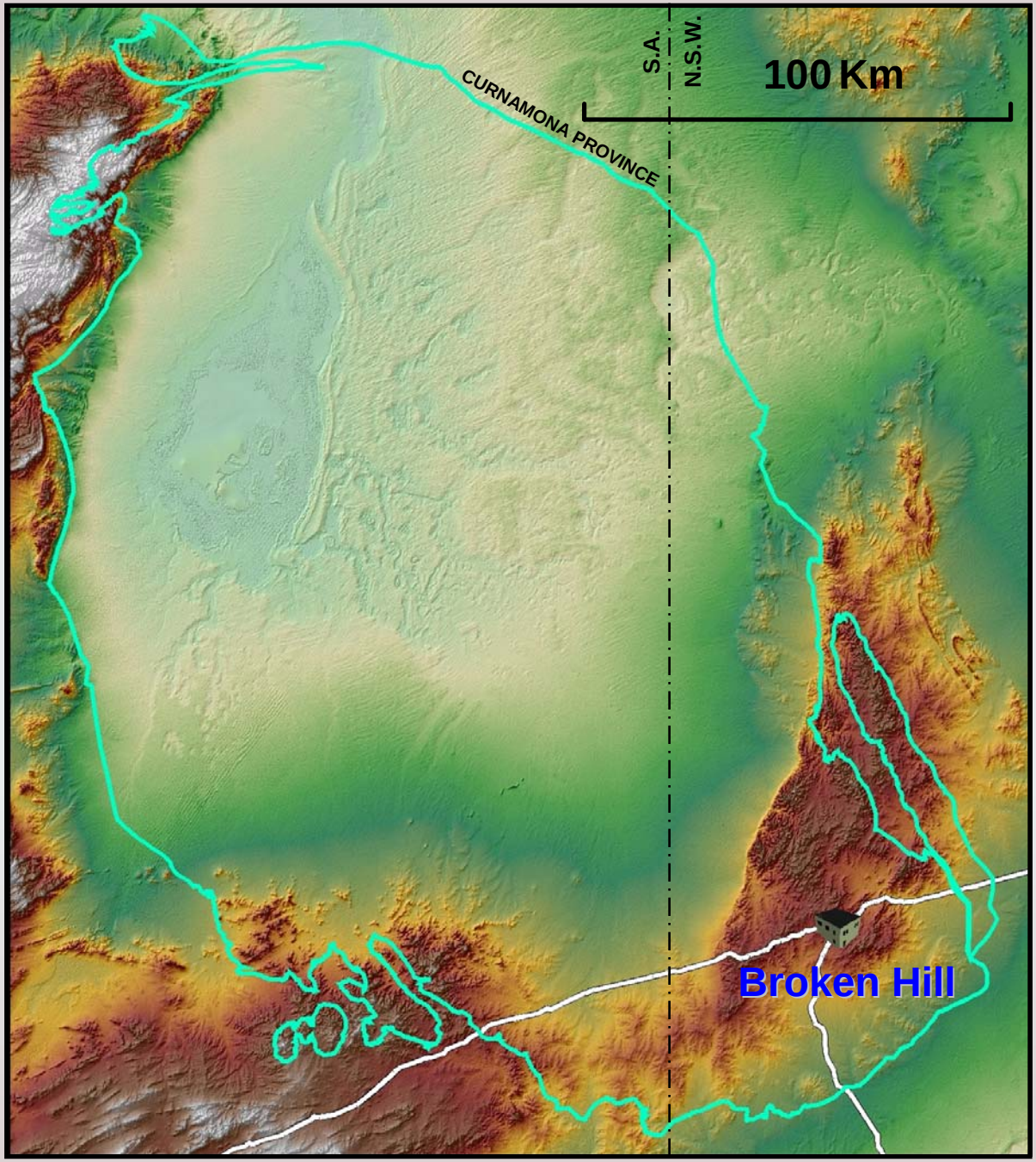
CRCLEME
Cooperative Research Centre for
Landscape Environments
and Mineral Exploration

Government
of South Australia
Primary Industries
and Resources SA

Surface Geochemical Expression of Bedrock Beneath Thick Sediment Cover, Curnamona Province, South Australia

Adrian Fabris, John Keeling, Roger Fidler
PIRSA – SA Geological Survey



- Meso to Palaeo-Proterozoic Craton
- Semi-arid
- Thick regolith cover

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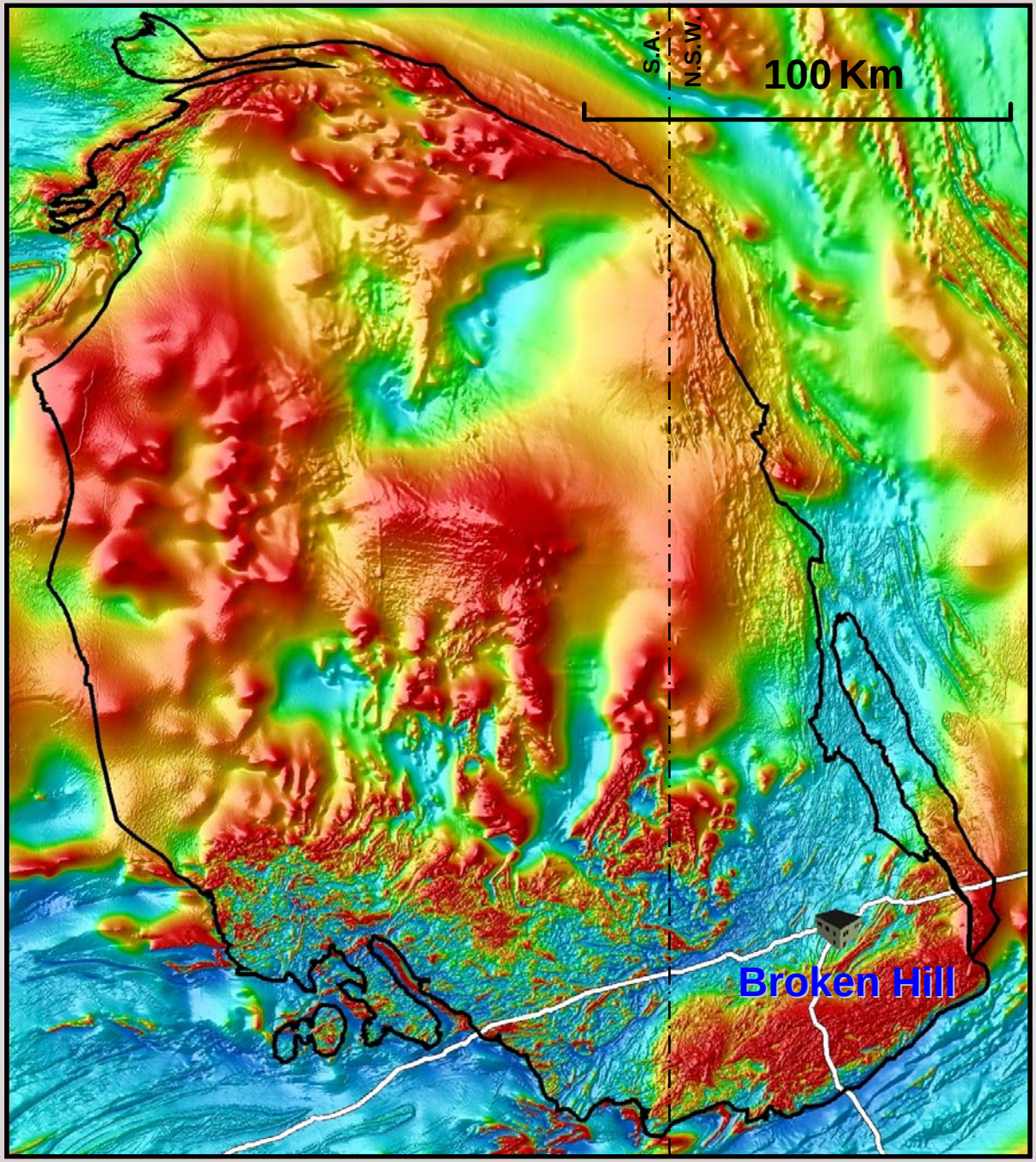

- Redox boundary >500 line km
- Drill hole traverses used to test

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Geochemical Techniques

- Partial Leach Methods
  - Aqua regia
  - Weak cyanide
  - Weak sodium hydroxide
  - Weak magnesium chloride
  - MMI-M (WAMTECH)

AMDEL

- Electrochemistry
  - CHIM (bottom of hole soil by aqua regia)
- Others
  - Soil deadsorption pyrolysis, vegetation, groundwater

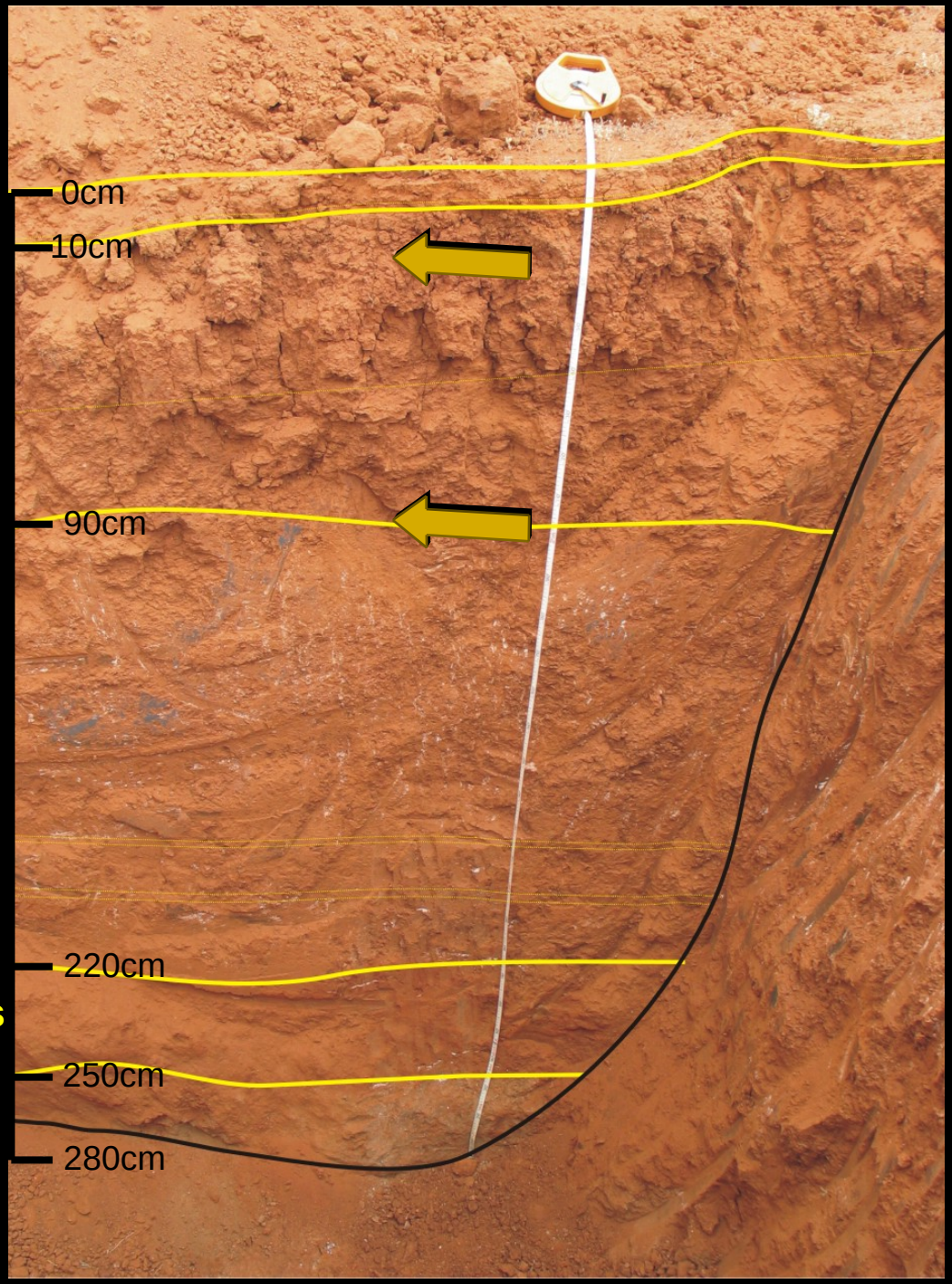
Alluvial/Aeolian

Abundant rootlets, minor carbonate

Abundant gypsum, Pedogenic carbonate

Sub-rounded gravels

Rhizomorphic carbonate



•Samples sieved to <200µm

Geochemical Techniques

- Partial Leach Methods
  - **Aqua regia**
  - **Weak cyanide** (partially dissolves amorphous Fe & Mn oxides, sulphates, chlorides and complexing ions exchanged onto clay surfaces)
  - **Weak sodium hydroxide** (oxidising agent)
  - **Weak magnesium chloride** (targets cation exchange sites on clay minerals)
  - **MMI-M (WAMTECH)**

AMDEL

- Electrochemistry
  - **CHIM (bottom of hole soil by aqua regia)**

Chinese CHIM

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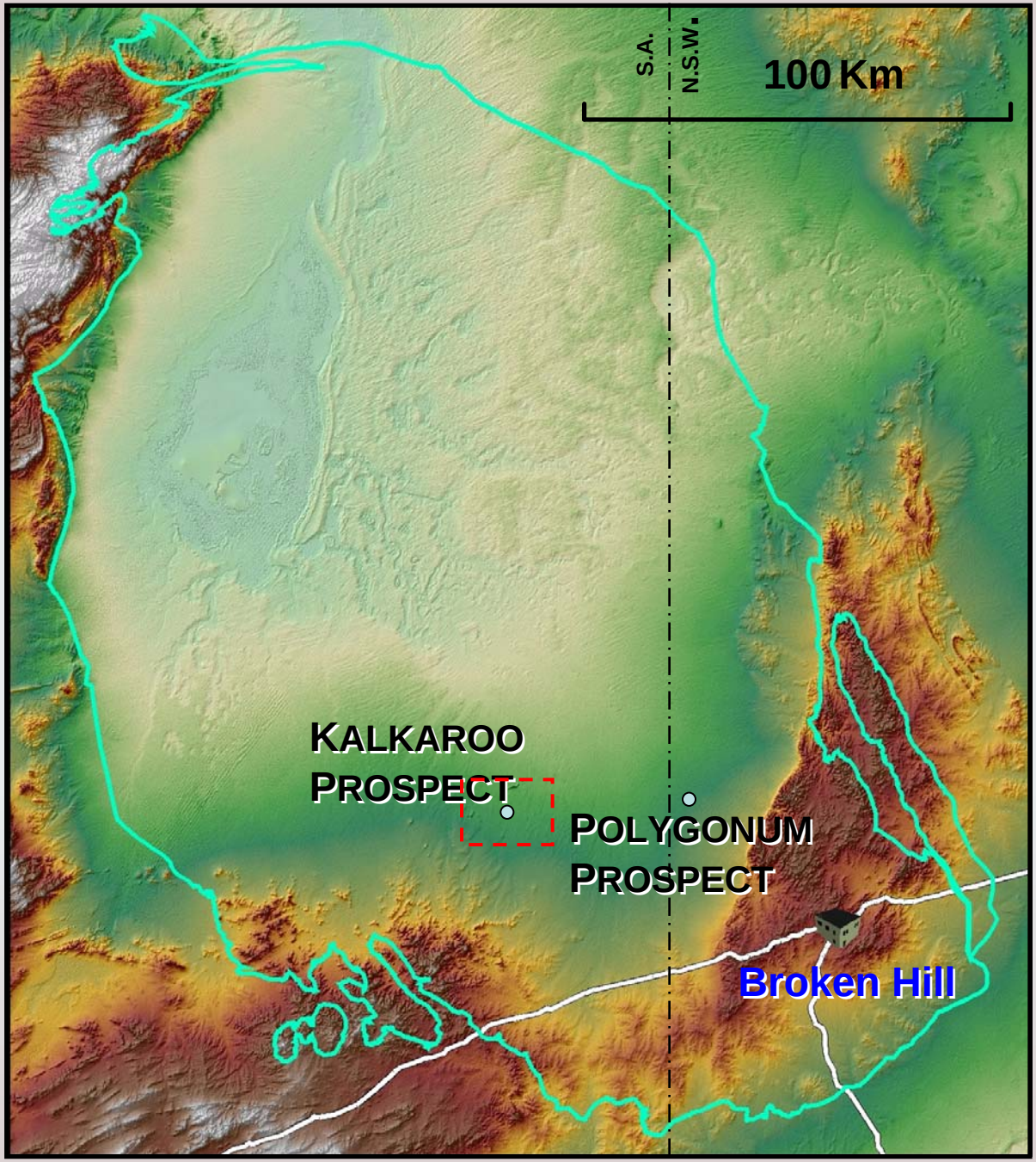
S.A.
N.S.W.
100 Km
KALKAROO
PROSPECT
POLYGONUM
PROSPECT
Broken Hill

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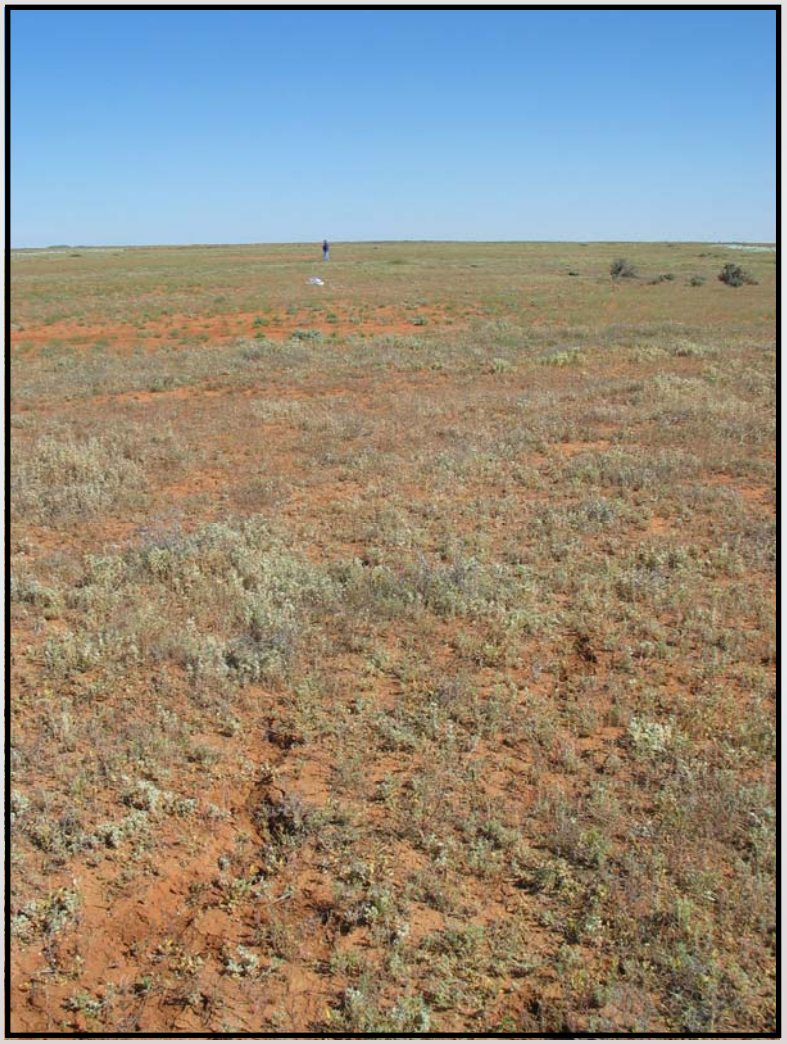
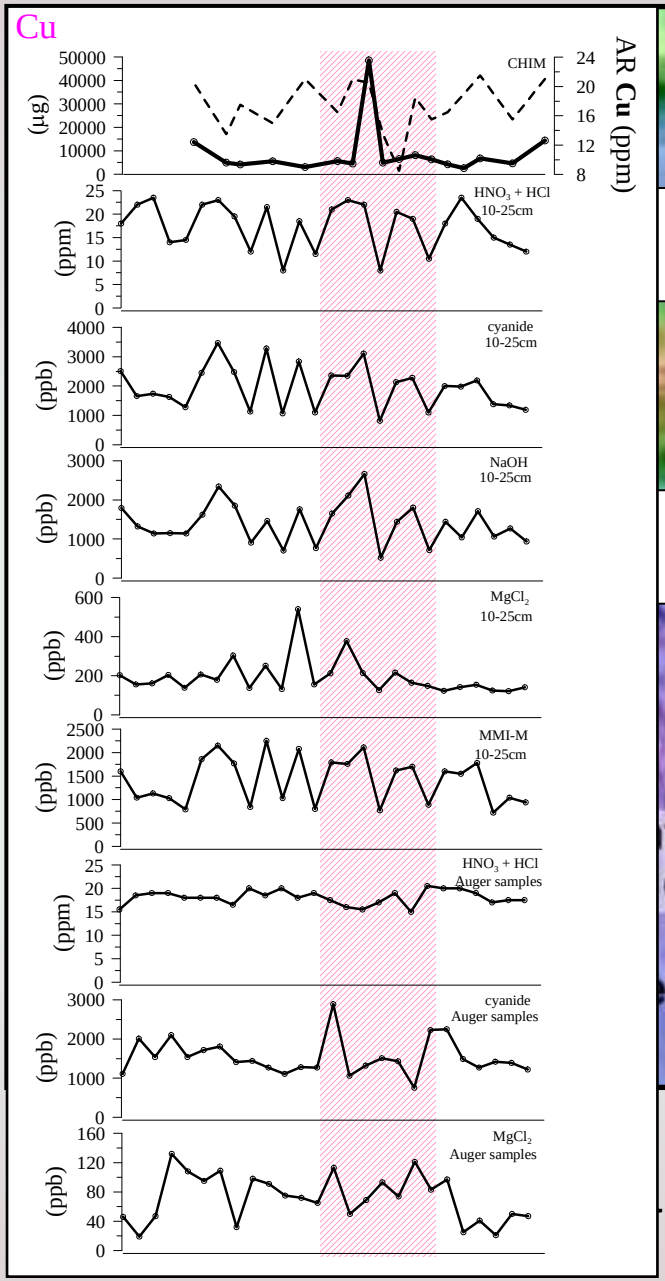
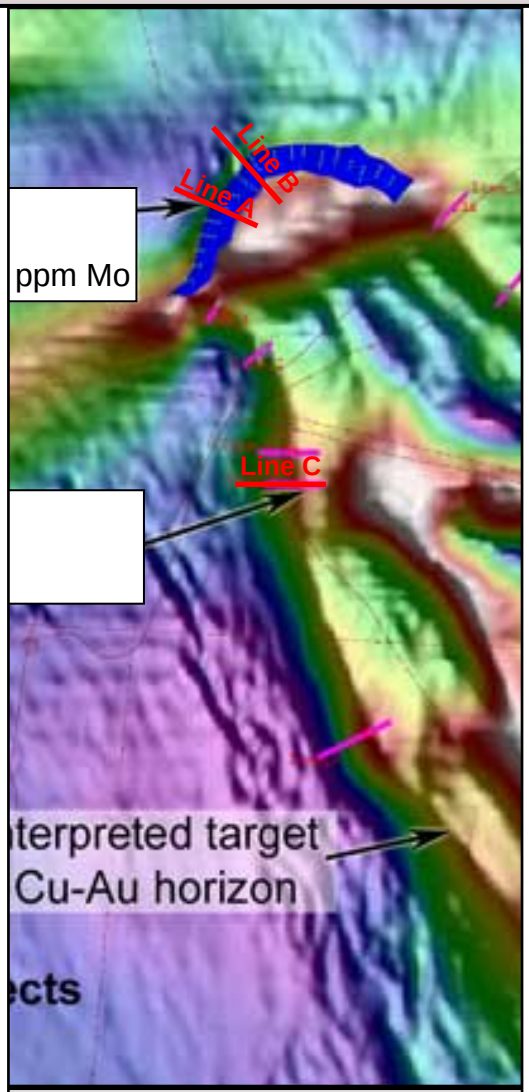
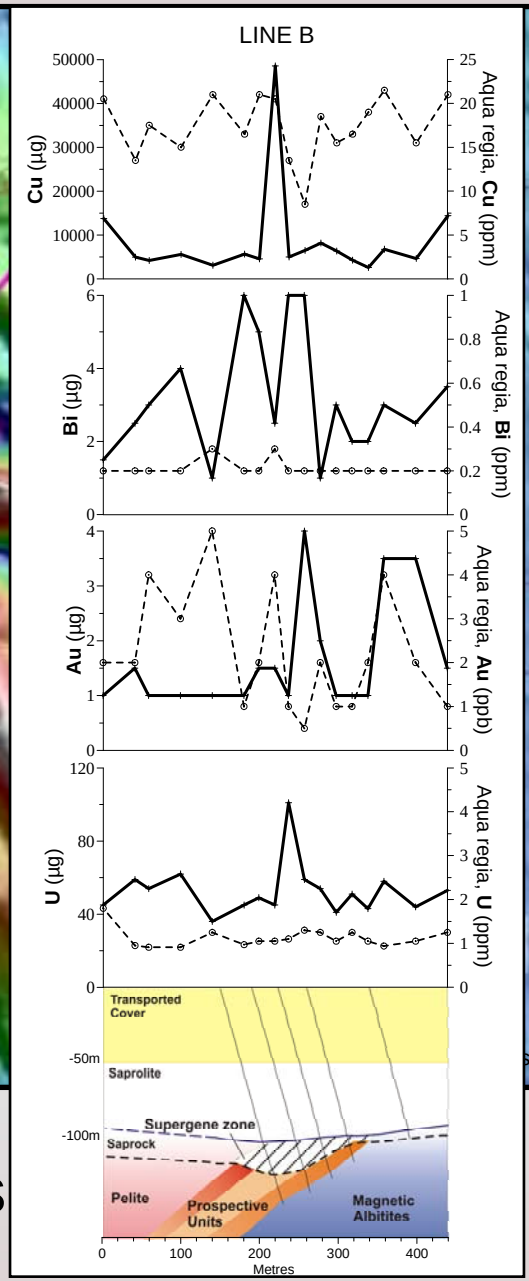
Kalkaroo Cu-Au-Mo

- Mineralisation within metasediments at 110m depth and ~ redox front
- Supergene zone common
- Regolith cover;
  - 30-50m Tertiary clay
  - 10m Quaternary clayey sand
  - 50m residual regolith









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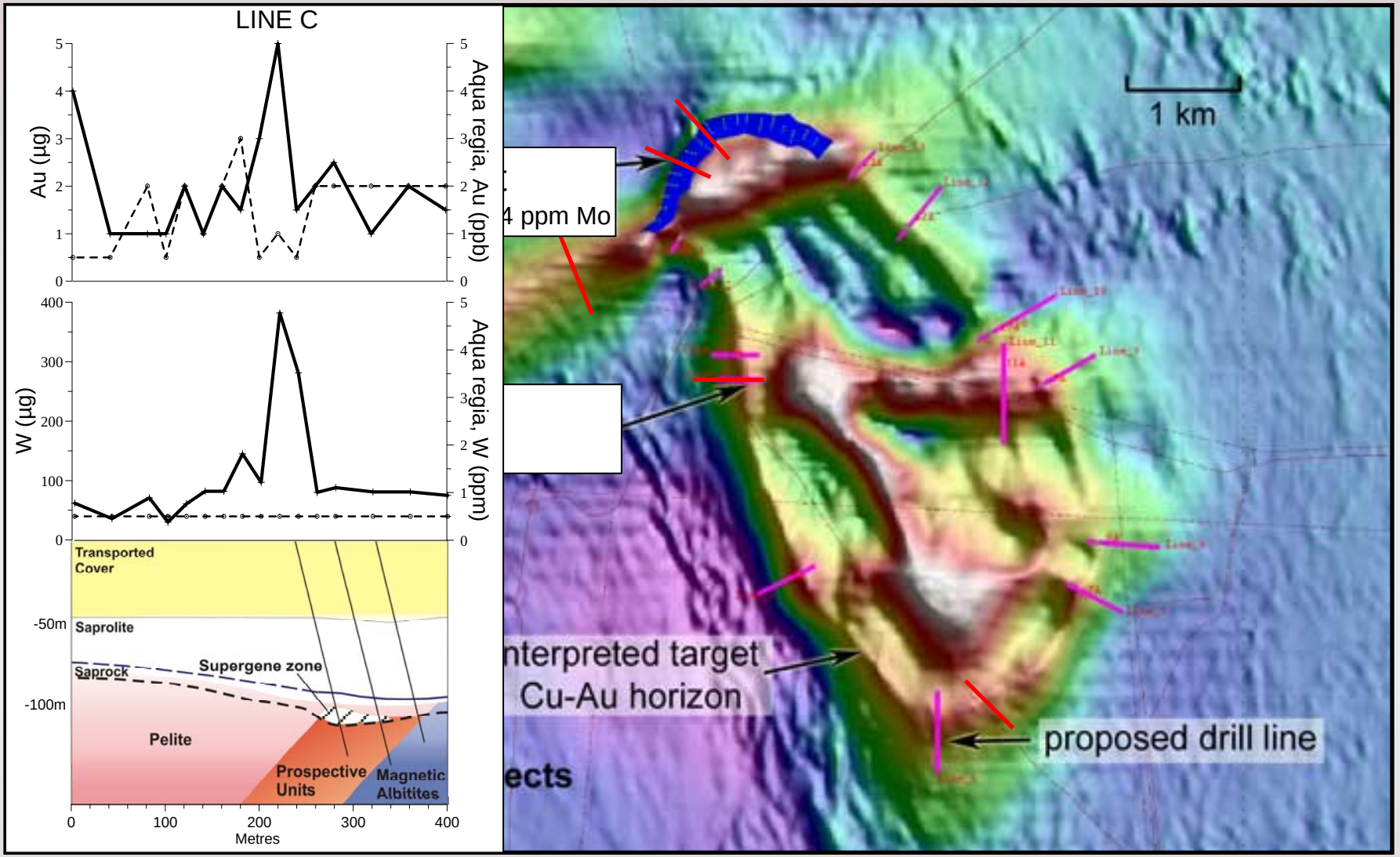
LINE C
Au (µg)
Aqua regia, Au (ppb)
W (µg)
Aqua regia, W (ppm)
Transported Cover
Saprolite
Saprock
Supergene zone
Pelite
Prospective Units
Magnetic Albitites
-50m
-100m
0
100
200
300
400
Metres
1 km
4 ppm Mo
nterpreted target
Cu-Au horizon
proposed drill line
ects

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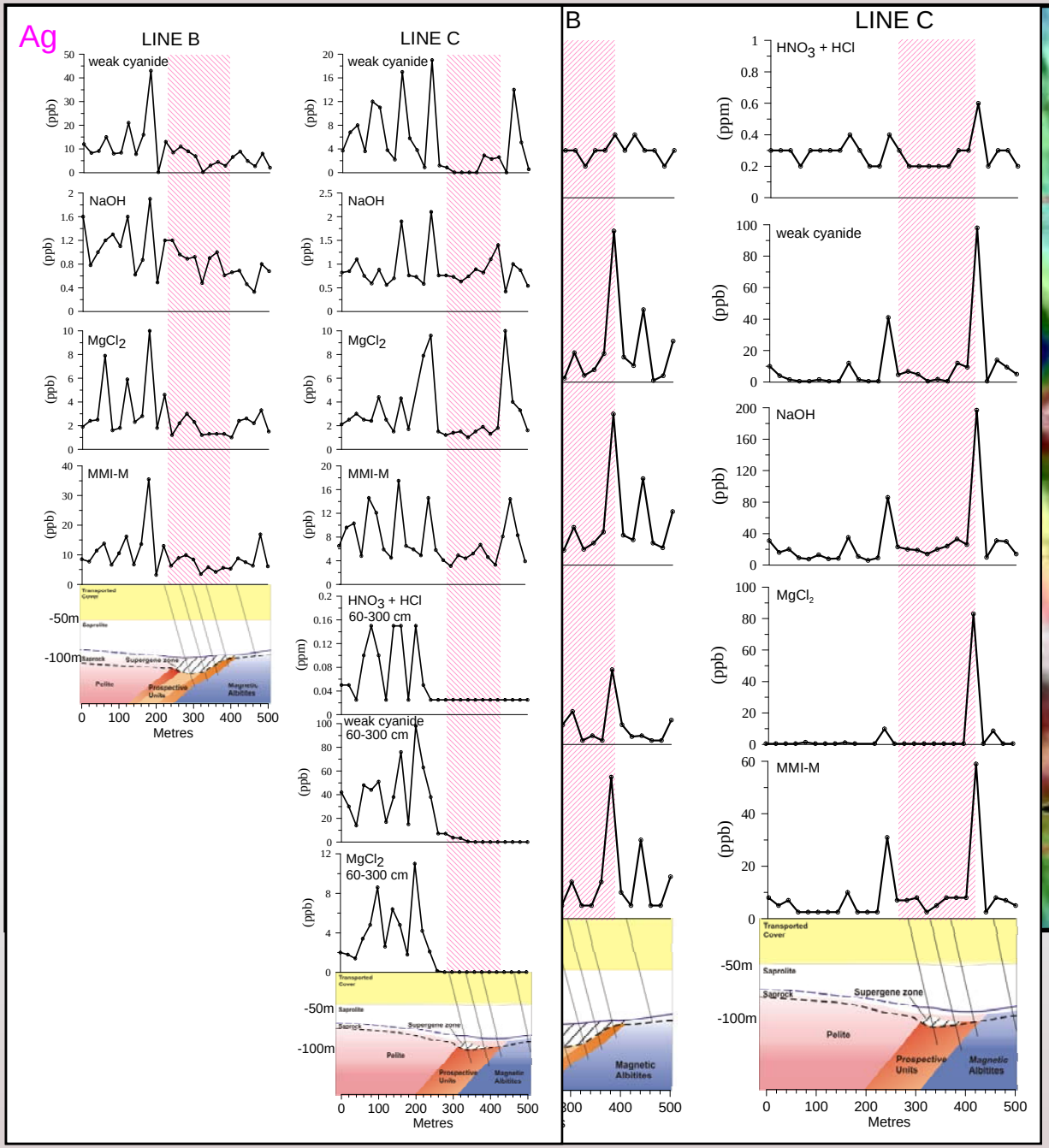

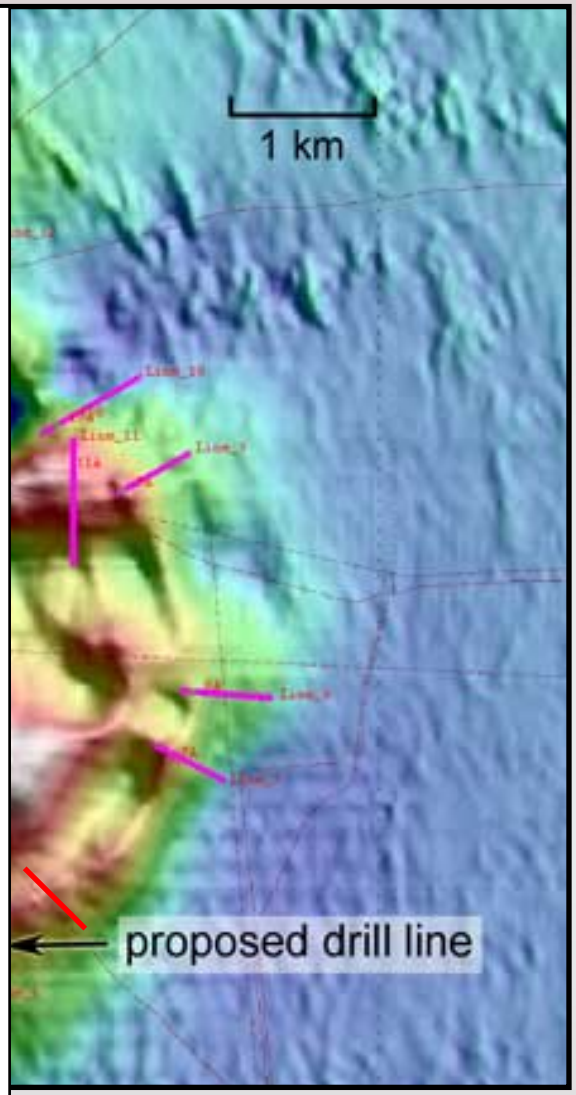

transported cover

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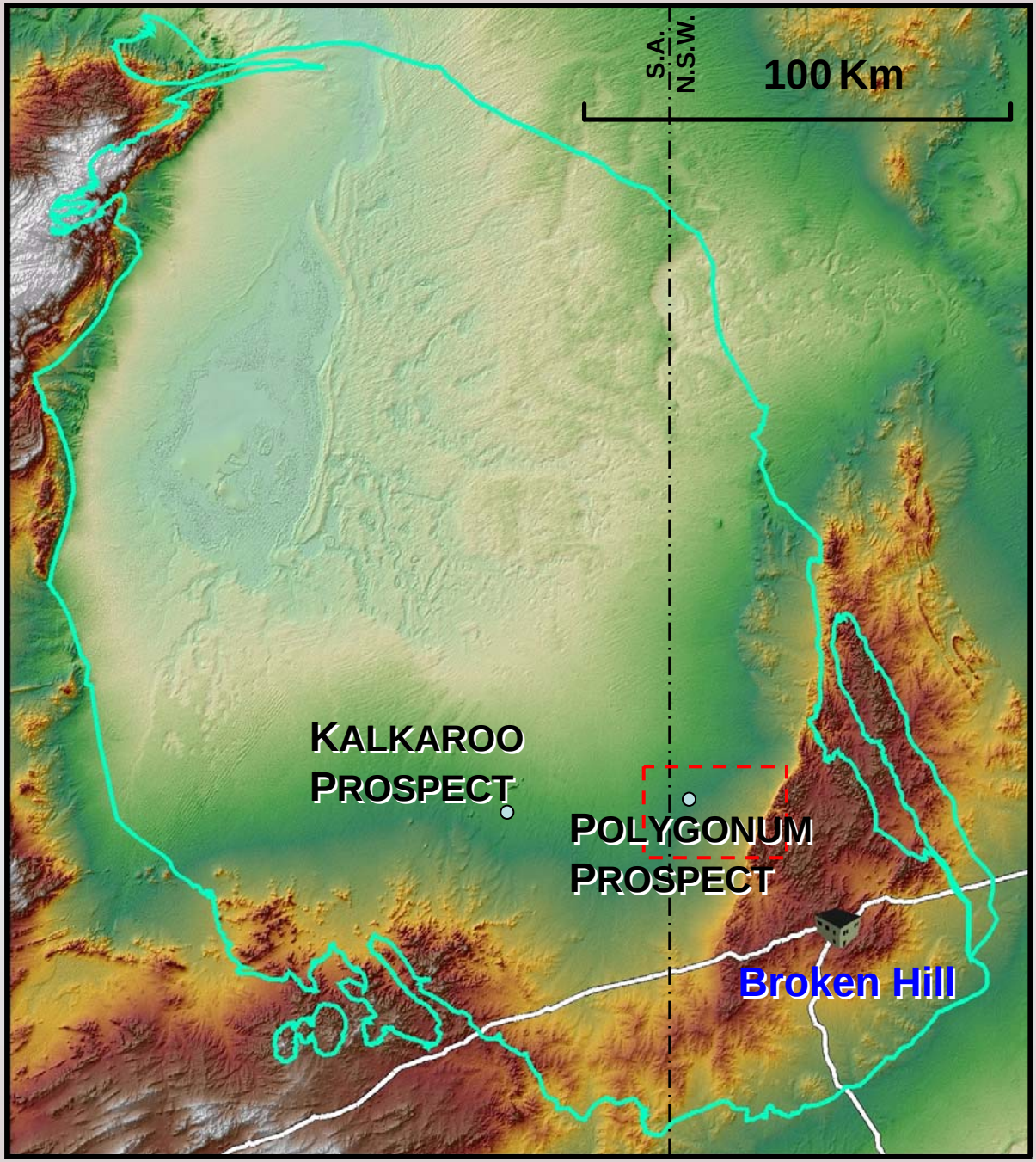
S.A.
N.S.W.
100 Km
KALKAROO
PROSPECT
POLYGONUM
PROSPECT
Broken Hill

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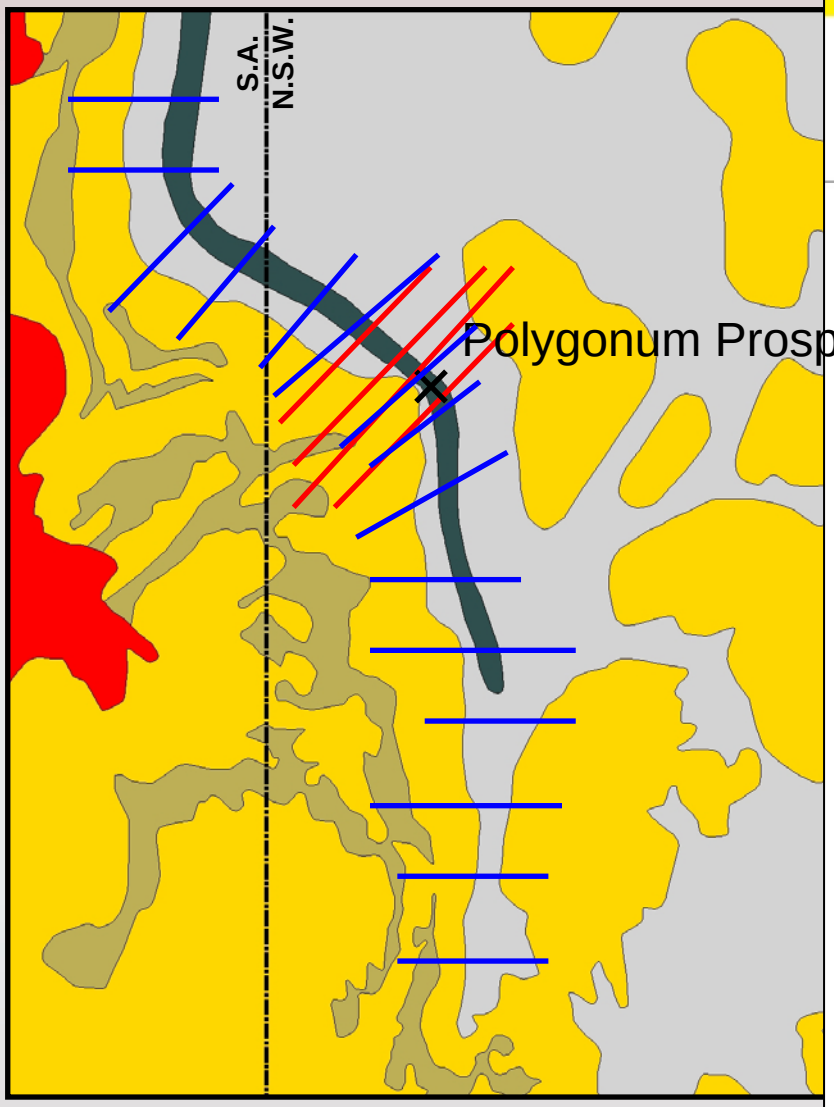

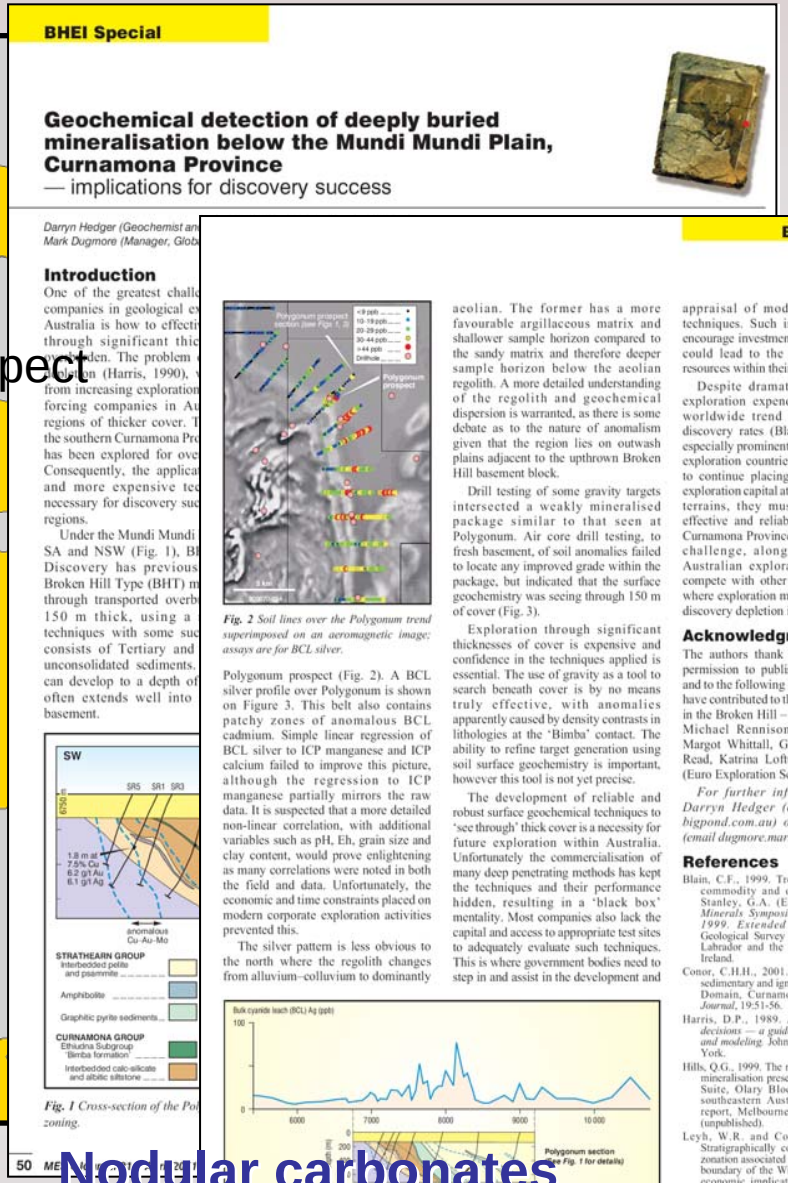

BHEI Special

Geochemical detection of deeply buried mineralisation below the Mundi Mundi Plain, Curnamona Province
— implications for discovery success

Darryn Hedger (Geochemist an
Mark Dugmore (Manager, Globa

Introduction

One of the greatest challe
companies in geological ex
Australia is how to effecti
through significant thic
n Hidden. The problem
ration (Harris, 1990),
from increasing exploration
forcing companies in Au
regions of thicker cover. T
the southern Curnamona Pro
has been explored for ove
Consequently, the applica
and more expensive tec
necessary for discovery suc
regions.

Under the Mundi Mundi
SA and NSW (Fig. 1), BH
Discovery has previous
Broken Hill Type (BHT) m
through transported overb
150 m thick, using a
techniques with some suc
consists of Tertiary and
unconsolidated sediments,
can develop to a depth of
often extends well into
basement.

Fig. 1 Cross-section of the Po
zoning.

50 ME

BHEI Special

Fig. 2 Soil lines over the Polygonum trend superimposed on an aeromagnetic image; assays are for BCL silver.

Polygonum prospect (Fig. 2). A BCL silver profile over Polygonum is shown on Figure 3. This belt also contains patchy zones of anomalous BCL cadmium. Simple linear regression of BCL silver to ICP manganese and ICP calcium failed to improve this picture, although the regression to ICP manganese partially mirrors the raw data. It is suspected that a more detailed non-linear correlation, with additional variables such as pH, Eh, grain size and clay content, would prove enlightening as many correlations were noted in both the field and data. Unfortunately, the economic and time constraints placed on modern corporate exploration activities prevented this.

The silver pattern is less obvious to the north where the regolith changes from alluvium–colluvium to dominantly aeolian. The former has a more favourable argillaceous matrix and shallower sample horizon compared to the sandy matrix and therefore deeper sample horizon below the aeolian regolith. A more detailed understanding of the regolith and geochemical dispersion is warranted, as there is some debate as to the nature of anomalism given that the region lies on outwash plains adjacent to the upthrown Broken Hill basement block.

Drill testing of some gravity targets intersected a weakly mineralised package similar to that seen at Polygonum. Air core drill testing, to fresh basement, of soil anomalies failed to locate any improved grade within the package, but indicated that the surface geochemistry was seeing through 150 m of cover (Fig. 3).

Exploration through significant thicknesses of cover is expensive and confidence in the techniques applied is essential. The use of gravity as a tool to search beneath cover is by no means truly effective, with anomalies apparently caused by density contrasts in lithologies at the 'Bimba' contact. The ability to refine target generation using soil surface geochemistry is important, however this tool is not yet precise.

The development of reliable and robust surface geochemical techniques to 'see through' thick cover is a necessity for future exploration within Australia. Unfortunately the commercialisation of many deep penetrating methods has kept the techniques and their performance hidden, resulting in a 'black box' mentality. Most companies also lack the capital and access to appropriate test sites to adequately evaluate such techniques. This is where government bodies need to step in and assist in the development and appraisal of modern geochemical techniques. Such involvement would encourage investment in exploration and could lead to the discovery of new resources within their States.

Despite dramatically increasing exploration expenditures, there is a worldwide trend of fast-declining discovery rates (Blain, 1999). This is especially prominent in so-called mature exploration countries. If companies are to continue placing large amounts of exploration capital at risk in these mature terrains, they must have access to effective and reliable techniques. The Curnamona Province faces a significant challenge, along with the entire Australian exploration industry, to compete with other parts of the world where exploration maturity is lower and discovery depletion is low.

Fig. 3 BCL silver profile of the Polygonum section, with the Polygonum prospect section

Acknowledgments

The authors thank BHP Minerals for permission to publish this information and to the following BHP personnel who have contributed to the exploration effort in the Broken Hill – Curnamona region; Michael Rennison, Richard Davis, Margot Whittall, Guy Gilbey, Jeremy Read, Katrina Loftus and Brett Rava (Euro Exploration Services).

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Pedogenic carbonates

- BLEG
- Aqua regia
- Terra Leach 1

Nodular carbonates

- Aqua regia

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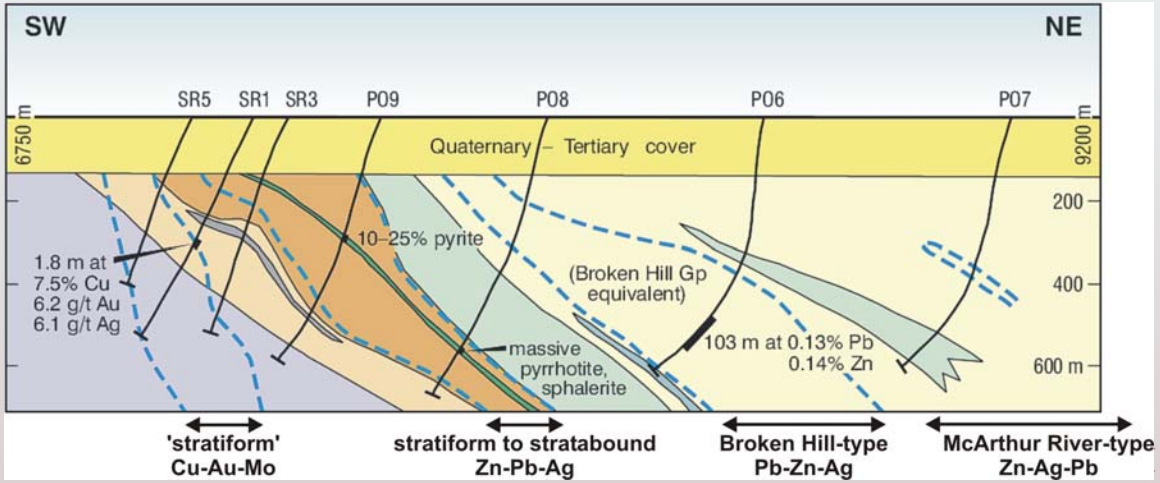
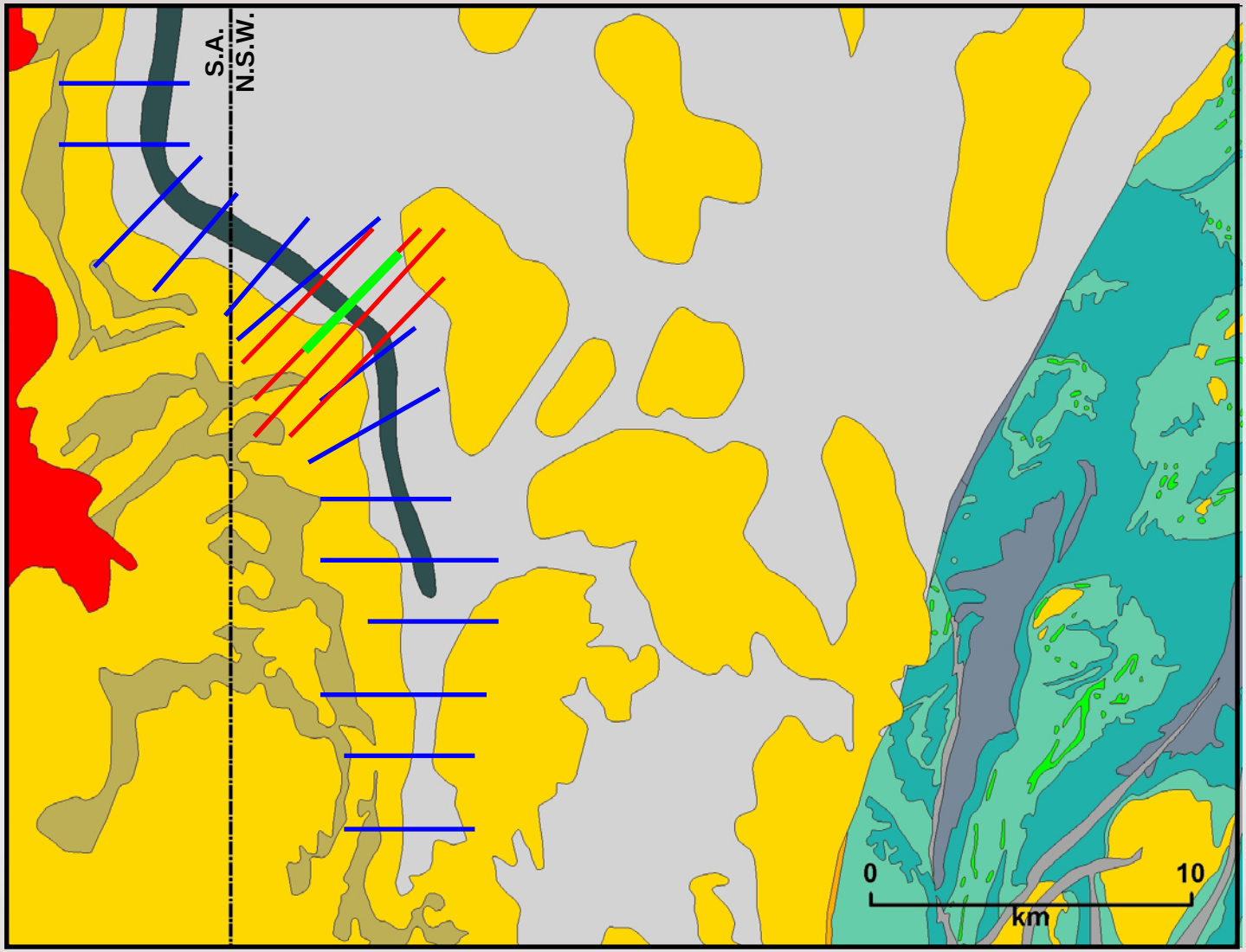
Polygonum – Platsearch NL Results

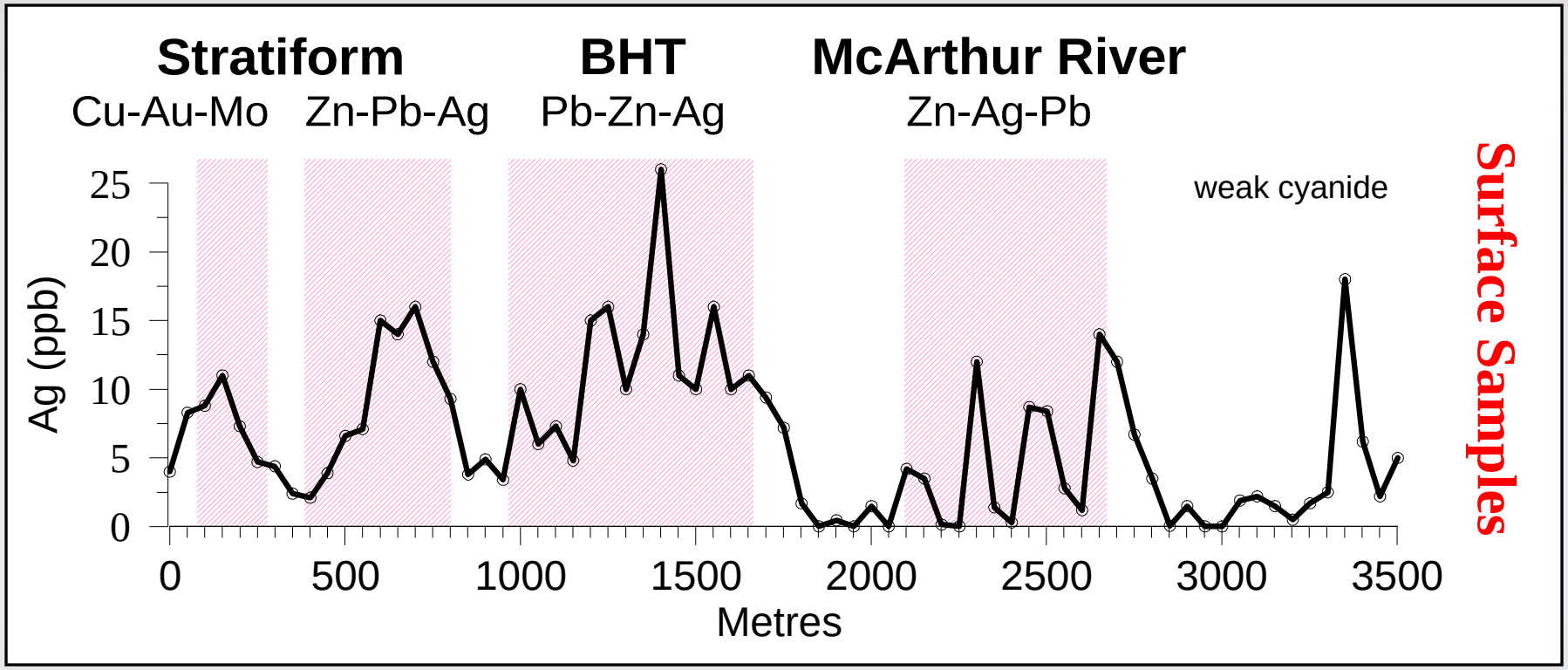
- **Repeated BHP Ag anomaly, most effectively using BLEG on pedogenic carbonate, Terra Leach 1 less so.**

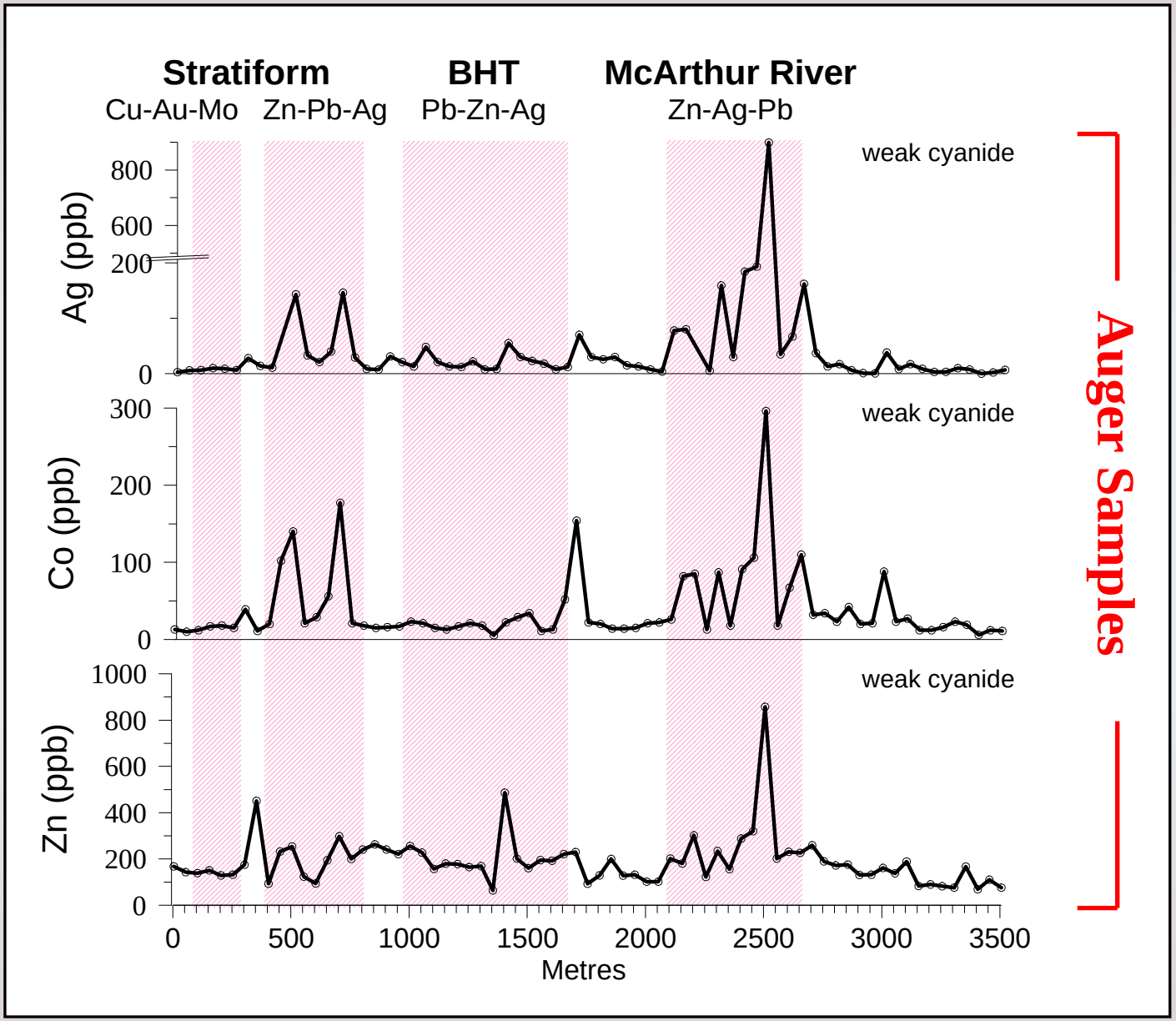
- **Suggestion of high background features in Cu, Zn, As, Co and Ni using aqua regia that correlated with underlying lithologies or extensive but low-level mineralisation.**

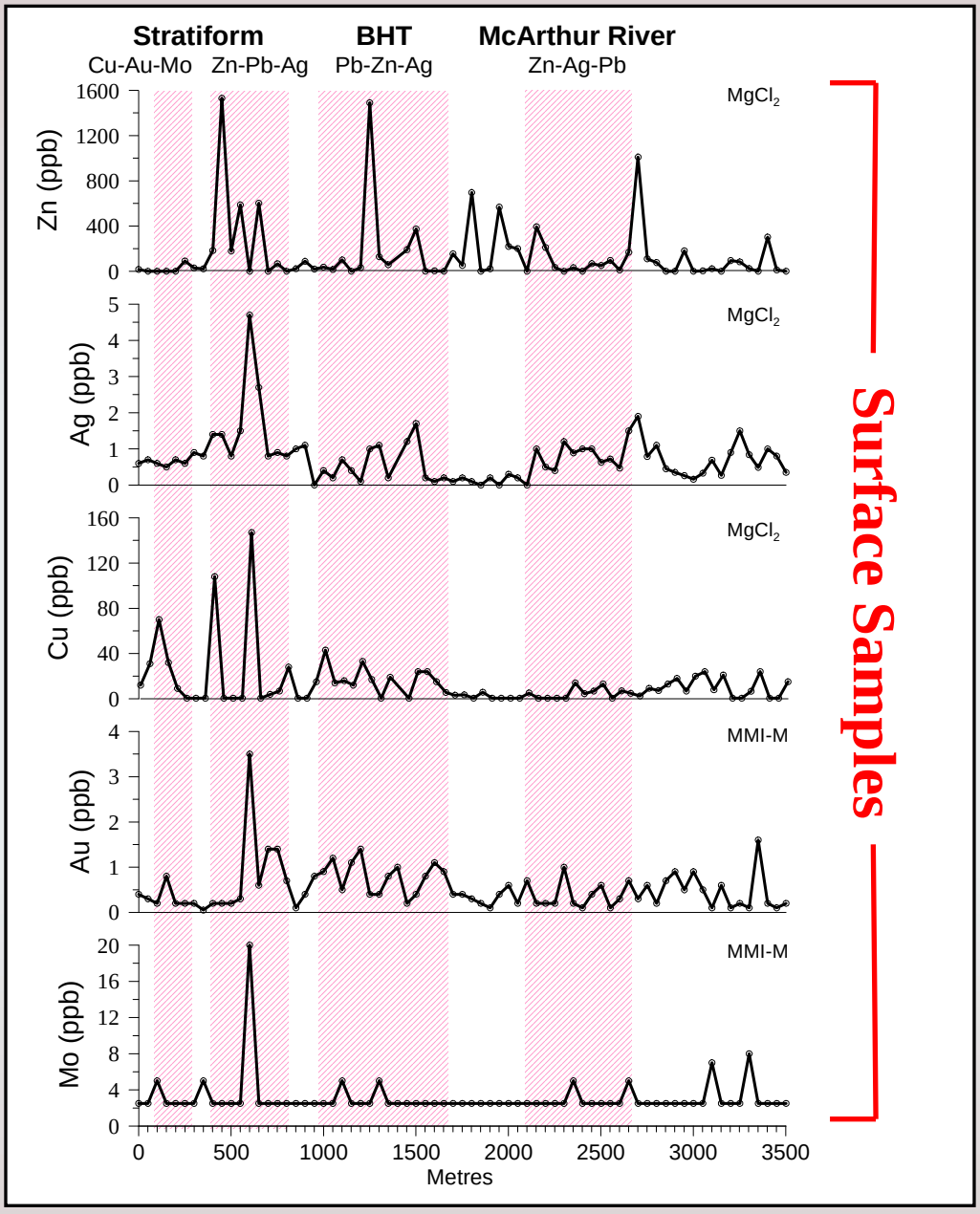
- **Sampling of the nodular and laminated calcrete was not successful in this area.**



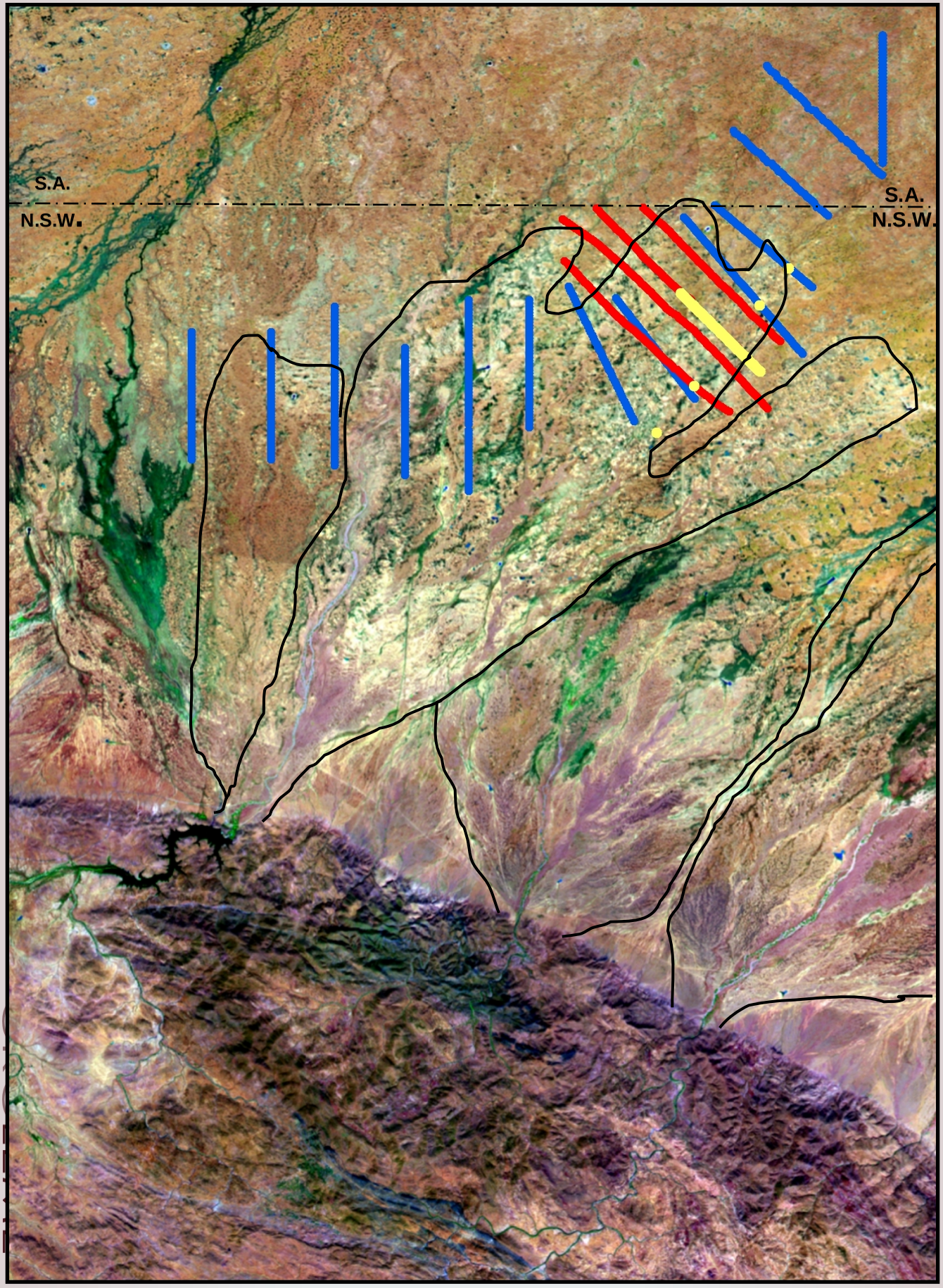

S.A.
N.S.W.
0
10
km

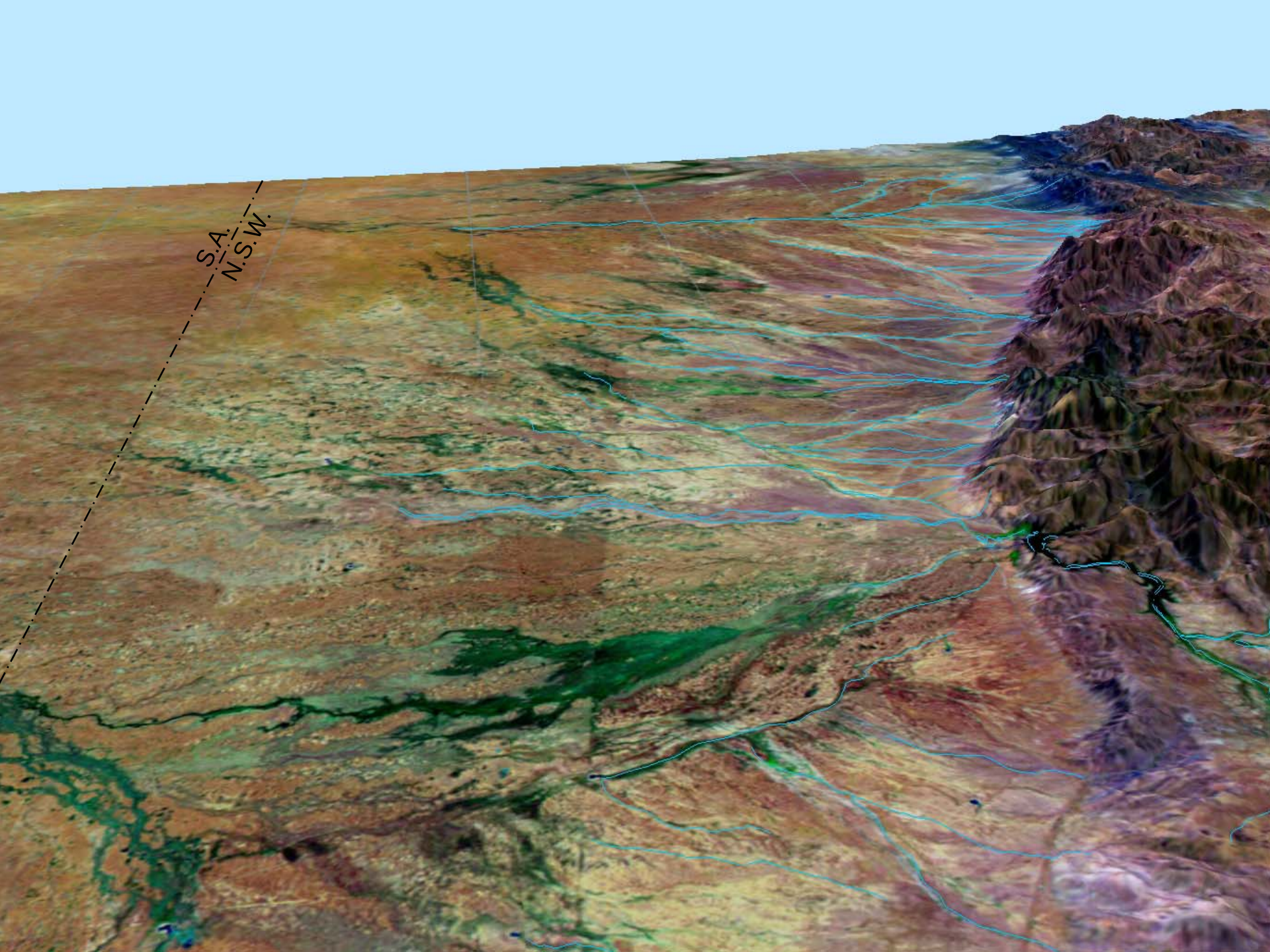

Stratiform
Cu-Au-Mo
Zn-Pb-Ag
BHT
Pb-Zn-Ag
McArthur River
Zn-Ag-Pb
weak cyanide
Surface Samples
Ag (ppb)
25
20
15
10
5
0
0
500
1000
1500
2000
2500
3000
3500
Metres


Stratiform
Cu-Au-Mo
Zn-Pb-Ag
BHT
Pb-Zn-Ag
McArthur River
Zn-Ag-Pb
weak cyanide
Ag (ppb)
800
600
200
0
weak cyanide
Co (ppb)
300
200
100
0
weak cyanide
Zn (ppb)
1000
800
600
400
200
0
0
500
1000
1500
2000
2500
3000
3500
Metres
Auger Samples

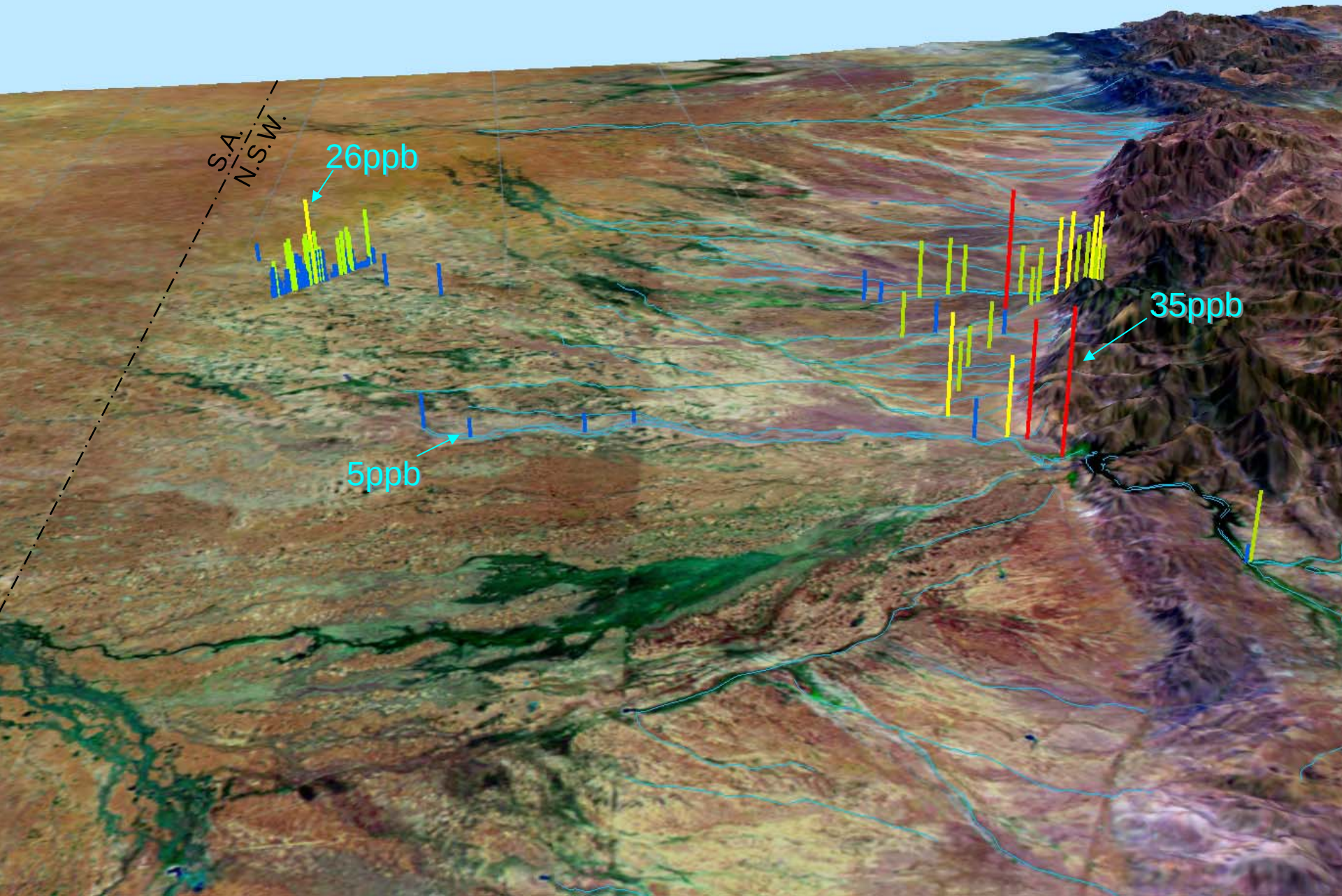

Stratiform
Cu-Au-Mo
Zn-Pb-Ag
BHT
Pb-Zn-Ag
McArthur River
Zn-Ag-Pb
Zn (ppb)
MgCl2
Ag (ppb)
MgCl2
Cu (ppb)
MgCl2
Au (ppb)
MMI-M
Mo (ppb)
MMI-M
Metres
Surface Samples


20km

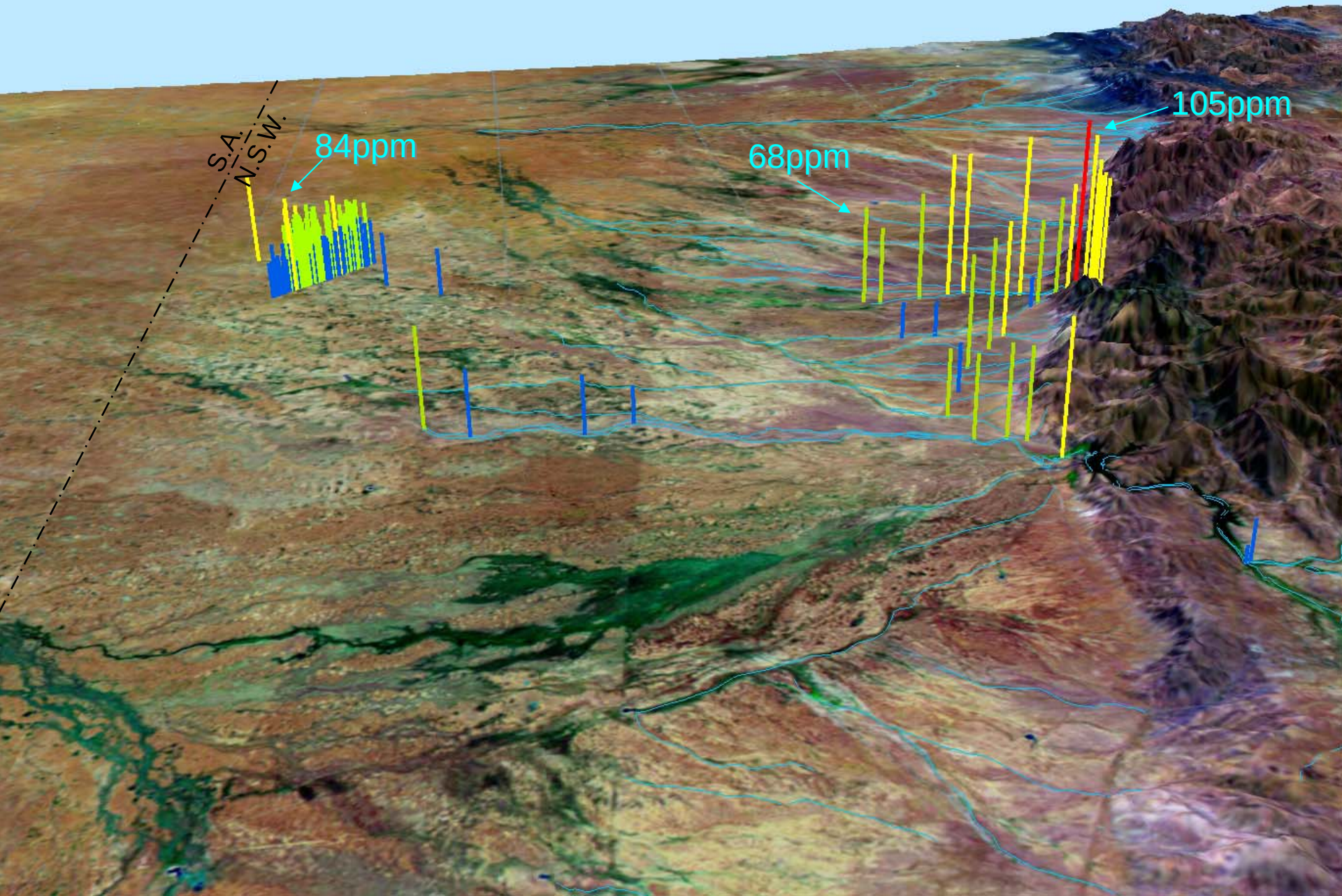

S.A.
N.S.W.
S.A.
N.S.W.


S.A.
N.S.W.

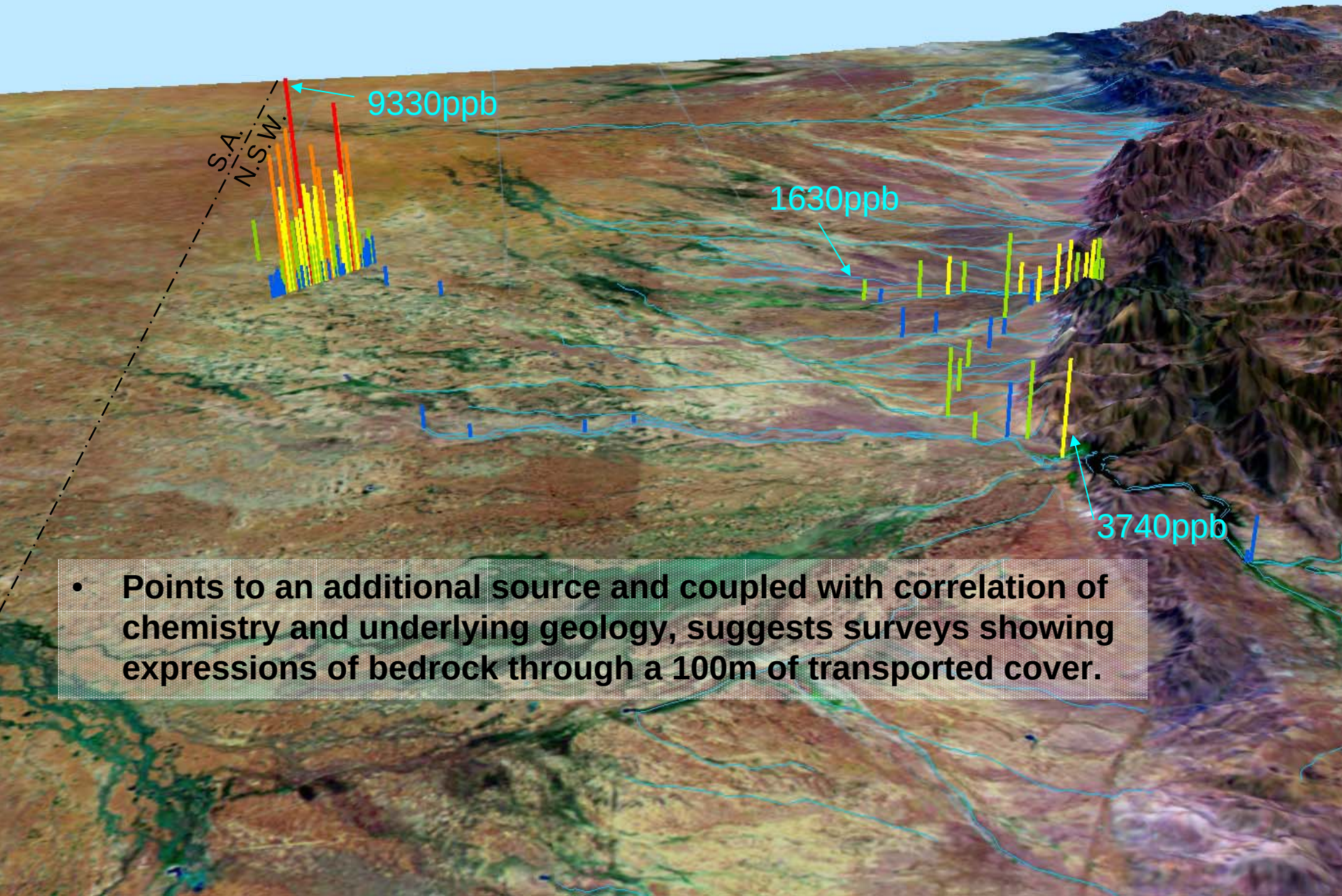
Ag – weak cyanide



Zn – aqua regia



Zn – weak cyanide



- **Points to an additional source and coupled with correlation of chemistry and underlying geology, suggests surveys showing expressions of bedrock through a 100m of transported cover.**

Summary

Exploration in areas of thick cover present significant challenges to the explorer. However, results such as;

- **the double-peaked Mo response to mineralised units (Kalkaroo),**
- **and apparent response in Ag to hanging wall units (Kalkaroo),**
- **elevated, multi-element responses over particular packages of strata &/or mineralisation at Polygonum,**

indicate that there is surface expressions of bedrock through as much as 100m of transported cover.