Geophysical Exploration for Gold:
A Major Company Perspective

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Geophysics Session

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Overview

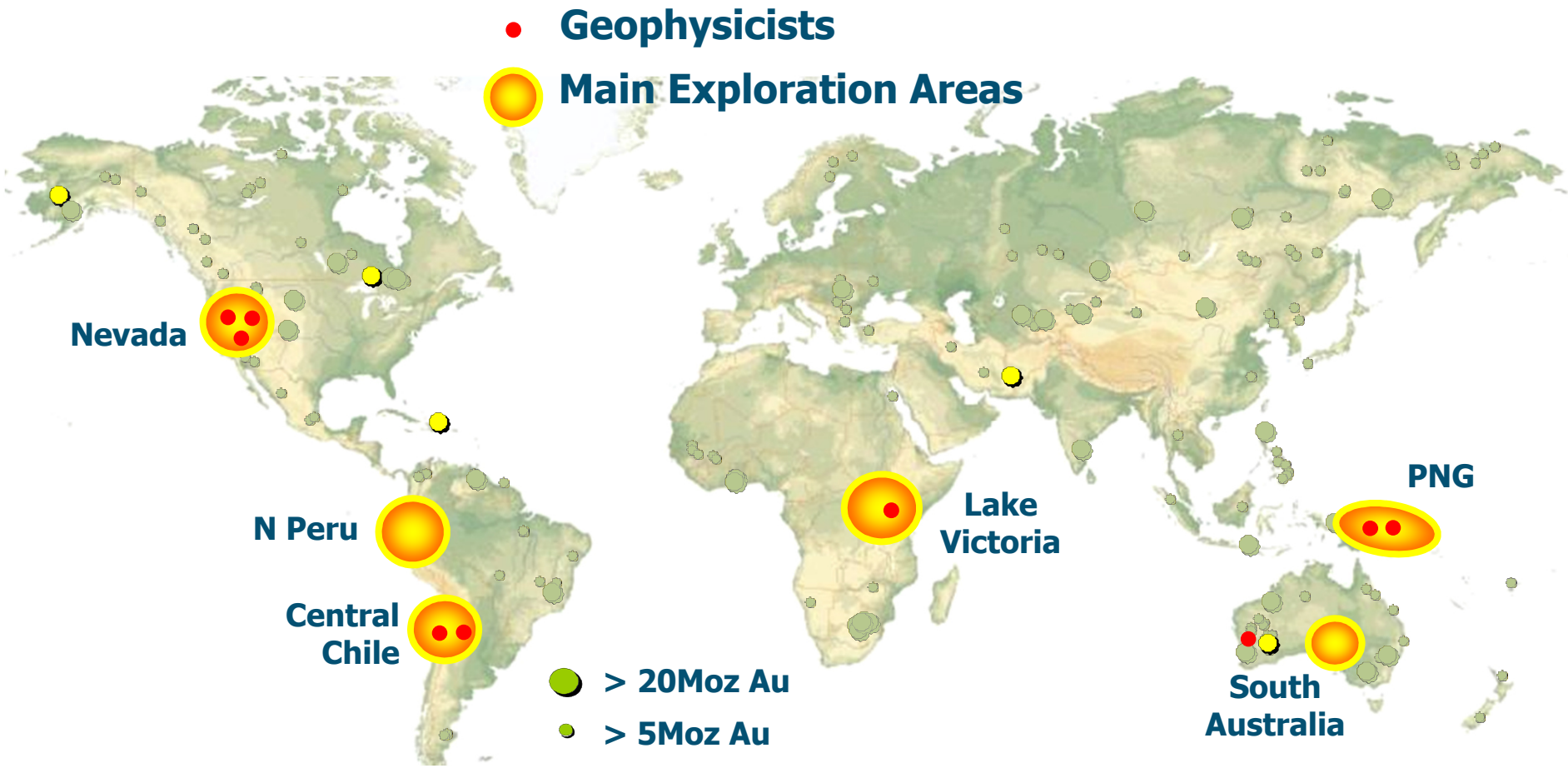
- Introduction
- Geophysics team
- Gold model types
- Examples
- Conclusions

Barrick Snapshot

- Leading gold producer
- Largest reserves (139.8 Moz)
- 2010 production
  - 7.8 Moz Au @ $457/oz
- 26 mines & 20,000+ people
- Strong financial position
- Deep project pipeline
  - Cortez Hills, Pueblo Viejo, Pascua-Lama, etc

Exploration Overview

- Team of 294
- 130 geoscientists (8.5* geophysicists)
- 10 exploration offices
- ~60 exploration projects
- 12 countries
- highly endowed districts



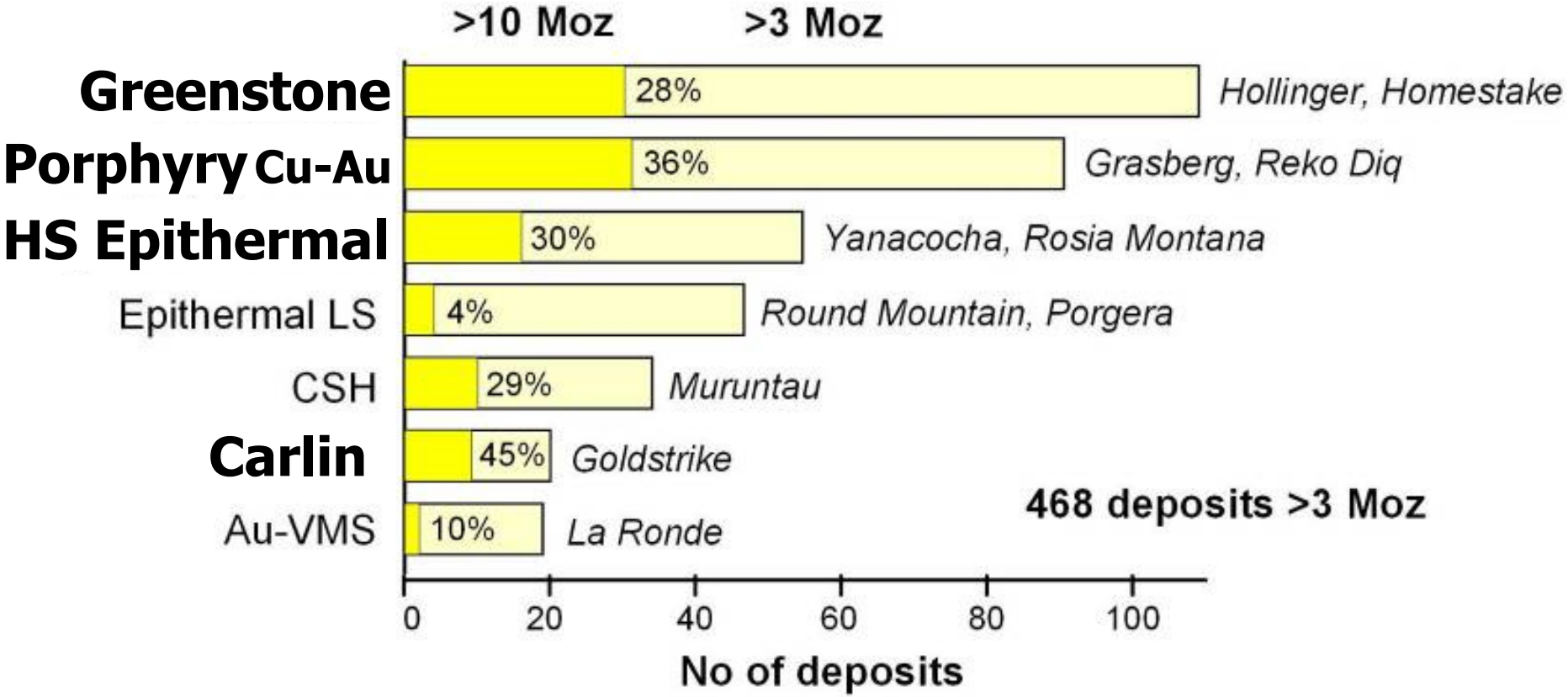
Geophysical Overview

Remote Landing - PNG

- Geophysical Team (8 Staff, 1 Part Time):
  - Average age 34
  - Strong in geology (2 geology degrees)
  - Mostly have honours or equivalent (7/9)
  - Graduate program (2 recruited after honours)
  - 14 vacation students over the past 10 years
  - Based in regional offices for maximum impact
- University/Research Support
  - Directly supported 8 Honours and 1 PhD in the last 10 years. **Currently 3 MSc. projects**.
  - 4 honours students now staff geophysicists
  - 1 honours student now mine exploration geo.
  - **KEGS Student fund**
  - ASEG Research Foundation
  - Curtin University of Technology (CUT)
  - Centre for Exploration Technology (CET)
  - University of Western Australia (UWA)
  - **University of British Columbia (UBC)**
  - University of Utah
  - Montana Tech. Dept of Geophysical Engineering
  - Industry Lead CRC / AMIRA
  - **Canada Mining Innovation Council Exploration Initiative**

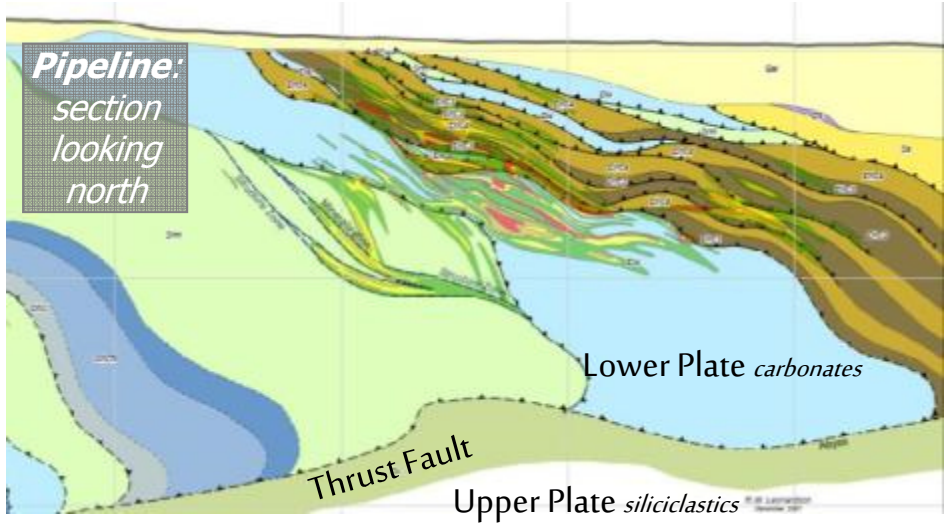
Targeting the Best Models

- Preferred target types:
  - High deposit abundance
  - Highest % of population >10 Moz deposits
  - Good economics and mineability



Carlin – Hardrock Seismic

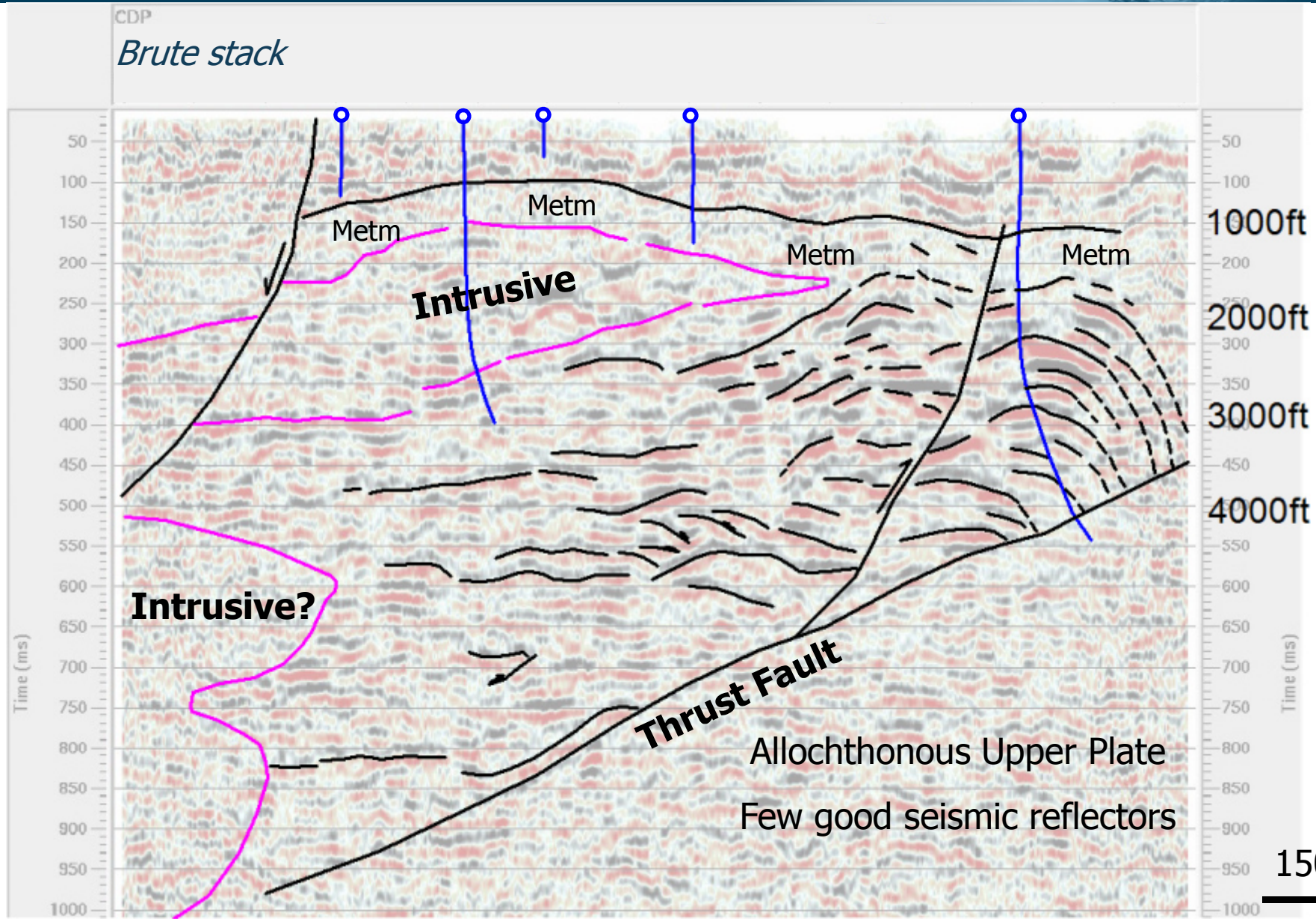
- Geology
  - Carbonate stratigraphy
  - Low-angle architecture
  - Thrusting and stacking
  - ***Au in antiform structure***



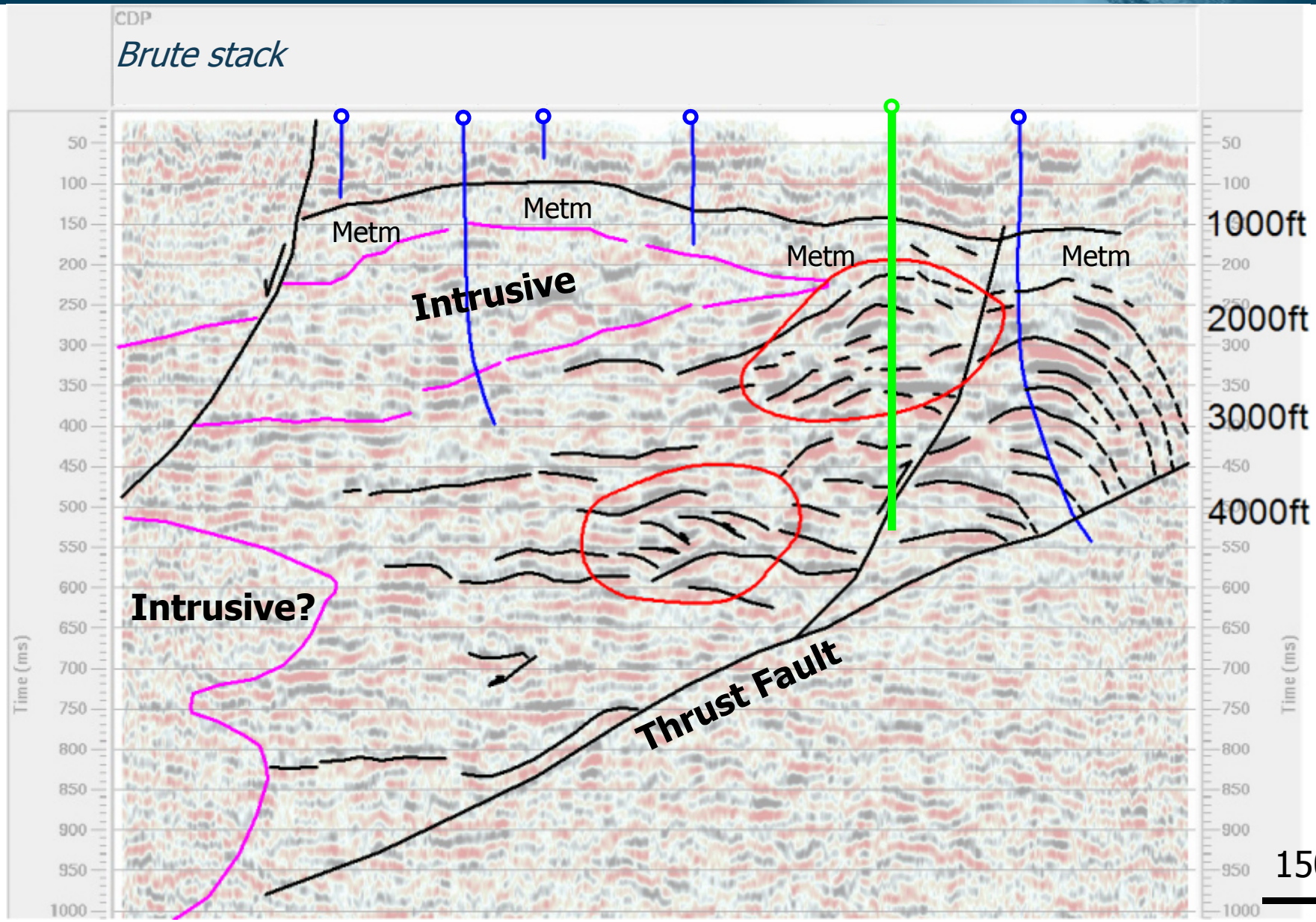
- Petrophysics
  - Density & velocity contrast between
    - lithologies
    - deposition facies
    - structure

- Hardrock Seismic
  - Acquisition:
    - High resolution & frequency
    - 10m receiver, 20m shot
    - At least 120 fold
    - 3D acquisition in 2011
  - Processing:
    - Statics corrections for topography
    - Huge velocity contrasts in near-surface

Carlin – Seismic Example

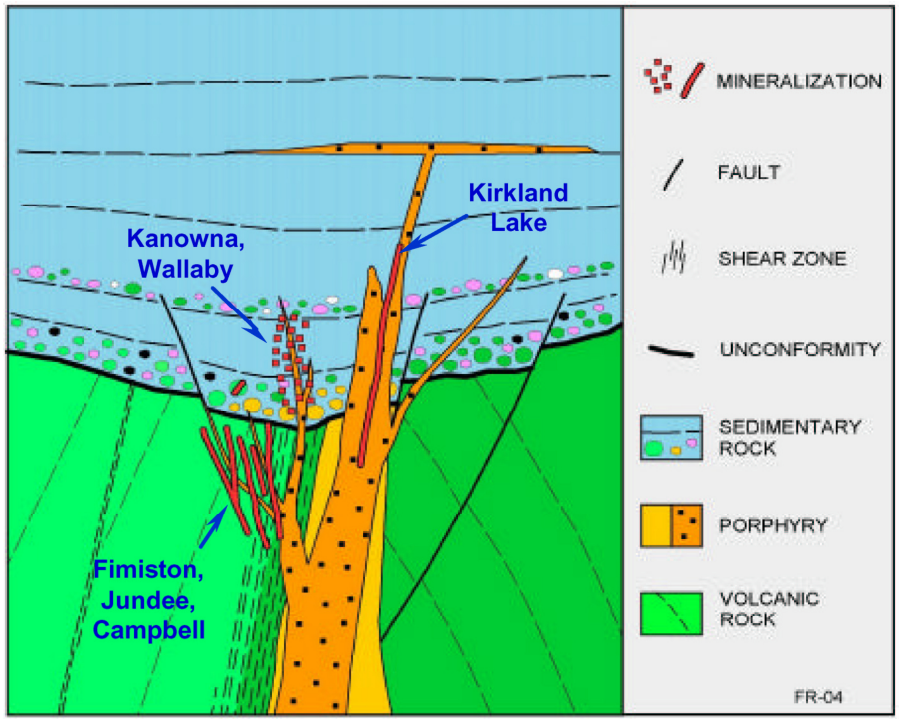


Carlin – Seismic Example (cont)



Greenstone – Airborne EM

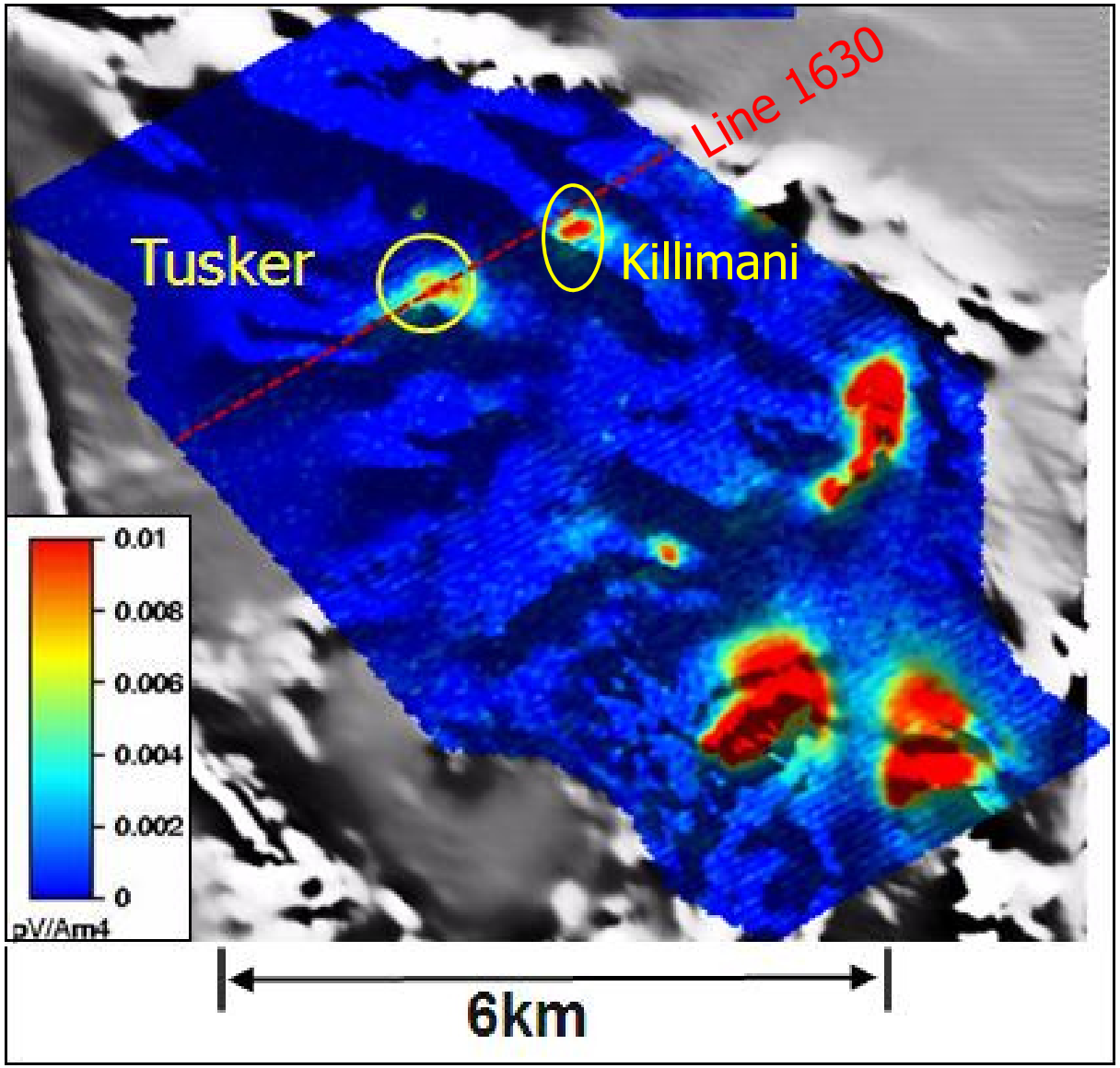
- Geology
  - Greenstone stratigraphy
  - Sediment hosted sulphide-rich end member
  - Near volcanic sequence or porphyry
  - ***Au associated with sulphides***
- Petrophysics
  - Resistivity contrasts
    - Disseminated sulphides
    - More resistive host
  - Density, magnetic contrasts (in strat.)
- Airborne EM
  - Acquisition:
    - High resolution (50/100m line spaced)
    - Target late time conductive responses
  - Processing:
    - Channel amplitude maps
    - 1D transforms and inversions routine



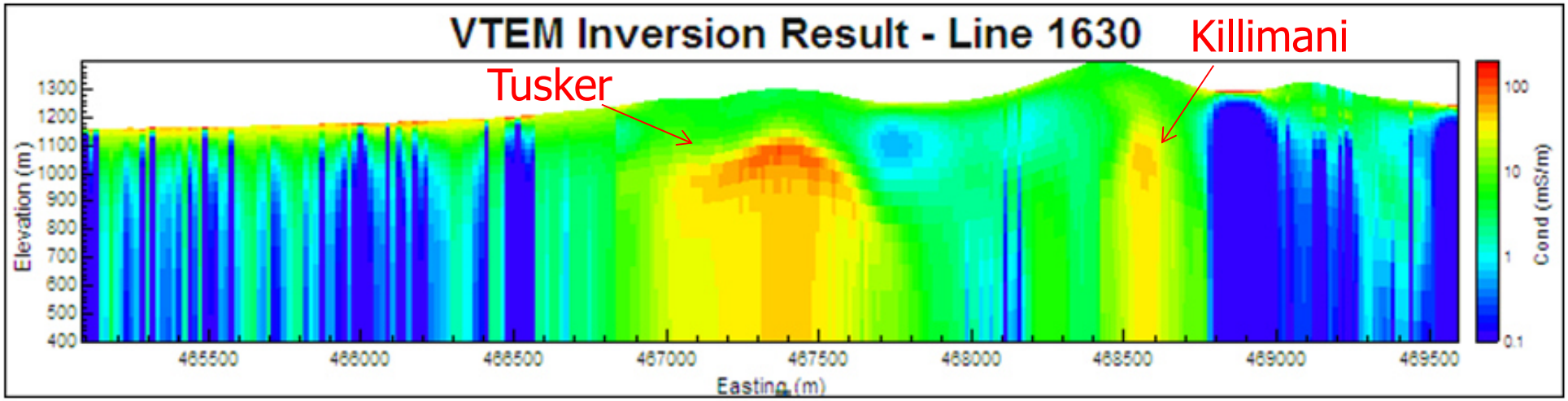
VTEM system

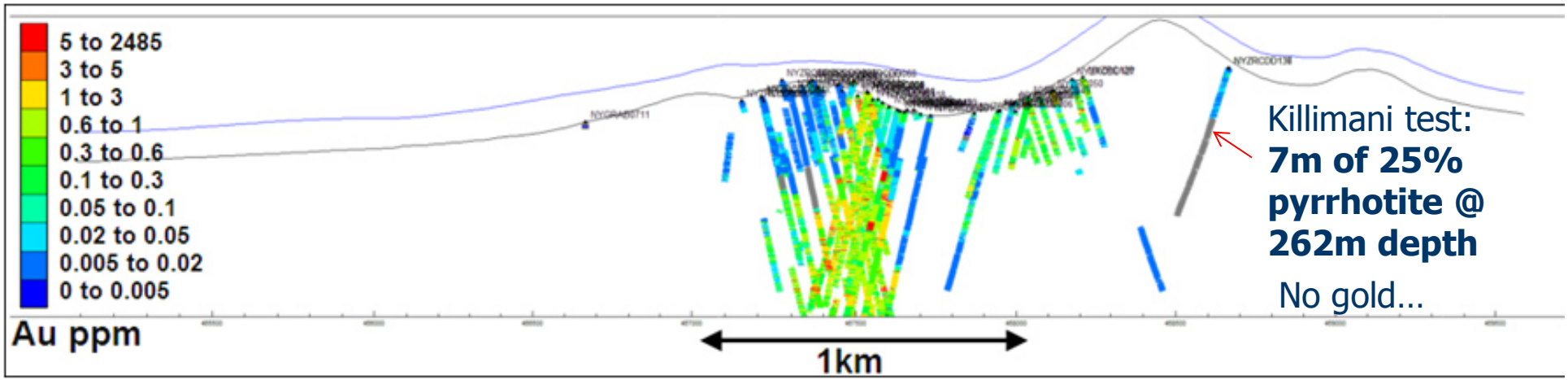
Greenstone – Airborne EM Example

- Helicopter time domain VTEM surveys
- Late time channel data (8.9 ms) shown
- Draped over greyscale magnetics (RTP 1VD)
- Tusker 4.54Moz @ 1.5g/t Au (2009)
- Killimani anomaly identified as another sulphide response



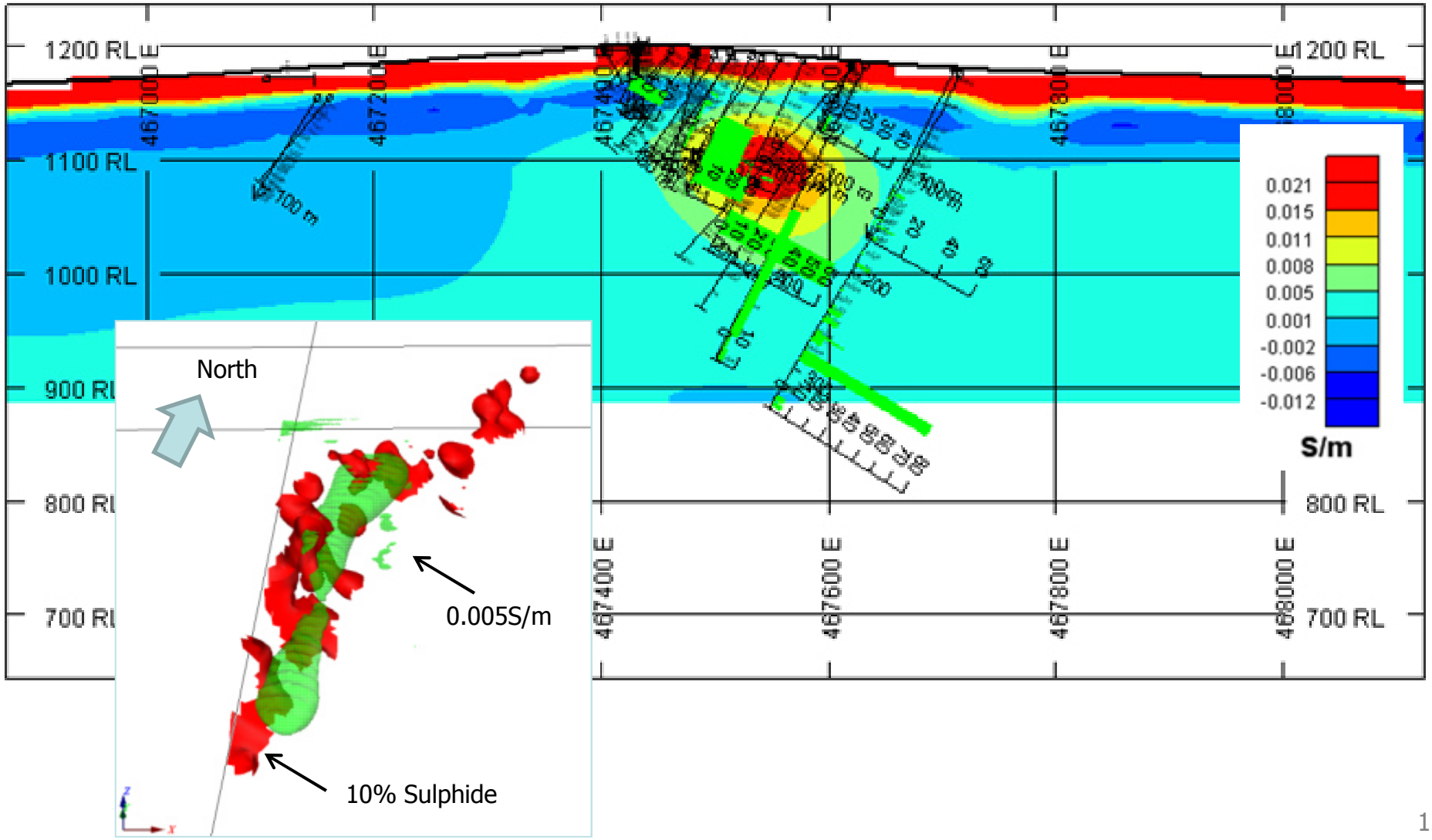
Greenstone – Airborne EM Inversion (1D)





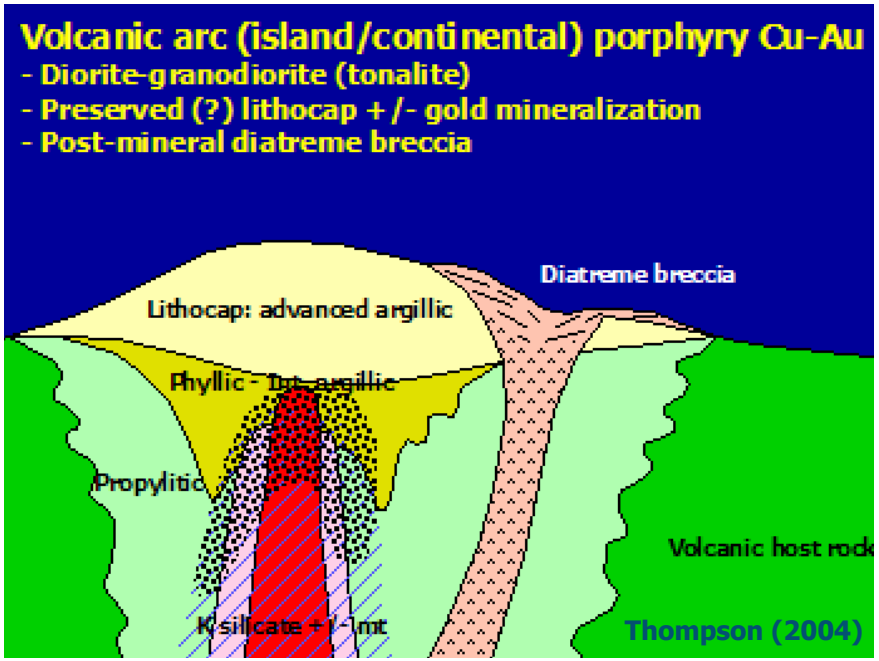
Greenstone – Airborne EM Inversion (3D)

- EMVision® 3D inversion by Technoimaging (footprint)
- H3DTDinv by University of British Colombia (UBC - GIF-IRC)



Porphyry – Various Methods

- Geology
  - Porphyries form in various settings
  - Usually at convergent plate margins
  - Commonly hosted in volcanics or sediments
  - ***Au in centre of porphyry system***



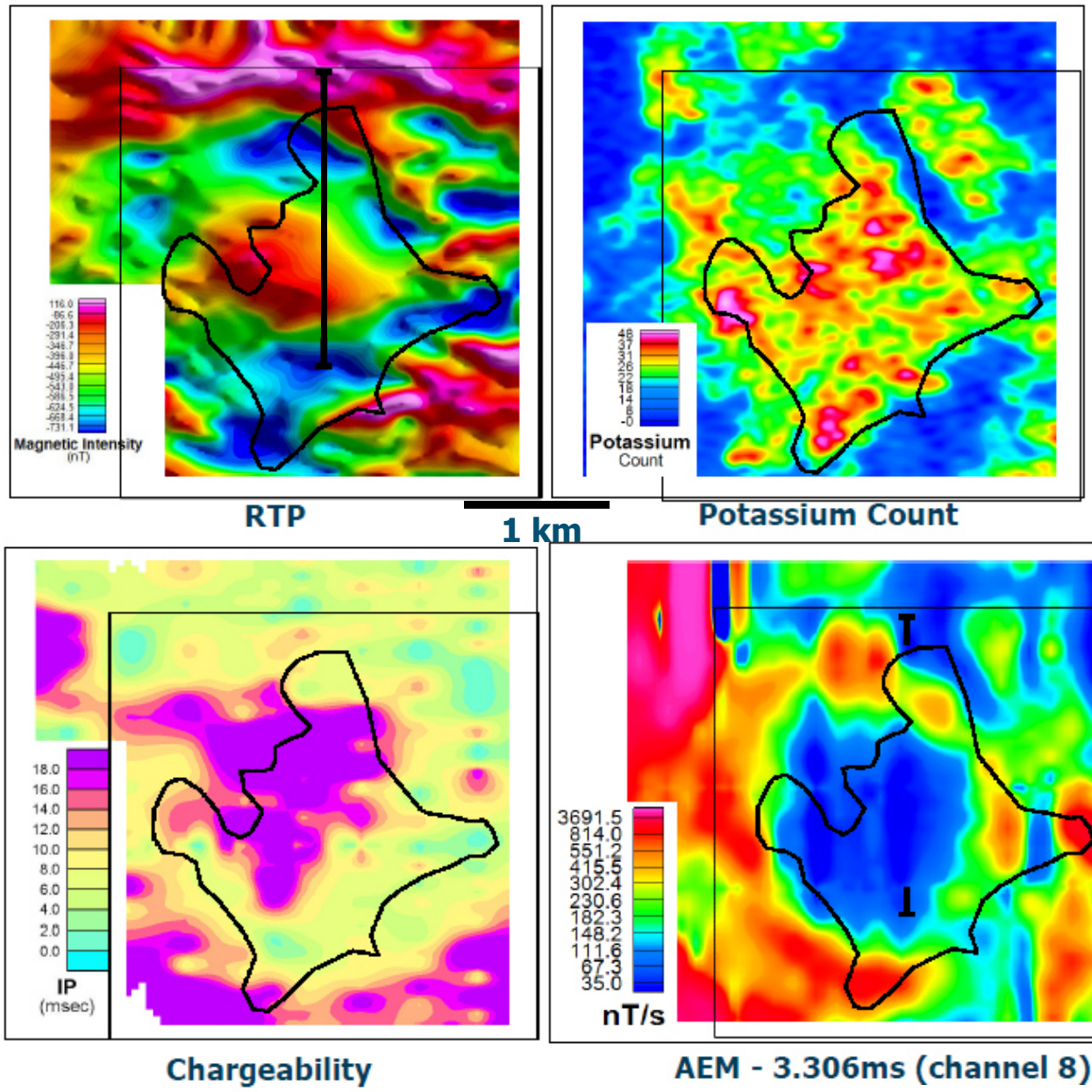
- Petrophysics
  - Magnetic, electrical & potassium contrasts
    - Alteration zonation
    - Response varies depending on host
    - Disseminated sulphides

- Various geophysical methods
  - Acquisition:
    - 1) Regional airborne mag & radiometrics
    - 2) Follow-up airborne EM
    - 3) IP/resistivity methods (100-200m dipoles)
  - Processing:
    - Channel amplitude maps
    - 1D/2D /3D transforms and inversions

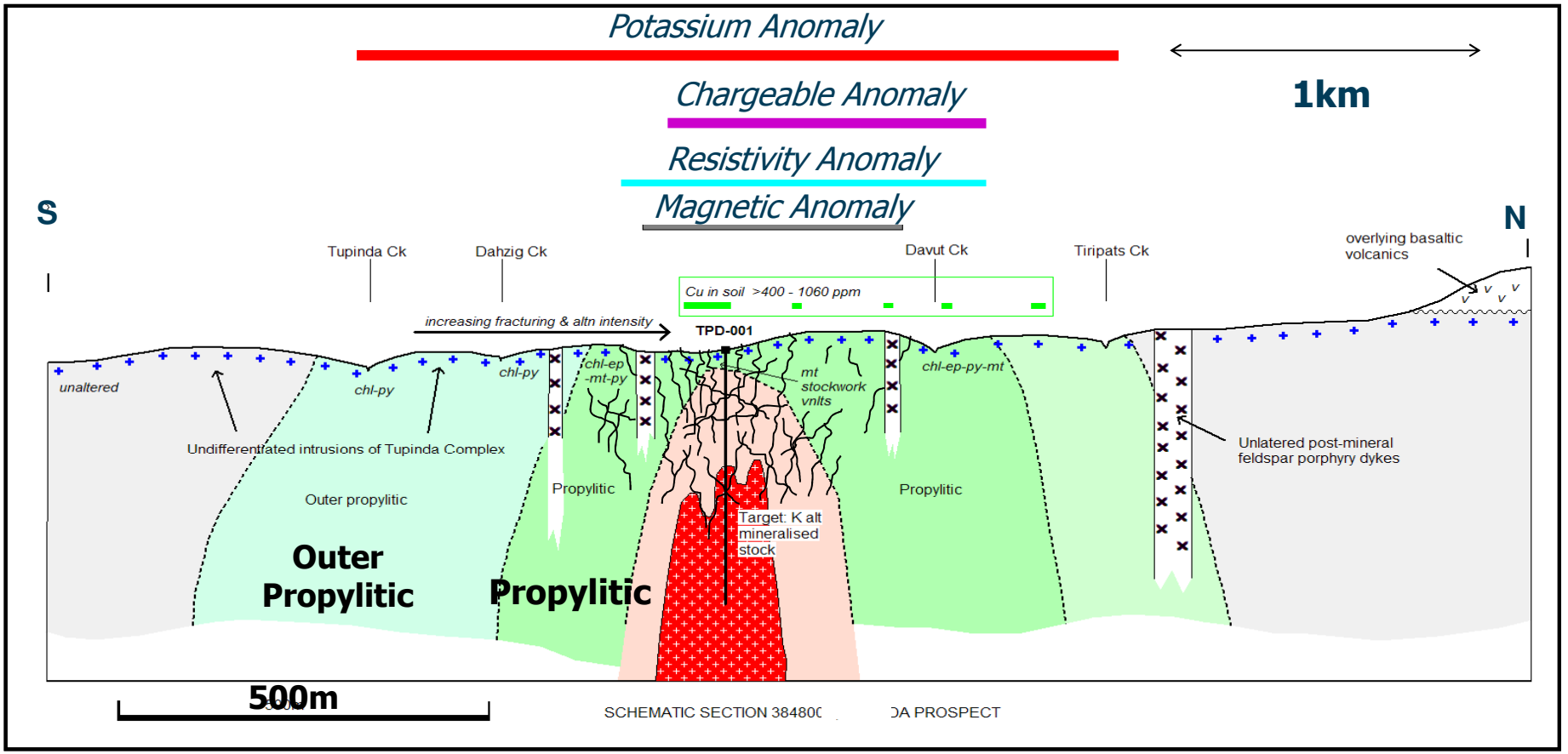
AEROTEM IV system

Porphyry – Integrated Example

- K-silicate core
  - magnetic
  - resistive
- Phyllic alteration
  - resistive
  - chargeable
- Propylitic alteration
  - chargeable
  - magnetic
- Outer propylitic alteration
  - Potassium anomaly



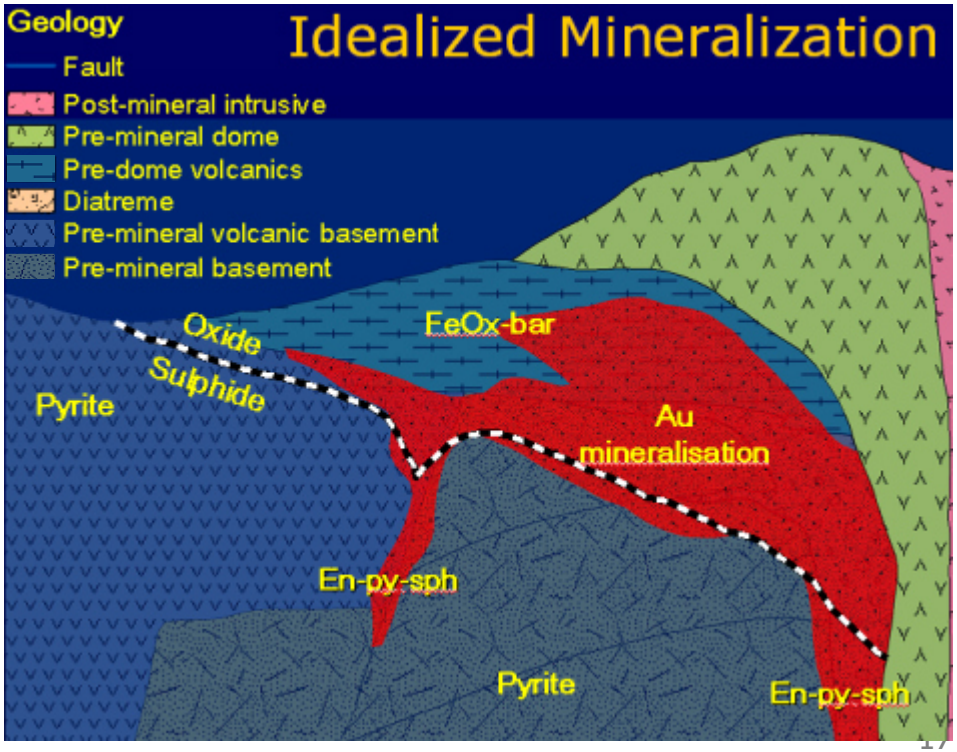
Porphyry – Geological Cross Section



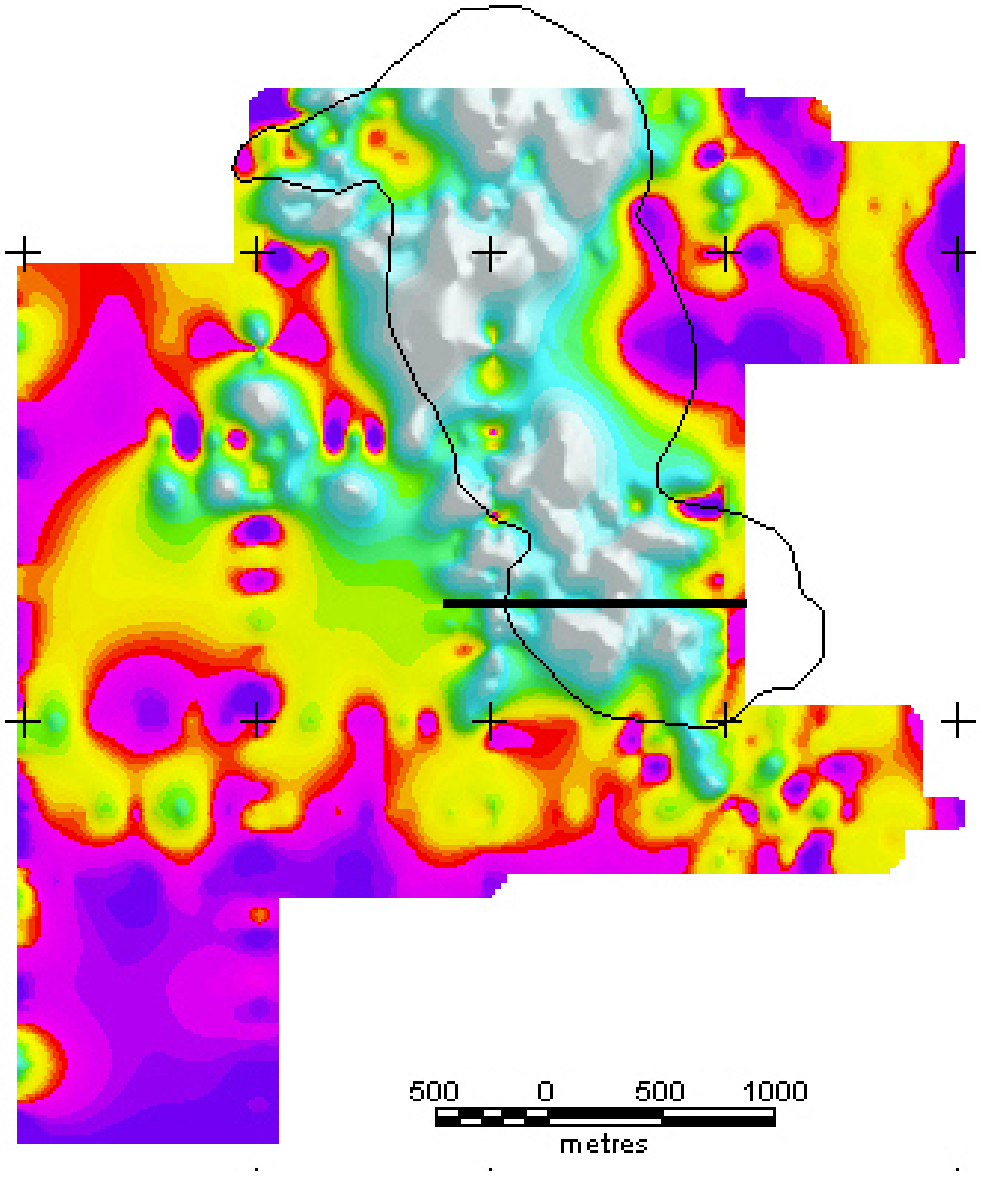
Epithermal (HS) – CSAMT

- Geology
  - Diatreme dome complexes with associated volcanics
  - Pre, syn and post mineral diatremes
  - Pre-mineral domes can be unaltered and overlying mineralisation
  - Large advanced argillic alteration zones (100's km^2)
  - Topographic highs of silicic alteration
  - ***Au in vuggy silica core***
- Petrophysics
  - Resistive, massive vuggy silica core
  - Magnetite depletion
  - Chargeable alteration halo
- Resistivity methods
  - Acquisition:
    - IP/res (100-200m dipoles)
    - CSAMT
  - Processing:
    - Amplitude maps, depth slices
    - 1D/2D inversions

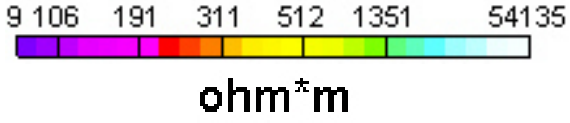
Vuggy silica



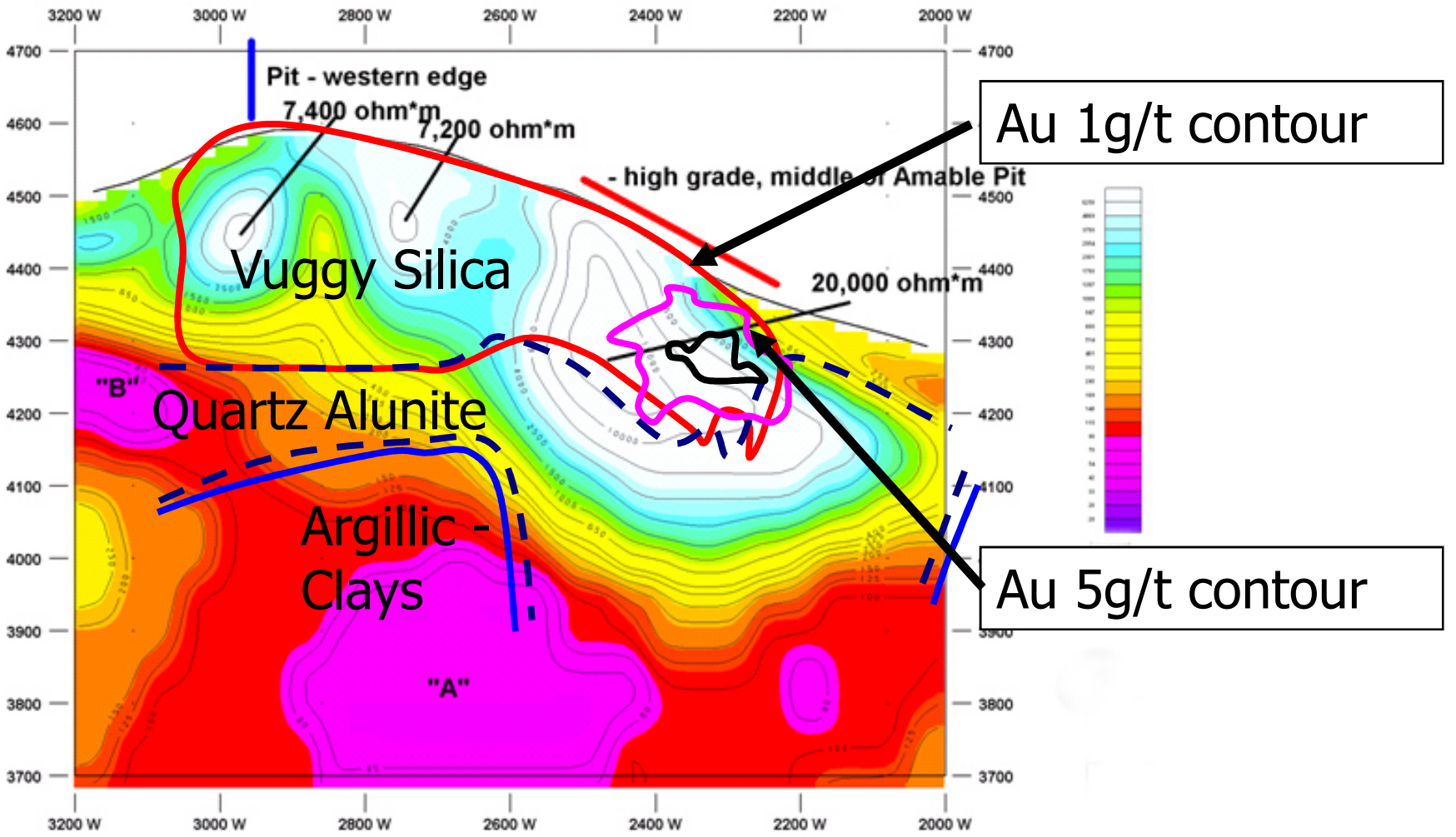
Epithermal (HS) – CSAMT Example



- Veladero: ~ 12.0 Moz Au proven and probable (2009)
- Image of CSAMT resistivity
  - 100m depth slice, with alteration outline
- 400m line spacing
- Cross section through anomaly



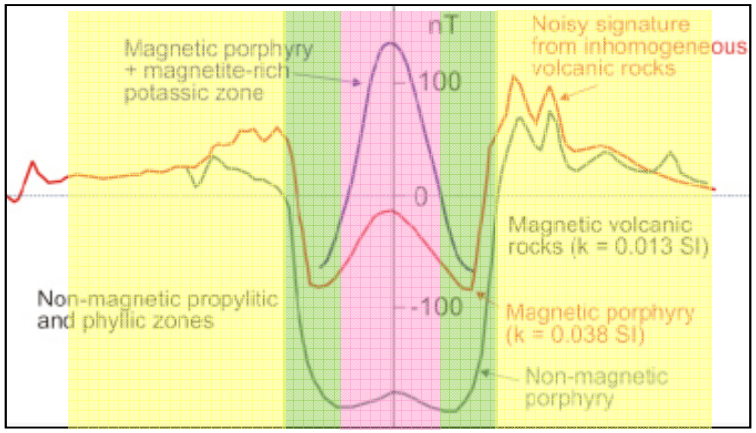
Epithermal (HS)– CSAMT Example

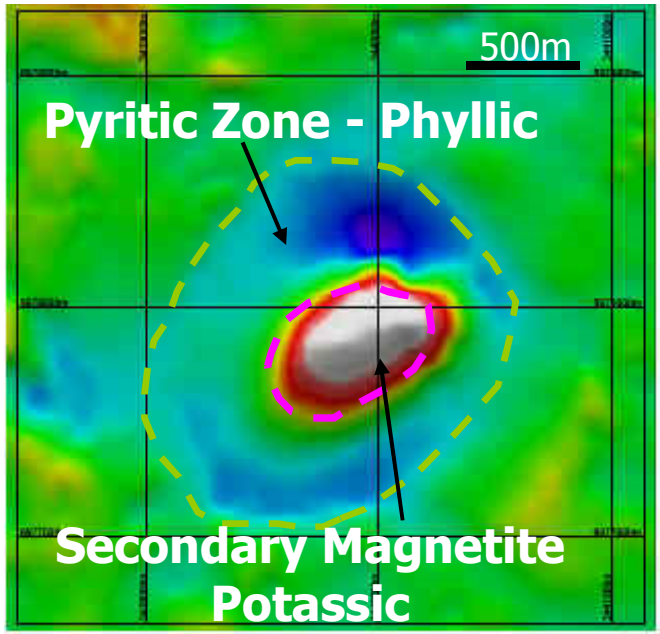


Research – Image Processing

Porphyry Filter

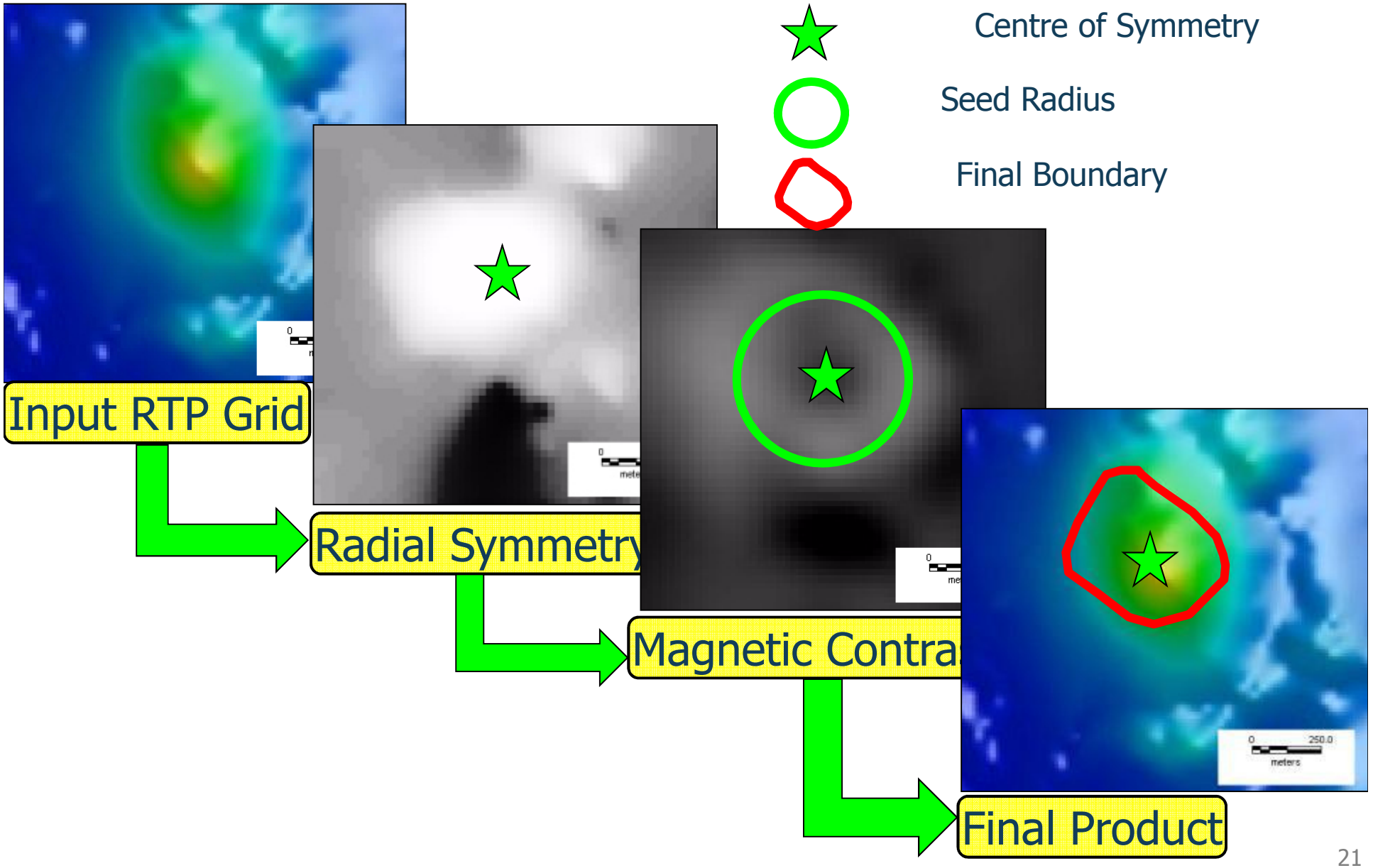
- Automatically detect and quantify porphyry magnetic signatures via user defined application of porphyry target model
- Research agreement between UWA-CET and Barrick signed in 2008 to sole-fund "Porphyry Texture Filter"
- Cu-Au rich porphyry focus
- Magnetic coverage available over most projects – capitalise on investment
- Rapid objective analysis of large datasets
- Discrimination within highly magnetic terrains and under cover



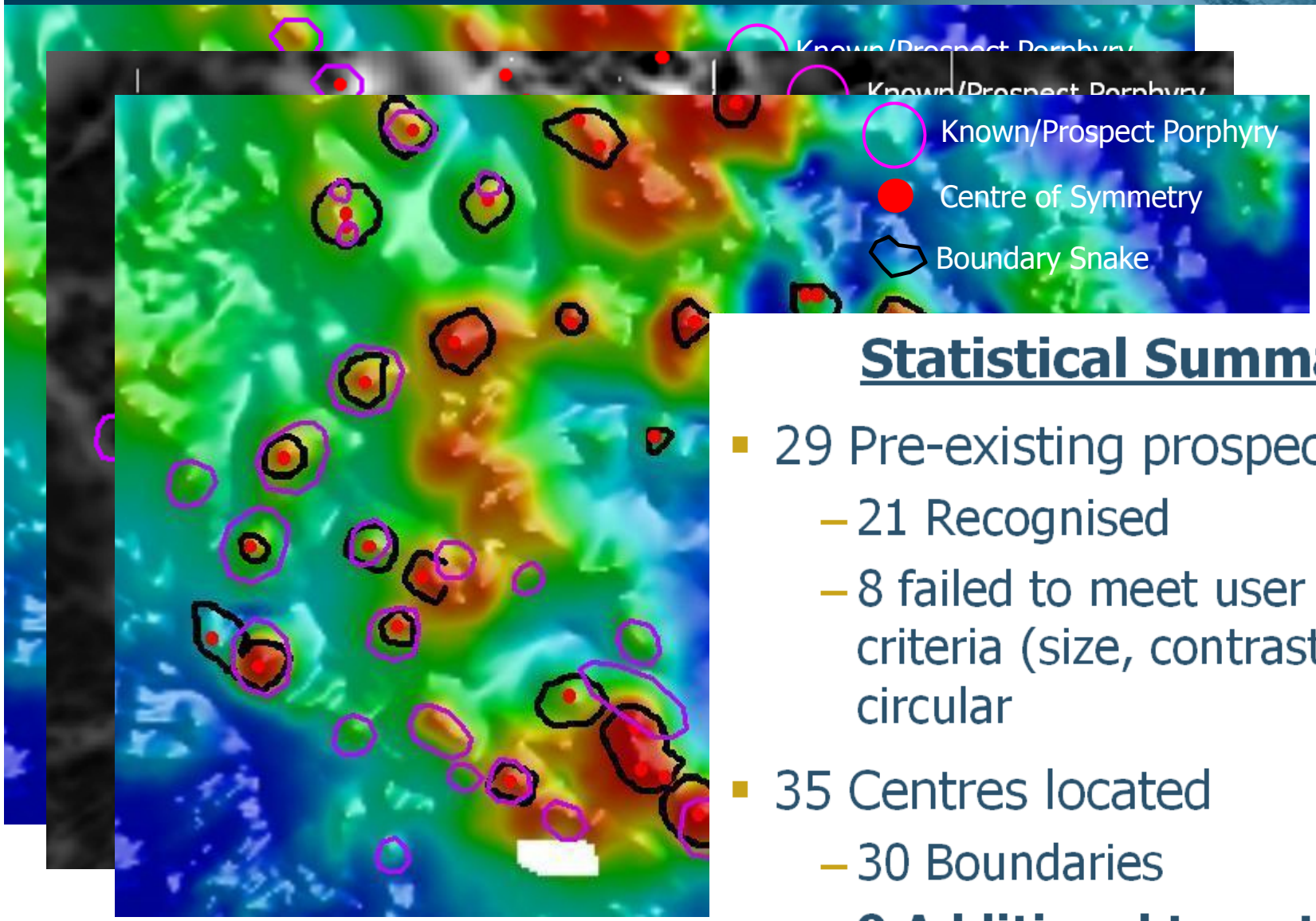


Modified from Clark - AMIRA P700

Research – Image Processing



Research – Image Processing Example



Statistical Summary

- 29 Pre-existing prospects
  - 21 Recognised
  - 8 failed to meet user defined criteria (size, contrast, not circular
- 35 Centres located
  - 30 Boundaries
  - **9 Additional targets**

Conclusions

- Barrick Gold
  - Leading gold producer, with largest reserves
  - 8 full time geophysicists, one part time. Average age 34, strong in geology, mostly have honours or equivalent
  - University, professional affiliate and research support
  - Preferred model type greenstone, epithermal, Carlin and porphyry Cu-Au
- Carlin: Hardrock Seismic
  - Seismic suits the carbonate stratigraphy, having low-angle structural control on architecture and good acoustic impedance contrasts between lithologies and deposition facies
  - Hardrock seismic requires high spatial resolution (10m receiver, 20m shot) and frequency and higher fold (120+)
- Greenstone: Airborne EM
  - Sediment hosted sulphide-rich end member is better suited to electromagnetic (EM) techniques
  - Conductive near-surface response usually identifies centre of the system

Conclusions (cont)

- Porphyry Cu-Au: Integrated Methods
  - Magnetics/ radiometrics to map potassic alteration is well known
  - Potassic core can be either conductive in sulphide-rich systems, or resistive in sulphide-poor systems, depending on host
  - Outer phyllic/ propylitic alteration is chargeable, magnetite destructive and is often resistive
- High Sulphidation Epithermal: CSAMT
  - Resistivity data can effectively map the typical alteration of advanced argillic with vuggy silica (resistive), advanced argillic with quartz alunite (moderate resistor), to argillic with intense clay (conductive, chargeable)
  - Magnetite depletion and chargeable alteration also system indicators
- Research Image Processing: Porphyry Filter
  - Developed an algorithm to detect near surface porphyry Cu-Au responses in magnetic data
  - The result was a fast, effective reconnaissance porphyry mapping tool for magnetic data. Can identify subtle response in presence of volcanics.