

Mineral Systems at Kalman, Cloncurry District

Mal Jones (GSQ)

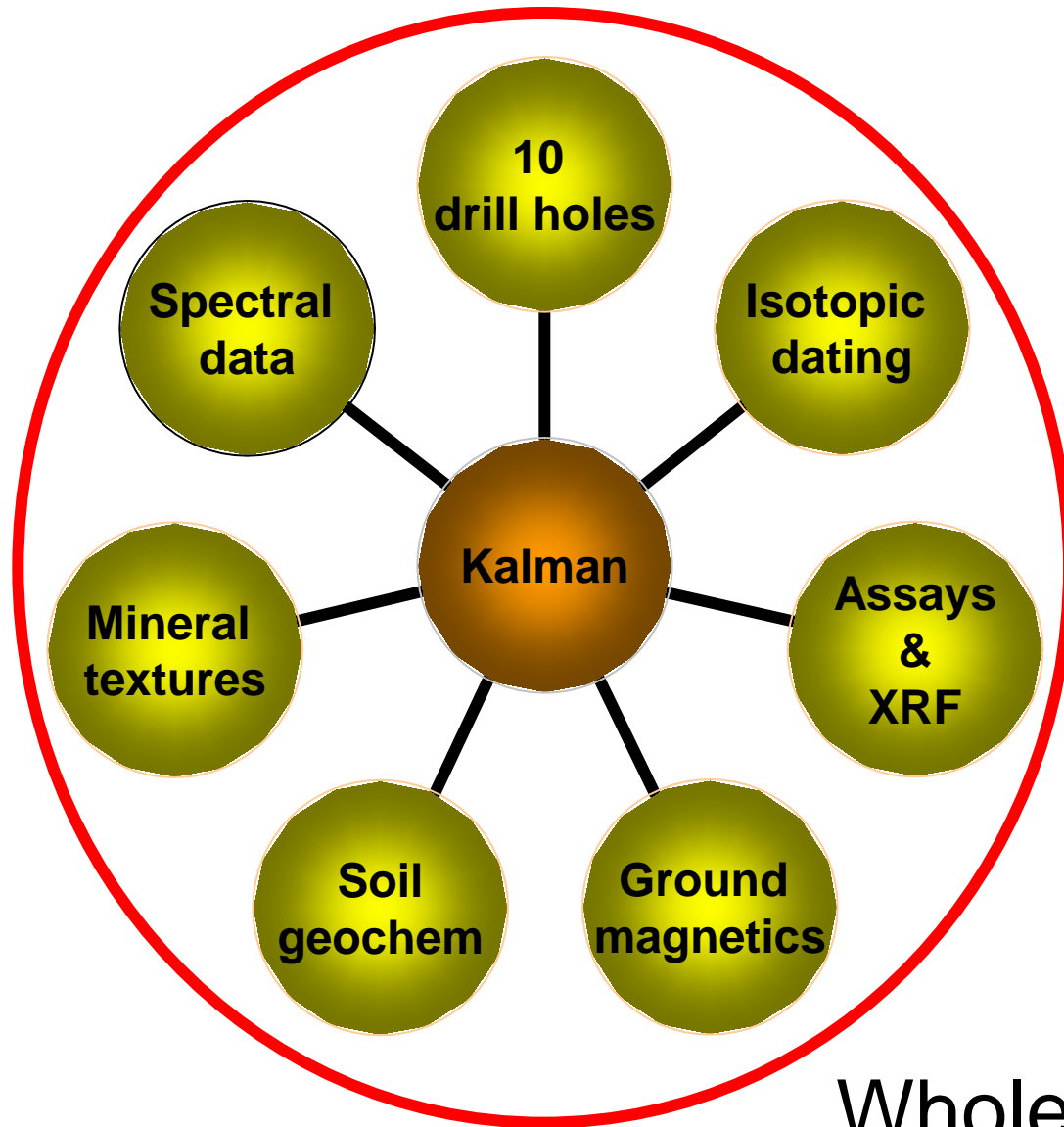
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Matthew Greenwood (GSQ)

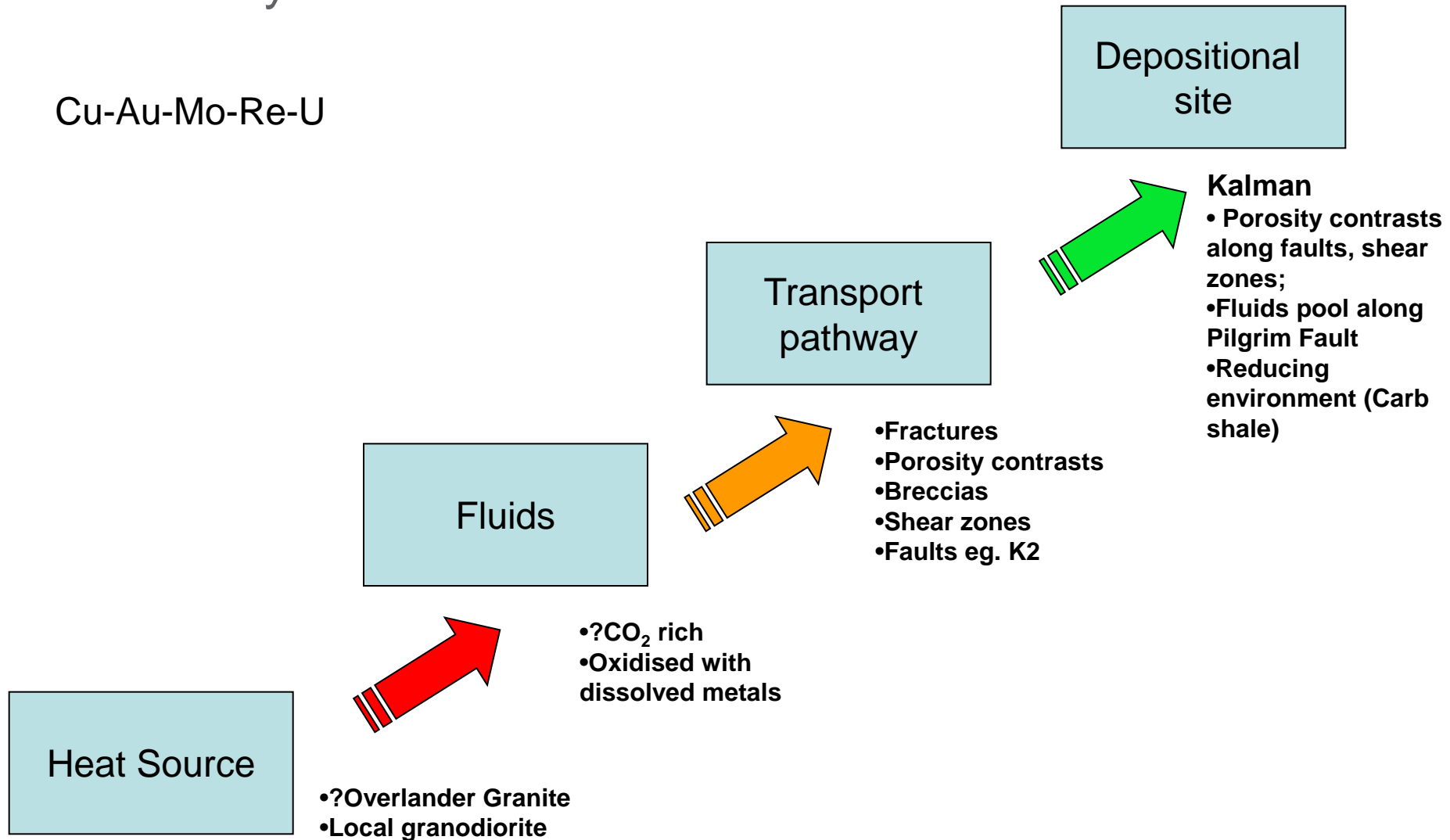
Data

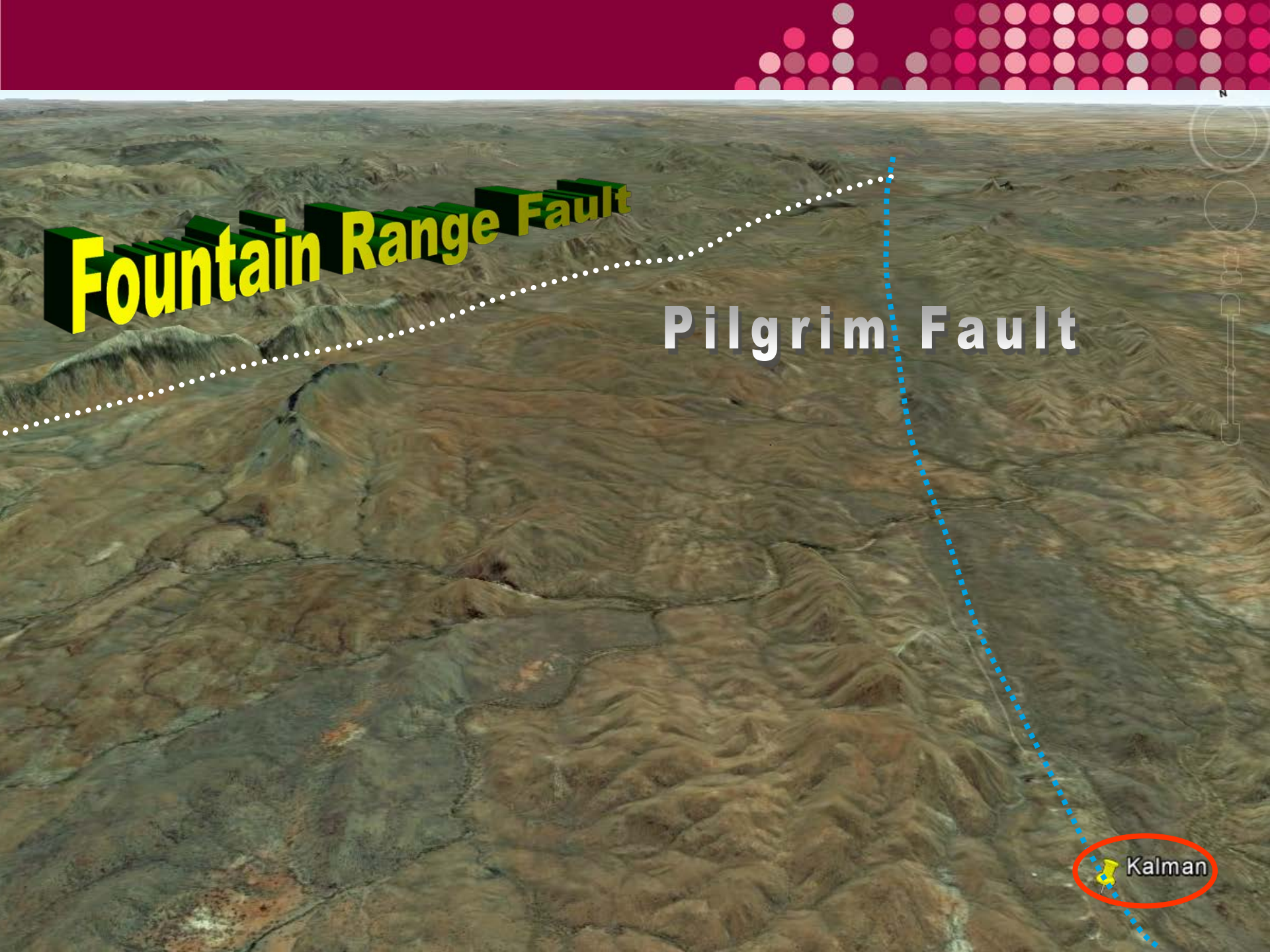


Whole=> Σ (parts)

Mineral System Model


Cu-Au-Mo-Re-U

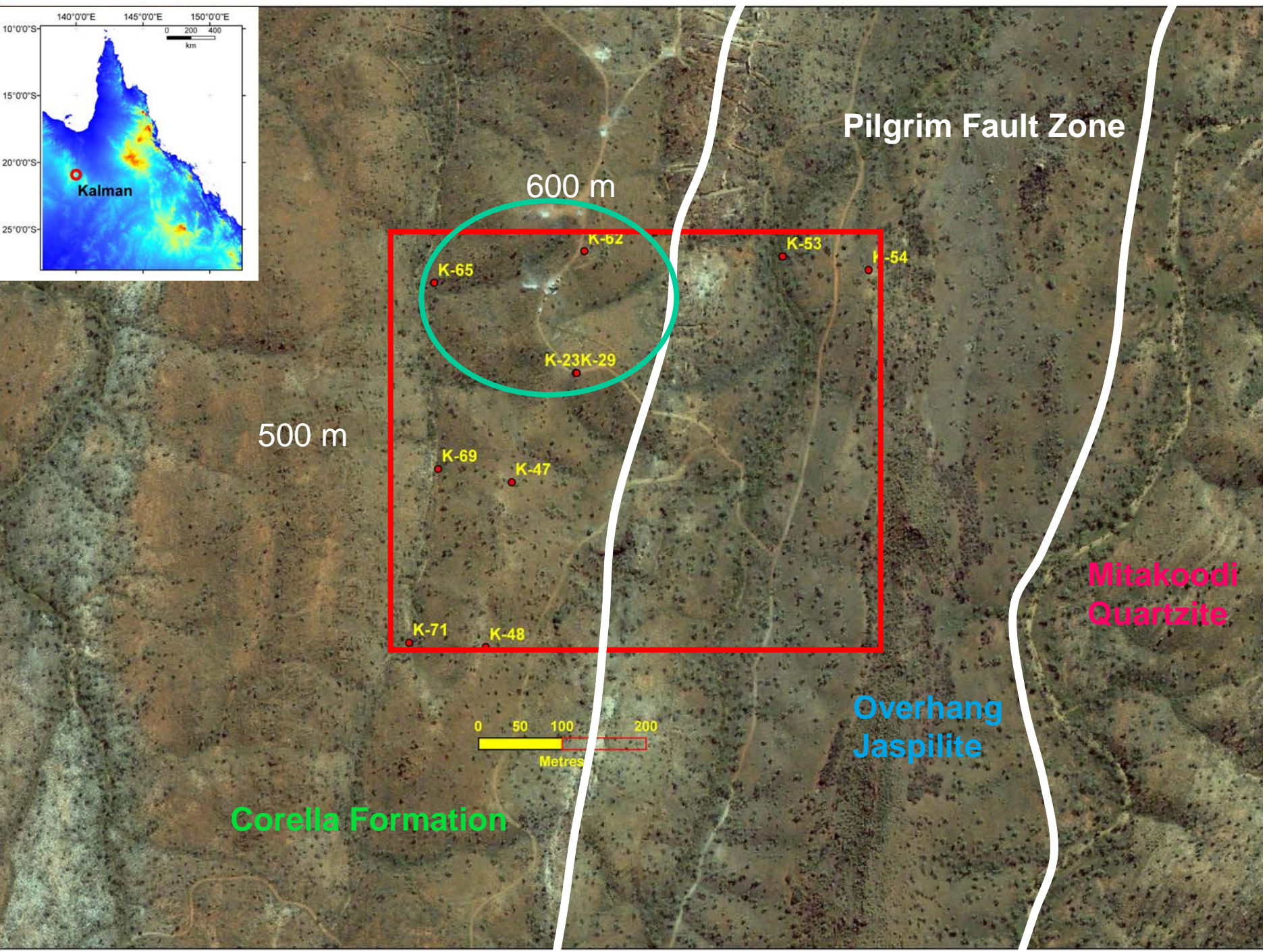
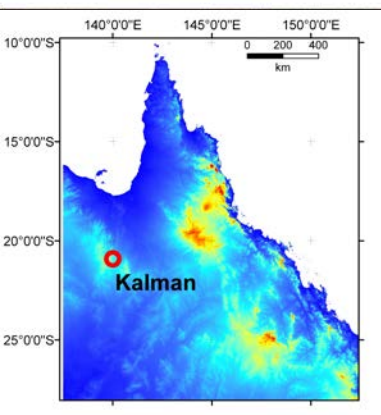




Fountain Range Fault

Pilgrim Fault

 **Kalman**



Mitakoodi Quartzite

Quartz vein

Carbonaceous shale



Breccia

Calcite

Metavolcanics



50 ppm Cu



Surface Cu stain

9.958557°

Cu in soil

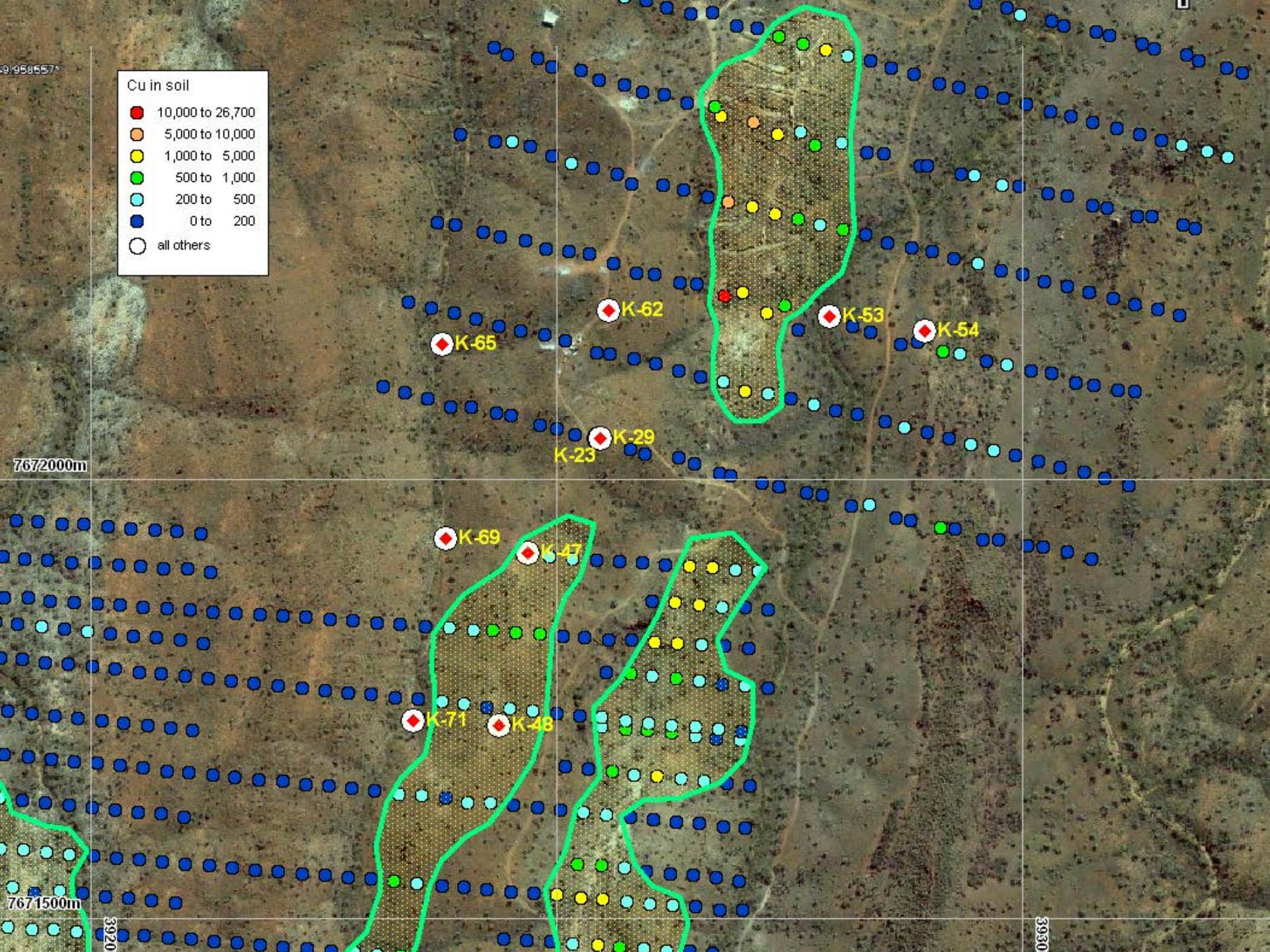
- 10,000 to 26,700
- 5,000 to 10,000
- 1,000 to 5,000
- 500 to 1,000
- 200 to 500
- 0 to 200
- all others

7672000m

7671500m

3920

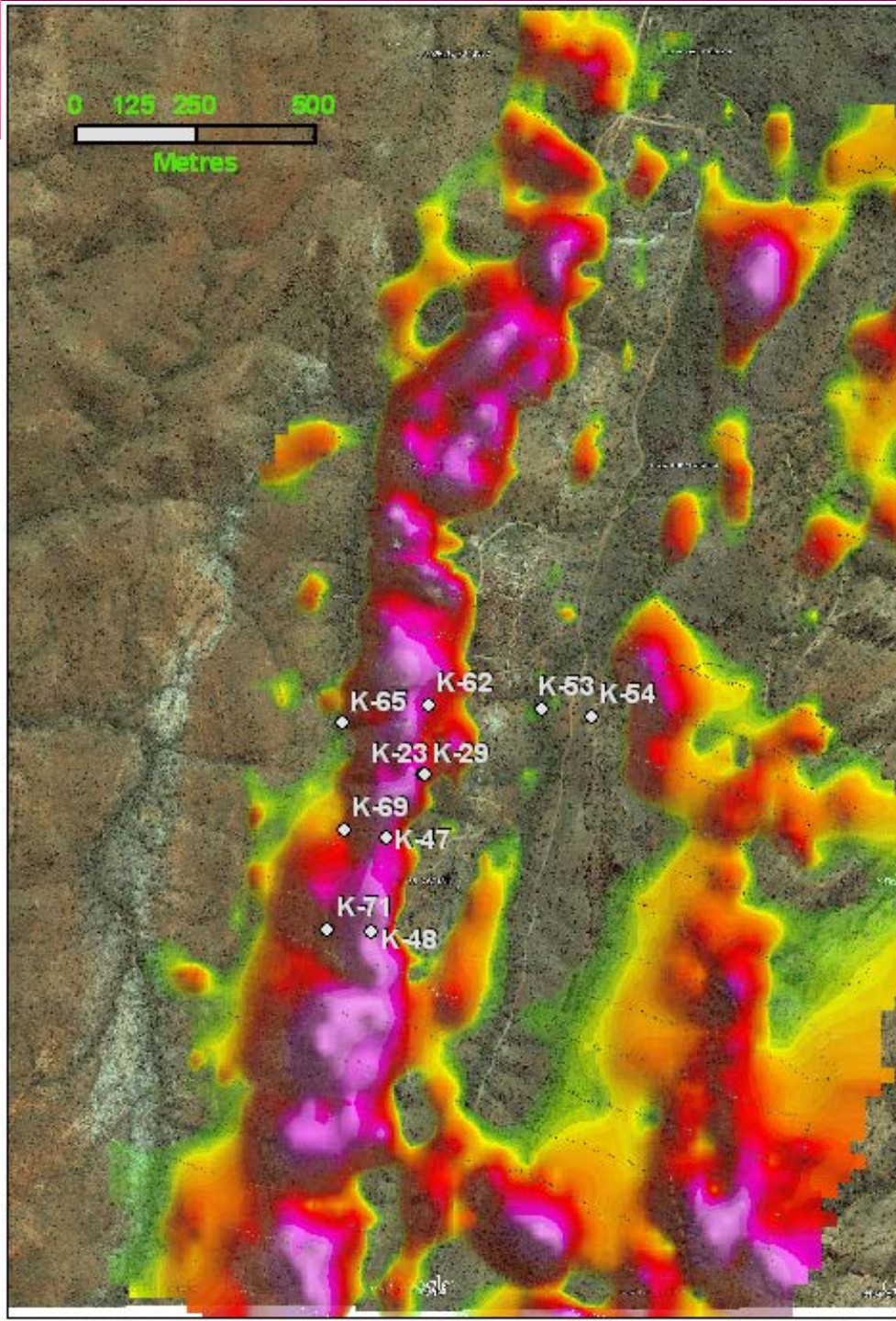
3930





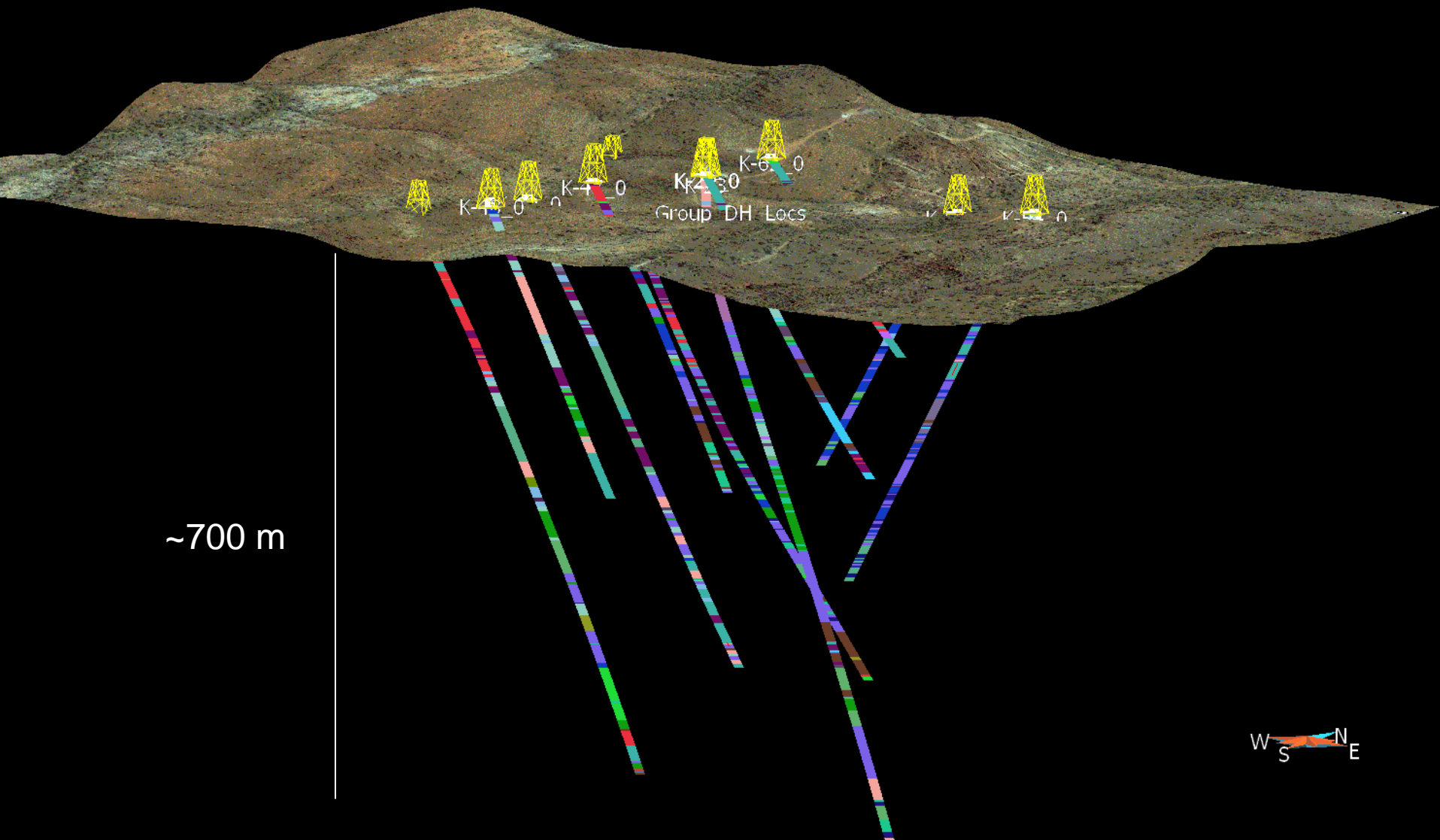
Xalman

Cu >200 ppm



Ground magnetics:
Investigates subsurface

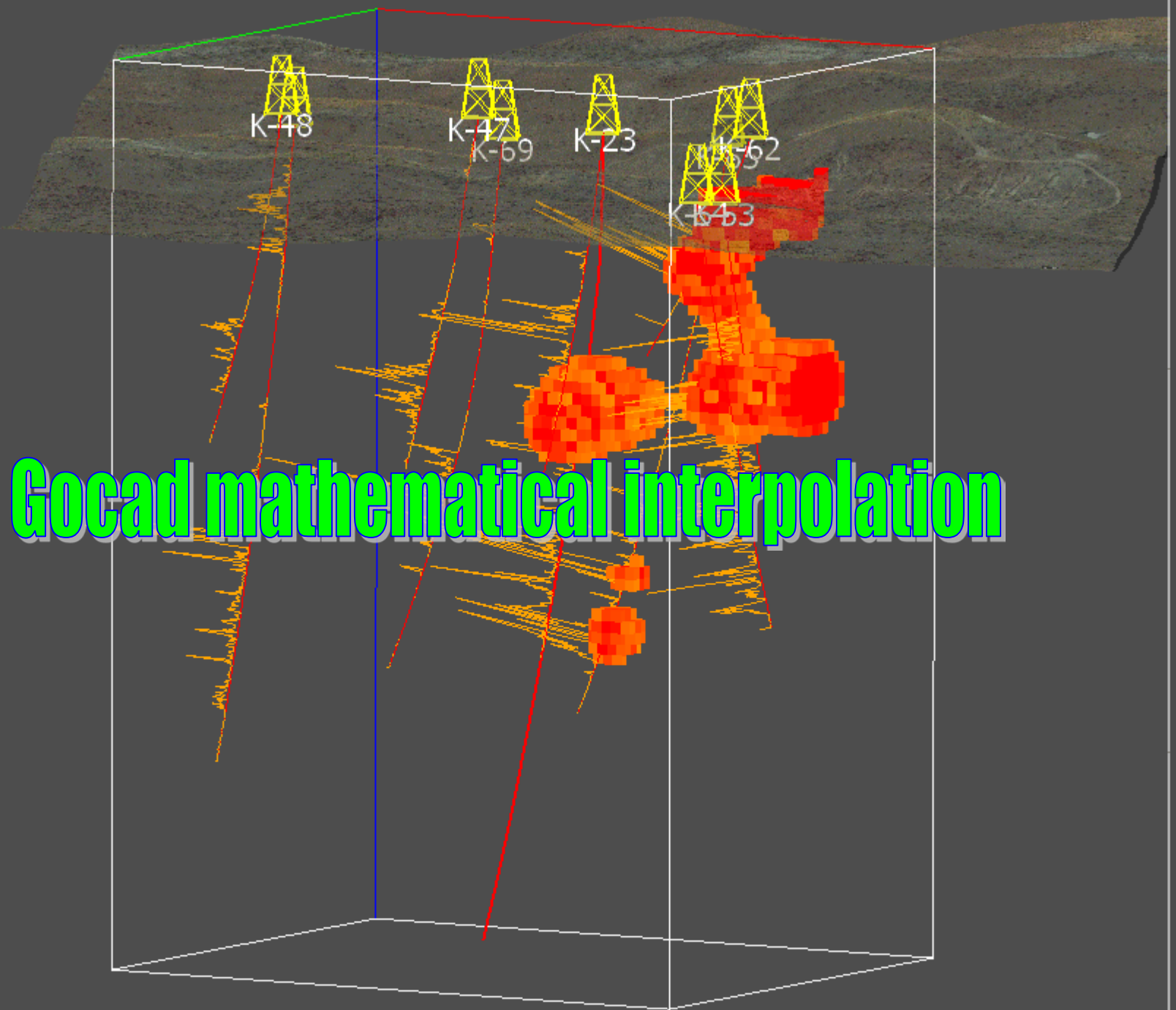
3D environment





Shape of the Cu ore body – Gocad interpolations

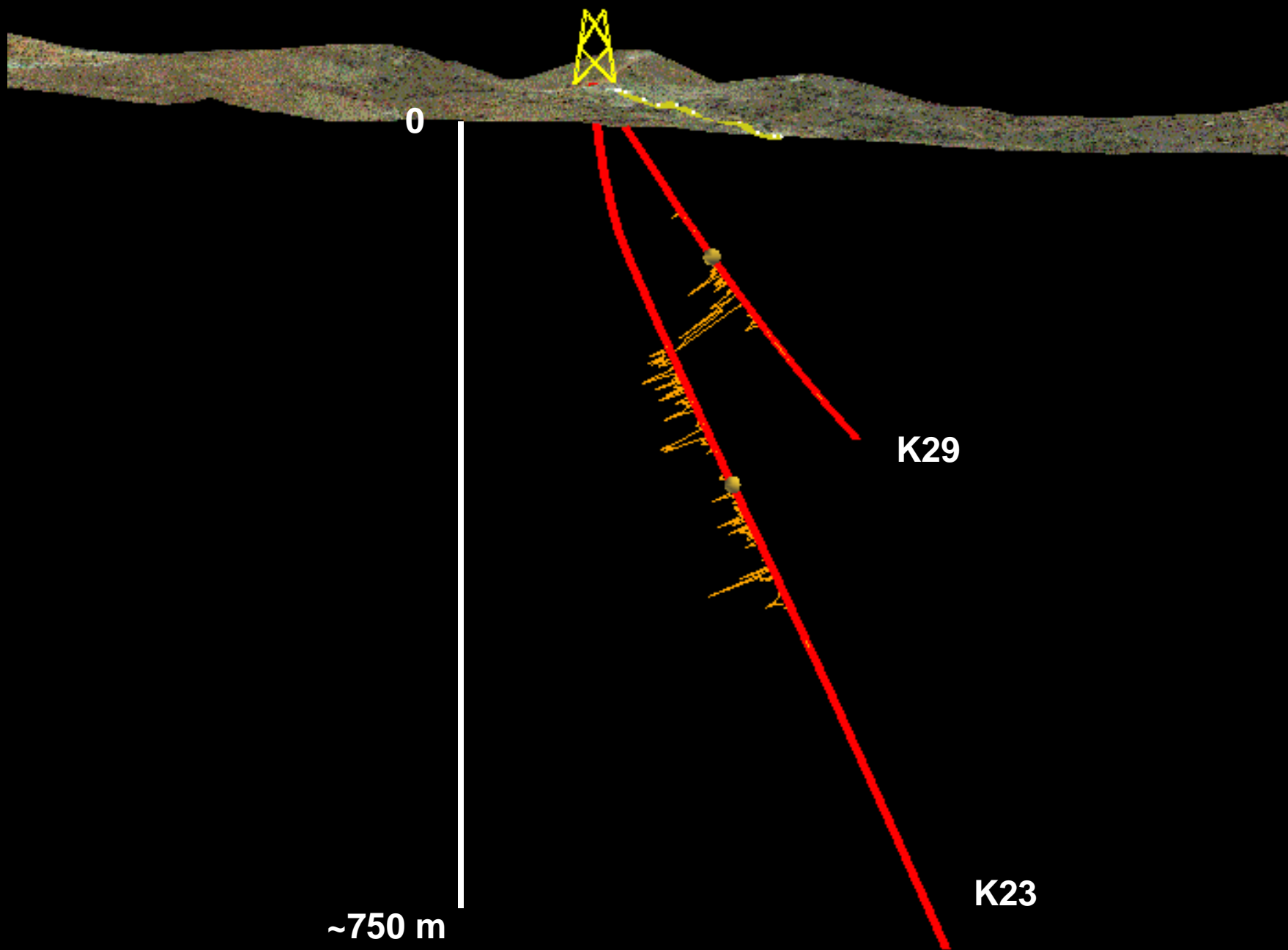
- Based on assay data



Gocad mathematical interpolation

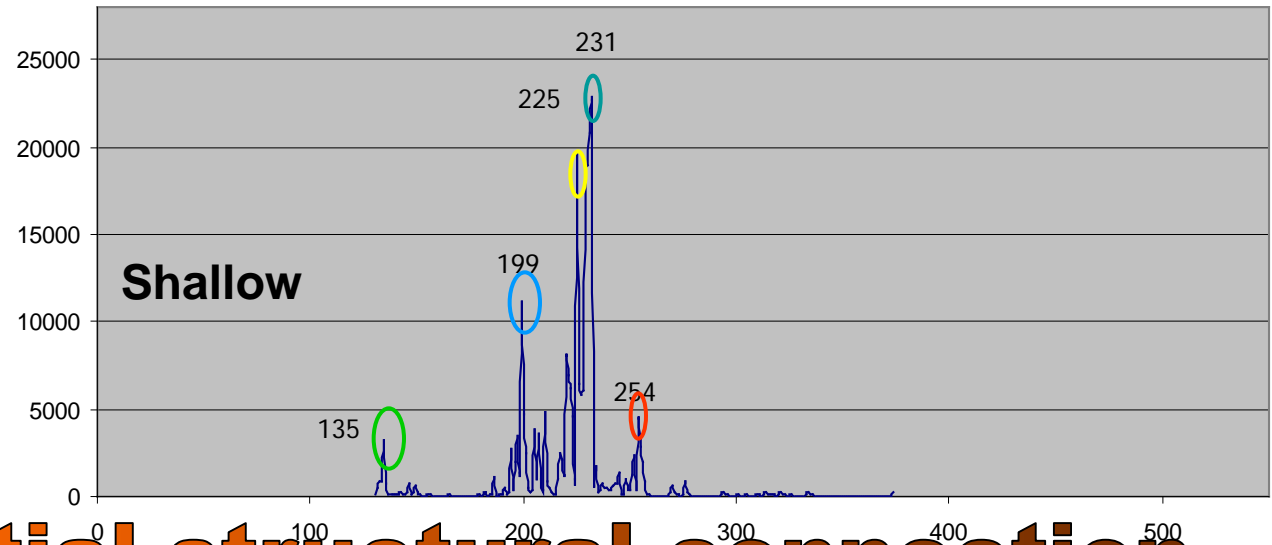


Continuity in detail, and controls on mineralisation



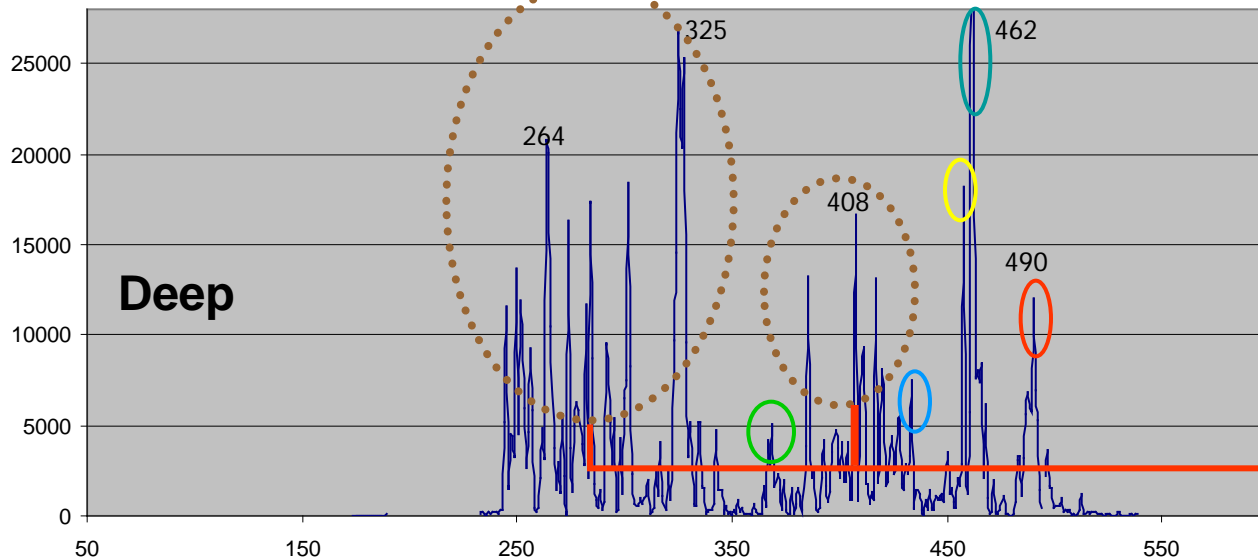
Ore body Fingerprinting Cu

K29 - Cu assays



**Infer partial structural connection
between K23 & K29**

K23 - Cu assays

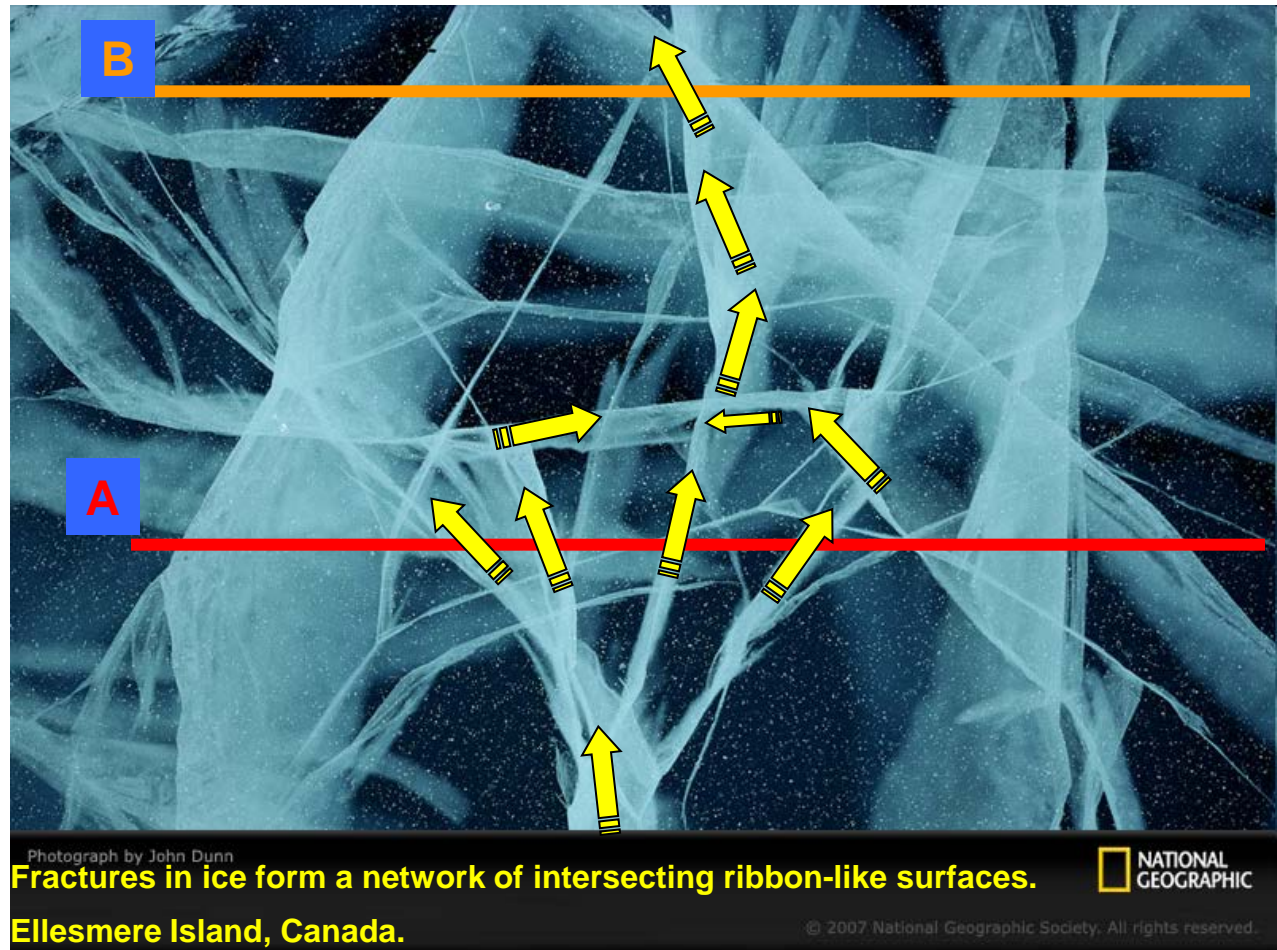


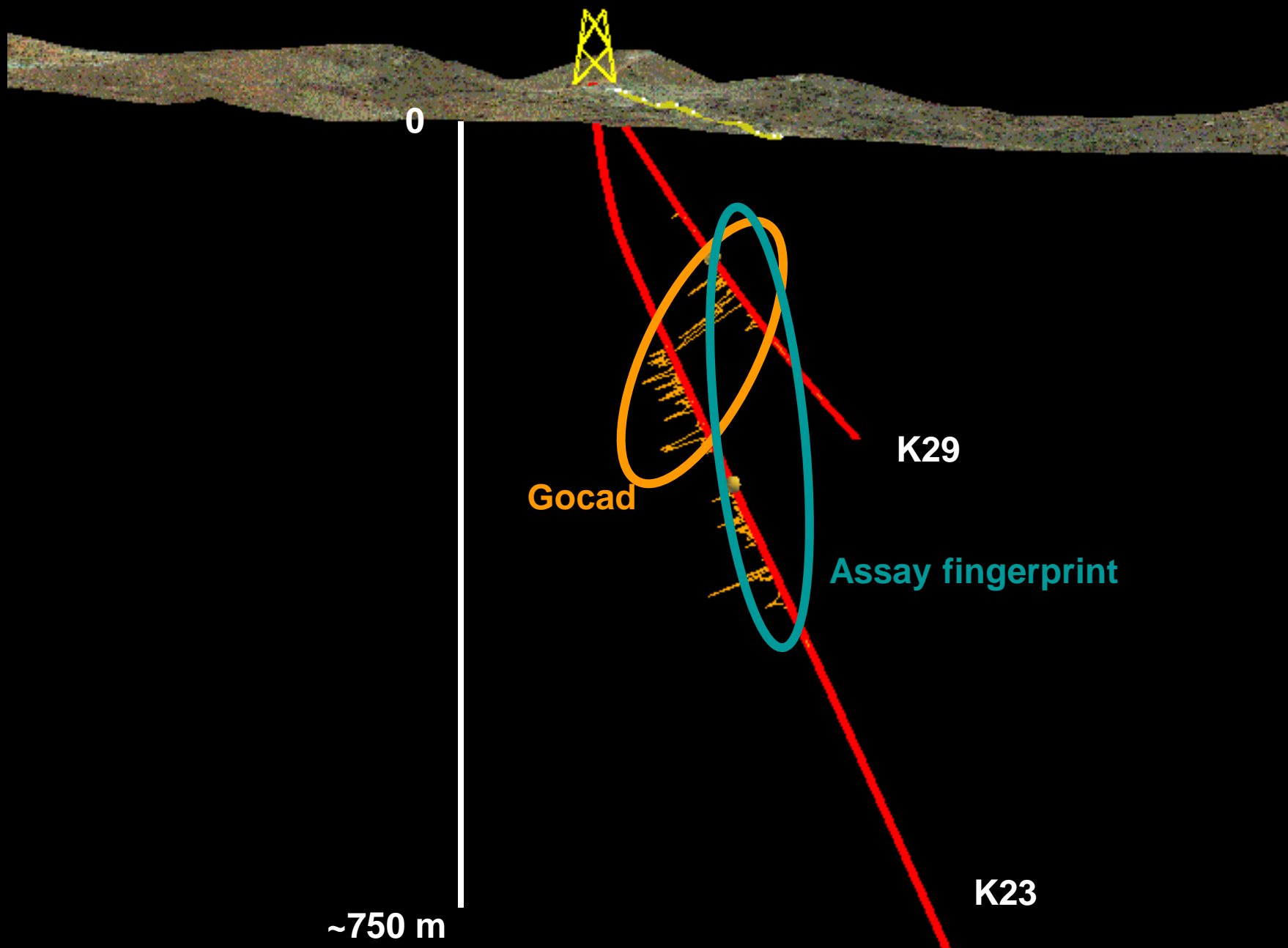
K23 intersection

- More peaks = closer to source, or
- contains separate additional mineralisation

Fracture analog

- Fracturing occurs due to external stress fields
- Expressed as complex intersecting fracture surfaces
- **Fractures form irregular planes of low pressure**
- Low pressure areas provide pathways for migrating fluids







Episodicity of mineralisation

- K65 – Mineral associations

K65

Cu

Four main Cu zones – may reflect branching fluid pathways
Third is most significant
Sharp ramp-up at top of first zone

Au

Anomalies correlate with Cu zones 1 (2) & 3
Zone 1 better defined by Cu than Au
Main Au, and 3rd Cu peaks match
Two high Au peaks around 600 m not matched by any other metals
Suggests Cu- and Au-bearing fluids used two of the same pathways
Cu and Au may have been carried by same fluids, and separately

Mo

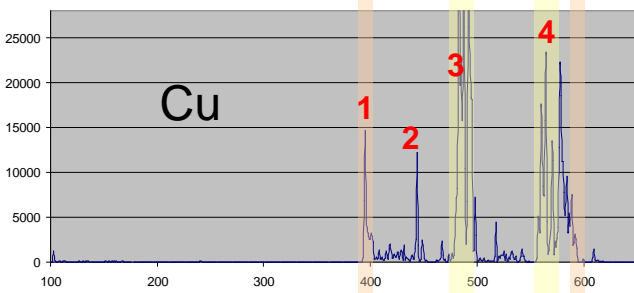
Lo value Mo anomalies of limited extent
Largest anomaly matches flank of deepest Cu anomaly
Suggests Cu 1,3,4, with Au have some association with weak Mo
Low retention of Mo from mineral fluids

U

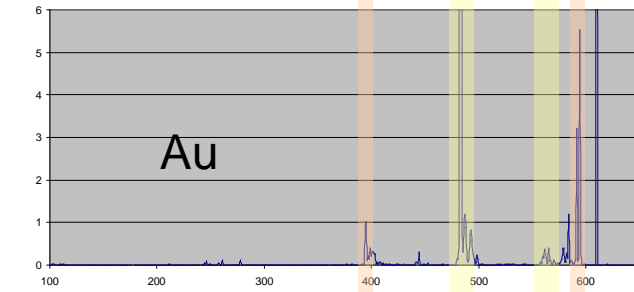
Two striking U anomalies
Single match with Cu-Au (Zone 1)
Some U may have accompanied Cu-Au mineralisation
Some separate U associated with weak Cu

Possible Separate Episodes:
Cu-(Au)-U; Cu; Cu-Au; U-(Cu); Au

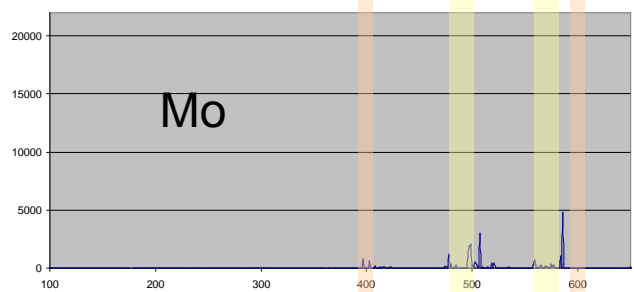
K65 - Cu assays



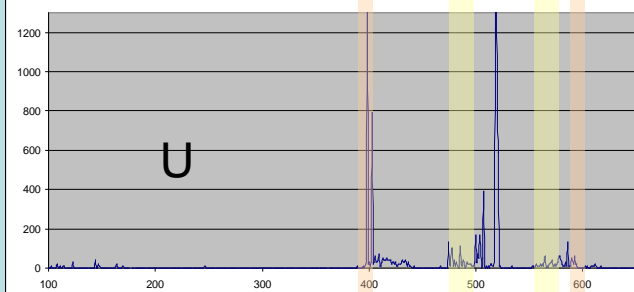
K65 - Au assays



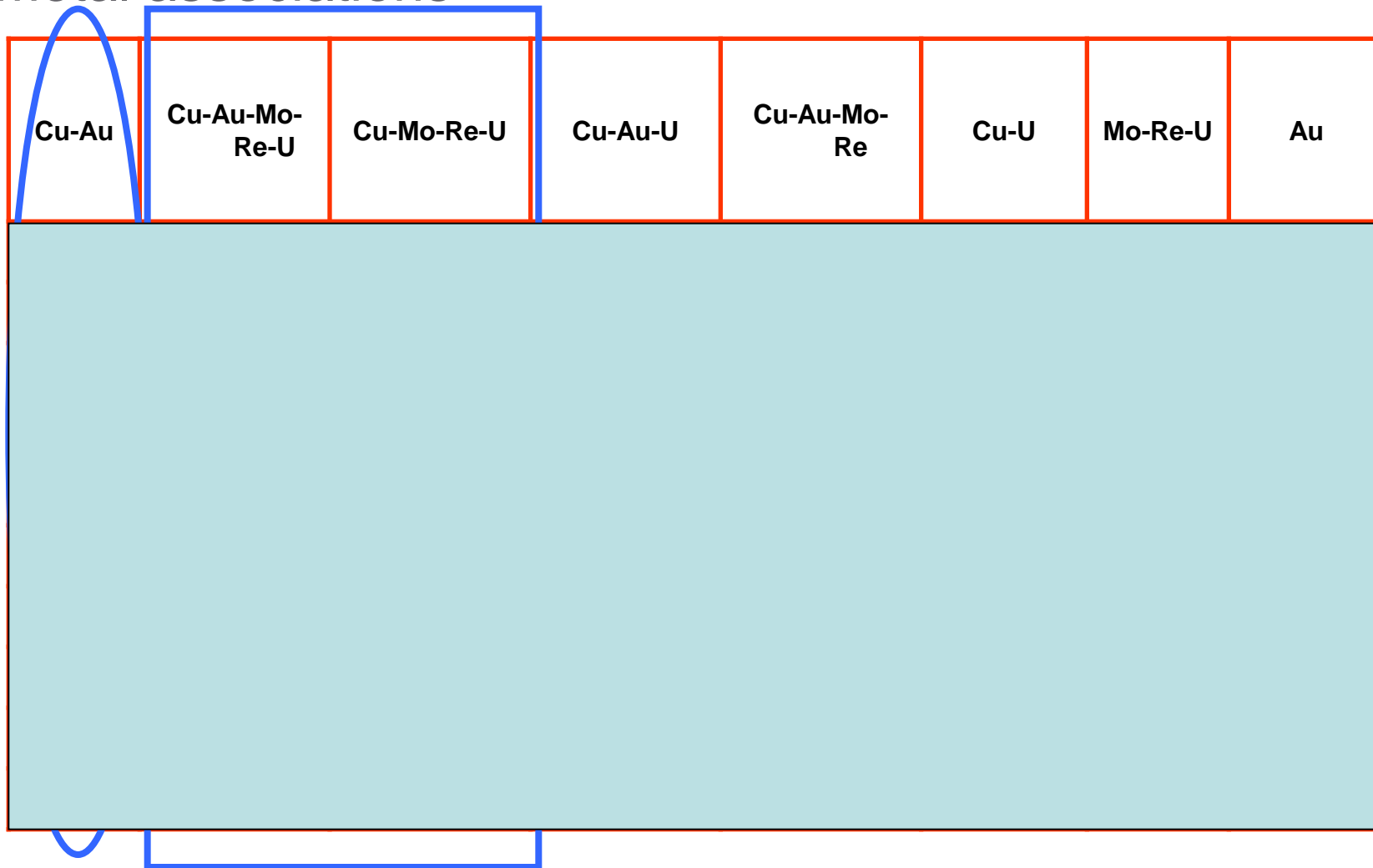
K65 - Mo assays



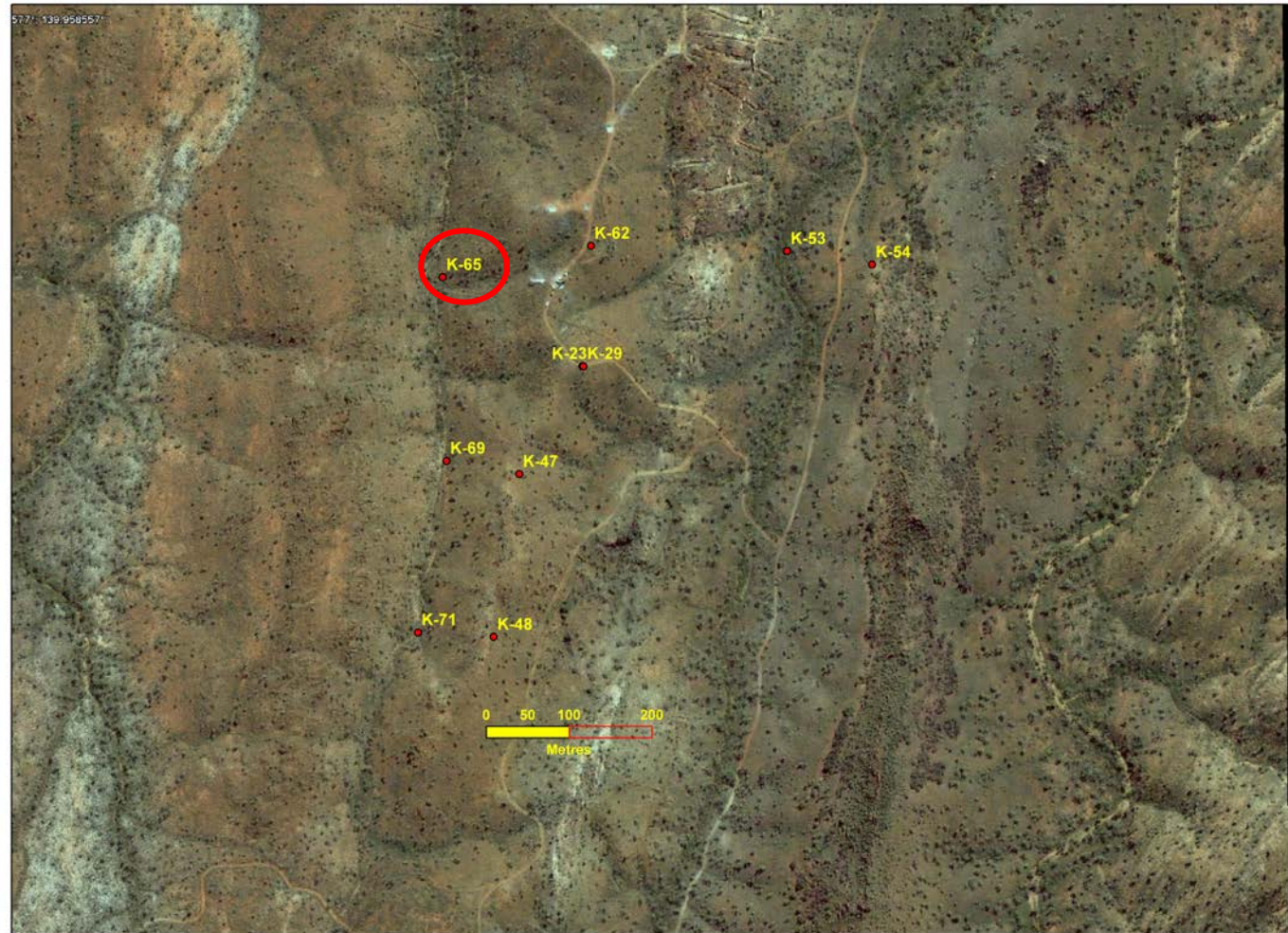
K65 - U assays

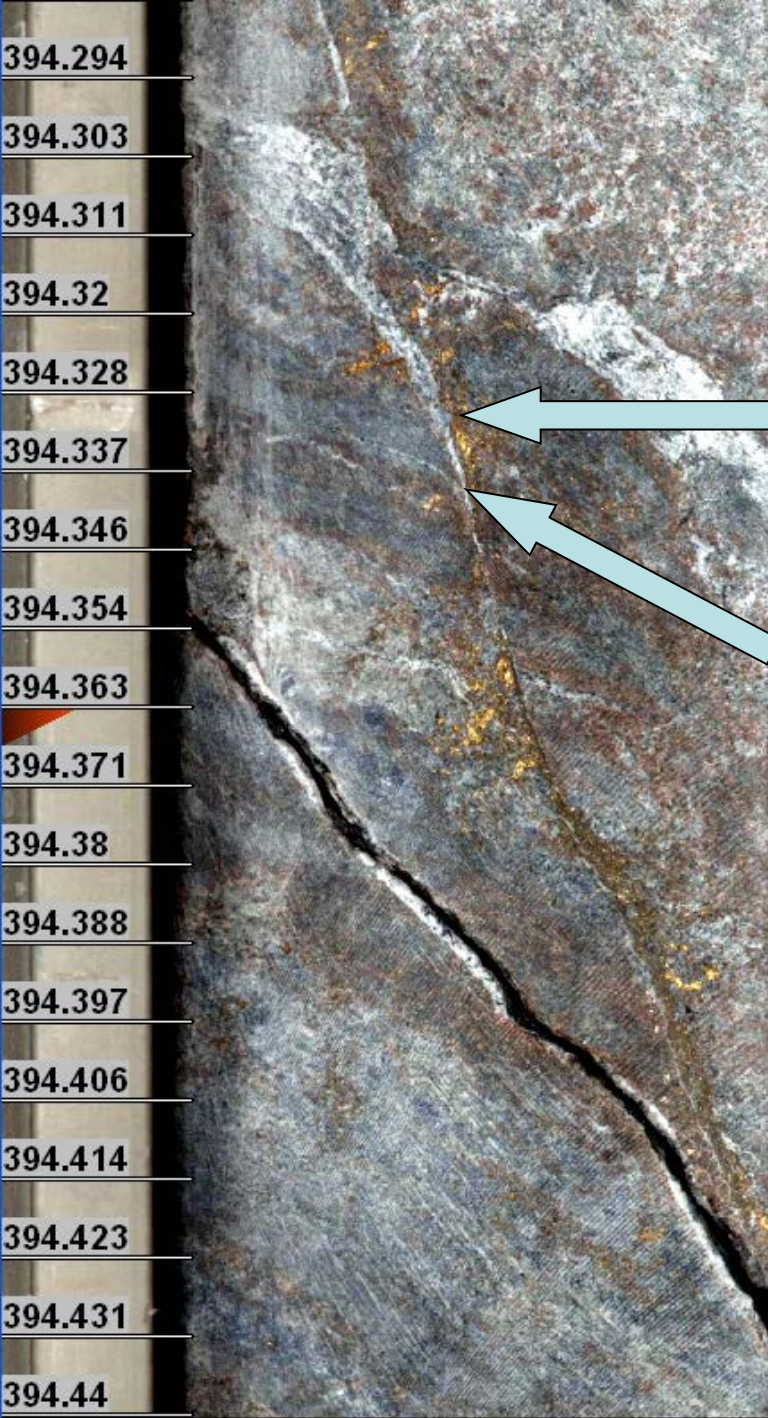


Metal associations



How 'bout the rocks?





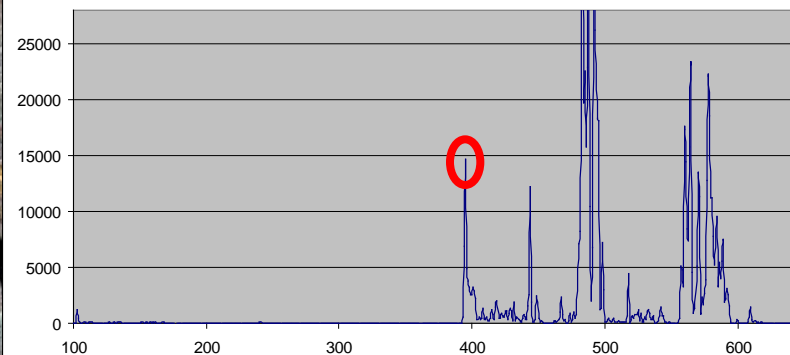
K65

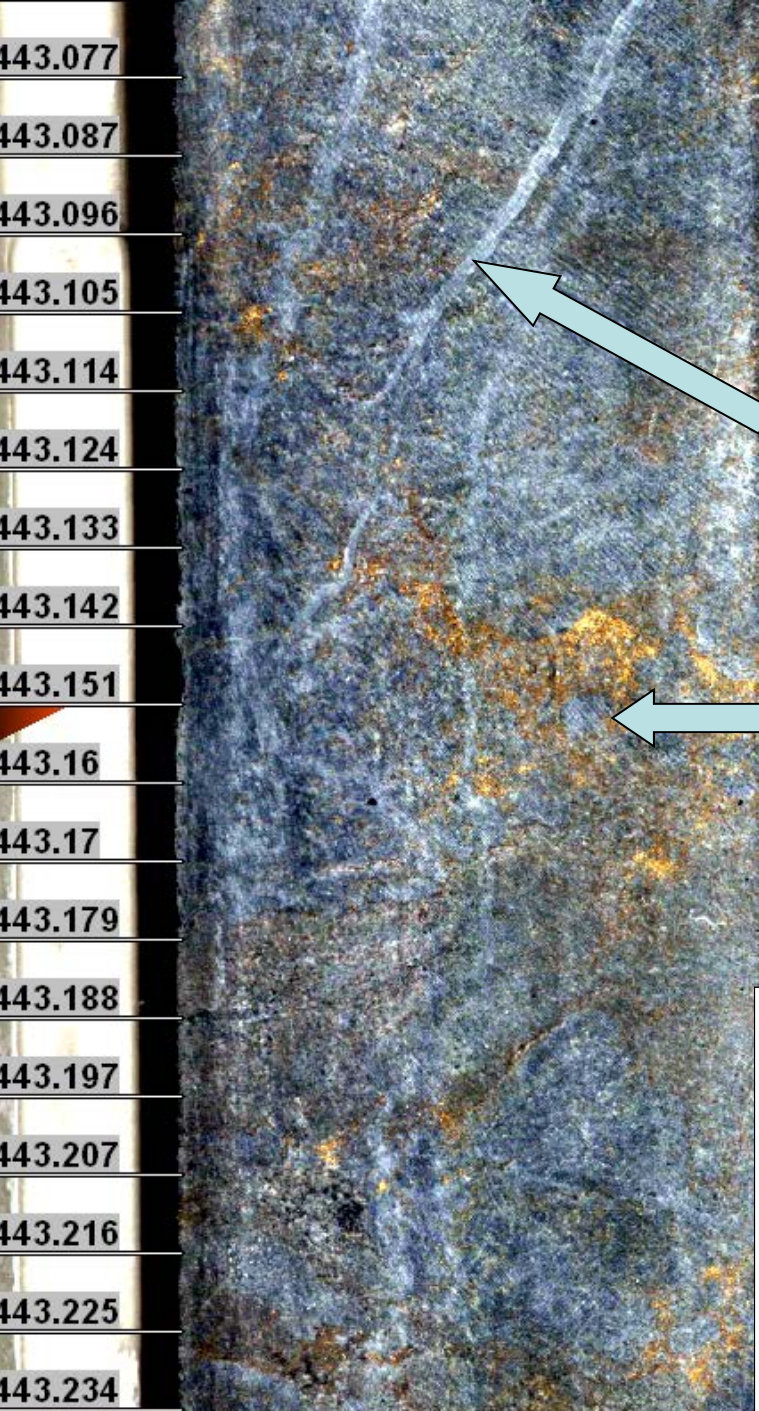
14700 ppm Cu

Fracture with associated
chalcopyrite mineralisation

Calcite influx has used the same
fracture as earlier chalcopyrite

K65 - Cu assays



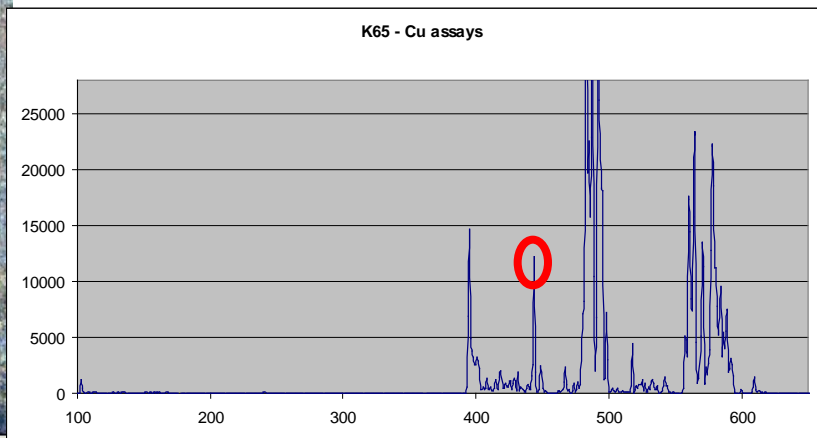


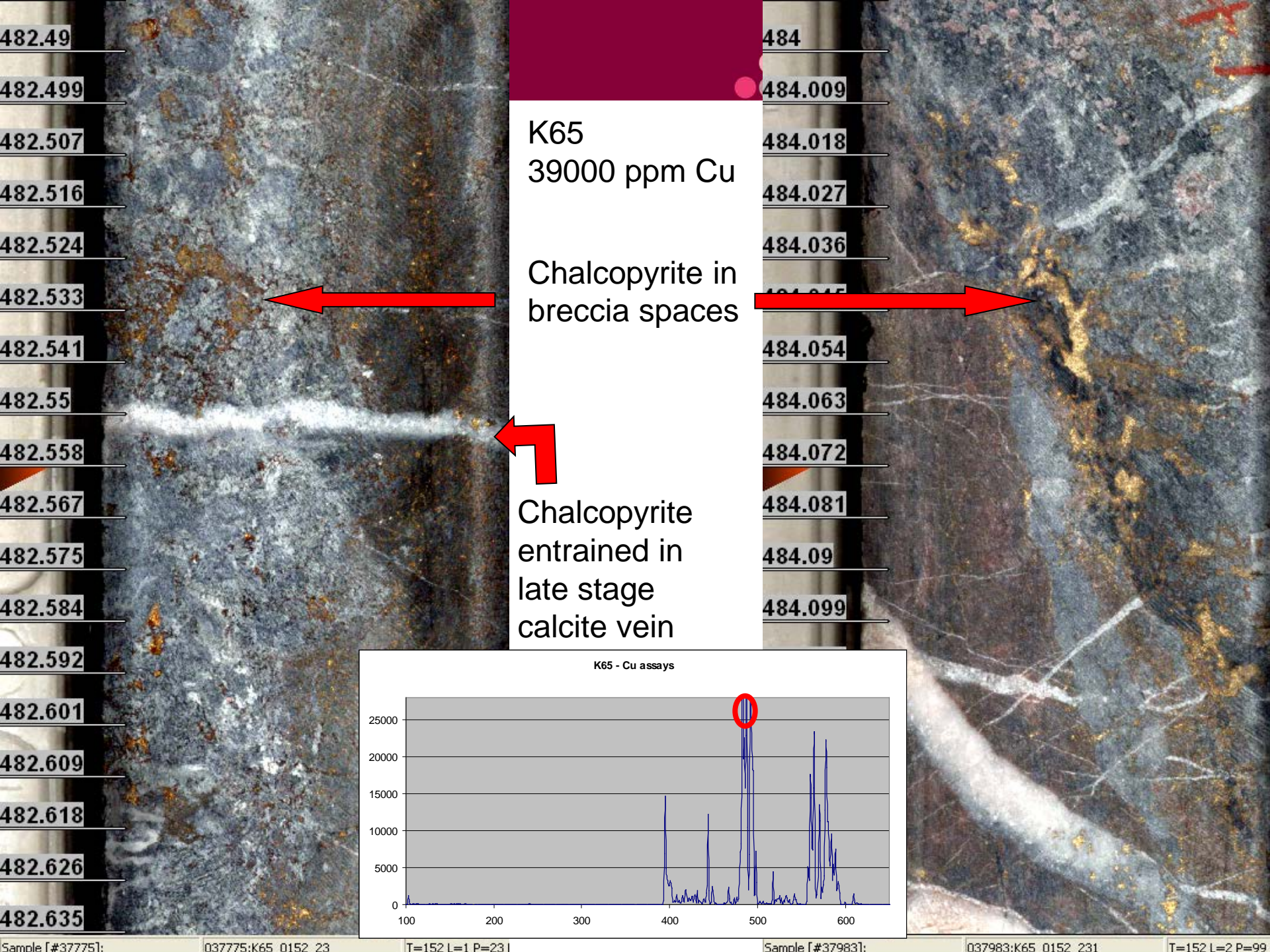
K65

12200 ppm Cu

Sharp late stage veins cut
chalcopyrite mineralisation

Irregular chalcopyrite mineralisation;
hint of vein association; continuity
obscured by later alteration



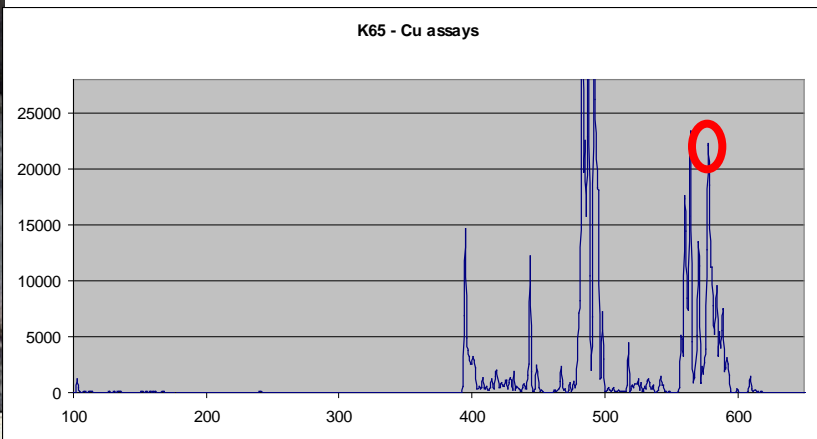




K65
22100 ppm Cu

Chalcopyrite in veins in
carbonaceous shale

Sample [#54083]: 054083:K65_0182_491 T=182 L=4 P=95



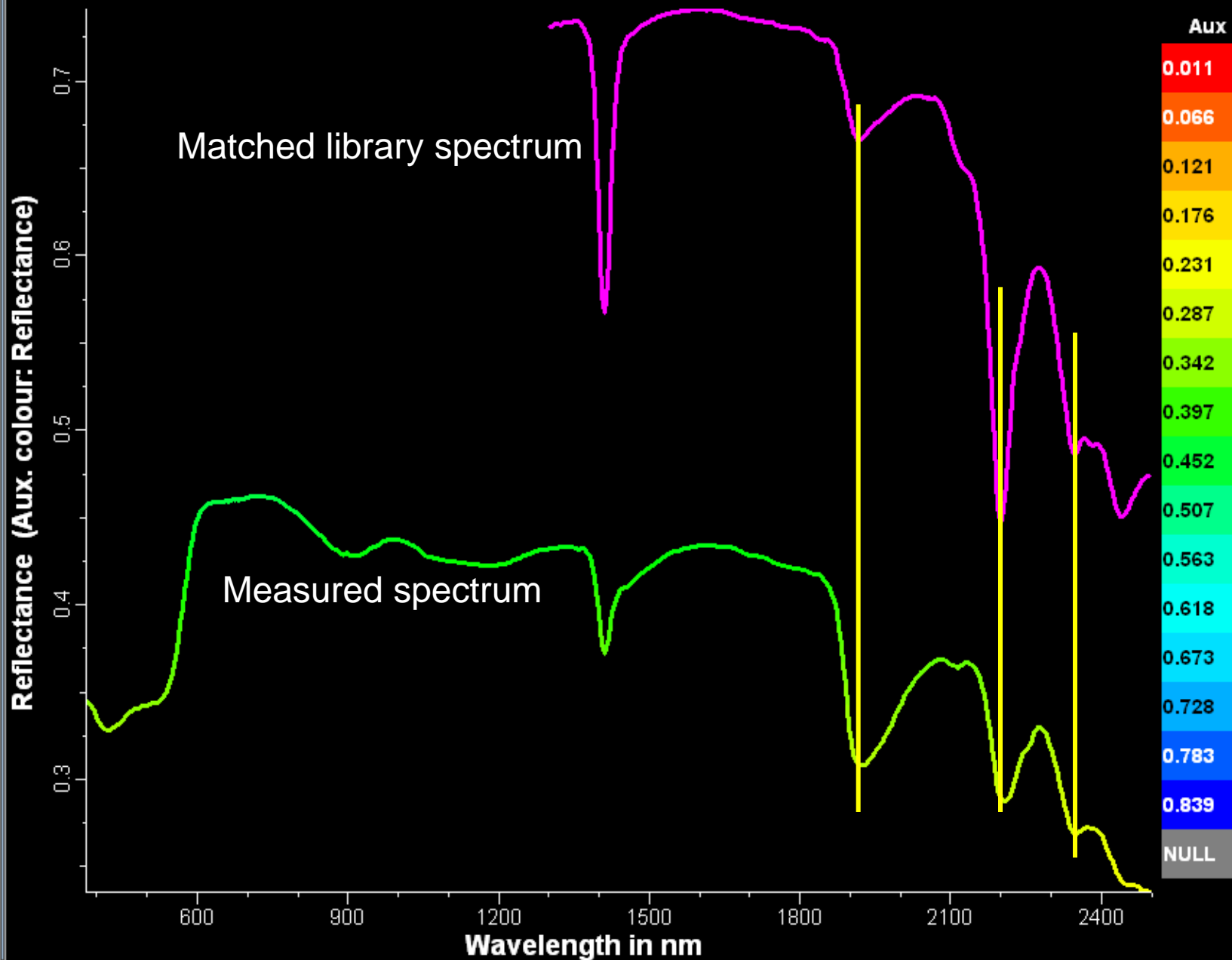


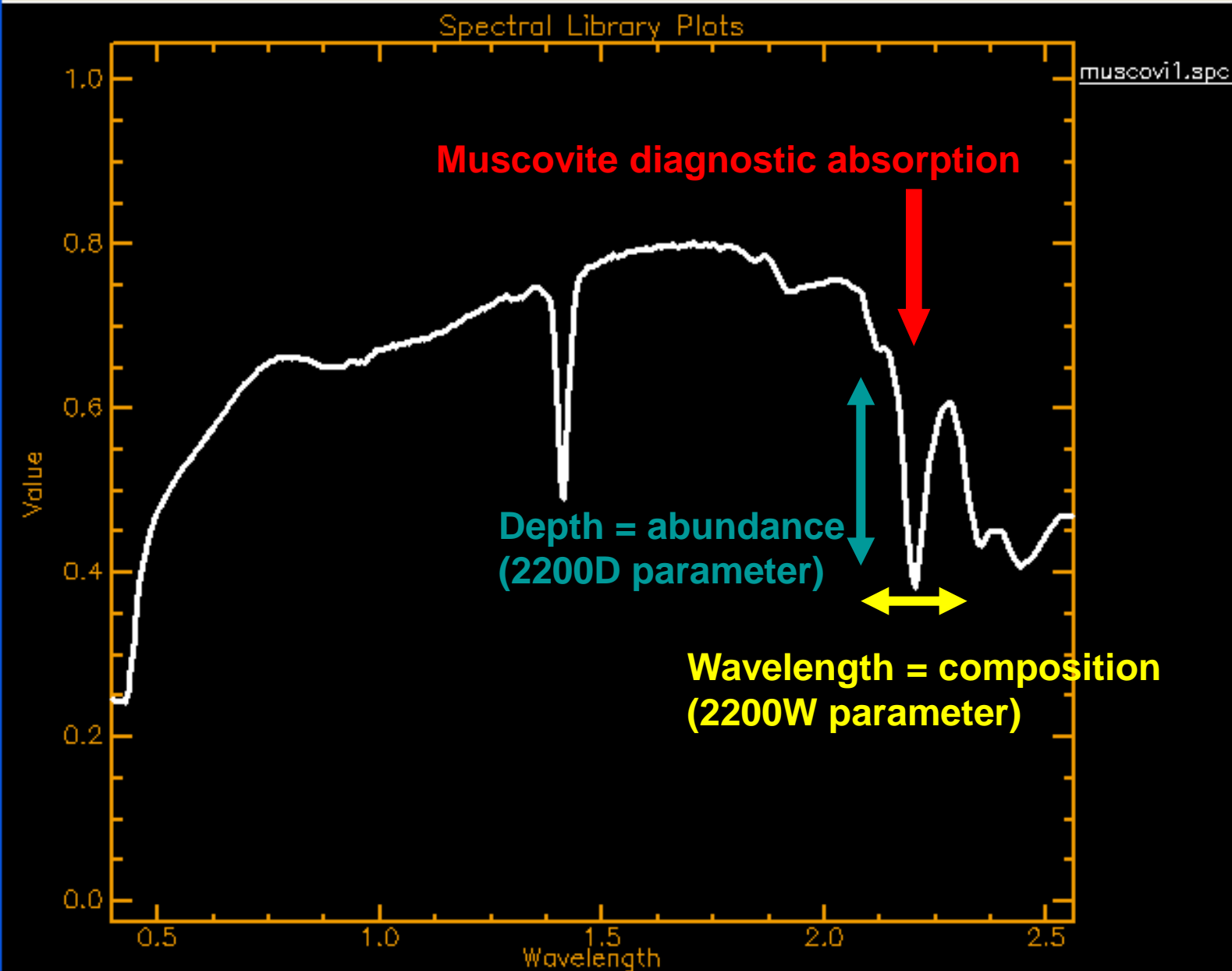
Spectral parameters - HyLogger

Sample
62701:K65_0199_133 T
62702:K65_0199_134 T
62703:K65_0199_135 T
62704:K65_0199_136 T
62705:K65_0199_137 T
62706:K65_0199_138 T
62707:K65_0199_139 T
62708:K65_0199_140 T
62709:K65_0199_141 T
62710:K65_0199_142 T
62711:K65_0199_143 T
62712:K65_0199_144 T
62713:K65_0199_145 T
62714:K65_0199_146 T
62715:K65_0199_147 T
62716:K65_0199_148 T
62717:K65_0199_149 T
62718:K65_0199_150 T
62719:K65_0199_151 T
62720:K65_0199_152 T
62721:K65_0199_153 T
62722:K65_0199_154 T
62723:K65_0199_155 T
62724:K65_0199_156 T
62725:K65_0199_157 T
62726:K65_0199_158 T
62727:K65_0199_159 T

Reflib
Kaolinite WX
Kaolinite PX
Dickite
Nacrite
Muscovite
Muscovite
Phengite
Phengite
Paragonite
Montmorillonite
Nontronite
Magnesium Clays
Palygorskite
Pyrophyllite
Diaspore
Gibbsite
Prehnite

T=199 L=2 P=26 D=630.037044 X=202.472046 H=K65 (Ref: Muscovite)



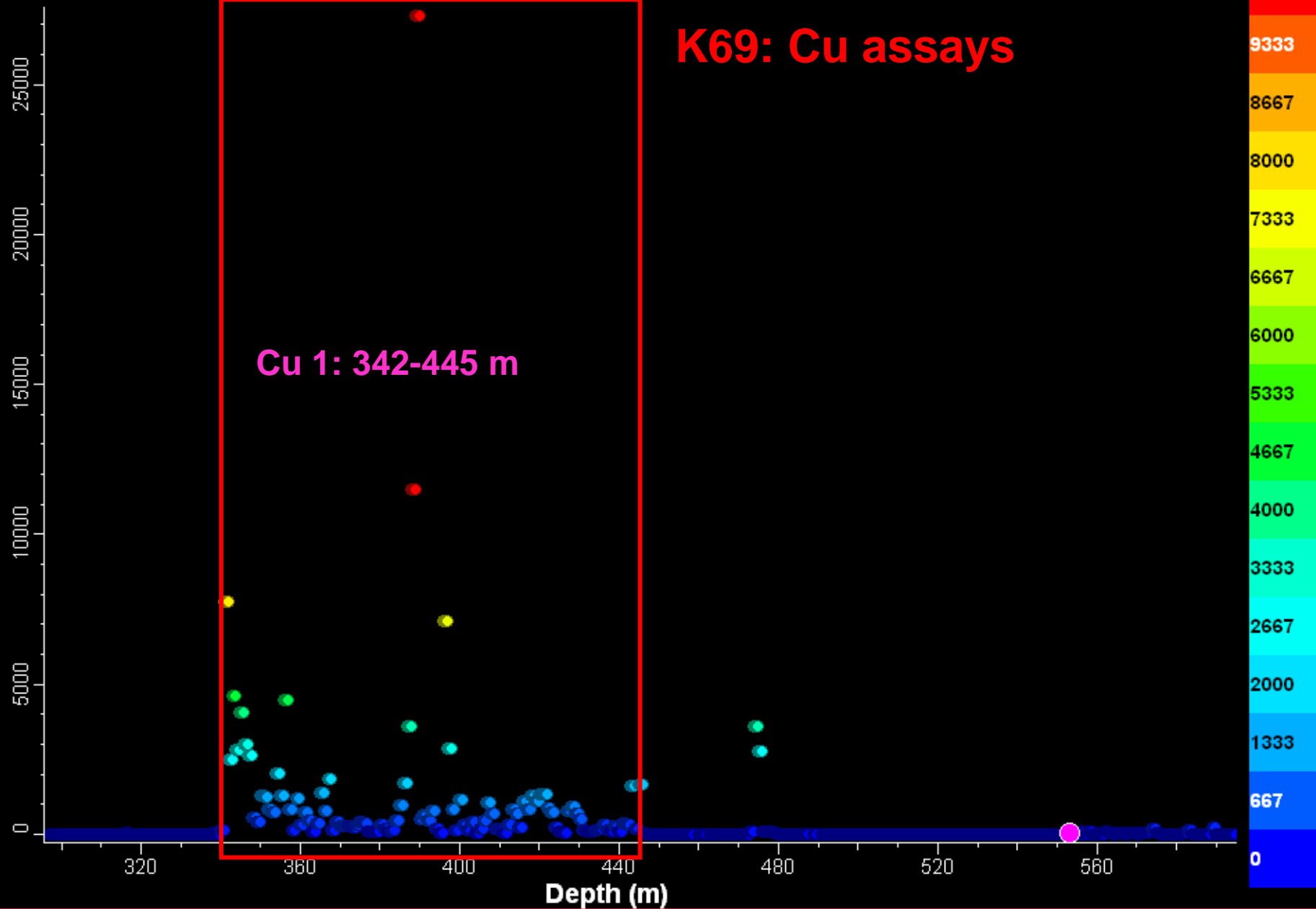


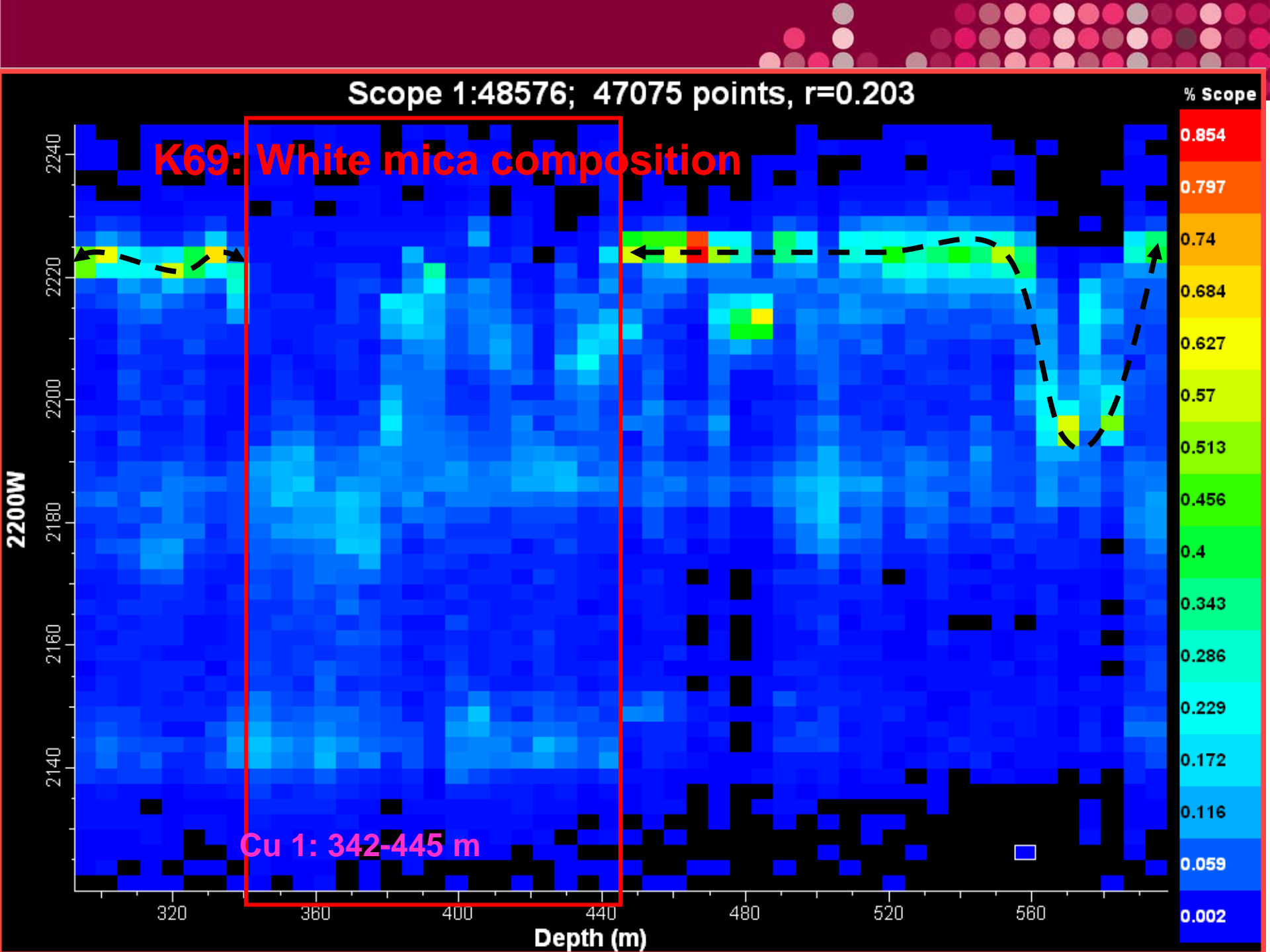
Scope 1:48576; 47990 points, $r=-0.175$; Aux: K69_Assay_Cu

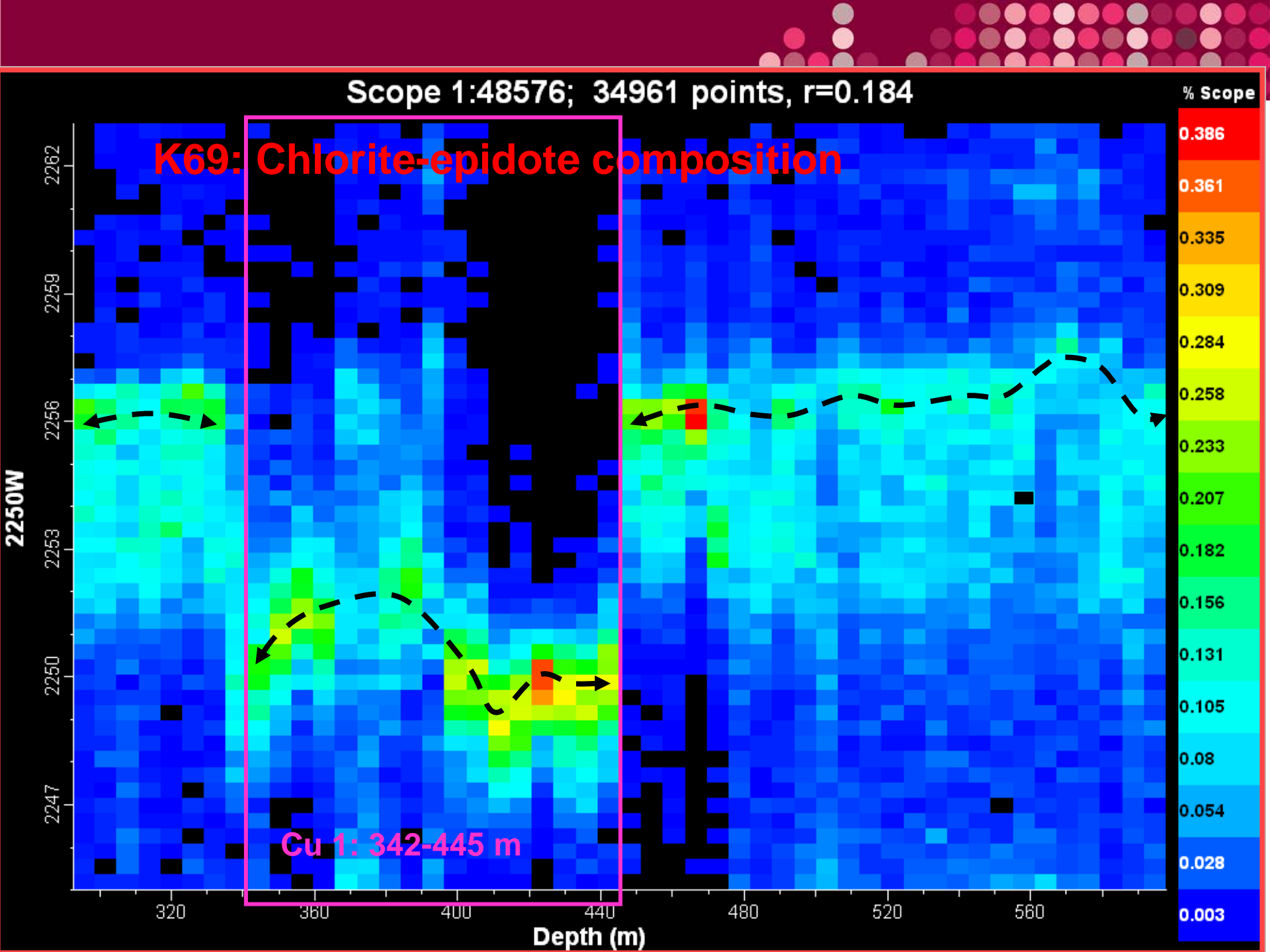
K69: Cu assays

K69_Assay_Cu

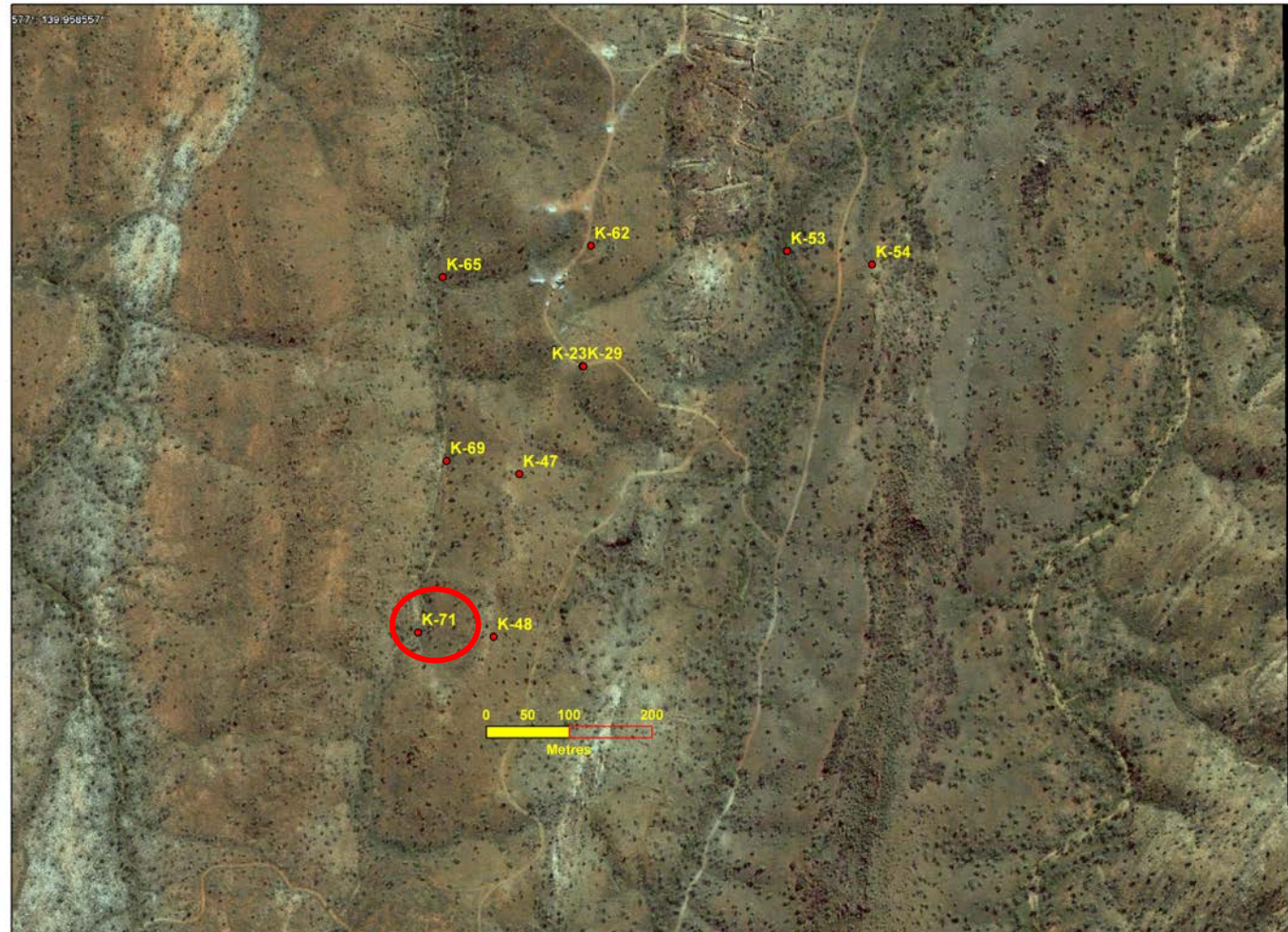
Cu 1: 342-445 m







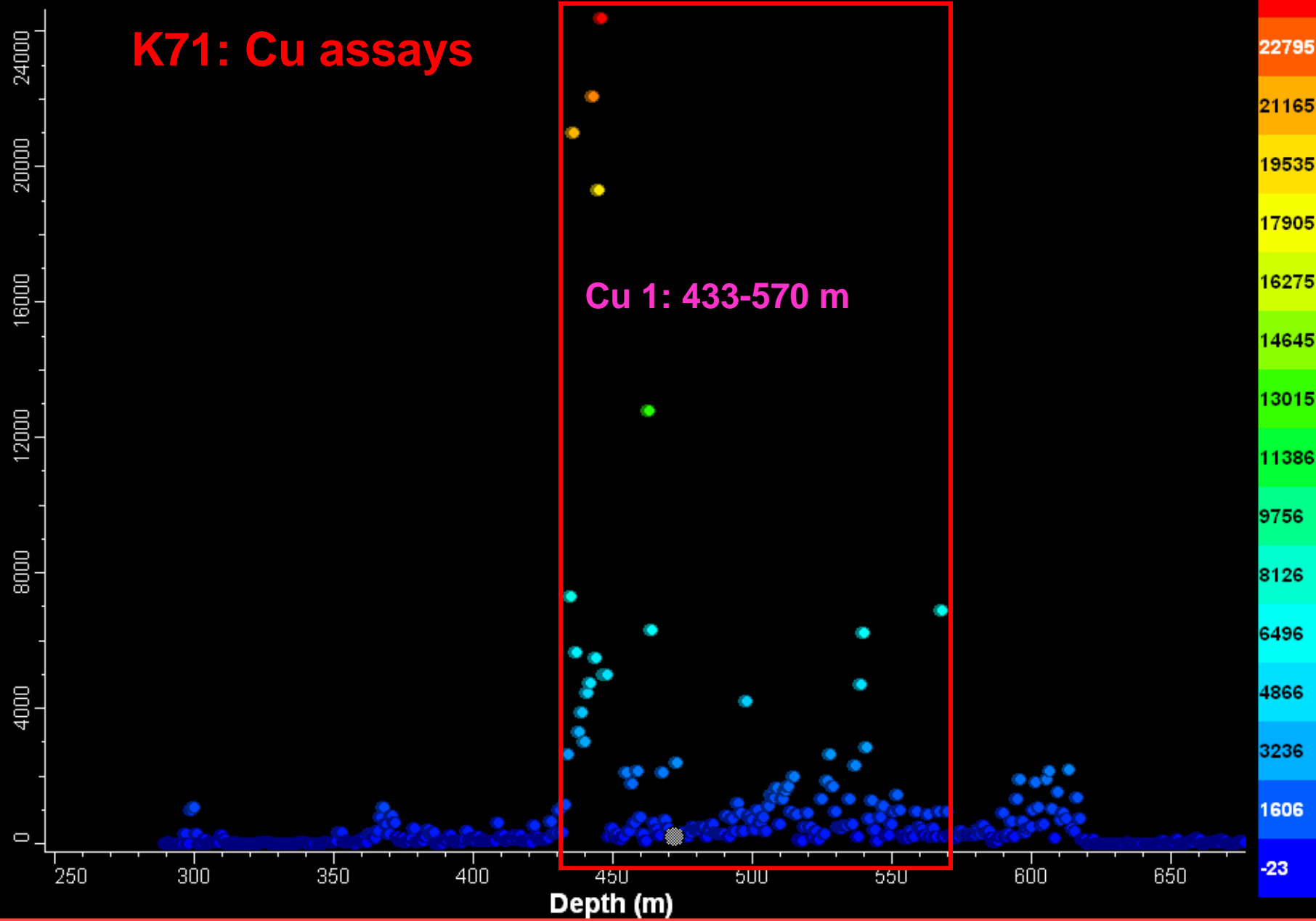
K71



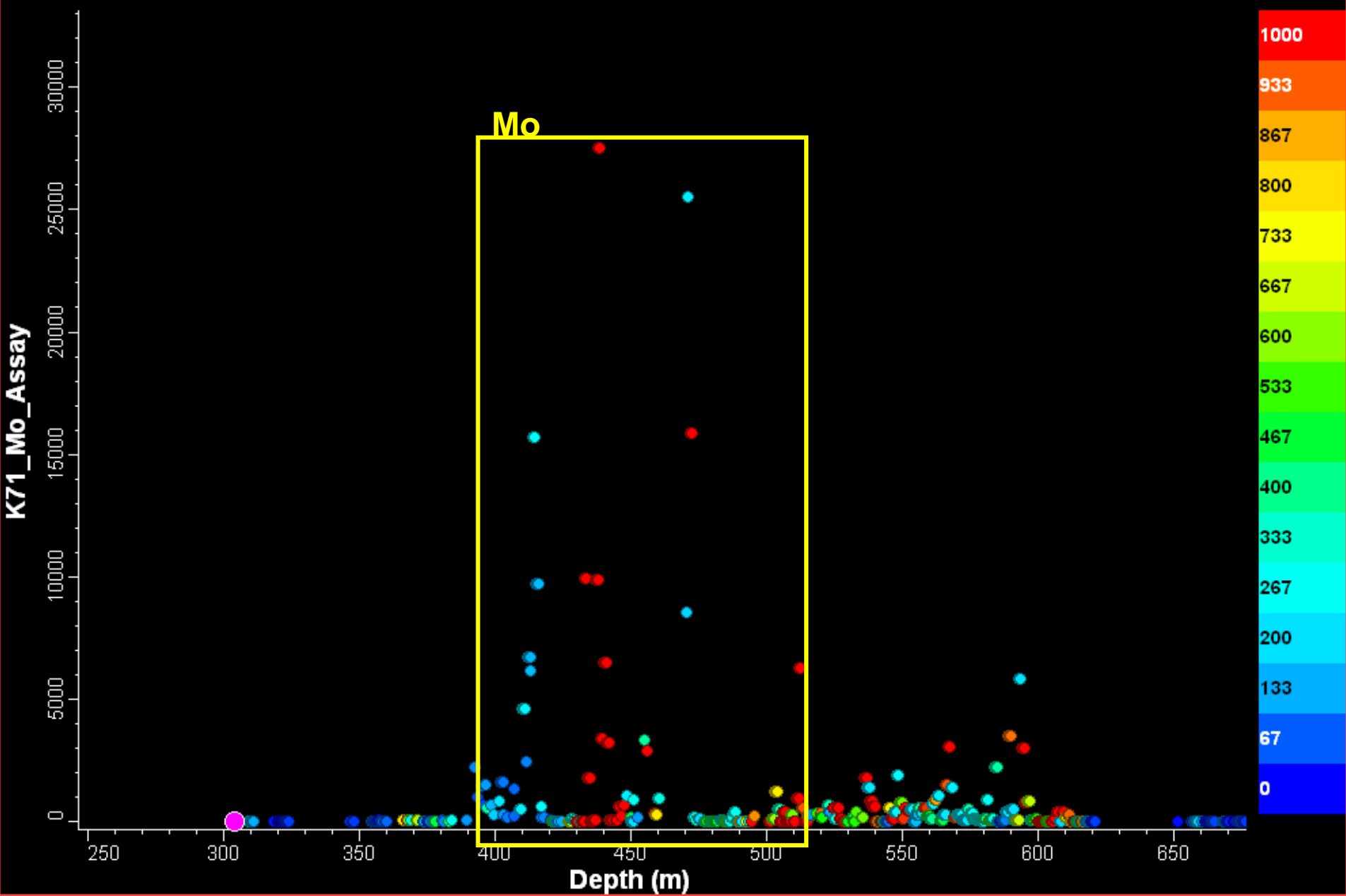
Scope 1:72336; 65132 points, $r=-0.0213$; Aux: K71_Cu_Assay

K71: Cu assays

K71_Cu_Assay



Scope = Grp1 uTSAS : White Micas; 9346 points, $r=-0.188$; Aux: K71_Cu_Assay



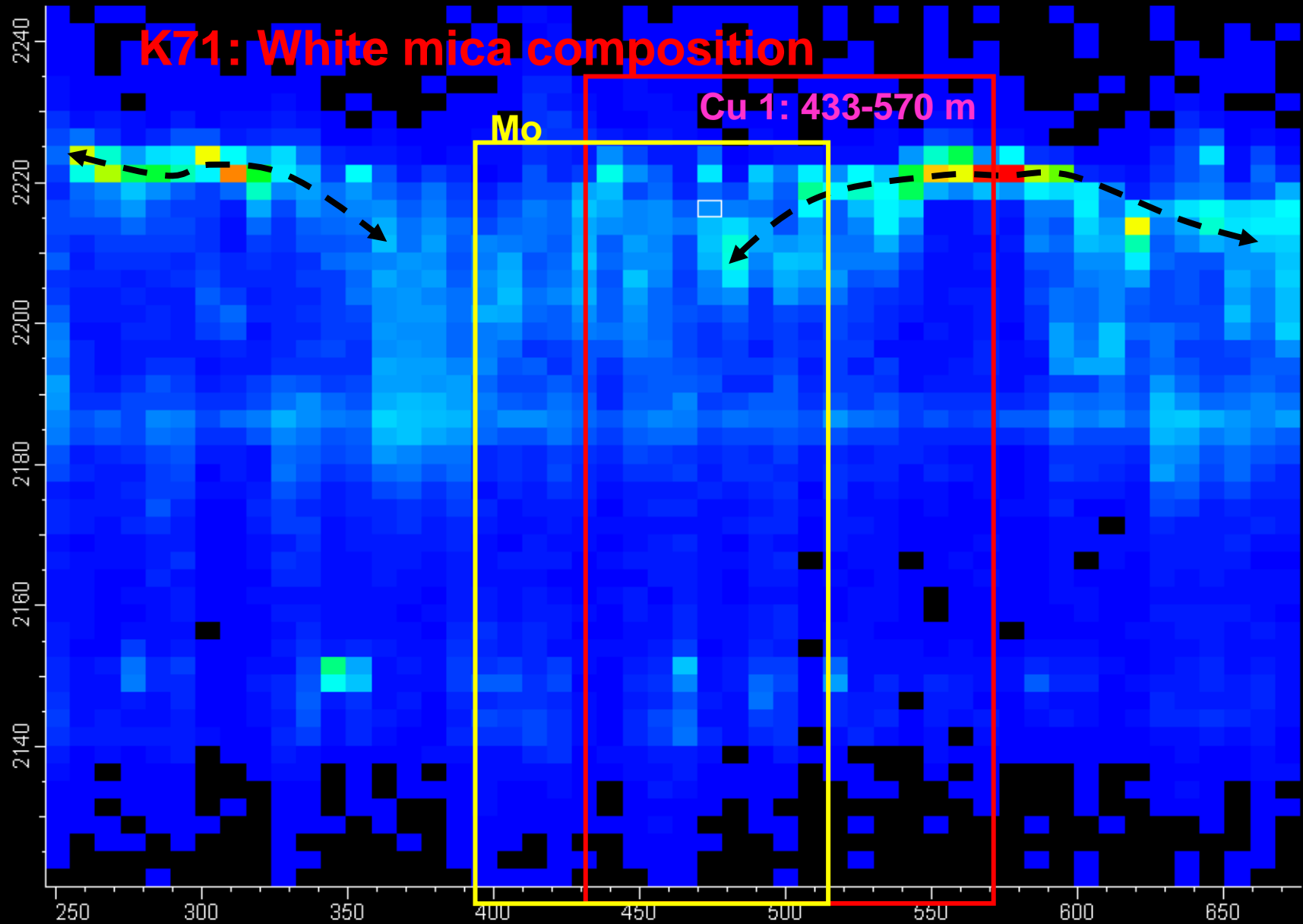
Scope 1:72336; 71592 points, $r=0.056$

K71: White mica composition

Mo

Cu 1: 433-570 m

2200W



% Scope

1.077

1.005

0.934

0.862

0.79

0.718

0.647

0.575

0.503

0.432

0.36

0.288

0.217

0.145

0.073

0.001

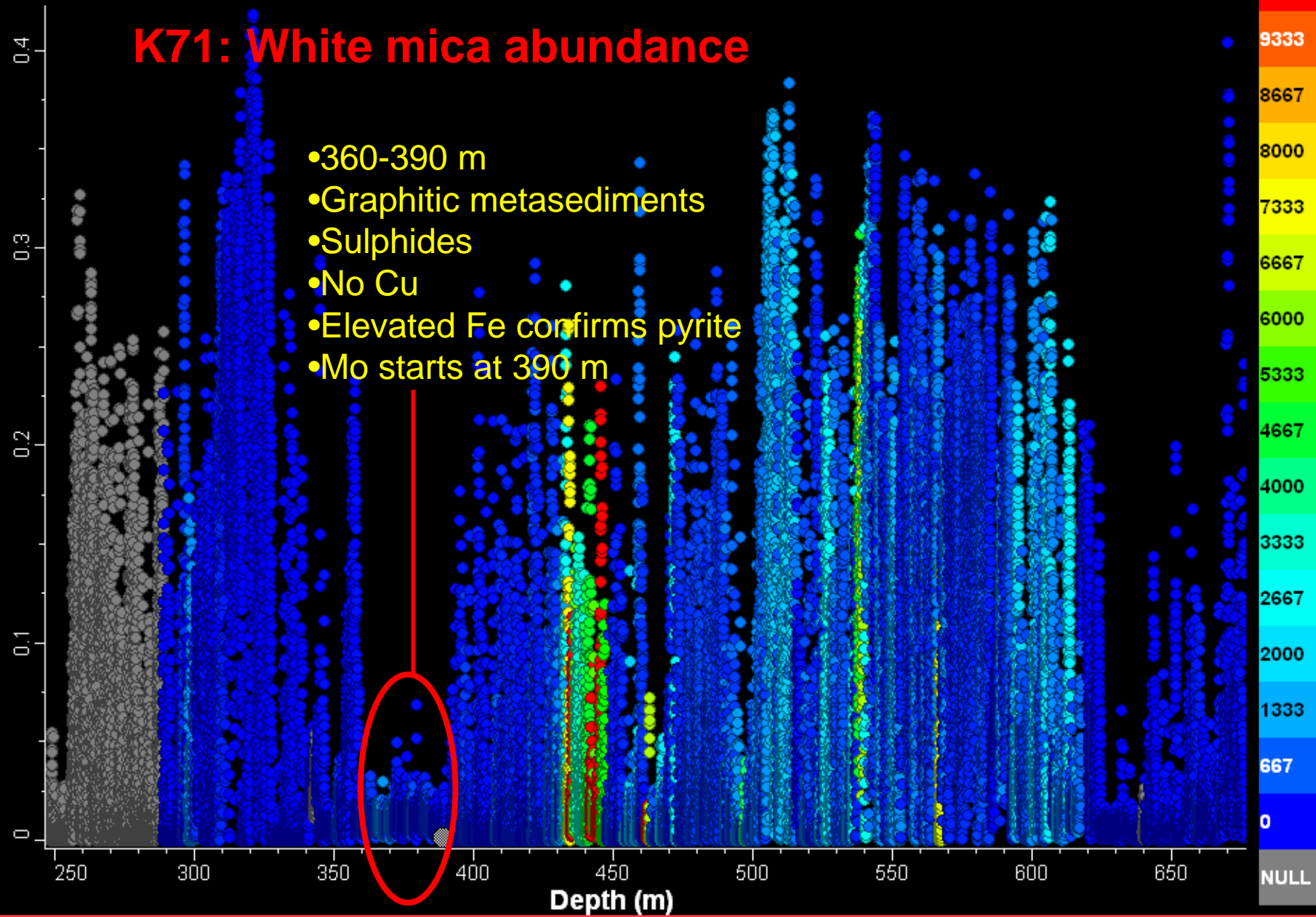
Depth (m)

Scope 1:72336; 47049 points, $r=0.0937$; Aux: K71_Cu_Assay

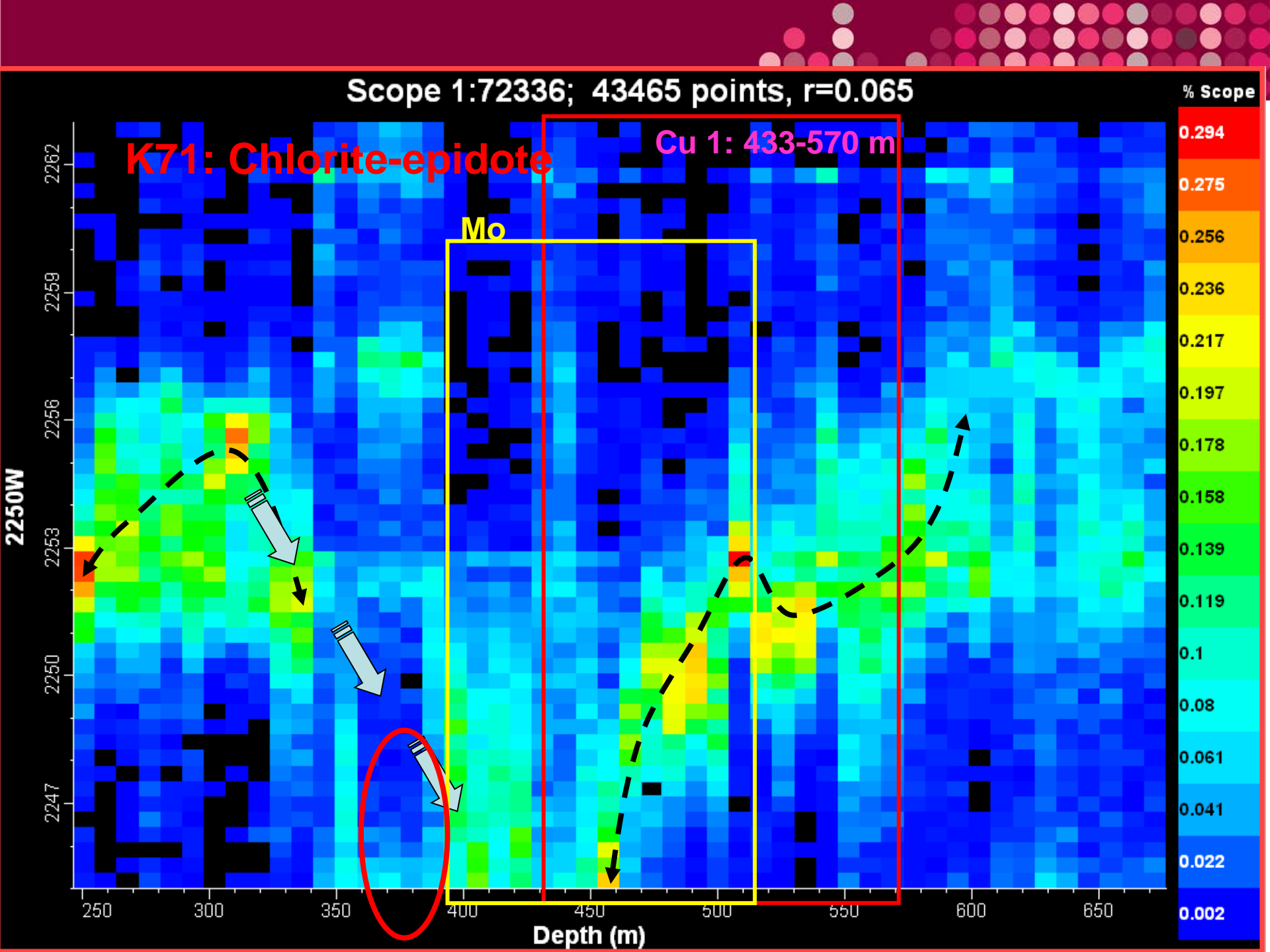
K71: White mica abundance

2200D

- 360-390 m
- Graphitic metasediments
- Sulphides
- No Cu
- Elevated Fe confirms pyrite
- Mo starts at 390 m

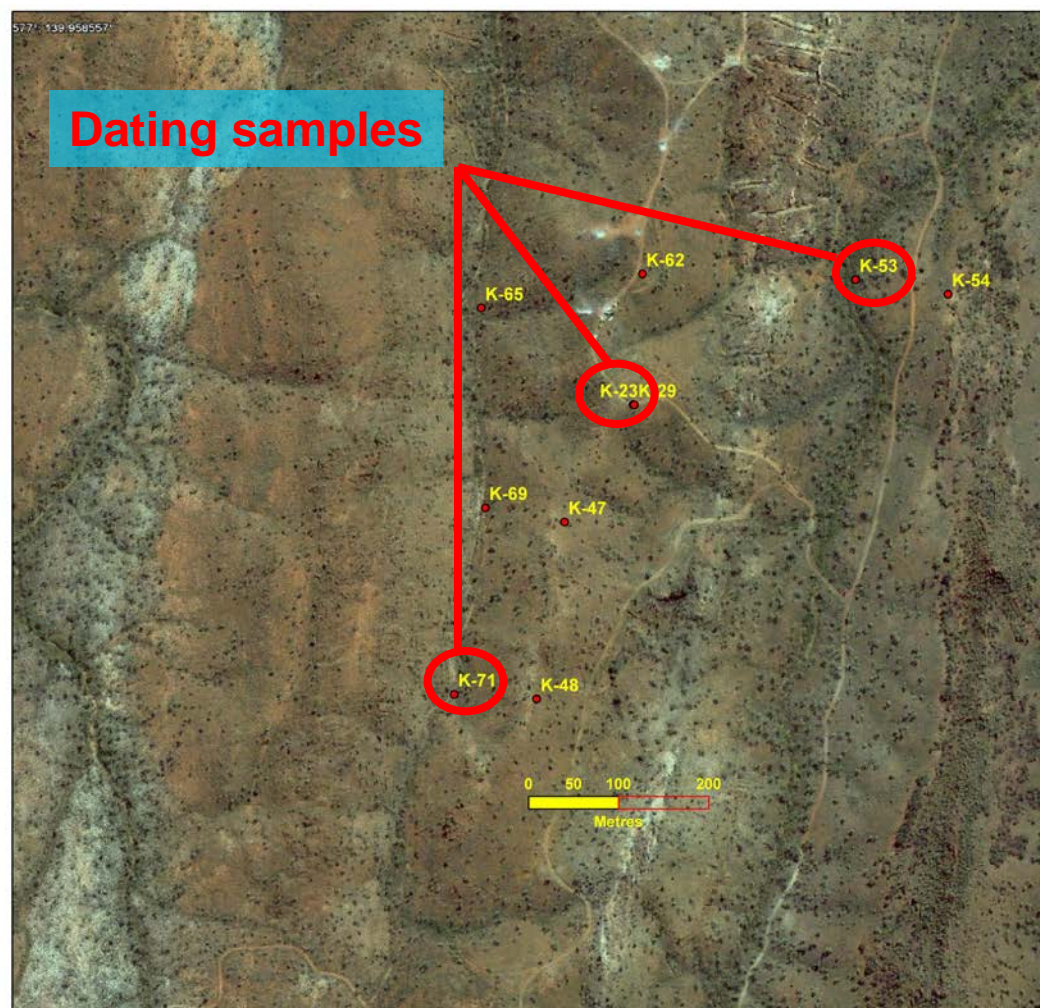


Depth (m)



Kalman isotopic dating: Re-Os

1. What is the age of Kalman
2. Where does Kalman fit with regional episodes of mineralisation
3. Are there multiple episodes of mineralisation at Kalman
4. How long has the mineral system operated at Kalman
5. Can different poly-metallic episodes be distinguished
6. Are different expressions of Molybdenite related to different ages





K23

Dating sample @
327-8 m

Molybdenite (semi-crystalline)

Pyrite/chalcopyrite next to molybdenite

Pyrite/chalcopyrite

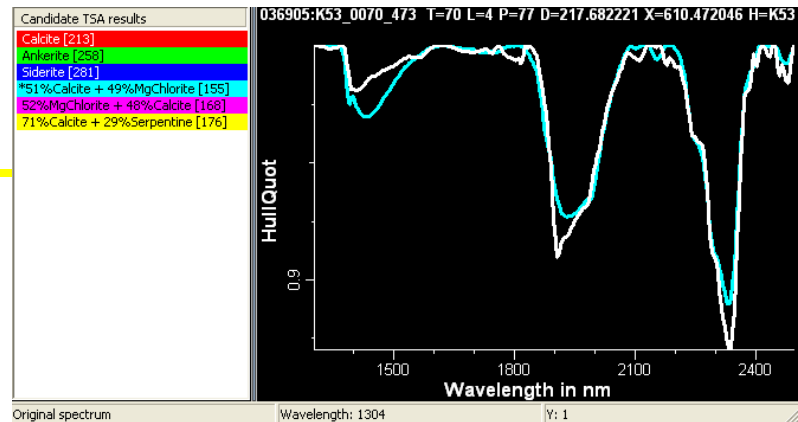
Molybdenite vein – partially obscured by
residual surface mud



K53

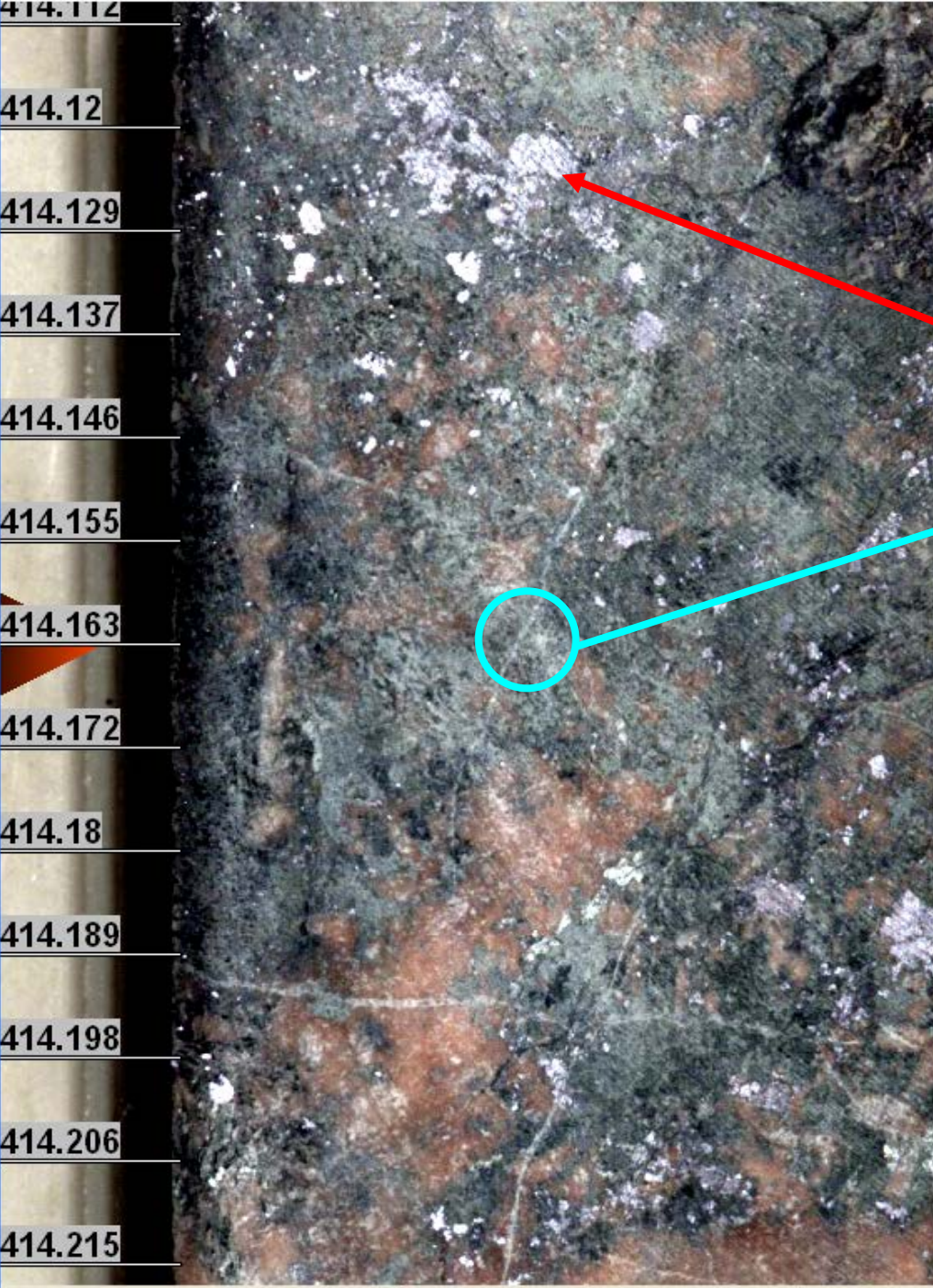
**Dating sample @
217-8 m**

Molybdenite vein

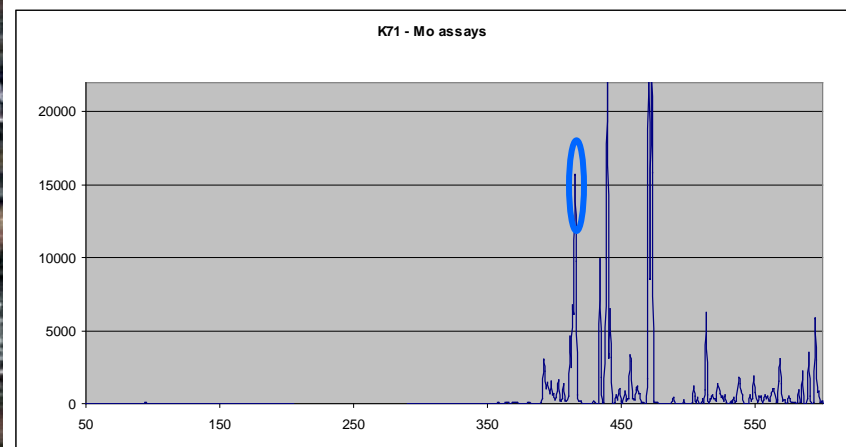
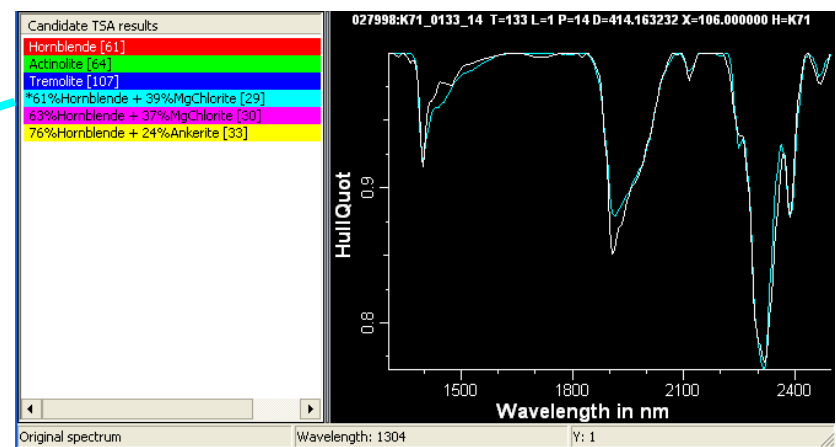


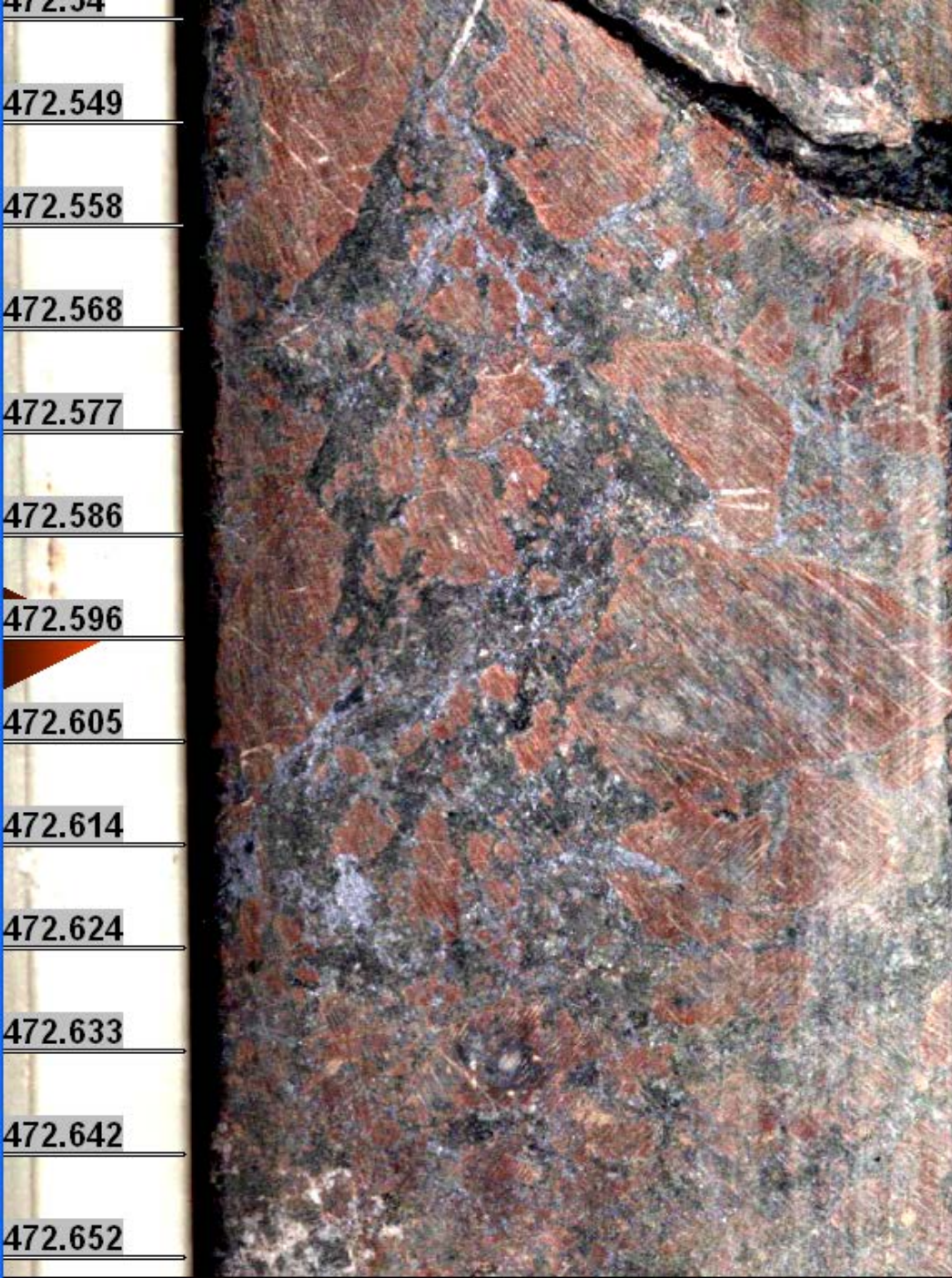
Molybdenite vein

Molybdenite veins conformable; calcite
includes crosscutting orientation



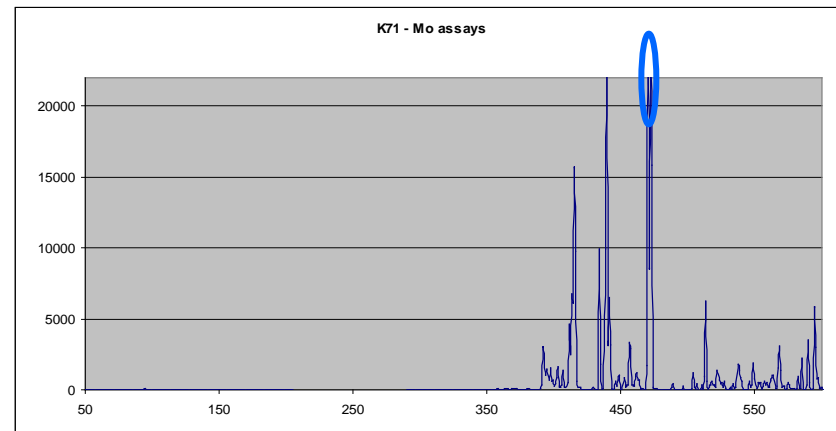
K71
Dating sample @
414-5 m
Molybdenite



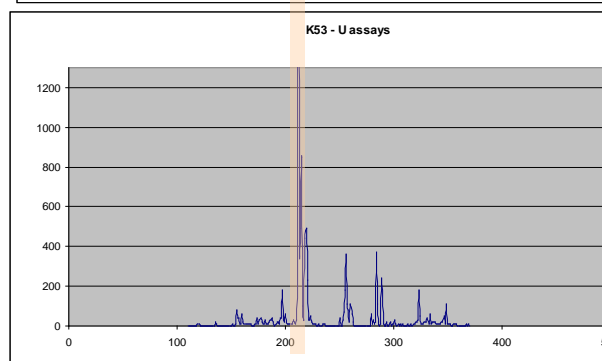
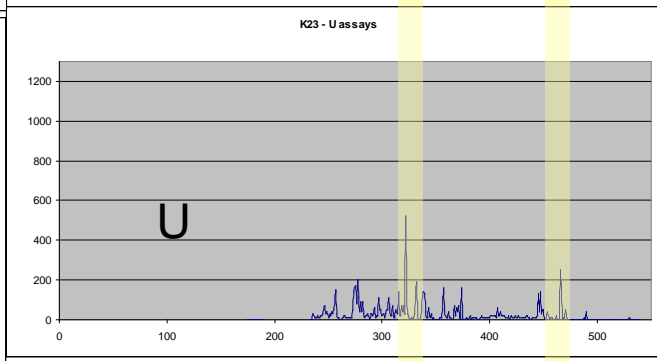
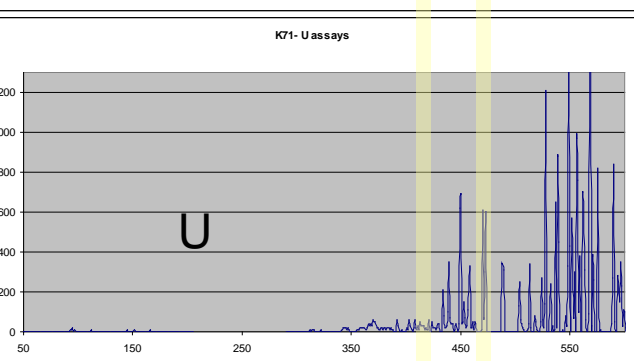
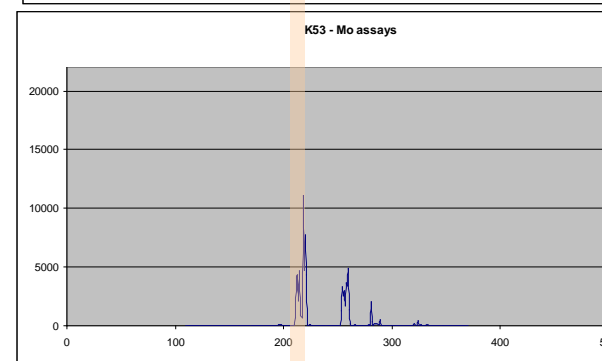
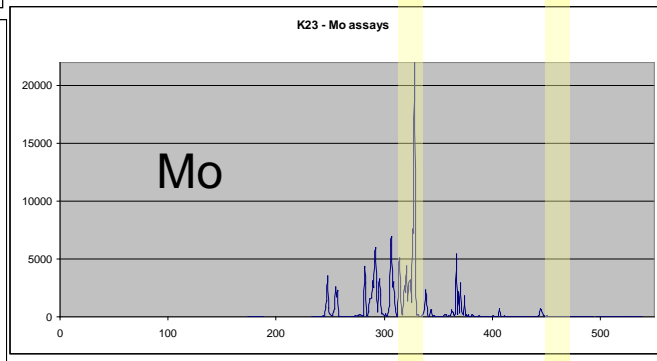
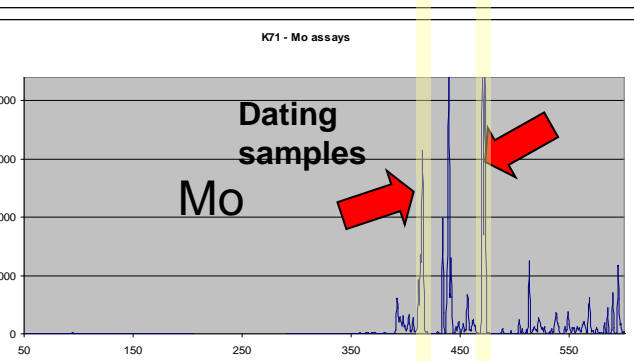
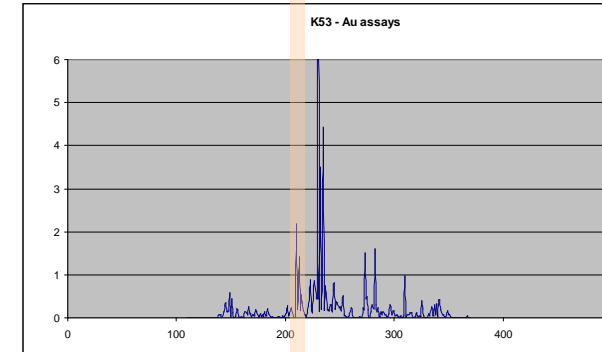
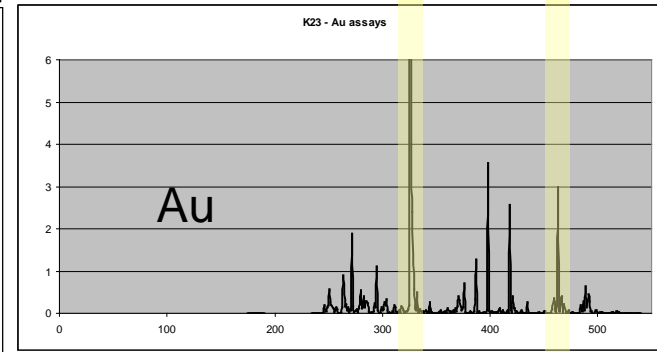
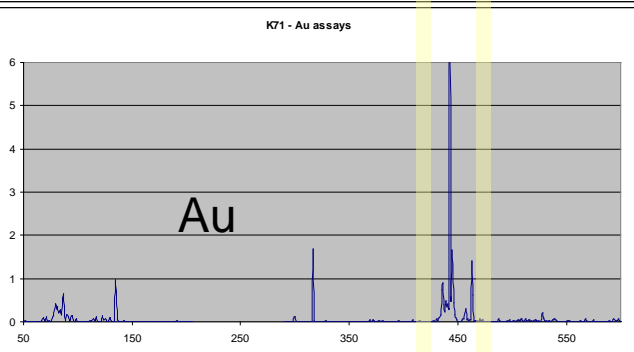
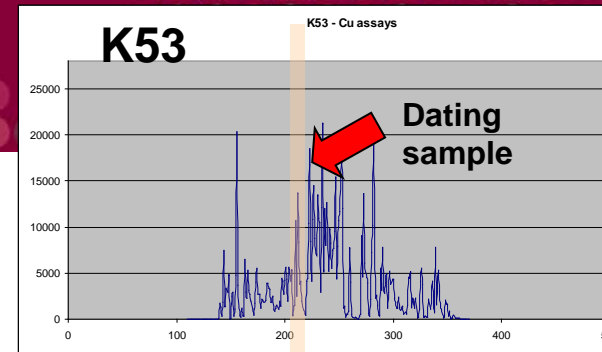
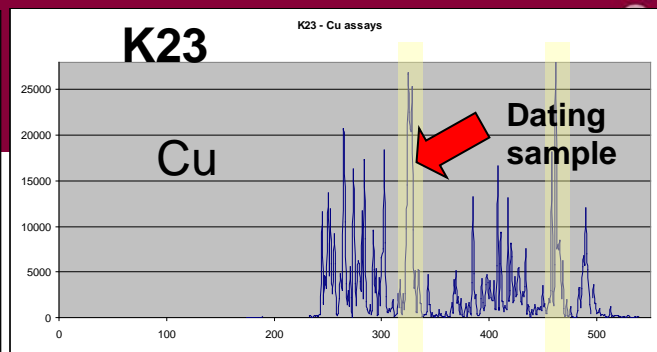
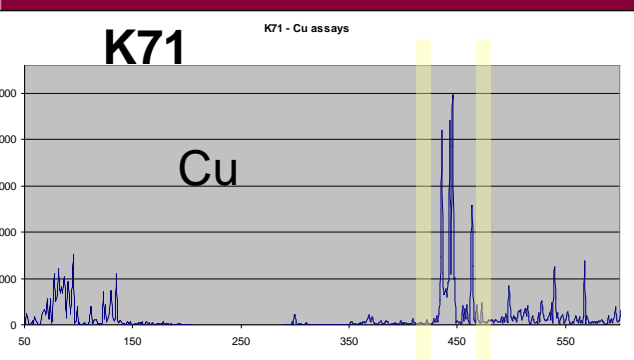


K71

Dating sample @ 472-3 m



- Pull-apart breccia contains Molybdenite in matrix.
- Shows vein form in part.
- Sharp boundaries in RR show no evidence of resorption. May be hot non-reactive fluids.
- Some similarities with Merlin core 80 km to southeast.



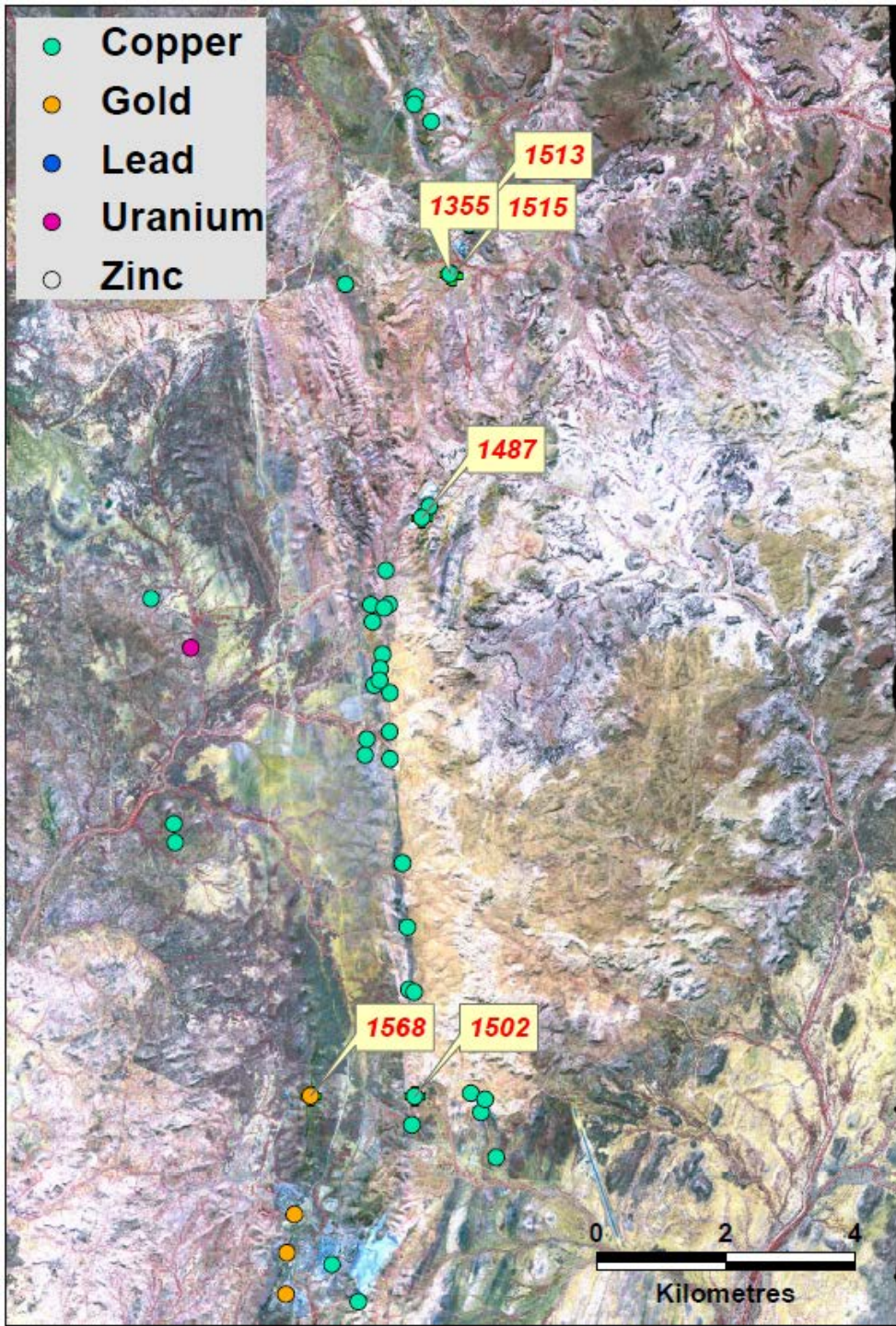


Re-Os Dating results

- **1475 Ma**
- **1560 Ma**
- **Cf Pb-Pb for Overlander Granite 1620 Ma**



Comparison with Mount Dore (Merlin)



Re-Os dates from the Selwyn area
(Duncan & others, 2011)



Conclusions

- Soil geochem – Cu anomalies extend to surface
- Gocad models depict ~N-S Cu ore body
- Assay data show evidence of:
 - fracture/fault network
 - episodic mineralisation
- White mica and Chlorite-Epidote spectral parameters – evidence of sharp boundaries to Cu; limited, or no alteration halo
- Rock textures show brecciation common in metal zones
- Re-Os dating
 - 1475 and 1560 Ma preliminary ages
 - Too young for nearest (known) intrusion
 - Similar time envelope to Selwyn region



KALMAN LAM