Mineral Mapping

3D model of a Supergene Gold Deposit derived from Spectral Mapping

Exploration Technologies 2011

Scott Halley

Australian Institute of Geoscientists

Supporting Geoscientists

ABSTRACT: A 3D MODEL OF A SUPERGENE GOLD DEPOSIT CREATED FROM SPECTRALLY DERIVED MINERALOGY

This paper describes a 3D mineralogical model of a supergene gold deposit. Within this deposit, two distinct subhorizontal gold enrichment layers are clearly apparent. However in detail the gold does not form flat horizontal sheets. The way in which intercepts could be joined from drill hole to drill hole was ambiguous and this had a significant impact on the resource modeling for the deposit. The resource geologist commissioned a spectral mapping study to see if it could improve confidence in the way the mineralized intercepts were correlated from hole to hole. Most of the drilling is RC, with a small percentage of diamond drill core. The spectra were measured with an ASD Terra Spec instrument. There is 12,000 meters of drilling. One spectrum was measured on every meter of core or chips.

The deposit is hosted within an Archean pillow basalt sequence. The basalts are intruded by numerous narrow diorite porphyries. There is a steep south-east dipping Archean unconformity, with the basalts overlain by sandstone and siltstone. There is a flat lying Tertiary unconformity, with transported sediments overlying oxidized Archean bedrock.

If the wavelength of the 2200nm feature in kaolinite-bearing samples is plotted against the width of the feature and a kaolinite crystallinity index, then three very distinct kaolinite types are apparent. These are kaolinite in the transported sediment, kaolinite in weathered basalt, and kaolinite in Archean sediments. There is a layer of supergene alunite formed at the Tertiary unconformity, so the alunite plus kaolinite type was used to model the Tertiary unconformity. The chlorite-sericite altered Archean sandstone is surprisingly difficult to distinguish from altered basalts in RC chips. The picks of the Archean unconformity in the diamond drilling combined with the boundary in kaolinite types in the oxide zone was used to model the Archean unconformity.

Within the weathering profile, there is a surprisingly sharp transition from goethite-kaolinite to fresh chlorite-sericite. This was modeled as the base of weathering. This surface has a distinct linear depression that runs parallel to the trend of gold distribution.

Higher in the weathering profile, there is a boundary between a very pervasive hematite blanket and pervasive goethite. This boundary was modeled, and it also showed a linear depression that was slightly offset from the depression in the base of weathering. Between the two depressions in the weathering fronts, there is a planar but somewhat patchy distribution of hematite within the goethite zone. These patterns in the weathering minerals are clearly mapping a fault. A fault surface was modeled that joined the dip in the hematite-goethite boundary, ran down the hematite zone, and ran along the dip in the base of weathering. This defines a fault plane dipping about 60 degrees to the south east. This plane runs sub parallel to the Archean unconformity, but is around 50 meters back into the basalts.

Within the fresh basalts, there are two very distinct groups in the chlorite compositions. The distinction is based on either the wavelength at 2250nm or the wavelength at 2340nm. This maps the boundary between an Fe-tholeiite and an Mg-tholeiite.

All of this information together provided a geological framework within which to examine the distribution of gold. The controls on the gold distribution are

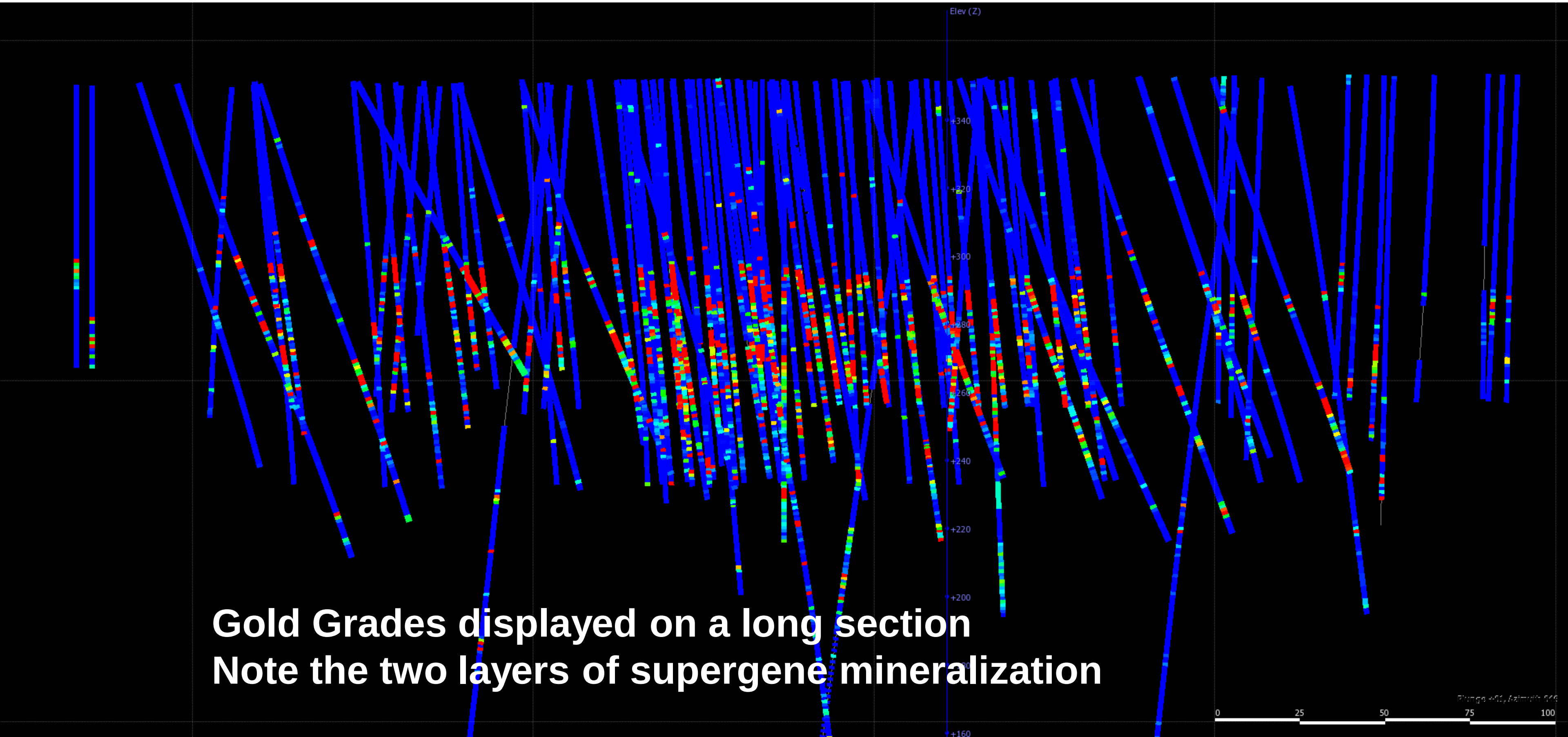
- the Archean fault,
- supergene enrichment of gold in the transitional weathering zone
- supergene enrichment of gold at a palaeo-water table
- a high grade supergene pod at the intersection of the fault with the contact between the two basalts.

The gold does not sit right on the fault, but rather as the water table has dropped, the gold descended vertically, and now sits on the footwall of the SE-dipping fault. Leapfrog was used to model the grade distribution. Leapfrog creates 3D grade contours. Rather than interpolating the grade in an isotropic manner, search directions with a variable degree of bias can be applied. Leapfrog can apply a grade distribution skew biased along multiple surface orientations simultaneously. The grade shells in this model were biased to follow the base of weathering surface and the fault plane at the same time.

This project took 12 days to measure the spectra and 3 days to interpret the spectra and build the model. The data was interpreted and modeled using a combination of TSG, ioGAS and Leapfrog. This has produced a much more robust geological model and improved confidence in grade modeling and continuity.

Two supergene horizons. Tabular upper layer.
Irregular lower layer. Correlations from hole to hole are ambiguous.

Small high grade zone, which has a big influence on the economics of the project. Important to correctly model this zone to make a well informed investment decision. Can a mineralogical model improve the certainty of the resource model?



Problem with the existing geological model;

The deposit was drilled during several different campaigns.

The holes were logged by many different geologists.

Logging is highly subjective, especially when logging drill chips.

Logging data is very inconsistent.

- **11,500 spectra measured from 98 RC and Diamond Drill Holes; one spectrum every meter.**
- **12 days data collection,**
- **Measured with an ASD Terra Spec instrument.**
- **Interpreted using “The Spectral Geologist”.**
- **Modeled in Leapfrog**
- **3 days data interpretation, modeling and reporting**

Supergene Mineralogy;

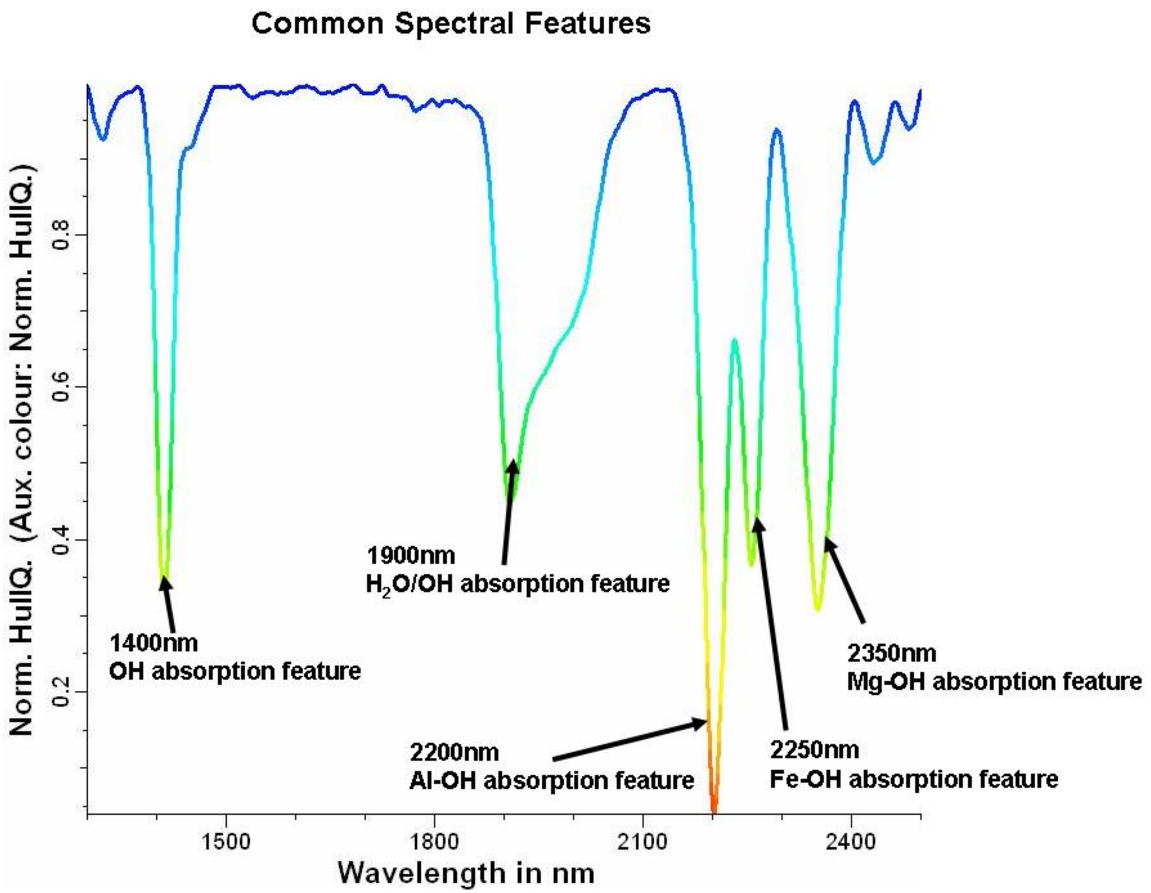
- 3 varieties of kaolinite, alunite, smectite clay, mixed kaolinite with residual sericite, hematite, goethite

Hypogene Mineralogy;

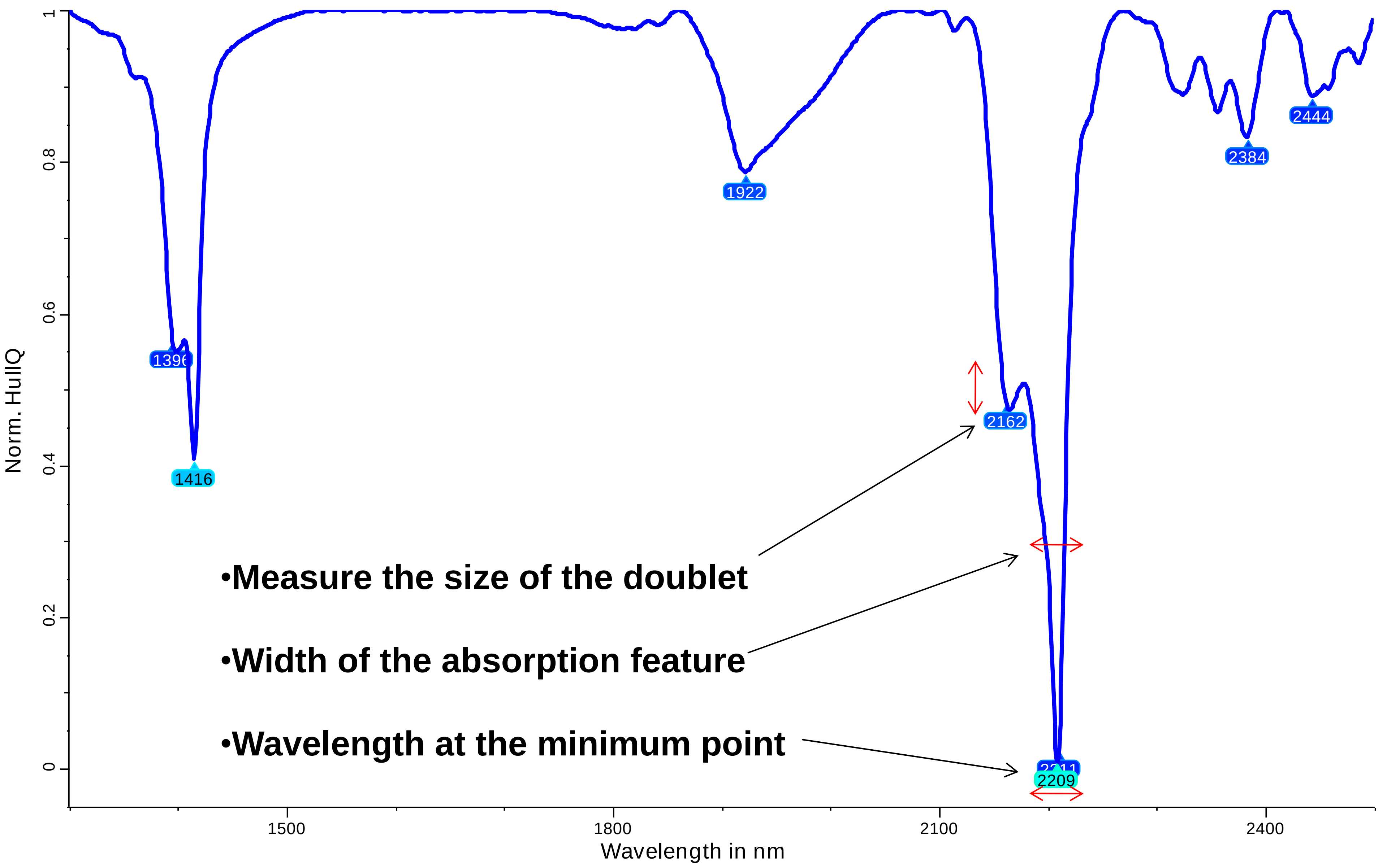
- sericite (variable solid solution), 2 varieties of chlorite, mixed sericite-chlorite, minor hornblende, epidote and talc.

How do we deal with big volumes of data?

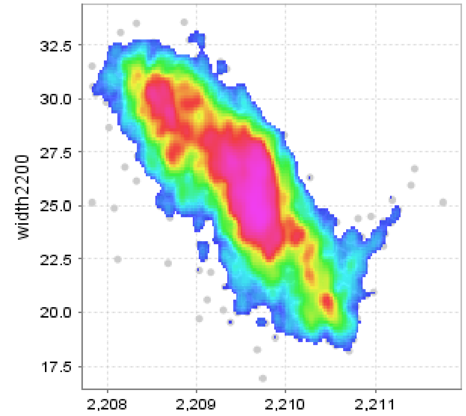
- Classify the silicate and oxide minerals.
- Measure the wavelength and relative depth of 4 or 5 key absorption features.
- The output is a table with 2 text fields and 10 numeric variables
- Treat this like an assay table.

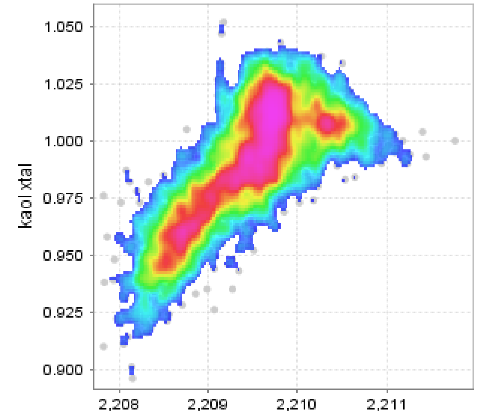


Kaolinite Spectrum

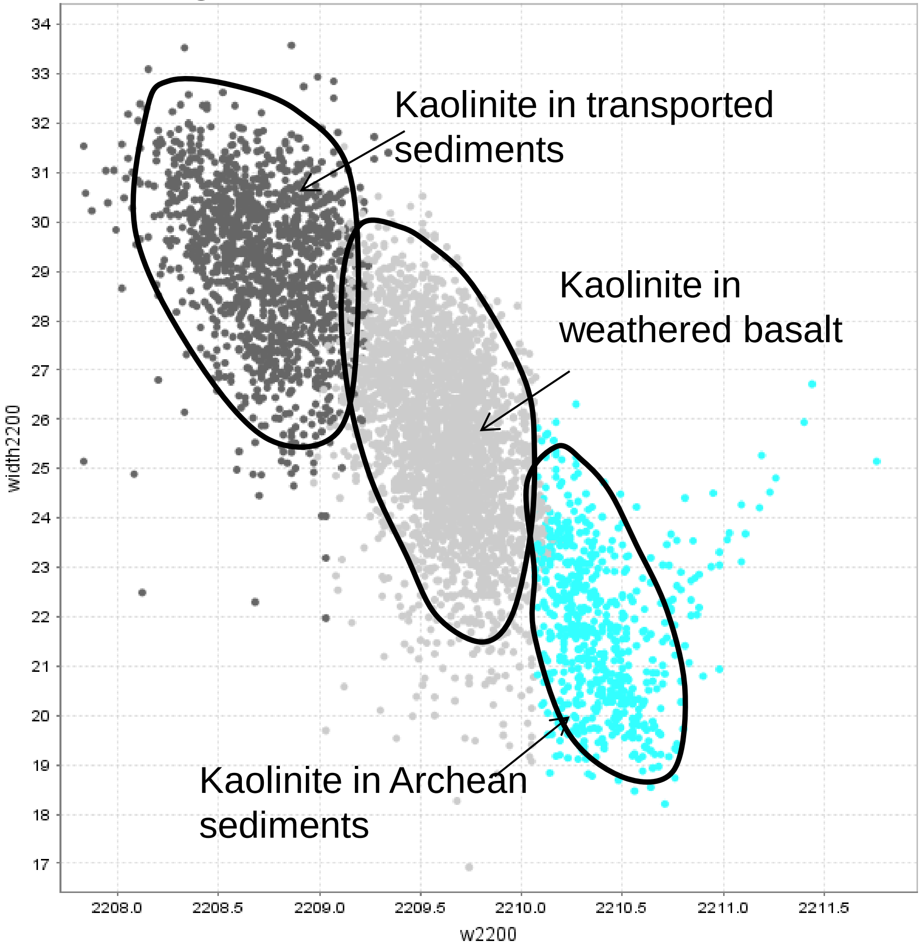


Kaolinite;
3 different types



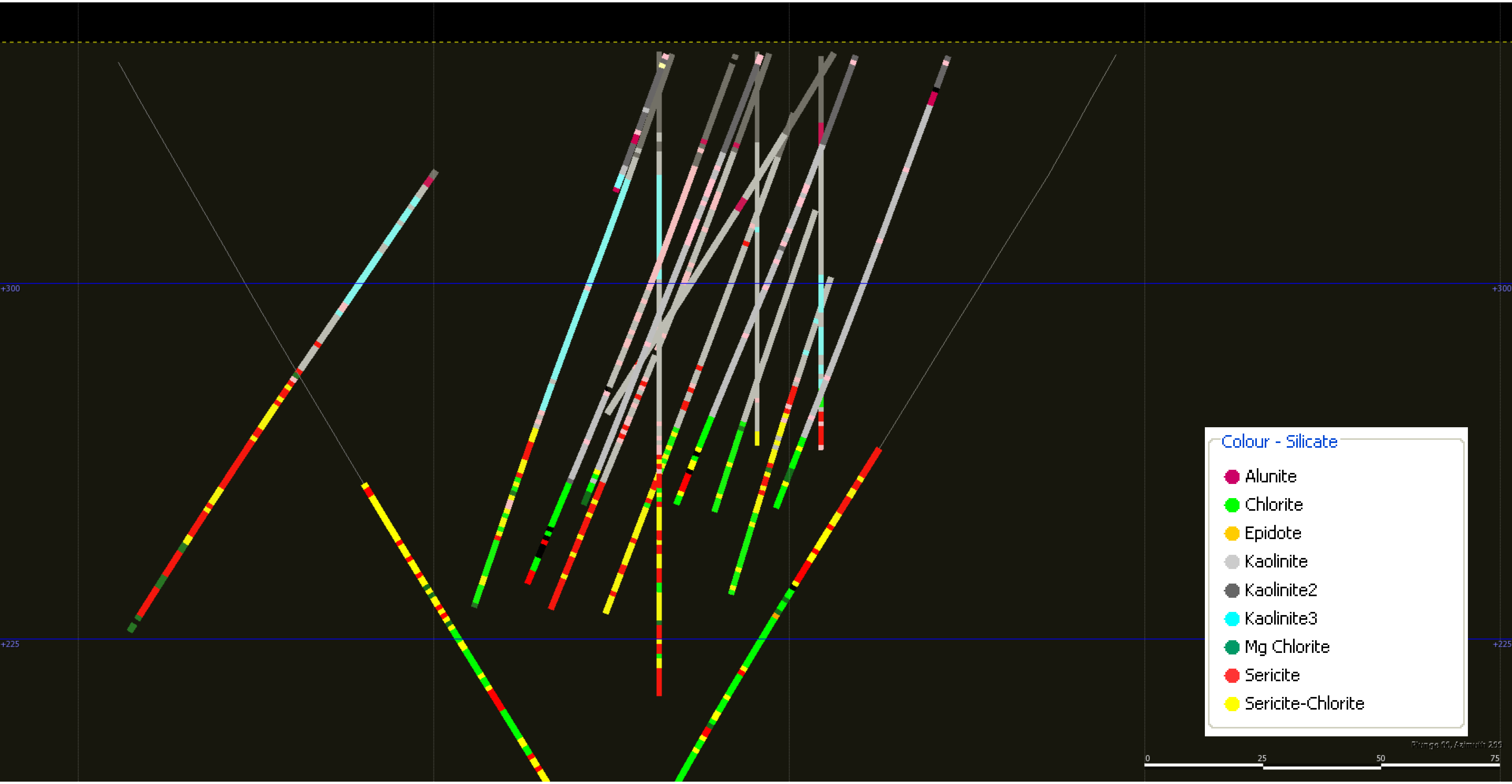


Wavelength vs width of 2200nm feature

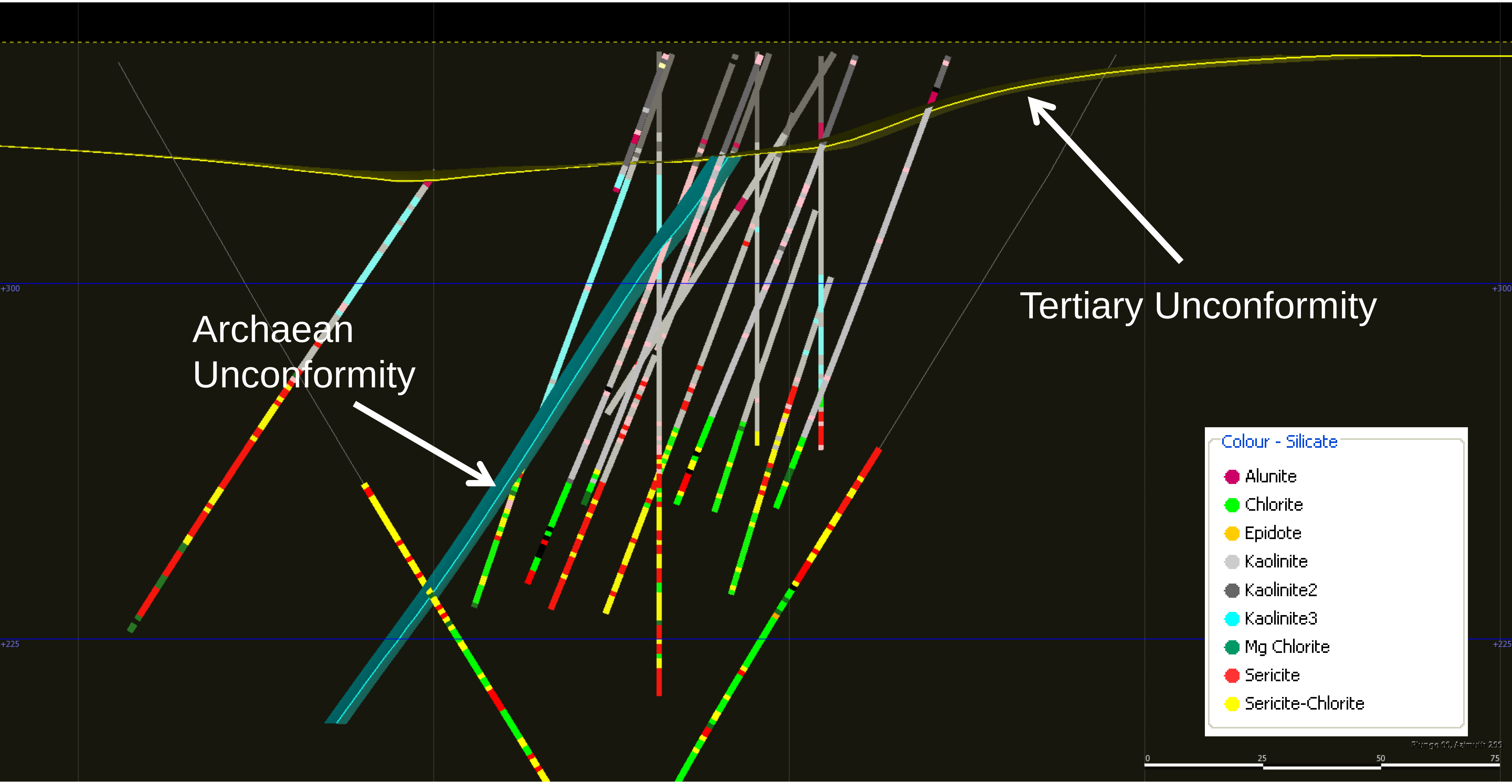


Wavelength vs size of 2160 doublet

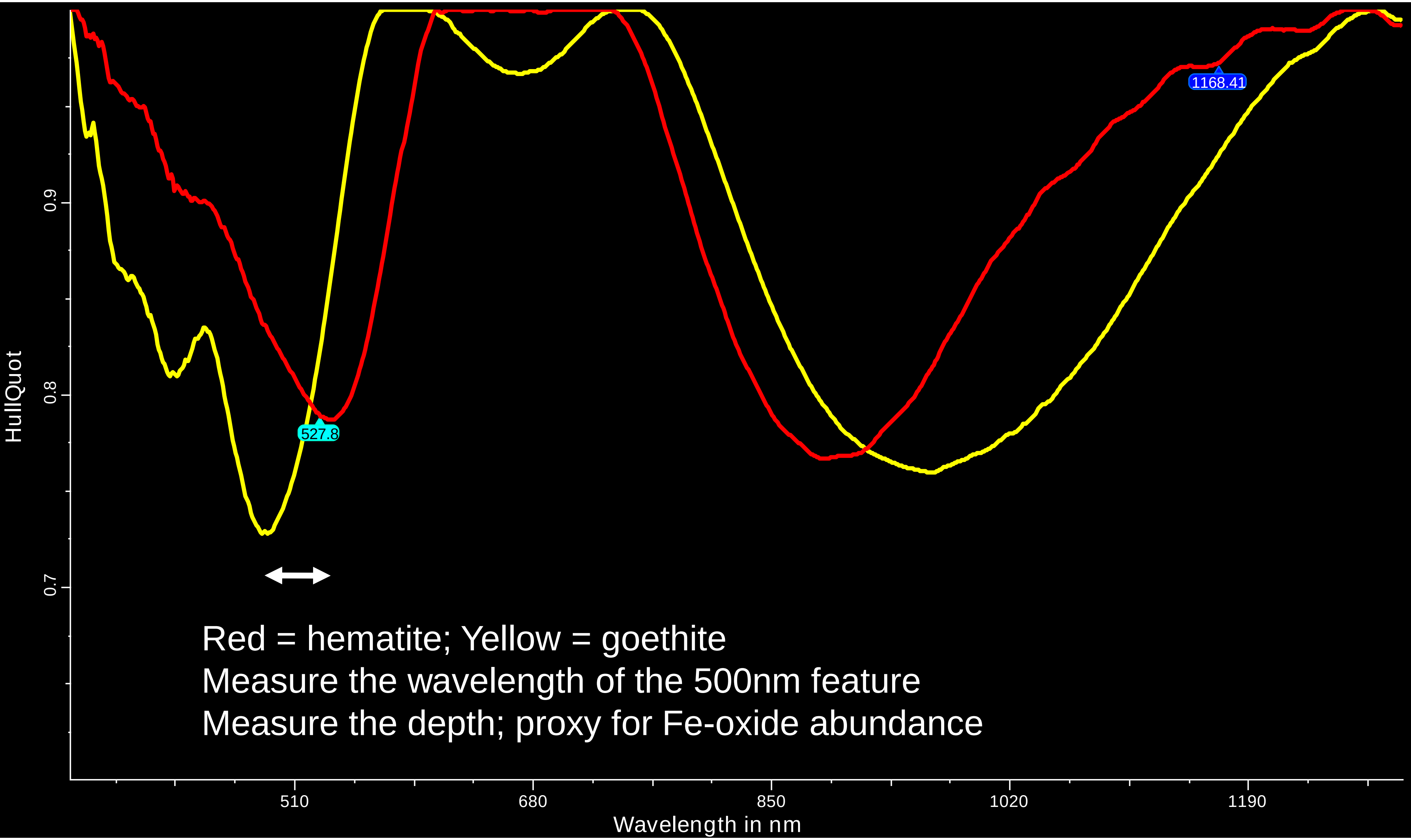
Silicate Mineralogy
Tertiary Unconformity



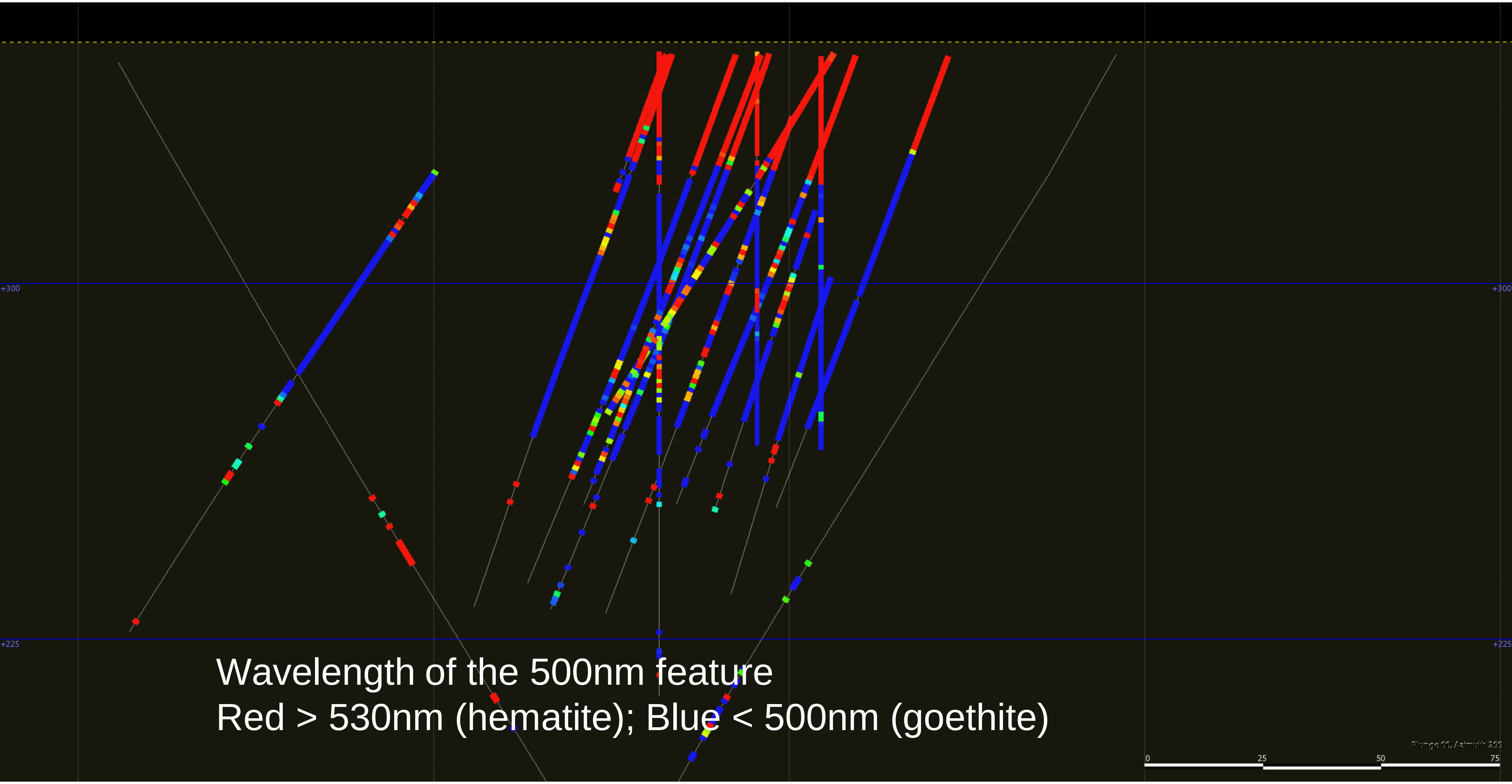
Silicate Mineralogy
Tertiary Unconformity



Hematite vs Goethite

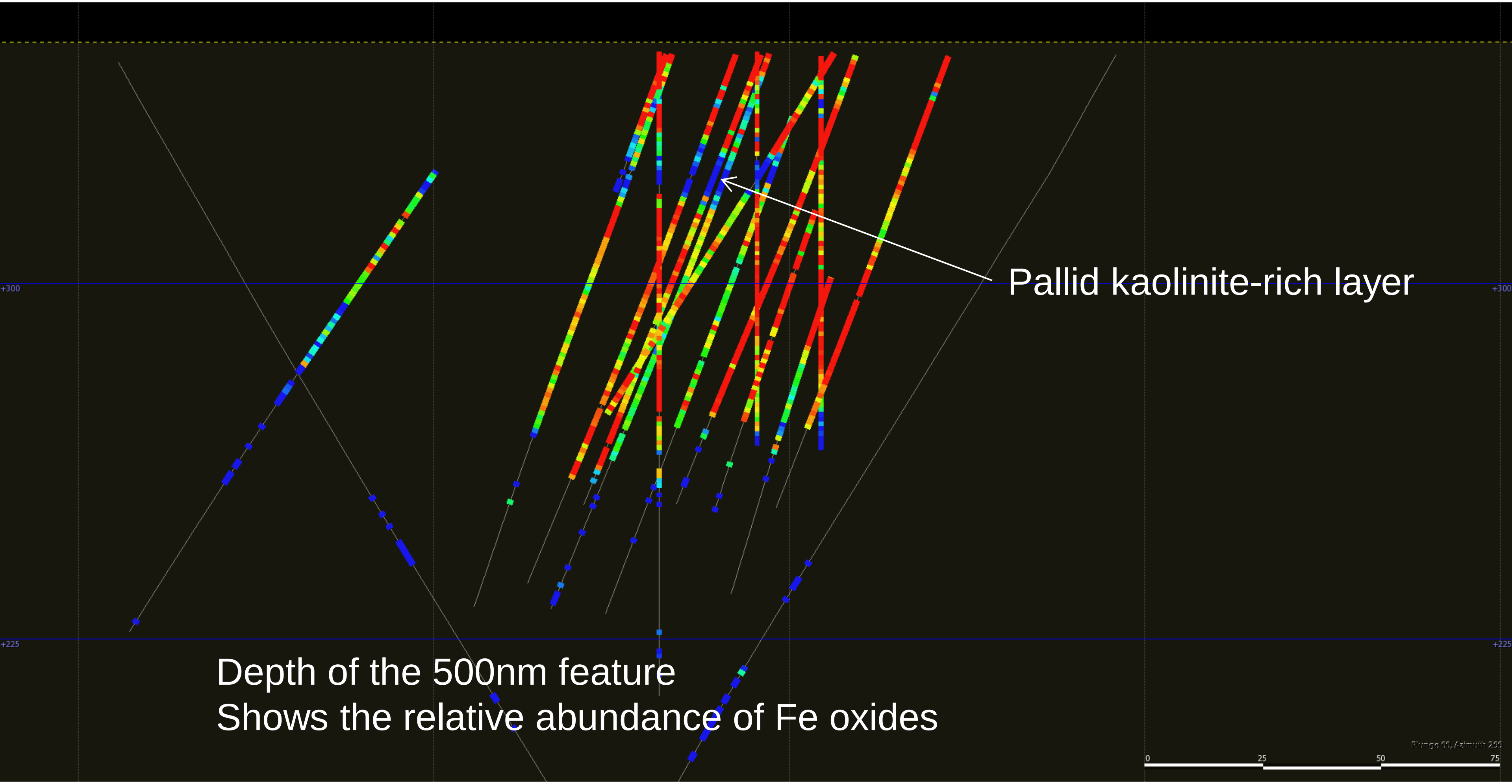


Hematite vs Goethite

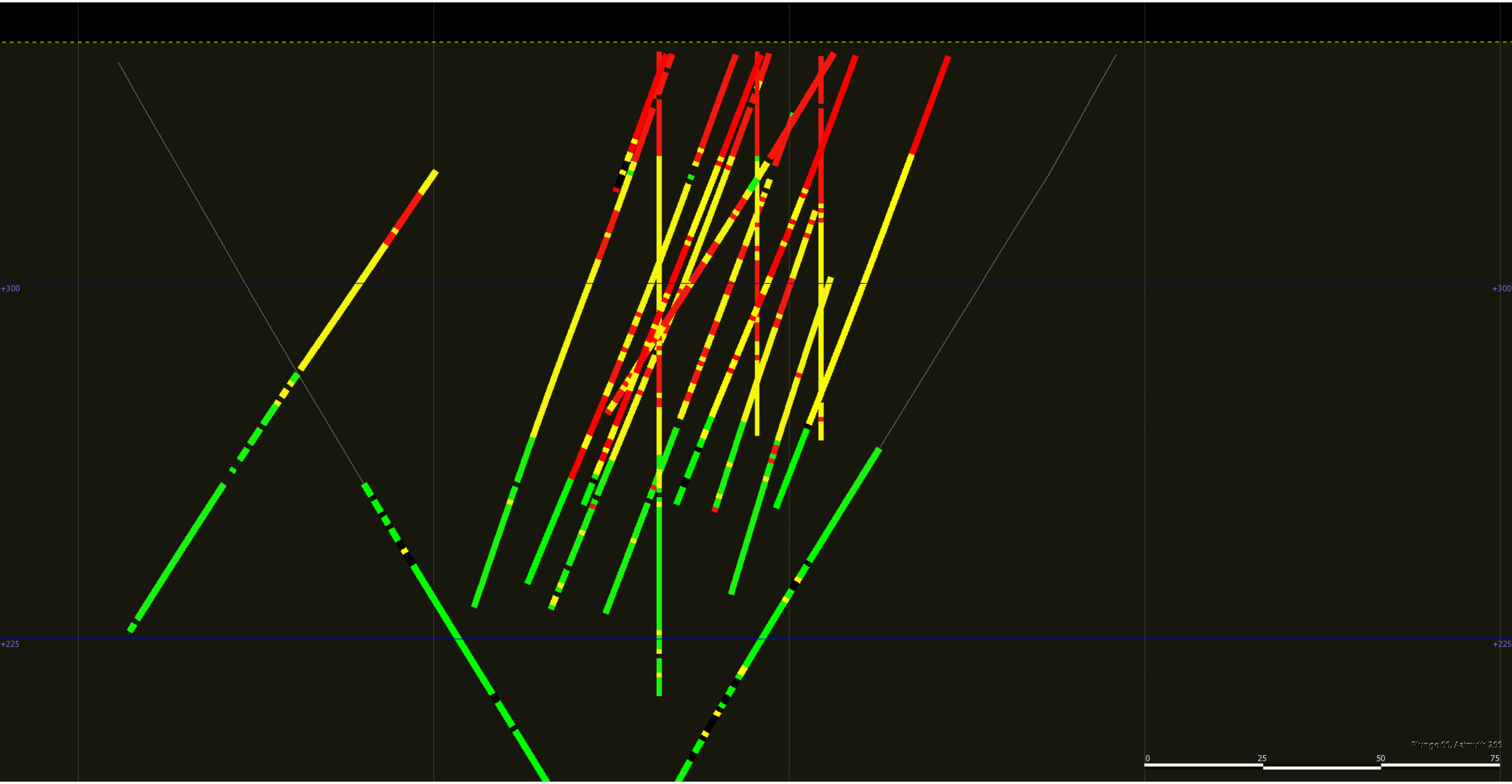


Wavelength of the 500nm feature
Red > 530nm (hematite); Blue < 500nm (goethite)

Hematite vs Goethite

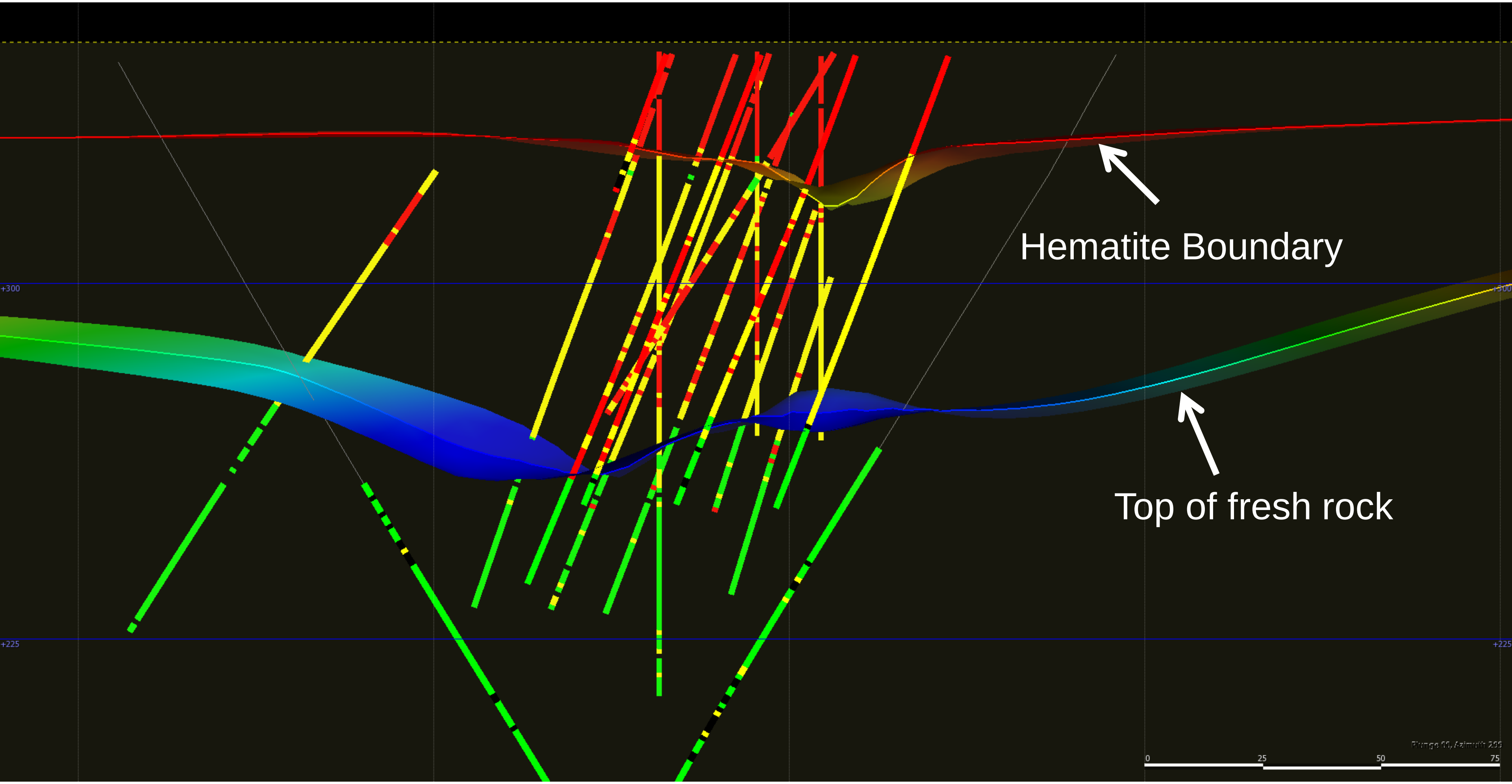


Hematite vs Goethite

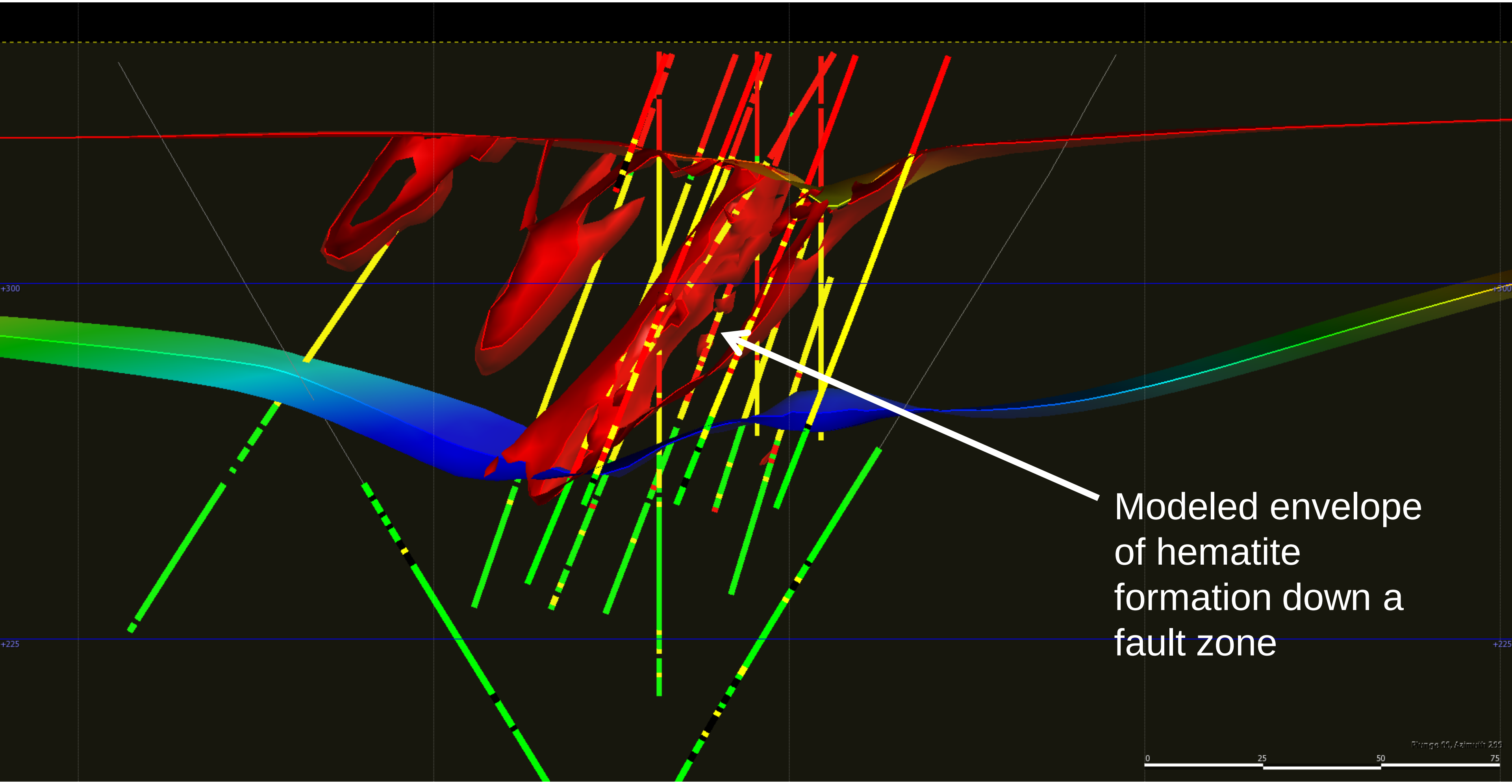


Hematite = red, Goethite = yellow, Fe silicates = green

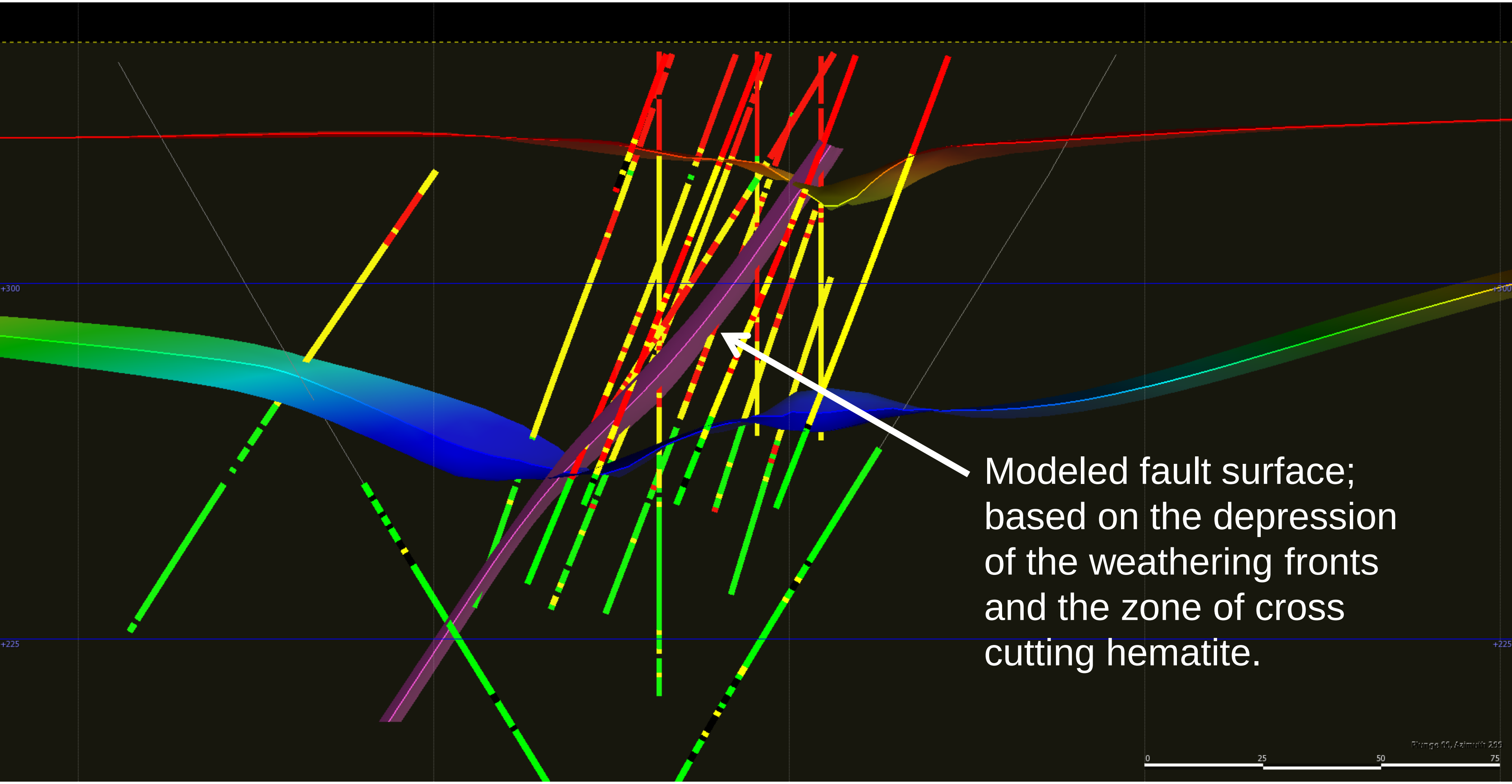
Hematite vs Goethite



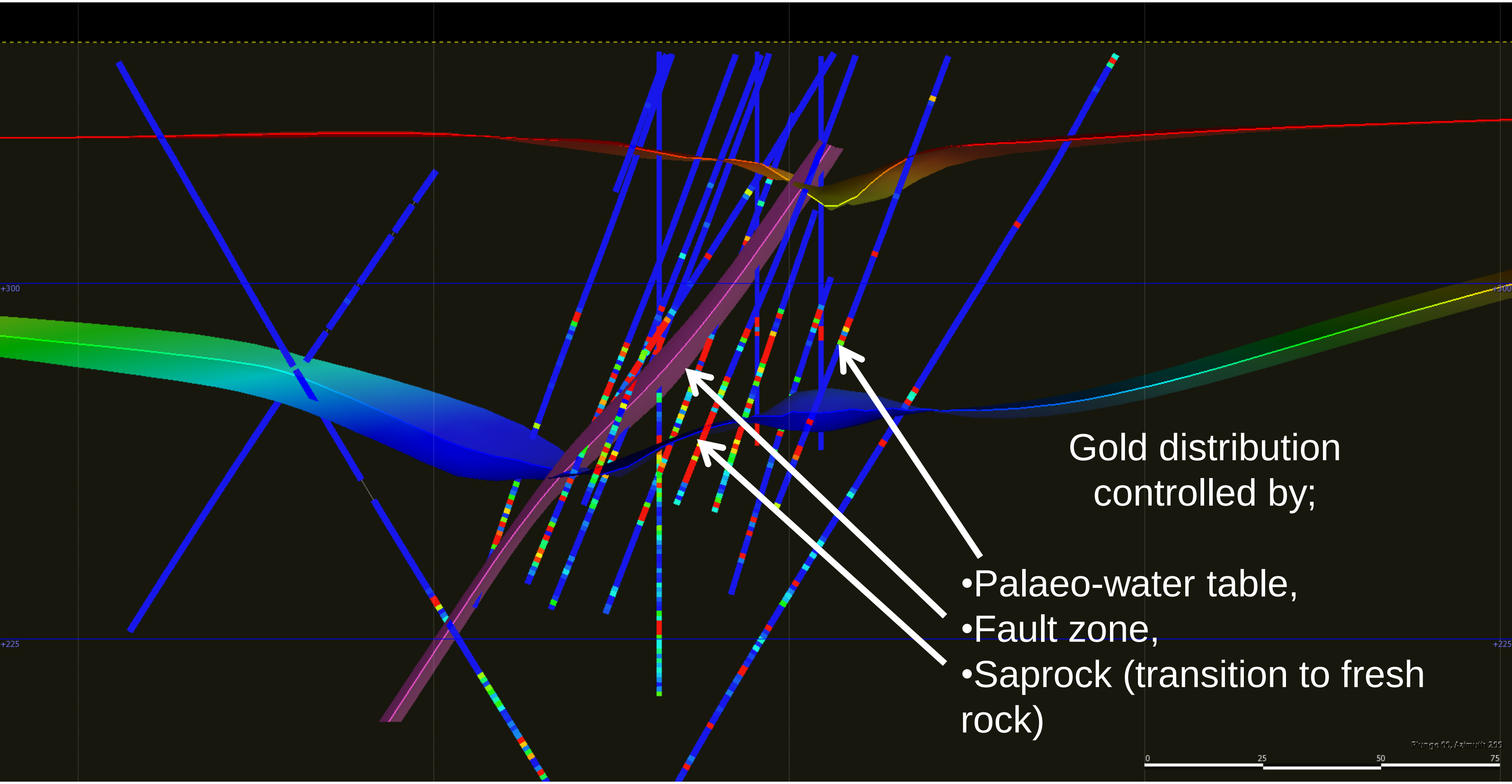
Hematite vs Goethite



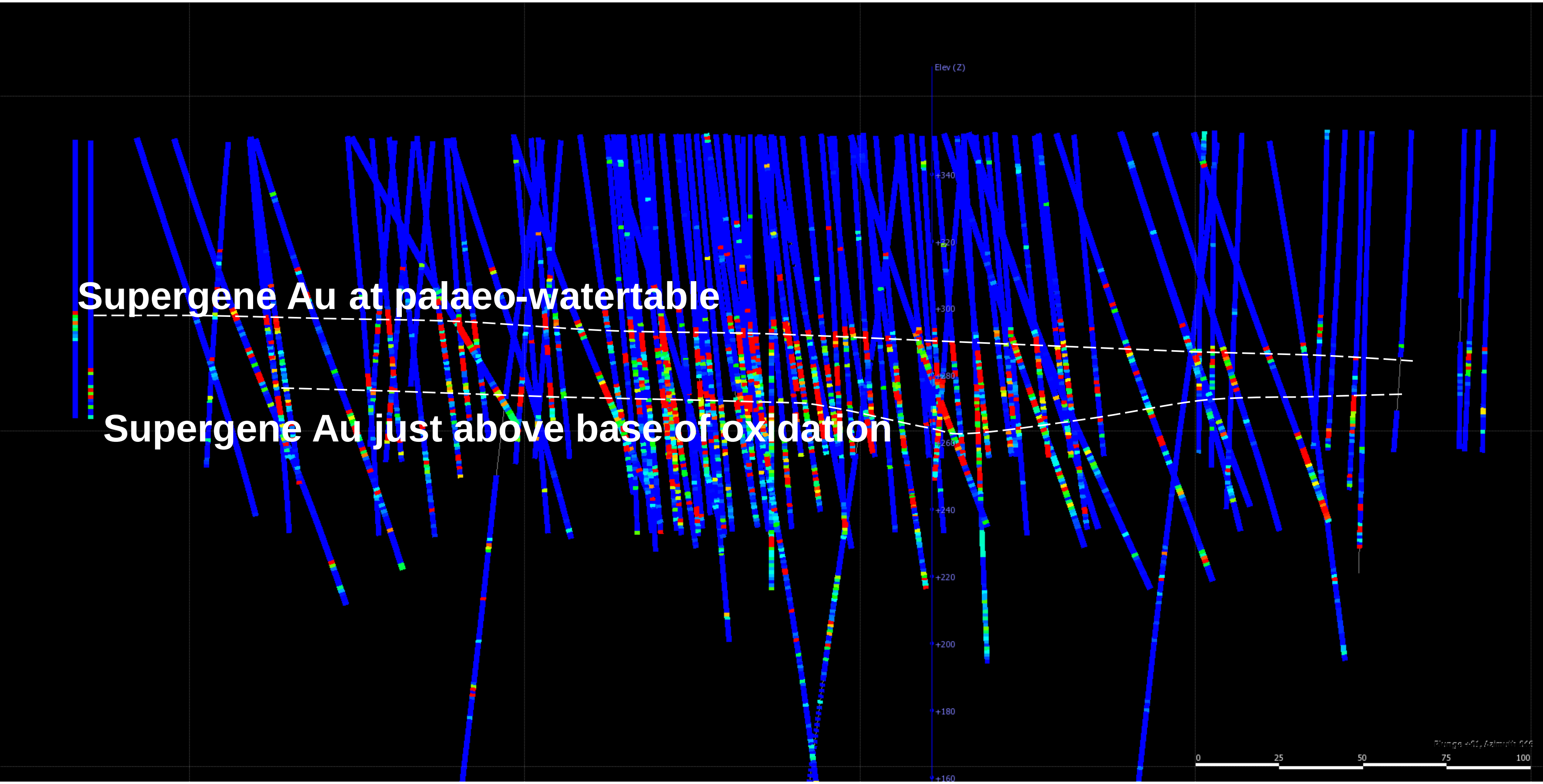
Hematite vs Goethite



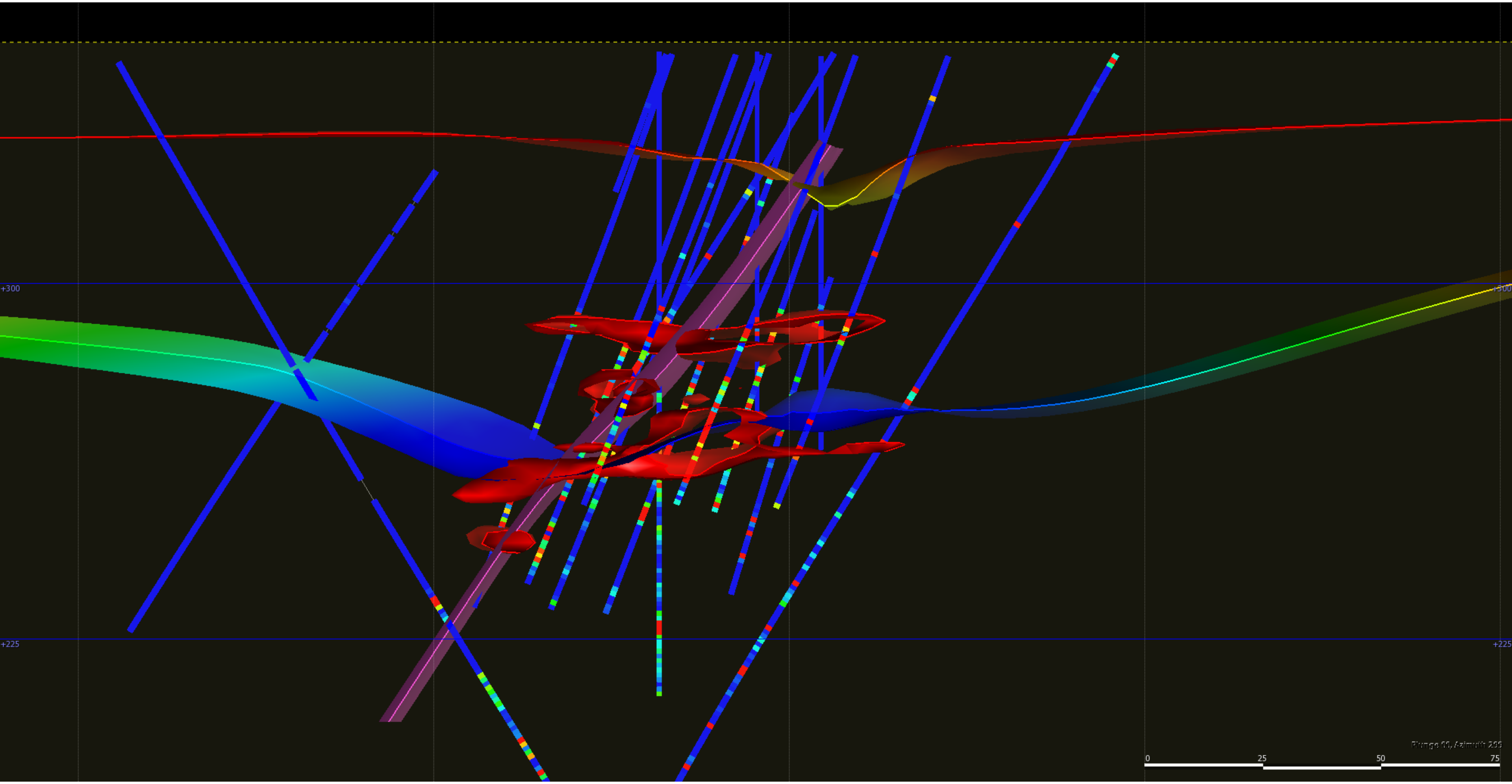
Gold Distribution



Gold Distribution

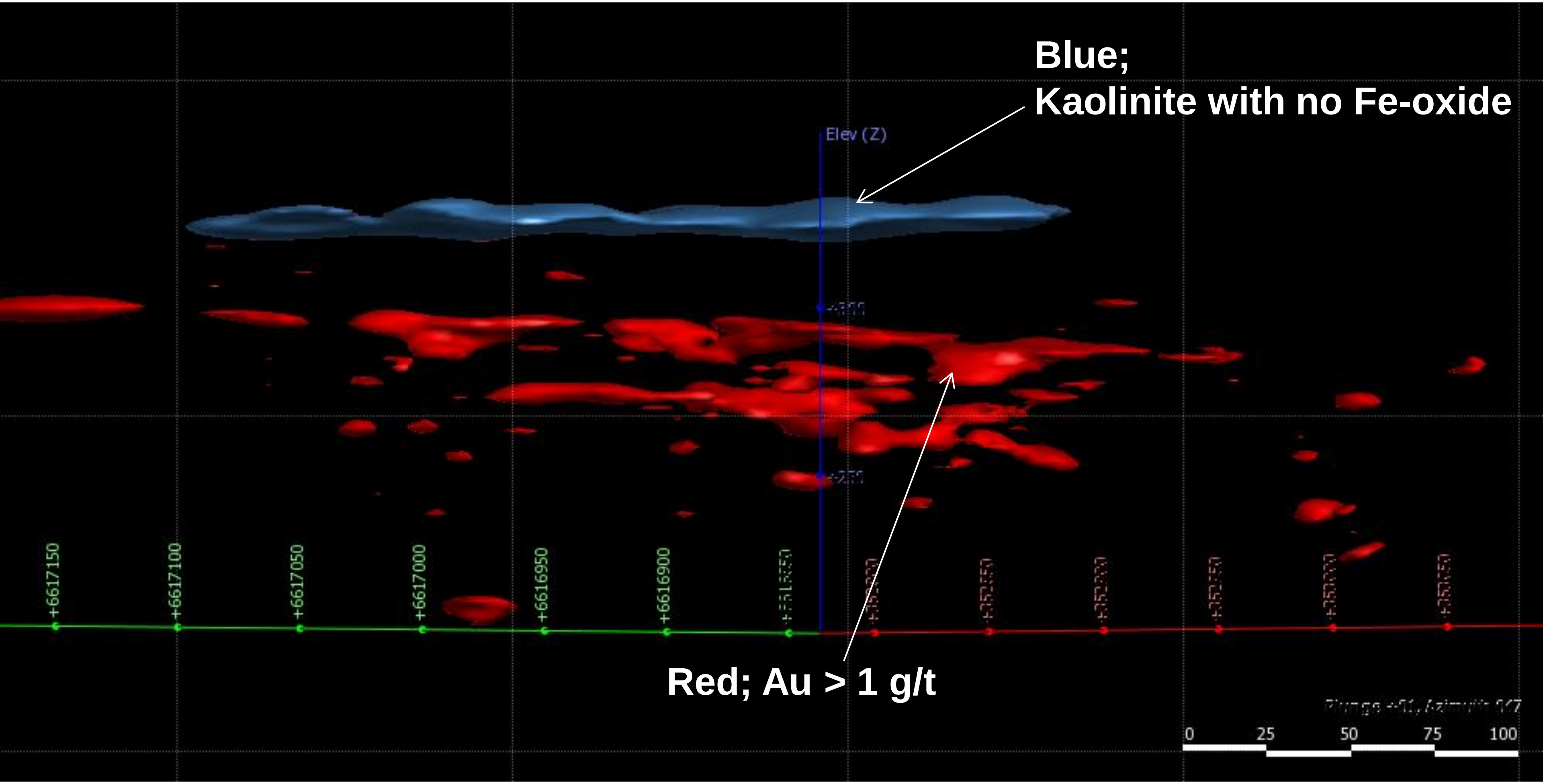


Gold Distribution



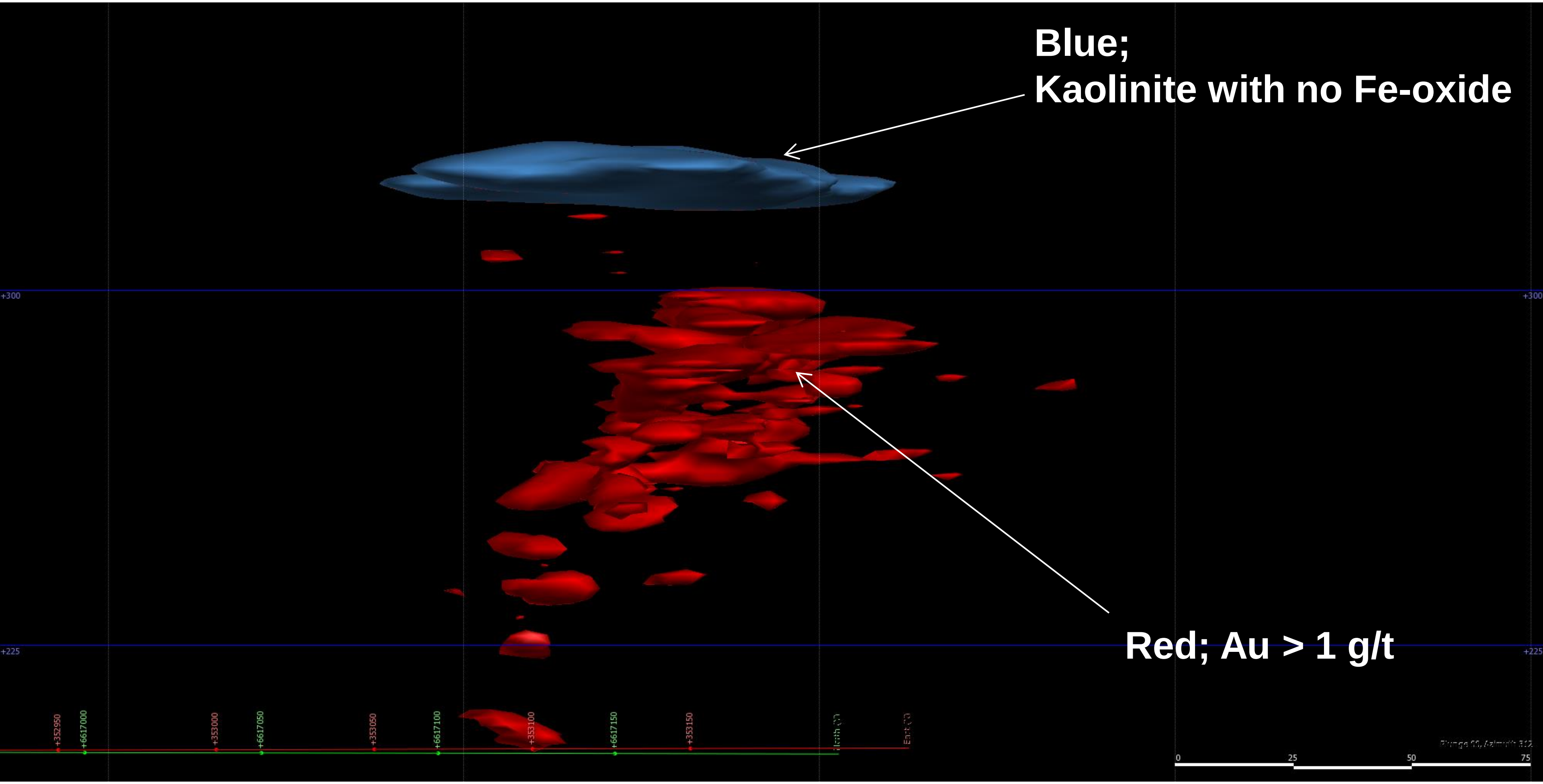
Interpolation of Au grade with a weighted search bias that includes the Top of fresh rock surface, the watertable surface and the fault surface

Gold Distribution – long section

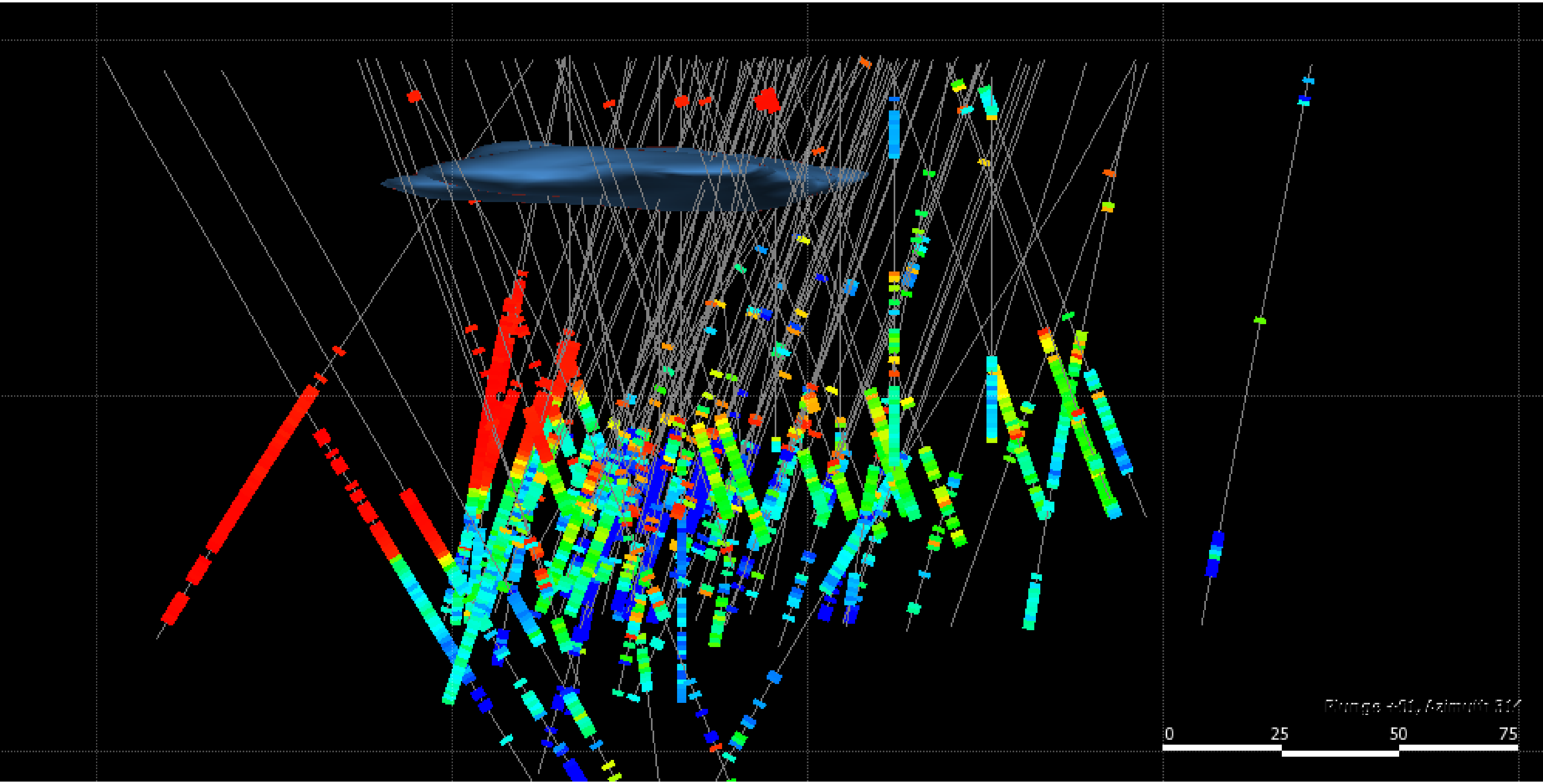


Red volume is >1.0 g/t Au
Blue volume; pallid, kaolinite-rich – goethite-poor zone in the upper saprolite

Gold Distribution – cross section

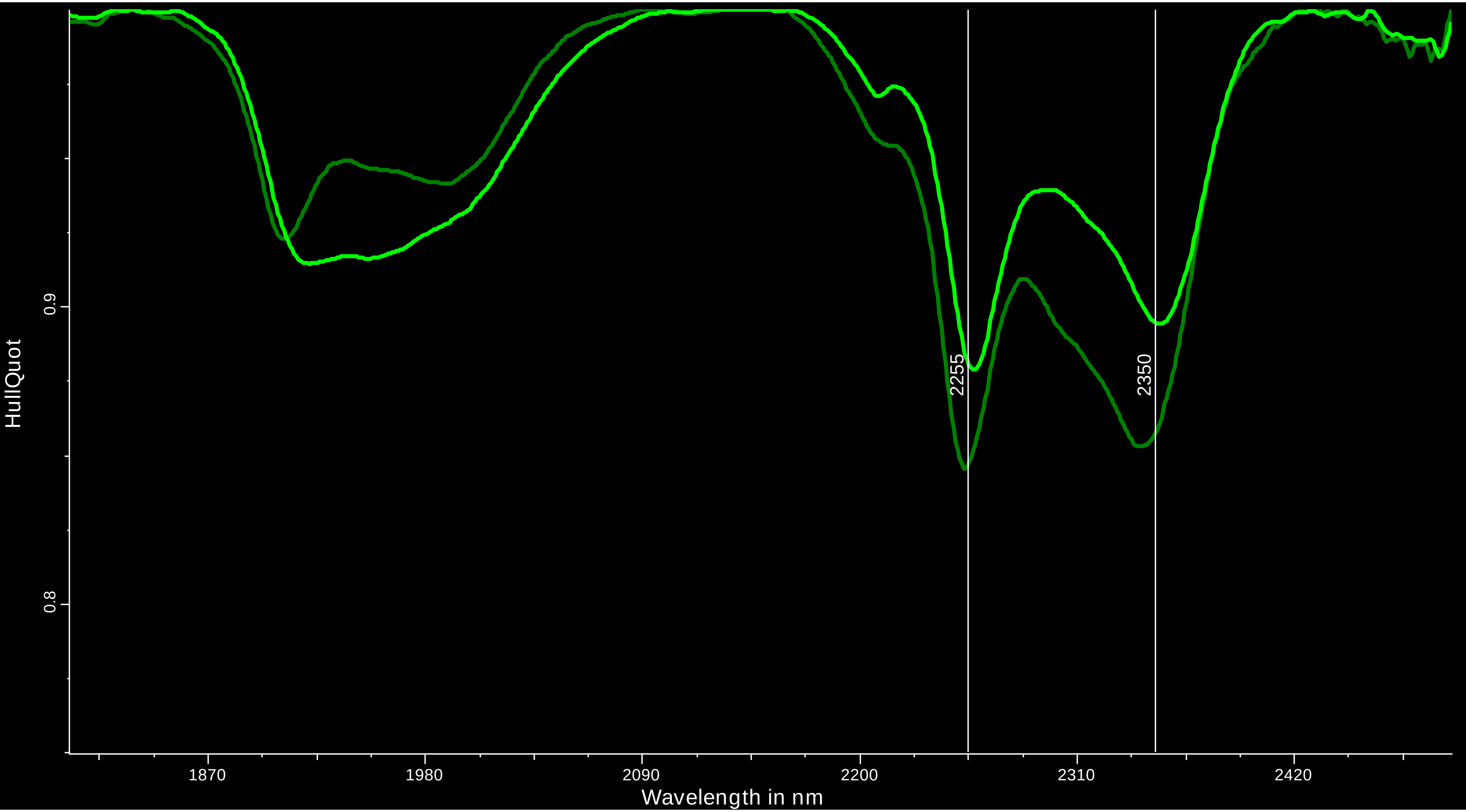


Sericite Chemistry



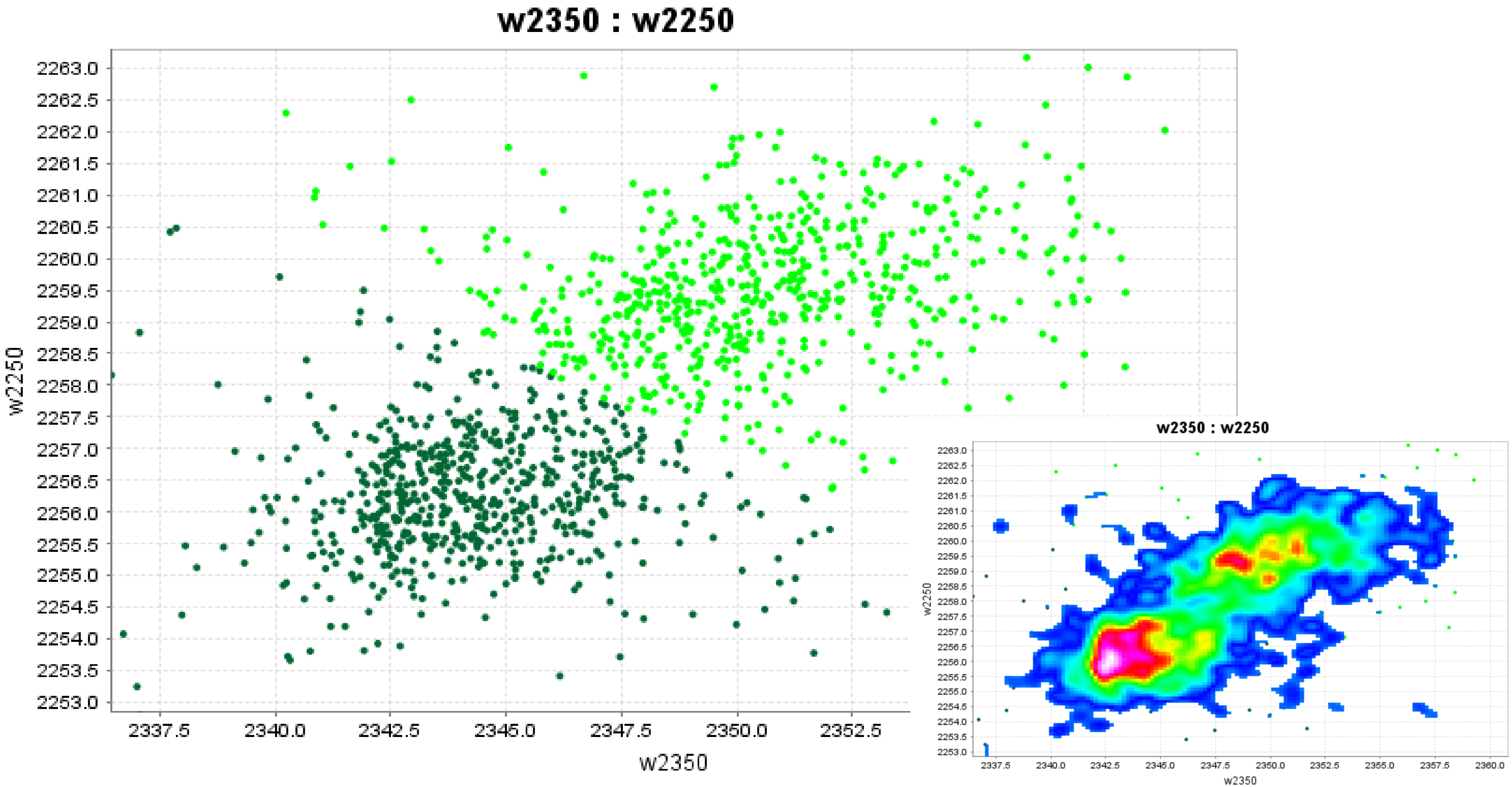
Wavelength of 2200nm feature in sericite; Orebody located on a sharp pH gradient
Red > 2215nm, phengite, alkaline pH zone
Blue < 2200nm, muscovite, acid pH zone

Chlorite Chemistry



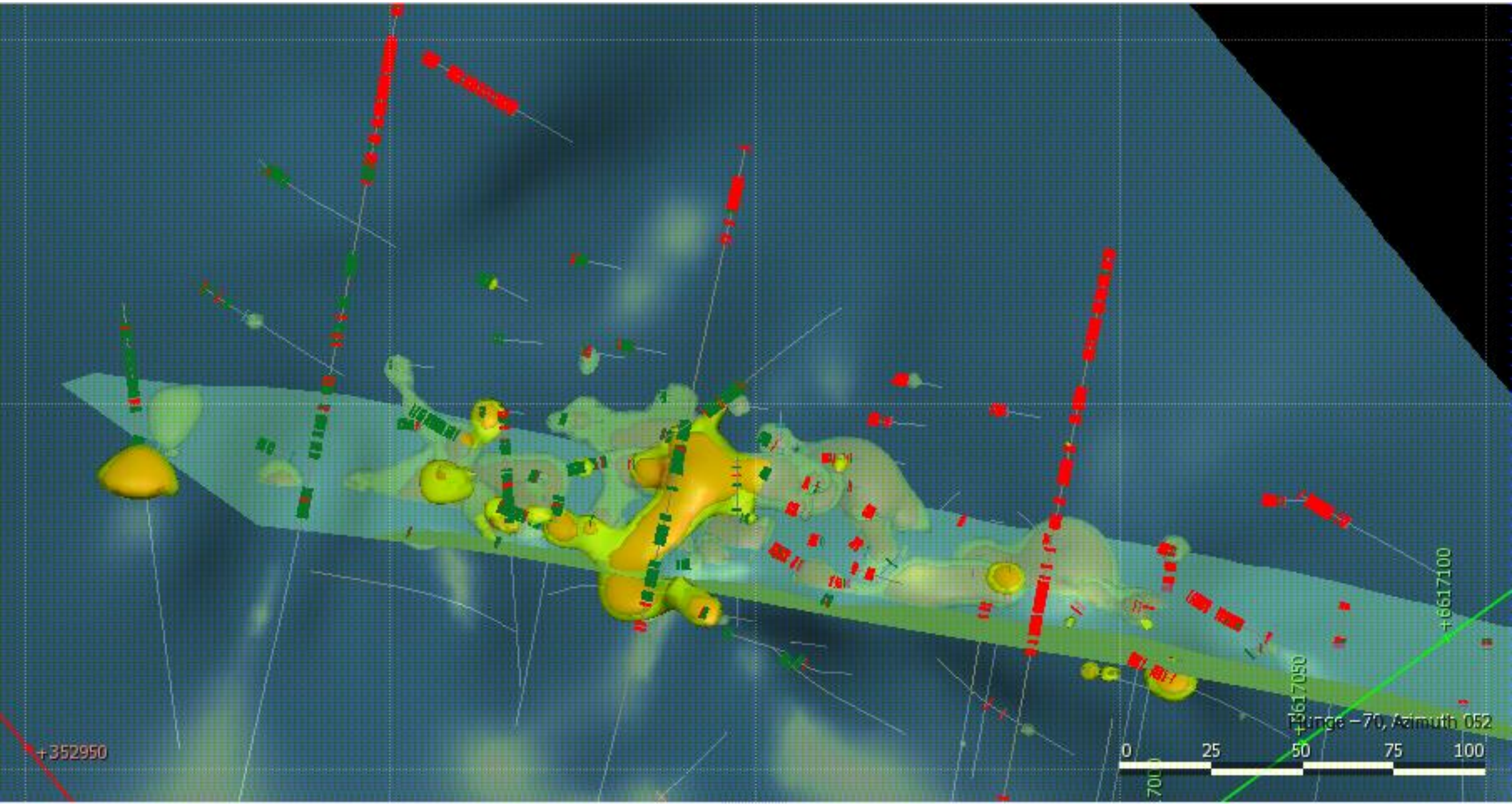
Dark green, Mg Chlorite
Pale green, Fe Chlorite

Chlorite Chemistry



Two types of chlorite; controlled by host rock. Mg vs Fe tholeiite
Dark green, Mg Chlorite Pale green, Fe Chlorite

Chlorite Chemistry



View looking from below. Red=Mg Chlorite, green=Fe Chlorite, shapes of gold isosurfaces. High grade pod sits on Fe to Mg tholeiite contact!

Mineral Mapping

What did we learn?

3 different types of kaolinite, 2 different types of chlorite, variety of sericite types; these cannot be logged visually.

Modeled Tertiary and Archean unconformities. Modeled controlling fault; => Robust geological model.

Correlation of grade with geological and regolith surfaces; => constrains grade interpolation.

Mineral Mapping

Conclusions.

Cheap, fast data collection.

Quantitative measurements, independent of geologist’s opinions and bias.

Data can be reduced to a simple classification, and set of numeric fields; ideal for modeling.

Just as easily applied to alteration mapping.

Spectral Mapping; Pros and Cons.

Pros.

- Takes the guess work out of logging.
- Fast.
- Low Cost.

Cons.

- Measurement and Mineralogy has advanced well ahead of MEANING
- Commonly ambiguous to interpret.
- ICP geochem is usually less ambiguous to interpret but much more expensive to collect.

The ideal is comprehensive spectral data calibrated against a broader sampling pattern of geochem.