Structural Evolution of the Keno Hill Ag-Pb-Zn mining district, Yukon

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Introduction

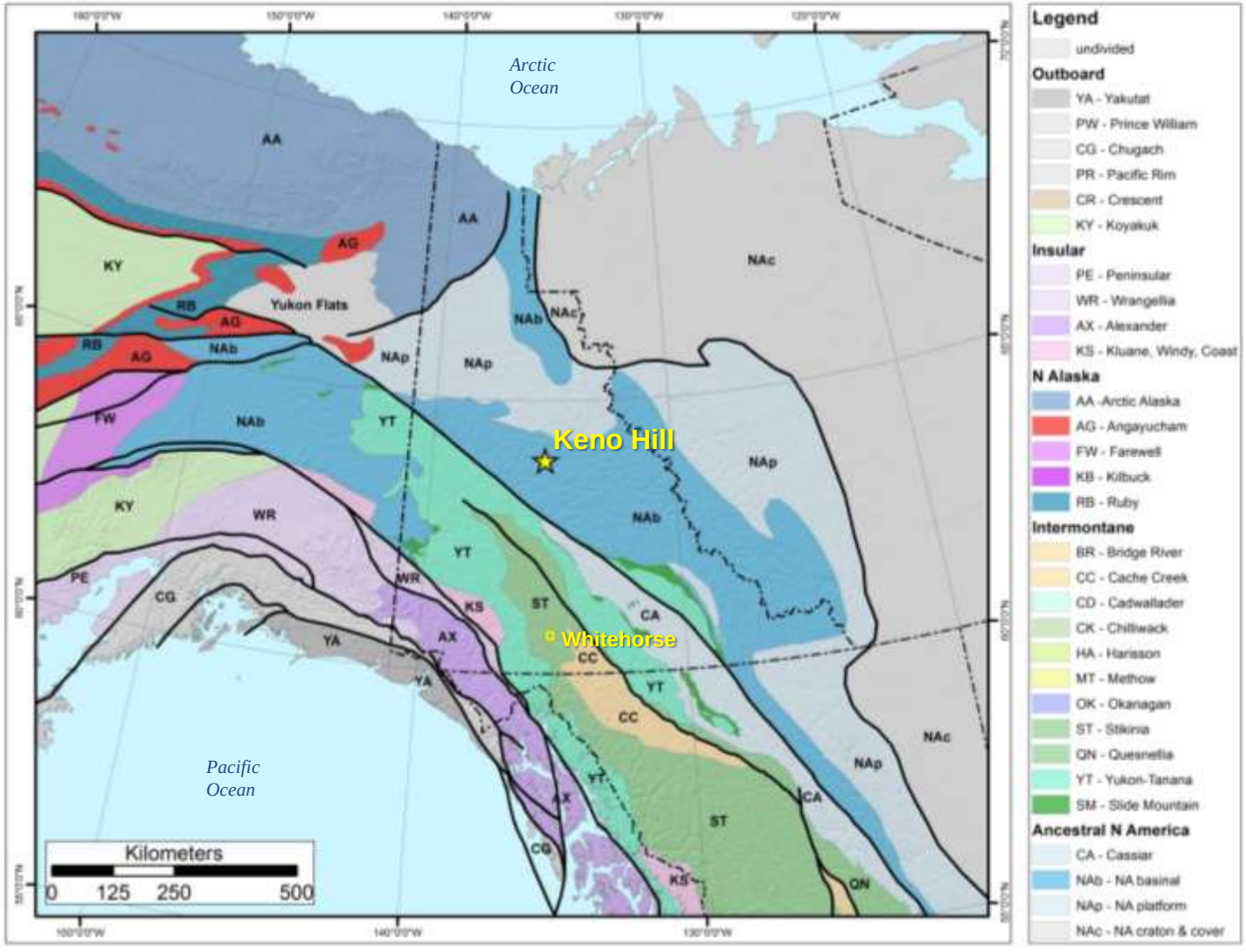
- **The Keno Hill Ag-Pb-Zn mining district is located in the central Yukon, approximately 350 km north of Whitehorse.**

- **Between 1913 and 1990 the camp produced:**
  - **> 6 M kg Ag @ average grade 1,373 g/t**
  - **300,000T Pb @ average grade 6.7%**
  - **195,000T Zn @ average grade 4.1%**

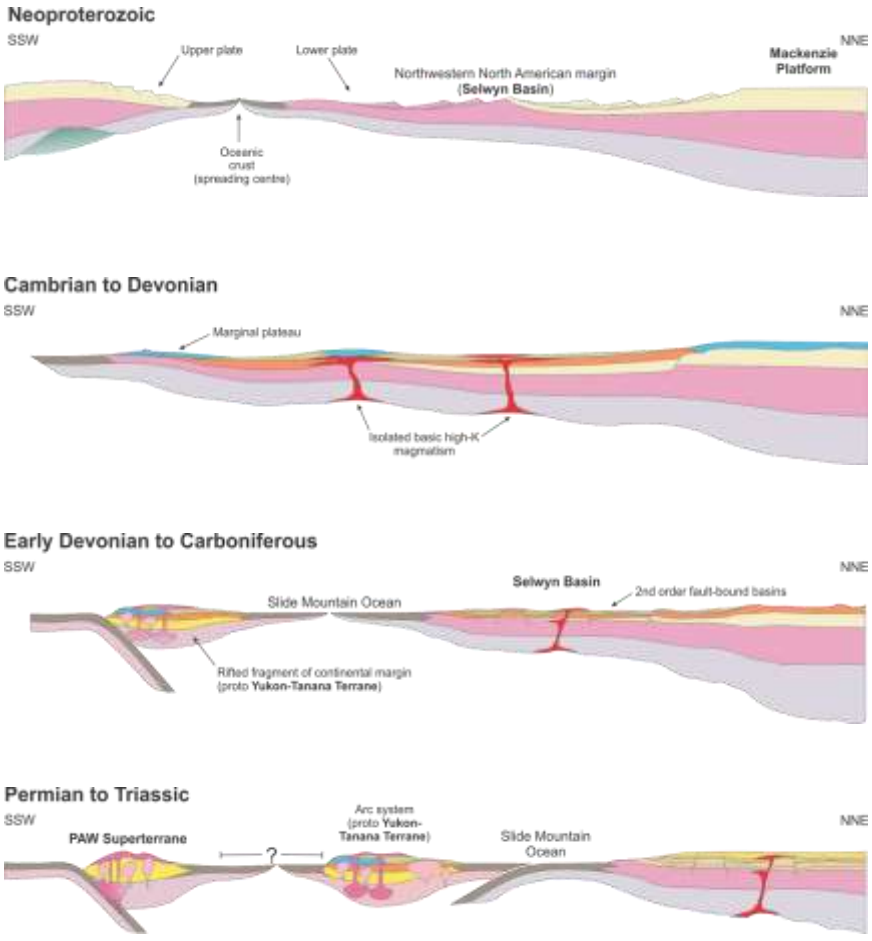
- **Fault-controlled, vein-type deposit**
  - **Ore is typically hosted in the Mississippian Keno Hill Quartzite of the Selwyn Basin.**

- **At least three deformation phases identified.**

Location and Regional Geology

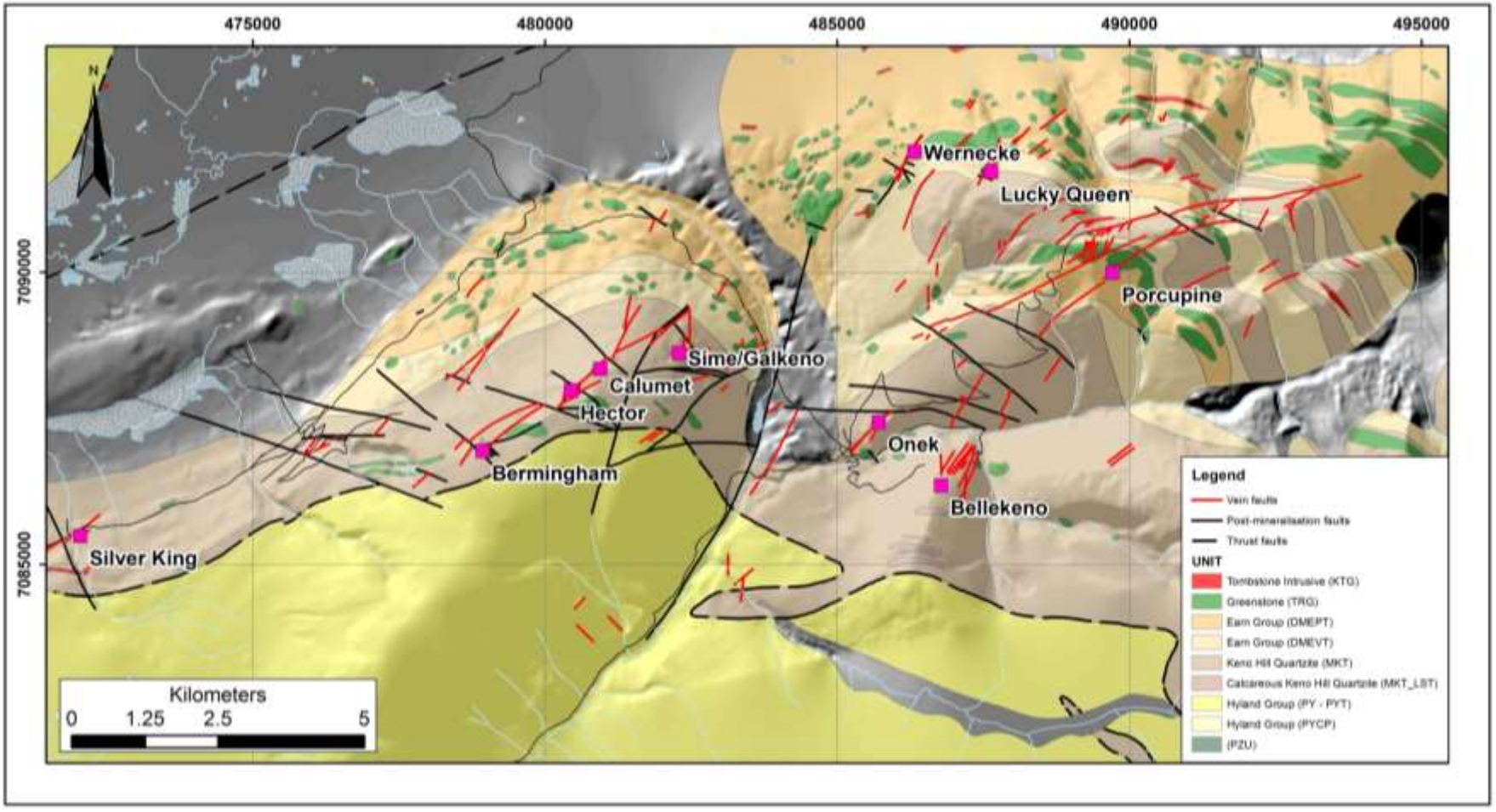


Location and Regional Geology



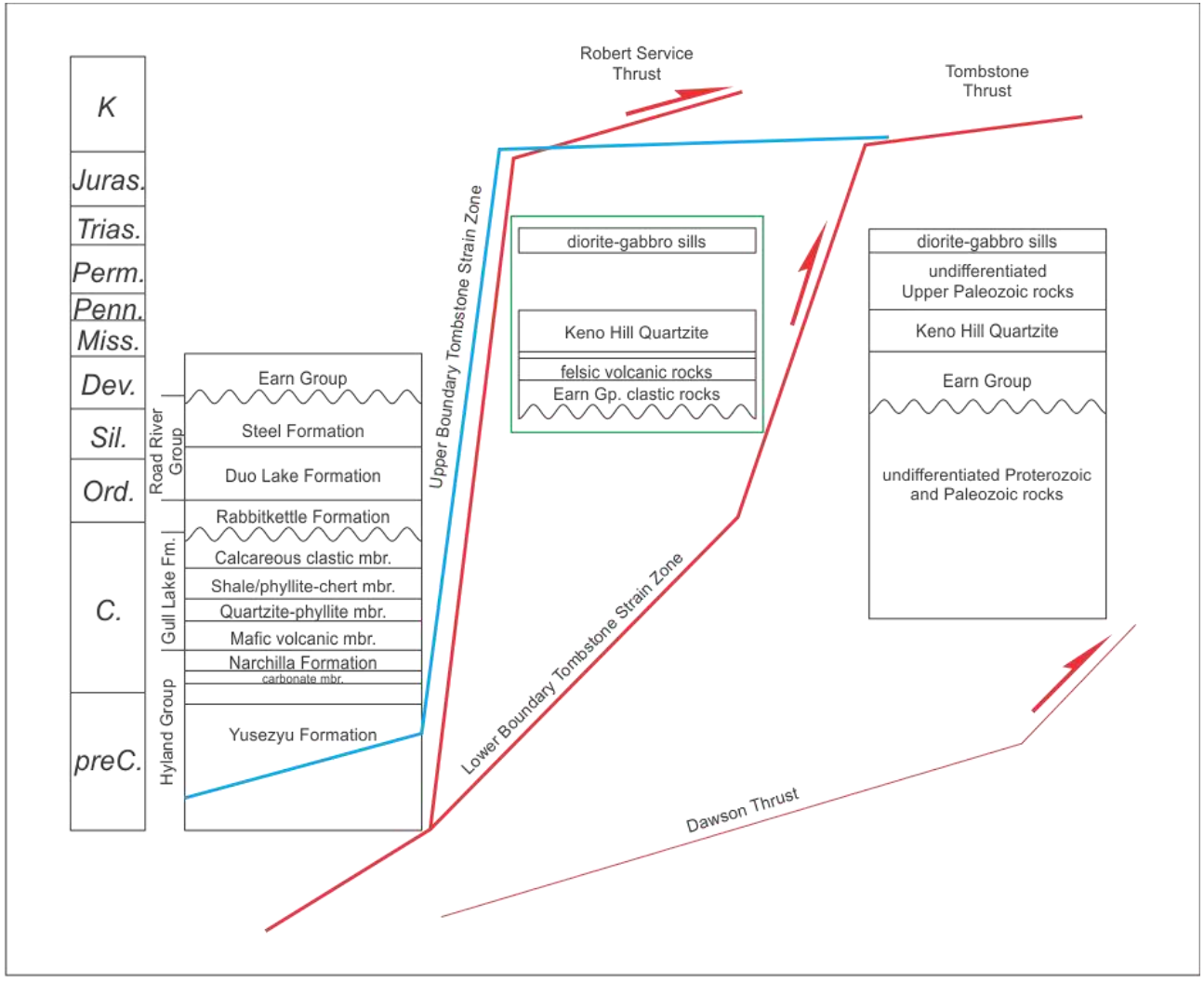
Modified after Mair et al., 2006.

District Geology



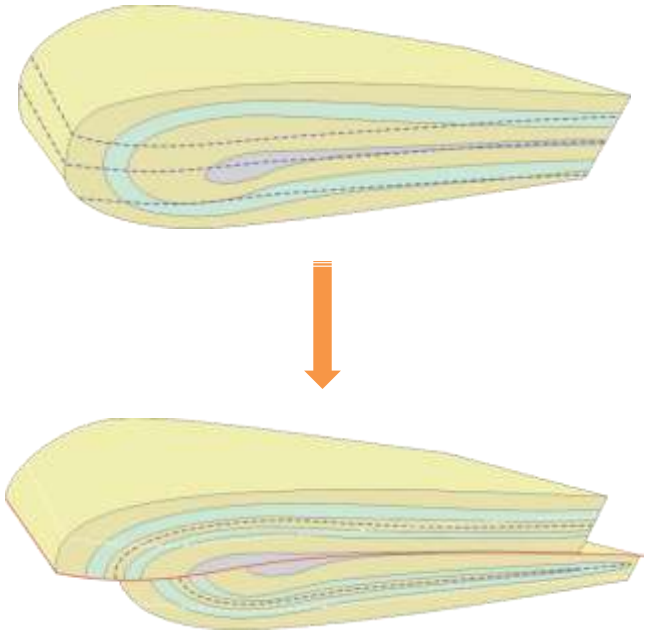
Modified after Murphy (1997), Boyle, (1965), and McOnie (2008).

District Geology



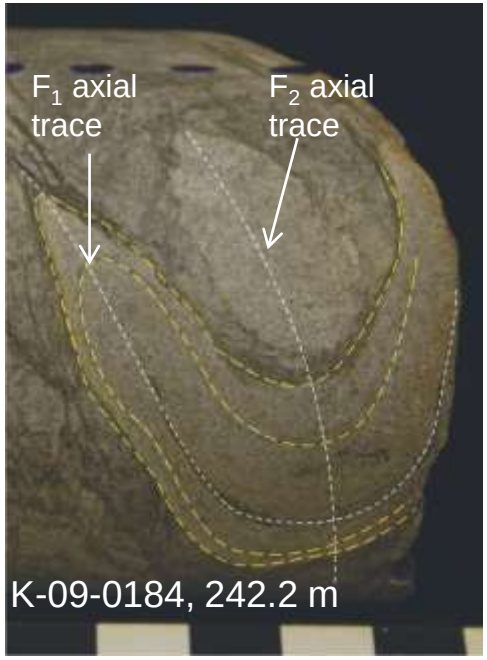
Murphy, 1997

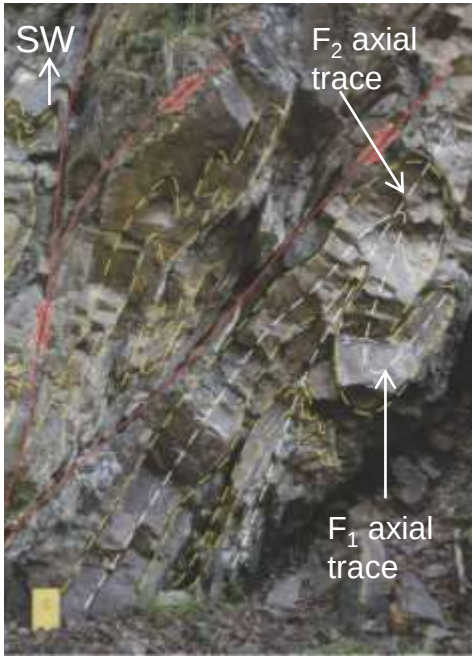
D_1 - Brittle Ductile Deformation

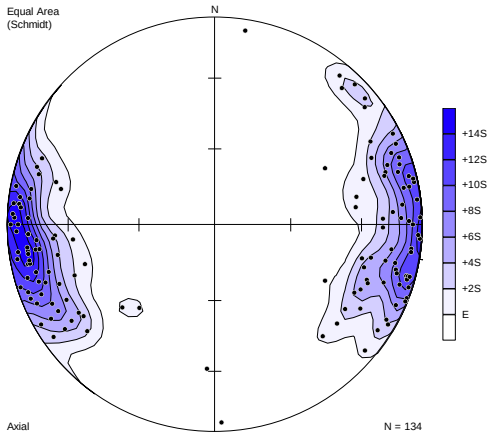


- Two phases (F_1 – F_2) of sub-coaxial, north to northwest verging isoclinal folding;
- North- to northwest-directed thrust faulting;
- Composite $S_{1\text{-}2}$ foliation development; and
- Greenschist grade metamorphism.

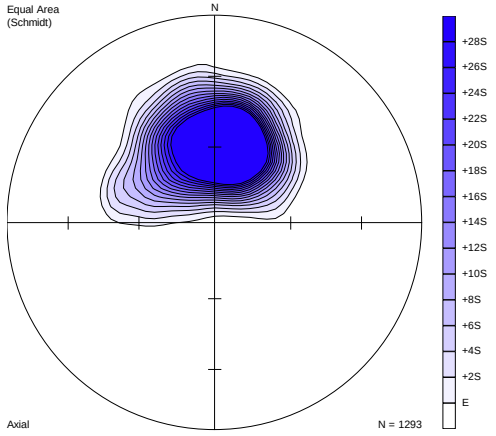
D_1 - Brittle Ductile Deformation







$F_{1\text{-}2}$ Fold axes



$S_{1\text{-}2}$ foliation (poles)

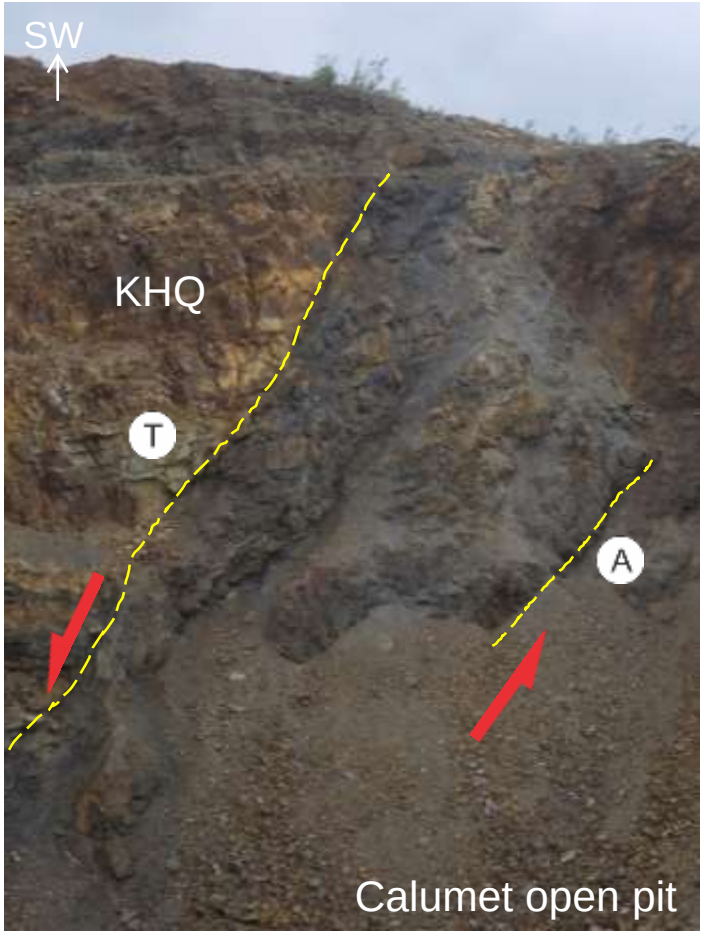
D_2 – D_3 Brittle Deformation

- Two sets of approximately orthogonal faults present in district.

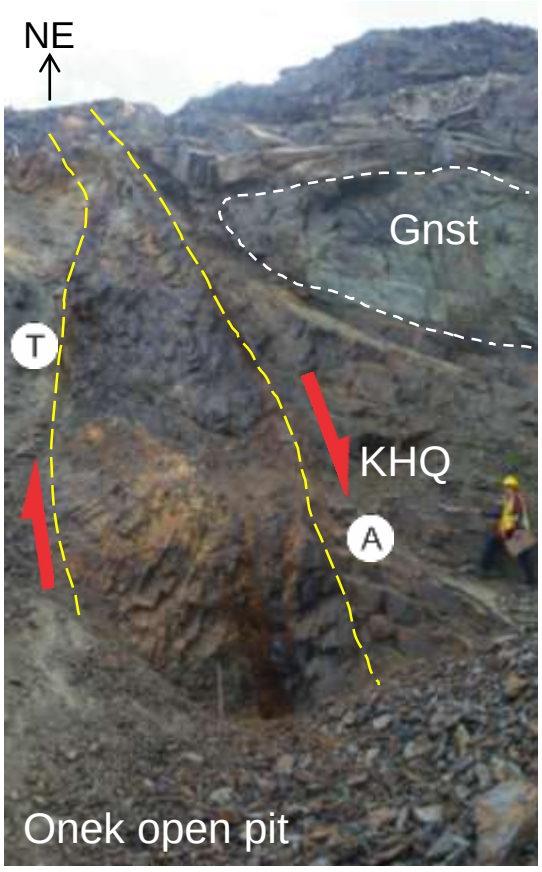
- D_2
  - Northeast- to east northeast-striking, typically sinistral to sinistral-oblique faults;
  - Moderate to steeply southeast-dipping
  - Commonly associated with Ag-Pb-Zn mineralisation (galena, sphalerite, siderite);
  - Sporadic quartz with minor associated Au.

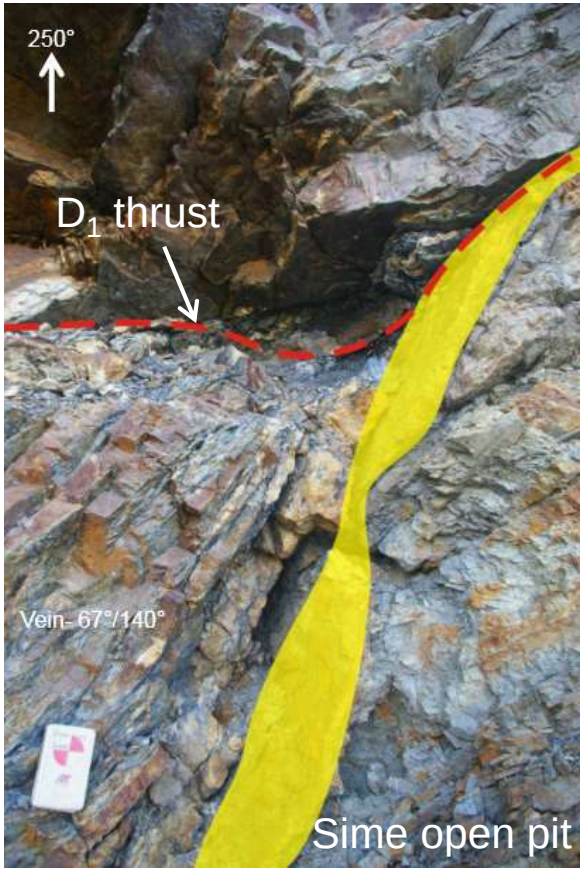
- D_3
  - Northwest- to north-striking dextral-oblique faults;
  - Moderate to steeply southwest-dipping;
  - Offset mineralised faults.

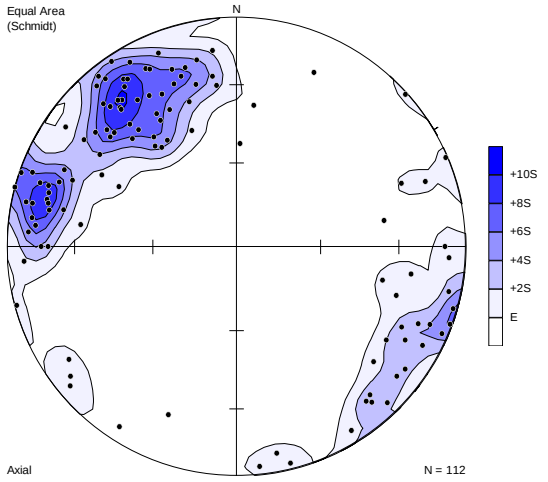
- F_3 folds: open, plunge shallowly southeast.



D_2 Brittle Deformation - Mineralisation

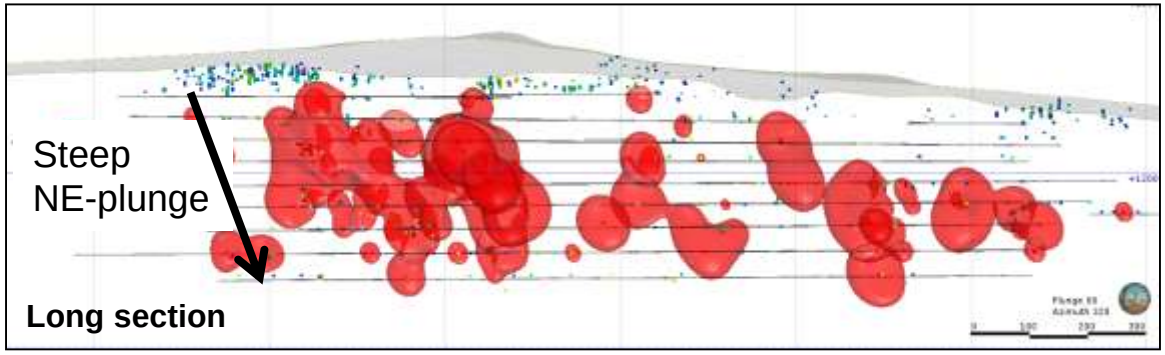


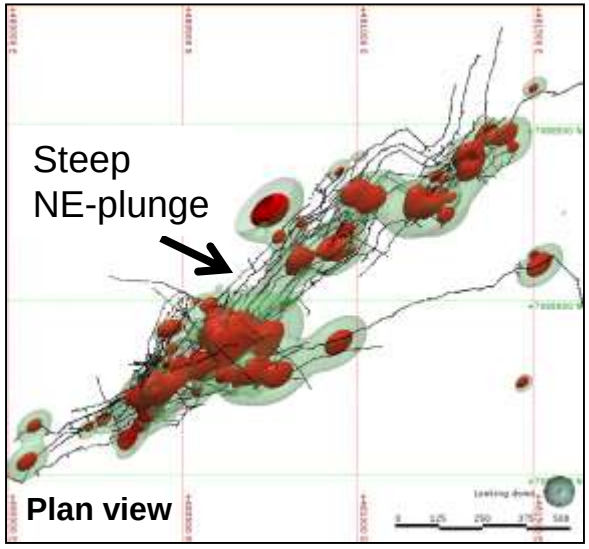


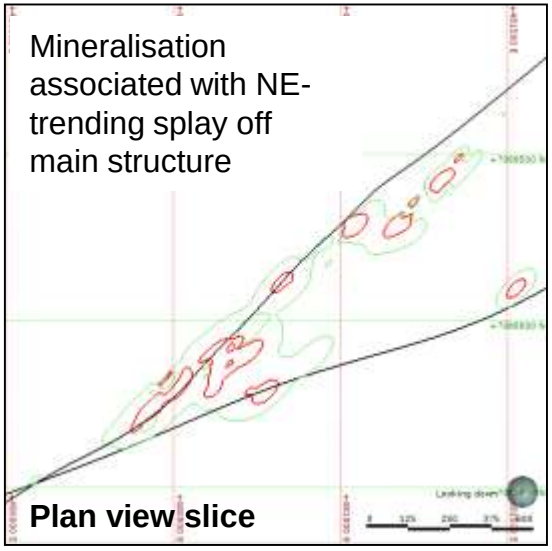


- Two main populations of D_2 faults:
  - Northeast-striking;
  - North northeast striking.

Local Controls on Mineralisation







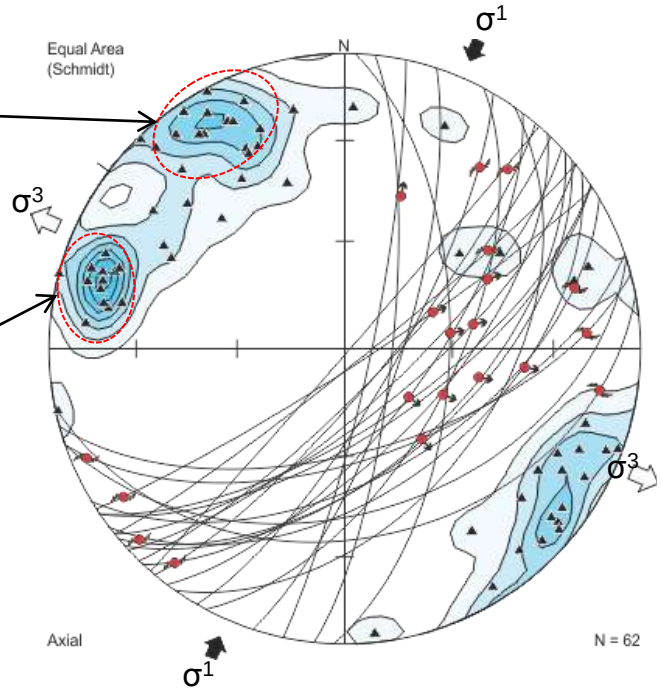
Grade shells – 400 gpt/Ag (green); 600 gpt/Ag (Red)

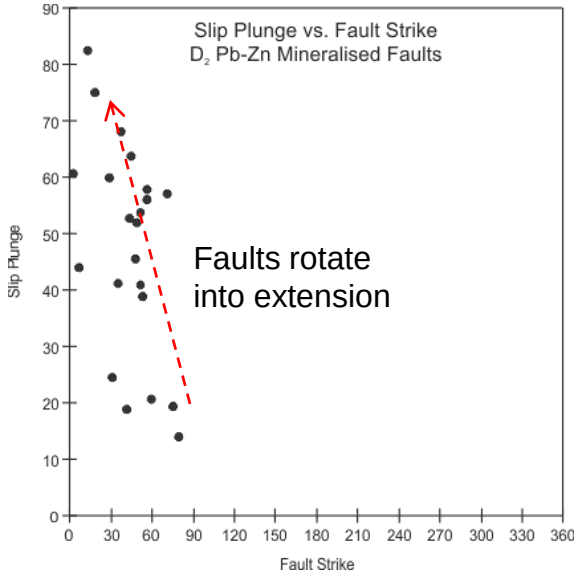
- Grade modelling of Hector-Calumet deposit
- High-grade ore shots plunge steeply towards the northeast.
- High-grade shoots spatially associated with NW-trending splay off main WNW-trending structure, and proximal to fault intersection.

Local Controls on Mineralisation

Pb-Zn veins typically <20 cm width

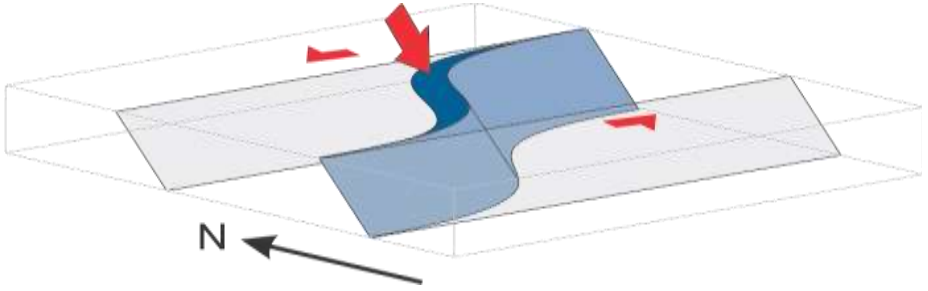
Pb-Zn veins typically 20 cm to >1 m width





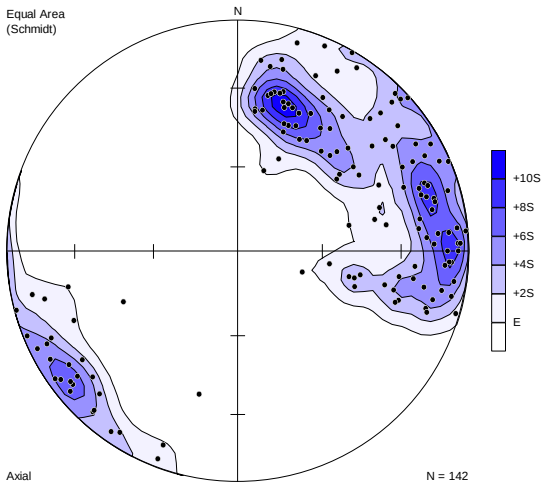
D_2 - Galena Hill

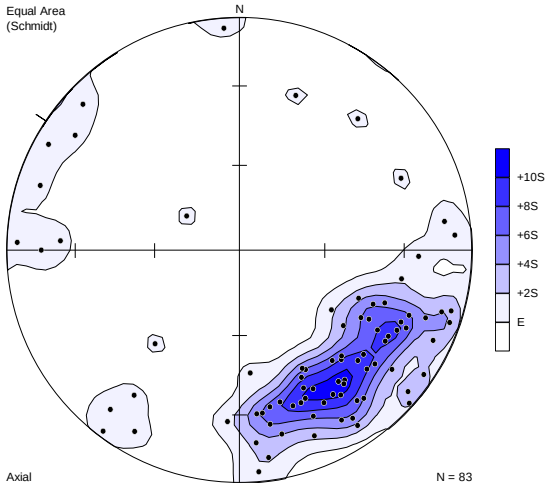
- Great circles are D_2 faults with observed mineralisation (typically galena);
- Red symbols are measured slip vectors on the D_2 faults;
- Triangles and contours are Pb-Zn veins (galena and sphalerite)



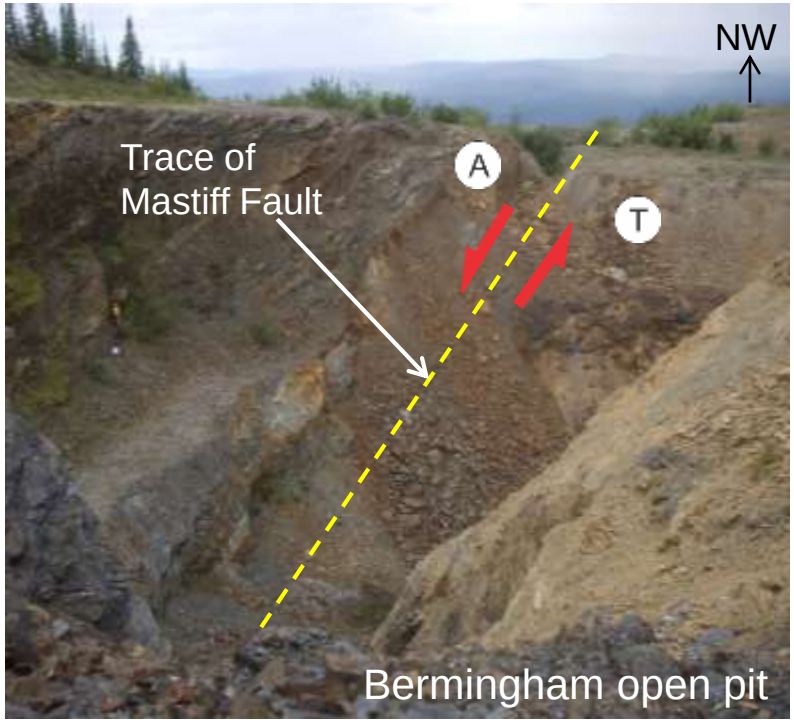
Brittle Deformation – Post Mineralisation

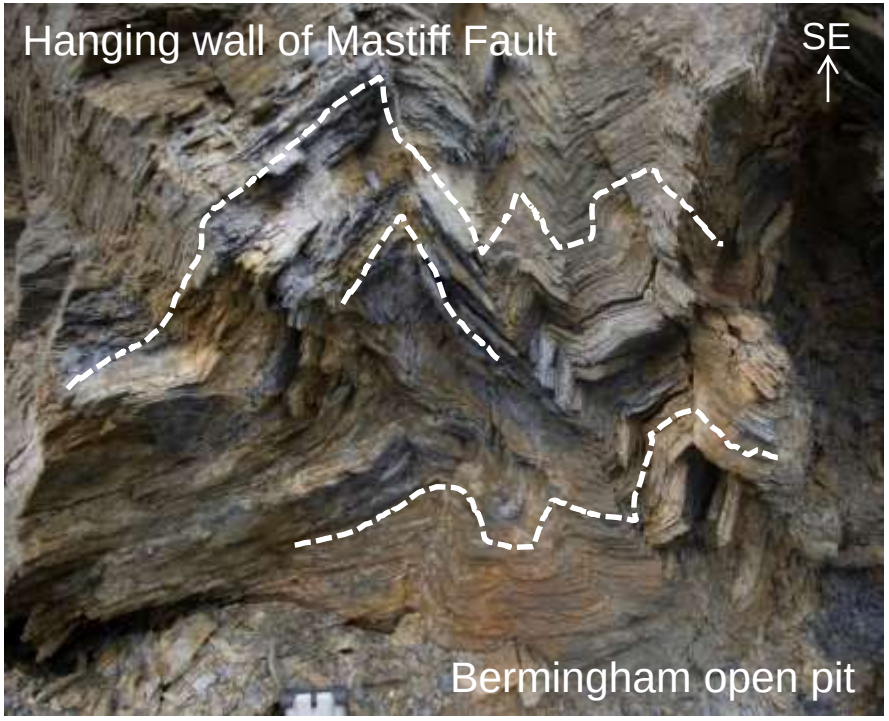
- D_3 structures are sporadically seen across the district.
- Northwest- to north striking faults;
- Slickenlines sporadically present but can give ambiguous slip vectors;
- Offset mineralised structures by up to 100 m;
  - Offsets indicate dextral oblique movement
- F_3 folds defined by warped foliation and plunge shallowly southeast.
- F_3 axial surfaces commonly sub-parallel to D_3 faults





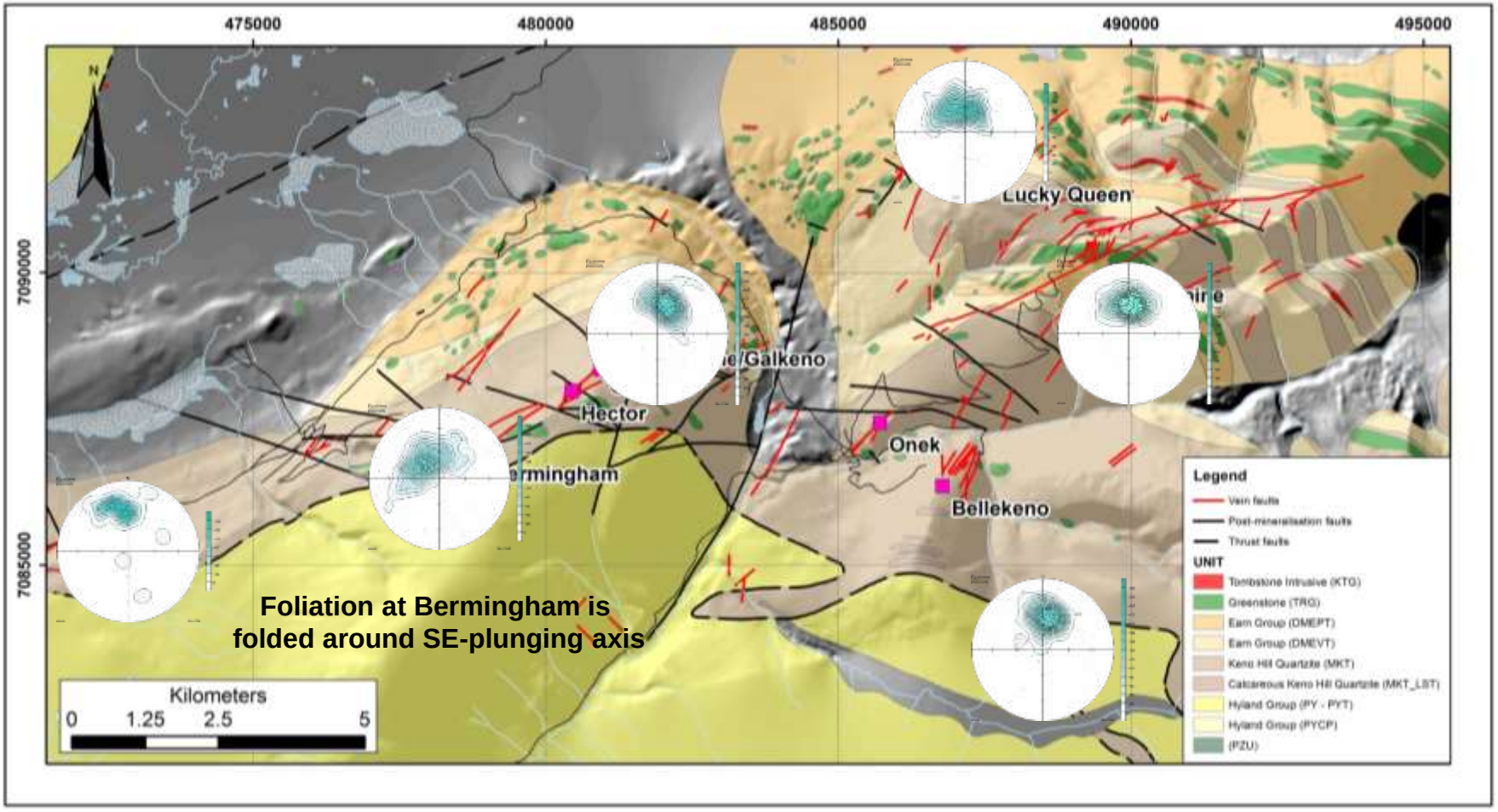
Brittle Deformation – Post Mineralisation





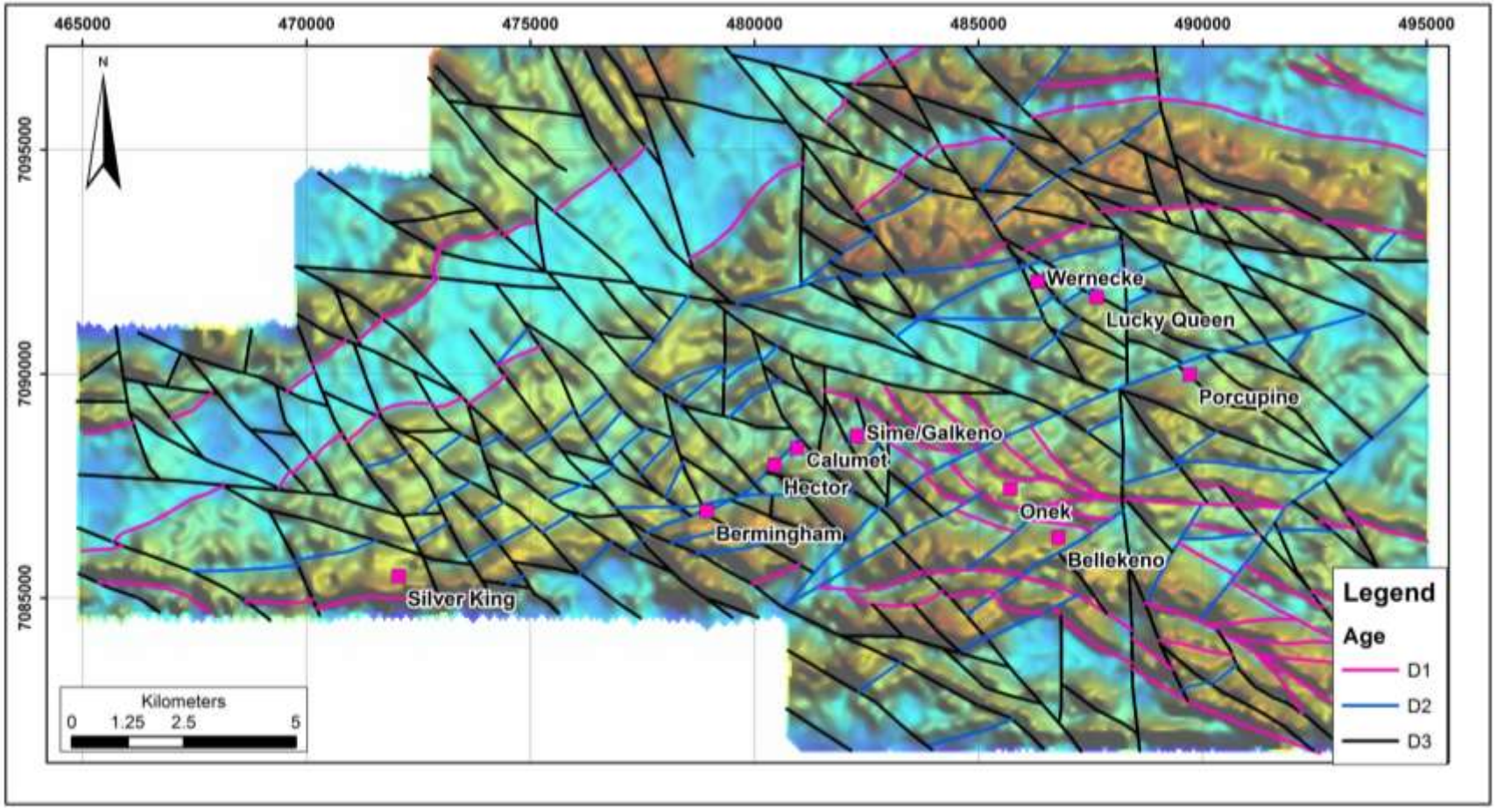
- Mastiff Fault offsets mineralisation, and sericite schist unit with a dextral oblique separation by at least 100 m;
- Polyclinal to chevron folds abundant in hanging wall – plunge southeast.

Brittle Deformation – F_3



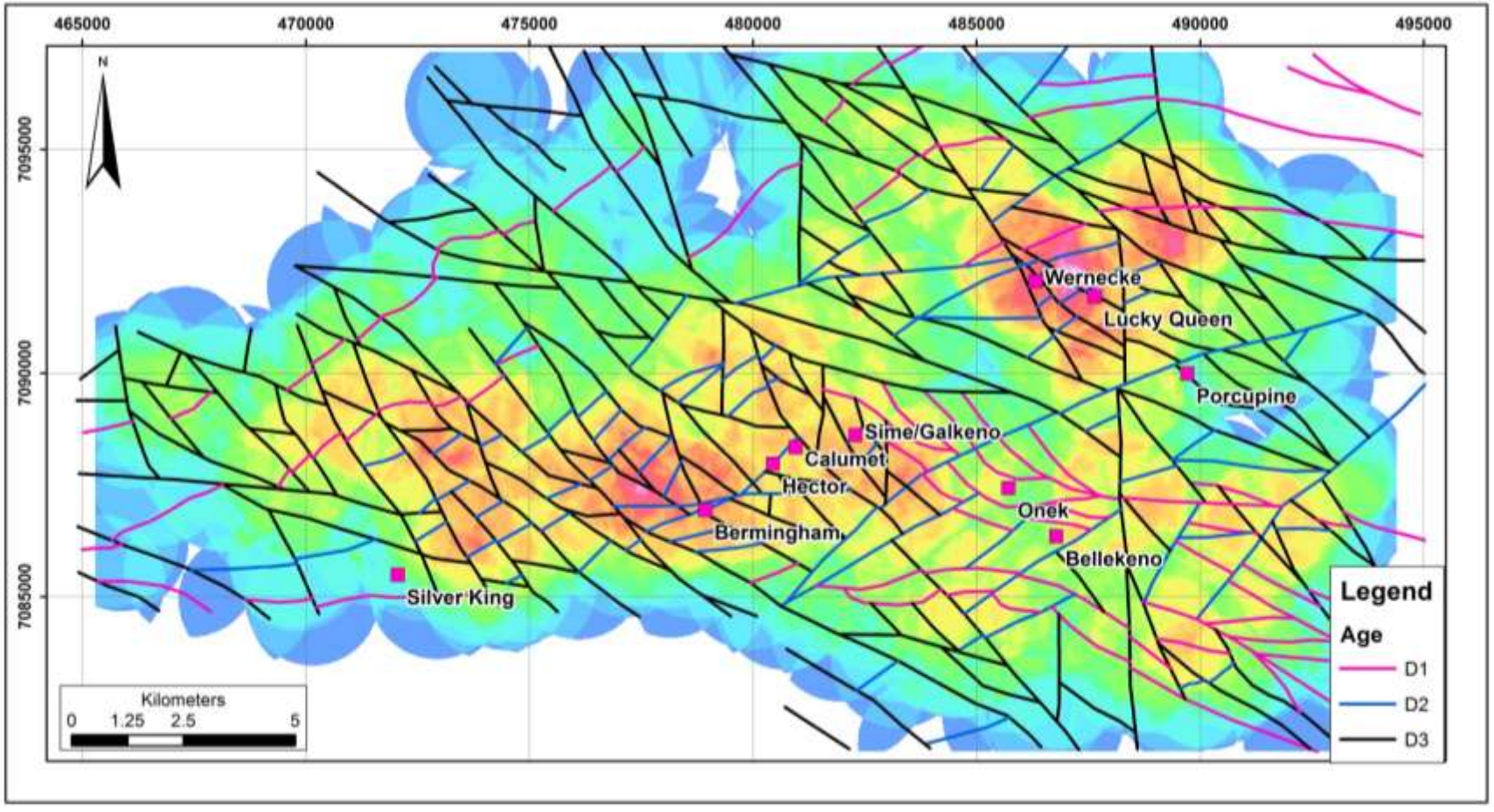
- Foliation is relatively uniformly dipping across district, except around the Bermingham deposit.

Localisation of Deformation



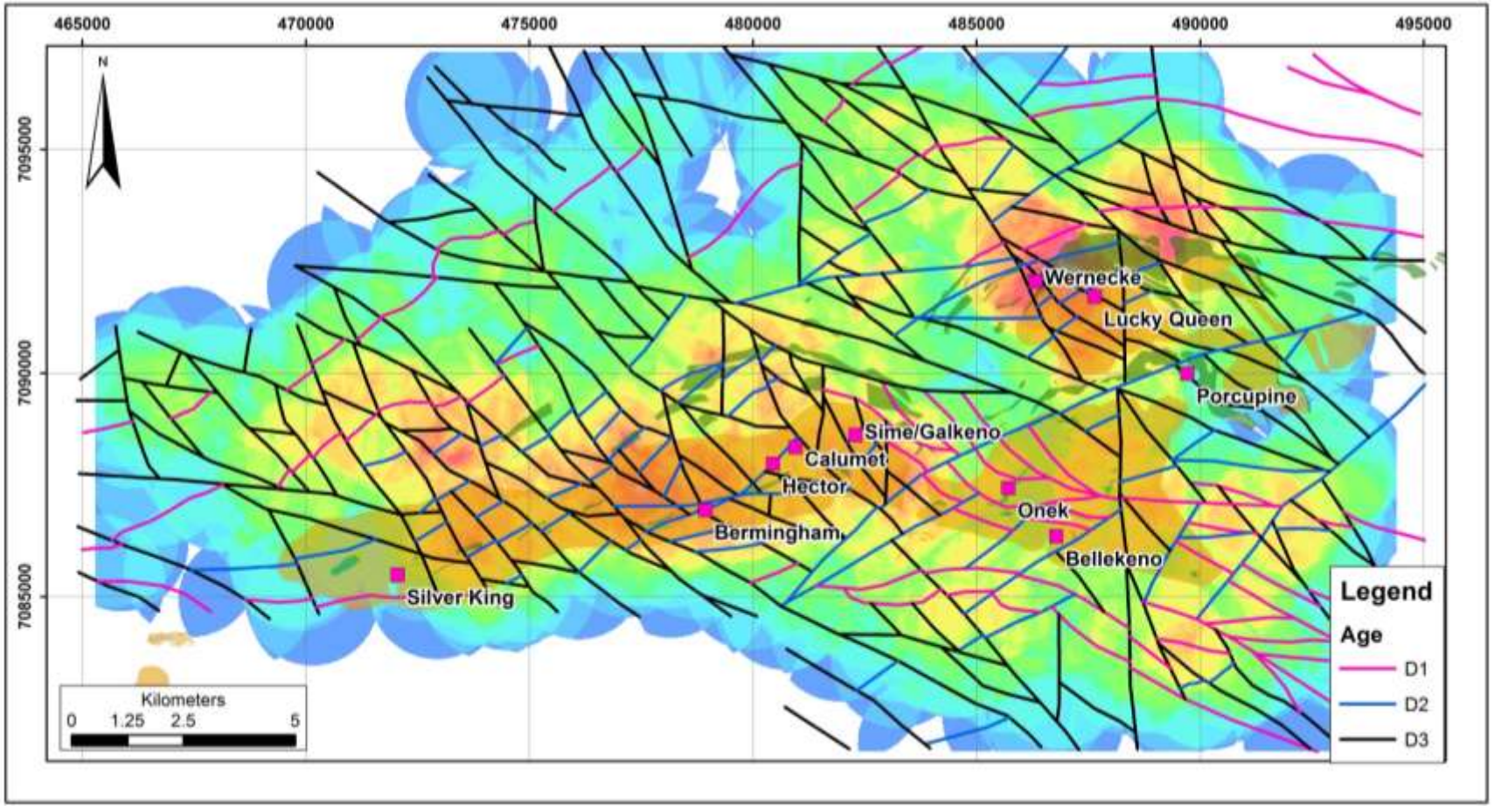
Helicopter Magnetic Survey - First Vertical Derivative

Localisation of Deformation



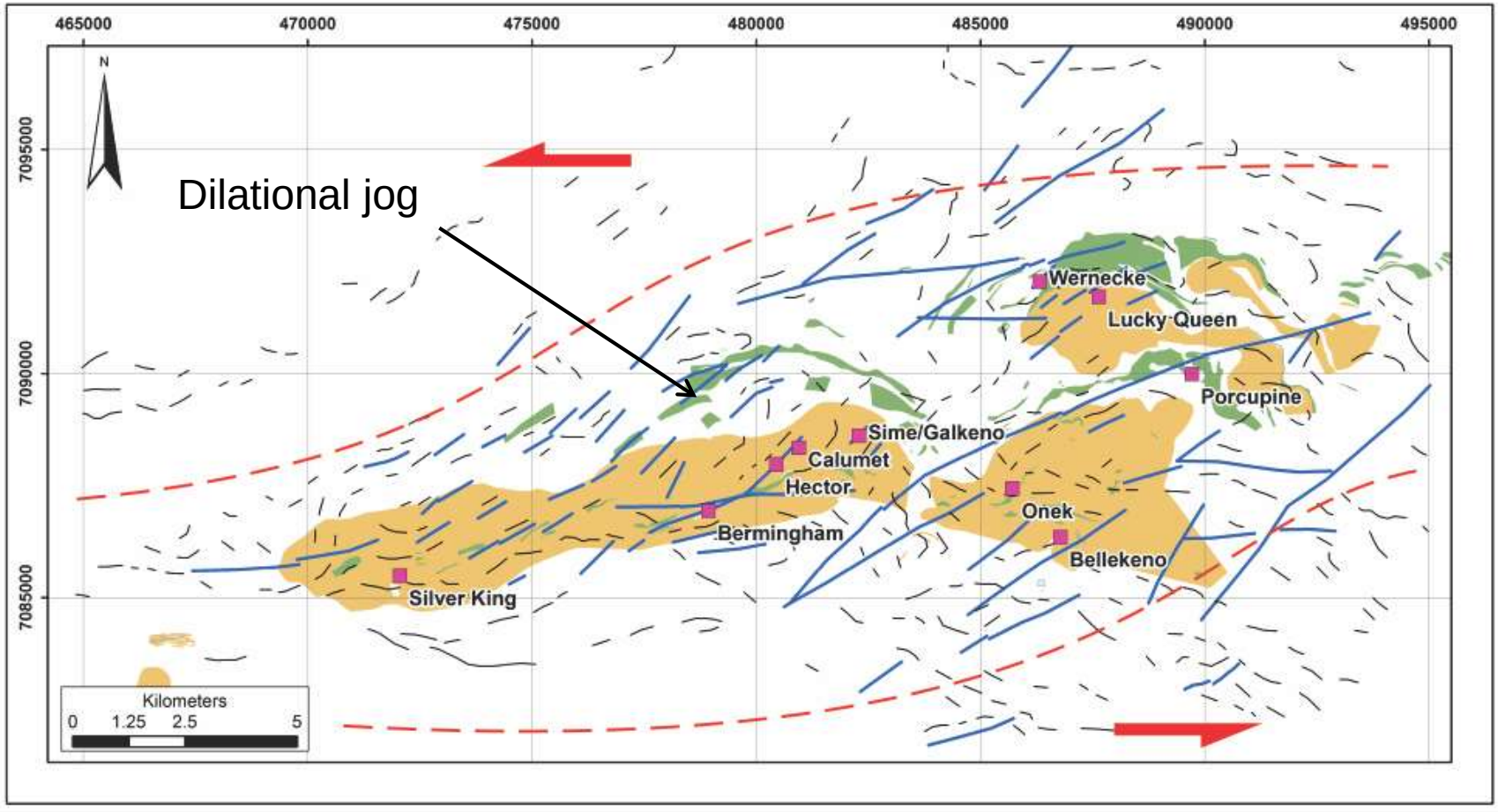
Lineament Density

Localisation of Deformation

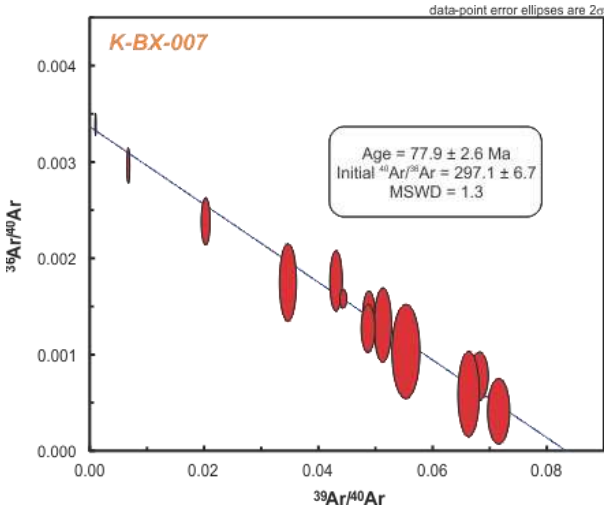


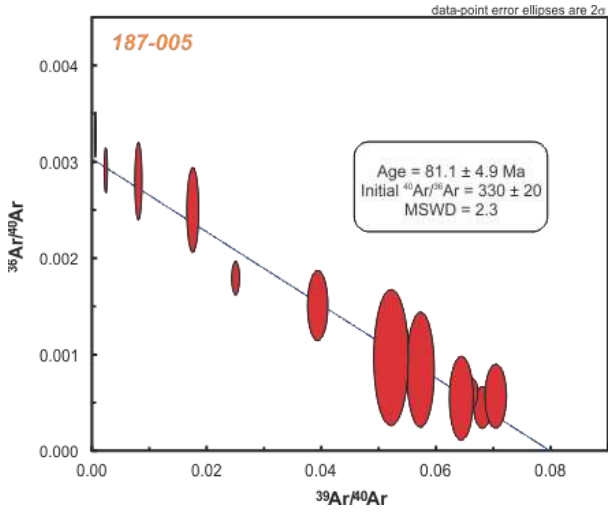
Lineament Density with Location of Keno Hill Quartzite and Greenstone (after McOnie, 2008)

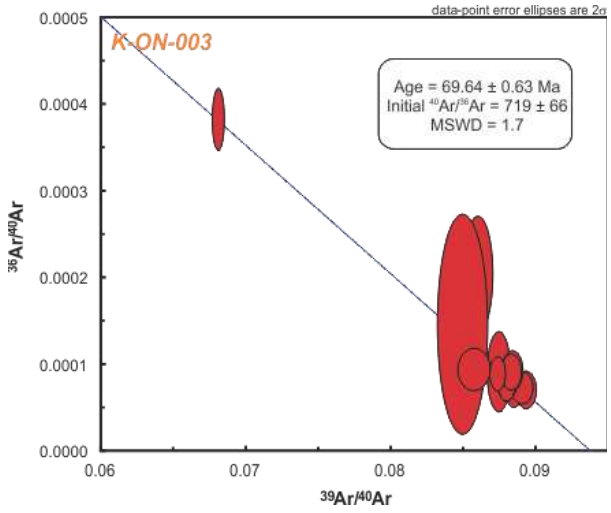
Localisation of Deformation



Age of Mineralisation

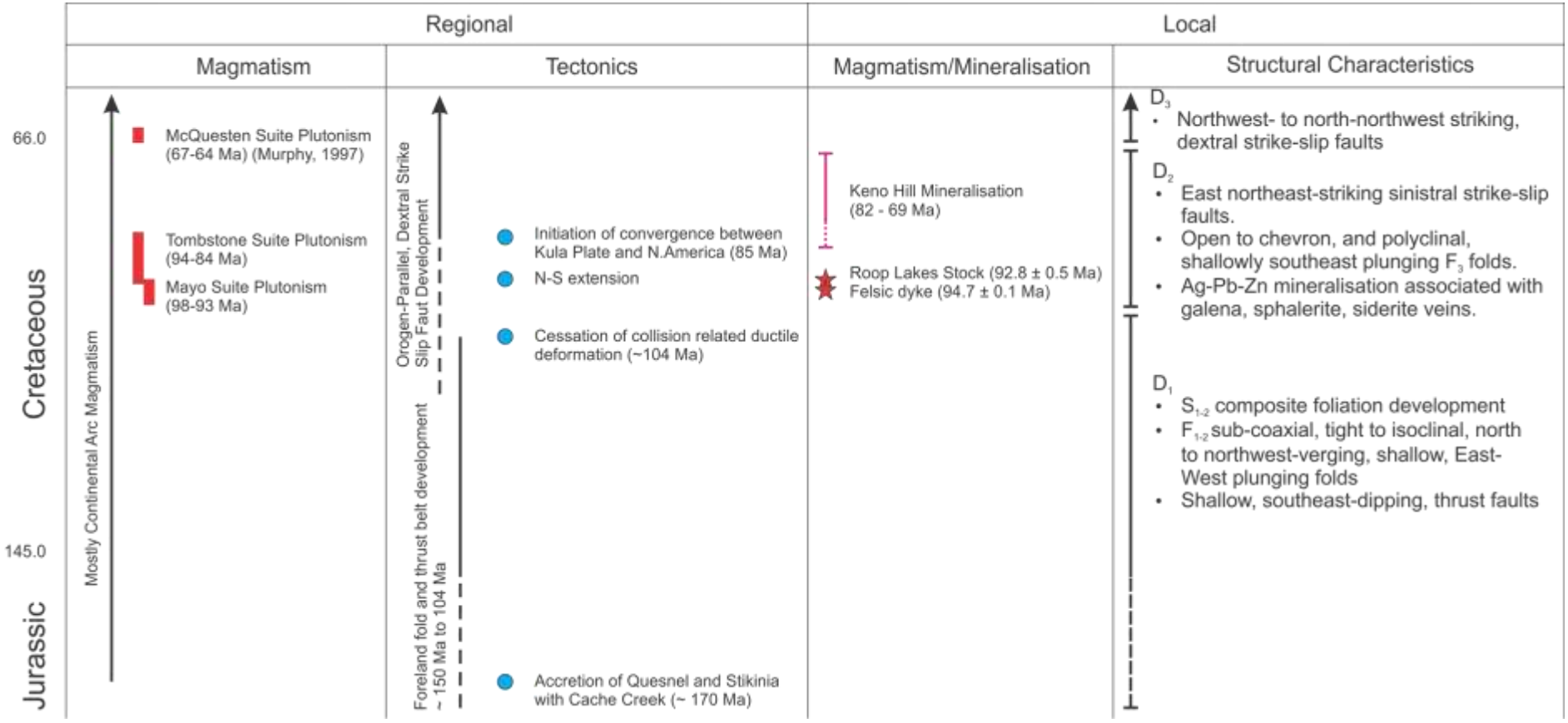






- 6 $^{40}Ar/^{39}Ar$ dates obtained from vein selvages. Ages range from 69.6 Ma to 81.1 Ma.
- Plateau ages give slightly older dates (72.1 to 85.5 Ma), but isochrons considered to give most reliable dates
- K/Ar analysis by Sinclair et al. (1980) give ages of 85.1 ± 10.2 Ma, and 88.9 ± 7.8 Ma.
- Hantlemann (2013) - Pb isotope model age 82 ± 31 Ma.

Age of Mineralisation



Conclusions

- Mineralisation focusing is controlled by complex interplay of lithology and structures.
- Mineralisation preferentially precipitated in packages of Keno Hill Quartzite and to a lesser extent greenstone.
- $F_{1\text{-}2}$ folds produce stratigraphic repetition and thicken packages of Keno Hill Quartzite and greenstone, and may produce sites for elevated mineralisation.
- Mineralising fluids were focused along sinistral-oblique D_2 faults. At left-stepping fault bends, where fault segments strike northeast to north northeast, faults become extensional, and provide dilational sites and wider zones of mineralisation.
- D_2 faults may have initiated as antithetic structures in response to the onset of orogen-parallel dextral displacement.
- Continued orogen-parallel displacement and a slight rotation of the local stress field produced D_3, post-mineralisation dextral-oblique faults that offset mineralised structures.

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