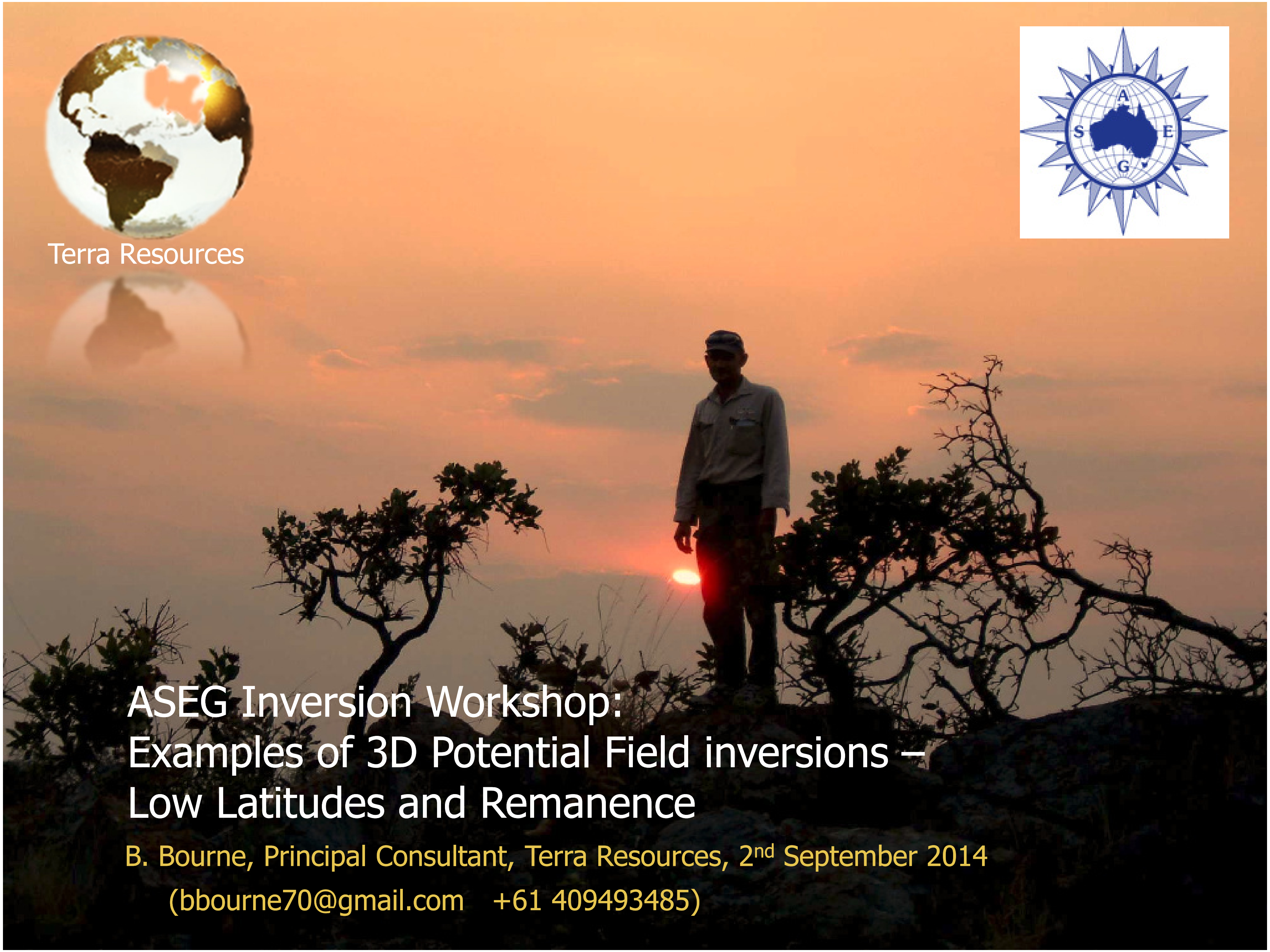
Terra Resources



ASEG Inversion Workshop: Examples of 3D Potential Field inversions – Low Latitudes and Remanence

B. Bourne, Principal Consultant, Terra Resources, 2nd September 2014

(bbourne70@gmail.com +61 409493485)

Introduction

- Remanence (and Porphyries)
- Alumbre Porphyry Project, Peru
- Geosoft MVI / IRI Inversion
- Regional Mafic Belt, Australia
- Conclusion

Magnetic Remanence - Causes

Terra Resources

- **Mineralogy/Lithology**
  - Fine grained magnetite (<20μm) eg rapidly chilled basalt, oxidised mafic intrusions (titanomagnetite)
  - Monoclinic pyrrhotite
- **Alteration**
  - Skarn
  - Hornfelsing
  - Or any processes resulting in above
- **Magnetisation History**
  - Systems that develop during long periods of consistent geomagnetic polarity much more likely to exhibit remanence-influenced signatures
  - Cretaceous Normal Superchron ~118 Ma to 83 Ma
  - Permo-Carboniferous (Kiaman) Reverse Superchron ~315 Ma to 260 Ma

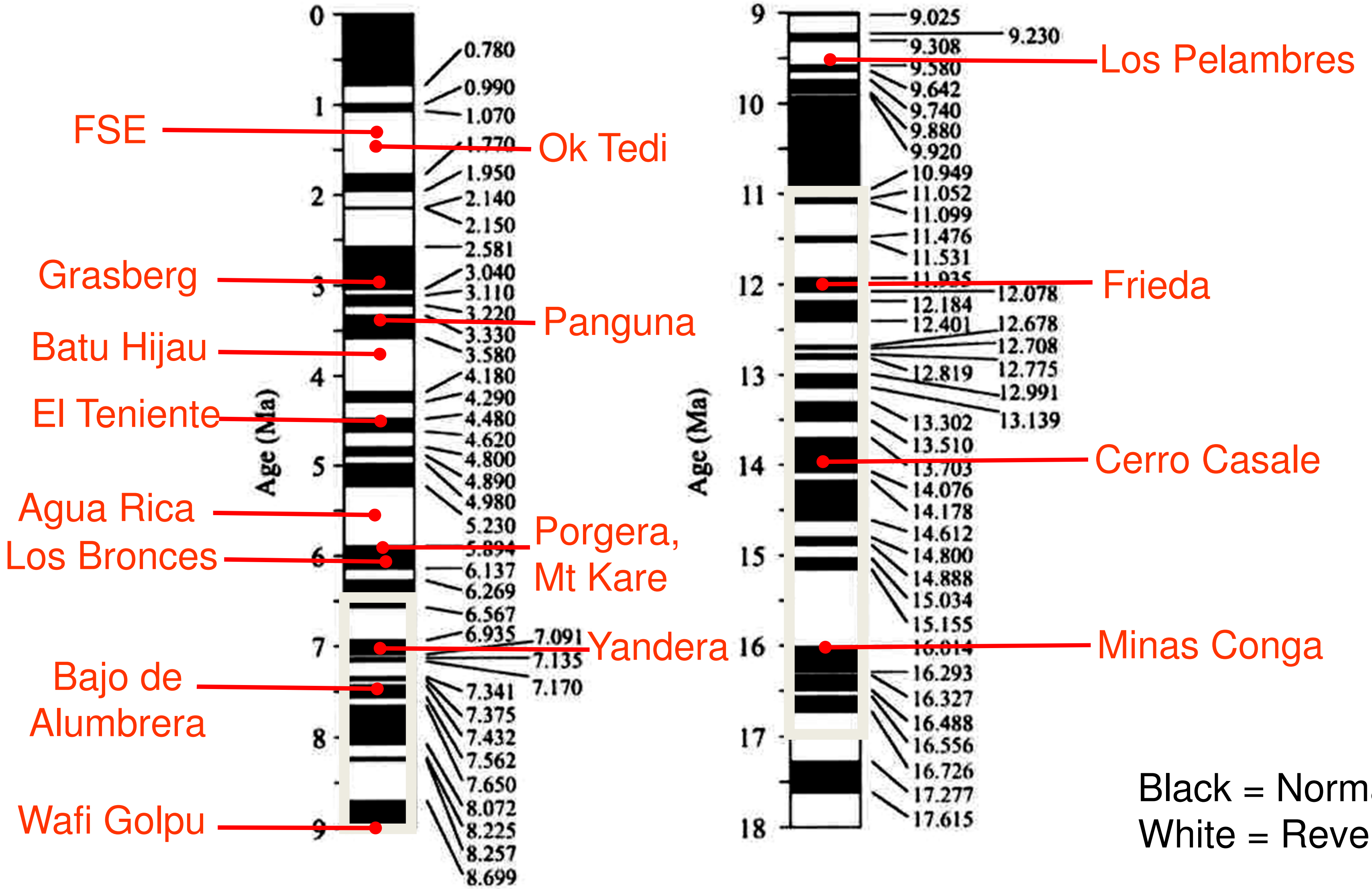
Implications for Porphyry Exploration

Terra Resources

- Most porphyry system magnetite is coarse-grained, therefore remanence < induced
- During age of mineralisation, earth's field direction was changing and multiphase intrusions/thermal events would be overprinted after each event cancelling out any likely effects of remanence
- **No known world class porphyry deposit with dominant remanent effects**
- Only likely source of remanence features in younger terrains are oxidised mafic intrusions and skarns
- Co-magmatic mafic events likely with world class porphyry districts

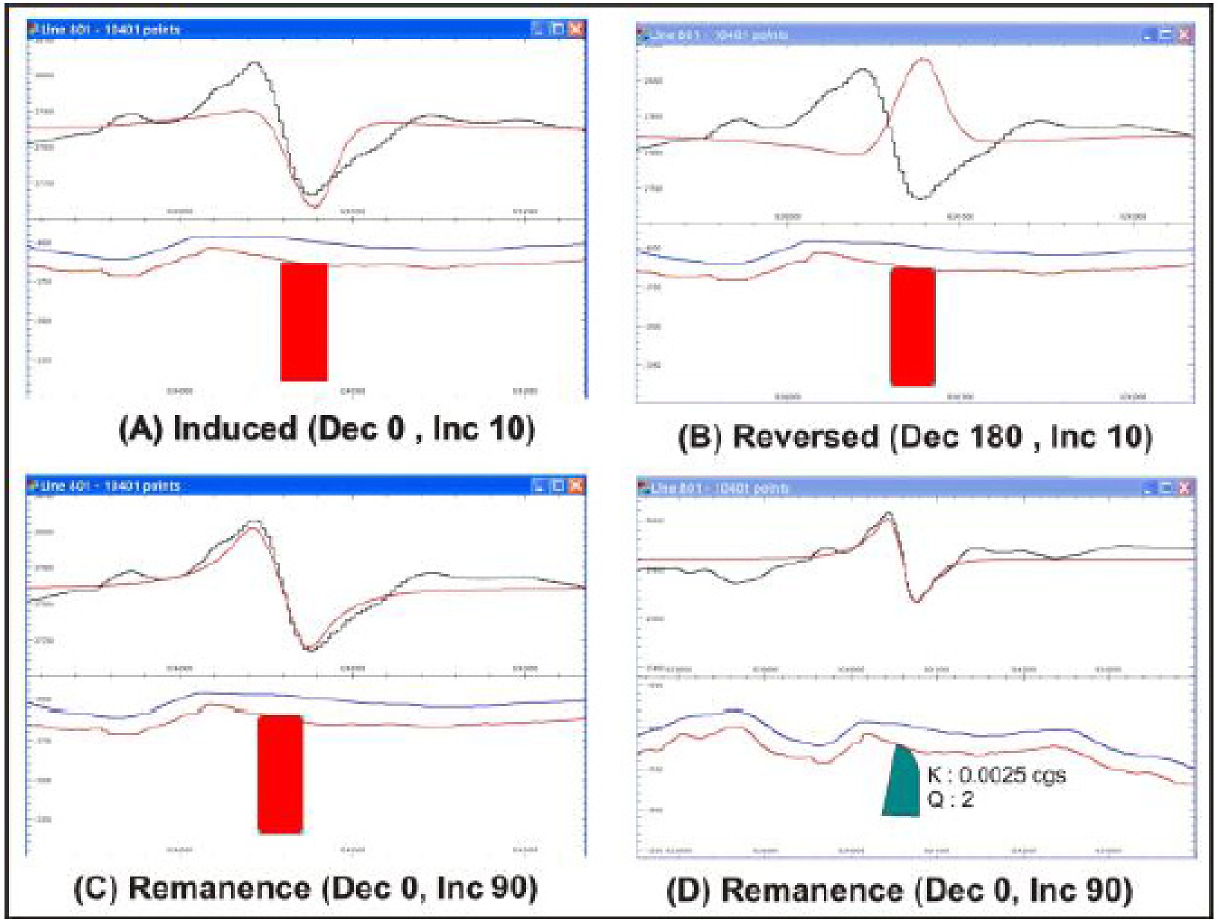
Implications for Porphyry Exploration

Terra Resources



Black = Normal
White = Reversed

Implications for Porphyry Exploration



After Hoschke (2013)

- Hosche (2013) showed that porphyry a prospect in South America has significant remanence
- A number of magnetic targets in the surrounding area are thought to have been missed because remanence was not considered
- After trialling new modelling inversion methods (such as MVI) better fits with geology/ susceptibility were being obtained when drilling for porphyries especially at low latitudes

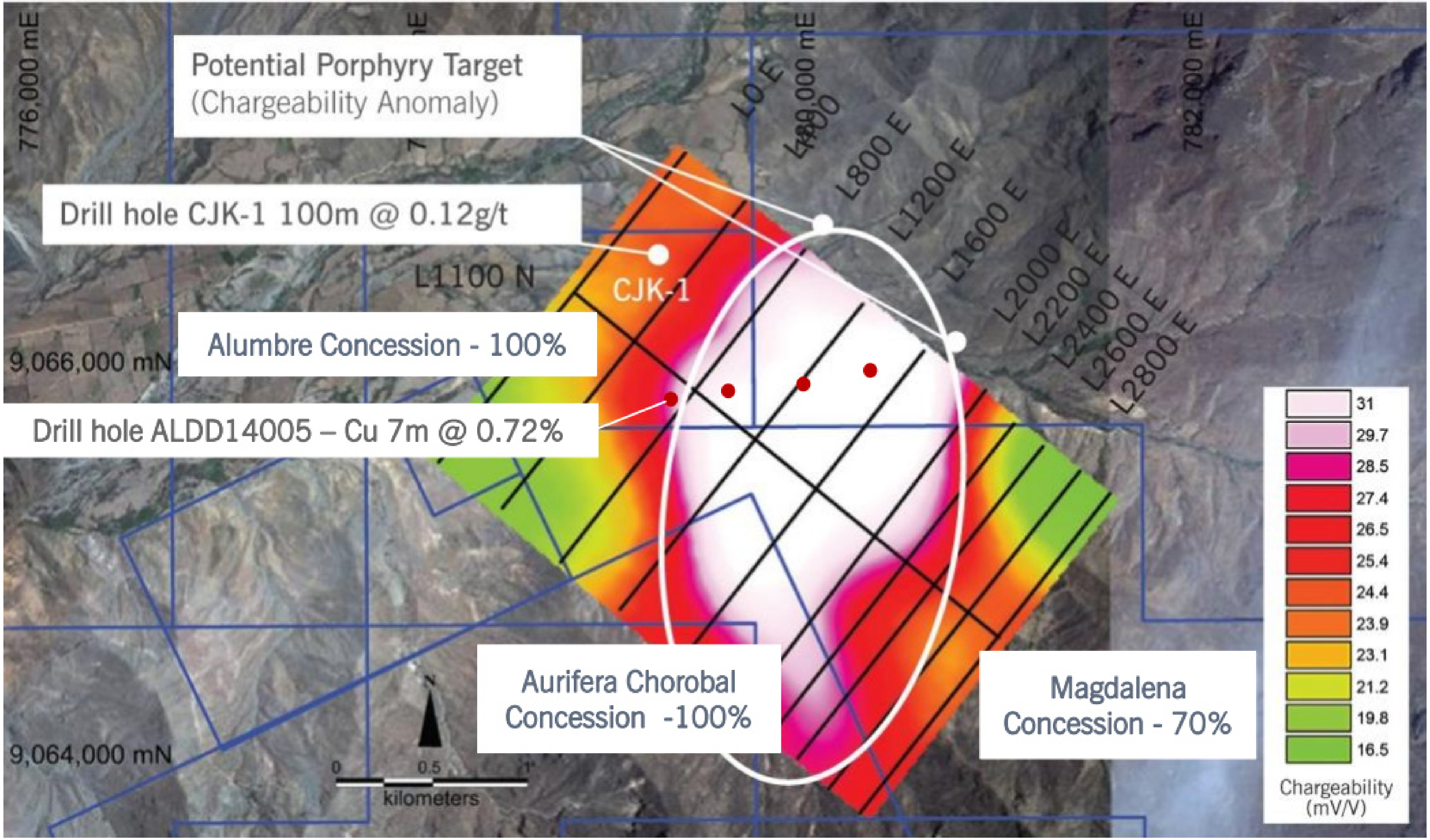
Alumbre Project – Peru Deposits

Terra Resources

PROMESA

Alumbre Project – Induced Polarisation

Terra Resources

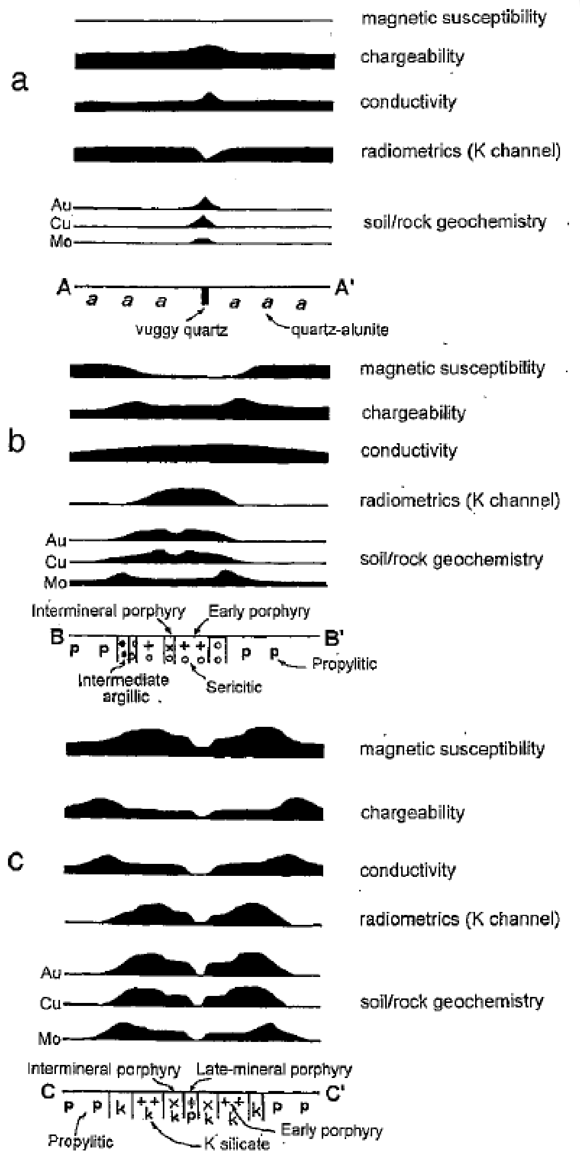


Geophysics Chargeability Results at 400m depth

PROMESA

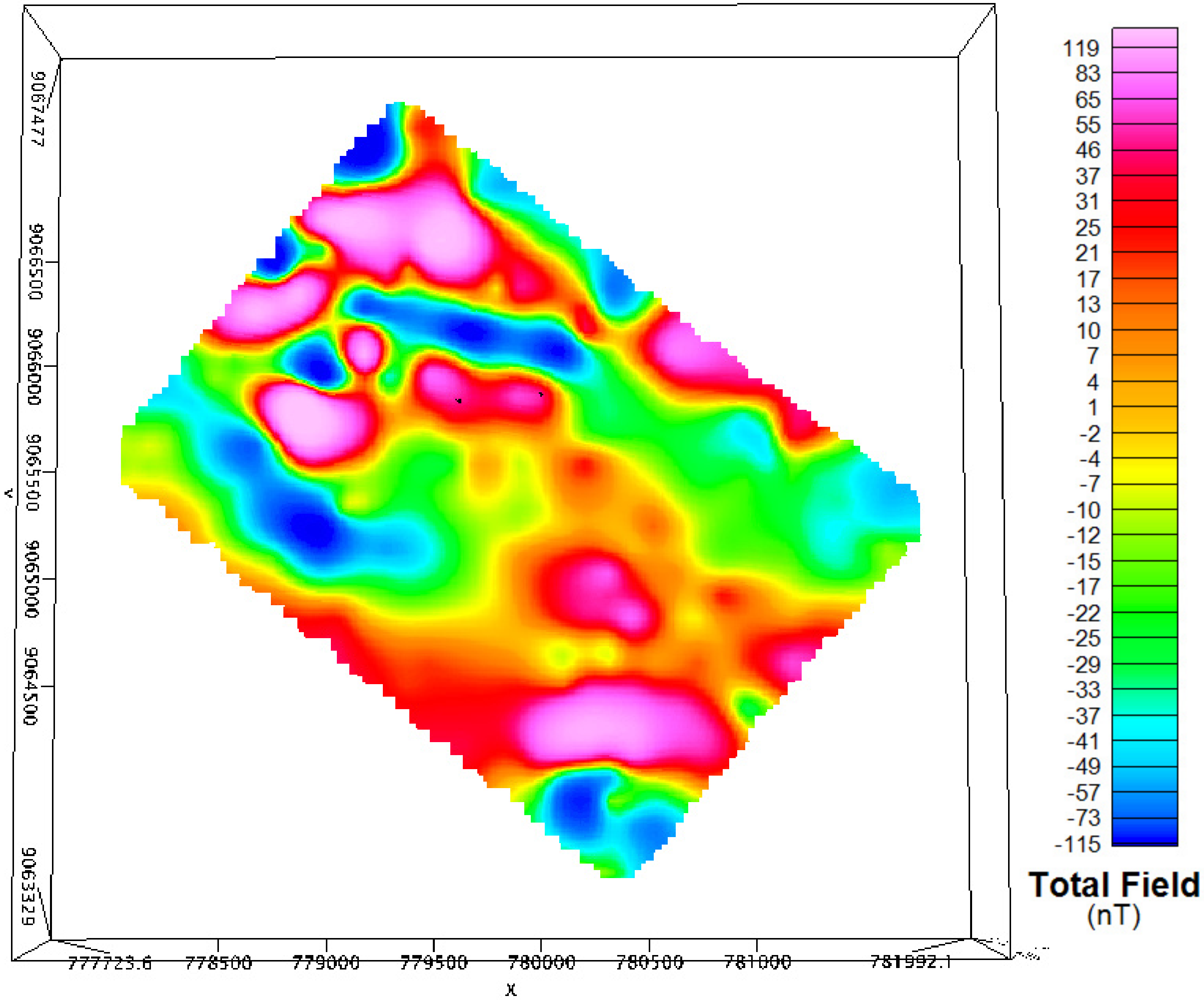
Au Rich Porphyry Geophysics

Terra Resources

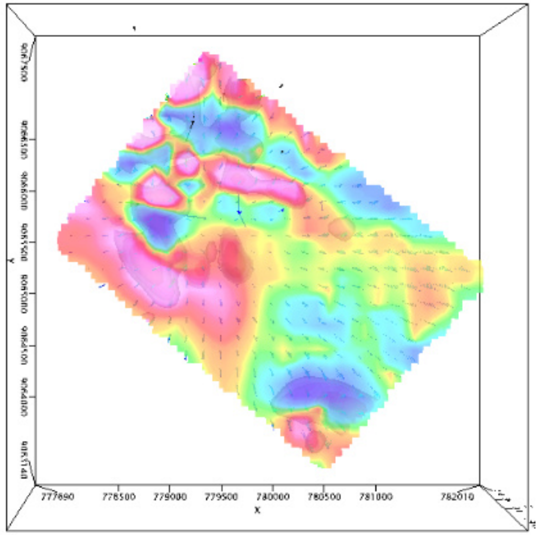


After Silitoe (2000)

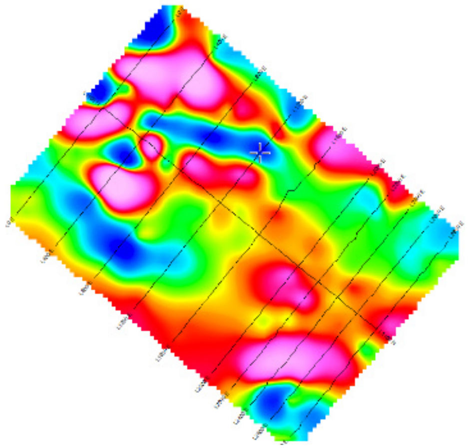
Alumbre Project - Ground Magnetics



Residual Magnetics – Total field data used for magnetic inversion from ground data



Residual Magnetics – RTP (amplitude correction 70 applied)



Residual Magnetics – TF (400m line spacing in NW and 200m in SE)

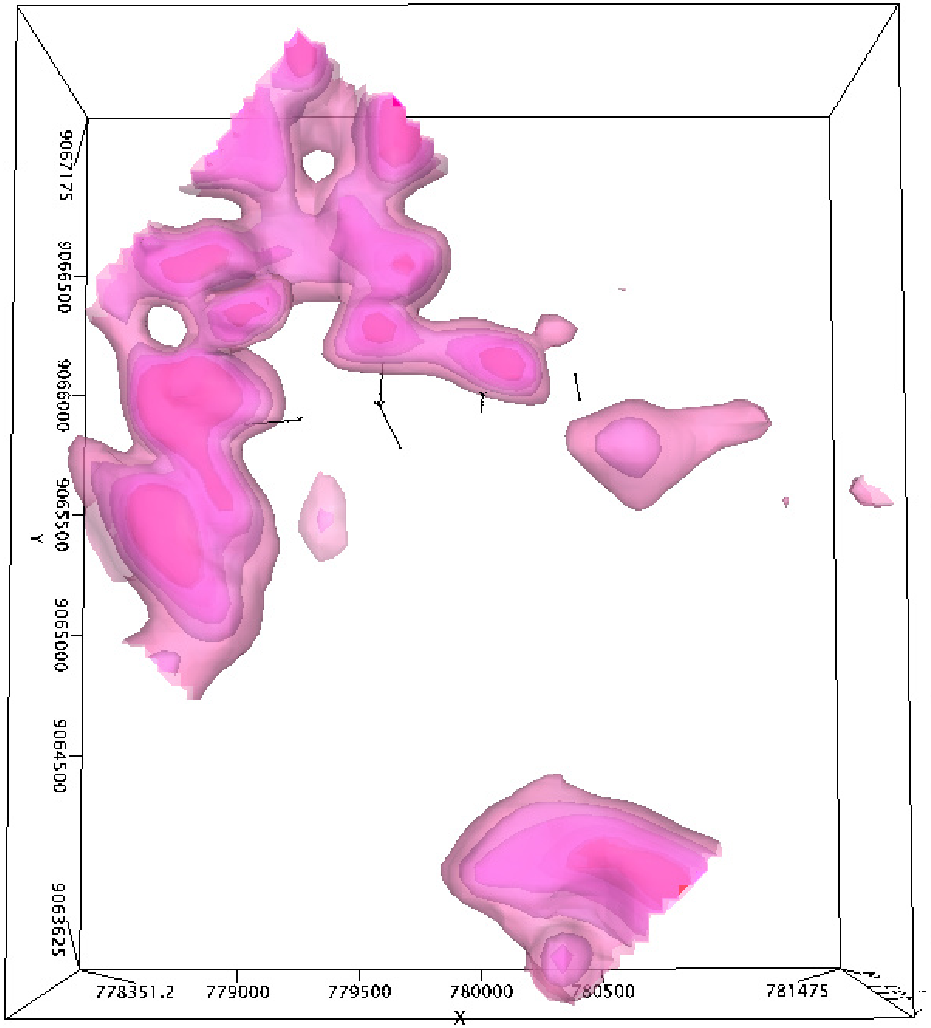
PROMESA

Magnetic Vector Inversion Modelling

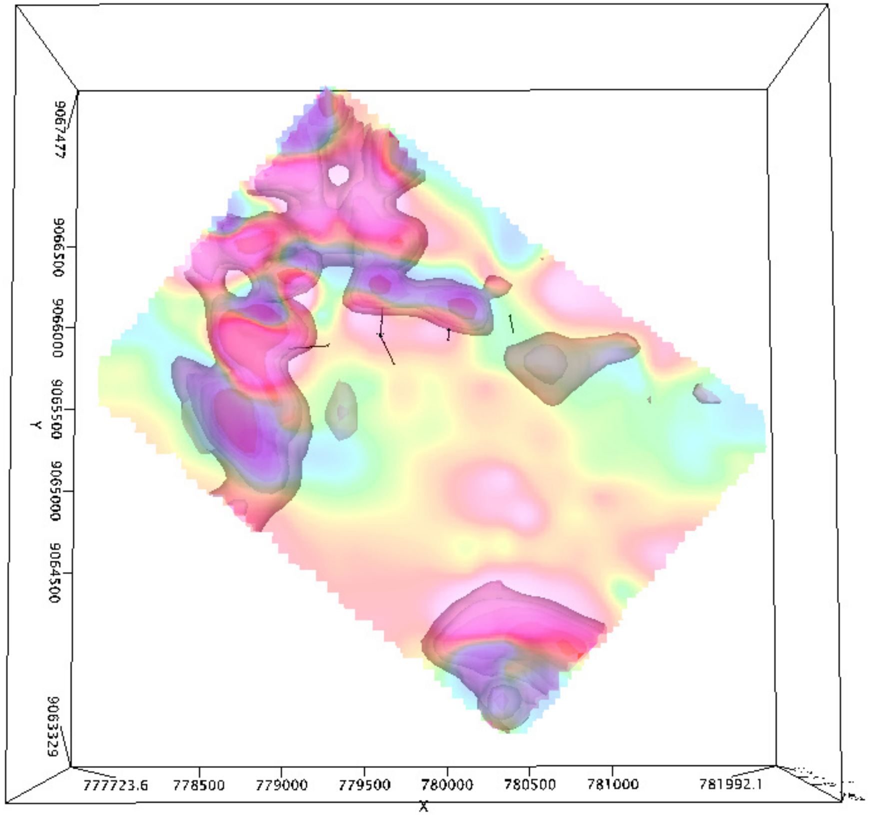
- Detailed magnetic modelling using Magnetic Vector Inversion (Ellis, 2012)
- MVI directly models the vector of magnetization based only on anomalous TMI data
- The method allows the modelling optimization process the freedom to orient the direction of magnetization to best fit the observed data
- Allows the interpreter to model features that may contain combination of remanent magnetization, demagnetization or anisotropic magnetic minerals
- MVI allows modelling of the different orientation of the magnetic field caused by porphyry intrusion at Alumbre
- Typical MVI modelling using 50 x 50 x 25m voxel, on 200m/400m ground magnetic data (single tie line)

Alumbre Project – Magnetic Vector Inversion

Terra Resources



Magnetics (pink) – Isosurfaces of susceptibility, +10 x 10-3 SI* in pink.

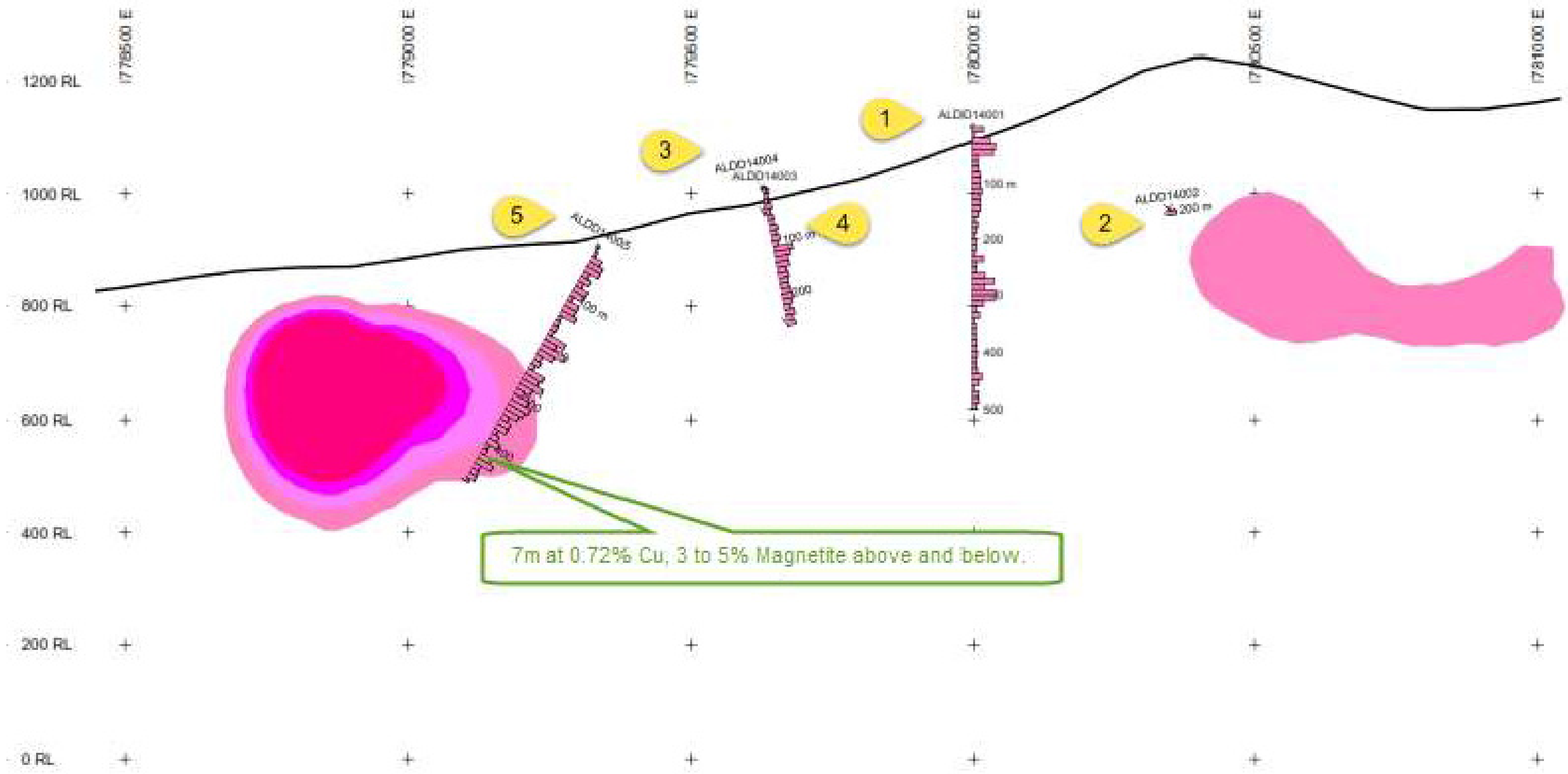


Total field magnetics with +10x10-3 SI* isosurface from the 3D MVI inversion in grey underneath.

Alumbre Project – Susceptibility Sections

Terra Resources

Section 9065750N

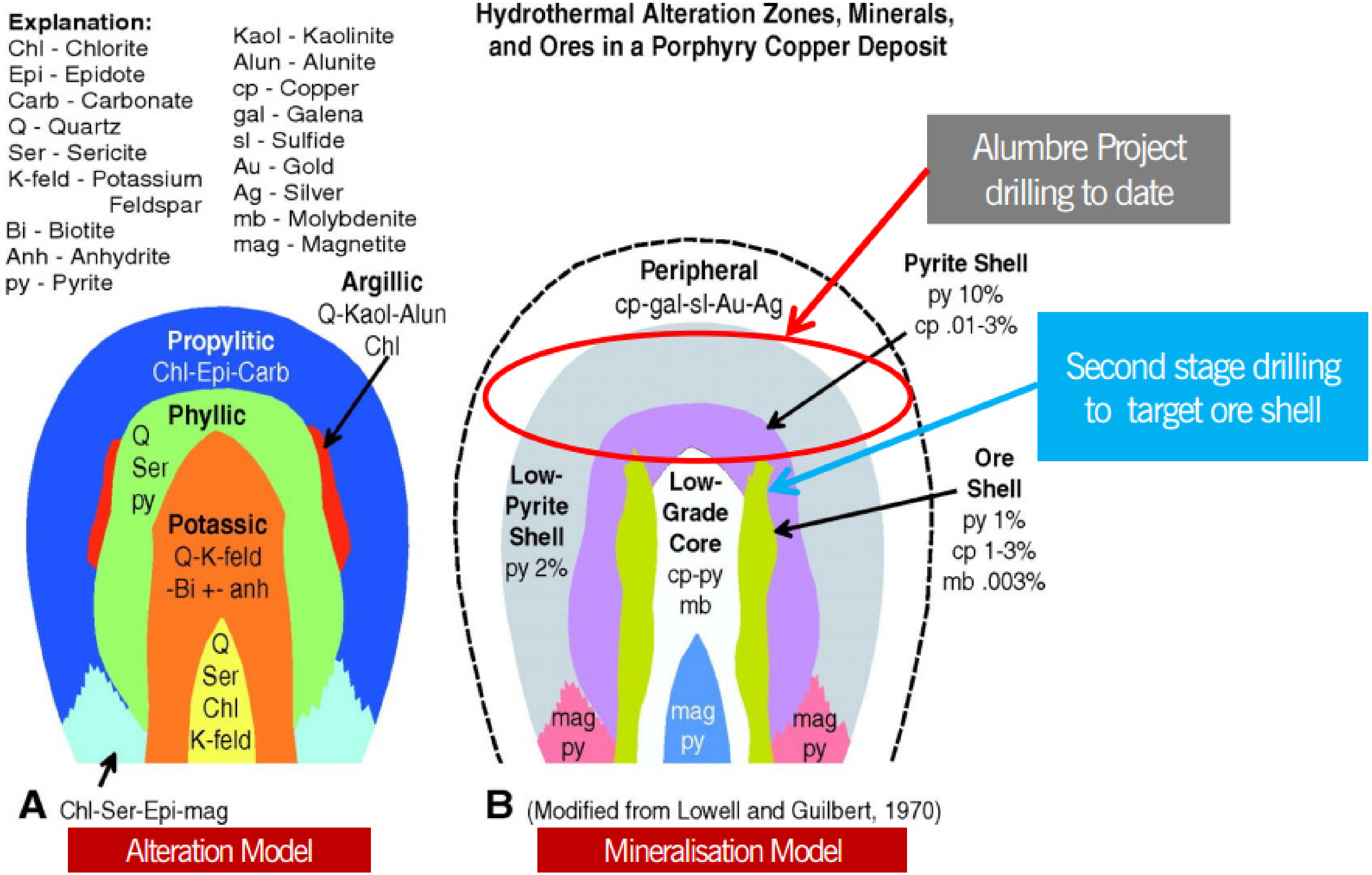


Magnetics (pink) – Isosurfaces of susceptibility, +10 x 10-3 SI* in pink. Centre +15 x 10-3 SI* in red, equivalent to +0.5% magnetite.

PROMESA

Alumbre Project - Geological Model

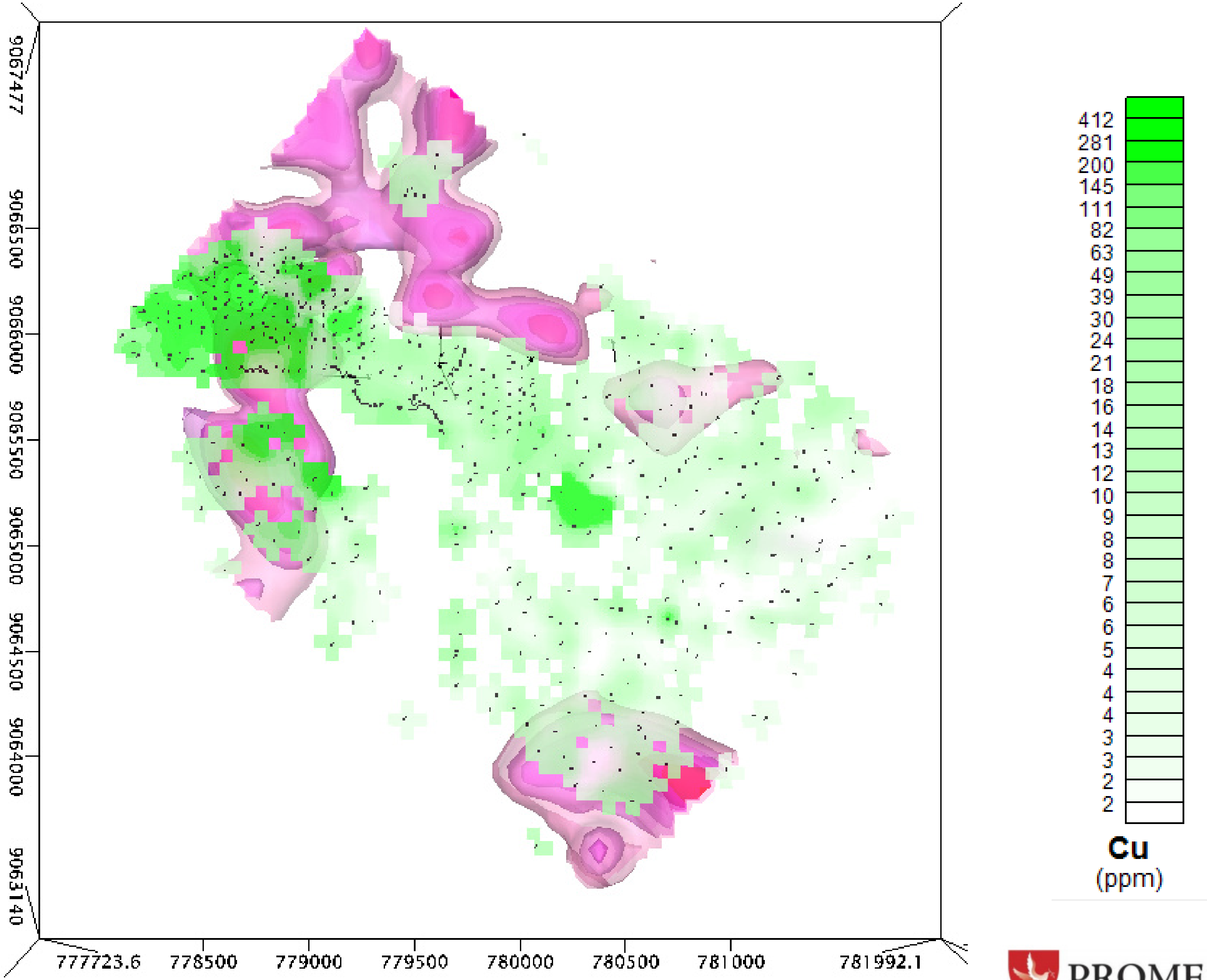
Terra Resources



Section View - Illustrated deposit model of a porphyry copper deposit (modified* from Lowell and Guilbert, 1970).** * Geosphere May 2006 vol. 2 no. 3 161-186 **Lowell, J.D., and Guilbert, J.M., 1970, Lateral and vertical alteration-mineralization zoning in porphyry ore deposits: Economic Geology, v. 65, p. 373–408

Alumbre Project - Modelling / Copper

Terra Resources

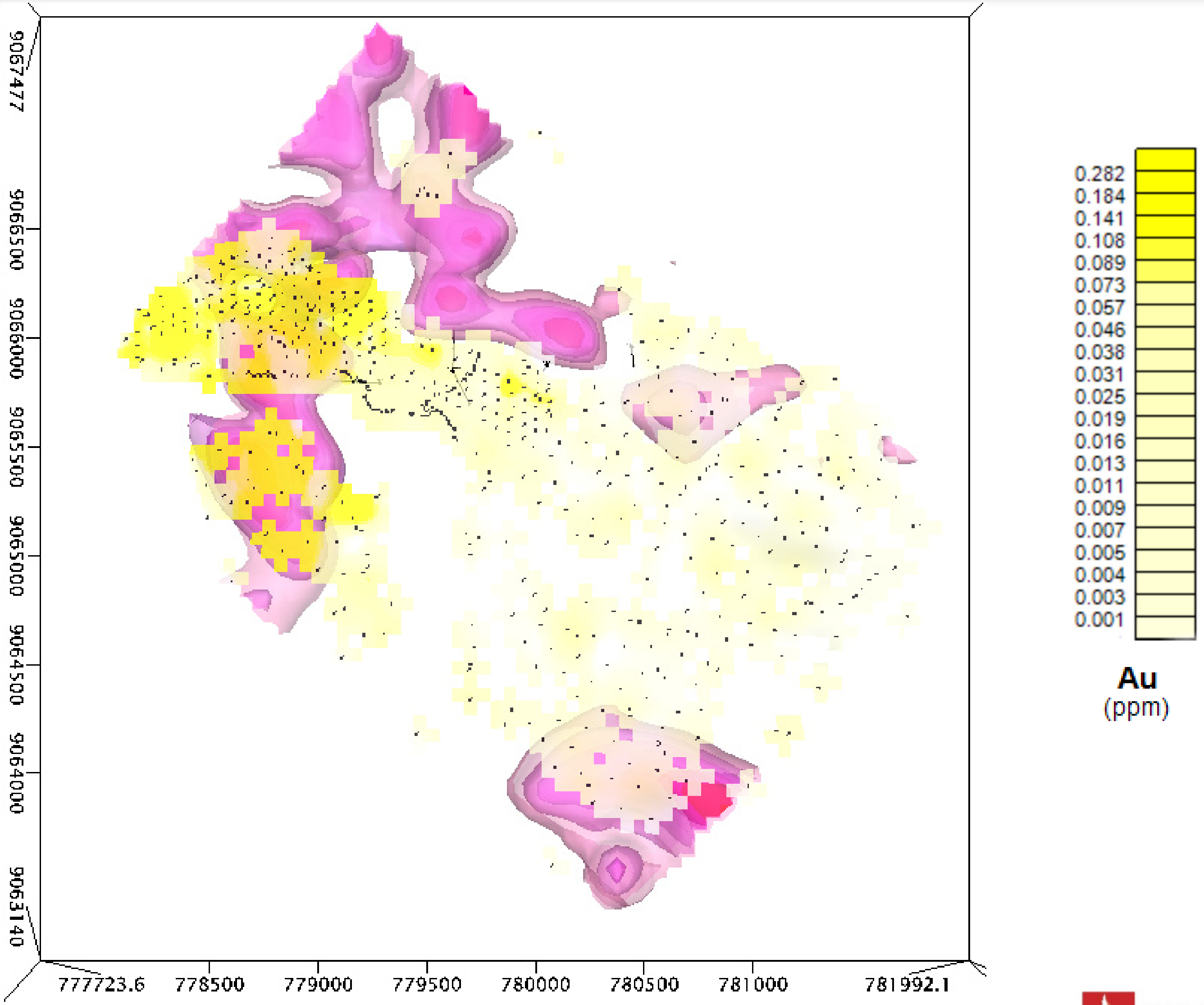


Magnetics (pink) – Isosurfaces of susceptibility, +10 x 10-3 SI* in pink. Centre +15 x 10-3 SI* in red, equivalent to +0.5% magnetite.

PROMESA

Alumbre Project - Modelling / Gold

Terra Resources

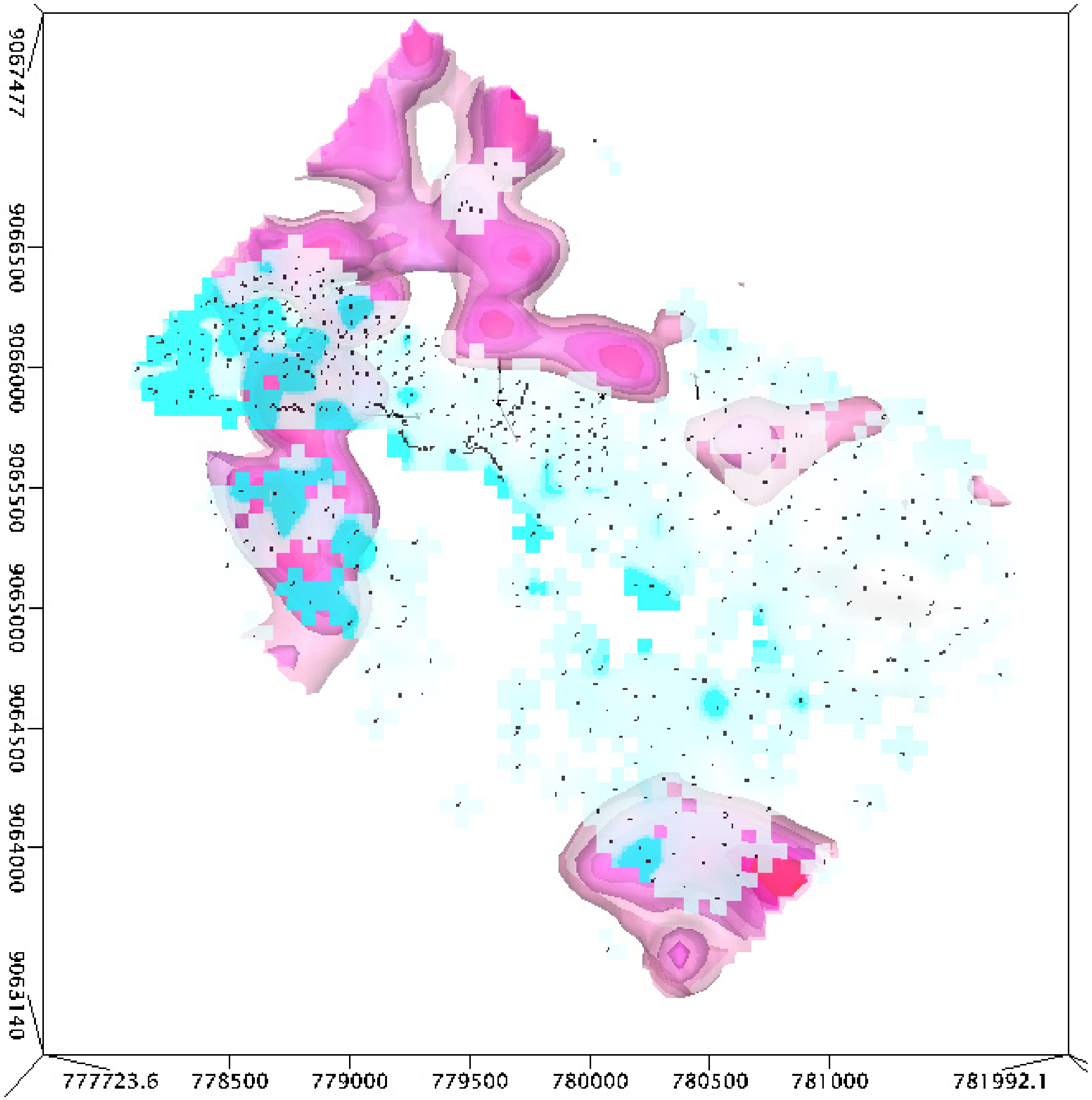


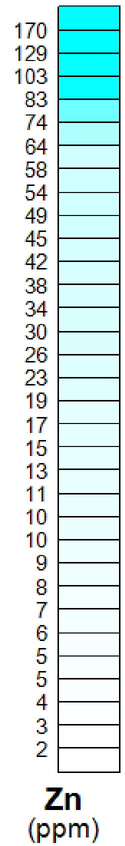
Magnetics (pink) – Isosurfaces of susceptibility, +10 x 10-3 SI* in pink. Centre +15 x 10-3 SI* in red, equivalent to +0.5% magnetite.

PROMESA

Alumbre Project - Modelling / Zinc

Terra Resources



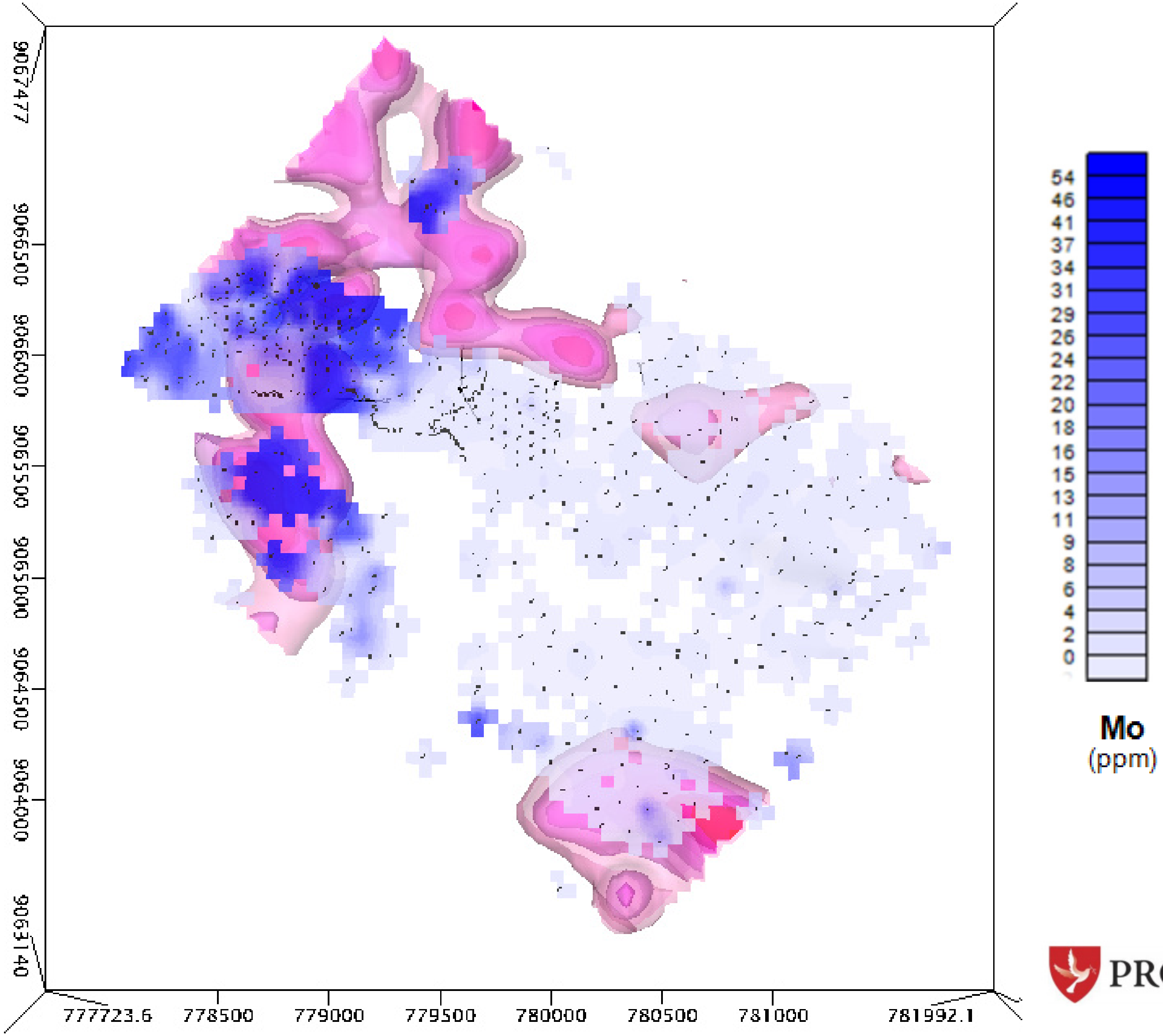


Magnetics (pink) – Isosurfaces of susceptibility, +10 x 10-3 SI* in pink. Centre +15 x 10-3 SI* in red, equivalent to +0.5% magnetite.

PROMESA

Alumbre Project - Modelling / Mo

Terra Resources

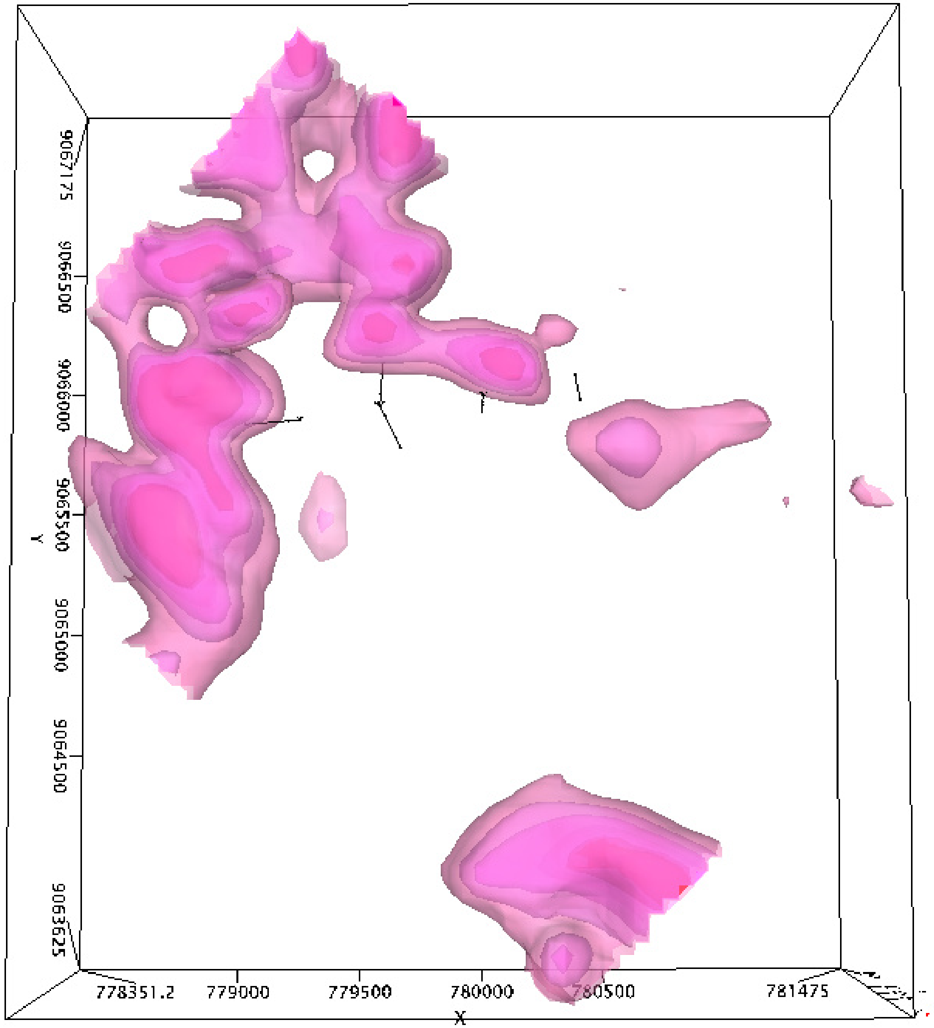


Magnetics (pink) – Isosurfaces of susceptibility, +10 x 10-3 SI* in pink. Centre +15 x 10-3 SI* in red, equivalent to +0.5% magnetite.

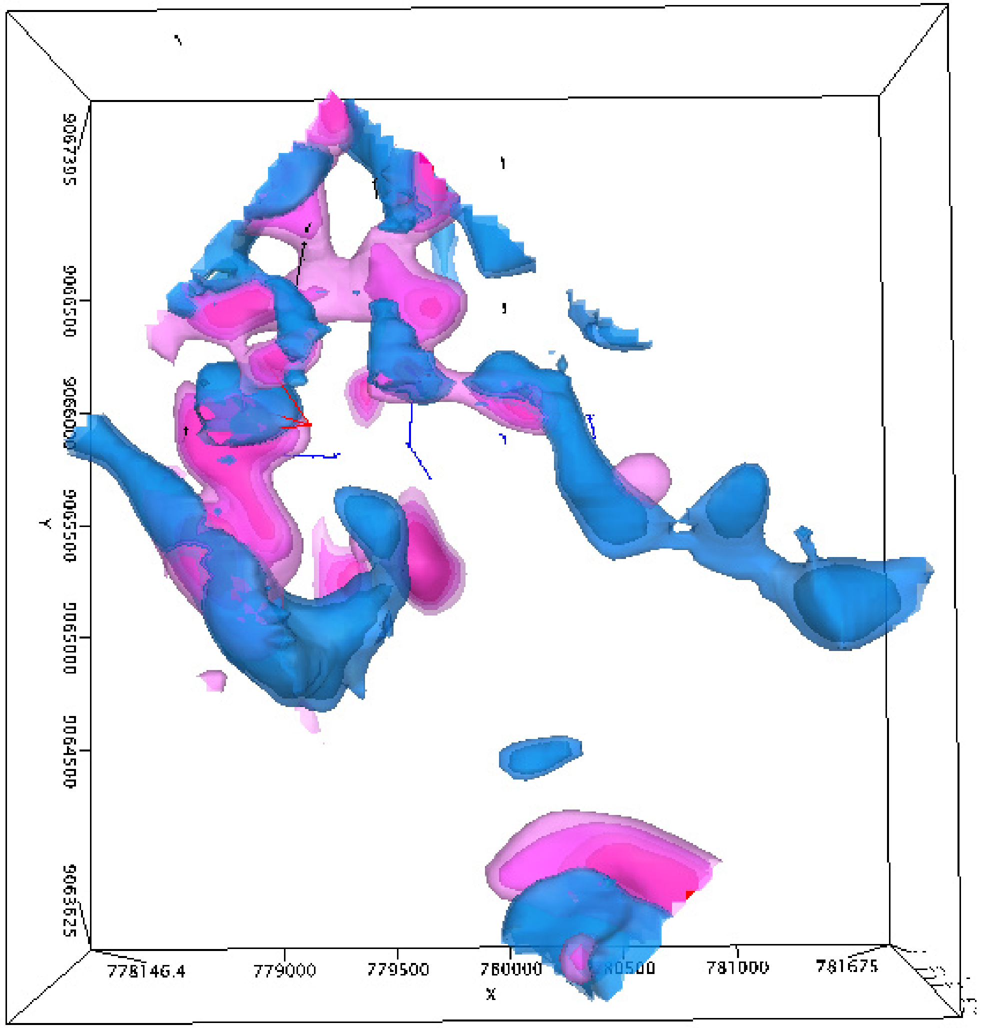
PROMESA

Alumbre Project - Magnetic Inversion

Terra Resources



Magnetics (pink) – Isosurfaces of susceptibility, +10 x 10-3 SI* in pink.

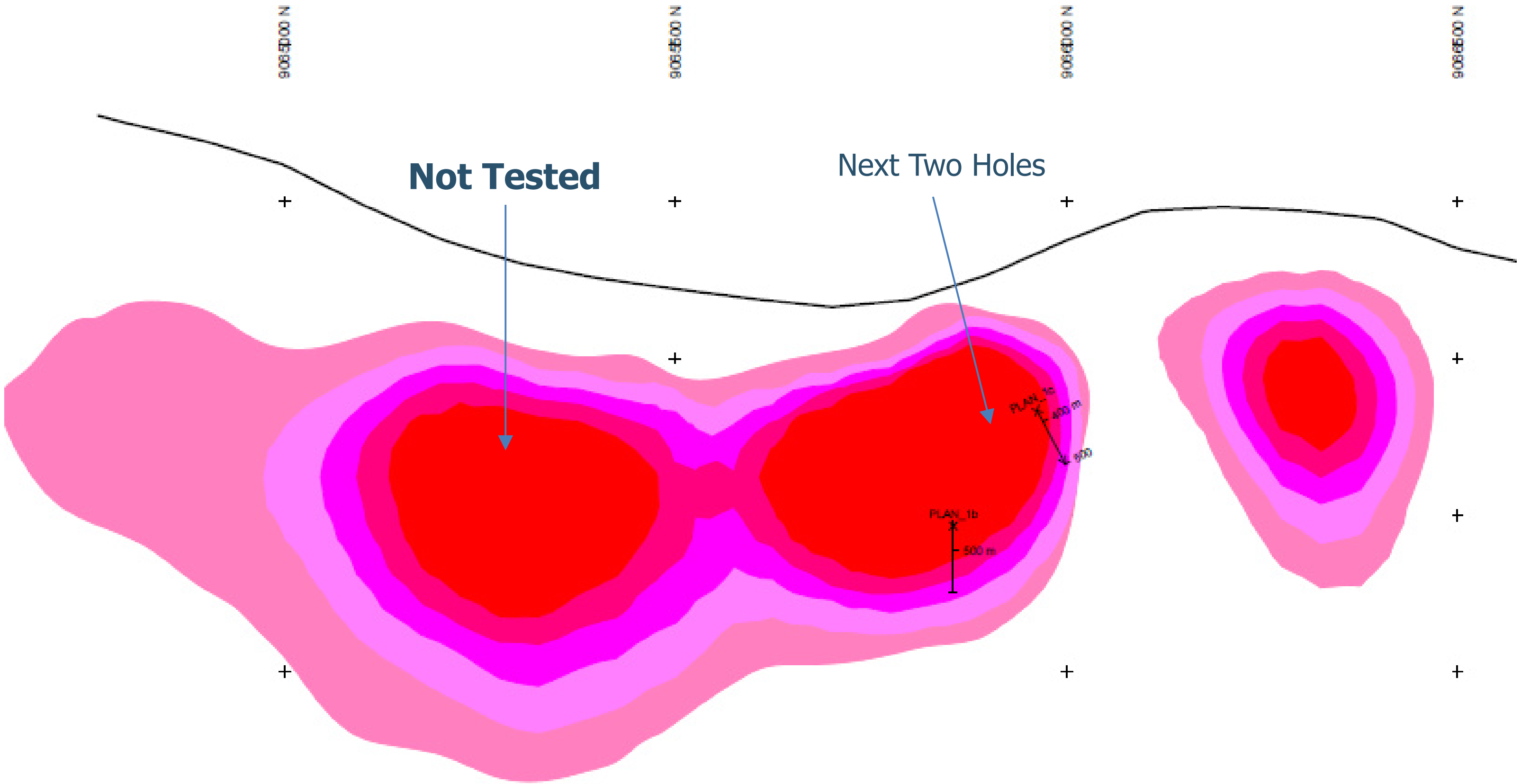


Modelled magnetics with +10x10-3 SI* isosurface from the 3D MVI inversion in pink and IRI standard inversion in blue.

Promesa – Alumbre Sections

Terra Resources

Section 778900E

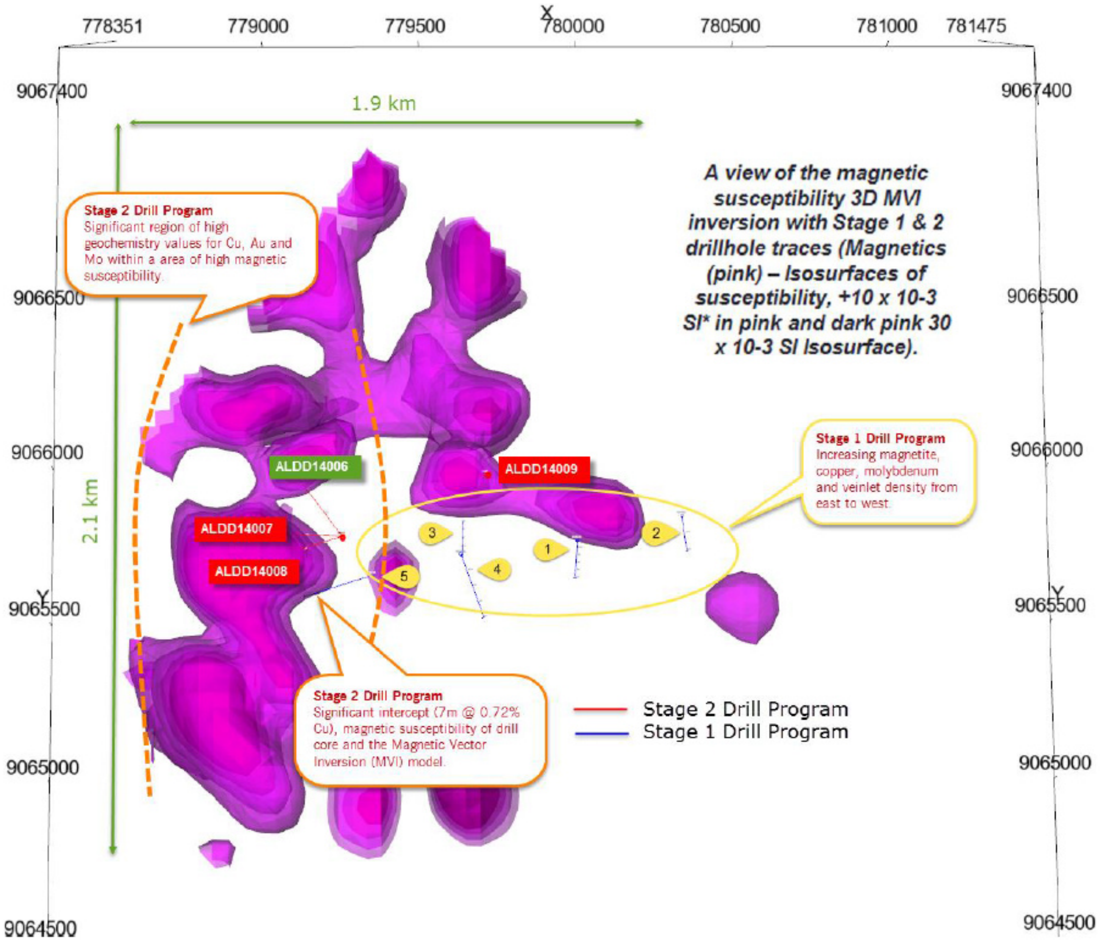


Magnetics (pink) – Isosurfaces of susceptibility, +10 x 10-3 SI* in pink. Centre +15 x 10-3 SI* in red, equivalent to +0.5% magnetite.

PROMESA

Alumbre Project - Drilling

Terra Resources



"The first drill hole, ALDD14006 has progressed to 303m with chalcopyrite and magnetite observed and increasing with depth" 28/9/14

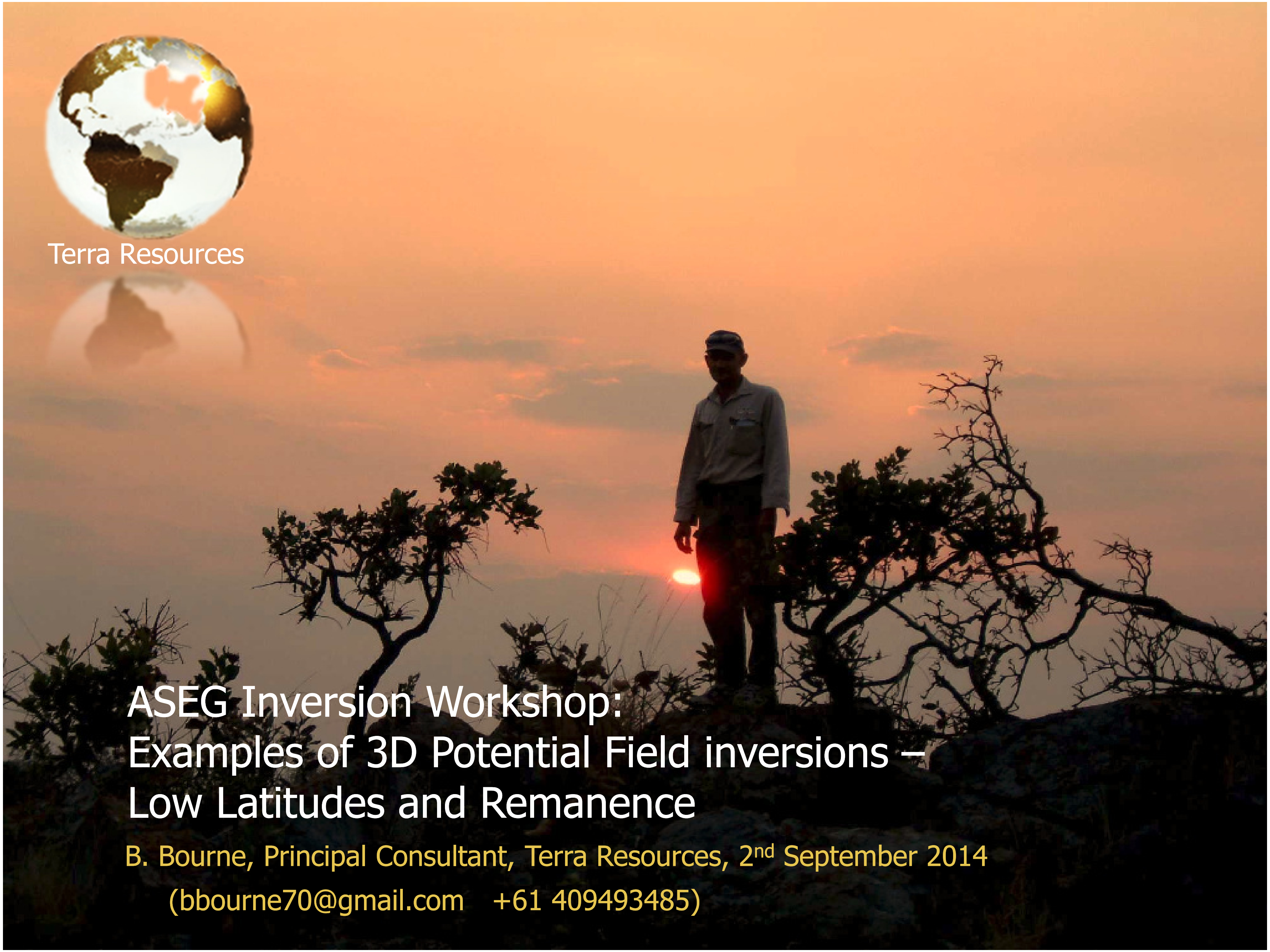
Magnetics (pink) – Isosurfaces of susceptibility, +10 x 10-3 SI* in pink. Centre +15 x 10-3 SI* in red, equivalent to +0.5% magnetite.

PROMESA

Conclusions

Terra Resources

- Recent advances in 3D inversion methods have led to the availability of techniques that look to address more complicated geological/ geophysical problems and challenge conventional thinking.
- After trialling new modelling inversion methods (such as MVI) better fits with geology/ susceptibility were being obtained when drilling for porphyries especially at low latitudes
- In addition, at a regional scale, geological features that appear to be normally magnetised may in fact have a remanent component.
- Alternative modelling techniques should be trailed and **all** data considered before planning follow-up exploration.



Terra Resources

ASEG Inversion Workshop: Examples of 3D Potential Field inversions – Low Latitudes and Remanence

B. Bourne, Principal Consultant, Terra Resources, 2nd September 2014
(bbourne70@gmail.com +61 409493485)