The truth about geophysical exploration and discovery in central NSW

Steve Collins
SMEDG April 2015

To this

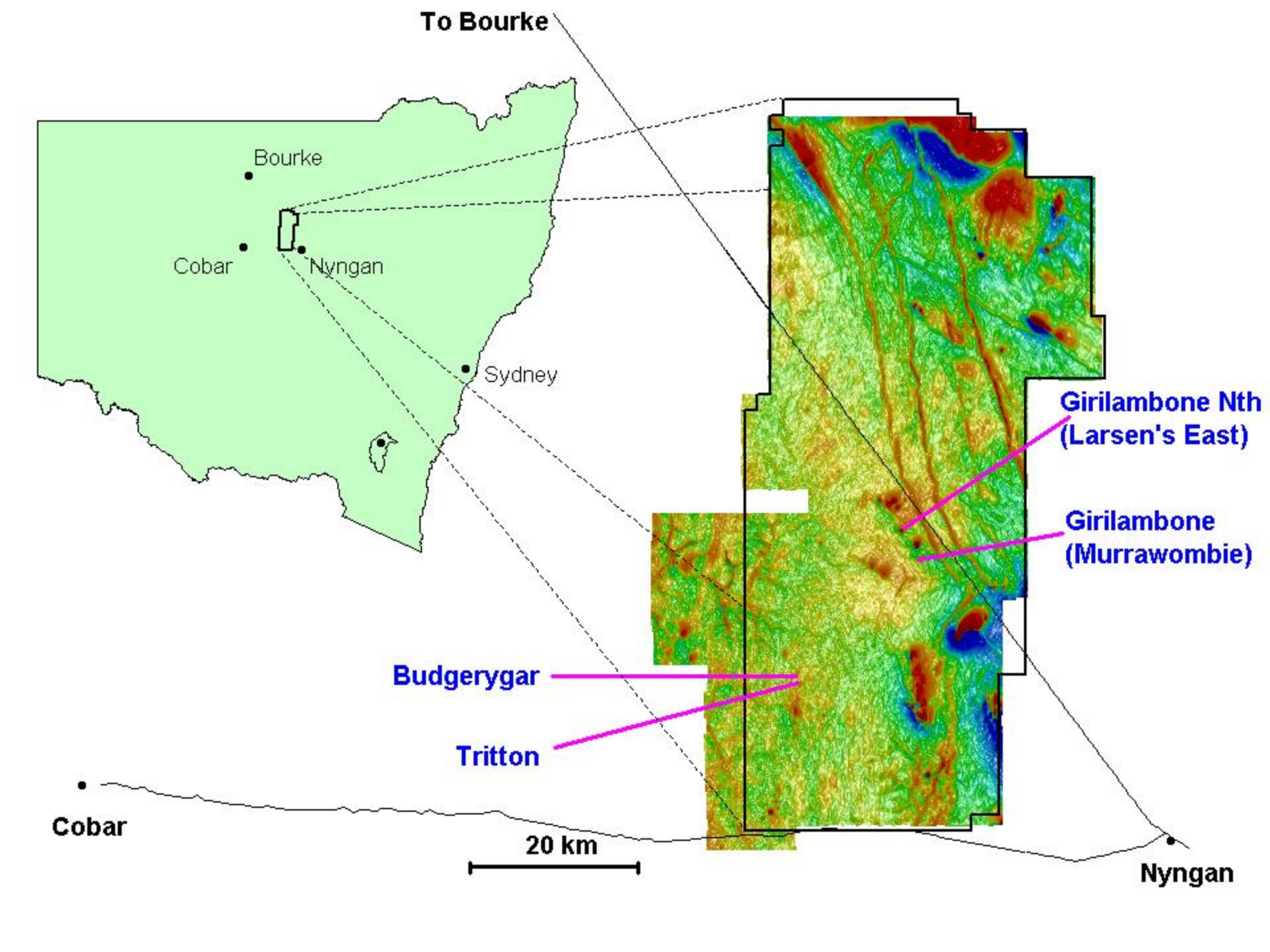
From this

”When you see a real ore deposit in your geophysical data – you will know it.”

True?

The Discovery of the Larsen's East and Tritton Ore Deposits.

Girilambone NSW


To Bourke
Bourke
Cobar
Nyngan
Sydney
Girilambone Nth
(Larsen's East)
Girilambone
(Murrawombie)
Budgerygar
Tritton
Cobar
20 km
Nyngan

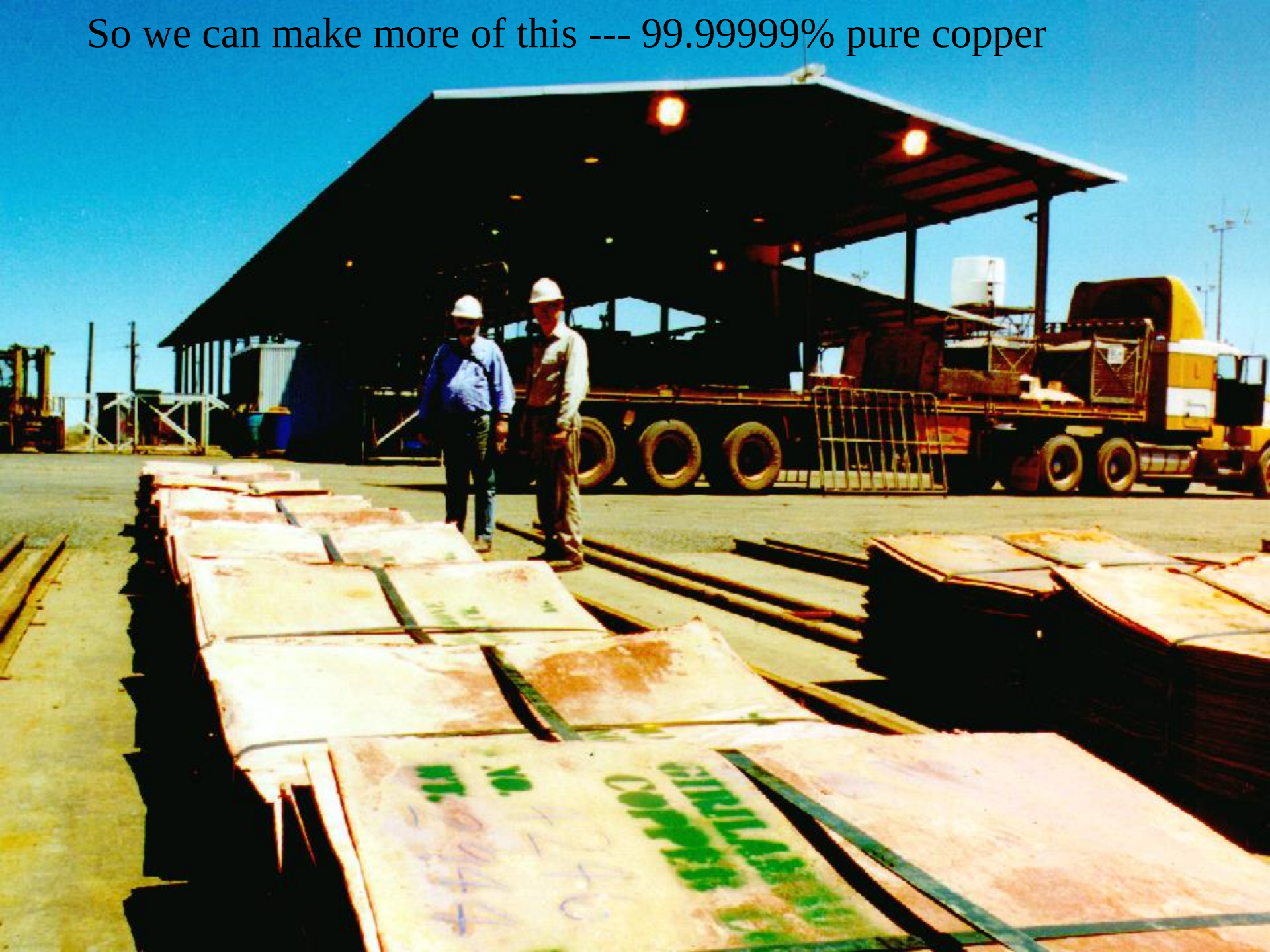

Looking for
more of this
Chalcocite

Don't mistake it for this

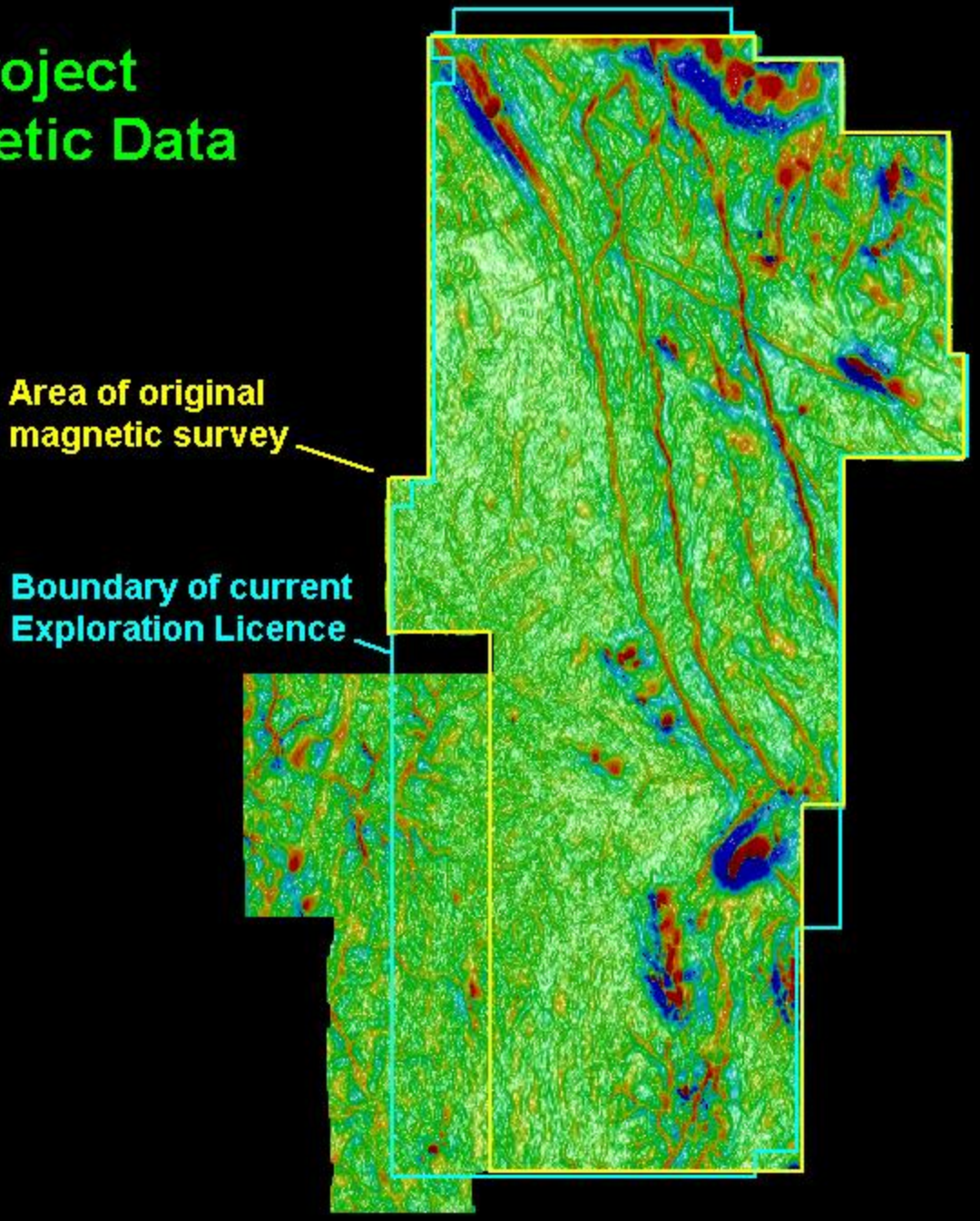
Unmineralised host rock

Or this will do

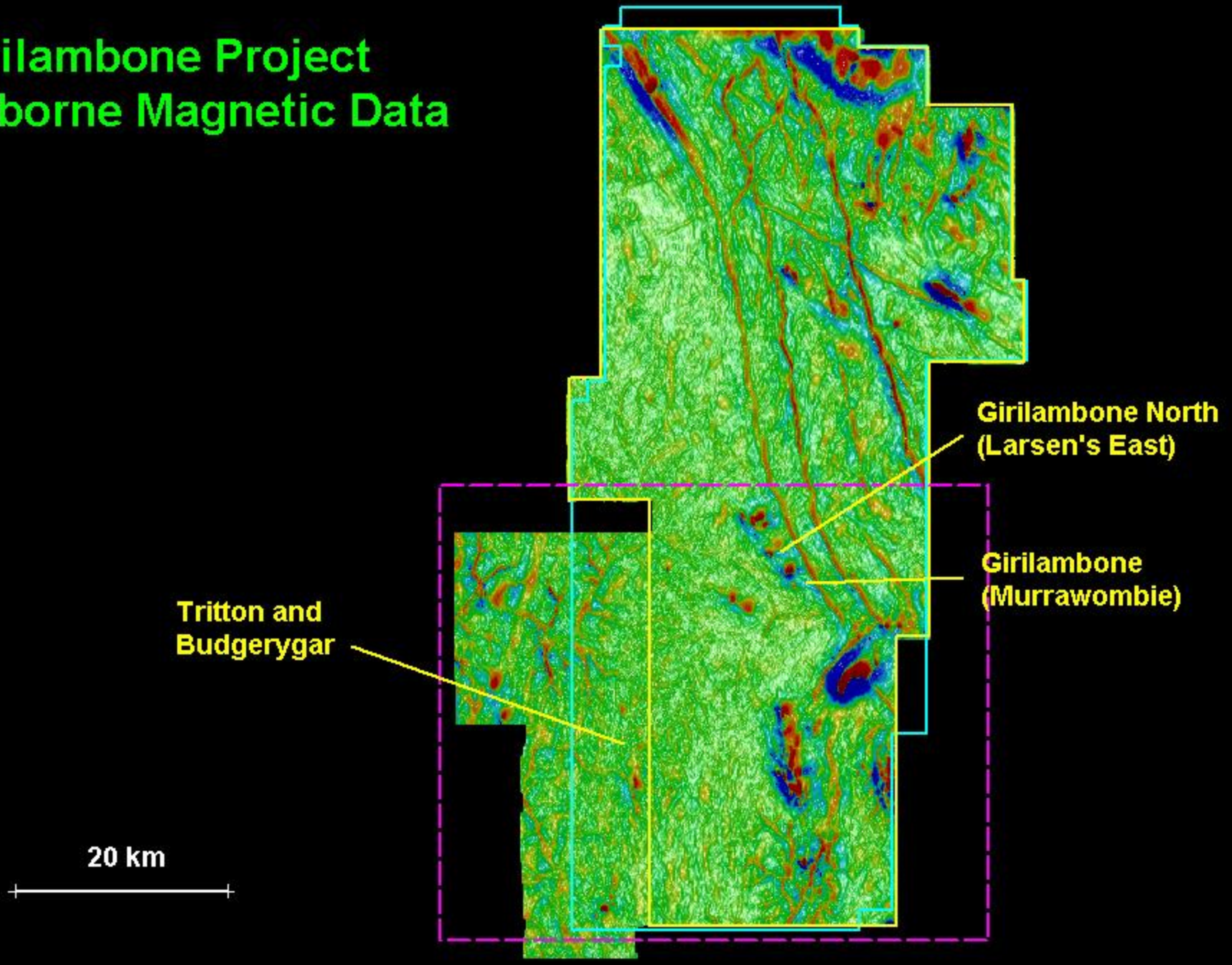
So we can make more of this --- 99.99999% pure copper

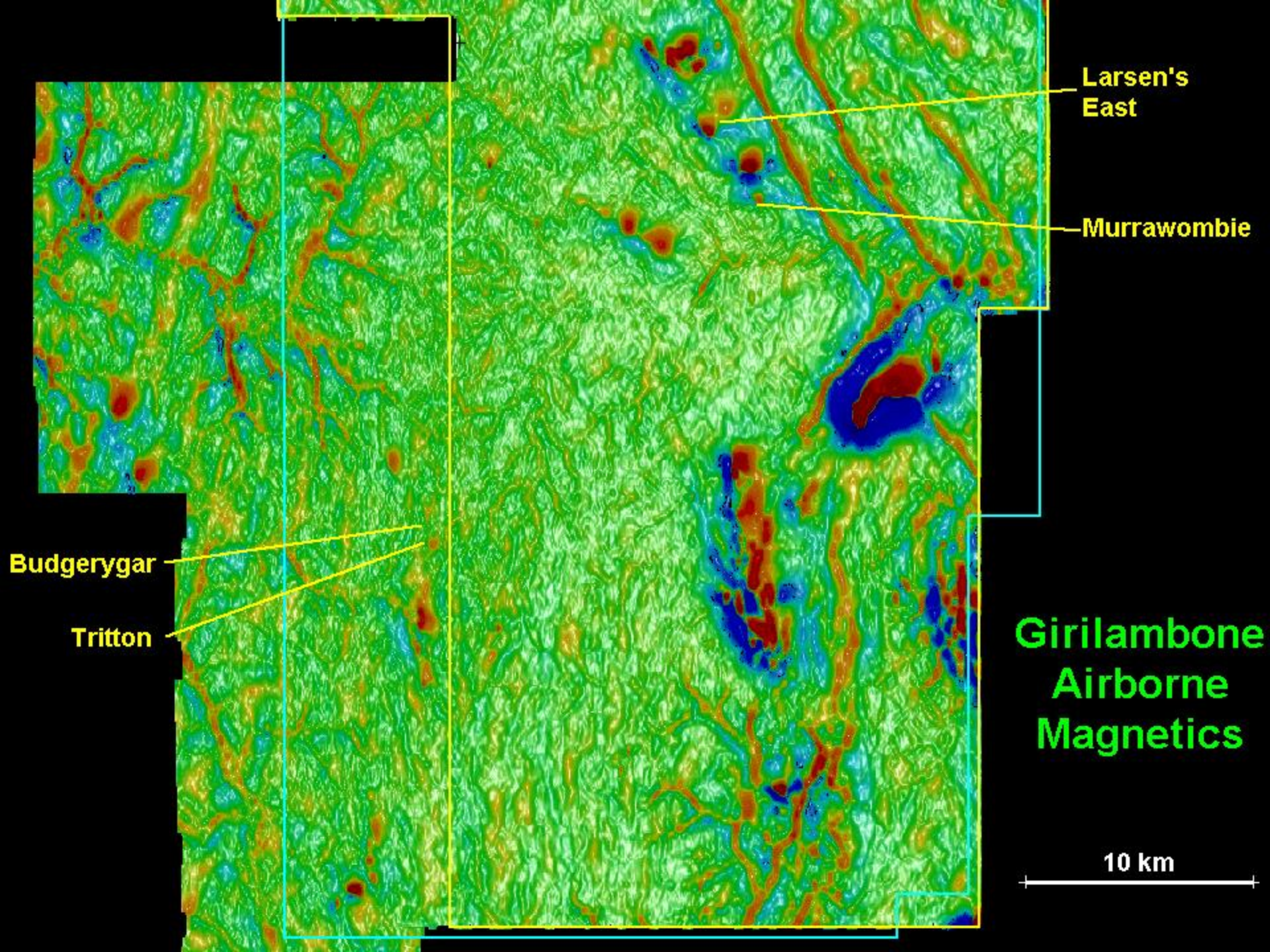


Girilambone Project
Airborne Magnetic Data



Girilambone Project
Airborne Magnetic Data



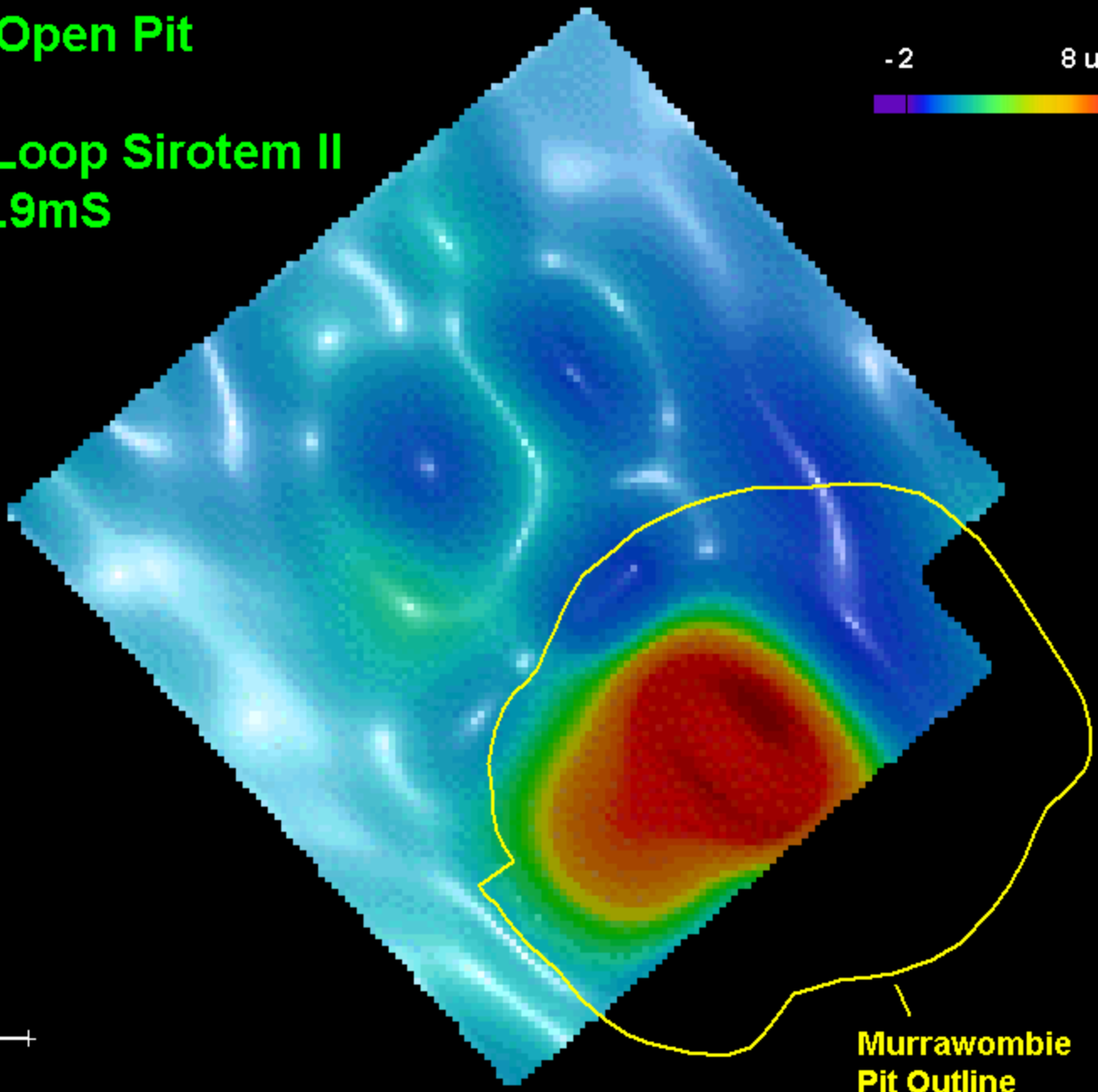

Larsen's East
Murrawombie
Budgerygar
Tritton
Girilambone Airborne Magnetics
10 km

Prior to the mine commencing, test moving loop EM surveys had been run. These detected sulphides beneath the mine.

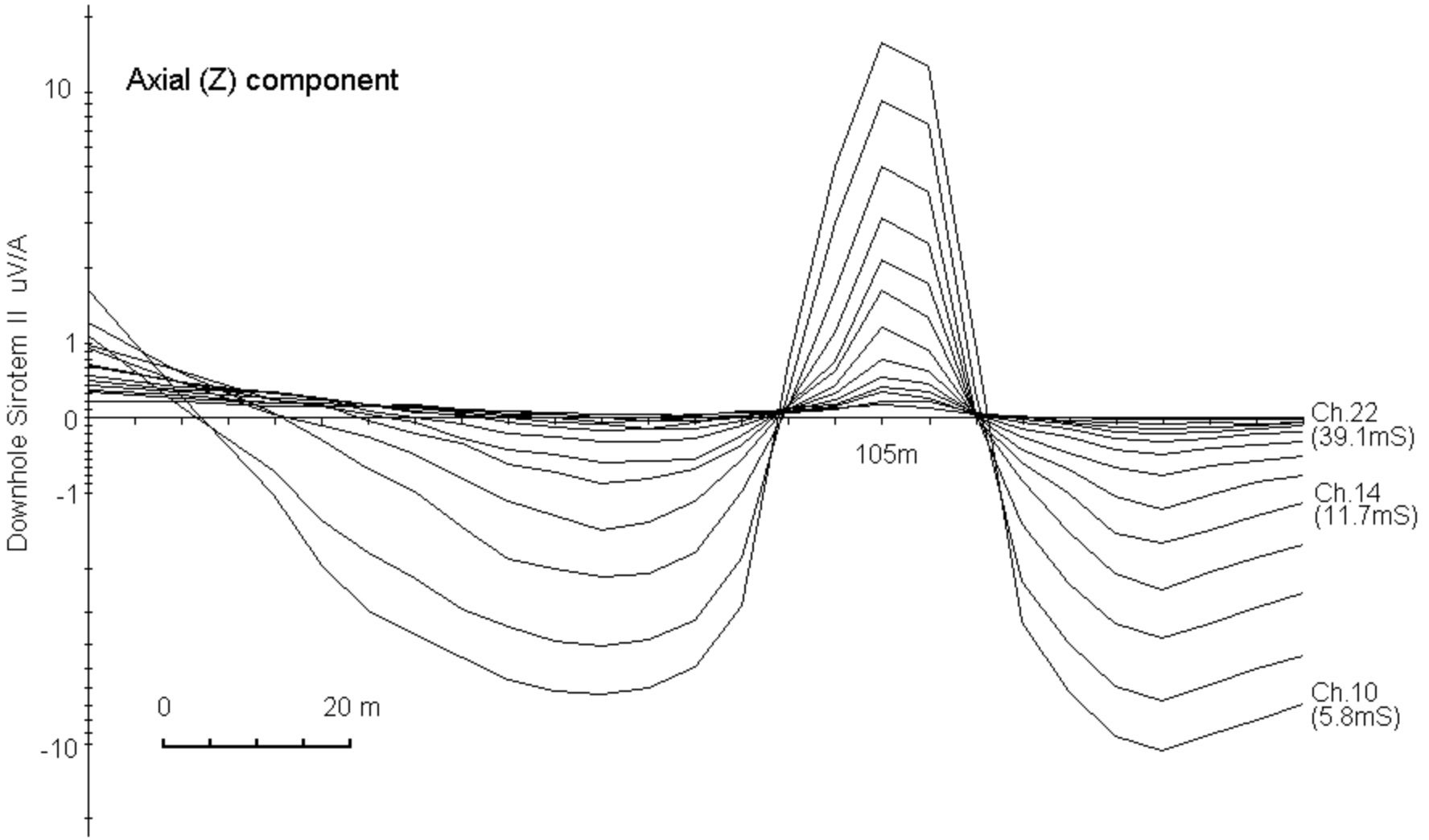
This was NOT the target which was the oxide copper near surface but detection of sulphides was seen as a possible indirect tool to find the supergene zones.

Girilambone Mine
Murrawombie Open Pit

100m Moving Loop Sirotem II
Amplitude at 4.9mS
1989 survey



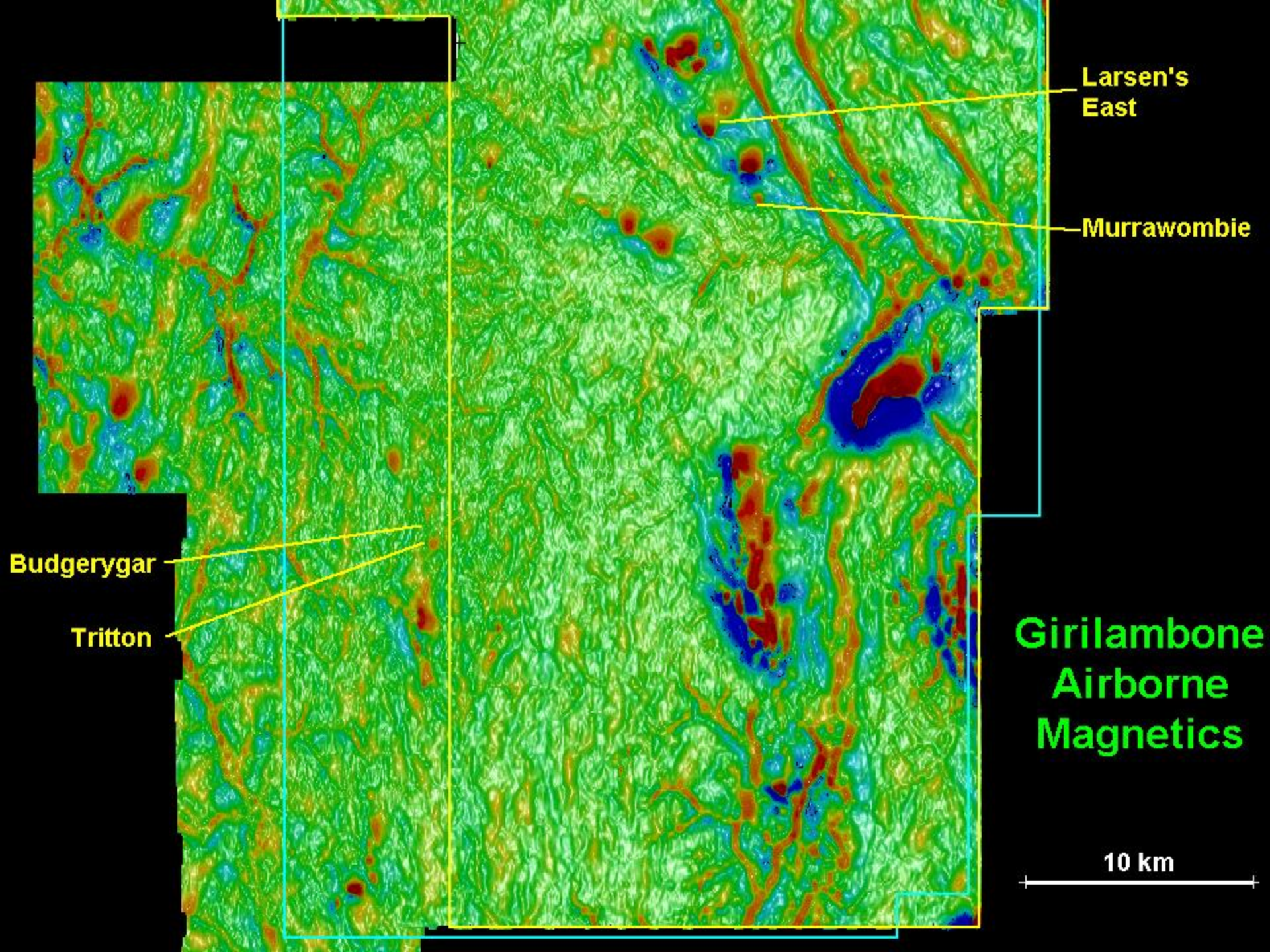
Downhole EM surveys beneath the mine confirmed that the sulphide veins were good conductors.



Girilambone - Downhole Sirotem Hole 72

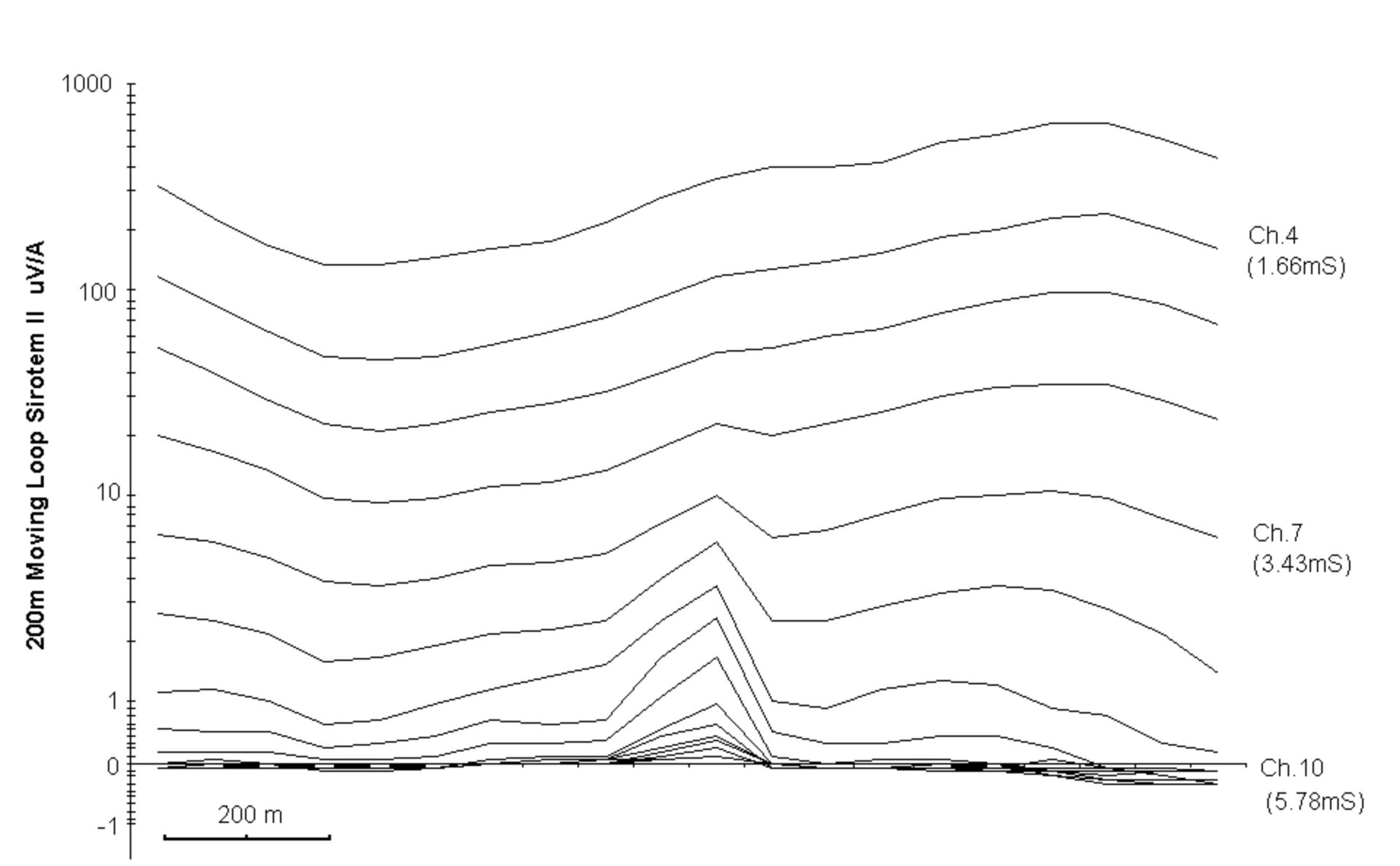
So a program of surface 200m moving loop Sirotem was commenced.

This started with a 2km square trial zone north of the mine at a prospect known as Northeast where there was a known small occurrence of oxide copper.


Larsen's East
Murrawombie
Budgerygar
Tritton
Girilambone Airborne Magnetics
10 km

The very first survey line detected a strong EM response.

But this was about a kilometre from the known oxide copper occurrence just east of an old working known as Larsen's Pit



Larsen's East - Line 12400N (Local grid)

Completion of the 2km square trial revealed a discrete strong conductor at Larsen' East

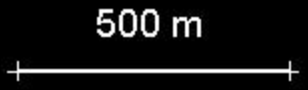
Negligible response was obtained over the known copper occurrence at Northeast.

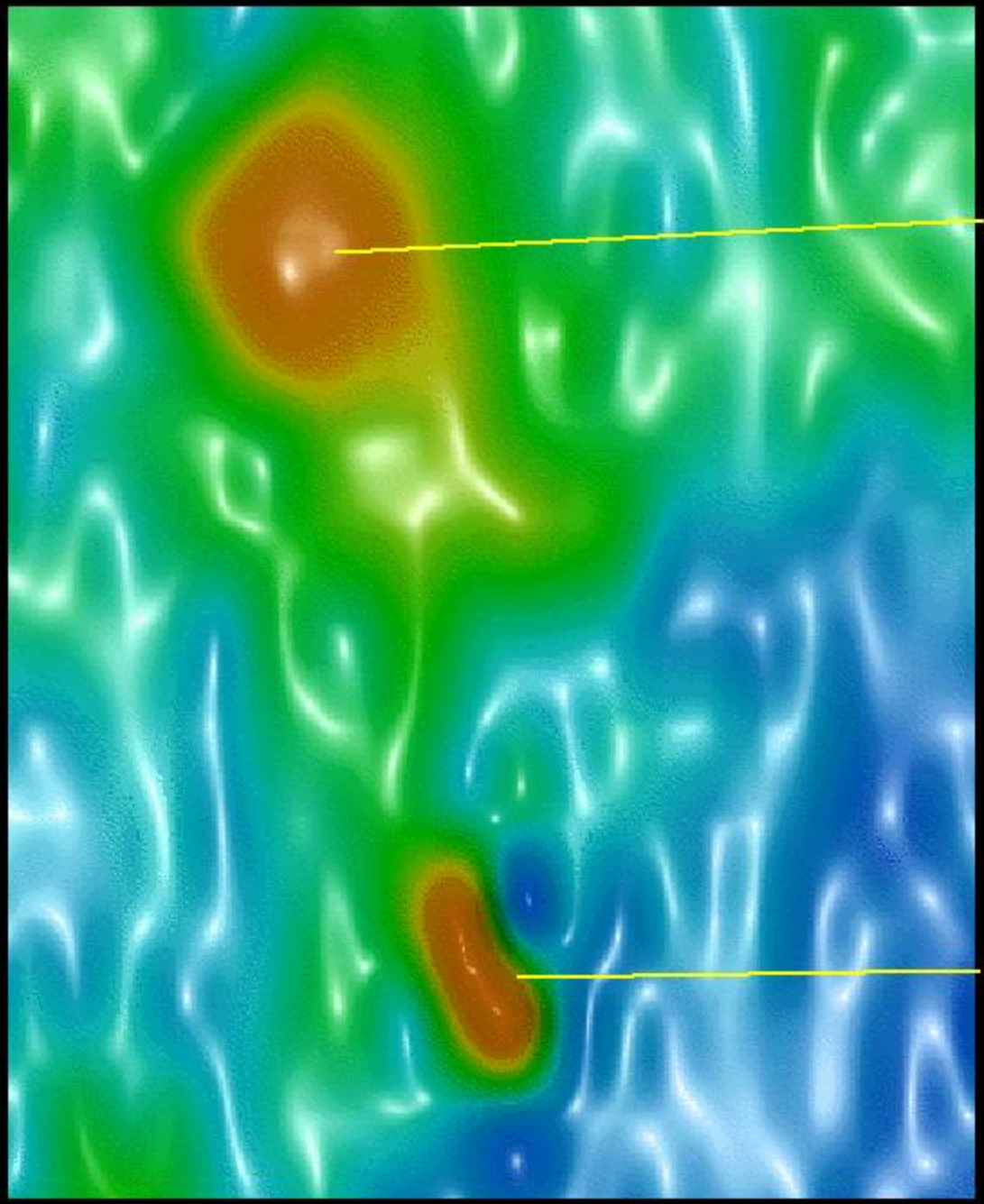
A large moderate conductor further north subsequently named 'Ben Hur'

Larsen's East

200m Moving Loop Sirotem II

Decay constant at 1uV/A





More detailed 100m moving loop EM confirmed these and also shows a small response at the original target – Northeast Prospect.

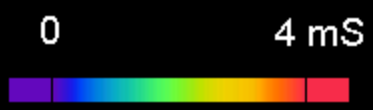
Subsequent drilling proved that the Larsen's East conductor was associated with oxidised copper mineralisation which was drilled out and added to the ore inventory.

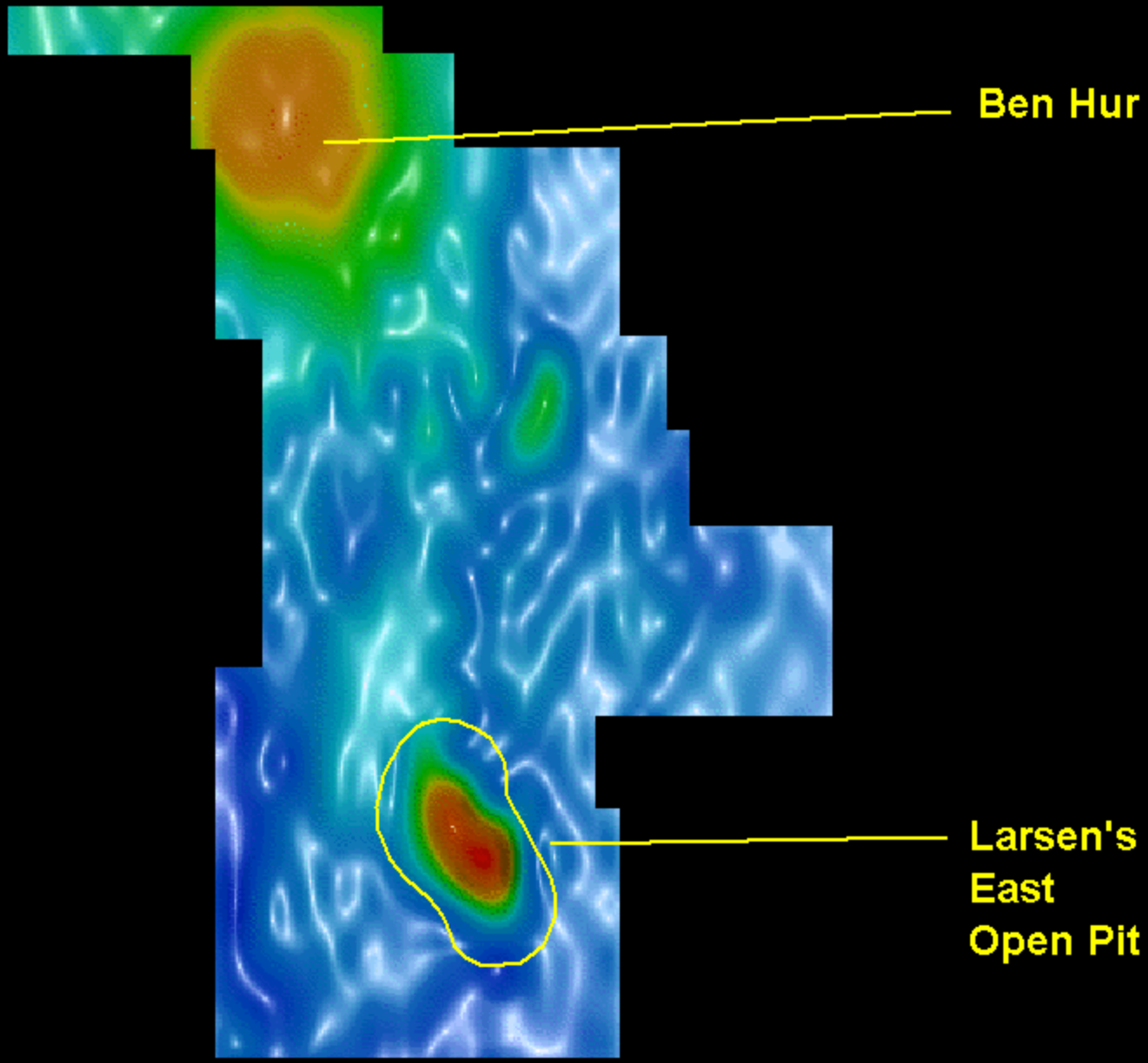
The Ben Hur conductor was graphite.

Larsen's East

100m Moving Loop
Sirotem II

Decay constant
at 1uV/A





IP surveying could not be run at Larsen's East at that time due to all the drilling activity.

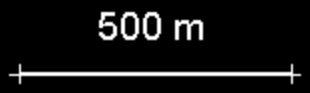
Ben Hur and Northeast both have an IP response

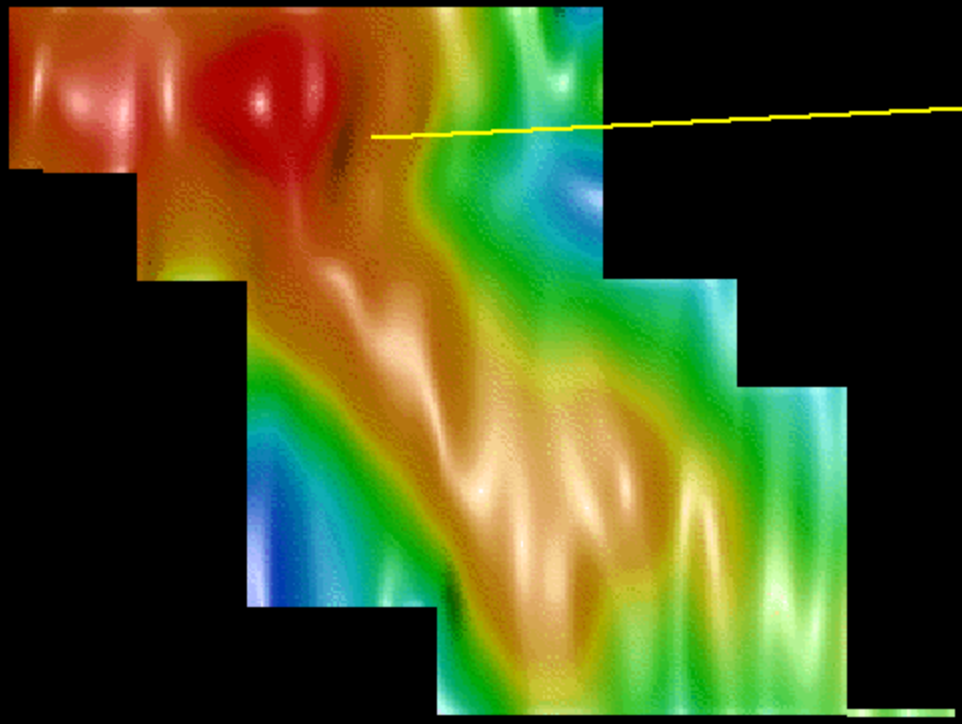
Later surveys show that Larsen's East has a distinct IP response

Larsen's East

100metre
Dipole-dipole IP

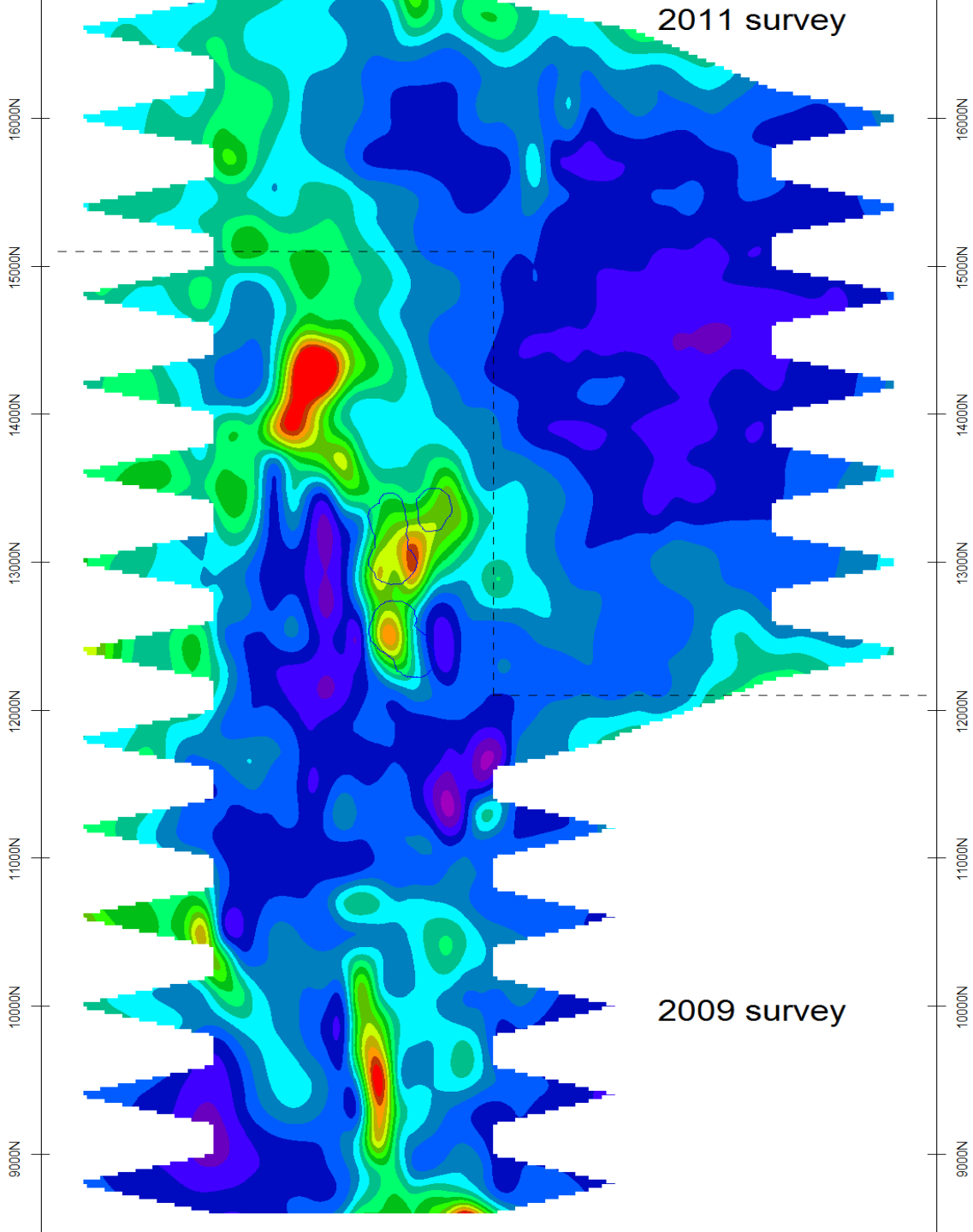
Fraser Filtered
IP Phase





Ben Hur

Larsen's
East
Open Pit


2011 survey
2009 survey
16000N
15000N
14000N
13000N
12000N
11000N
10000N
9000N

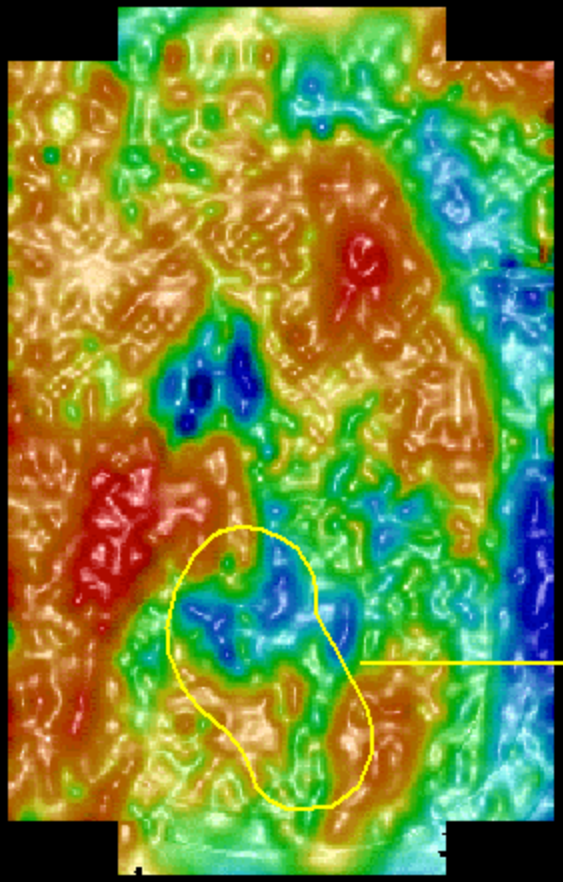
Gravity surveying over the area gave a complicated pattern with local highs adjacent to the deposits.

But no direct indication of the ore zones.

Larsen's East

Detailed Gravity

200m High Pass Filtered



Ben Hur

Larsen's East Open Pit

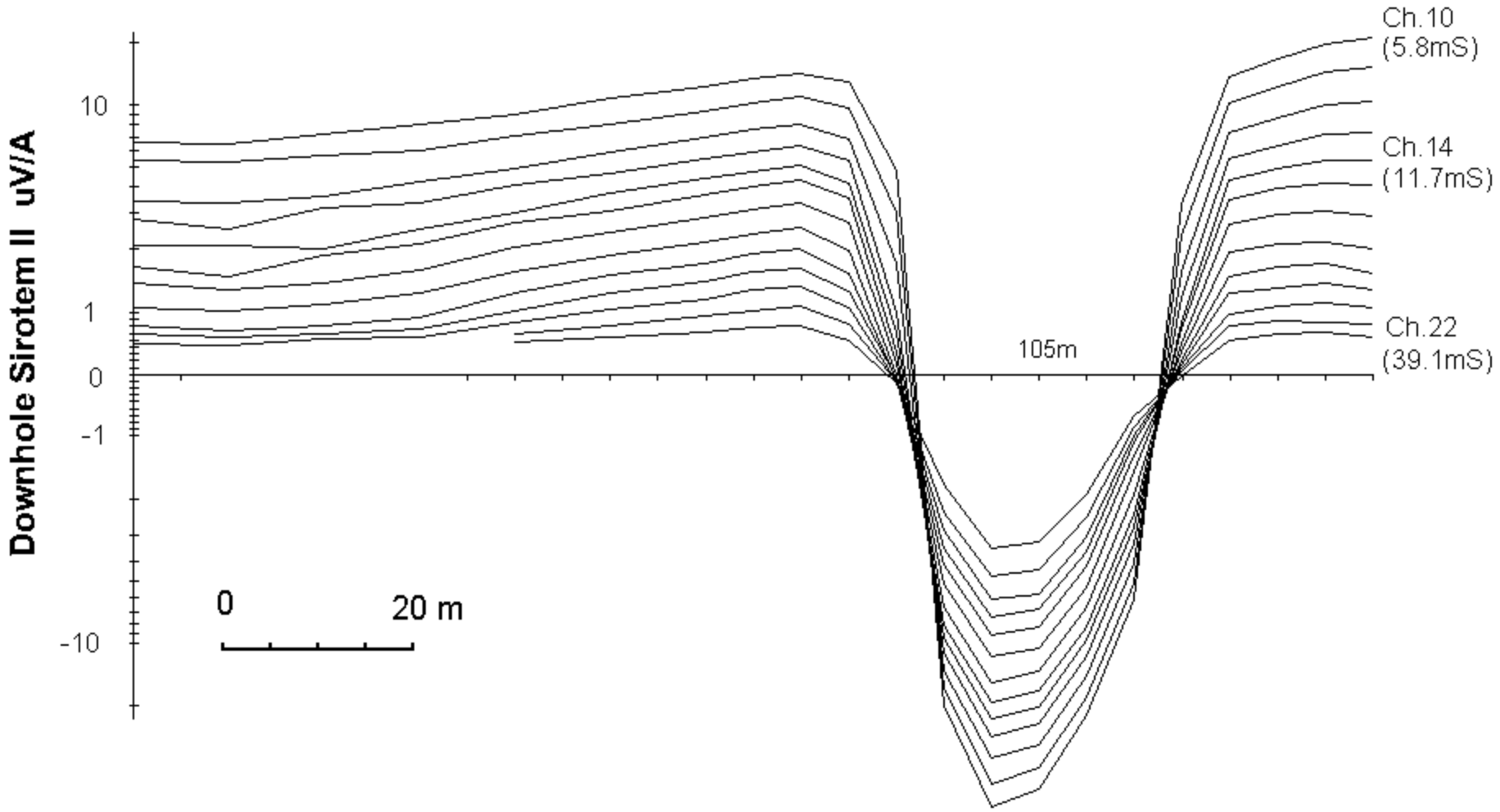
- 0.2 0.2 milligal

True North

500 m

Downhole EM through the ore zone consistently showed offhole responses that suggested the conductors were steeply dipping with at least two en-echelon lenses.

This was not consistent with drilling results at 25m centres which suggested a 45 degree dipping ore zone.
The mine was planned on the basis that the drilling interpretation was correct.



Larsen's East - Downhole Sirotem Hole 3

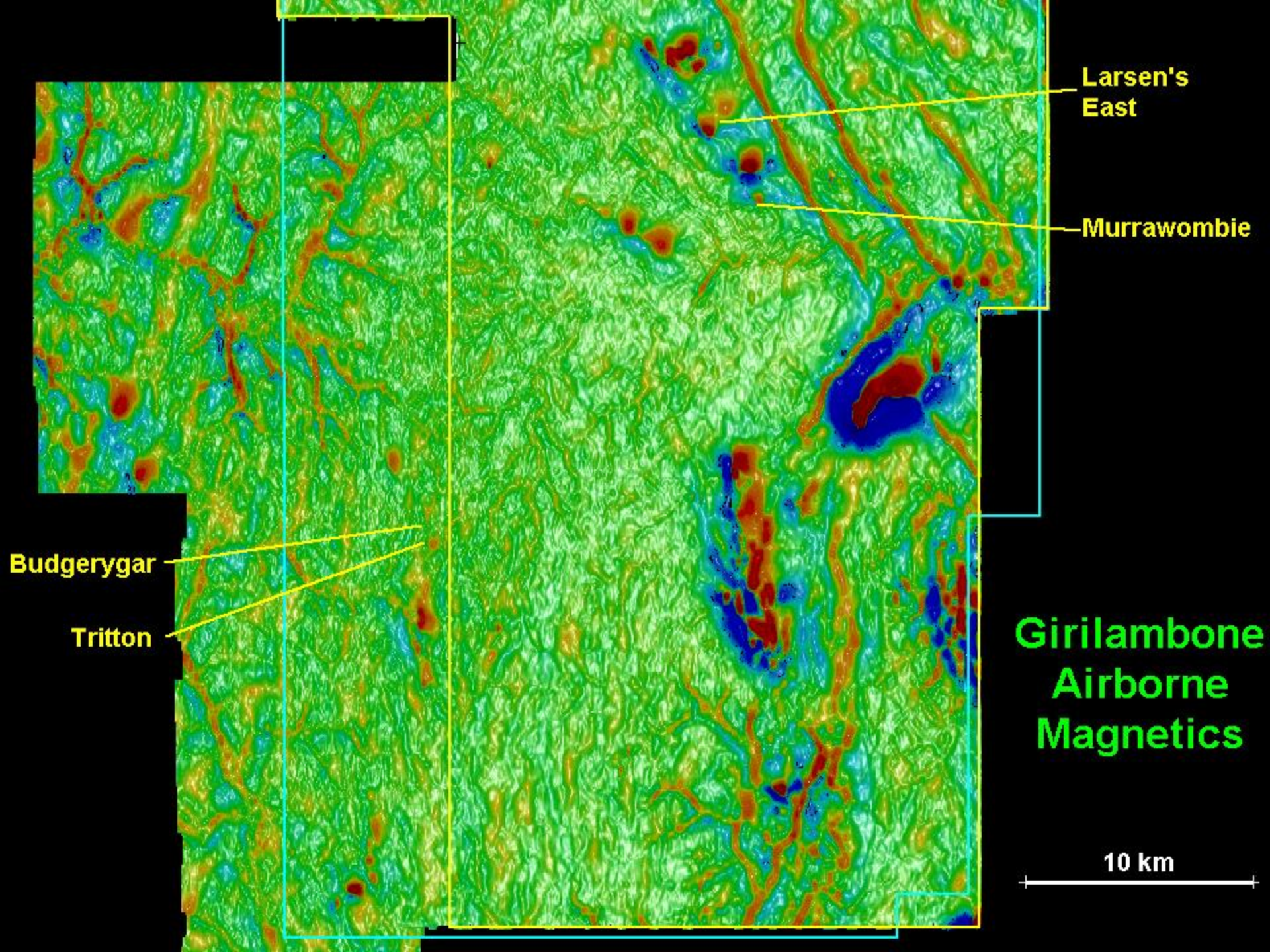
When the zone was mined, the downhole EM was proven correct.
Lesson learned – always drill some scissor holes.

Attempts to recover the high grade zones (conductors) eventually resulted in the collapse of the pit wall.

Larsen's East - Final Pit - Looking South

An exploration licence to the southwest covering the historic Great Hermidale, Budgerygar and Budgery mines was relinquished by other explorers.

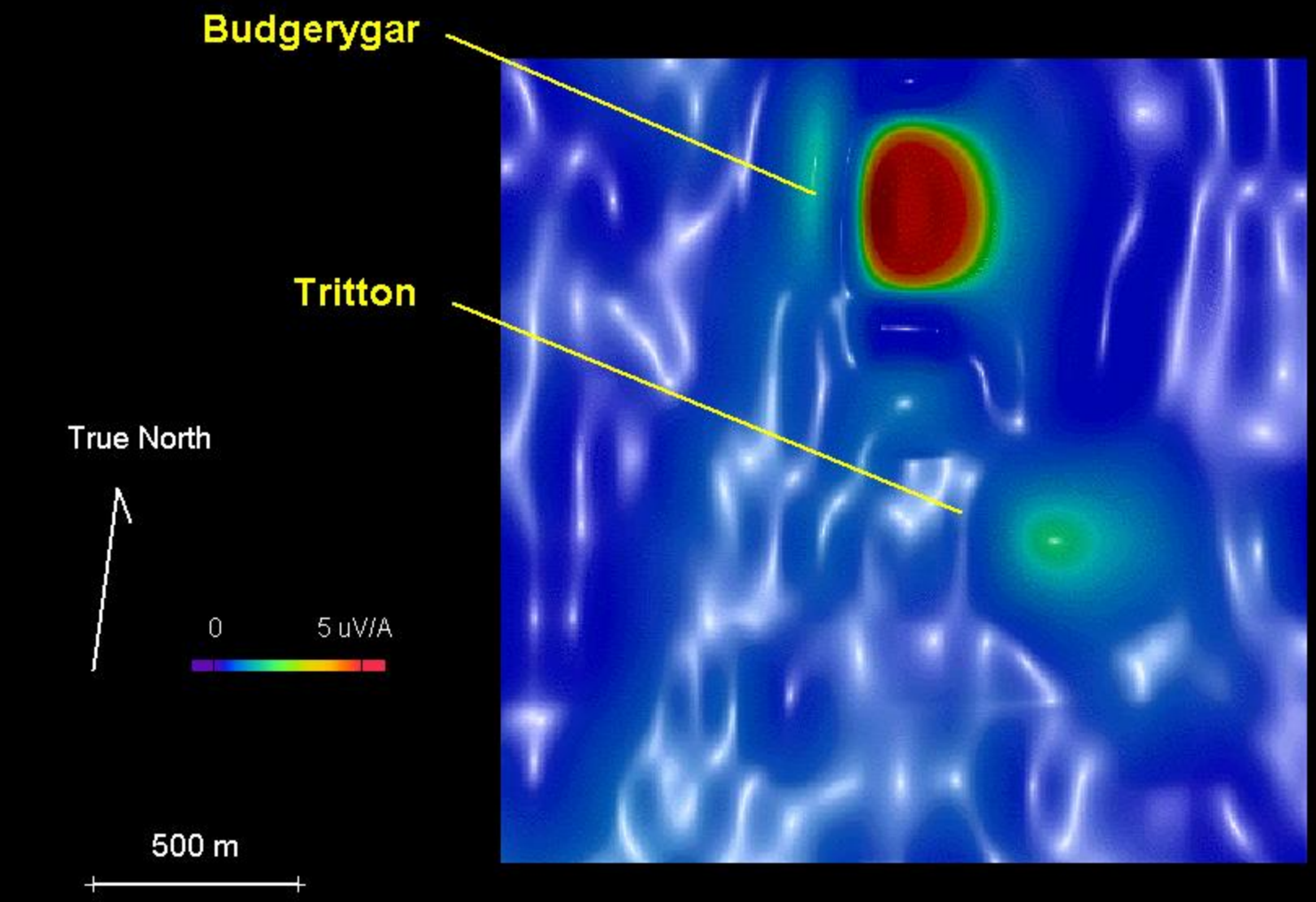
This licence was acquired and the airborne magnetic data added to the Girilambone data base.


Larsen's East
Murrawombie
Budgerygar
Tritton
Girilambone Airborne Magnetics
10 km

Because of the success of the exploration strategy of using ground EM at Larsen's East it was decided to use this in the new areas

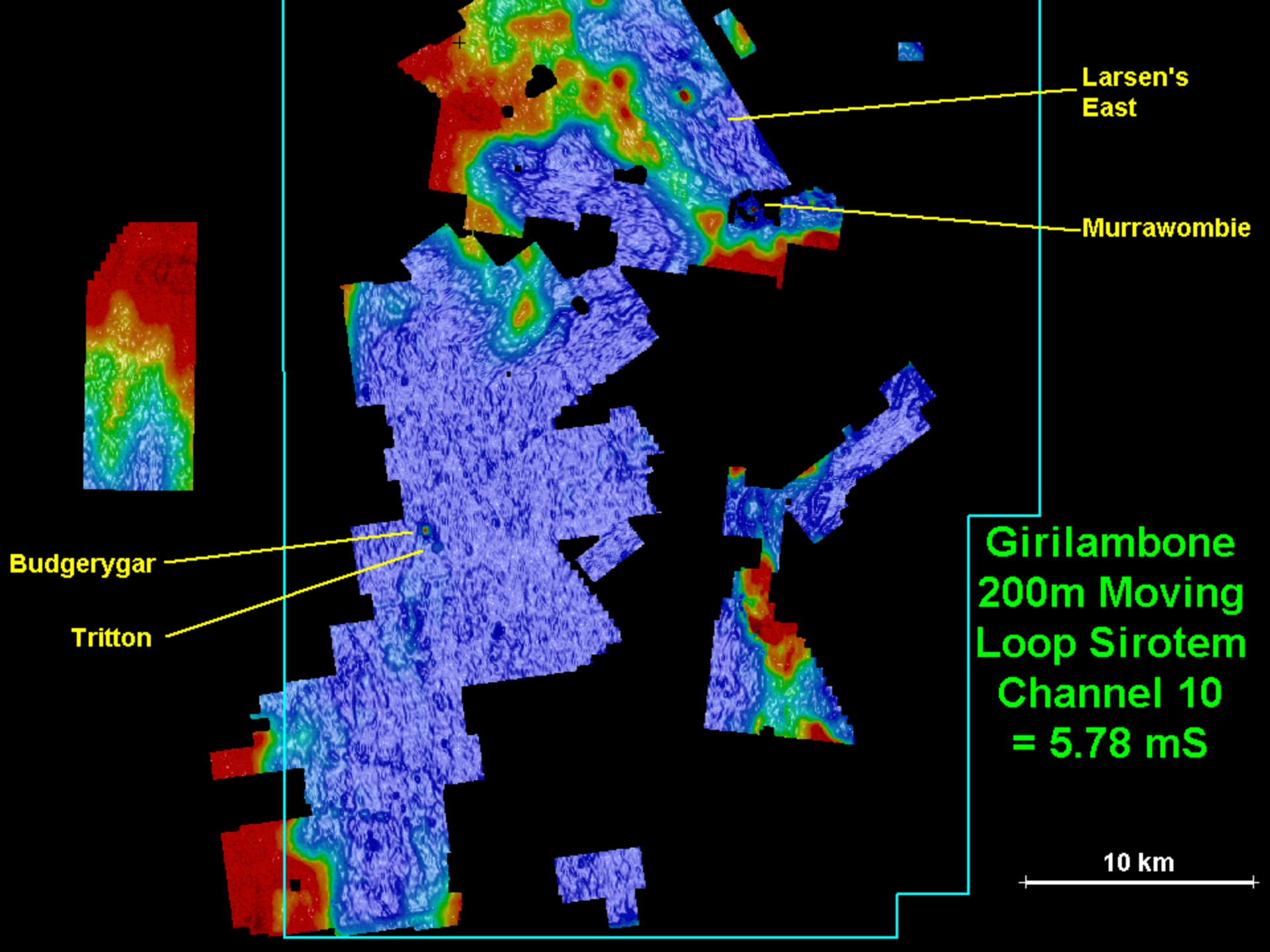
The surveying started in the area surrounding the old Budgerygar Mine. Known sulphides there showed a strong response so the survey was extended.

Tritton - 200m Moving Loop Sirotem - Channel 10 (5.78mS)



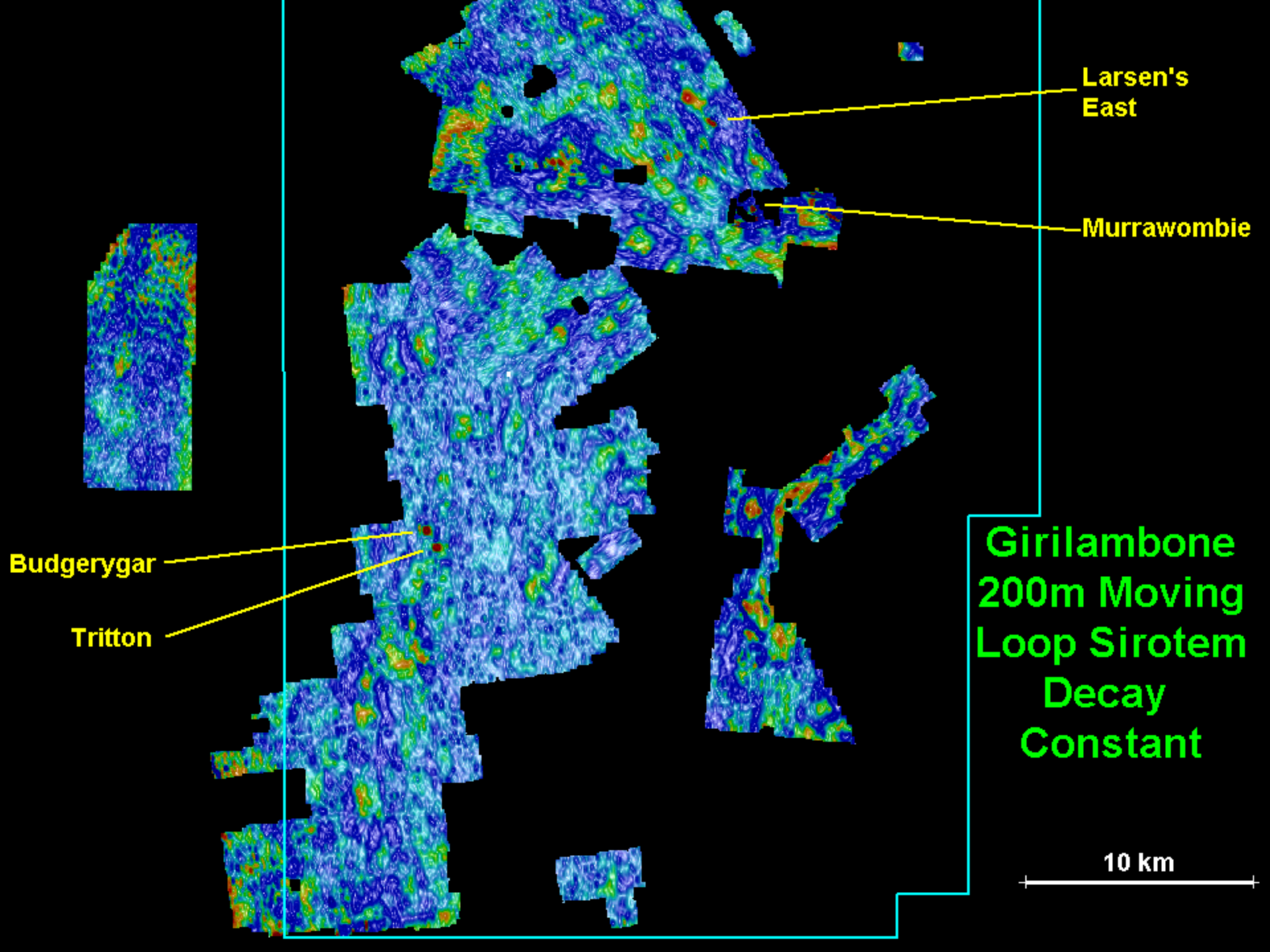
The discovery of the Tritton EM response offered encouragement that this technique could be effective and the EM surveying continued for several years

Eventually a huge area was covered with 200m moving loop Sirotem. Unfortunately no further deposits were detected with this technique.


Larsen's East
Murrawombie
Budgerygar
Tritton
Girilambone
200m Moving
Loop Sirotem
Channel 10
= 5.78 mS
10 km

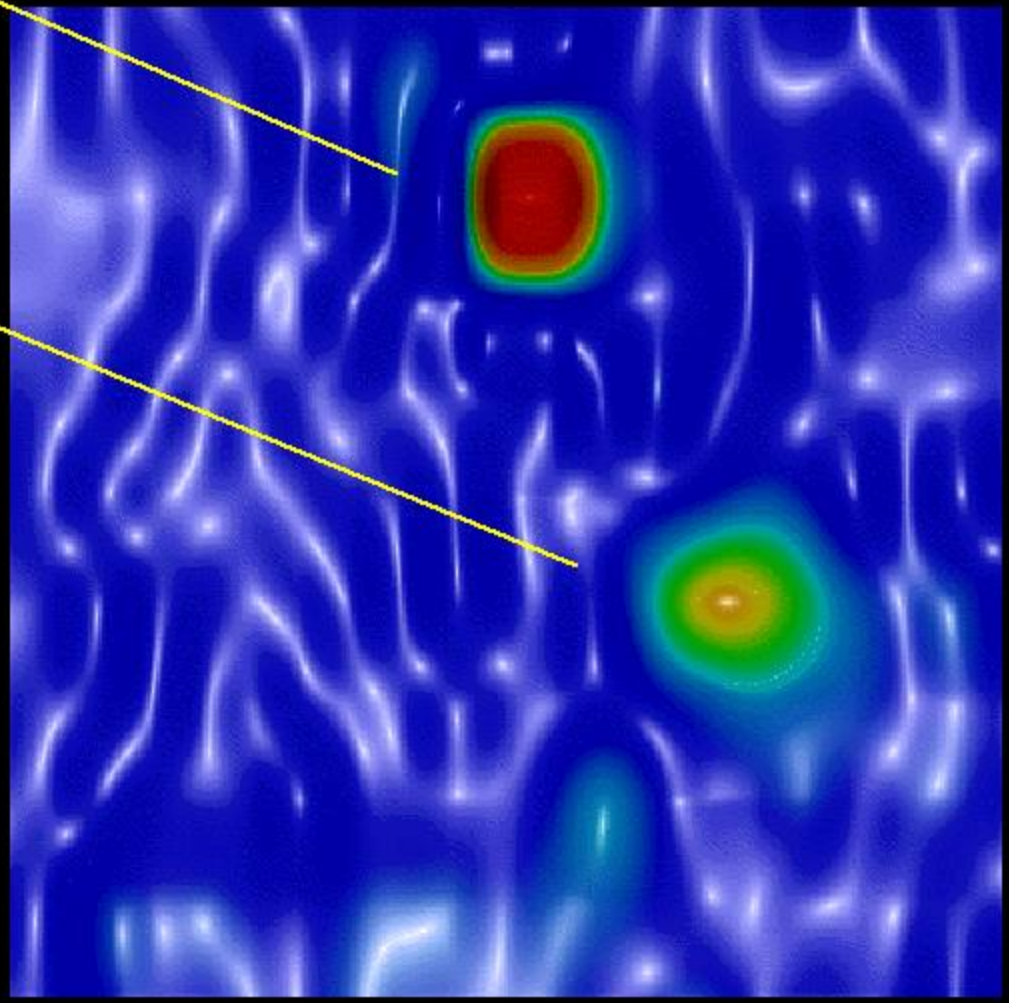
The Budgerygar and Tritton conductors were very apparent in these data .

They were highlighted by the presentation of the data as a time constant. All further data was examined closely as both response amplitude and time constant.

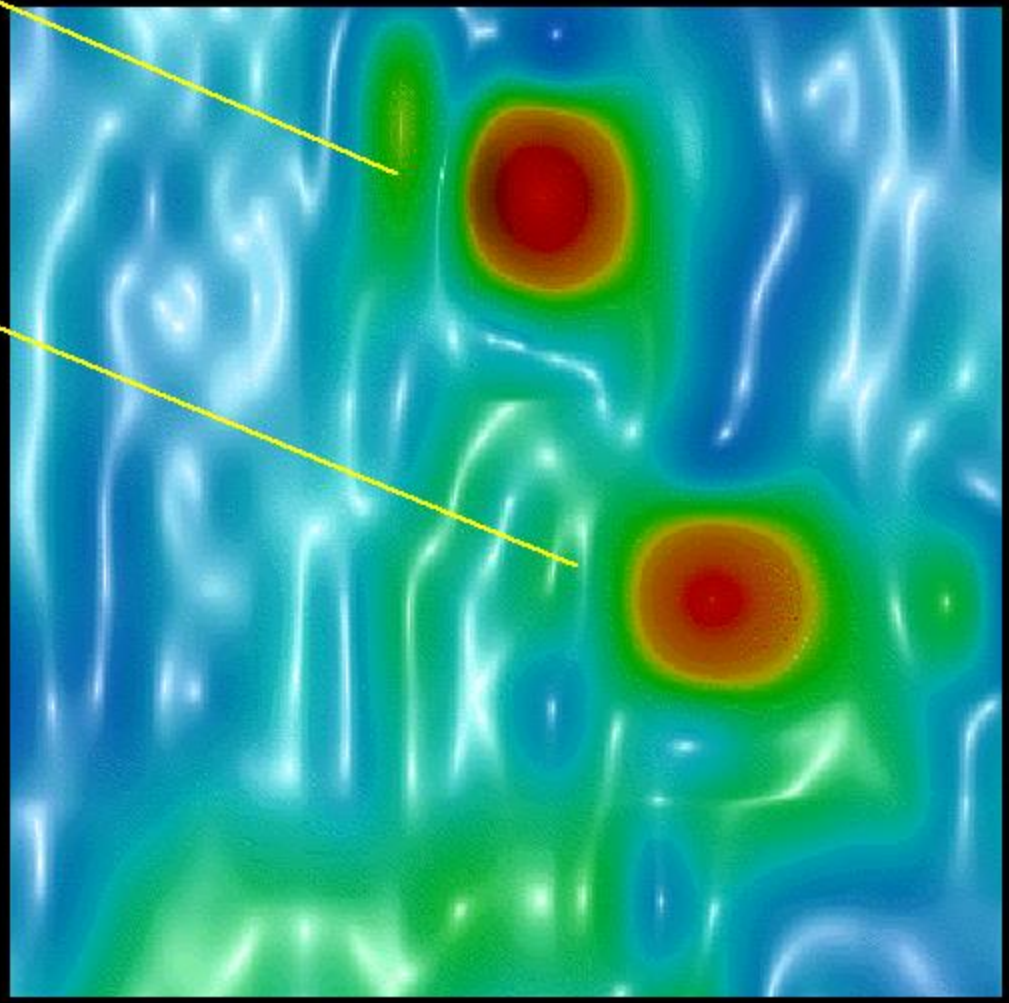

Larsen's East
Murrawombie
Budgerygar
Tritton
Girilambone 200m Moving Loop Sirotem Decay Constant
10 km

Decay (time) constant presentation was also of use on a local scale

Tritton - 200m Moving Loop Sirotem - Channel 16 (15.58mS)



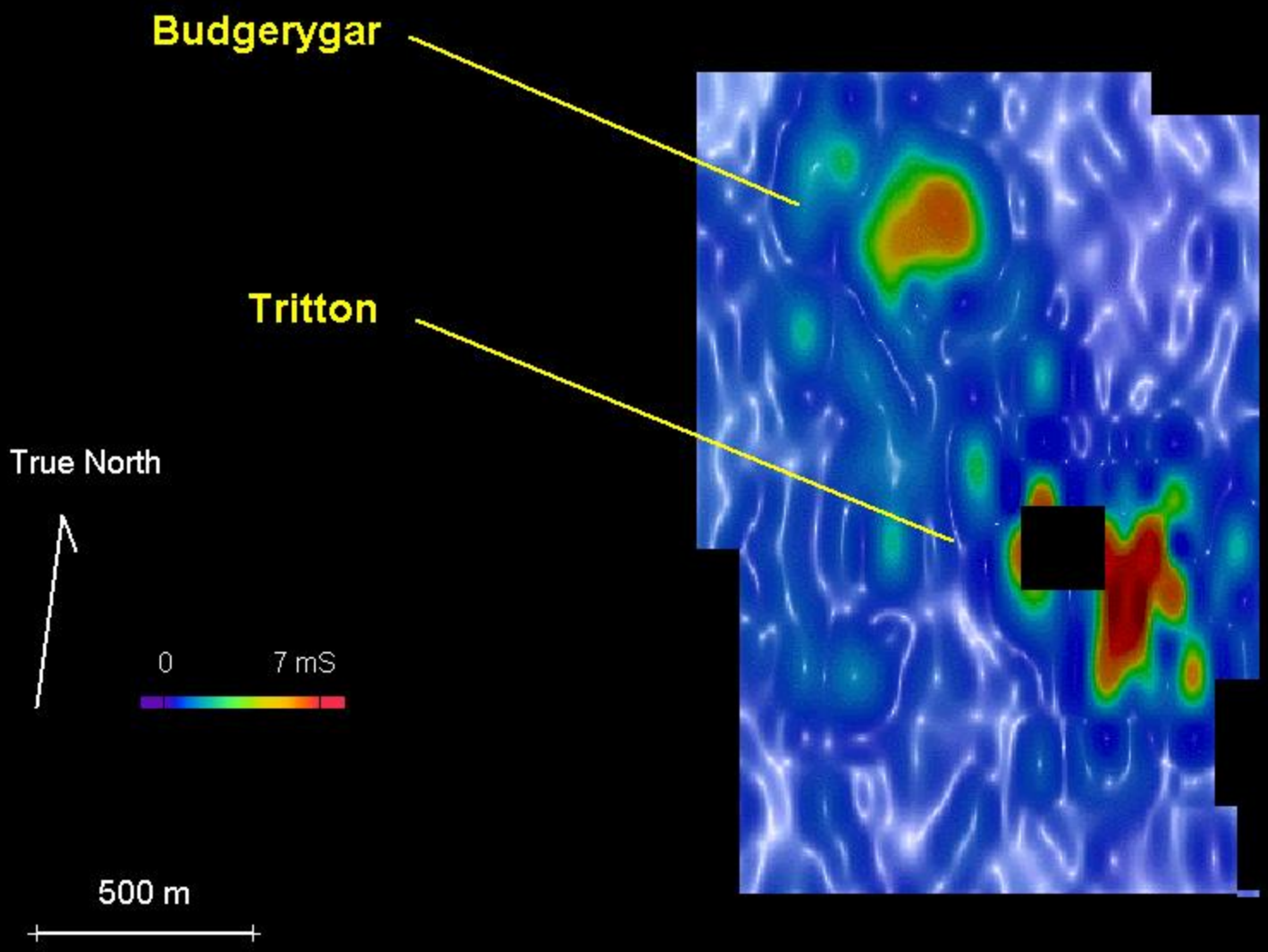
Tritton - 200m Moving Loop Sirotem - Decay Constant



Detailing with smaller moving transmitter loops highlighted the conductors further. And gave higher resolution details for further interpretation.

With the smaller transmitter loops and reduction to time constant form, it became obvious that Tritton was the stronger of the two conductors.

Tritton - 100m Moving Loop Sirotem - Decay Constant



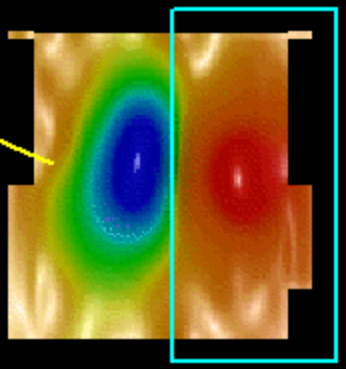
Fixed loop Sirotem surveys confirmed the moving loop data and sharpened up the interpretation in terms of depth and location.

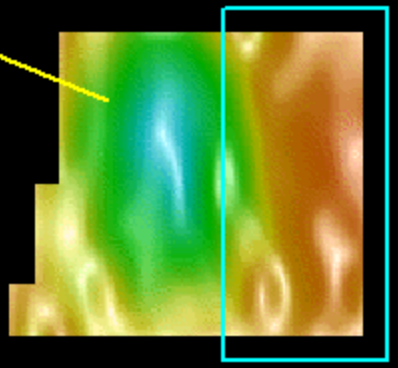
With this survey geometry a conducting response is a broad negative. The adjacent high indicated dip to the east. The Tritton conductor is deeper and hence the response is broader

Tritton - Fixed Loop Sirotem - Channel 16 (15.58 mS)
Horizontal X (East) Component

Budgerygar

Tritton





True North

-1 0.5 uV/A

500 m

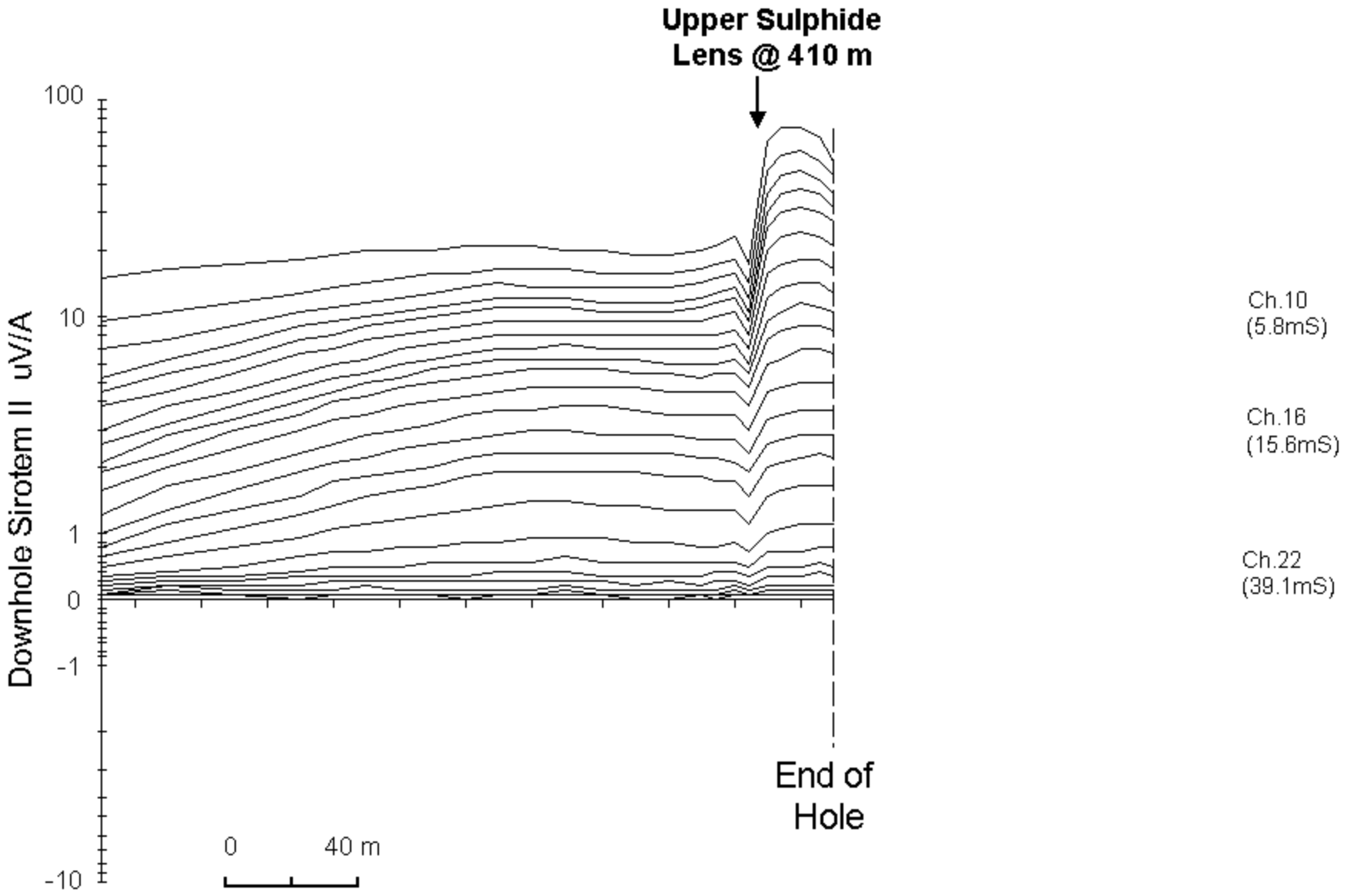
Seven RC holes were drilled updip from the interpreted conductor searching for oxide copper resources.
None were found.

For the eighth hole (of ten proposed) it was decided to test the actual conductor to check that it was a sulphide body.

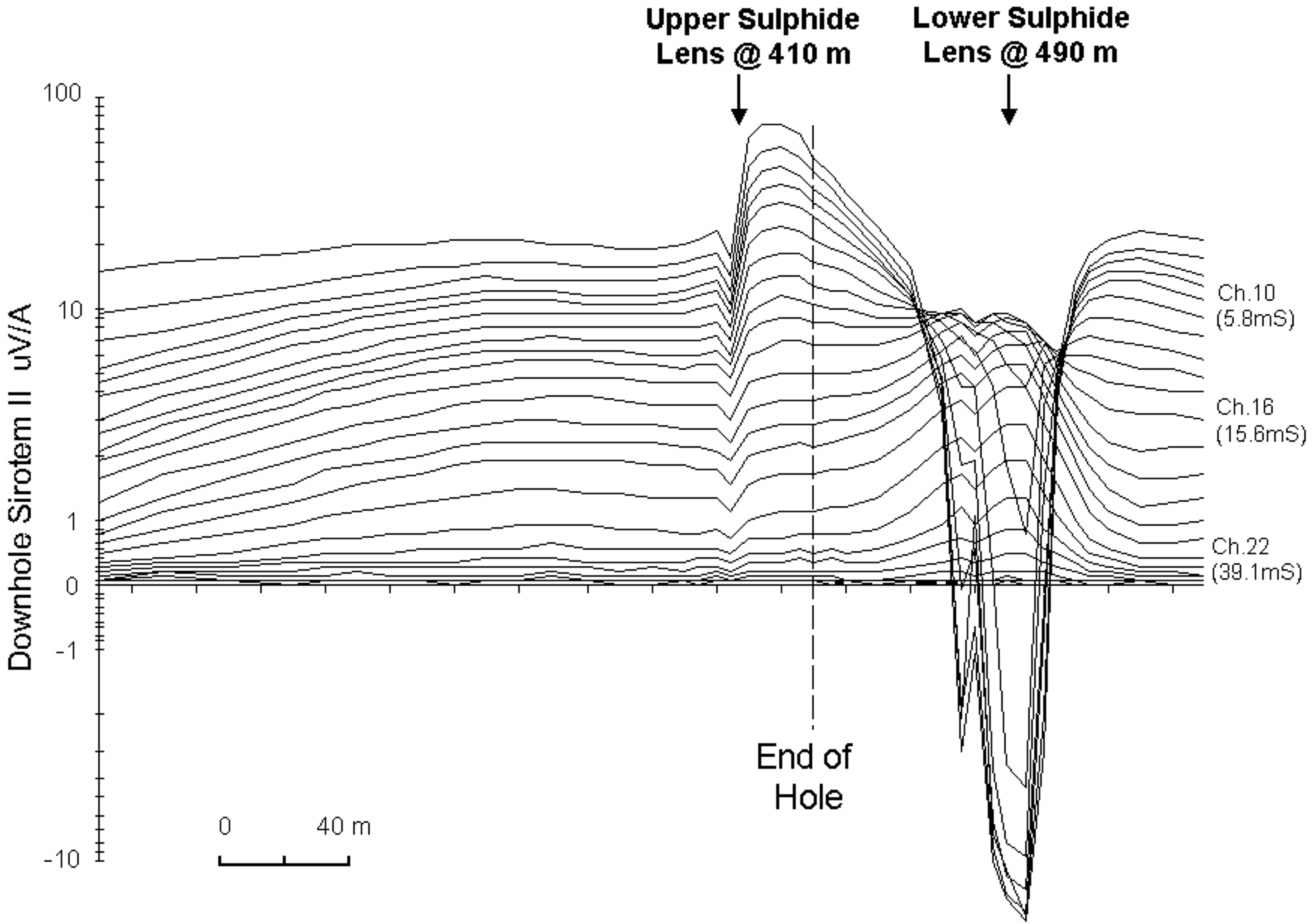

TRITTON PROJECT
BDS 055
TRAY 28
FROM 621·84 – 628·22 m
5908

Hole 10 (downdip from the discovery hole 8) was logged with downhole EM to beyond the mineralised horizon.

The EM contractor, Peter McSkimming, recognised that the mid time channels were still rising past the mineralisation and recommended the hole be extended.

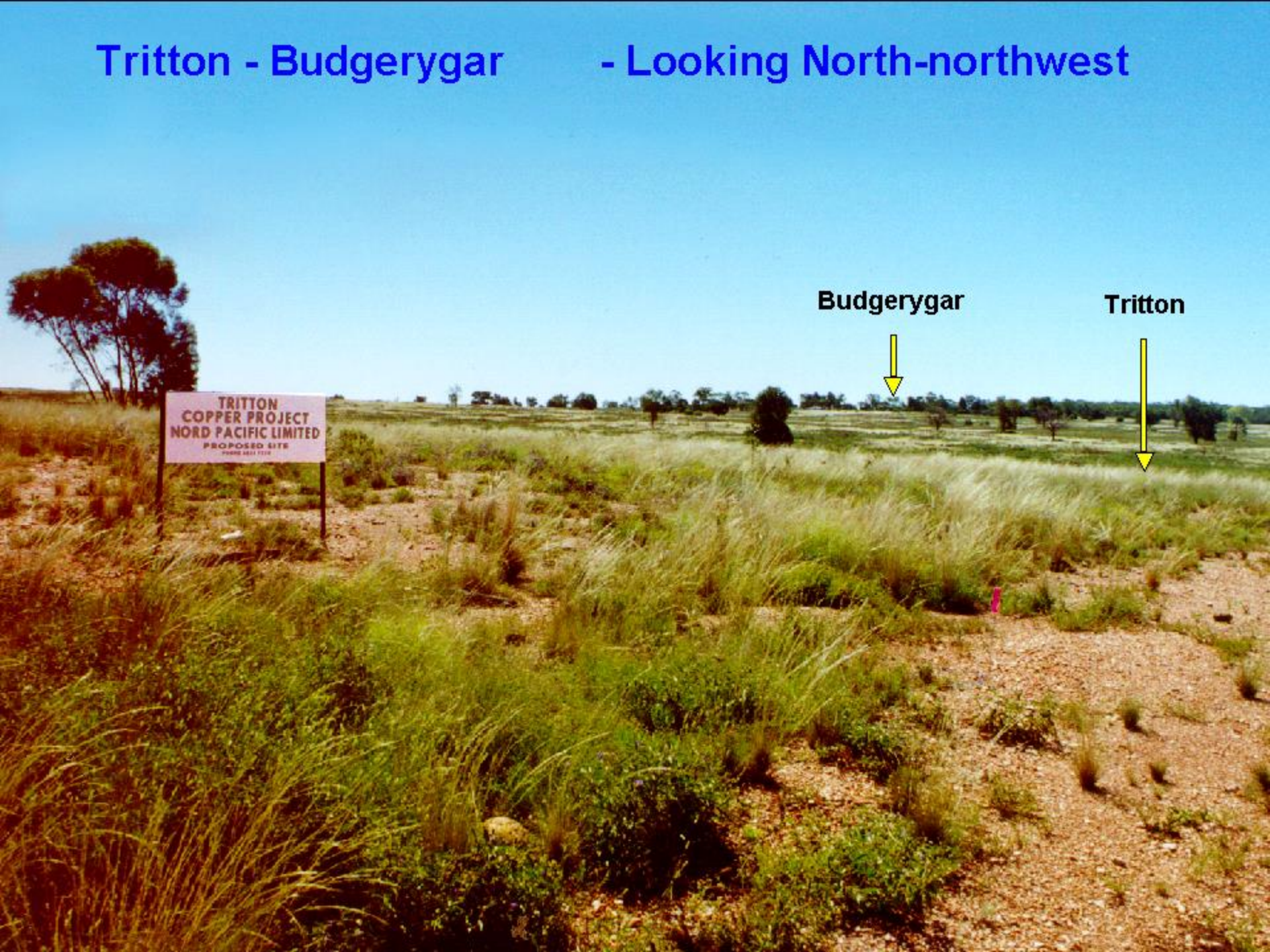


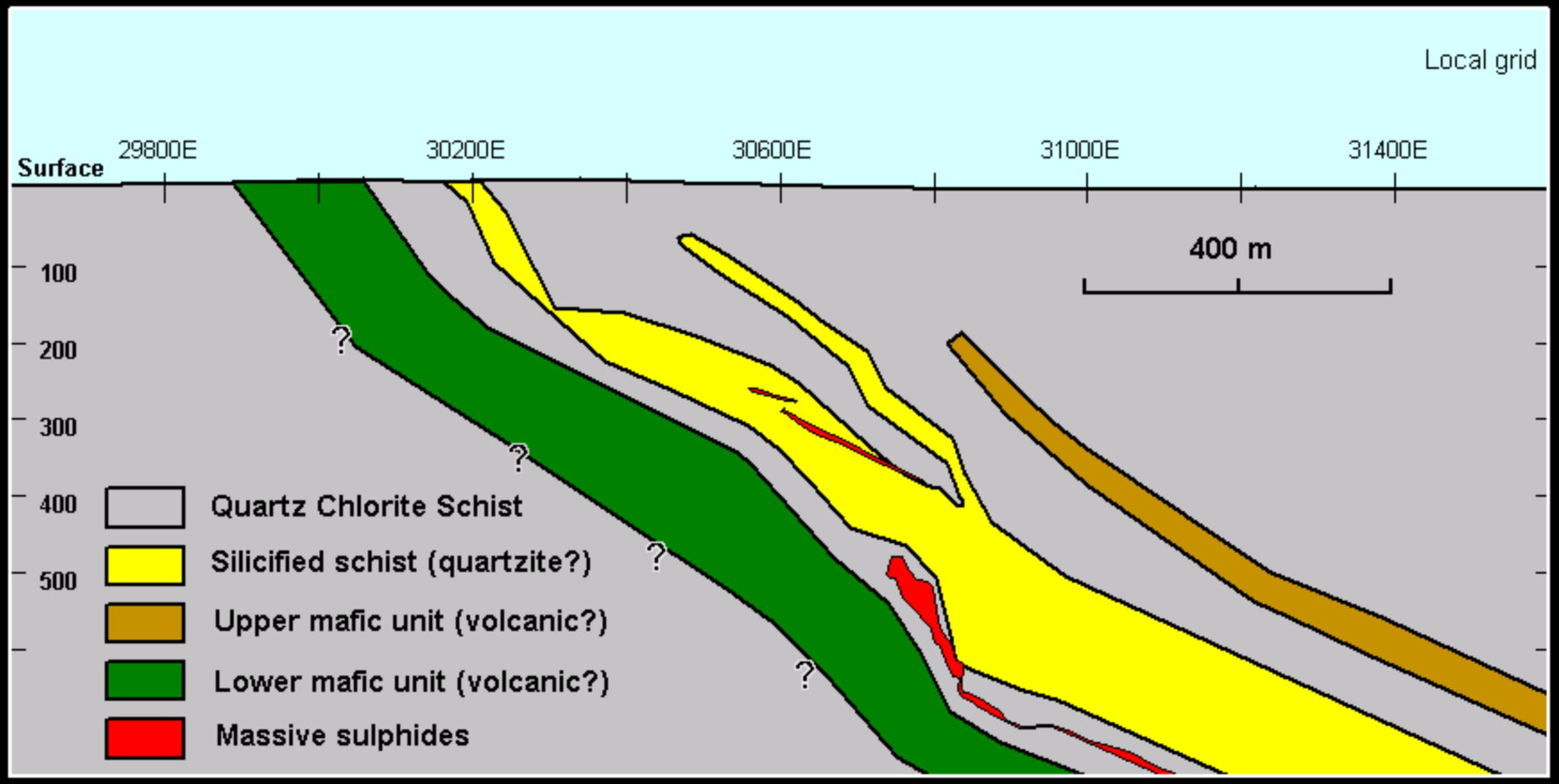
Tritton - Downhole Sirotem Hole 10



Tritton - Downhole Sirotem Hole 10 (Extended)

Tritton - Budgerygar - Looking North-northwest

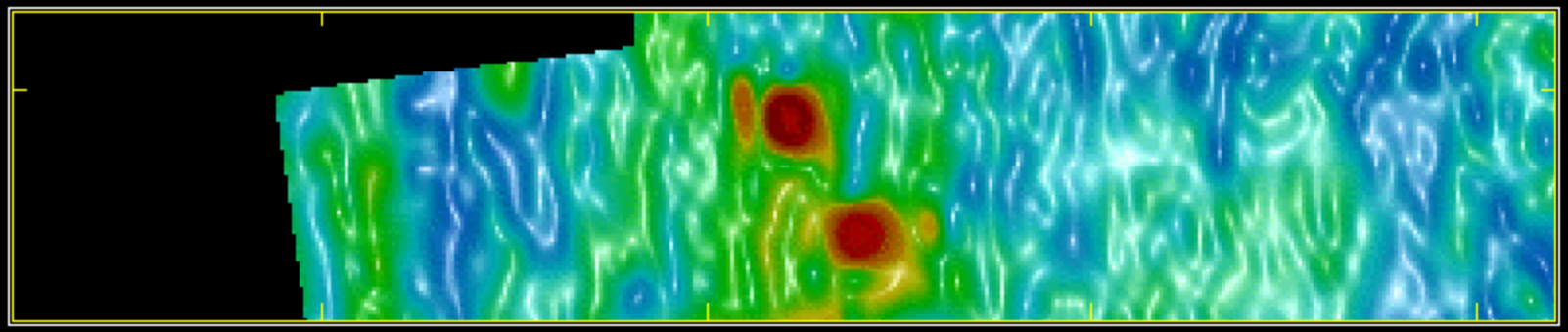




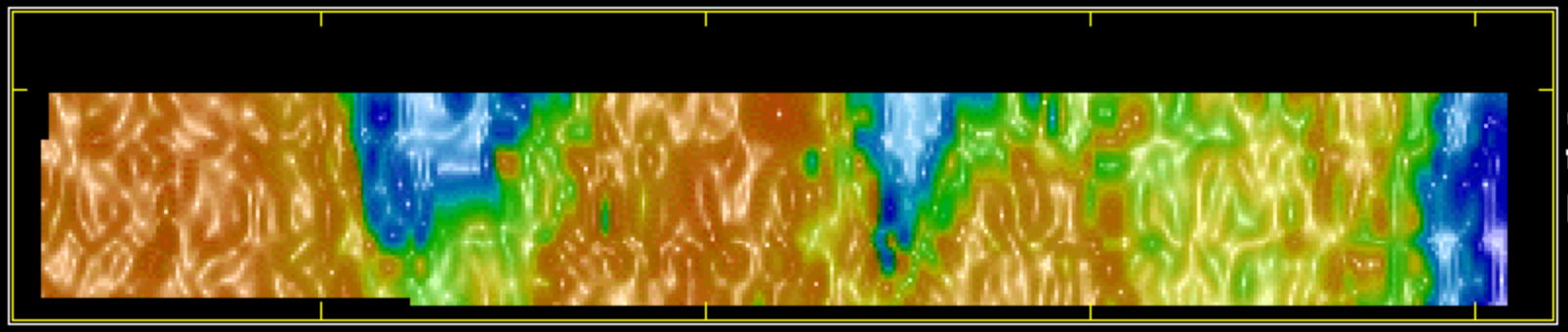
Tritton - Geological Cross Section - Line 29300N (Local grid)

After several years of ground EM surveying (and two discoveries) it was decided that the expense was too great. Airborne EM tests were carried out over the known Tritton/Budgerygar sulphides.

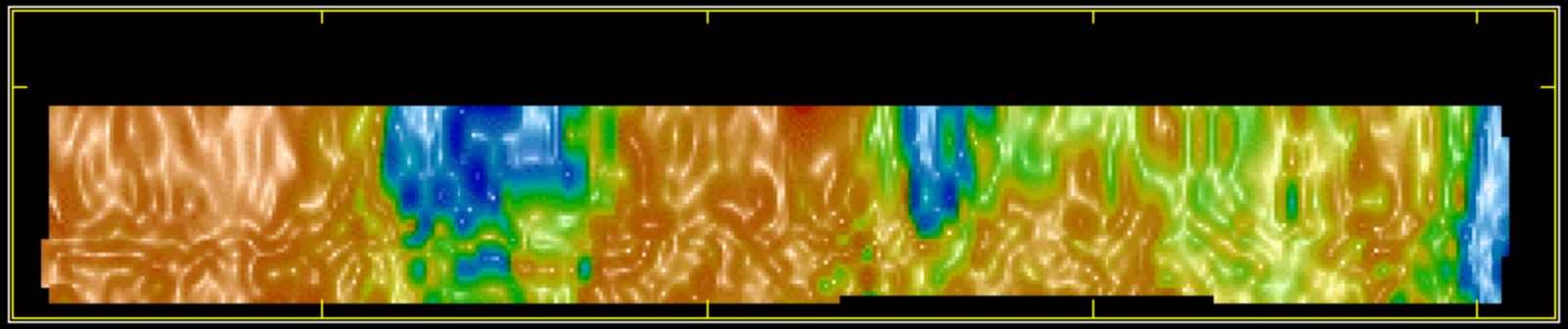
A Geotem Deep survey was flown at 100m line spacings in both directions to determine if it was possible to detect Tritton.



200m
Moving Loop
Sirotem II



Geotem Deep
West-East
Flown



Geotem Deep
East-West
Flown

0 2.5 mS

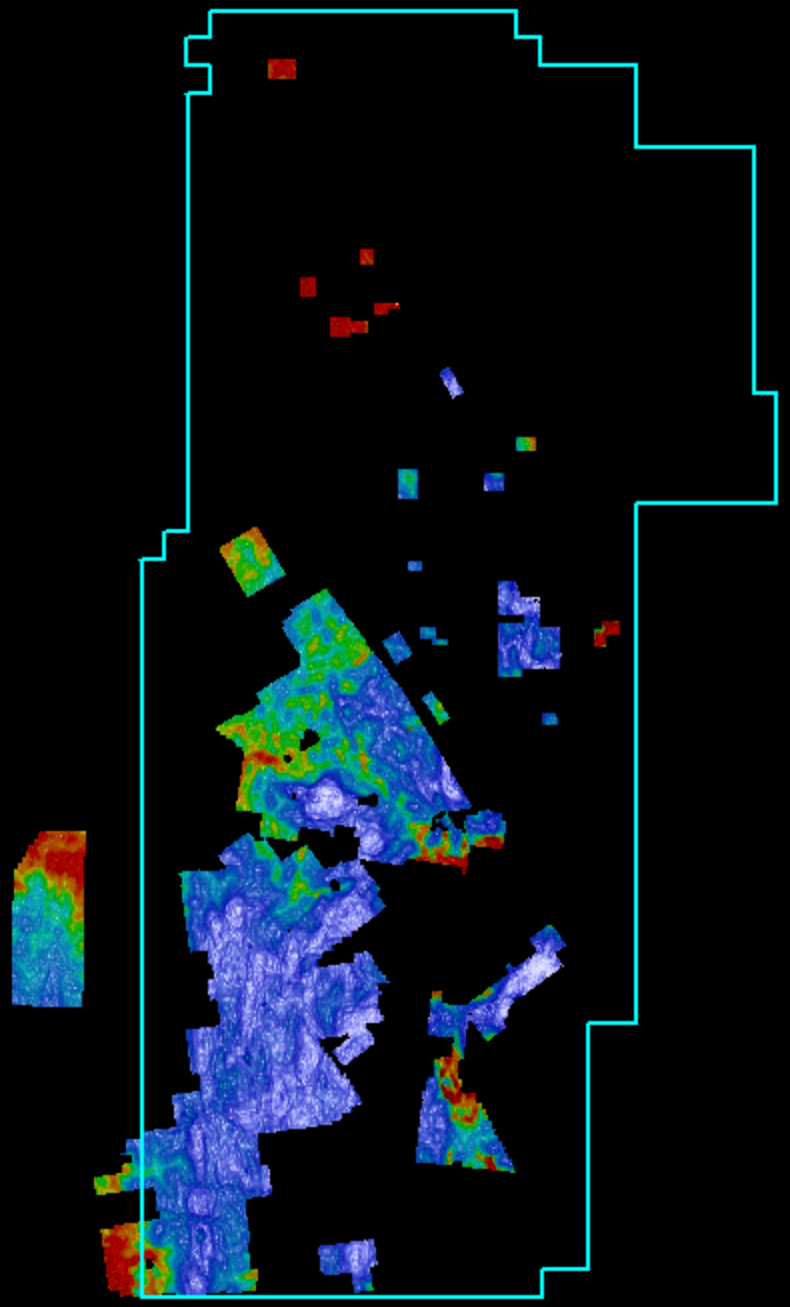
Tritton / Budgerygar - Comparison of Sirotem and Geotem Data
Sirotem Decay at 1uV/A - Geotem Total Field Decay at 100 ppm

The Geotem system was unable to detect the Tritton conductor due to its depth of burial. The fact that the shallower sulphides at Budgerygar were detectable was sufficient to allow the use of the airborne system over broader areas.

The areas to be covered with Geotem were most of the prospective areas within the exploration licences that had not been covered with ground EM.

Girilambone Project
200m Moving Loop
Sirotem II

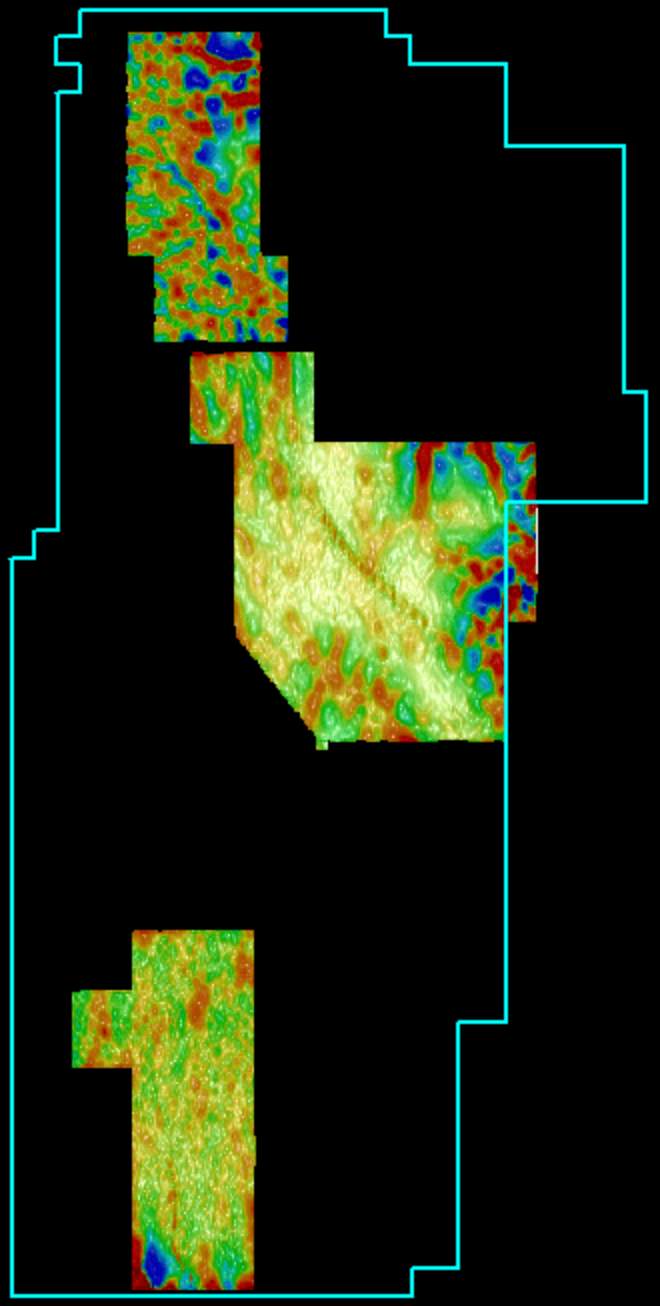
Channel 4 = 1.66 mS



20 km

Girilambone Project
Geotem Deep

Principle Component 1
Mid Times Ch's 7-11
High Pass Filtered



20 km

Only one clearly anomalous response was detected. This was confirmed using ground EM surveys and drill tested. Unfortunately it was due to graphite, similar to the Ben Hur Prospect.

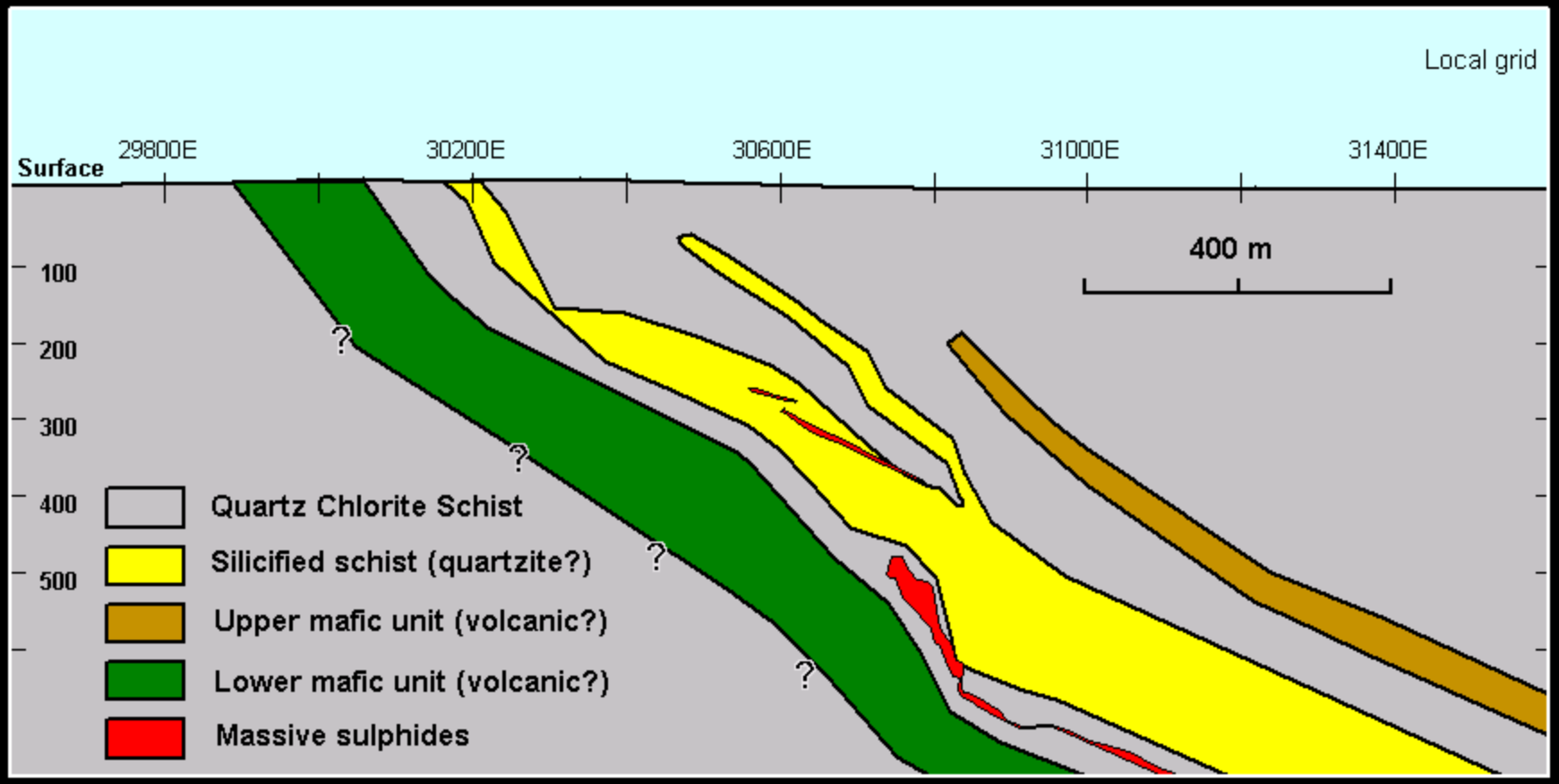
Test surveys were also flown using the then experimental Hoistem system but no responses were detected over the Tritton deposit.


"Look! Up in the sky!"
"Is it a bird?"
"Is it a plane?"

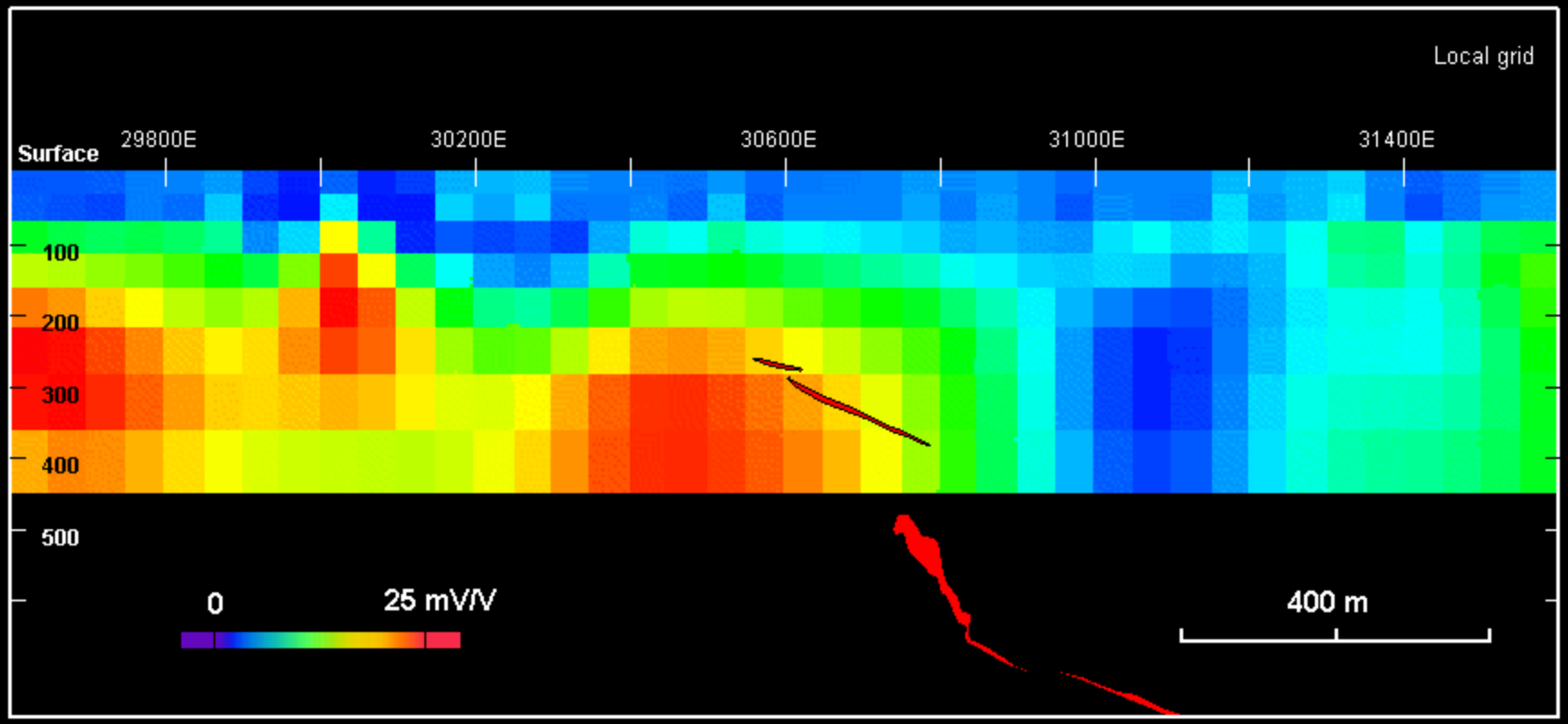
A single line of MIMDAS pole-dipole IP and MT was run over the deposit.

IP values are elevated in the footwall rocks but there is no distinct response directly associated with the deposit.

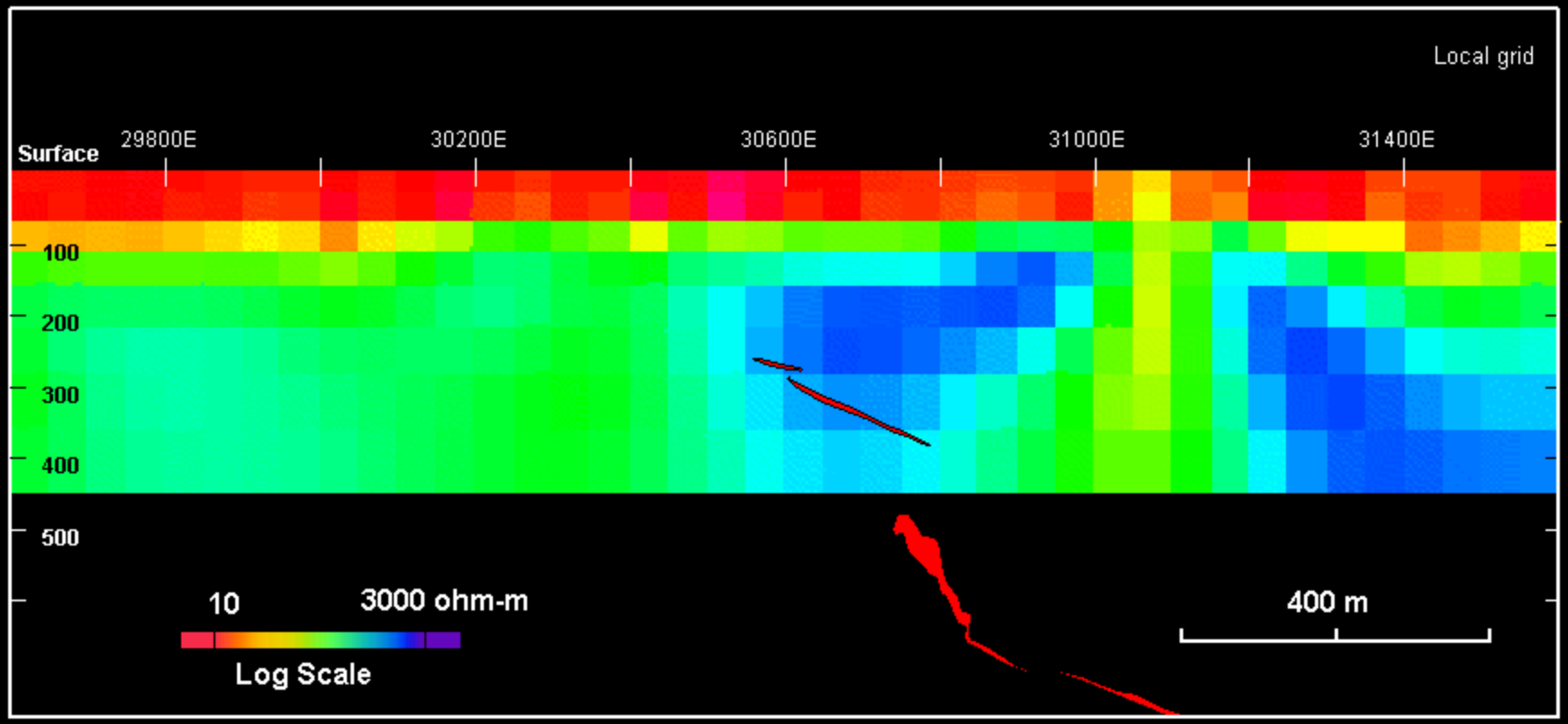
This is consistent with an exhalative genesis for the deposit.



Tritton - Geological Cross Section - Line 29300N (Local grid)



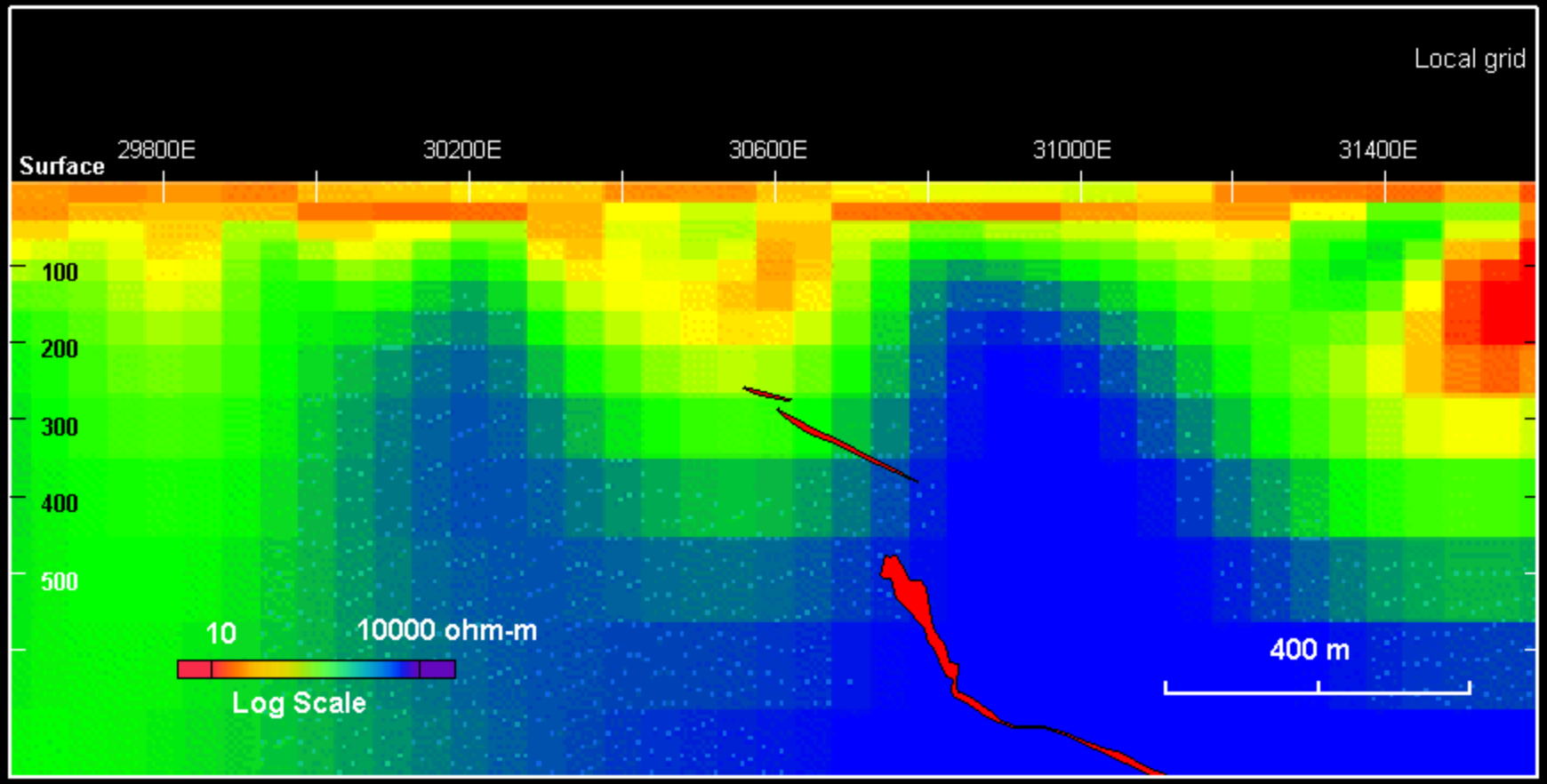
Tritton - MIMDAS - 2D Inversion of IP Chargeability



Tritton - MIMDAS - 2D Inversion of IP Resistivity

The magnetotelluric (MT) data failed to detect the deposit despite the fact that it is a strong EM conductor.

The intrinsically plane wave nature of the MT signal makes this technique inappropriate for detecting compact, short strike length targets.



Tritton - MIMDAS - 2D Inversion of Magnetotellurics

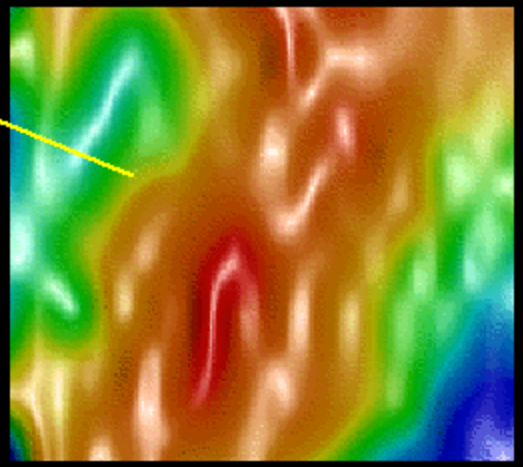
At the time that the mine was starting construction, there were no funds available to further test IP or gravity surveys prior to construction

Contractor Hugh Patterson volunteered to run a detailed gravity survey over the area of the mine site free of charge so that the data would be available for subsequent exploration evaluation.

Tritton - Detailed Bouger Gravity

Budgerygar

Tritton



True North

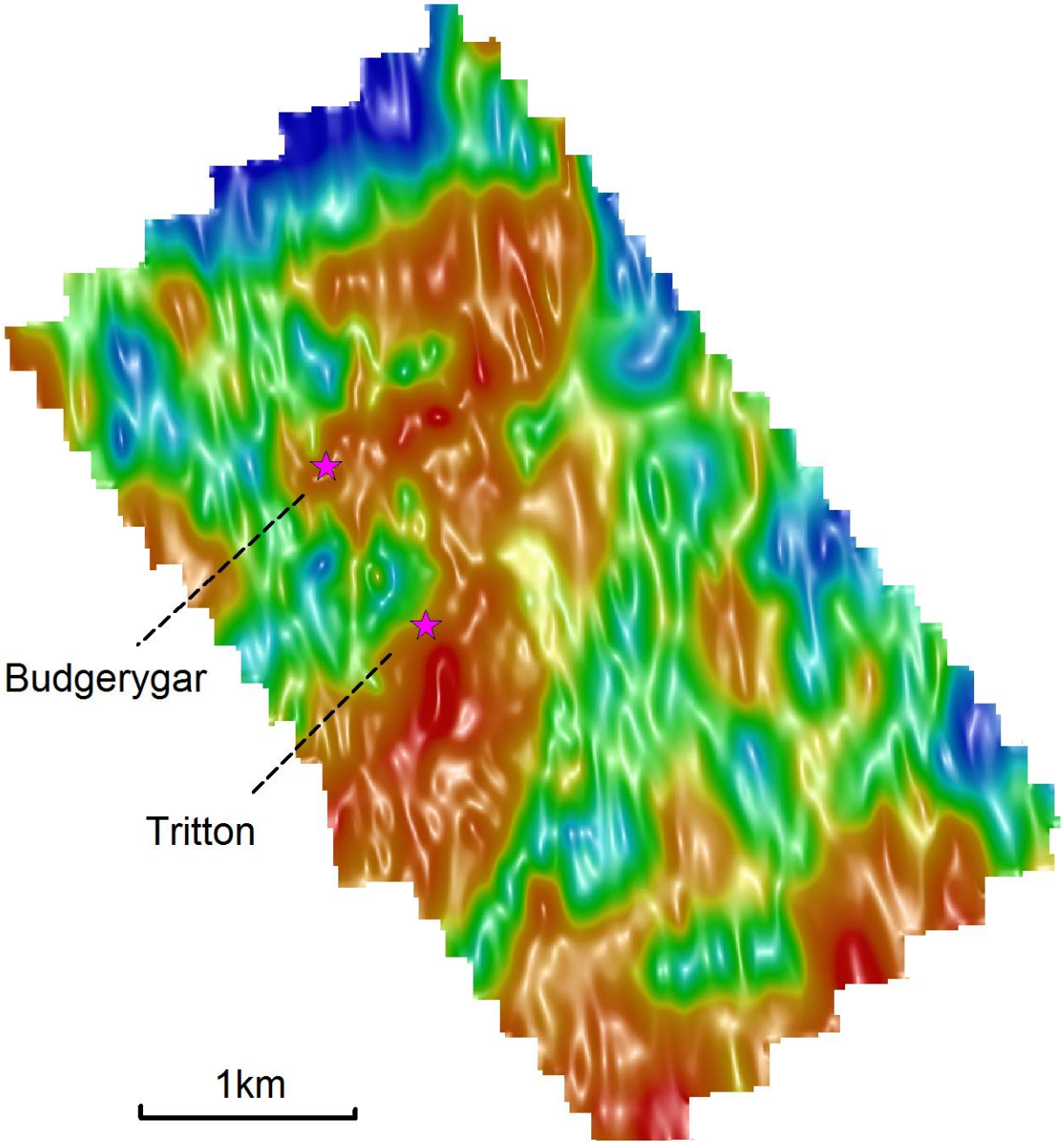
0 1 milligal

500 m

Subsequently, the gravity survey was expanded considerably. The data shows that the deposits do not have a coincident gravity high but have an association with adjacent elevated gravity.

This is similar to the observations from North Girilambone.

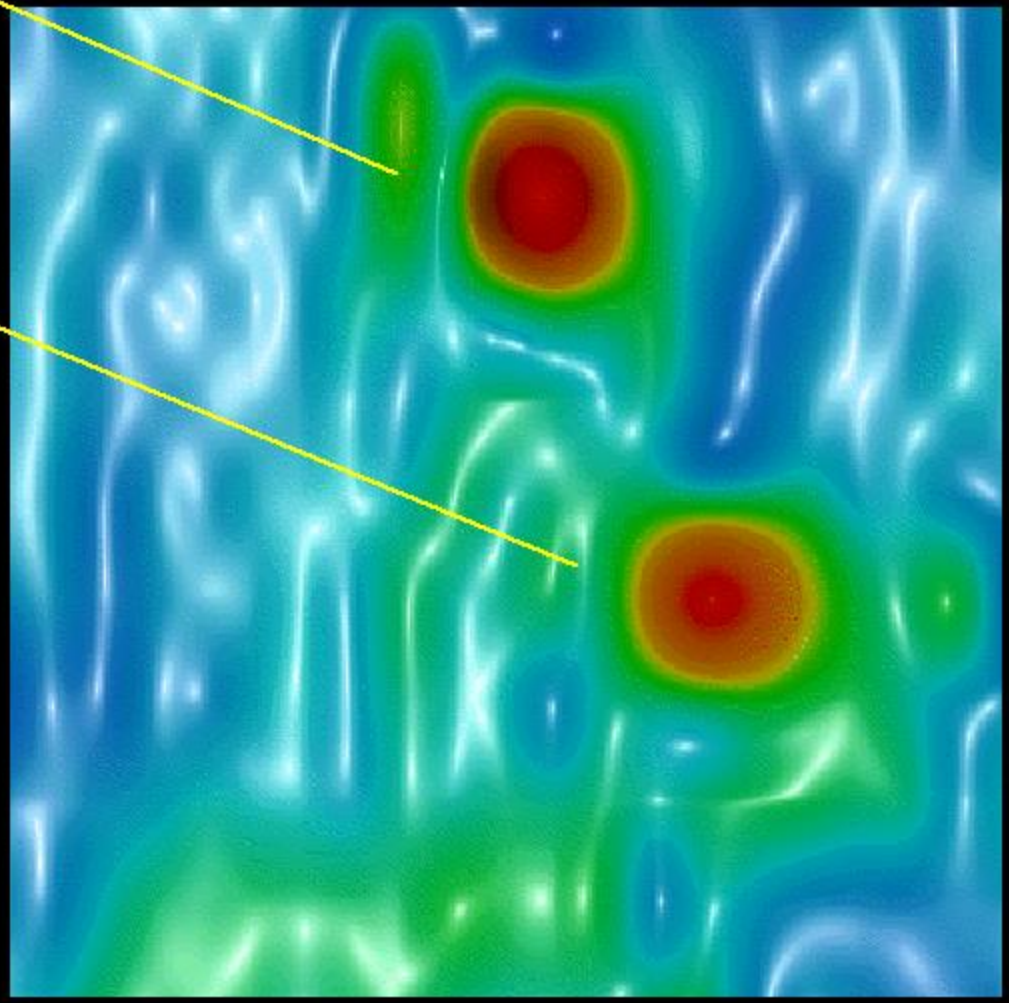
The gravity high may be due to silicification associated with the deposits.


Budgerygar
Tritton
1km

”When you see a real ore deposit in your geophysical data – you will know it.”

Probably – if the right technique is used but only to a limited depth (possibly 300m for this style of deposit).

Tritton - 200m Moving Loop Sirotem - Decay Constant

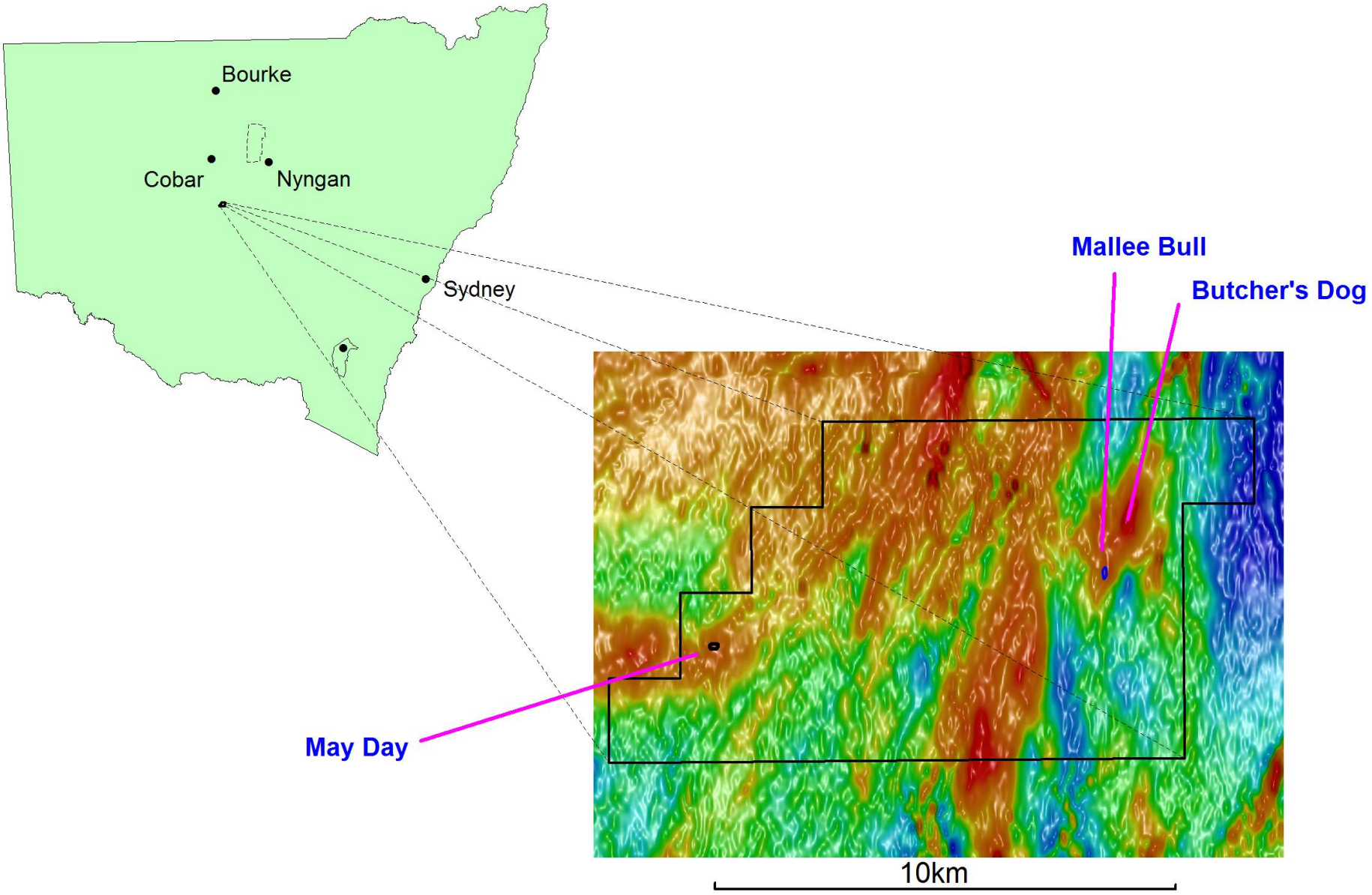


Fast forward a decade or so

And move 120km southwest

The Discovery of the Mallee Bull Ore Deposit.

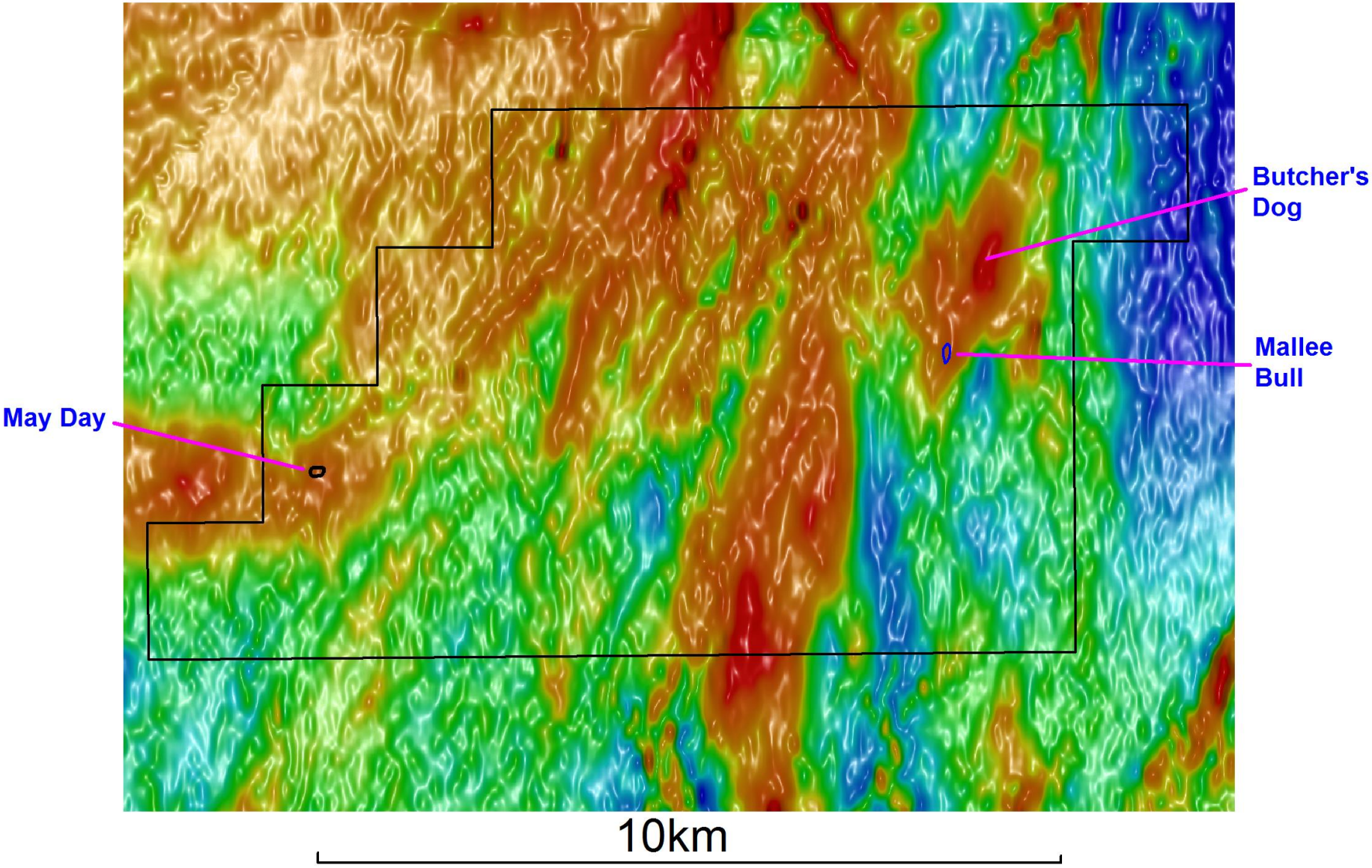
Gilgunnia NSW


Bourke
Cobar
Nyngan
Sydney
Mallee Bull
Butcher's Dog
May Day
10km

Exploration was concentrated around the abandoned May Day Mine which lies immediately southwest of the Gilgunnia gold fields.

Considerable magnetic, IP and drilling work had been carried out by previous explorers.

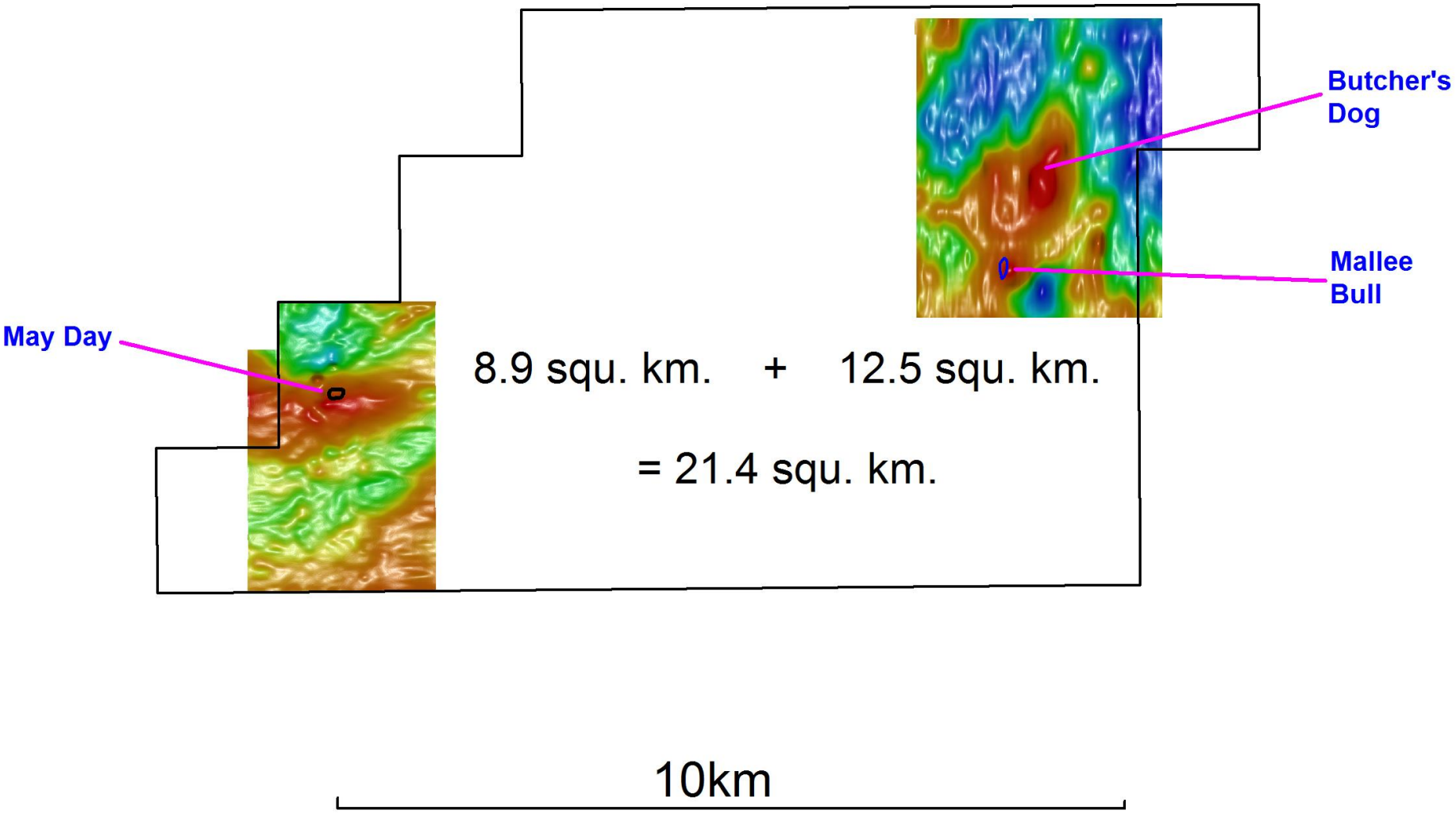
May Day - Mallee Bull Regional Airborne Magnetic Data



Other explorers were using VTEM heli-borne EM surveying on the adjacent exploration licences.

Despite very tight budgets it was decided to fly two postage stamp sized VTEM surveys over the May Day Mine and the nearby Four Mile goldfields.

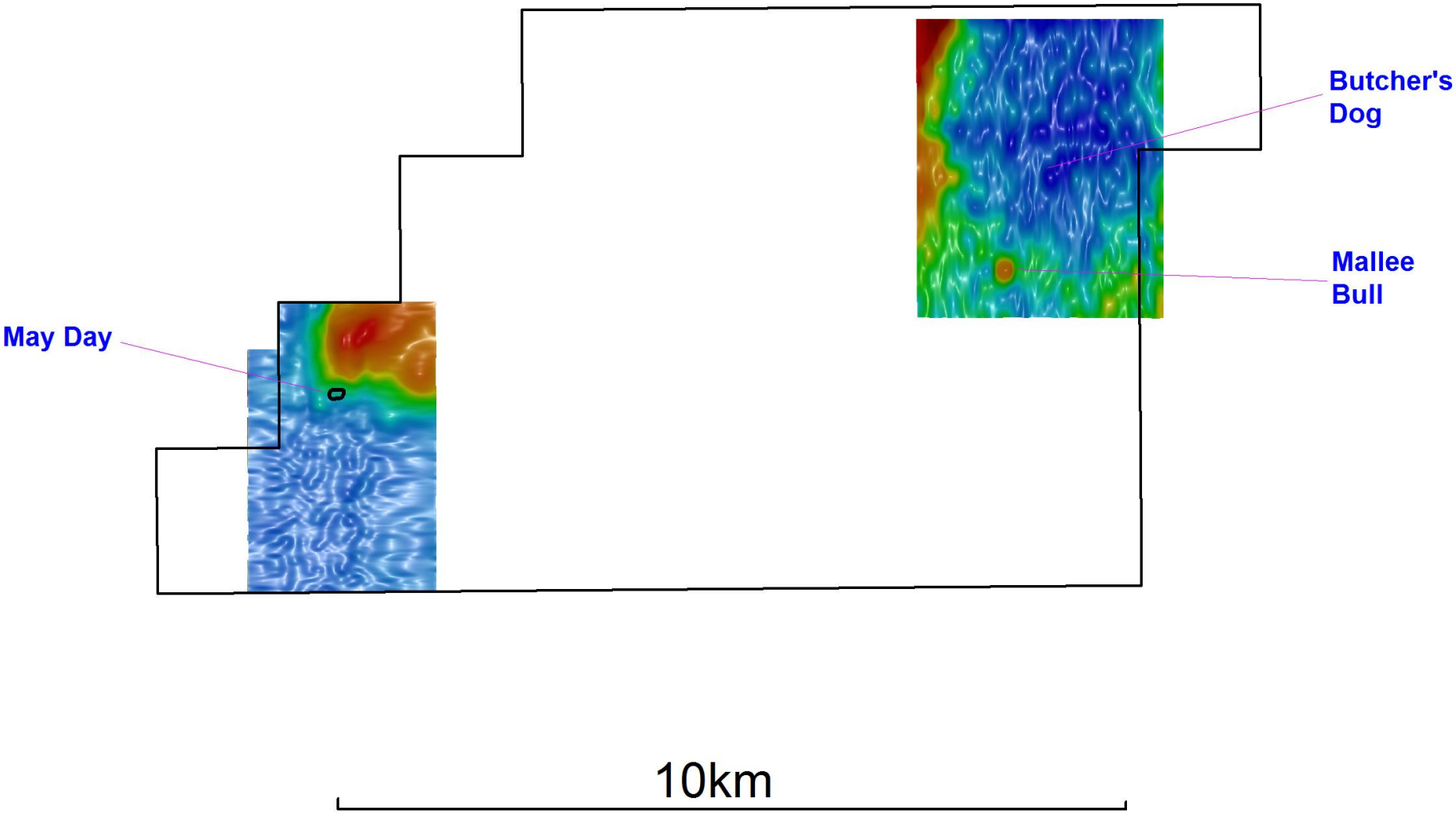
May Day - Mallee Bull Magnetic Data (from VTEM survey)



This was against the advice of the consultant geophysicist (yours truly) who thought (based on previous experience at Girilambone) that the money would be better spent on a comprehensive ground EM survey over May Day.

Had this advice been followed, there would be excellent ground EM data at May Day but Mallee Bull would probably remain undiscovered.

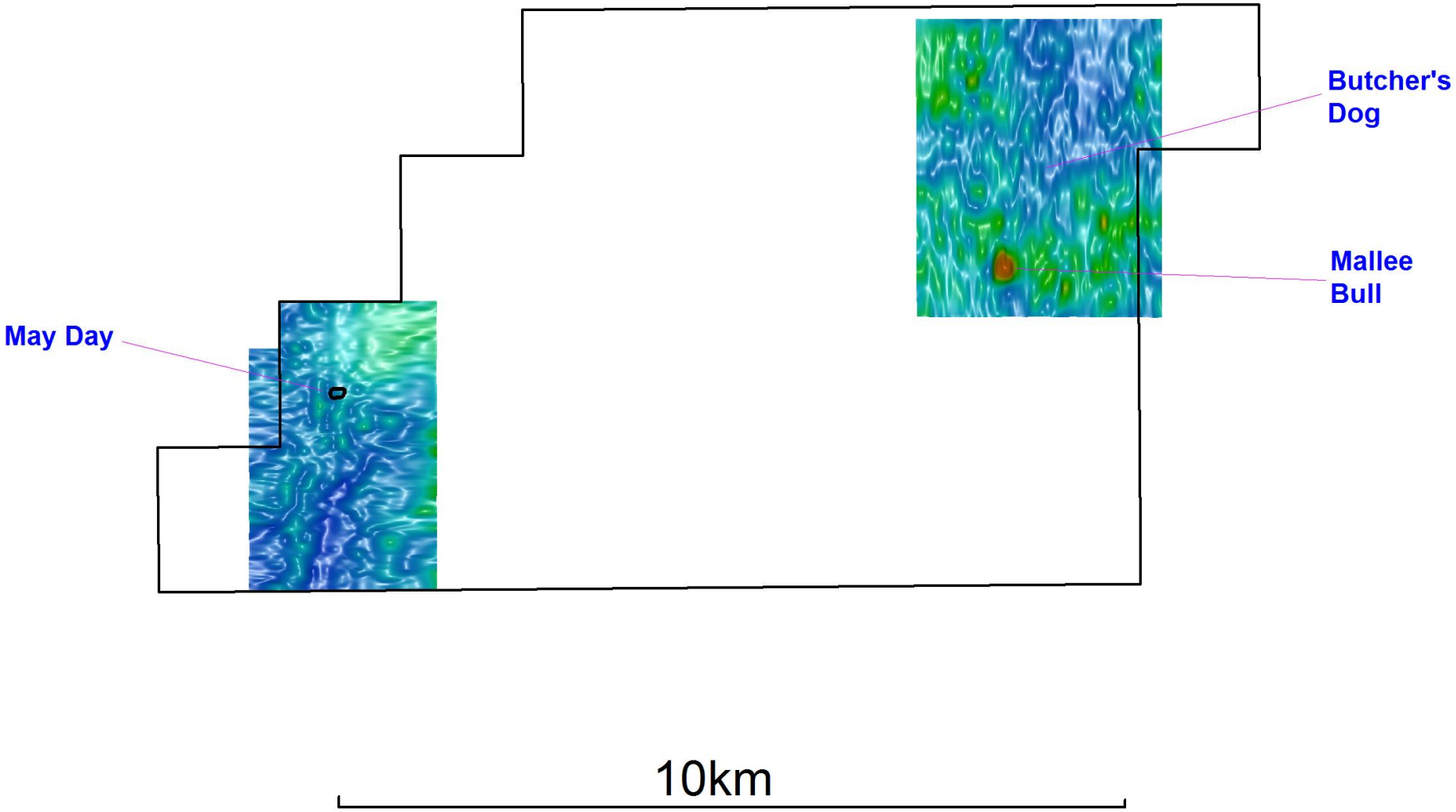
May Day - Mallee Bull Late time VTEM data



BINGO!

Lady Luck smiled down.

May Day - Mallee Bull VTEM Time Constant

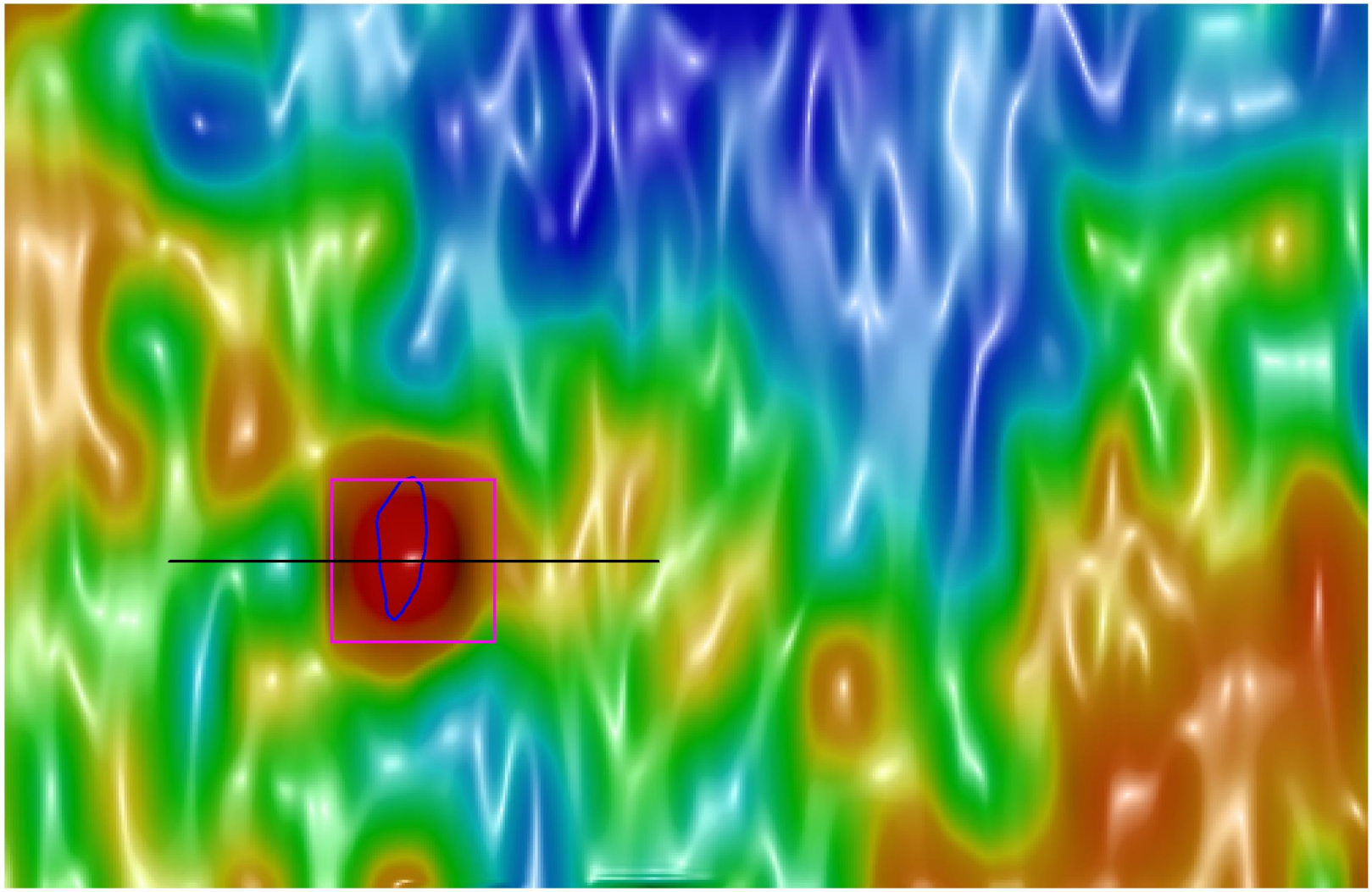


With the budget now extremely thin the question of how to follow up the VTEM response was addressed.

An EM contract crew was nearby so a single line of fixed loop ground EM was planned.

In the event of no response, another line at right angles to this would have been run to check for west-east strike. This turned out to be unnecessary.

Mallee Bull Late time VTEM data



A clear deep response occurs at late times.

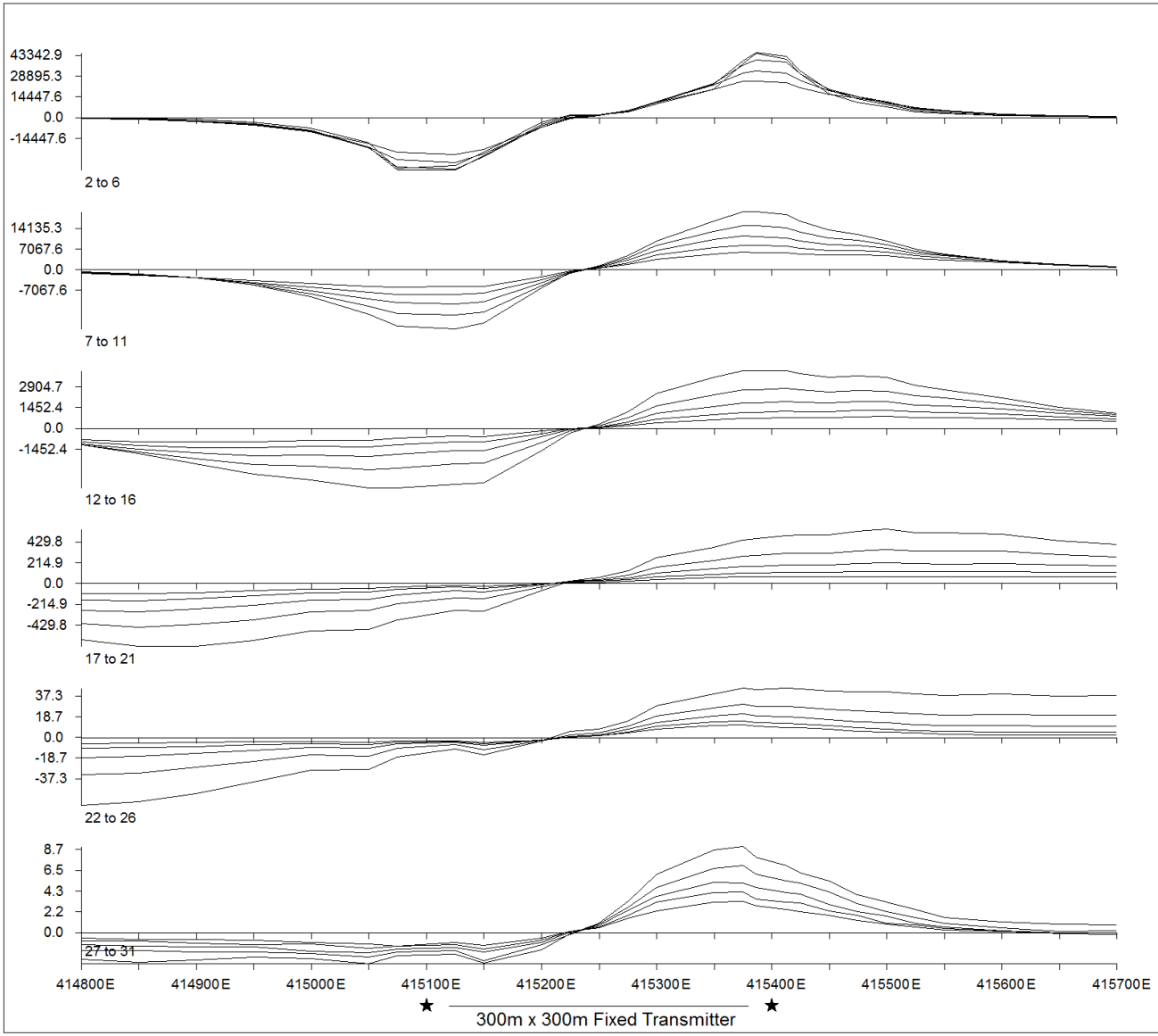


Figure 4

Mallee Bull Prospect
VTEM folllow up
Crone PEM Fixed Loop

Line 6413350N
[MGA55 GDA94]

X (East) component

Eureka!

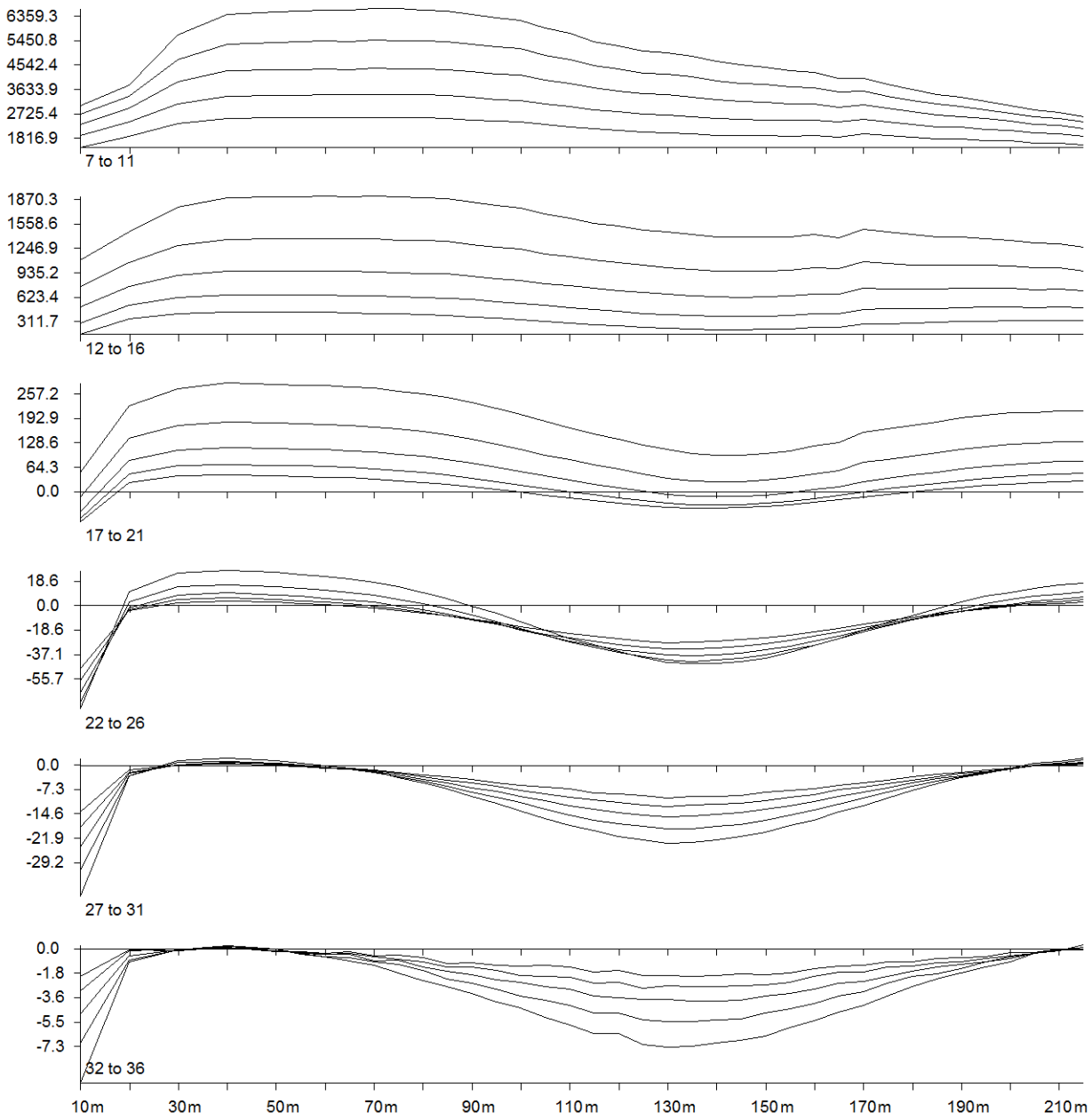
Let's drill

(But we don't have any money!)

Somehow funds for a drill hole were found.

The hole intersected minor sulphides but no massive conductor.

Downhole EM was run to check that the EM target had been tested.

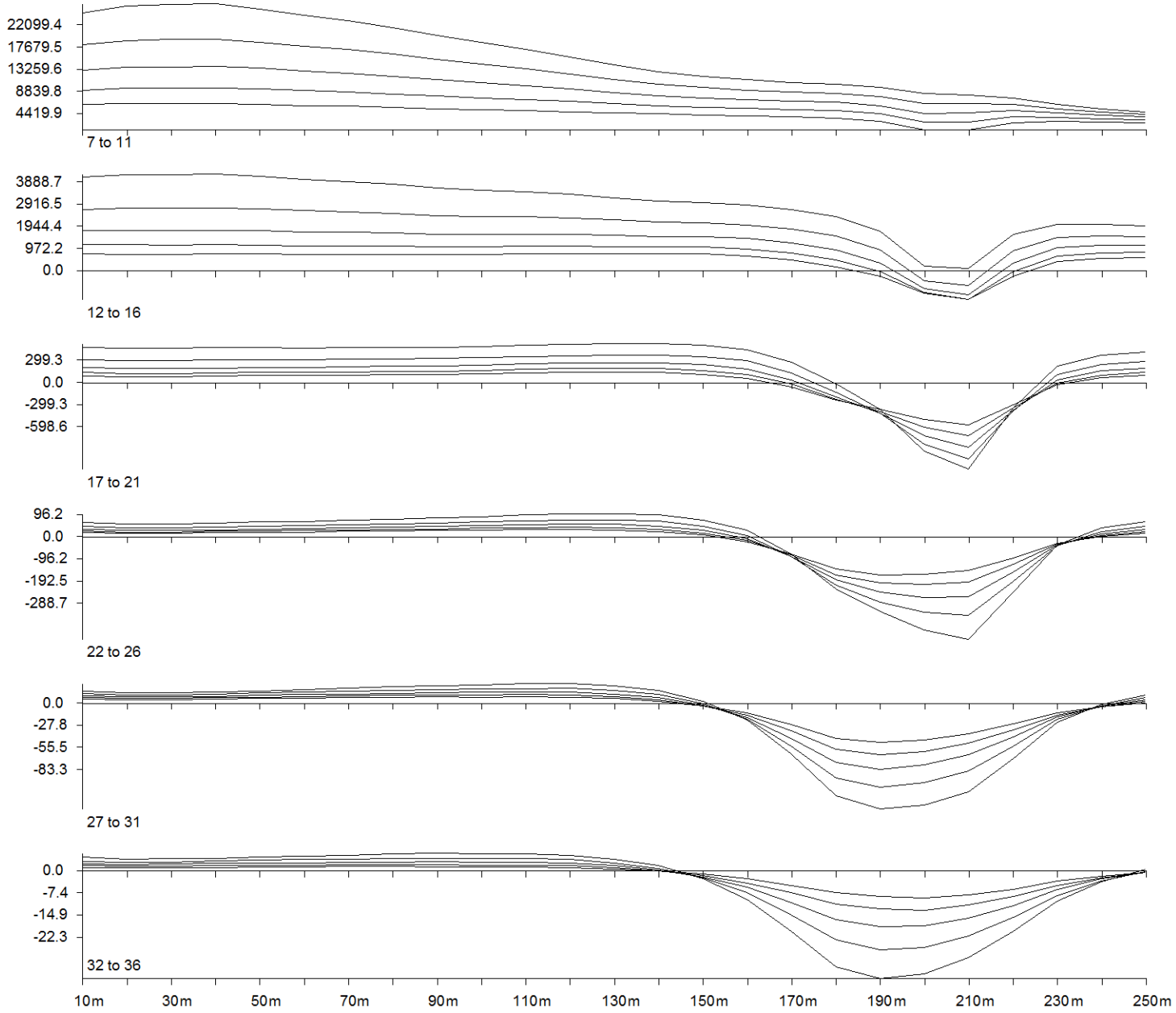


Mallee Bull Hole RC2 Downhole EM A-component

OOOPS Missed it!

Drill again!

(But we now have less money!)



Mallee Bull Hole RC4 Downhole EM A-component

OOOPS Missed again!

Drill yet again!

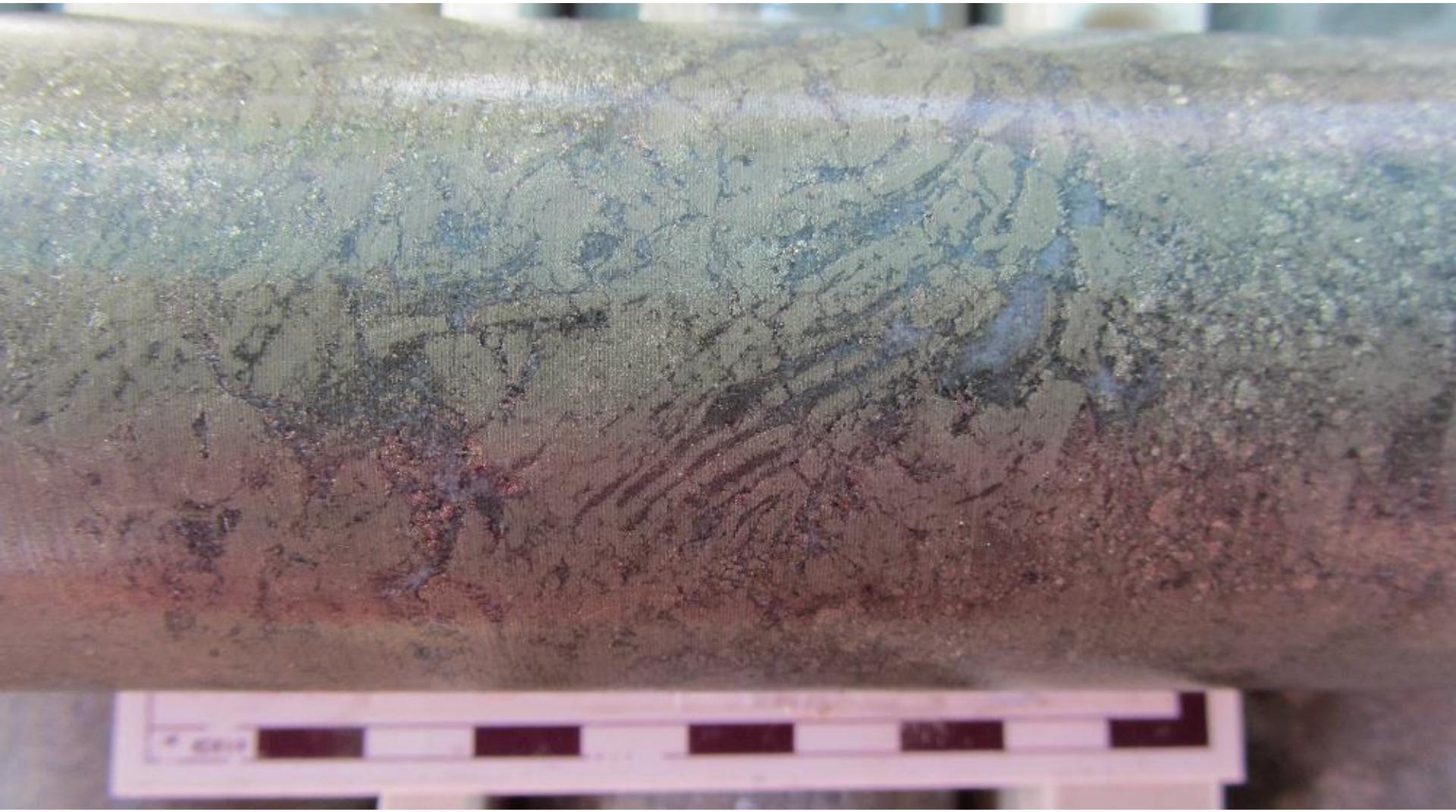
(Surely you are joking!)

As happens, the initial holes had both deviated very badly and had tested almost the same patch of ground, well away from the interpreted EM target.

Lesson learned – survey your drill holes – even if it costs money you don't have.

A third hole was drilled hesitantly based on the downhole EM results (but with the memory of Larsen's East and Tritton still vividly clear).

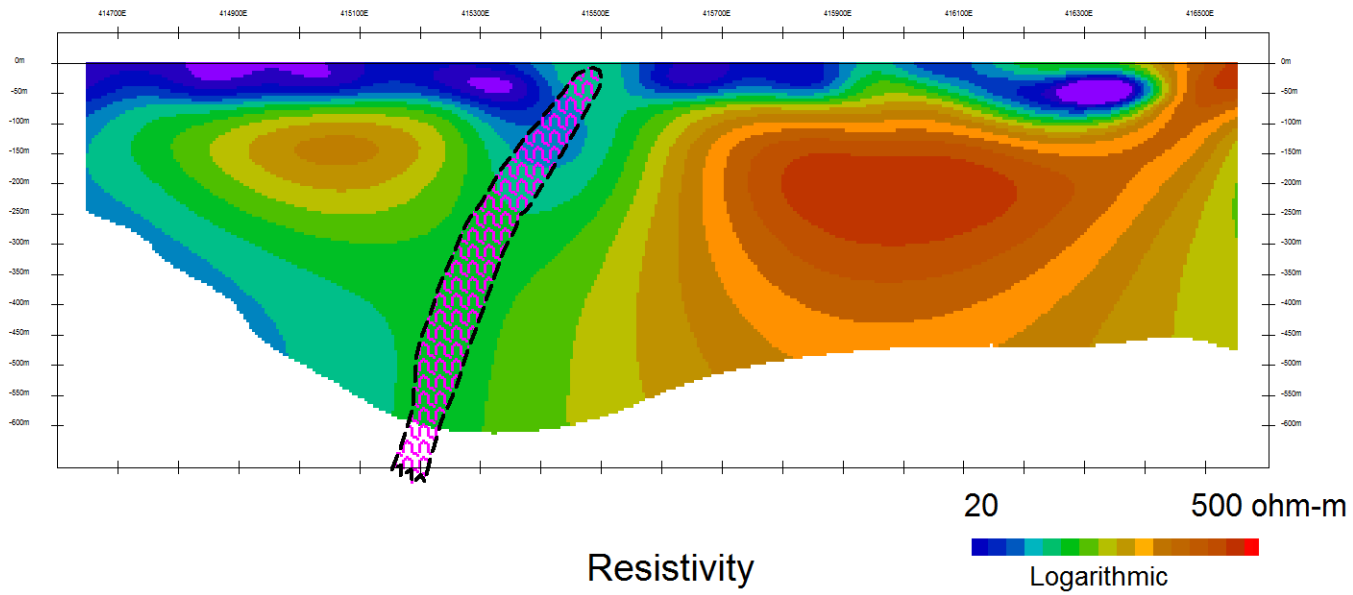
“Trust the Force (aka downhole EM) Luke!”

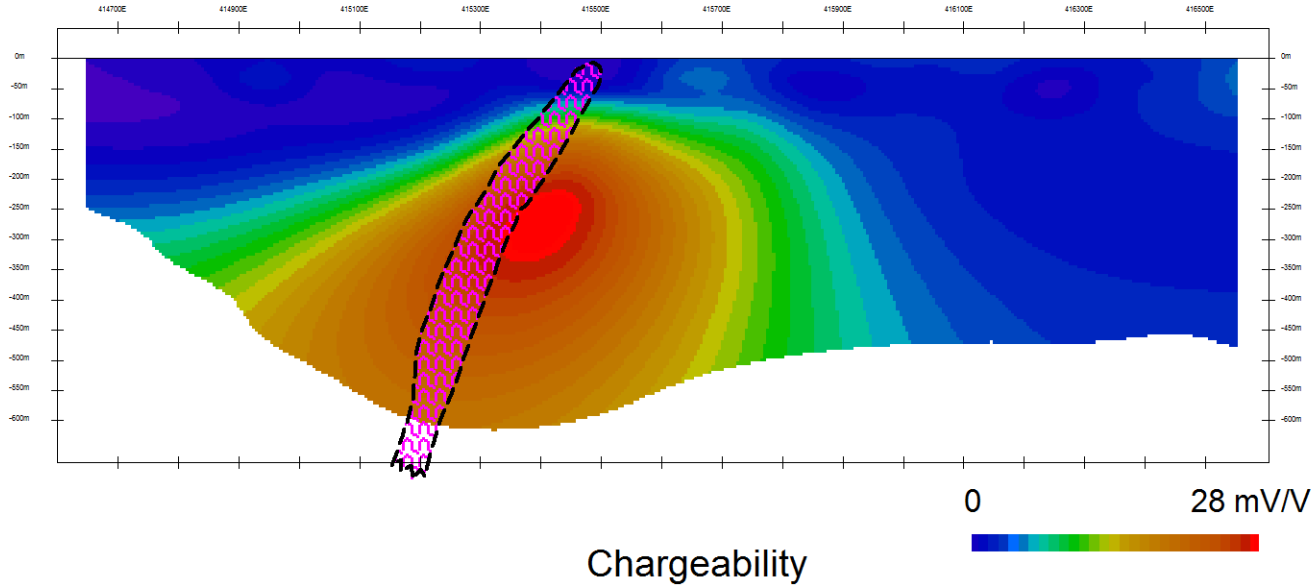


At last!

Once the deposit had been confirmed by drilling a single line of 100m dipole-dipole IP was run.

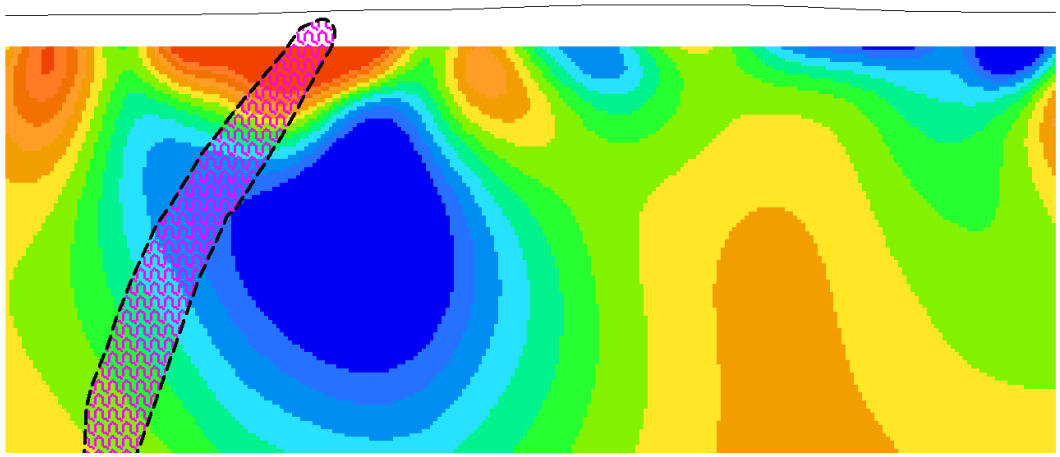
2D inversion modelling of these data appeared to indicate that the deposit was associated with a moderate IP anomaly and a minor resistivity low.


414700E
414900E
415100E
415300E
415500E
415700E
415900E
416100E
416300E
416500E
0m
-50m
-100m
-150m
-200m
-250m
-300m
-350m
-400m
-450m
-500m
-550m
-600m
20
500 ohm-m
Logarithmic
Resistivity


414700E
414900E
415100E
415300E
415500E
415700E
415900E
416100E
416300E
416500E
0m
-50m
-100m
-150m
-200m
-250m
-300m
-350m
-400m
-450m
-500m
-550m
-600m
0
28 mV/V
Chargeability

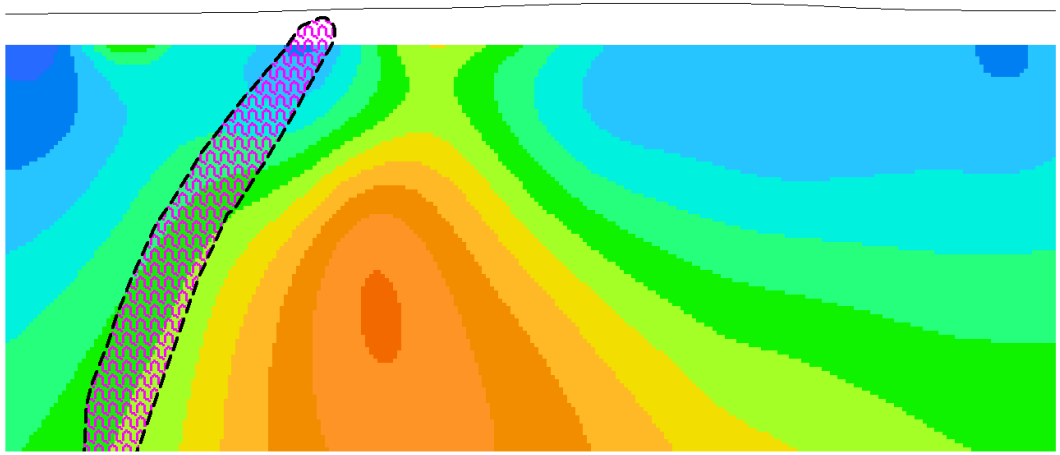
But later 3D offset pole-dipole surveys and 3D inversion modelling shows that the IP response (and a strong resistivity low) lie in the footwall rocks below the deposit.

As with the Girilambone deposits, this is strongly suggestive of a syngenetic exhalative genesis for the deposit.



Resistivity

500m



IP Chargeability

Mallee Bull 3D IP model

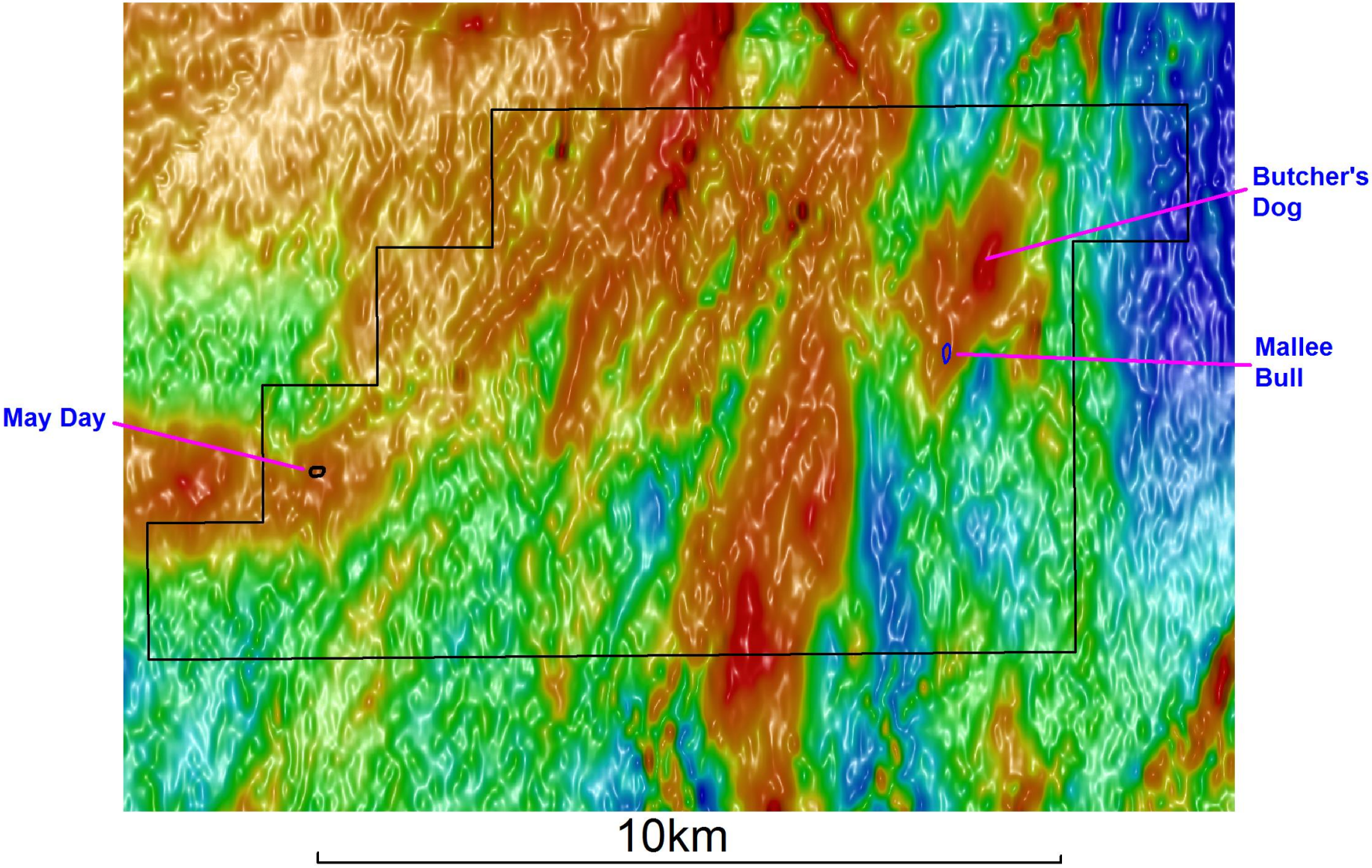
With the deposit discovered and definition drilling underway, attention turned to the search for extensions or additional deposits.

In particular the large deeply buried magnetic target to the north was of considerable interest due to the presence of pyrrhotite in the Mallee Bull deposit.

This prospect was named Butcher's Dog to conform to the theme "as fit as a mallee bull" and now "as fit as a butcher's dog"

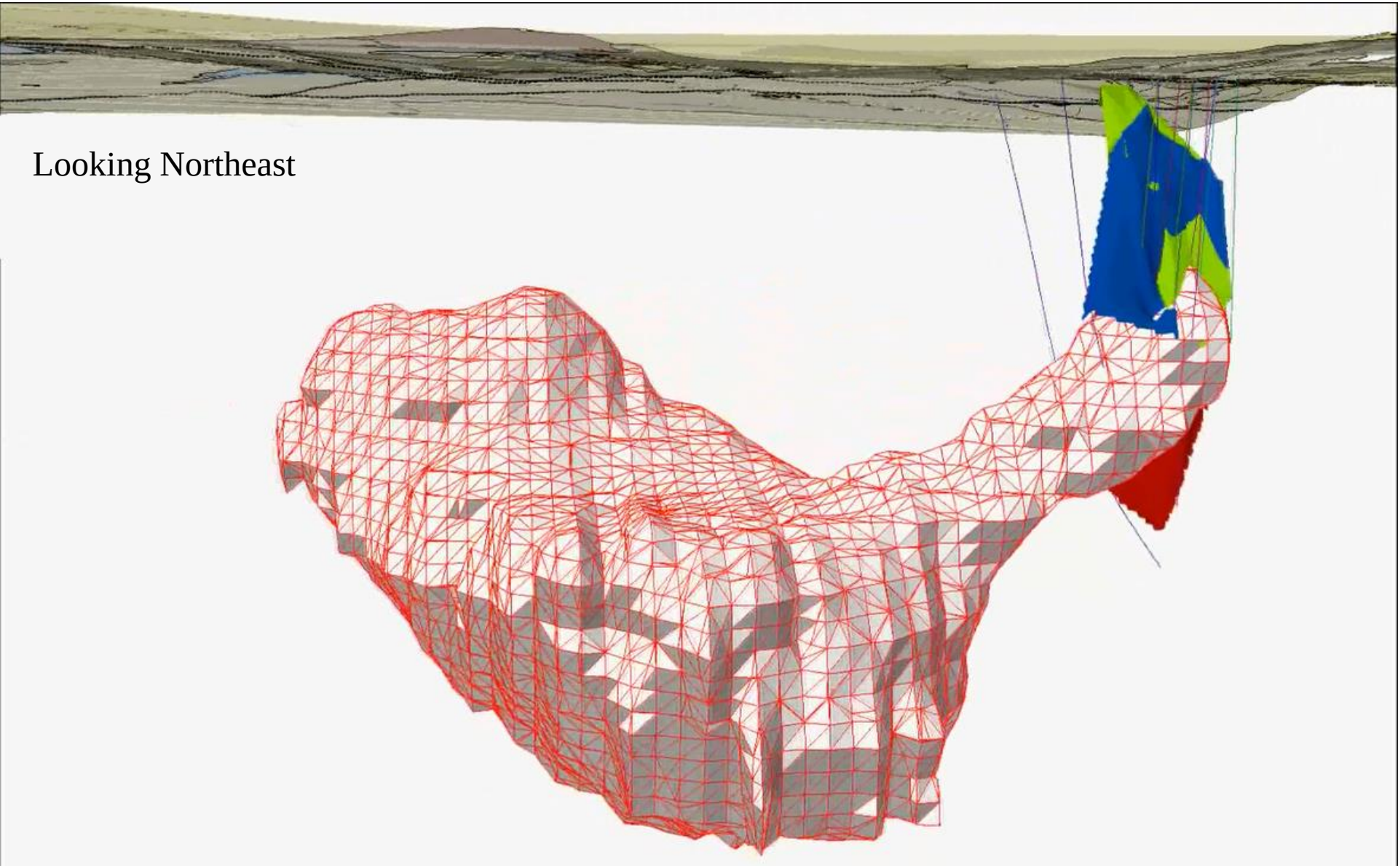
For fear of upsetting the ASX this naming theme was never extended to "as fit as a fiddle"

May Day - Mallee Bull Regional Airborne Magnetic Data



3D inversion modelling of the surrounding magnetic data seems to suggest a strong link between the Mallee Bull and Butcher's Dog prospects.

The implication is that Butcher's Dog is a much deeper and very much larger extension of the Mallee Bull system.

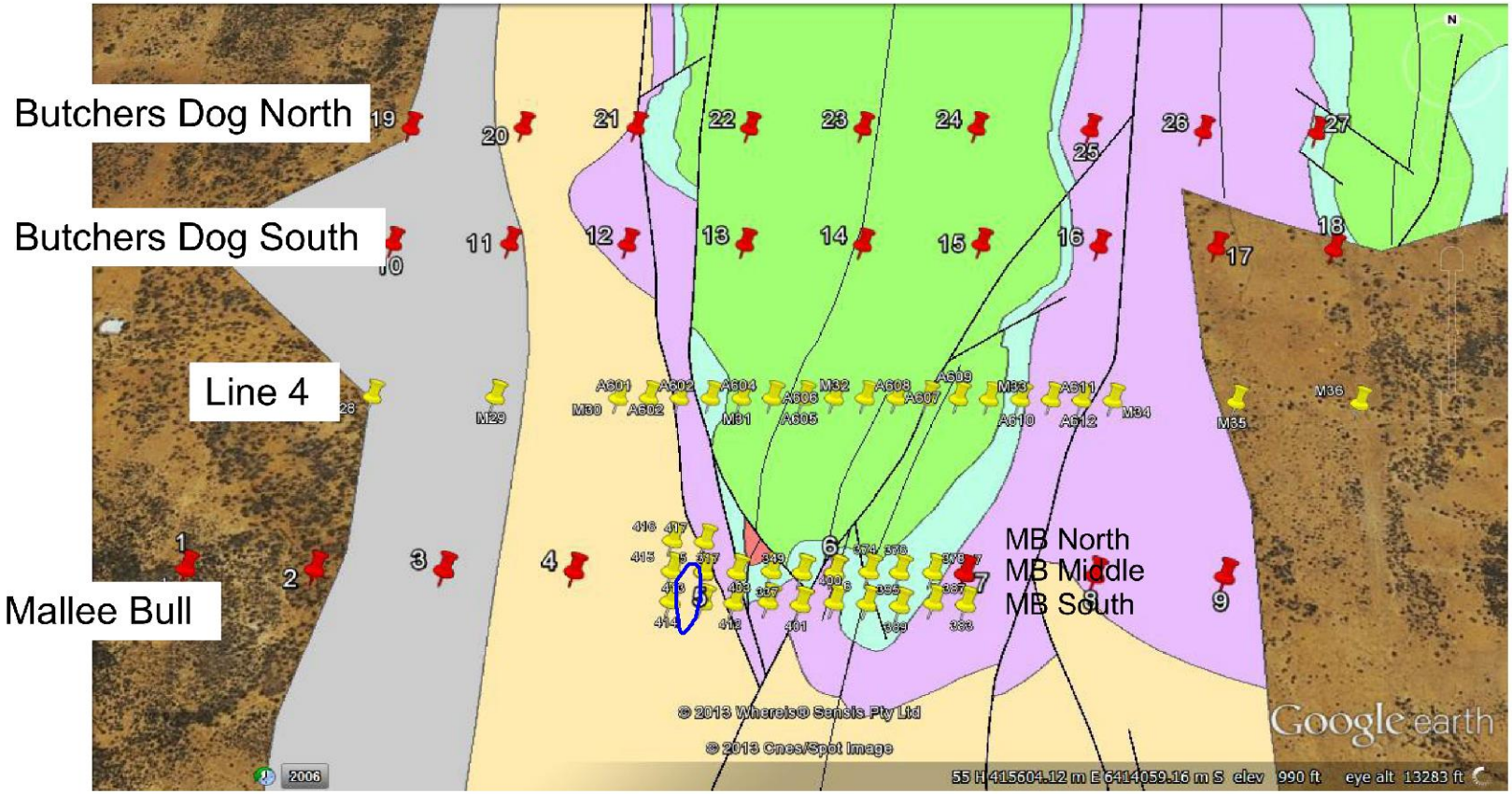


Mallee Bull / Butcher's Dog 3D Magnetic model

A deep drill hole based on the magnetic models intersected disseminated pyrrhotite at the Butcher's Dog prospect.

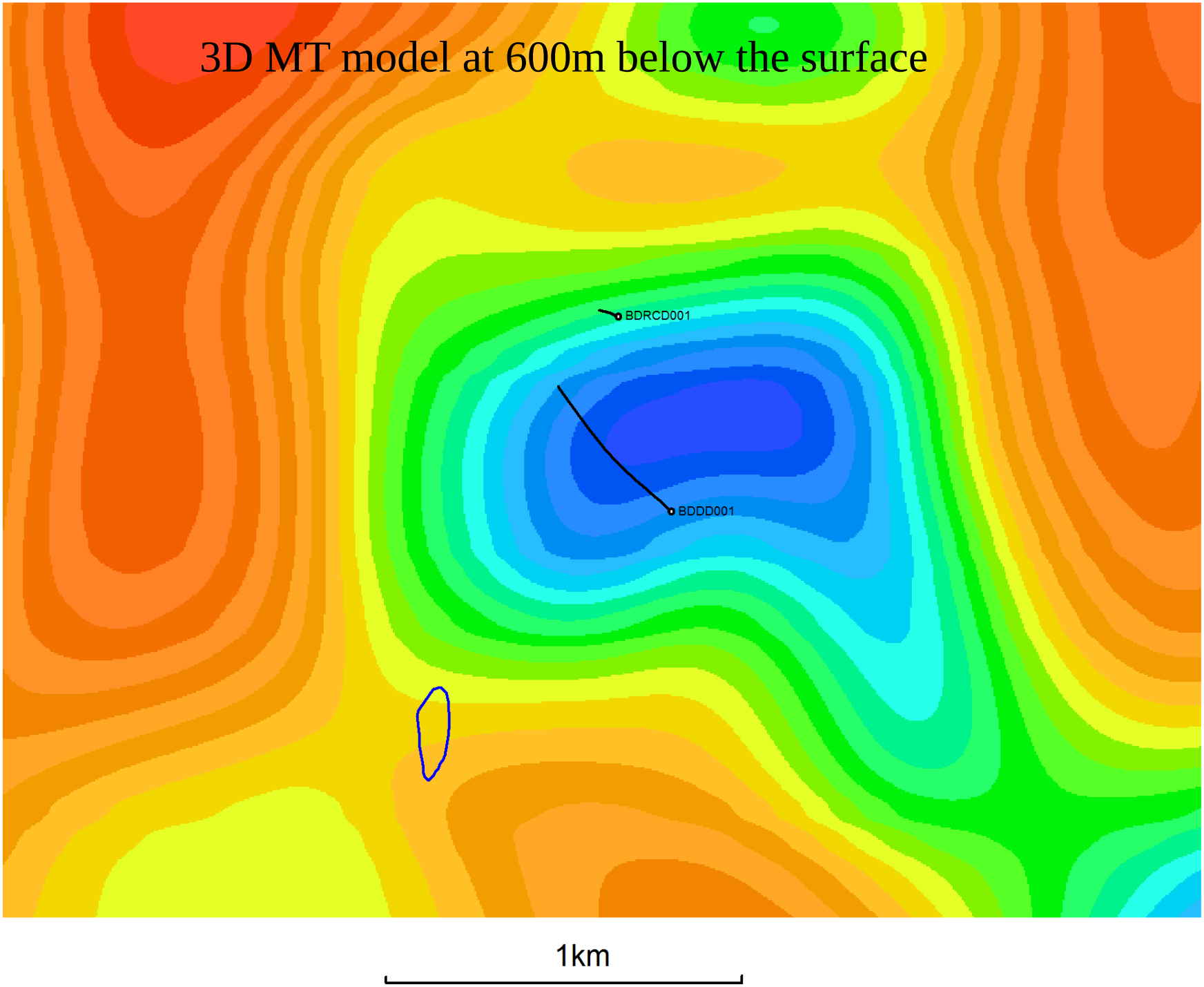
Due to the great depth of the magnetic source (approximately 1km), further investigation was undertaken with a so-called “deep penetration” technique standard and audio frequency magnetotellurics MT and AMT

Survey Lines on Geology



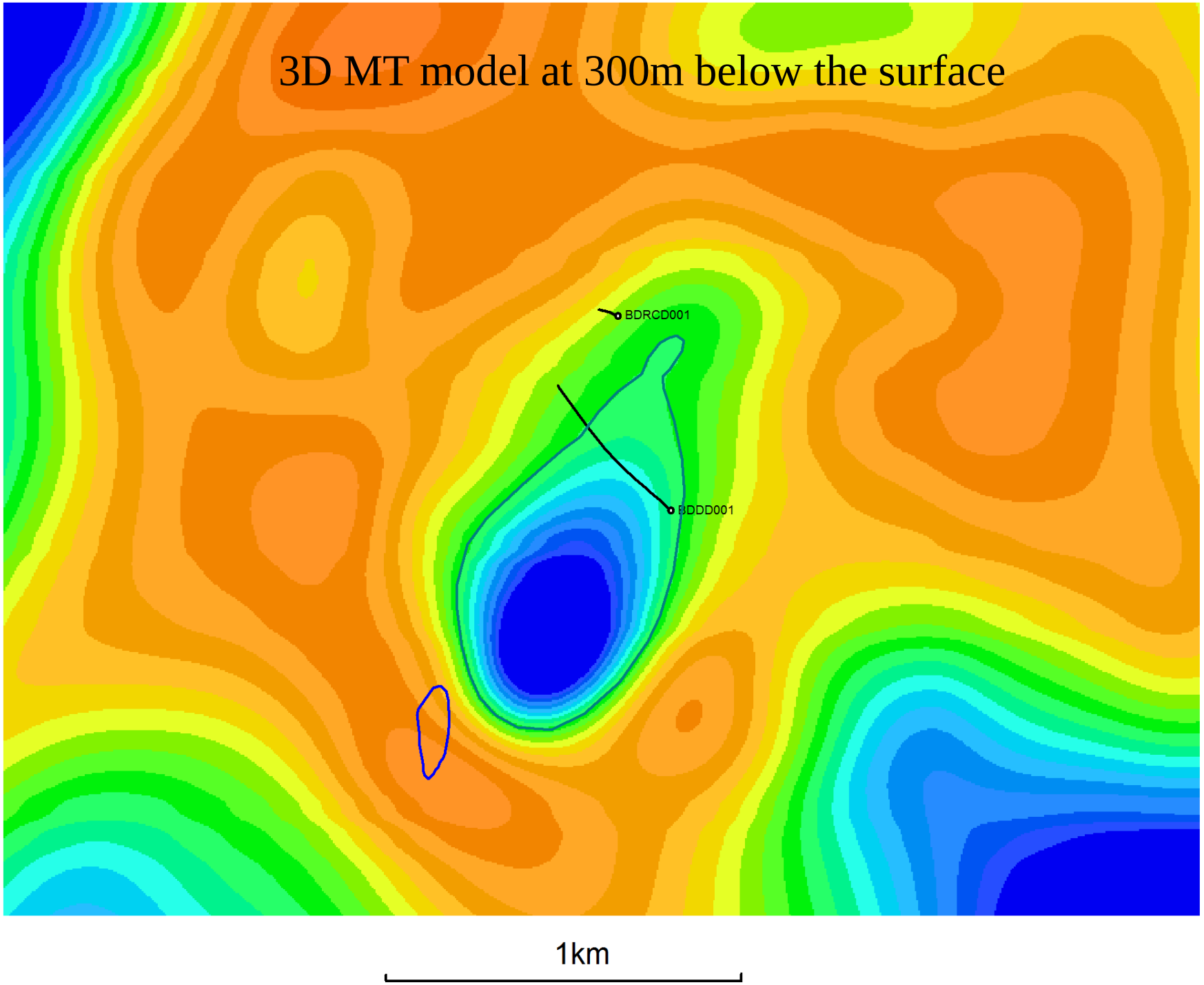
A 3D inversion model of the combined MT and AMT data was generated.

This model indicated that a deep conductor was coincident with the interpreted deep magnetic source.


3D MT model at 600m below the surface
BDRCD001
BDDD001
1km

Examination of the 3D MT model closer to the surface shows that the MT conductor continues up-plunge almost to the surface

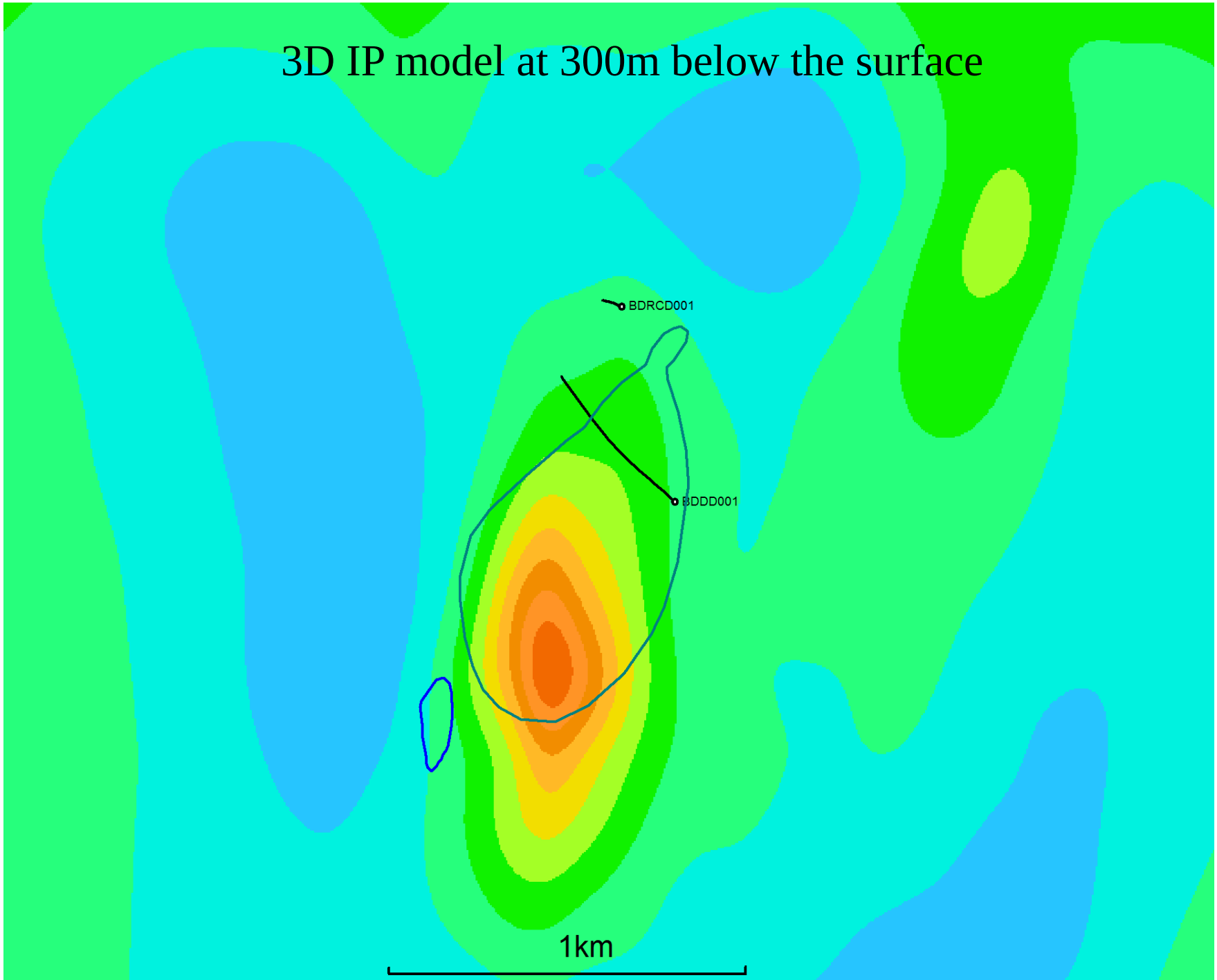
However, the MT / AMT surveys did not detect the ore deposit. This is similar to MT results for Tritton.
This technique is inappropriate for small highly conducting targets.


3D MT model at 300m below the surface
BDRCD001
BDDD001
1km

Comparison of the 3D MT model with the 3D IP model shows that the MT conductor is directly coincident with footwall IP source.

This response in IP and MT is assumed to be a pyrrhotitic feeder zone for the mineralisation at Mallee Bull.

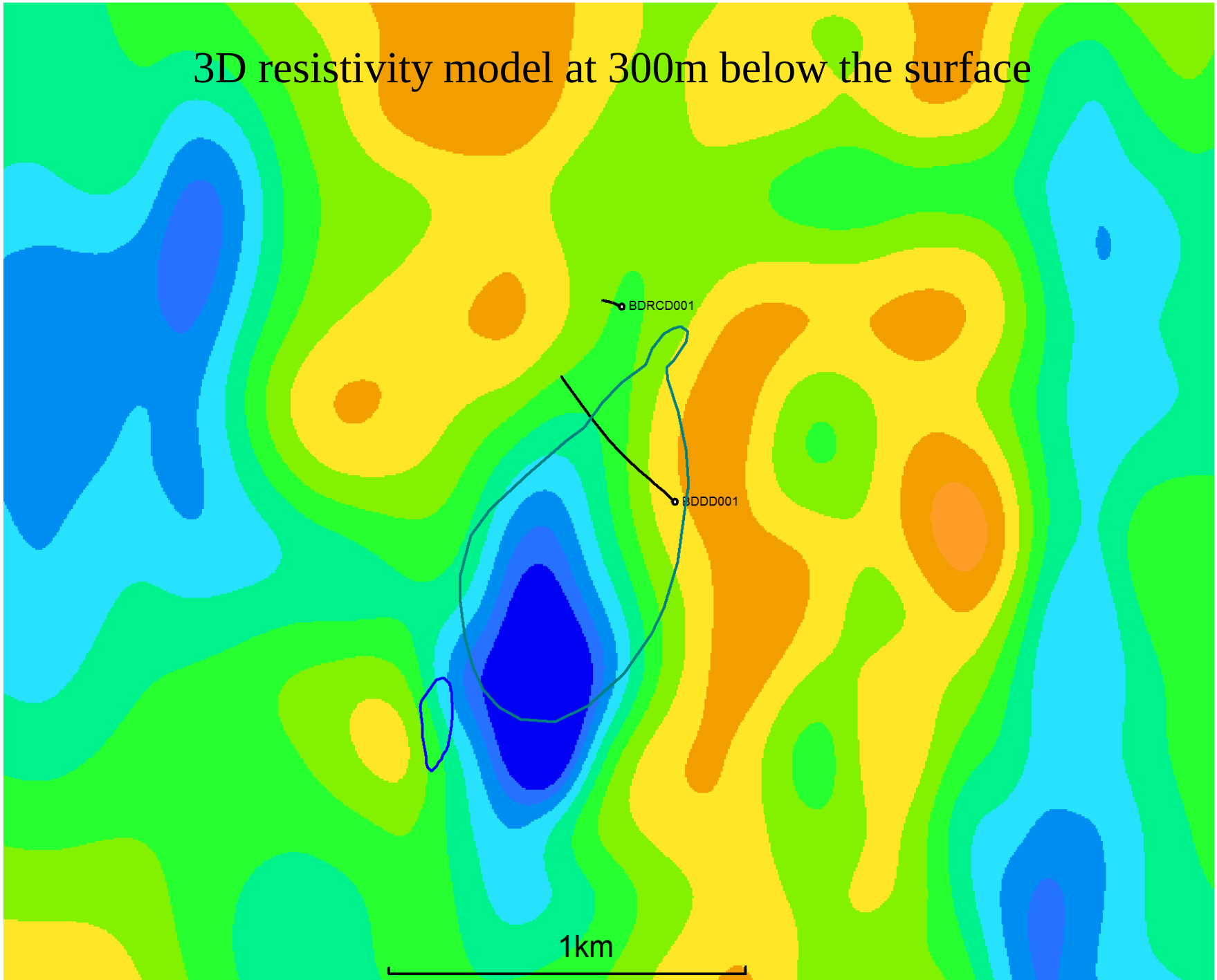
3D IP model at 300m below the surface



This zone is visible as a distinct resistivity low in the 3D IP / resistivity inversion model.

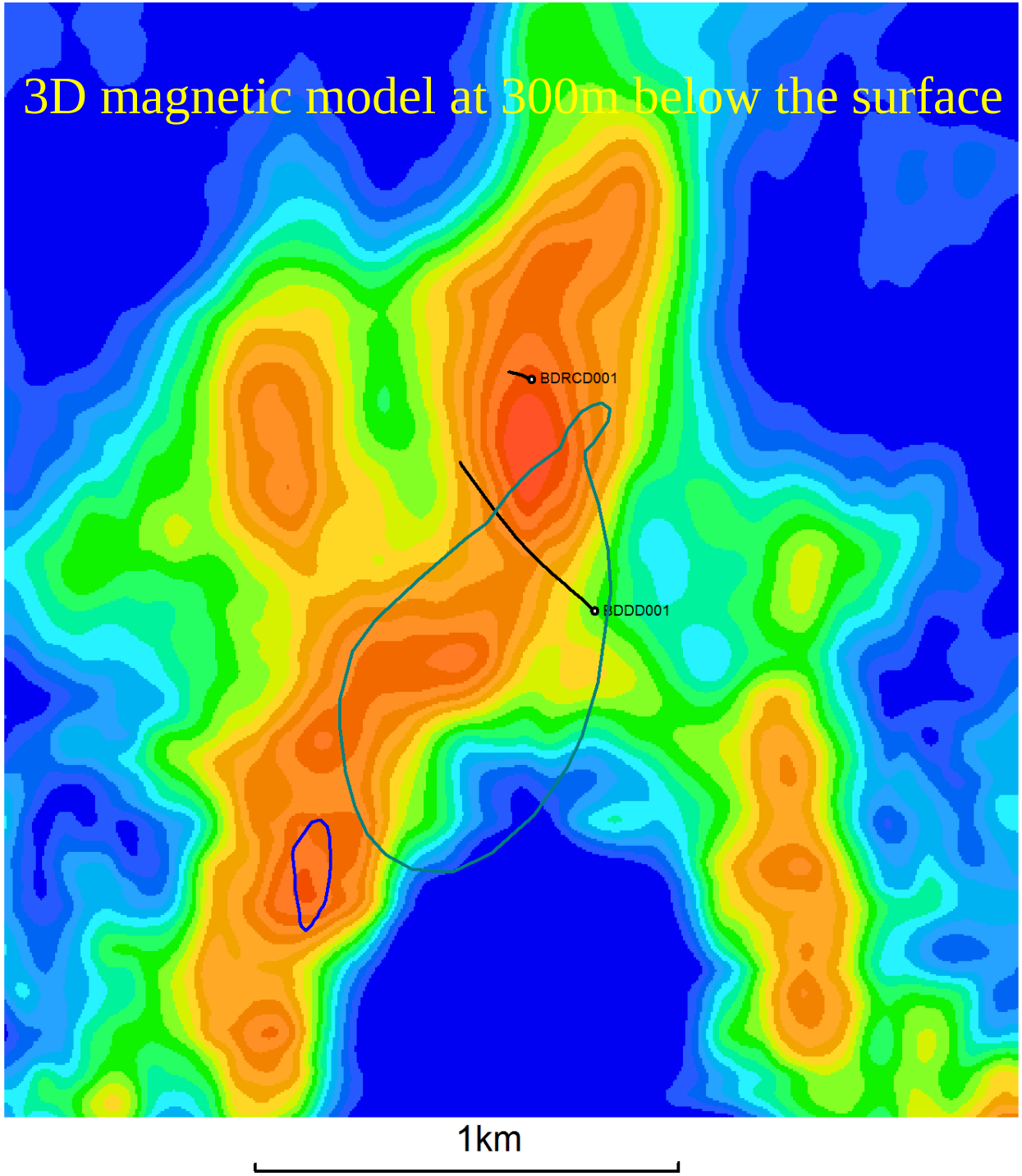
The resistivity low / IP high /MT conductor can be traced to greater depths in the IP model than it can in the MT model.

3D resistivity model at 300m below the surface



The IP / resistivity / MT source is semi-coincident with the magnetic trend in the 3D magnetic model.

The likely source of these effects is a large, north plunging zone of disseminated pyrrhotite.

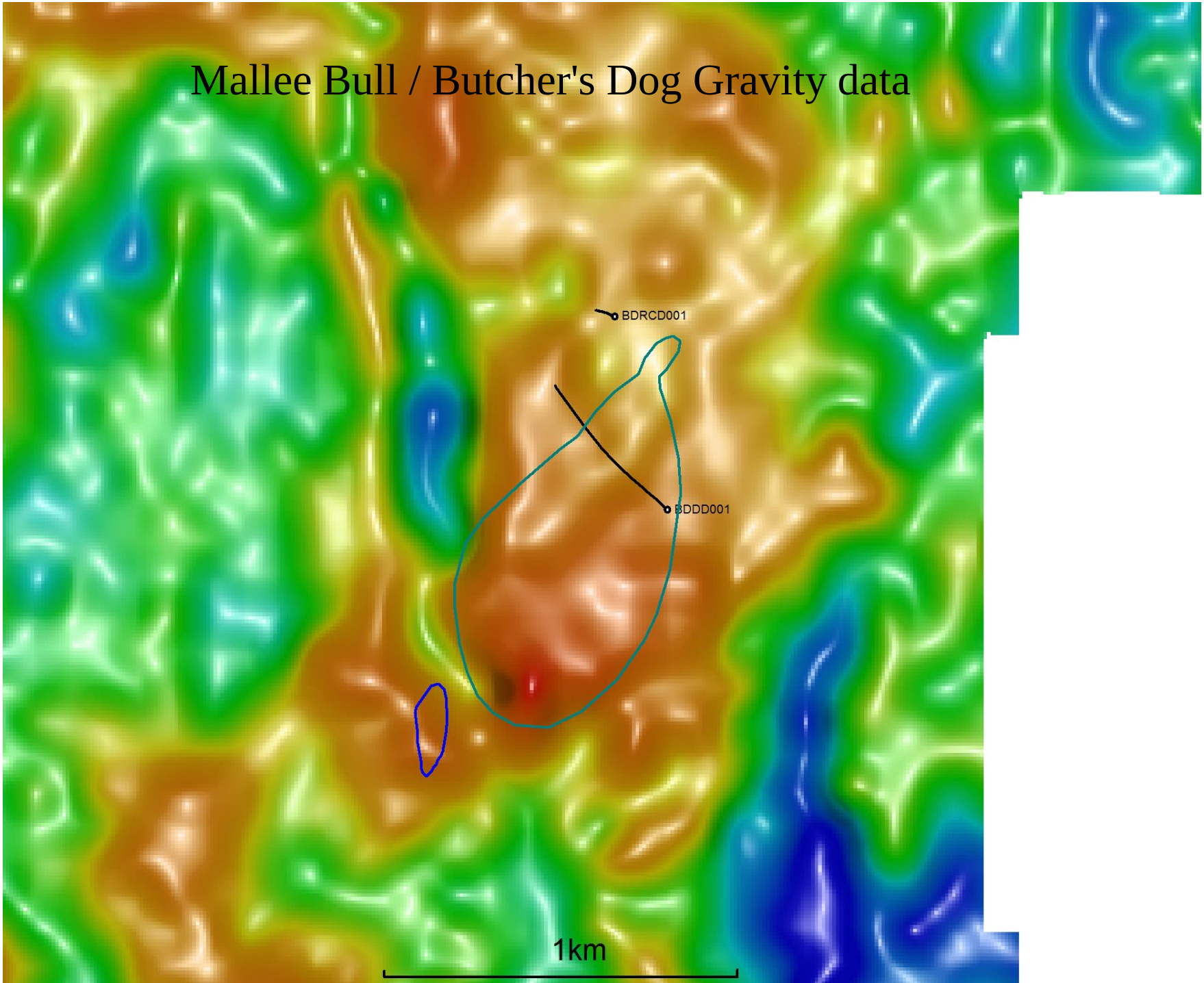

3D magnetic model at 300m below the surface
BDRCD001
BDDD001
1km

Gravity data shows a high directly coincident with the anomalies

This is assumed to be due to sulphide alteration and silicification.

Like other deposits in the Cobar region, the gravity high is associated with the ore body but not directly coincident.

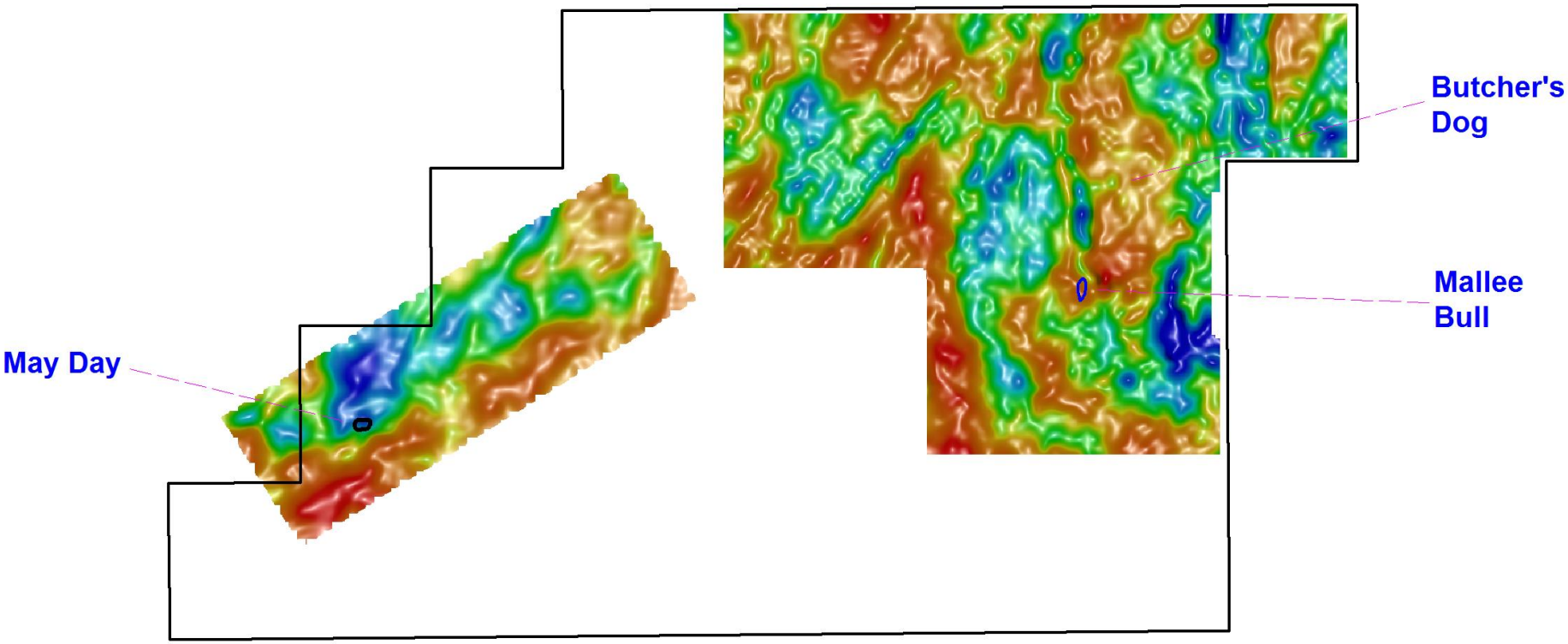
Mallee Bull / Butcher's Dog Gravity data



In a more regional context, the gravity high cannot be considered a true "anomaly".

However, similar gravity highs are worth further investigation.

May Day - Mallee Bull Gravity Data



”When you see a real ore deposit in your geophysical data – you will know it.”

True?

Based on the data from Girilambone and Gilgunnia, the right sort of EM survey will produce an "obvious" response over an ore deposit. Not so for other methods.

However, for deeper deposits this may not be true.

Personally I hope that one day a really subtle geophysical response will turn out to be an ore deposit. I am still waiting....