Part 2:
Regional interpretation, Balfour area

Introduction

The Balfour survey area is situated on the northwest coast of Tasmania (fig. 1.1). The geology of the area comprises relatively unmetamorphosed quartzite, siltstone and mudstone sequences of the Proterozoic Rocky Cape Group. Outcrop in the area is relatively sparse, although detailed surface geology is available in some areas, e.g. Temma and Balfour 1:25 000 scale maps (Everard *et al*., 2003). The 1:250 000 scale geological map of the area is shown in Figure 2.1. A large number of minor mineral deposits occur around the historic mining centre of Balfour, and the survey area is prospective for copper, tin-tungsten and gold.

Interpretation

Apparent resistivity maps

Figures 2.2 and 2.3 show the 980 Hz VCX apparent resistivity and HCP ternary conductivity maps derived from the HEM data. TMI and ternary radiometric images are shown in Figures 2.4 and 2.5. Geological boundaries (1:250 000 scale, Brown *et al*., 1995) have been superimposed on these figures. The very good comparison between the mapped geology and the HEM data clearly demonstrates the excellent geological mapping capabilities of the Hummingbird system. HEM data also indicate the presence of a number of units and structures within the survey area which that do not appear on the 1:250 000 scale geological map. A digital elevation model of the survey area is shown in Figure 2.6.

Some important features in the AEM data are denoted by the letters A–M on Figure 2.7. These are discussed individually below.

A1. This 2 km × 2 km conductive zone corresponds in part to outcropping Tertiary basalt. Thick basalt flows throughout west and northwest Tasmania are typically electrically conductive (see also the discussion of Figure 3.8). This basalt is interpreted as extending several hundred metres to the east and west of its mapped outcrop on the basis of the HEM data.

A2. A discrete conductive zone to the east of A1 is interpreted as further, unmapped Tertiary basalt. This interpretation is supported by a broad thorium radiometric anomaly which encompasses HEM anomalies A1 and A2. Minor patchy basalt outcrop is also interpreted approximately 1 km south of A2.

A3. Mapped Tertiary basalt at this location has no HEM signature, and it is interpreted as being thin in comparison with the basalts at A1 and A2.

A4. A string of minor basalt outcrops extend to the south of A1 between 5 427 000 mN and 5 431 500 mN. A number of these small basalt outcrops appear as good conductors in the HEM apparent conductivity map (fig. 2.2). Localised conductive zones at 310 400 mE, 5 432 500 mN and 310 600 mE, 5 429 500 mN have associated thorium anomalies, and are most likely to be further small, unmapped basalts. Other possible basalt outcrops identified in the HEM data occur at 310 400 mE, 5 430 200 mN; 312 200 mE, 5 425 000 mN; 312 000 mE, 5 424 250 mN; and 313 000 mE, 5 421 500 mN. These anomalies lie within a zone of low radiometric response (Lagoon River Quartzite), and have no distinct radiometric signature.

B. A mapped northeast-trending fault has an obvious HEM expression where it truncates the NNW-trending resistive Lagoon River Quartzite. This fault is considered to be a splay off the Roger River Fault (D. Seymour, Mineral Resources Tasmania, pers. comm.).

C. Numerous north-south trending linear bedrock conductors, with strike extents of 1-2 km, have been identified around the historic mining area of Balfour. The large strike extent of these conductors suggests they are most likely to be carbonaceous units of the Balfour Sub-group, which are known to contain up to 40% graphite (Veska, 1993). Further linear conductors interpreted as carbonaceous shales are evident at approximately 320 500 mE, 5 437 500 mN and 323 500 mE, 5 439 500 mN.

D. A resistive zone within the Balfour Sub-group corresponds to outcropping Neoproterozoic Forest Conglomerate and Quartzite (Togari Group) at Mt Frankland. The location of the main apparent conductivity low at Mt Frankland suggests that this unit extends to the southeast of its mapped surface outcrop within the shallow subsurface.

E. A large resistive zone running though the central part of the survey area corresponds to the mapped extent of the Lagoon River Quartzite.

F. Four prominent bedrock conductors have been identified at around 320 500 mE, 5 425 000 mN within the Lagoon River Quartzite. These are not associated with any known mineralisation, and are worthy of ground follow-up.

G. A conductive unit corresponds closely to the mapped extent of the Pedder River Siltstone (the basal unit of the Rocky Cape Group). This unit has a strong radiometric signature, and the unit boundaries derived from ternary conductivity and radiometric images show close agreement.

H. Zones of high conductivity at low frequency (red colours on Figure 2.3) within the Pedder River

Siltstone correspond to thorium-enriched radiometric anomalies in the radiometric data. These possibly indicate unmapped resistive cover sequences overlying the Pedder River Siltstone.

I. High conductivities close to the coast at 315 000 mE, 5 416 000 mN and 310 000 mE, 5 424 000 mN are interpreted as Quaternary sand containing saline groundwater.

J. The Balfour Shear Zone (Webster, 2002) has been clearly mapped throughout the southern half of the survey area by the HEM survey, where it juxtaposes resistive Lagoon River Quartzite to the west, and conductive lithologies of the Balfour Sub-group to the east. A number of prominent east and northeast-trending faults which cut the Lagoon River Quartzite to the north of J are apparent in HEM, magnetic and radiometric data. These faults are marked on the HEM interpretation map (fig. 2.8).

K. A resistive zone within the surrounding, conductive units has not been recognised in previous geological mapping. Recent ground-truthing of the HEM data indicates that this resistive zone corresponds to outcropping Lagoon River Quartzite (J. Everard, Mineral Resources, pers. comm.). Flight line 11271, which crosses this resistive zone, is discussed in the *conductivity-depth* section below.

L. Several faint northeast-trending HEM anomalies are associated with a ?Neoproterozoic dolerite dyke swarm. The anomalies of these dykes are most clearly seen in the 980 Hz and 7000 Hz VCX apparent resistivity data. Modern drainage paths are commonly controlled by these dykes, and some HEM anomalies are possibly related to the presence of alluvium within these drainages.

M. This area has been mapped as Lagoon River Quartzite. HEM data however suggest a pronounced change in lithology within the quartzite, with a strong, northeast-trending conductivity boundary located at approximately 335 000 mE. The conductive units to the southeast of this boundary have a similar conductivity signature to rocks of the Balfour Sub-group near L.

A summary interpretation map of the Balfour area is shown in Figure 2.8.

Responses of known mineralisation

Bedrock conductors with strong responses at low frequency (880 Hz and 980 Hz) have been manually picked from raw profile data. Broad anomalies likely to be due to changes in lithology, and those associated with obvious radar altimeter spikes, were excluded during the picking process. Numerous isolated and stratigraphic bedrock conductors have been identified. However, only two known deposits, Robbie's Sn (324 300 mE, 5 429 000 mN) and Strickland-Temma Fe-Pb-Sn (310 000 mE, 5 434 000 mN) have associated HEM anomalies. A HEM anomaly at 310 000 mE, 5 433 800 mN may represent the southern extension of the Strickland-Temma mineralisation. However, the Strickland-Temma mineralisation occurs in an area of conductive basalt outcrop (A1 above), and the HEM anomalies could also be due to a local change in the thickness or conductivity of the basalt.

A number of other deposits appear to be closely associated with major structures interpreted from the HEM data. These include an unnamed copper deposit at 322 100 mE, 5 430 700 mN, an unnamed Sn-Pb-Cu deposit at 323 200 mE, 5 427 800 mN, and the Section 4238M Cu deposit at 323 300 mE, 5 428 000 mN.

EMFlow and Sengpiel conductivity-depth sections

Conductivity-depth sections for four profiles within the survey area are shown in Figures 2.9–2.12. The locations of the profiles are indicated on the summary interpretation map (fig. 2.8).

Line 10241 (fig. 2.9)

This survey line crosses the mapped and interpreted basalts A1 (310 000 mE) and A2 (313 500 mE). The EMFlow and Sengpiel sections indicate the presence of resistive material below both basalts, and the basalt thickness implied by the CDI section is around 20-40 metres. This estimated thickness assumes that the conductivity of the basalts is reasonably uniform, i.e. that they are fractured throughout their entire thickness. A conductor at 321 700 mE is probably associated with carbonaceous shales within the Balfour Sub-group. High Sengpiel conductivities between 323 000 mE and 325 000 mE are not seen in the EMFlow CDI, and are likely to be associated with drift errors or other noise in the measured responses.

Line 10651 (fig. 2.10)

This line crosses carbonaceous shales of the Balfour Sub-group at 328 500 mE and 324 100 mE, and Tertiary basalt at 312 000 mE. Large gaps in the Sengpiel section denote very small measured responses associated with resistive lithologies, e.g. the Forest Conglomerate and Quartzite at Mt Frankland (326 600 mE). Weak conductors at 320 000 mE and 318 000 mE are likely to be due to changes in lithology within the Lagoon River Quartzite. A weak conductor at 311 500 mE is associated with a 300 nT local magnetic anomaly, and could represent minor mineralisation. A weakly-conductive zone at >100 m depth between 313 000 mE and 320 000 mE in the EMFlow CDI is not indicated in the Sengpiel section. The small magnitude of the observed low-frequency responses, the depth of the inferred conductive zone, and the noisy appearance of the EMFlow CDI suggest that this is a processing artifact and not a real feature.

Line 10741 (fig. 2.11)

The strong anomalous response at 320 300 mE is associated with one of the conductors located close to the contact between the Lagoon River Quartzite and the Pedder River Siltstone (marked F on fig. 2.7). Both EMFlow and Sengpiel conductivity-depth sections indicate the conductor to be at 40–50 m depth, and dipping to the west.

Line 11271 (fig 2.12)

High Sengpiel conductivities between 332 000 mE and 335 000 mE are not seen in the EMFlow CDI, and are likely to be associated with drift or levelling errors in the measured responses. A broad conductive zone between 328 200 mE and 329 200 mE has a coincident deep magnetic anomaly, and corresponds to mapped exposure of the Balfour Sub-group. Webster (2002) has suggested that this magnetic anomaly is due to alteration of the Lagoon River Quartzite by a shallow granitic intrusion to the east of the Balfour Shear Zone. As noted above, recent geological ground truthing has shown that highly-resistive Lagoon River Quartzite crops out around 330 000 mE. It is not possible to determine the presence or absence of shallow granite below the Lagoon River Quartzite, given the lack of a significant resistivity contrast between these lithologies.

EMFlow conductivity-depth slices

Conductivity-depth slices from EMFlow data at 20 m, 70 m, and 120 m below surface are shown in Figures 2.13 to 2.15.

The main features of the 20 m depth slice are the conductive Tertiary basalts in the northwest of the survey area (A1, A2, and A4 in Figure 2.7), conductive Quaternary material at around 315 000 mE, 3 147 000 mN, and a number of stratigraphic conductors (carbonaceous shales) within the Balfour Sub-group at around 327 500 mE, 5 429 000 mN.

Considerable geological detail can be seen in the 70 m depth slice. With the exception of the Tertiary basalts (A1–A4), most of the anomalous features noted above can be clearly discerned. Comparison of the interpreted position of the Balfour Shear Zone (J on fig. 2.7) on the 20 m and 70 m depth slices suggests that, near surface, the contact between the Lagoon River Quartzite and Balfour Sub-group dips shallowly to the west at an angle of approximately 20°.

The 120 m depth slice contains little geological information, although the edges of units occurring at shallower depth are well defined. Conductors associated with the margins of units occur at the Forest Conglomerate (D in fig. 2.7), the fault boundary between the Lagoon River Quartzite and the Pedder River Siltstone (J in fig. 2.7), and the edges of the previously unmapped exposure of the Lagoon River Quartzite (K in fig. 2.7). These ‘conductors’ are considered to be artifacts resulting from one-dimensional EMFlow interpretation of HEM anomalies generated by two-dimensional contacts between lithologies of differing conductivity.

A widespread zone of moderately high conductivity beneath mapped exposure of the Lagoon River Quartzite (322 500 mE, 5 415 000–5 432 500 mN) is also likely to be an artifact generated by EMFlow. This apparent artifact at depth was discussed in the interpretation of flight line 10651 (fig. 2.10).

Figure 2.1
Balfour 1:250,000 geology with EM survey boundary

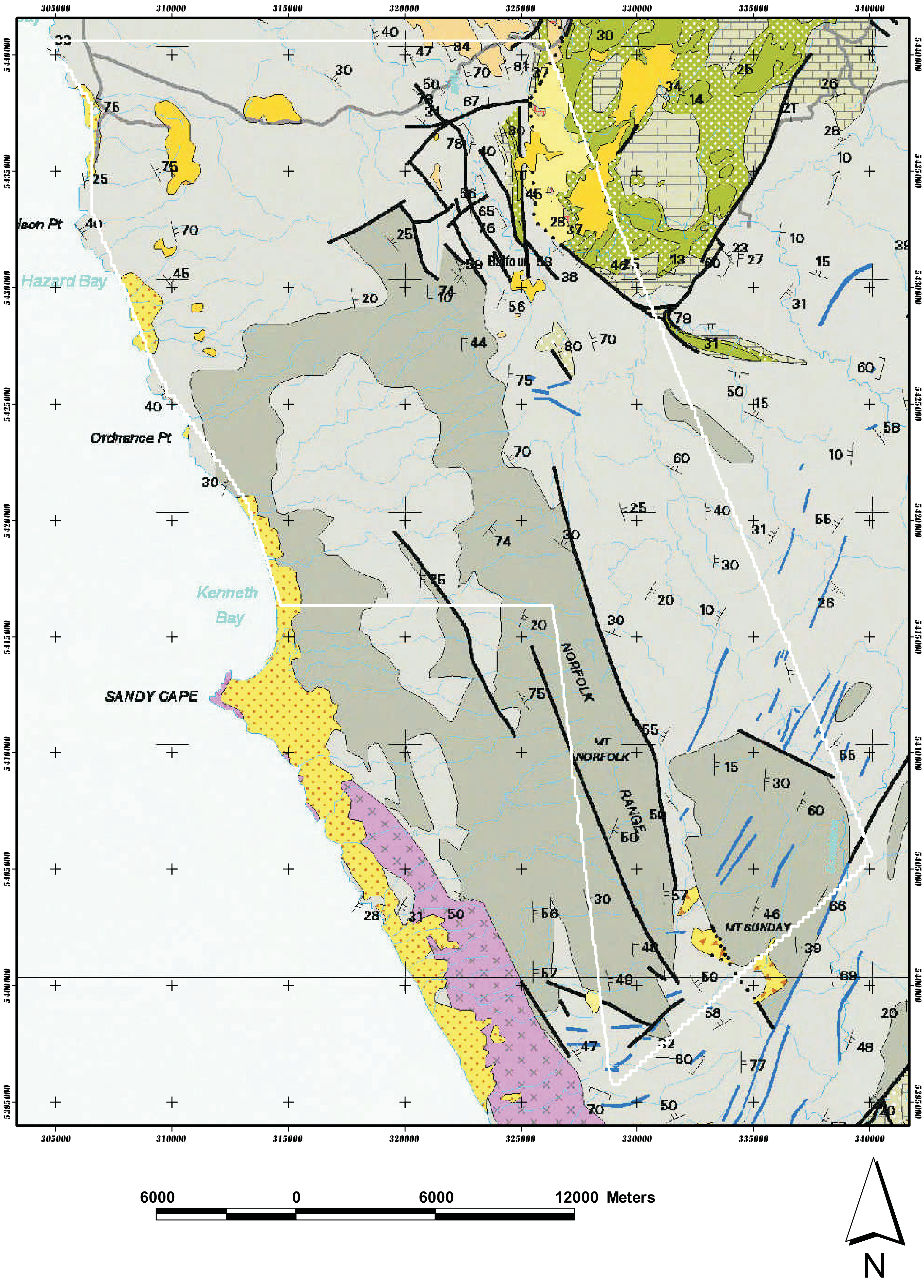


Figure 2.2
Balfour 980 Hz apparent resistivity with 1:250,000 geology

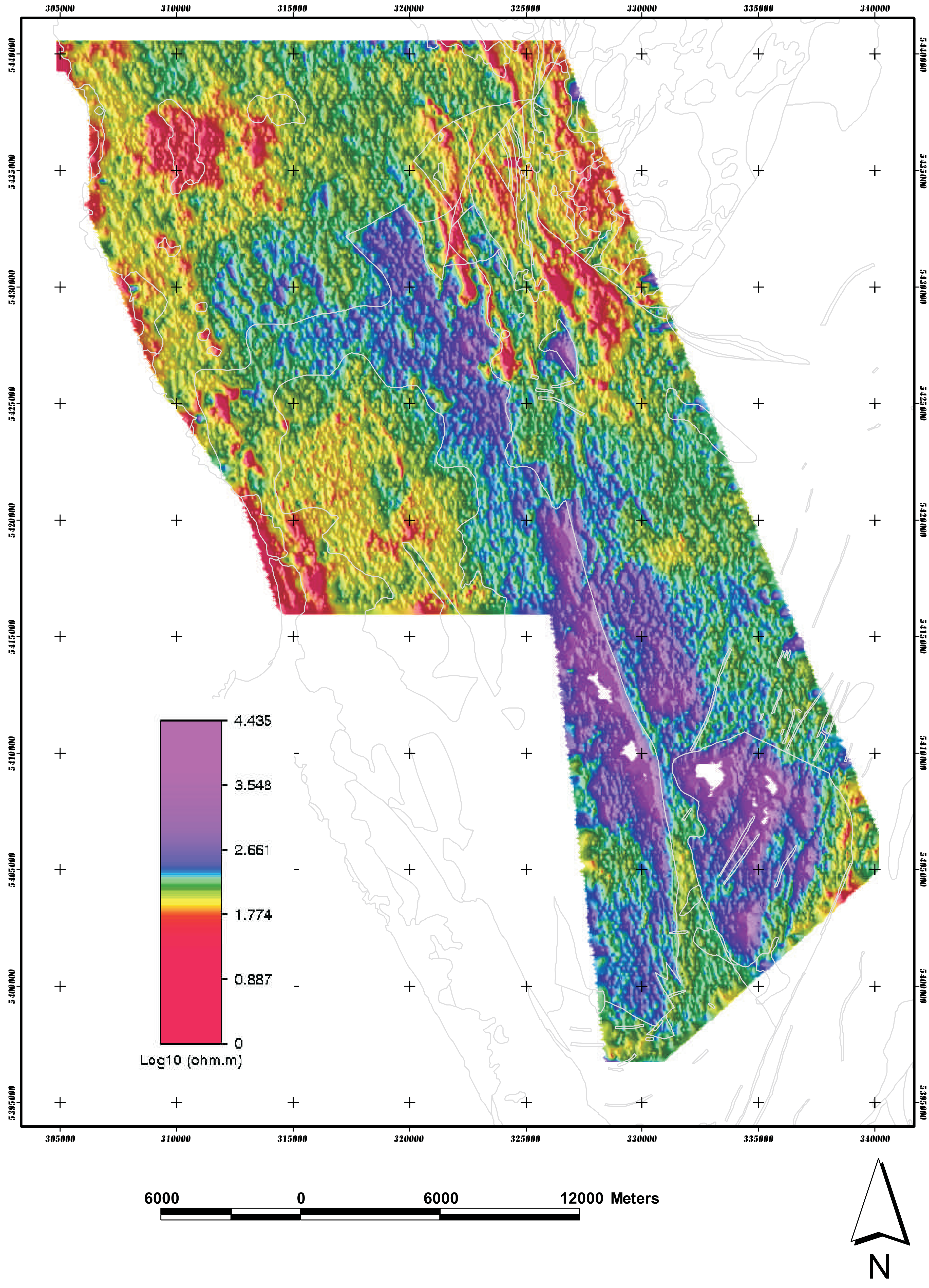


Figure 2.3
Balfour HCP ternary conductivity with 1:250,000 geology

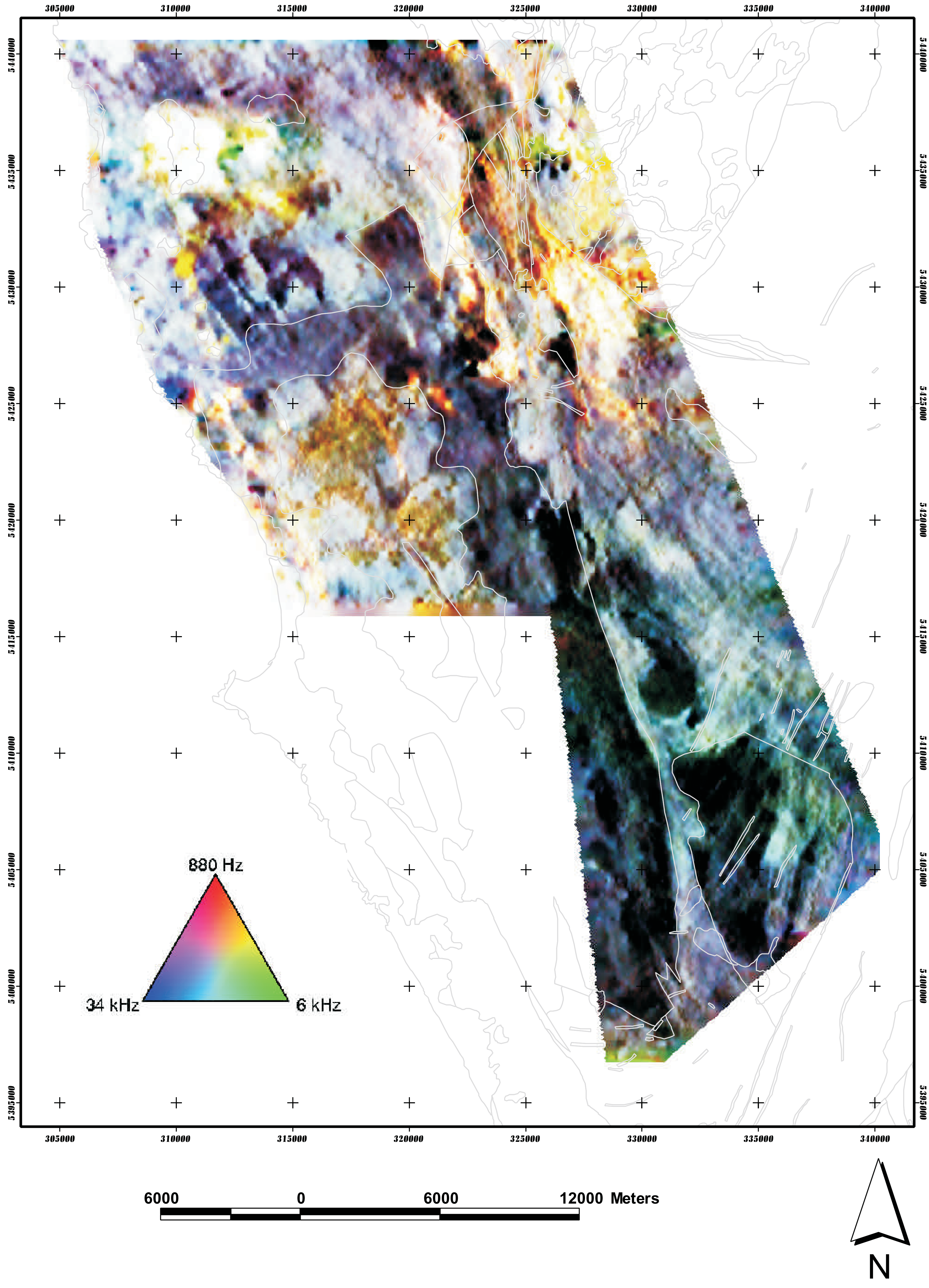


Figure 2.4
Balfour WTRMP TMI with 1VD enhancement,
EM survey boundary and 1:250,000 geology

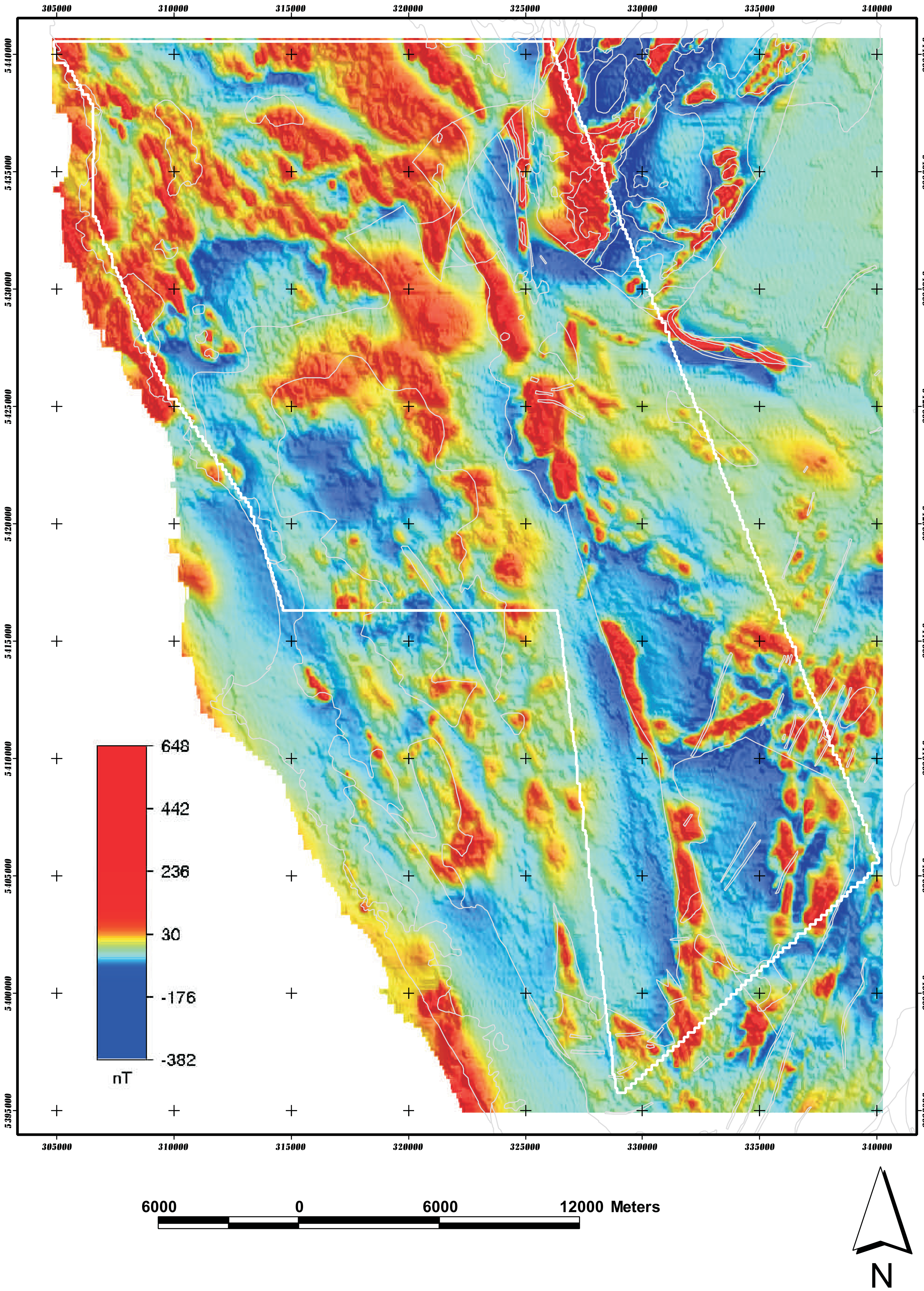


Figure 2.5
Balfour WTRMP ternary radiometrics with 1:250,000 geology and EM survey boundary

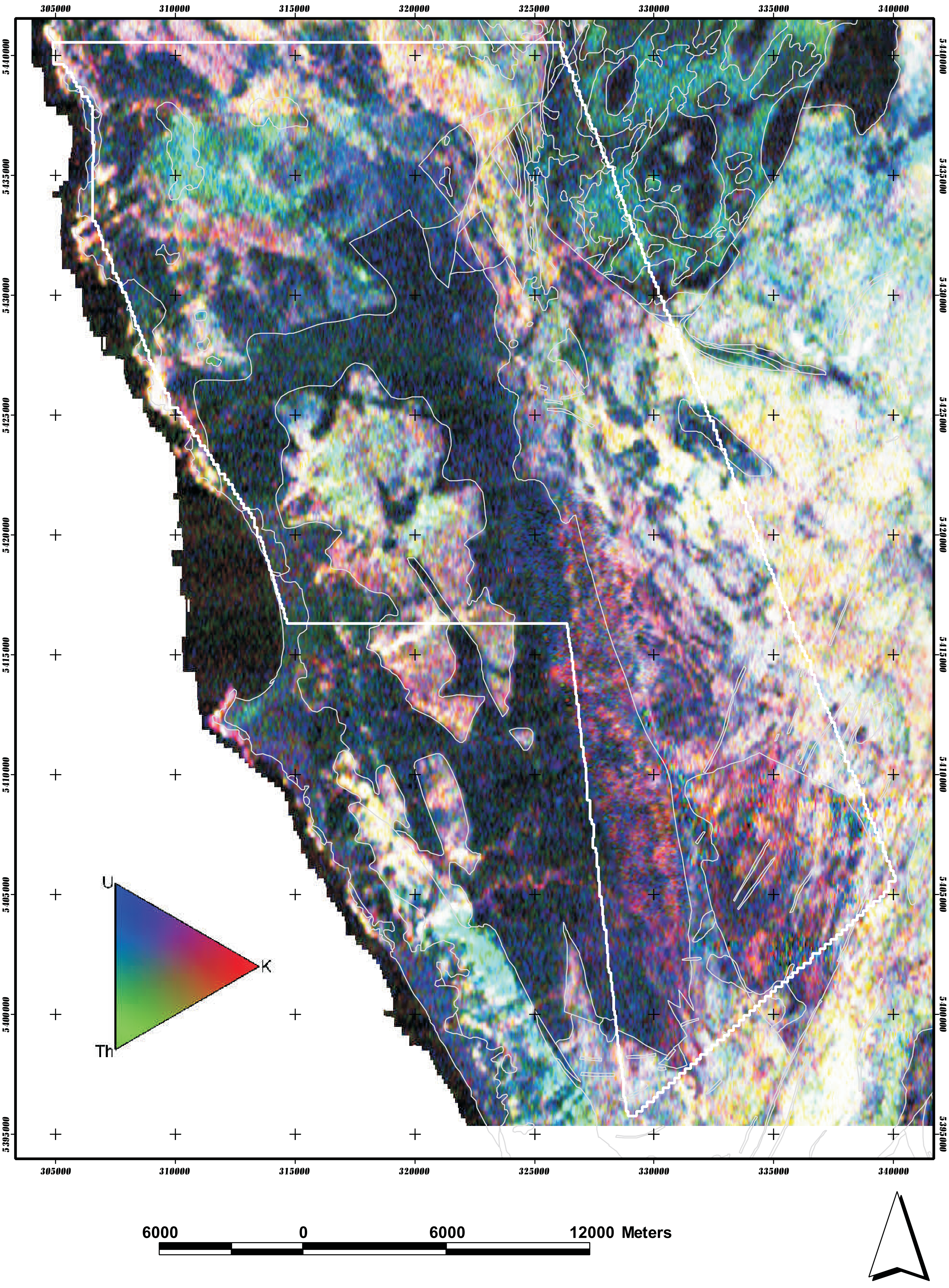
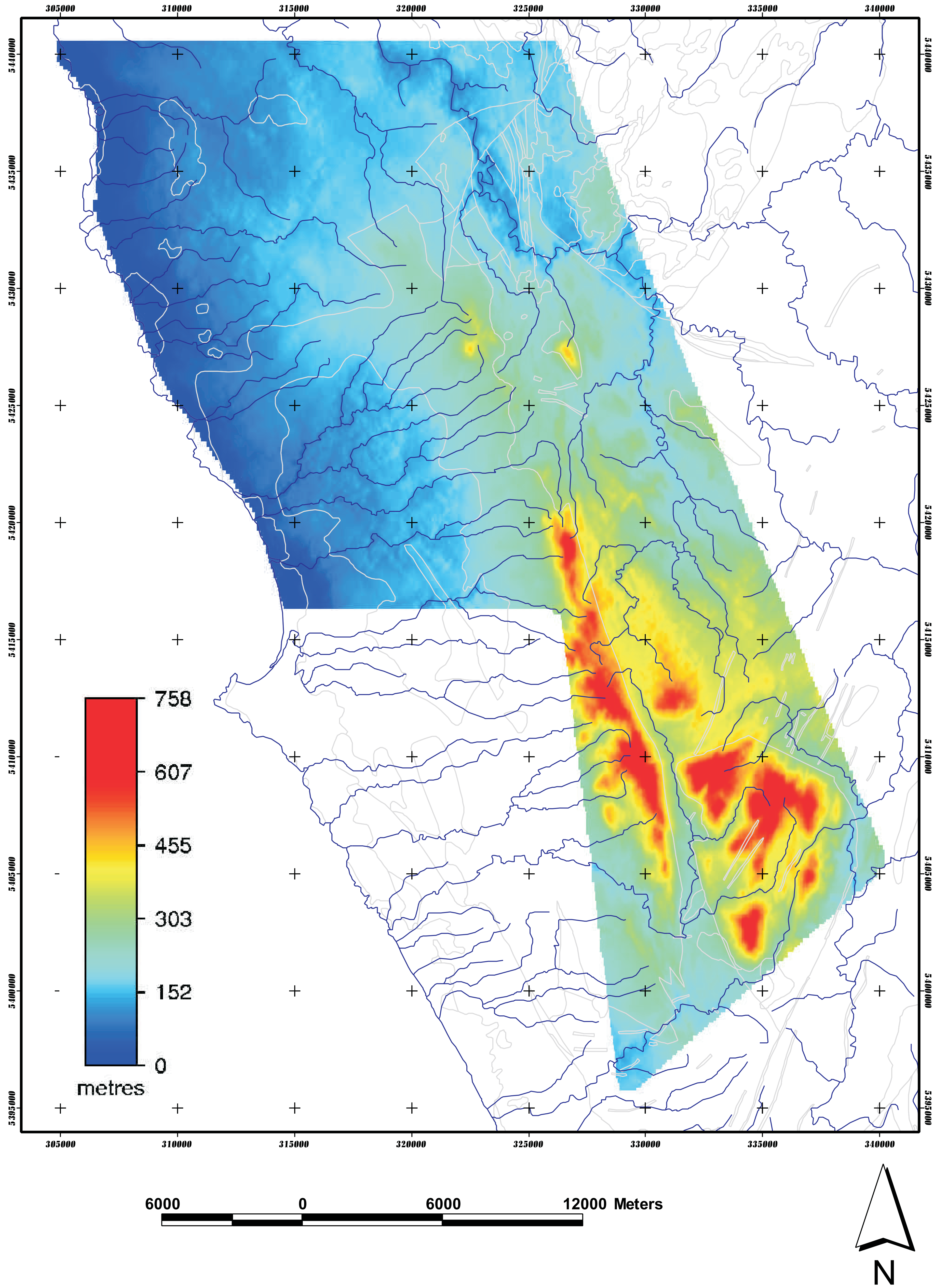


Figure 2.6
Balfour digital elevation model with drainage and 1:250,000 geology



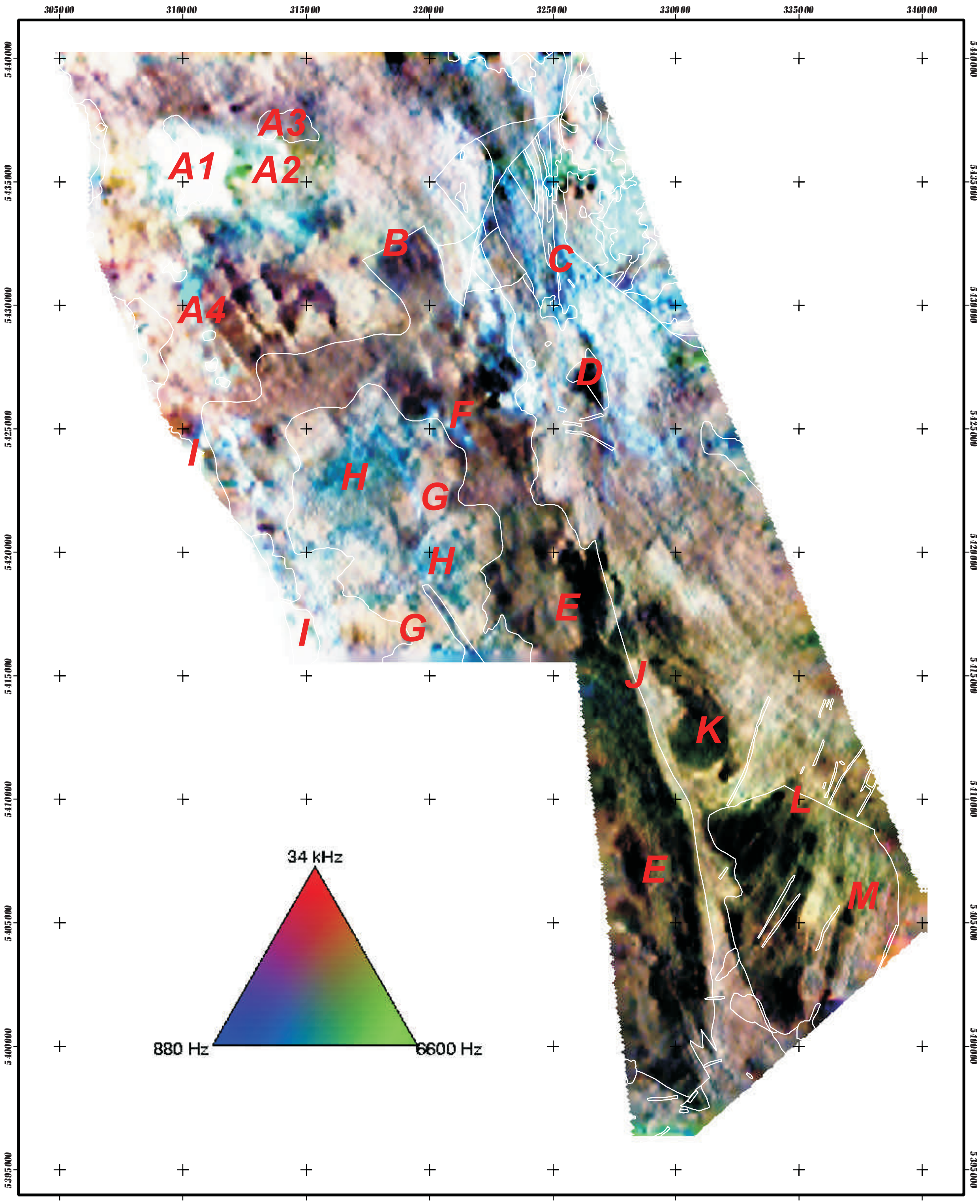
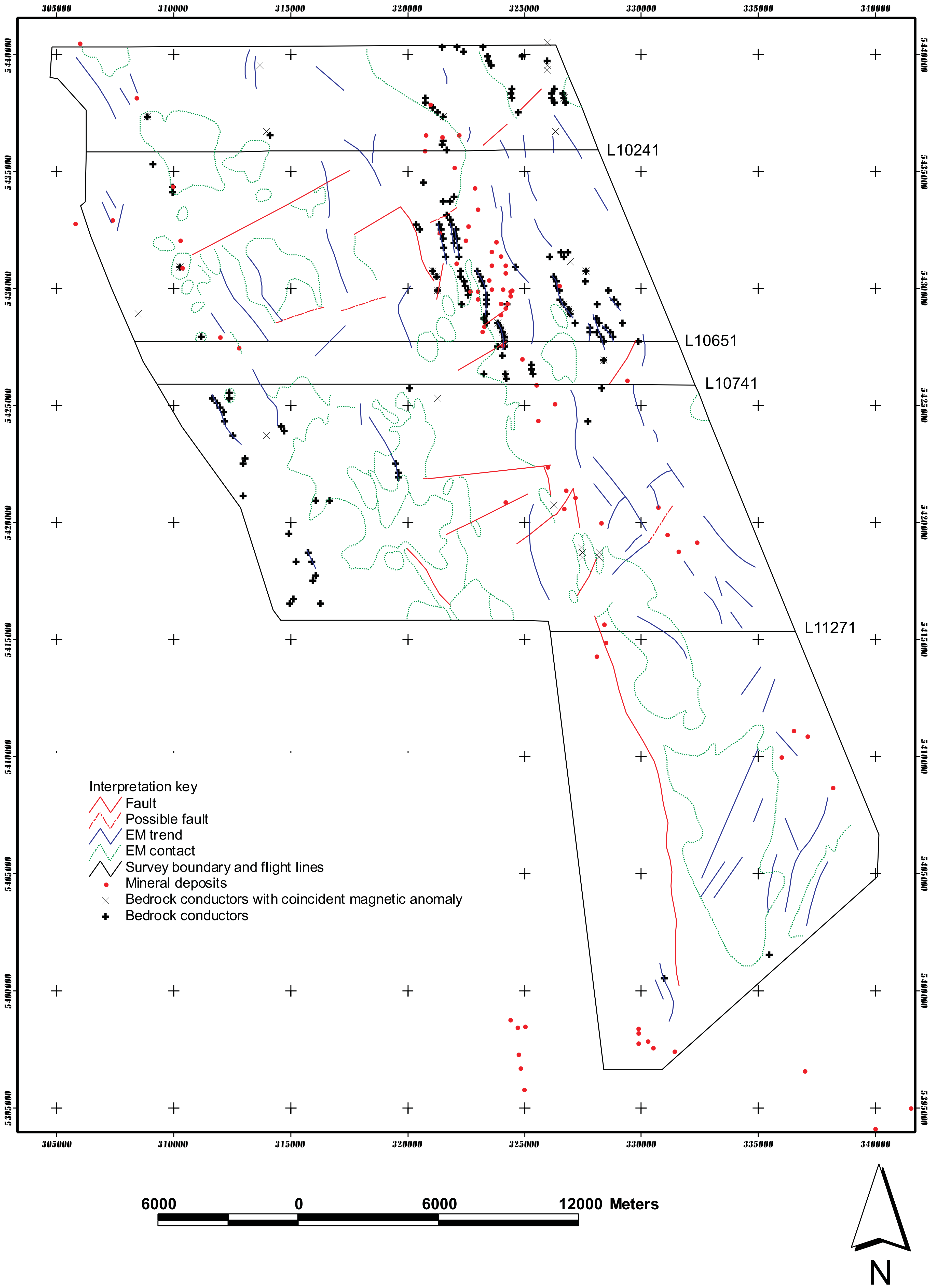


Figure 2.7

HCP Ternary conductivity map with major features marked (A-M)

Figure 2.8
Balfour HEM interpretation, with known mineral deposits and bedrock conductors



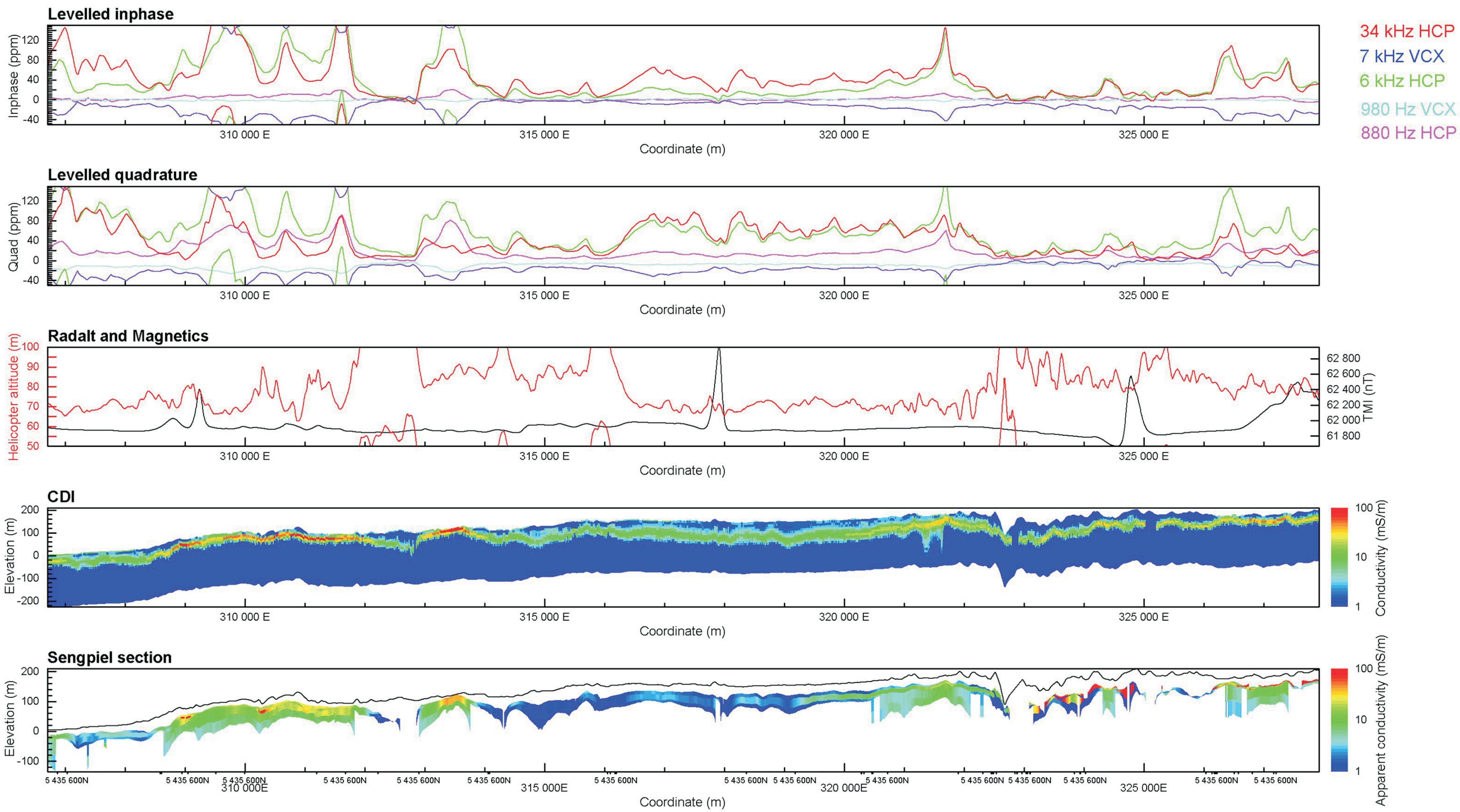


Figure 2.9
Balfour, NW Tasmania
Line D10241

Levelled inphase and quadrature data
Radar altimeter and TMI
EMFlow v3.2 conductivity-depth image
Sengpiel section

0m 1000m 2000m 3000m 4000m

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An electromagnetic interpretation of west and northwest Tasmania

March 2003

Coordinates: AGD66/TMAMG 55

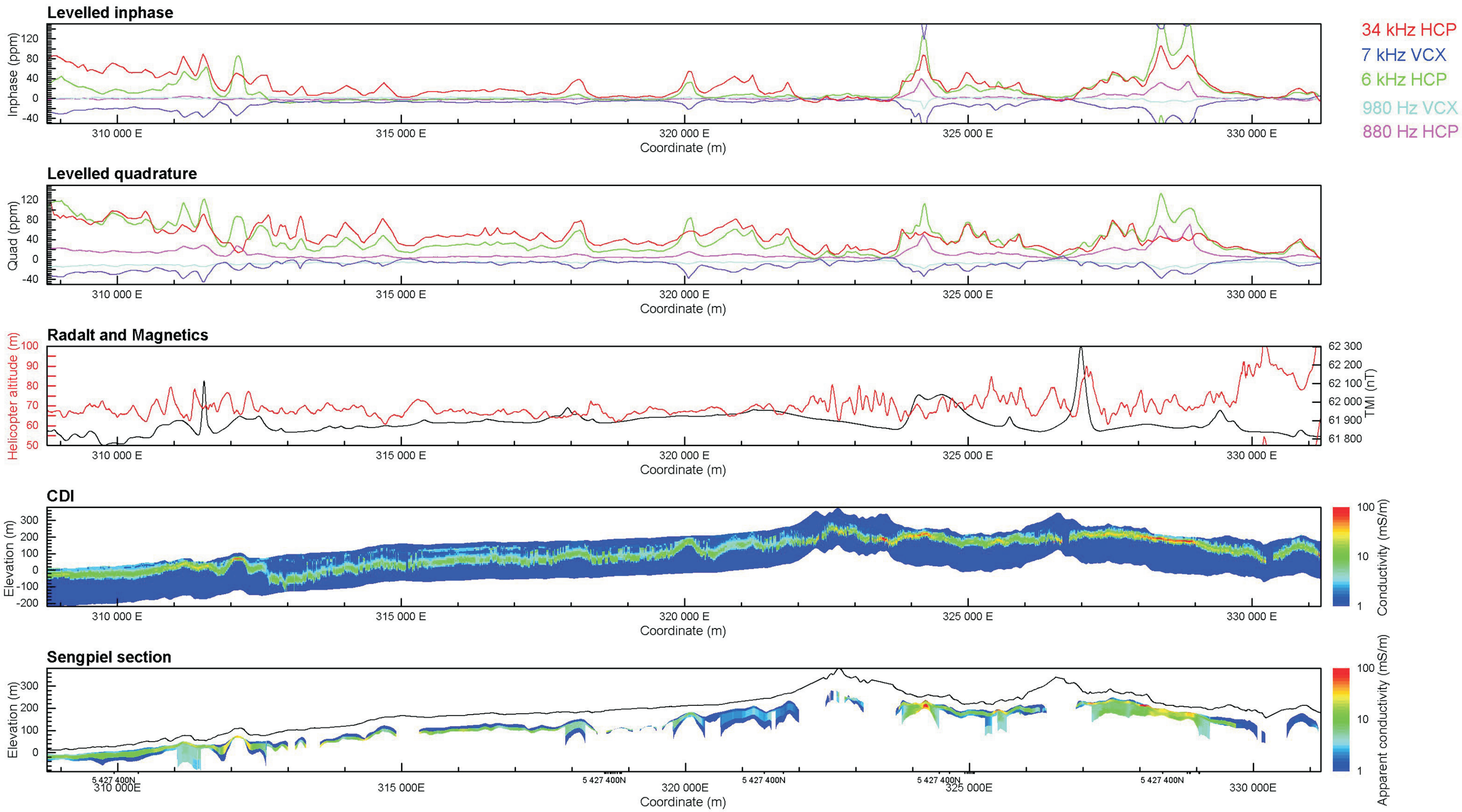

Figure 2.10
Balfour, NW Tasmania
Line D10651

Levelled inphase and quadrature data
Radar altimeter and TMI
EMFlow v3.2 conductivity-depth image
Sengpiel section

0m 1000m 2000m 3000m 4000m

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Coordinates: AGD66/TMAMG 55

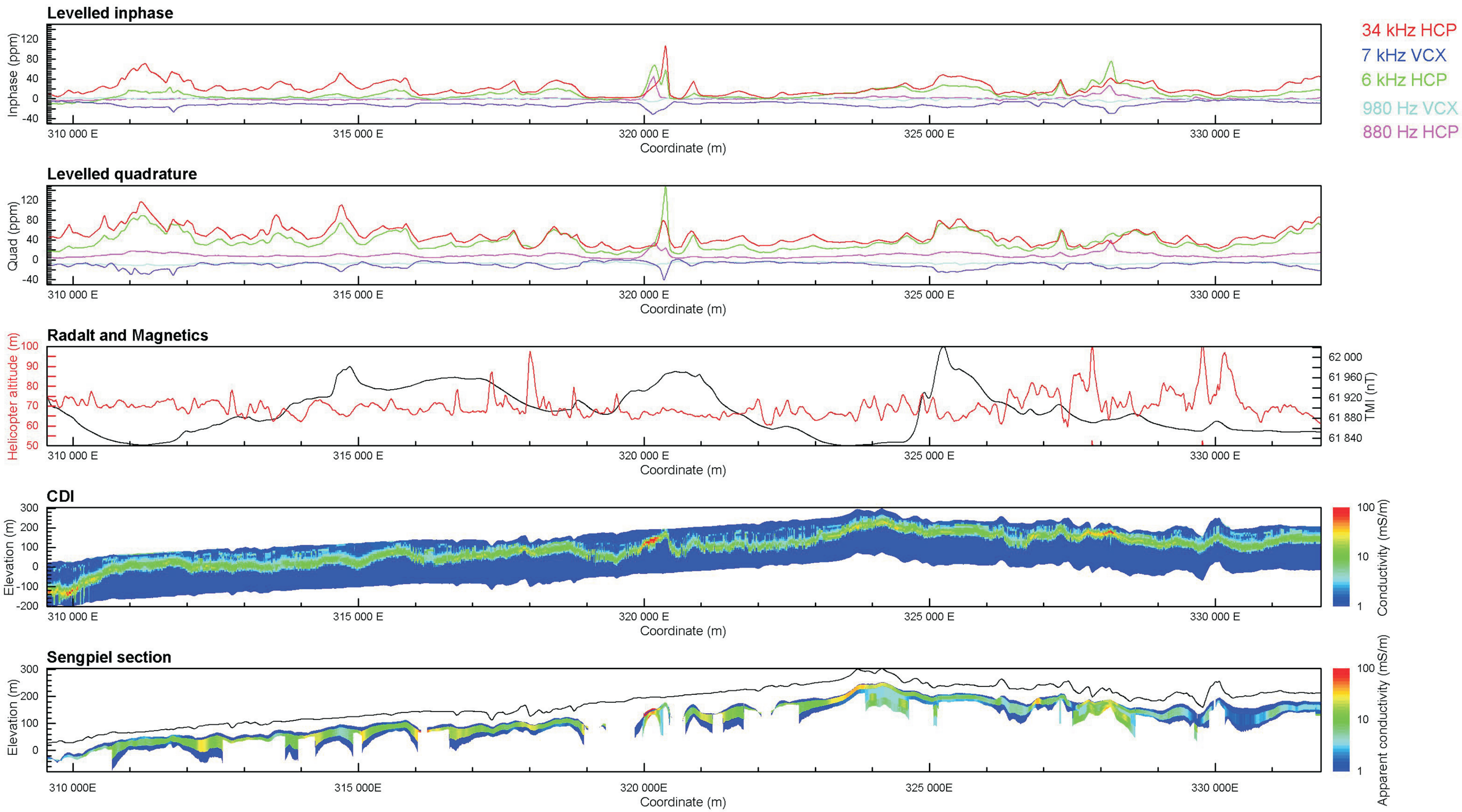

Figure 2.11
Balfour, NW Tasmania
Line D10741

Levelled inphase and quadrature data
Radar altimeter and TMI
EMFlow v3.2 conductivity-depth image
Sengpiel section

0m 1000m 2000m 3000m 4000m

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Coordinates: AGD66/TMAMG 55

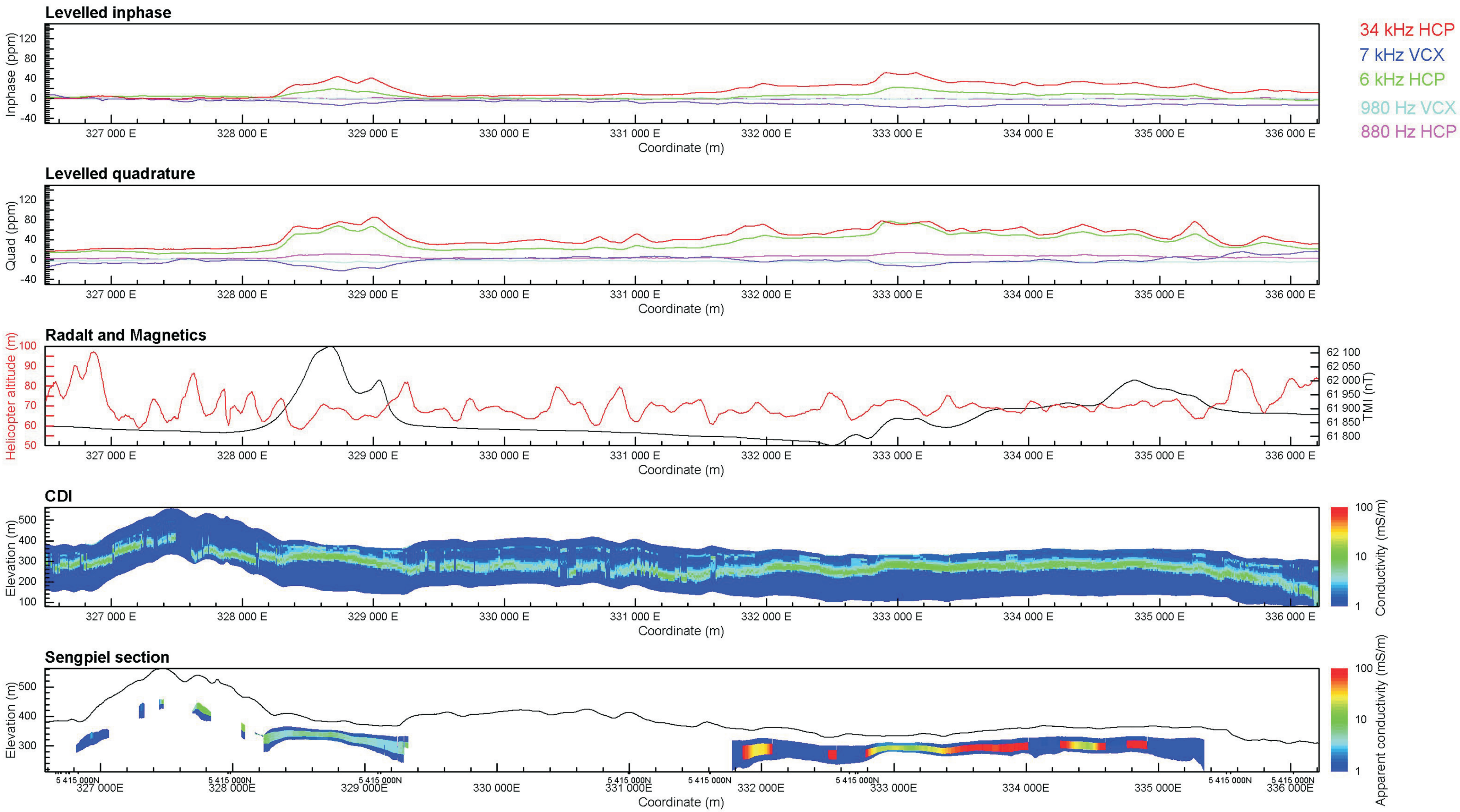

Figure 2.12
Balfour, NW Tasmania
Line D11271

Levelled inphase and quadrature data
Radar altimeter and TMI
EMFlow v3.2 conductivity-depth image
Sengpiel section

0m 400m 800m 1200m 1600m

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March 2003

Coordinates: AGD66/TMAMG 55

Figure 2.13
Balfour EMFlow 20 m depth slice with 1:250,000 geology

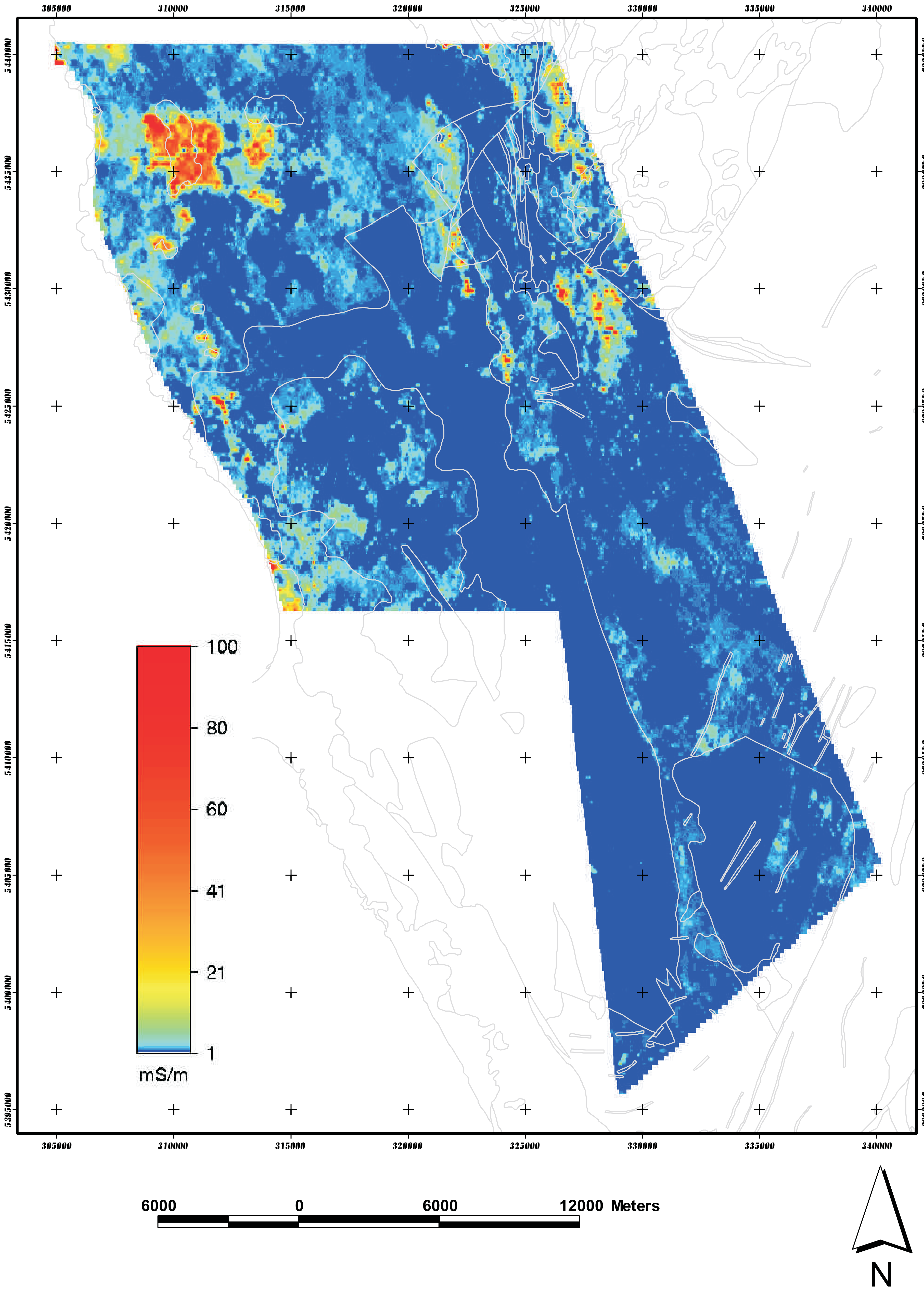

Figure 2.14
Balfour EMFlow 70 m depth slice with 1:250,000 geology

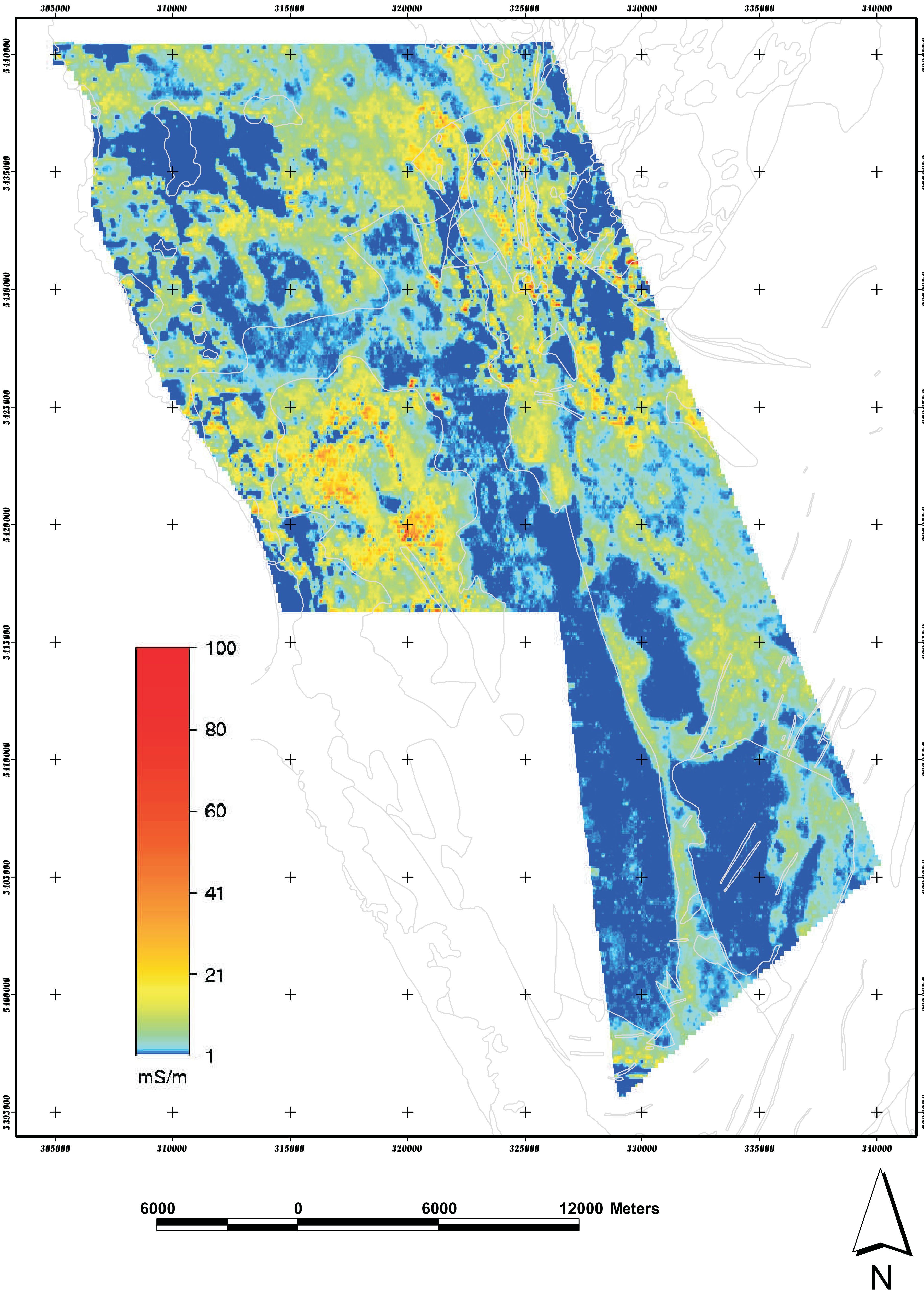

Figure 2.15
Balfour EMFlow 120 m depth slice with 1:250,000 geology