0.03 SI.

This is also evident in plan view. Figure 8 shows the DIGHEM TMI image (top), the DTM image (bottom) and the calculated uniform earth response (sus 0.03 SI) in the middle. The correlation of the uniform earth response with the observed magnetics is very evident in the mine area. In the northern part of the map area, strong magnetic anomalies are observed indicating that the earth susceptibility in these areas is much higher than 0.03 SI and so the uniform earth response does not match the observed.

It appears that the magnetic low correlating with the ore zone is largely caused by the topographic depression generated by the open pit.

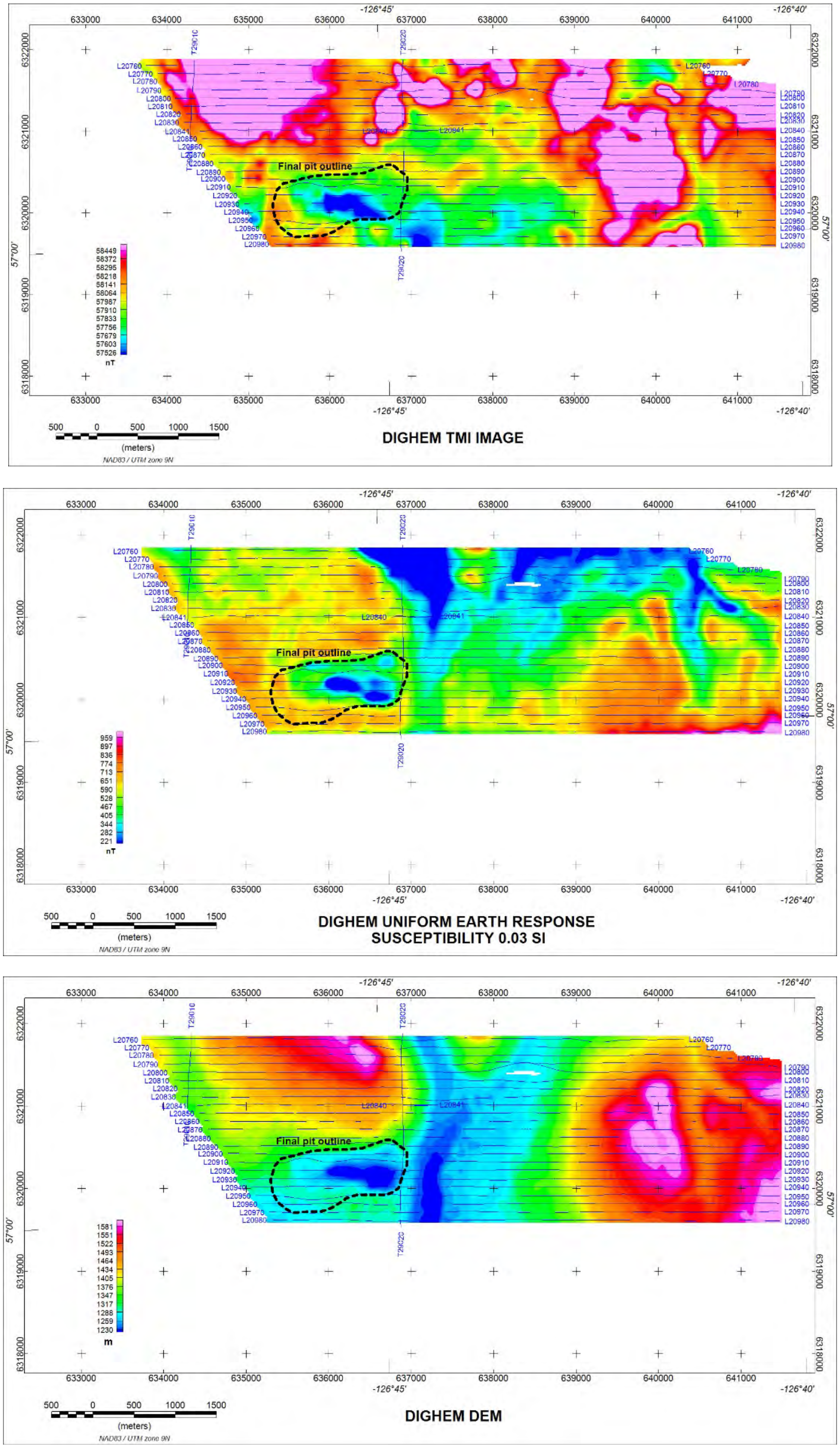


Figure 8: DIGHEM TMI (top), DEM (bottom), magnetic response of a uniform earth with sus 0.03 SI (middle).

ZTEM SURVEY

To further explore this issue the magnetic data from the 2014 ZTEM survey was analyzed. The TMI and RTP images in the mine area are shown in Figure 9. An even stronger magnetic low correlates with the open pit area.

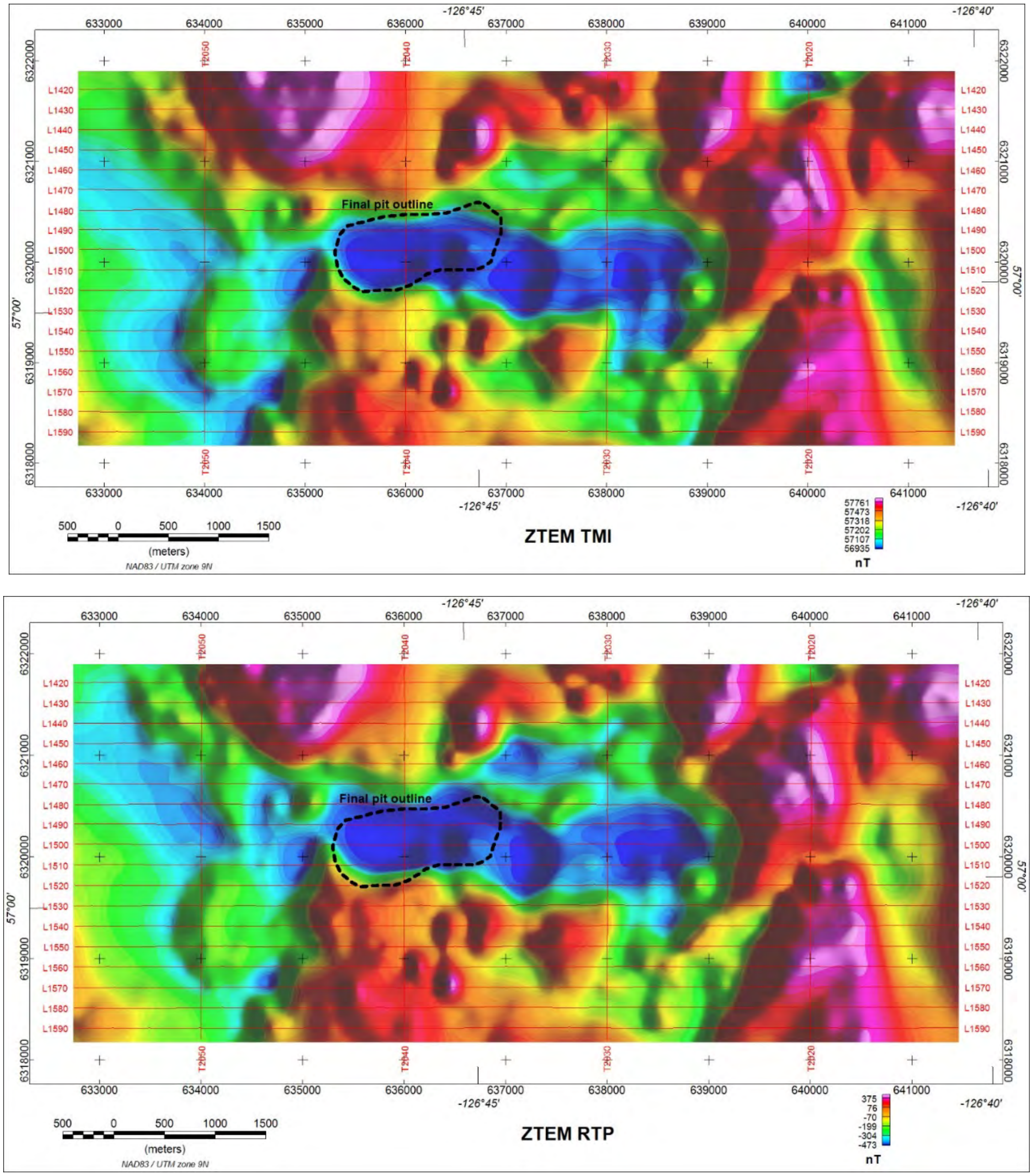


Figure 9: ZTEM (2014) magnetic images: TMI (top) and Reduced to Pole – RTP (bottom).

The changes in topography within the mine area through time are shown in Figure 10. The SRTM (top) was acquired in February 2000, early in the open pit mining. The open pit had been significantly deepened by the time of the DIGHEM in August 2002. The bottom image shows the DTM calculated from the ZTEM survey, flown after the mine had closed. This maps the upper part of the open pit well, but the pit was half-filled with water by this time.

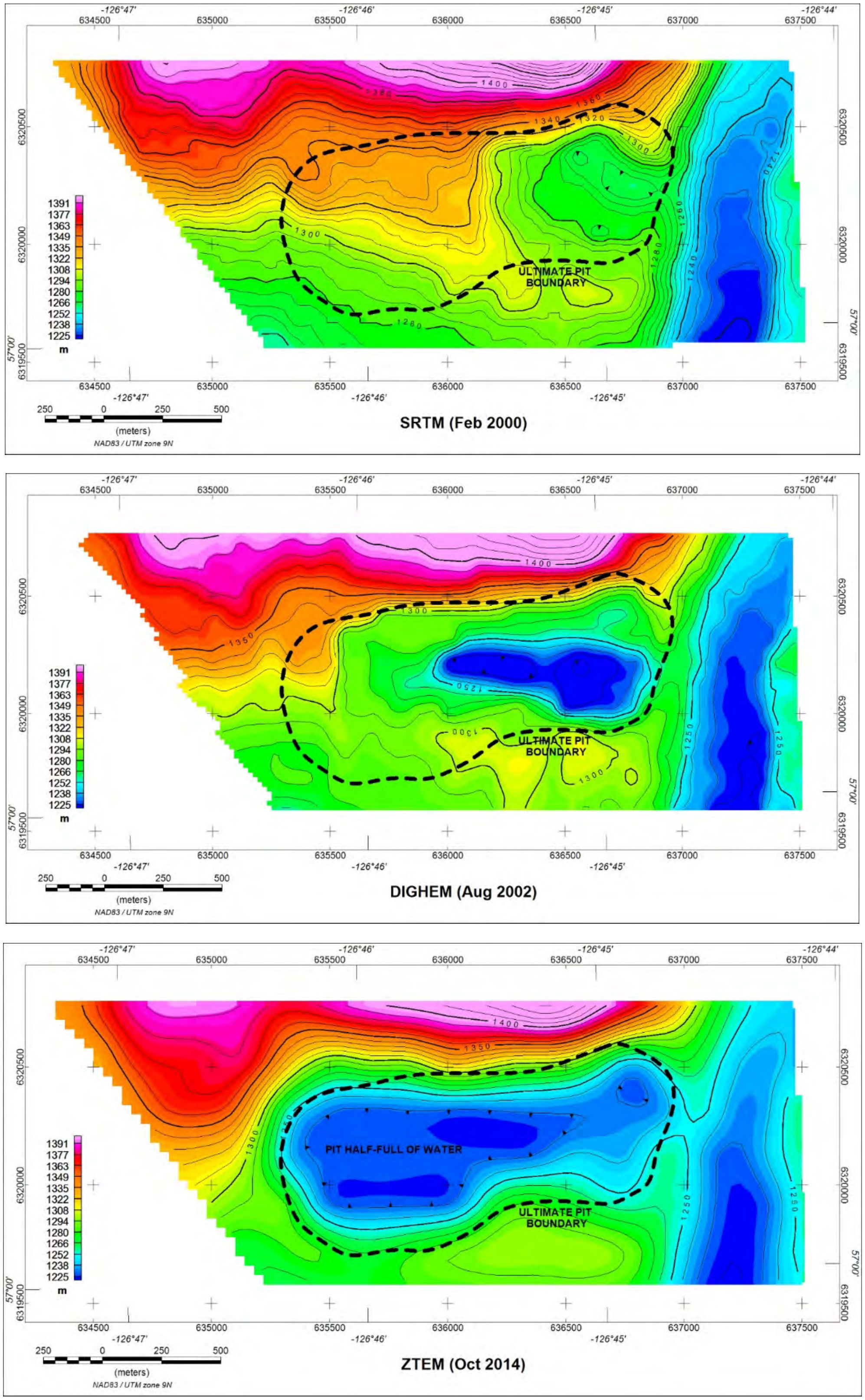


Figure 10: DTM's for various times. Note that ZTEM (2014) maps the water level in the half-full pit.

The model response of a uniform earth (susceptibility 0.03 SI), including the effects of the final open pit below water level, is shown in Figure 11. The upper surface of the uniform earth is the DEM calculated from the ZTEM survey. The ZTEM DEM survey maps the water level within the pit, so a 3D model of the pit boundaries below that depth was generated (blue body) and given a susceptibility of -0.03 SI to offset the uniform earth response in this region.

There is a strong correlation between observed and modeled profiles, indicating that the topography is causing much of the observed anomalies.

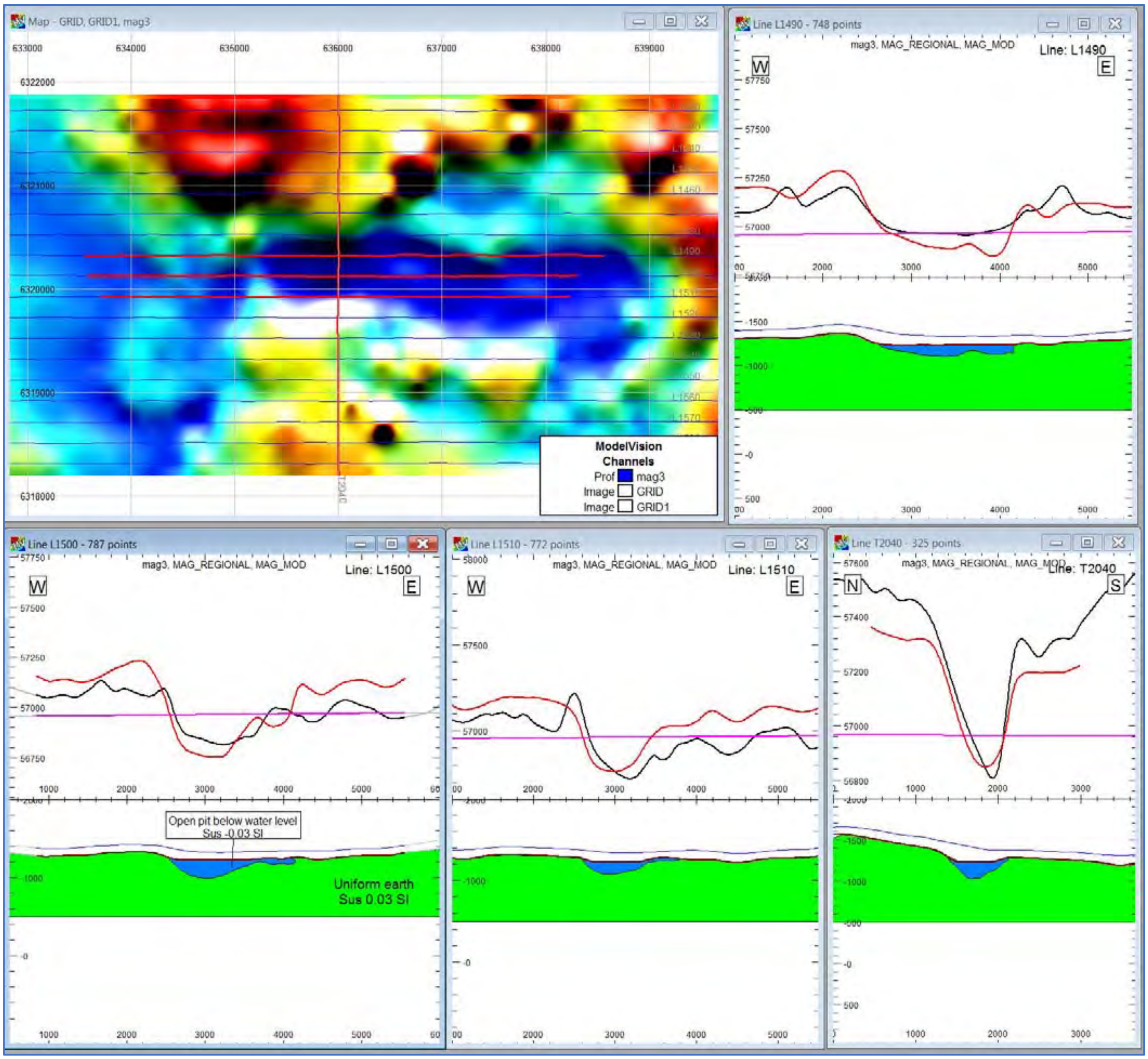


Figure 11: ZTEM response of uniform earth (sus 0.03 SI), including open pit below water level.

Figure 12 shows only the responses of the open pit below water level. The amplitude of these negative anomalies is greater than 200 nT.

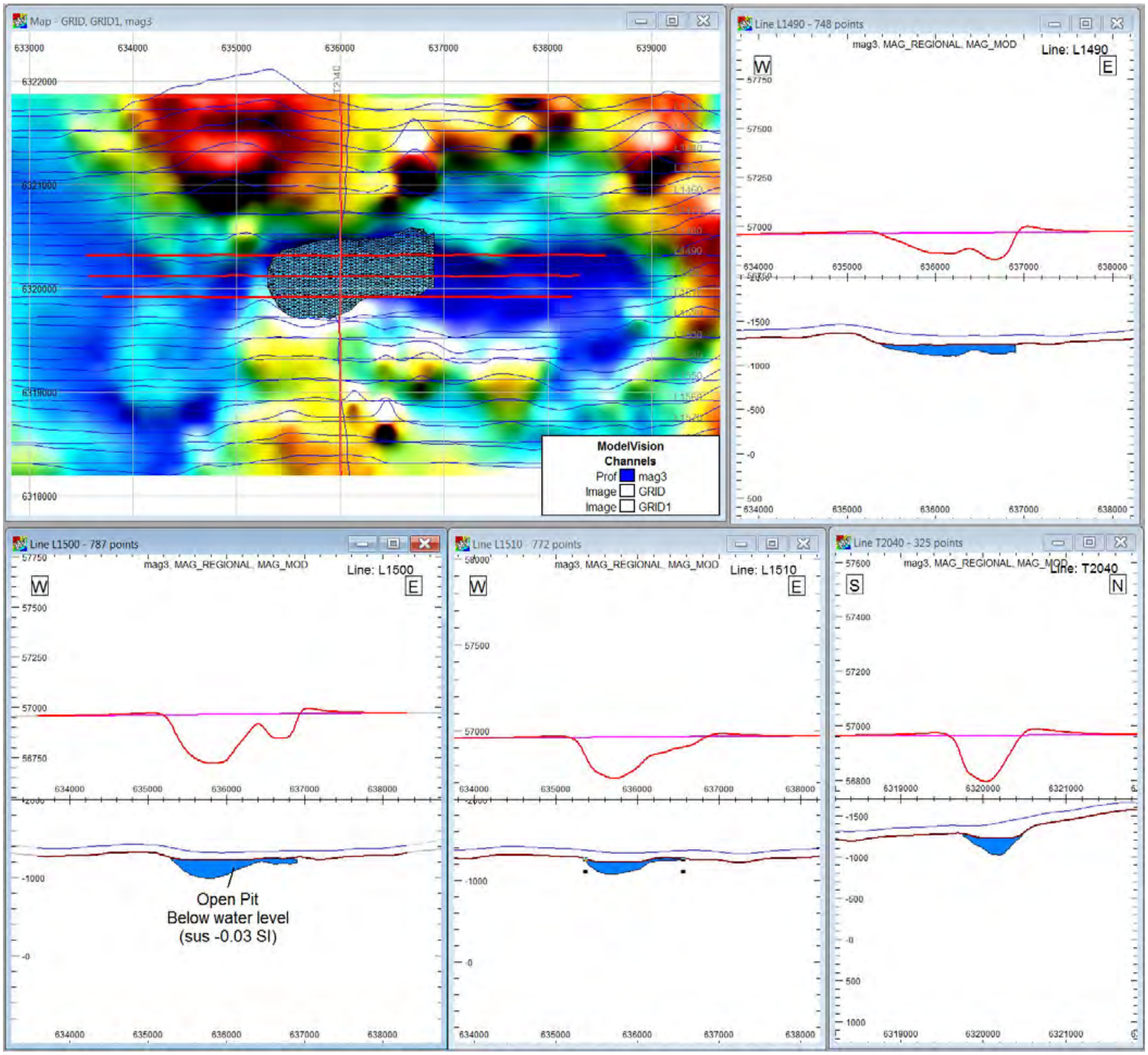


Figure 12: ZTEM response of open pit below water level.

Plan views of the ZTEM TMI, modeled earth response (sus 0.03 SI) including the effects of the open pit and the DEM area shown in Figure 13. The uniform earth response shows a general correlation with the TMI image indicating that much of the latter is due to topographic variations. In particular, there is a very good correlation between the two data sets in the vicinity of the open pit.

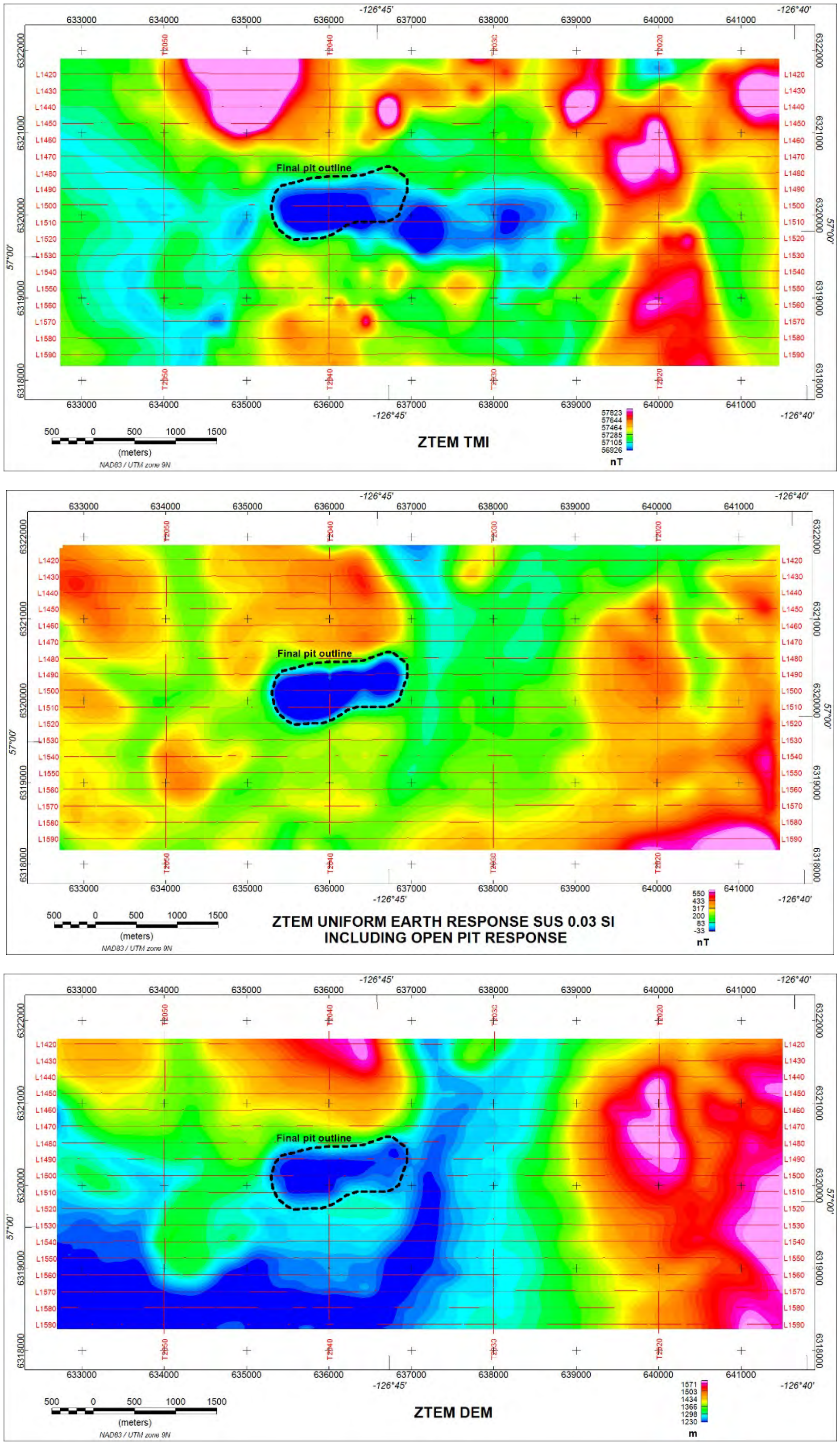


Figure 13: ZTEM TMI (top), DEM (bottom), magnetic response of a uniform earth with sus 0.03 SI including open pit response(middle).

Pseudo-DIGHEM Survey Using SRTM Topography

As a final check, the magnetic response of a uniform earth (sus 0.03 SI) using the Feb 2000 SRTM topography (very early in the mining) was calculated. The DIGHEM lines were used, but with a fixed sensor height of 35 m above the SRTM topography. The result is shown in Figure 14. No significant magnetic low correlates with the ore zone, except for a localized low in the NE of the open pit, which actually correlates with a minor topographic depression on the SRTM image (see Figure 10 for better resolution of this feature).

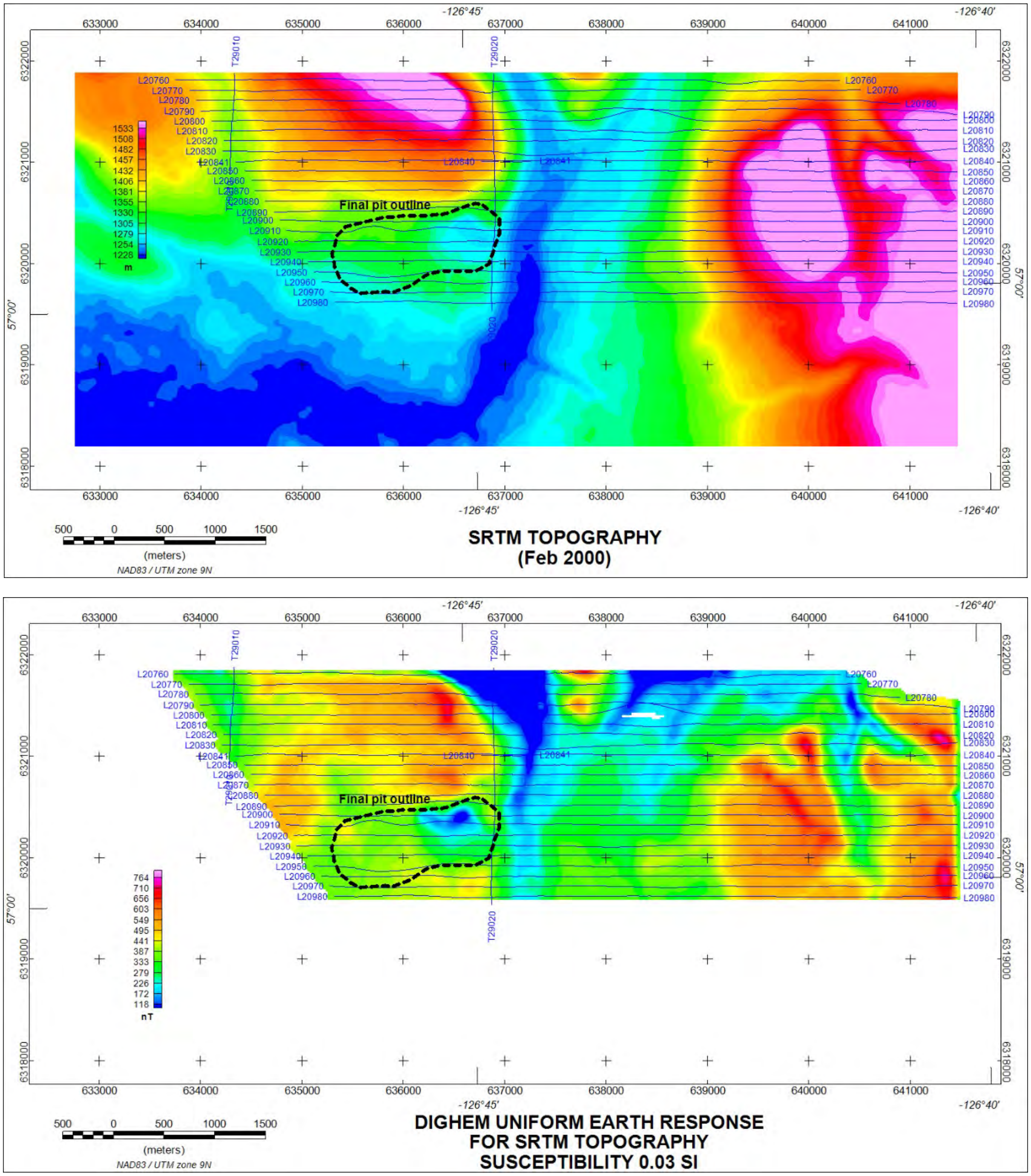


Figure 14: Magnetic response of a uniform earth (sus 0.03 SI) using SRTM topography. Pseudo DIGHEM survey, with fixed mag sensor height of 35 m.

CONCLUSIONS

The most satisfactory explanation for the negative magnetic anomalies correlating with the Kemess South ore zone, observed on the DIGHEM and ZTEM surveys, is that they are due to the topographic lows produced by the open pit. The amplitude of the lows increased significantly from the time of the DIGHEM survey (when the pit was relatively shallow) to the ZTEM survey (flown after mining finished and the maximum pit depth was reached).

REFERENCES

Duuring, P., Rowins, S.M., McKinley, B.S.M., Dickinson, J., Diakow, L.J., Kim, Y.S. and Creaser, R.A. 2008; Magmatic and structural controls on porphyry-style Cu-Au-Mo mineralization at Kemess South, Toodoggone District of British Columbia, Canada. Miner Deposita, May 2009, 44:435.

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