An Overview of Graphite Projects from Asia to Africa

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- Era Gems DMCC
- Australian Institute of Geoscientists
- SRK Consulting

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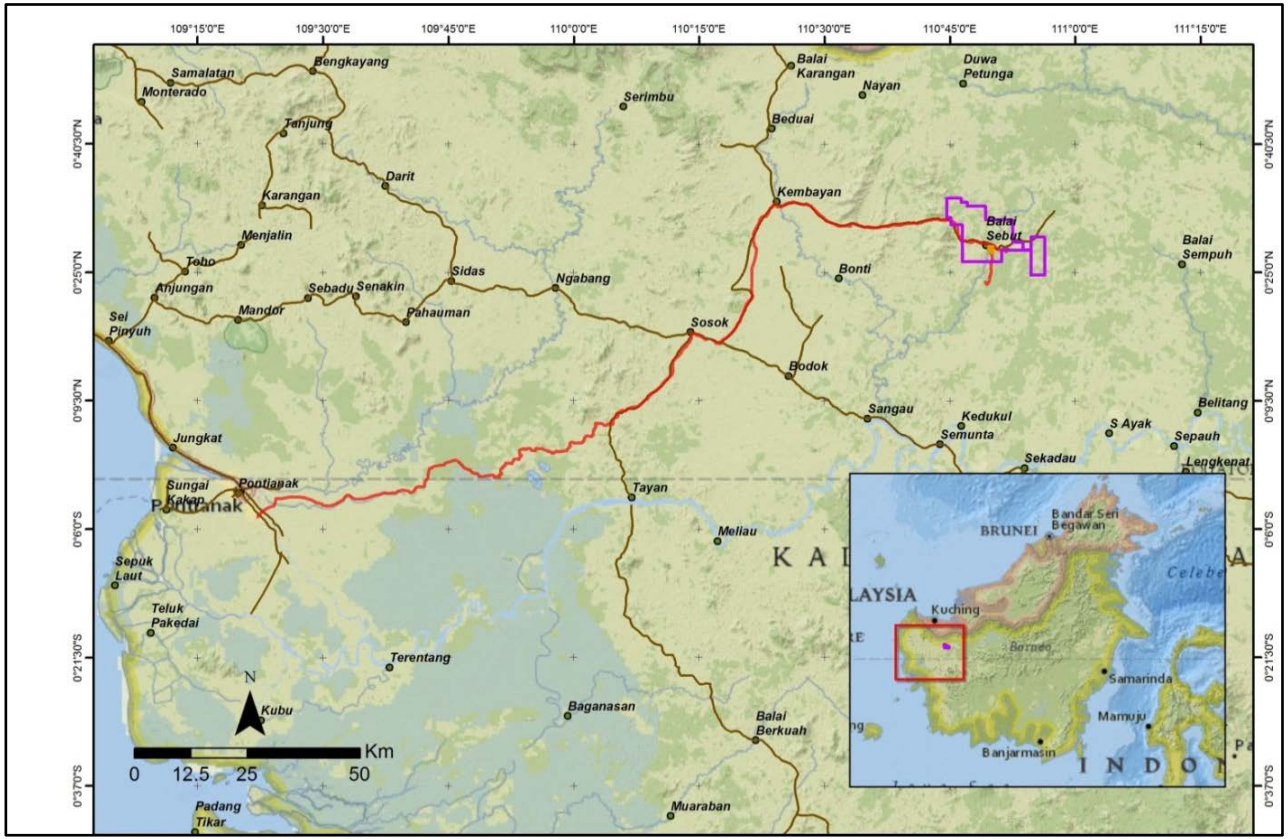
Outline

- Amorphous fine-flake Graphite – example Balai Sebut Graphite Project, Sanggau, West Kalimantan, Indonesia
- Vein & Lump Graphite – example Kahatagaha-Kolongaha graphite mine, Sri Lanka
- Flake Graphite – example Ruangwa graphite project, Lindi Region, Tanzania
- Concluding Thoughts



Location – Balai Sebut graphite project

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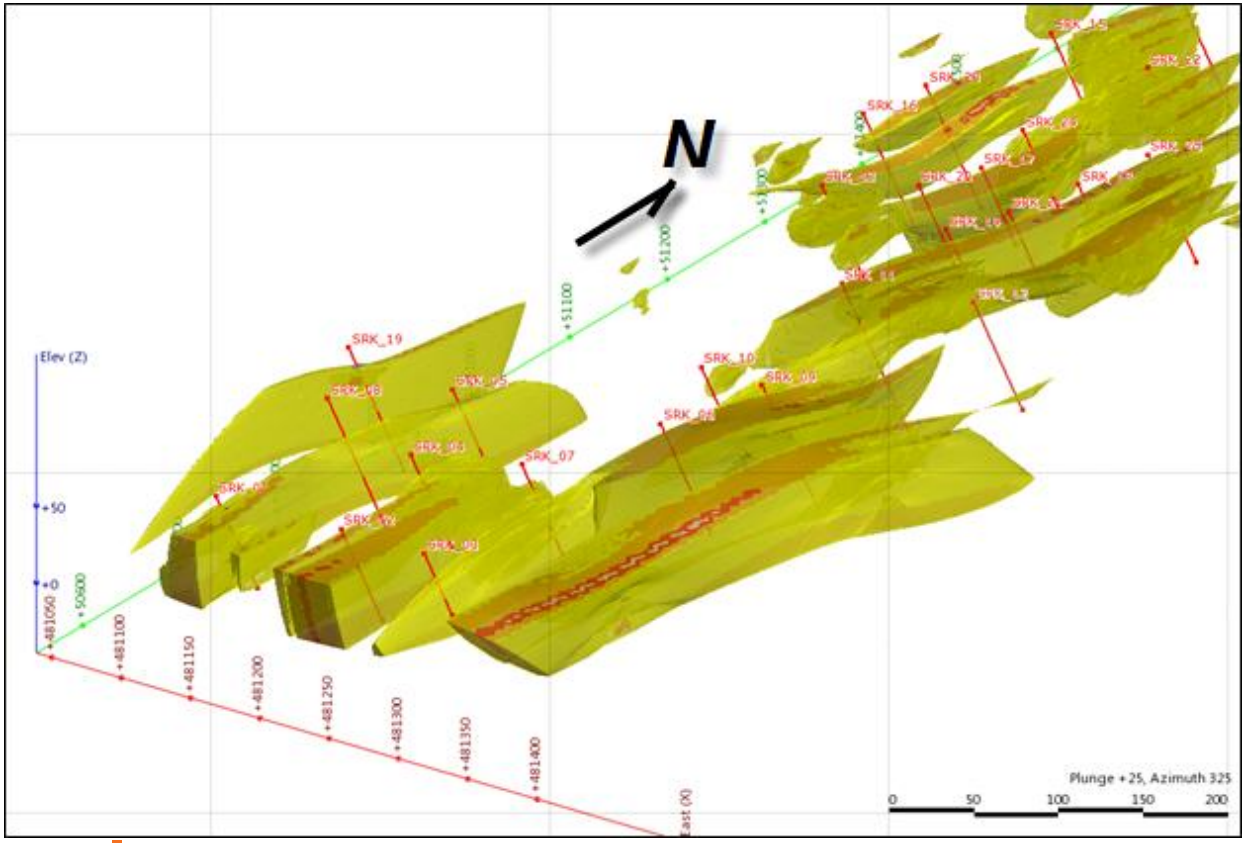
Amorphous & fine-flake graphite

- Thin carbonaceous graphitic units intercalated with graphite poor siliciclastic units
- Strong NNE striking foliation steeply dipping to the west and plunging northward
- Granite intrusion in the west and doleritic sills within the main deposit
- Abundant faulting (and associated gouge)
- Polyphase deformation - folds and boudinage
- Cross-cutting quartz and calcite veins



Resistivity survey - NNE trending, steeply dipping series of zones of high conductivity (>0.21 S/m)

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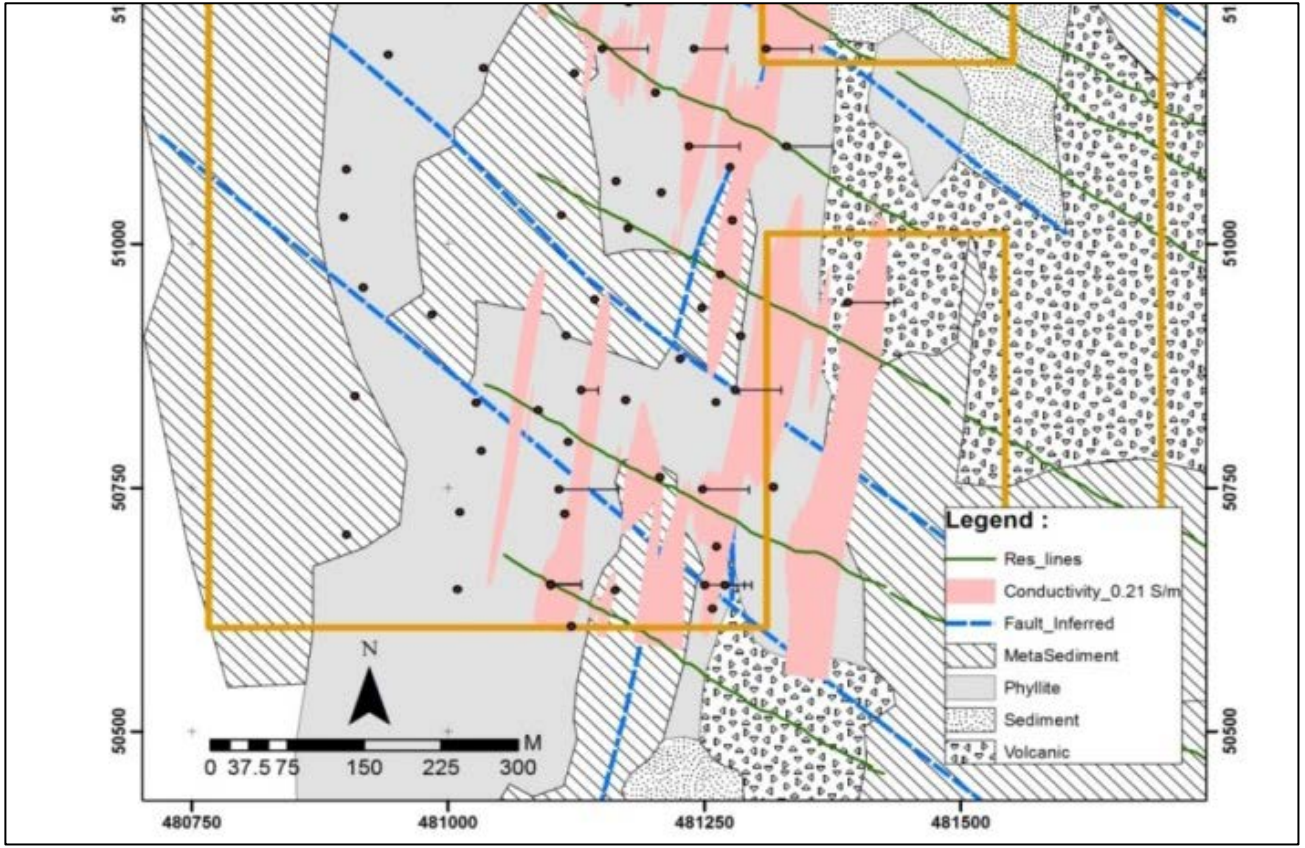

Simplified geology showing zones of resistivity > 0.21 S/m (pink

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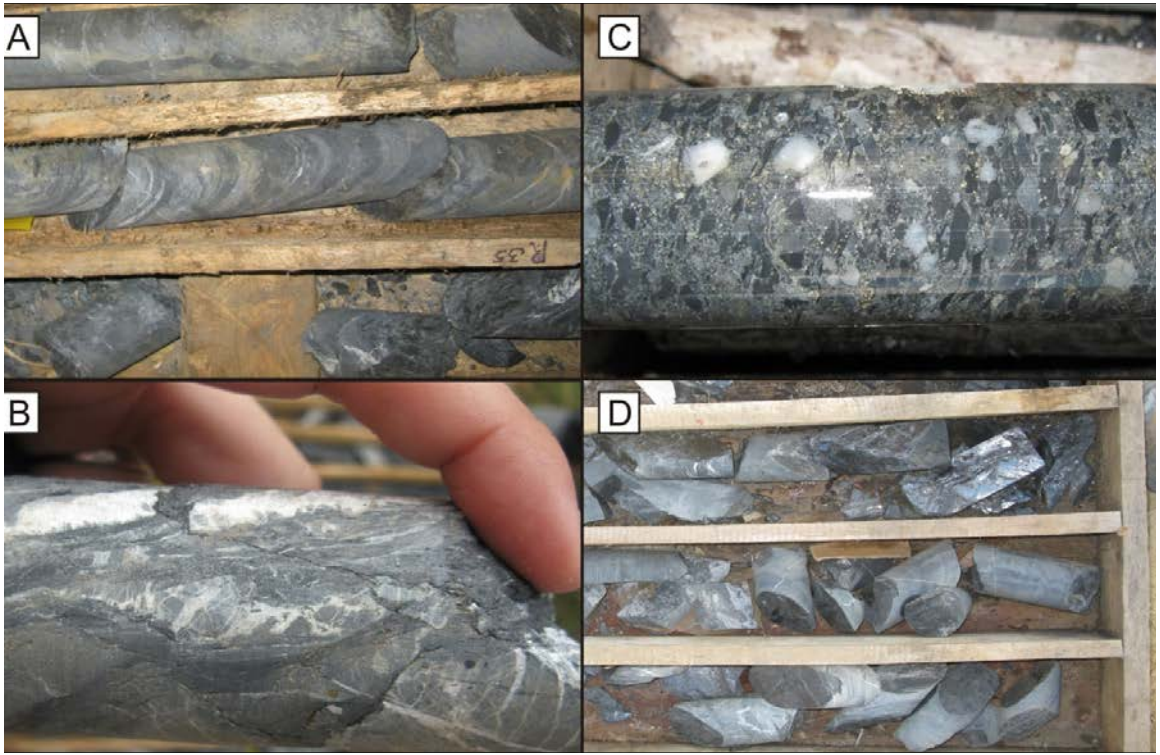
A: Banded / stratiform

B: Shear hosted

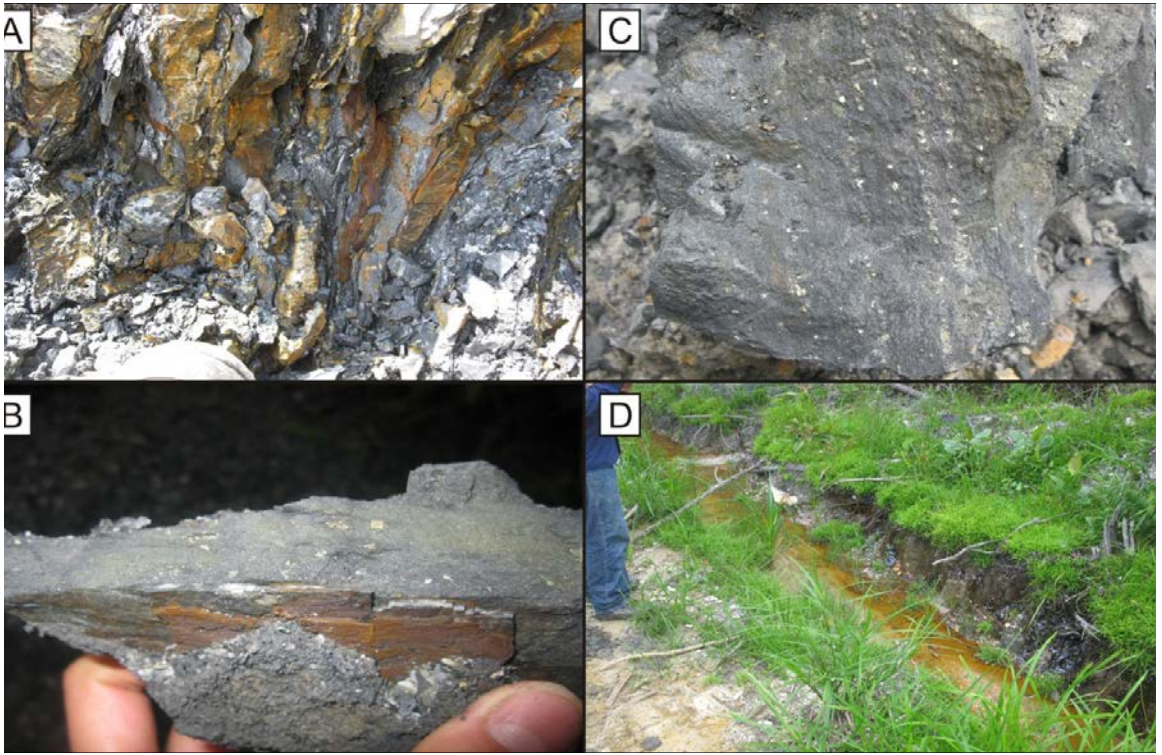


C: Breccia with graphite clasts

D: Disseminated graphite with calcite veining

Styles of graphitic mineralisation observed in drill core

A: Iron staining in shear hosted graphite due to pyrite



C: Coarse-grained disseminated pyrite in phyllite bands

B: Vein and coarse-grained disseminated pyrite in phyllite

D: Acid drainage in road drain

Styles of Sulphide Mineralisation and acid drainage issues

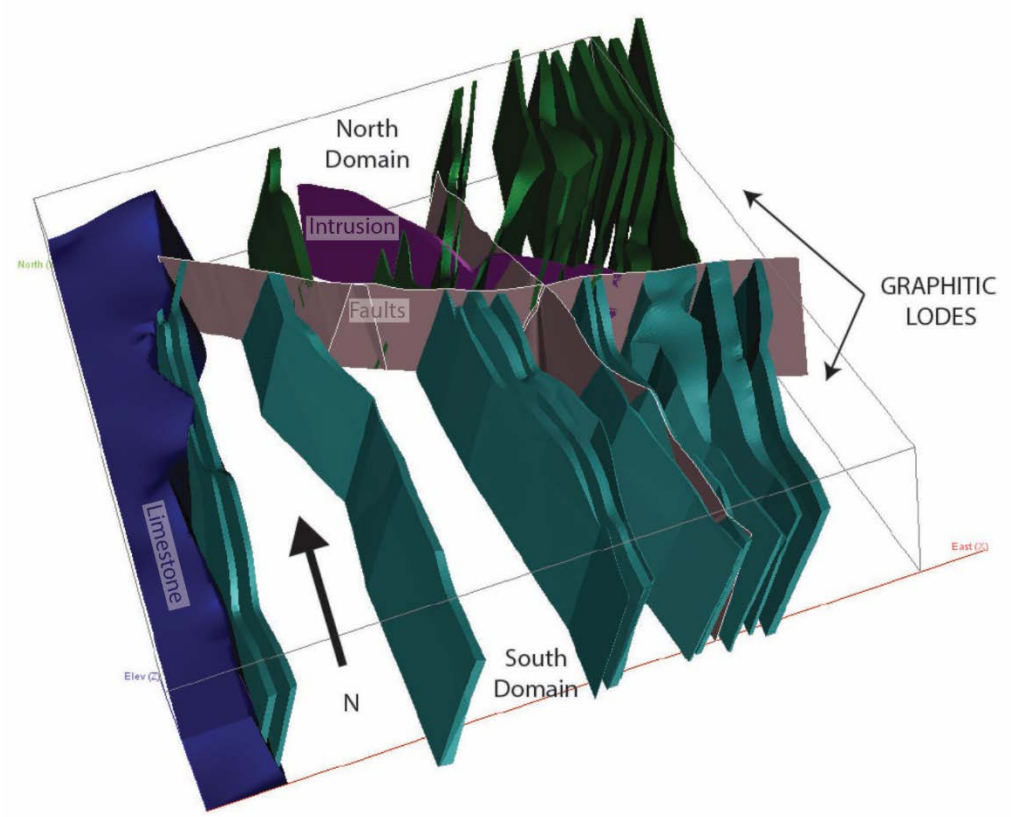
NS Normal fault exposed in main pit

Shear fabric wrapping around boudins

Faulting offsets lodes

Fault rotation effects variography

Style of graphitic mineralisation strongly influenced by brittle to brittle-ductile shearing



Modelled Graphitic Domains – North and South of fault

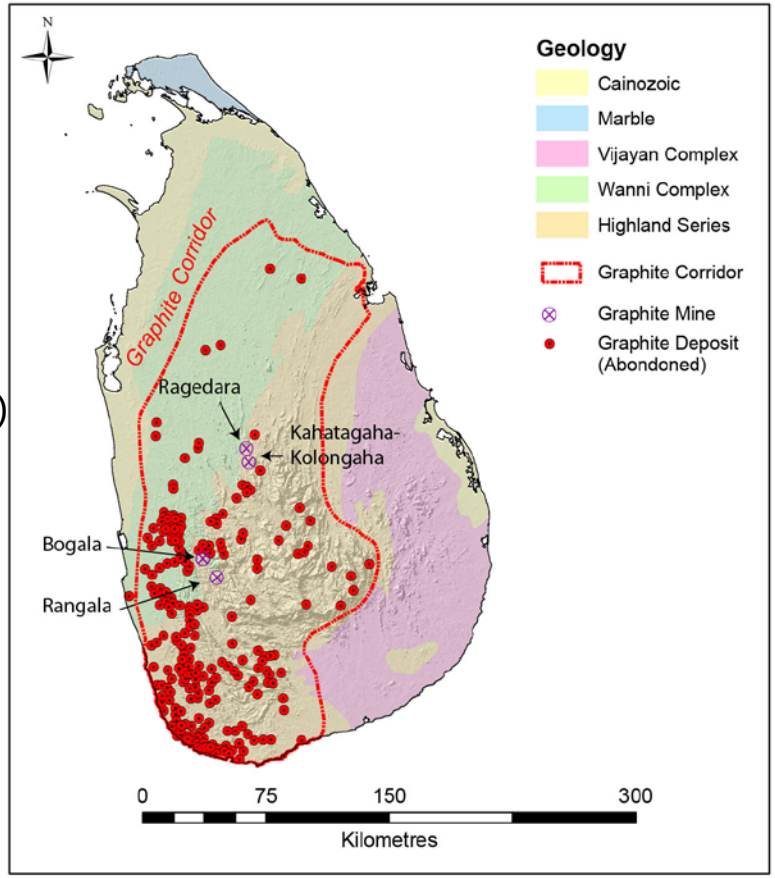
Sri Lankan vein and lump graphite

- Largest known occurrences of crystalline vein graphite
- Hosted in sequences of upper amphibolite facies metamorphic rocks including garnet-rich, orthopyroxene-bearing quartzo-feldspathic rocks and garnet-biotite gneisses.
- Quartz-feldspar pegmatite parallel to main foliation and interlayered with garnet-rich metabasites and quartzites
- Very little disseminated graphite within host rocks
- TGC ranging from 95 to 97% and can be beneficiated to 99.9%

Palaeoproterozoic – Neoproterozoic high-grade metamorphic rocks

Three major lithotectonic units

- Highland Complex (2,000 Ma)
- Wanni Complex (1,080 Ma)
- Vijayan Complex (1,000 Ma)



Majority of deposits in SW

Located in NNE-SSW corridor

Hosted in Highland and Wanni complexes

Simplified geology showing location of known graphite deposits and abandoned deposits

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A: Lift at bottom of main shaft

B: Typical adit

C: Graphite vein with associated sulphides

D: Underground Survey Control point

E: Graphite vein showing Needle type

Kahatagaha-Kolongaha Graphite Mine (KKGM) - 1,130 ft level

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Zoned Graphite Vein – richest in centre

Example on display at the Geological Survey of Mines Bureau

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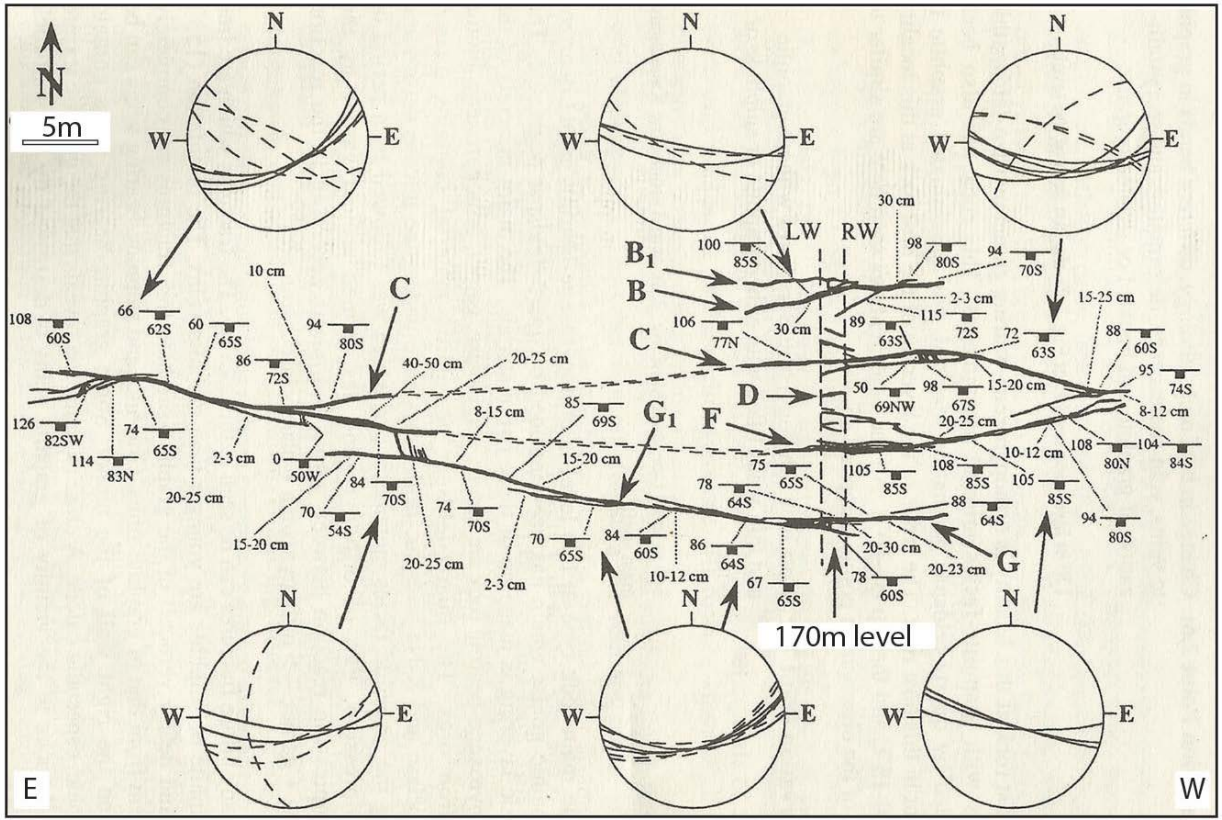
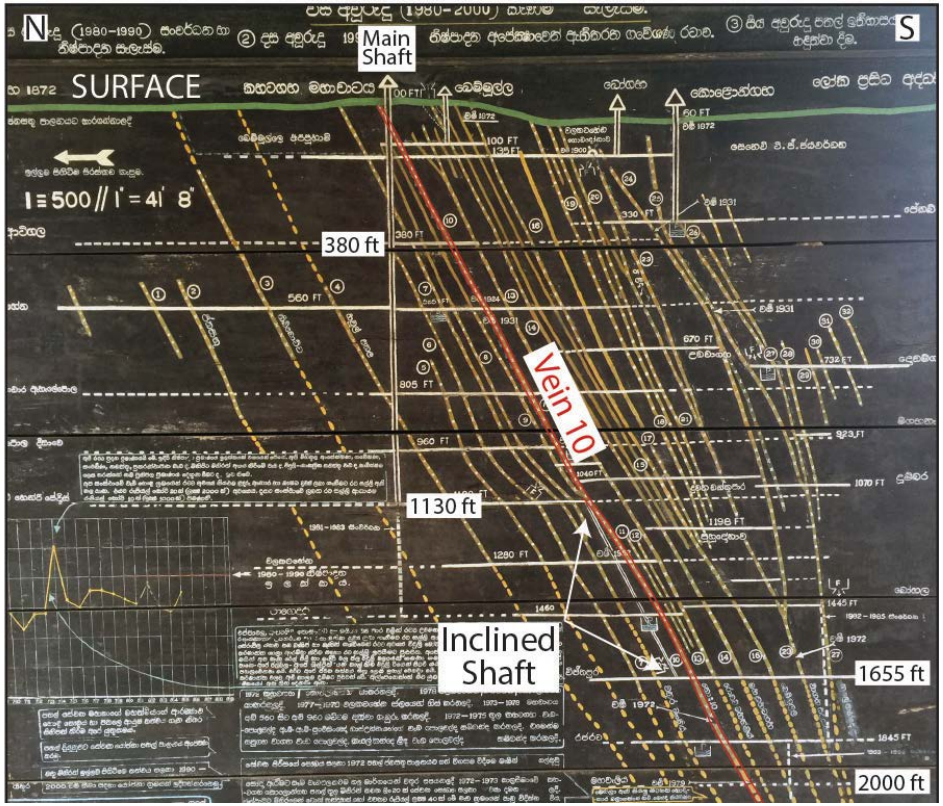


Sketch of graphite veins between 190 and 210m from main shaft at 170m RL



Section showing veins (originally compiled in 1980)

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Grade control and quality assessment

Stockpile of waste (graphite with rock fragment)

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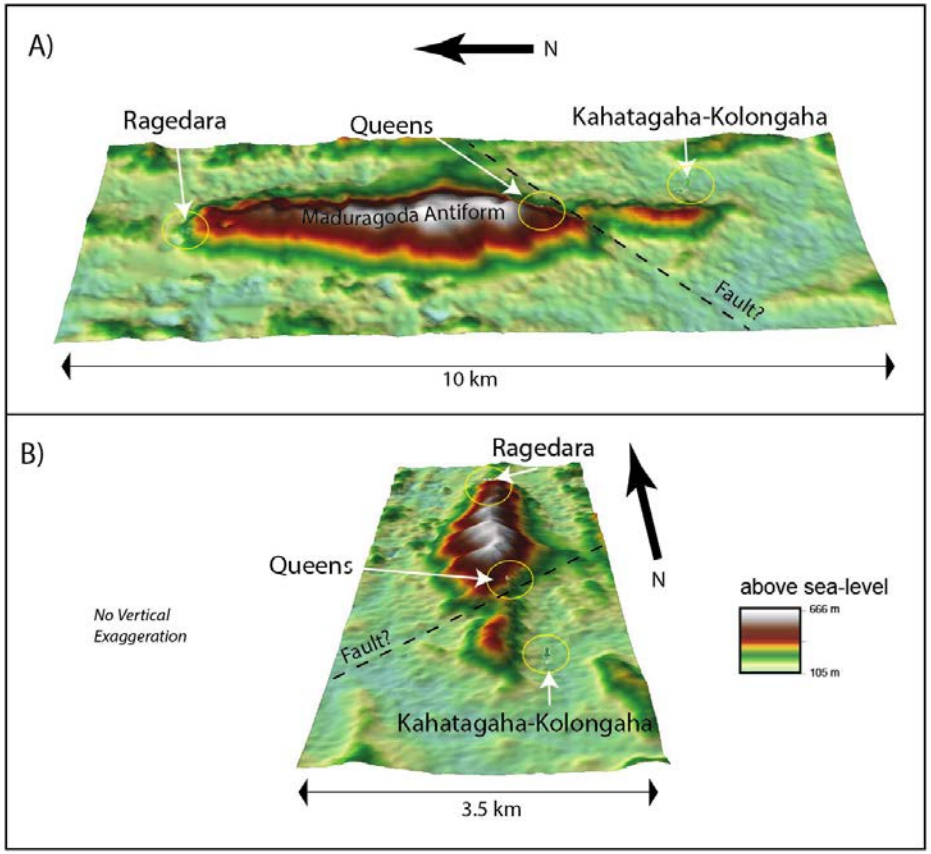
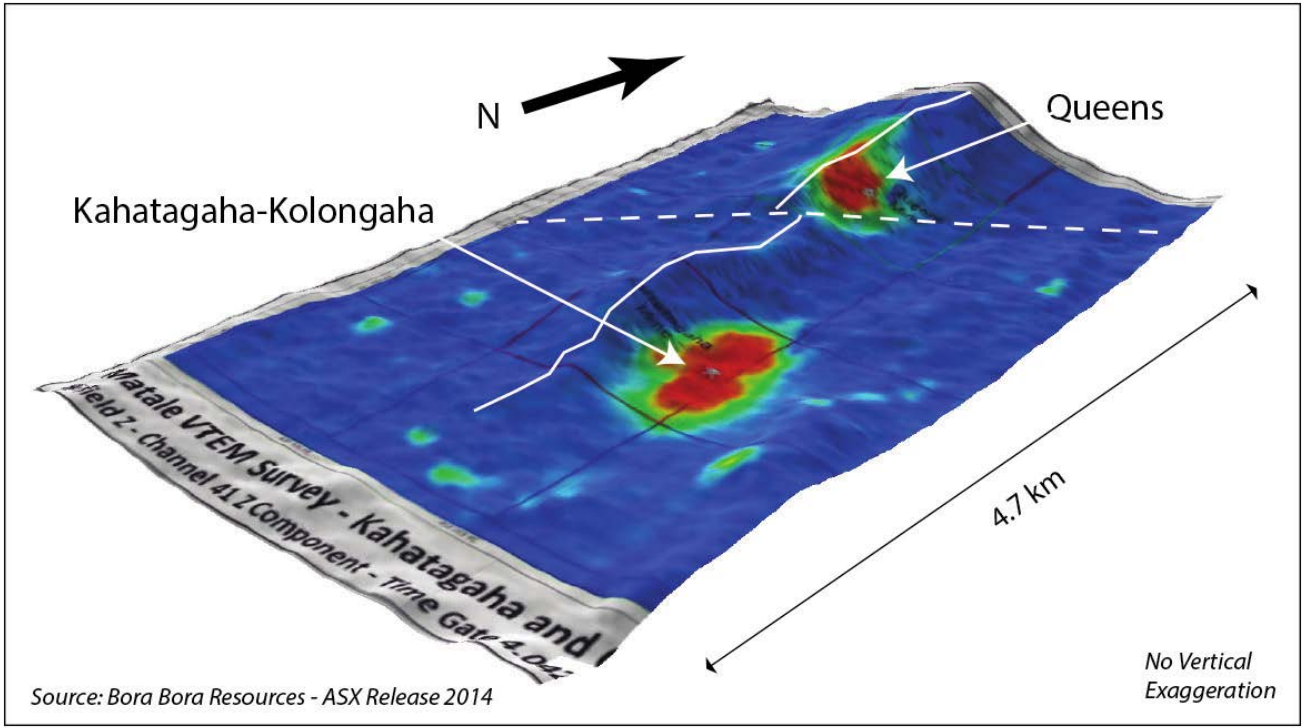


Topography showing double-plunging antiform and existing mines



VTEM Survey anomaly of Queens Mine and KKGM

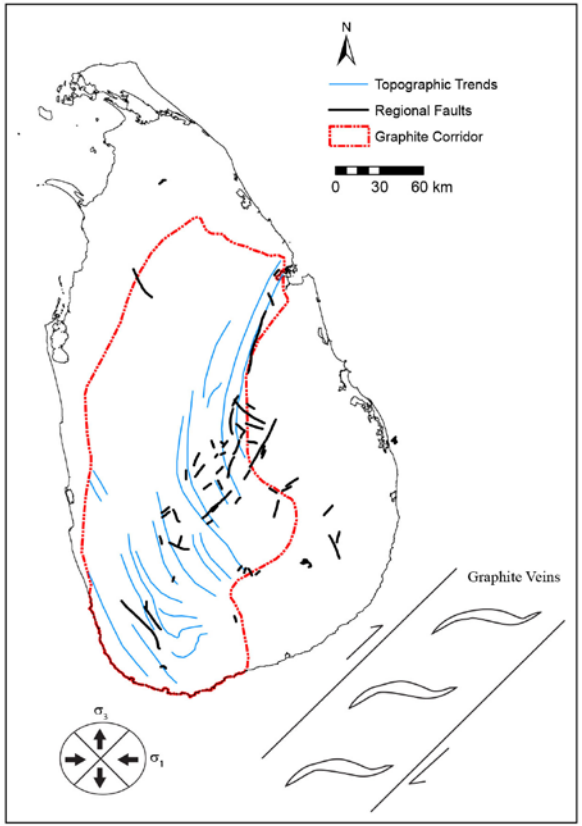
Veins are sub-parallel and restricted along strike

Variable spacing between each vein

Thickest parts of the vein toward the centre, and thin and disappear at tips

Vertical extent of the veins greater than horizontal component

Number of veins reduce at depth but become thicker



Associated with fold and re-folded double-plunging antiforms

Symmetrical development, supporting a progressive crack-seal precipitation in an east-west orientation

EW directed maximum and NS minimum horizontal compression

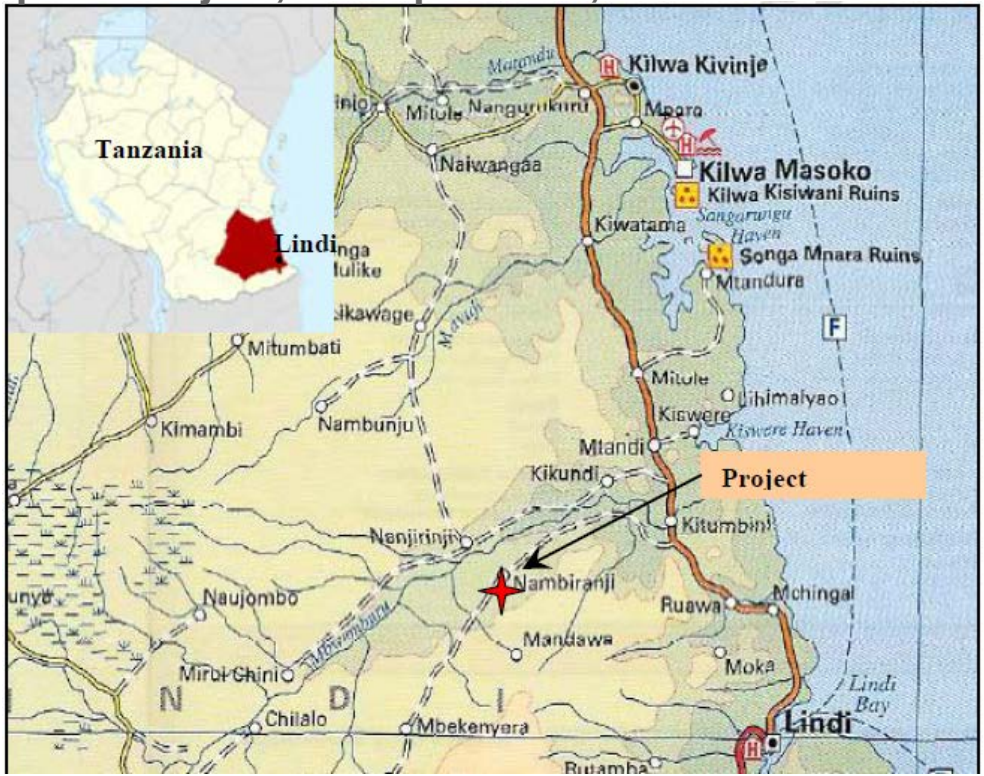
Flow direction (or intermediate stress) ~vertical

Regional Shear Model of Graphite Vein Emplacement

Summary

- Associated with double plunging antiforms
- Regional structural event of vein emplacement
- Crack-seal vein model of development

Ruangwa Graphite Project, Lindi province, Tanzania



Ruangwa Graphite Project, Lindi Province, Tanzania

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Geology and Structure – Flake Graphite

- Neoproterozoic rocks of Mozambican belt
- Amphibolite facies metamorphisim
- Host rocks fine grained schists containing mica and graphite
- Polyphase deformation
- Concordant foliation and layering of graphite is slightly anticlockwise to regional fabric dipping around 36° toward the E
- Dips steepen to the W, and strike swings clockwise toward N
- Graphite flake size shows mostly medium to coarse with occasional jumbo

Characteristics

- Occurs as disseminated ore and as schists, lodes and bands in gneisses, quartzite and impure marble
- Graphite is of flaky variety and carbon content varies from 1-2% in disseminated, to as high as 47.9% in graphite schists
- Thickness vary from 2 to 50+m but distinct pinching and swelling along strike (and down dip?)
- Flake size and grade increases when associated with quartz-feldspar pegmatites
- In some case, large jumbo graphite flakes are oriented perpendicular to the wall of thin pegmatites and veins

Example of Graphite mineralisation in core

Disseminated and vein style graphite mineralisation

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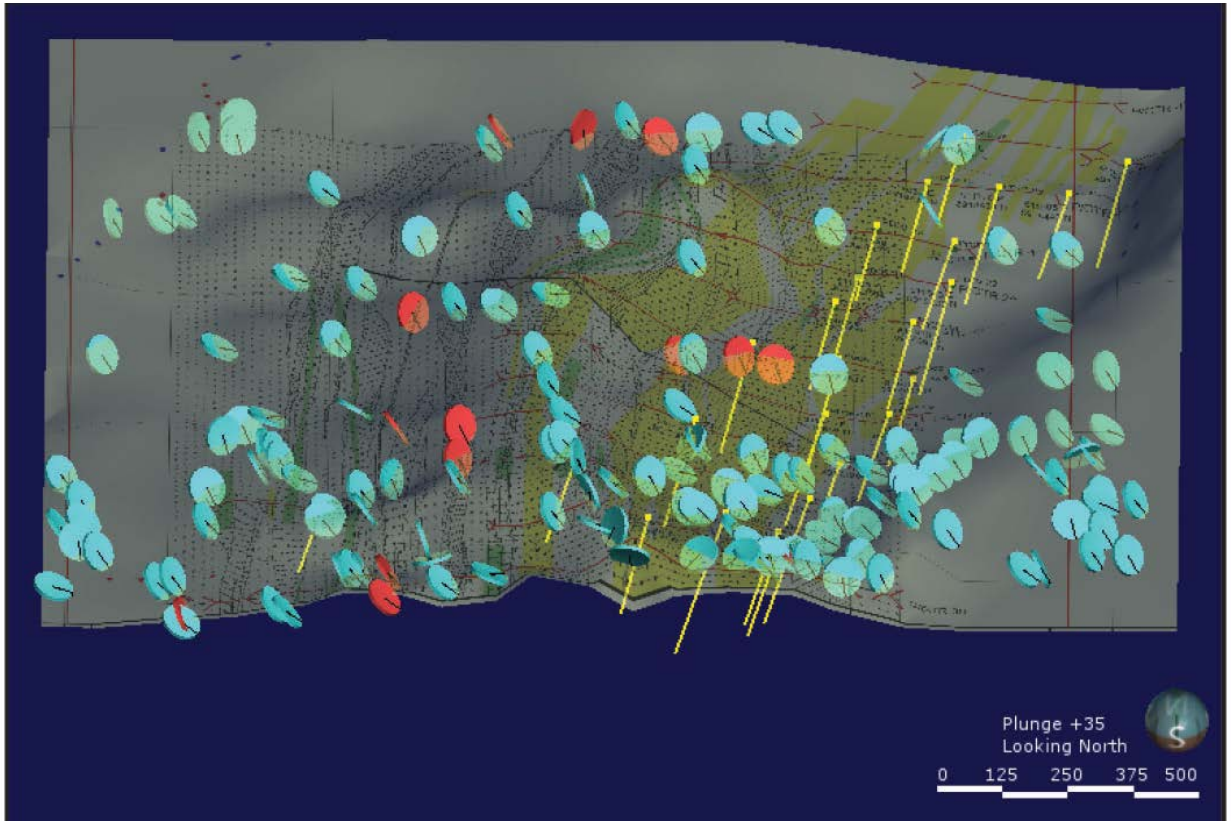
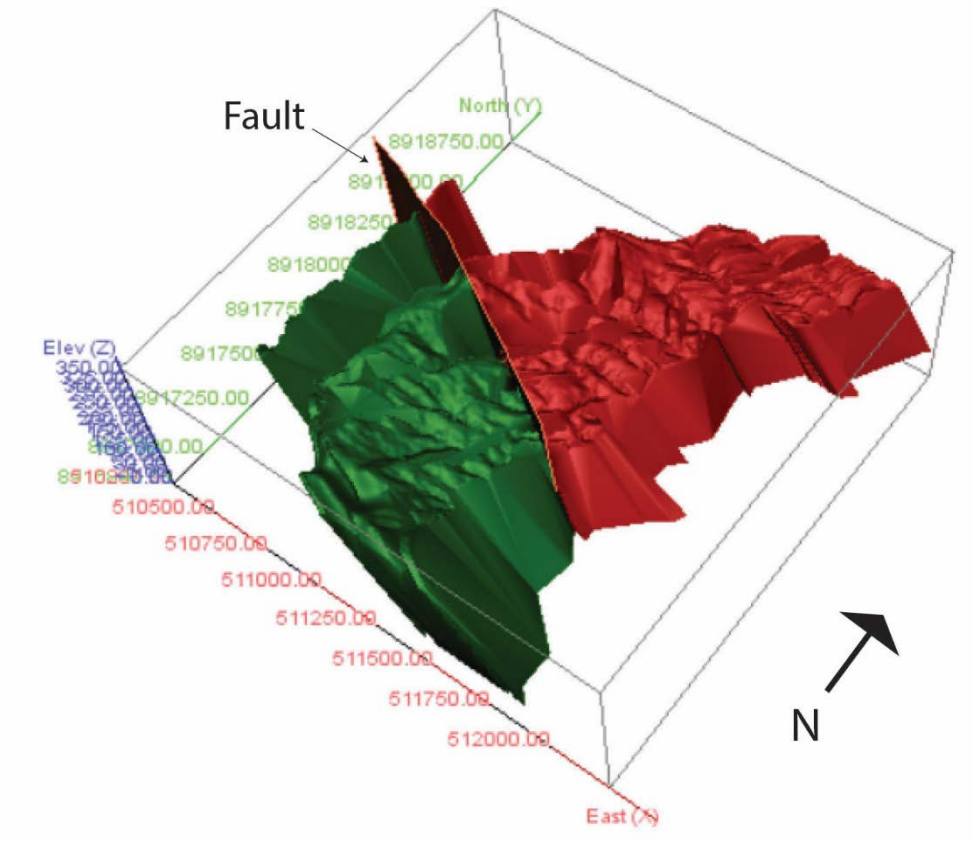
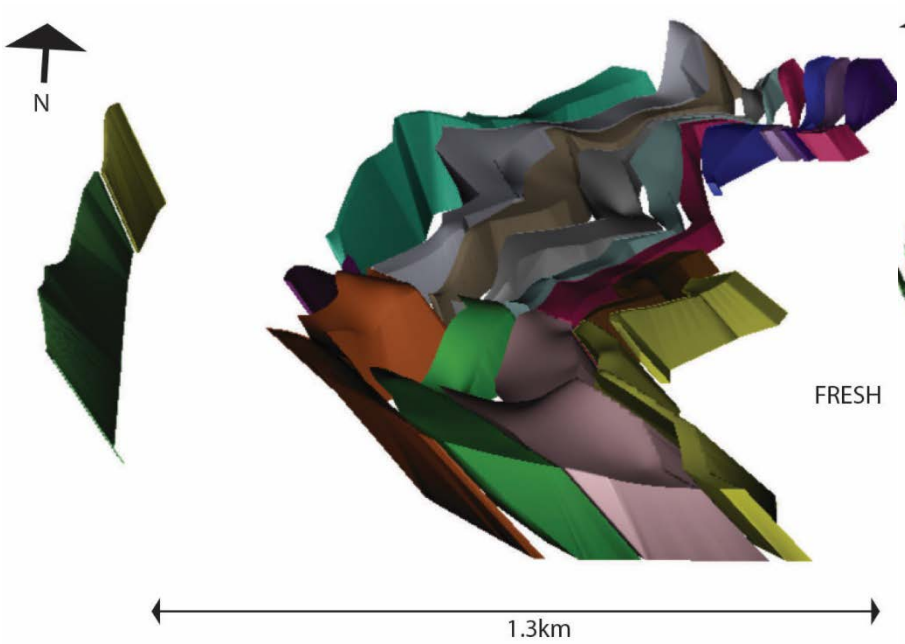
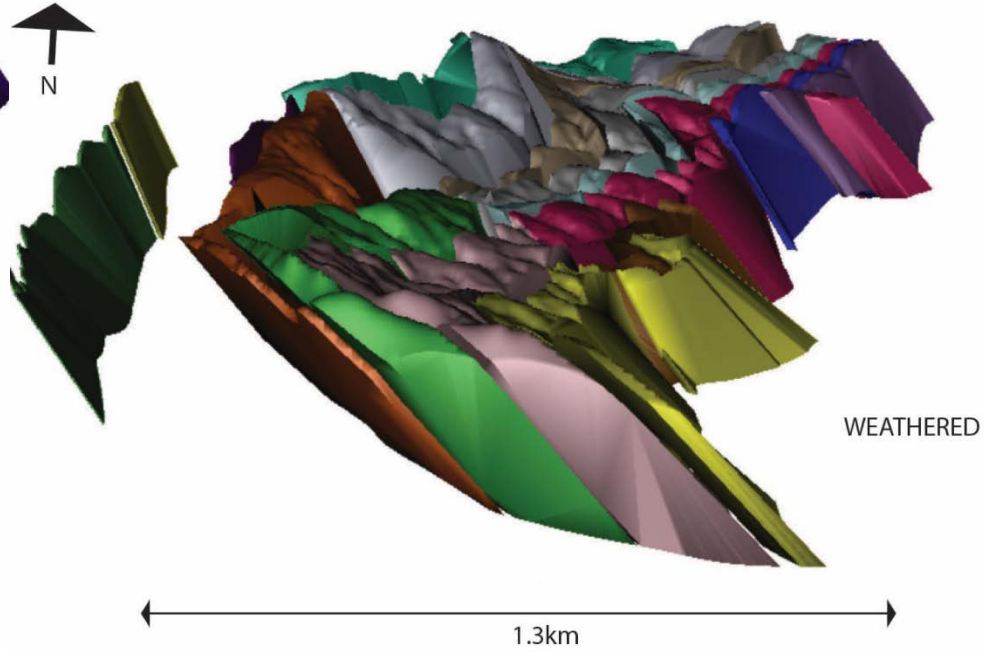


Structural discs of foliation and shear zones



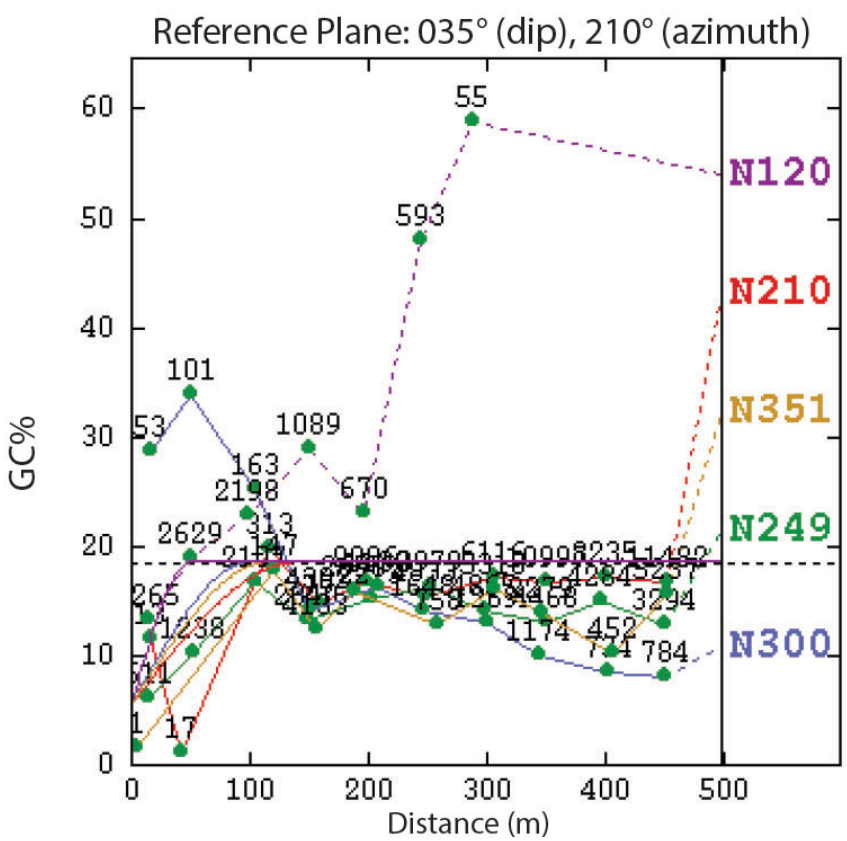
Modelled lodes offset and slightly rotated by NW-SE fault

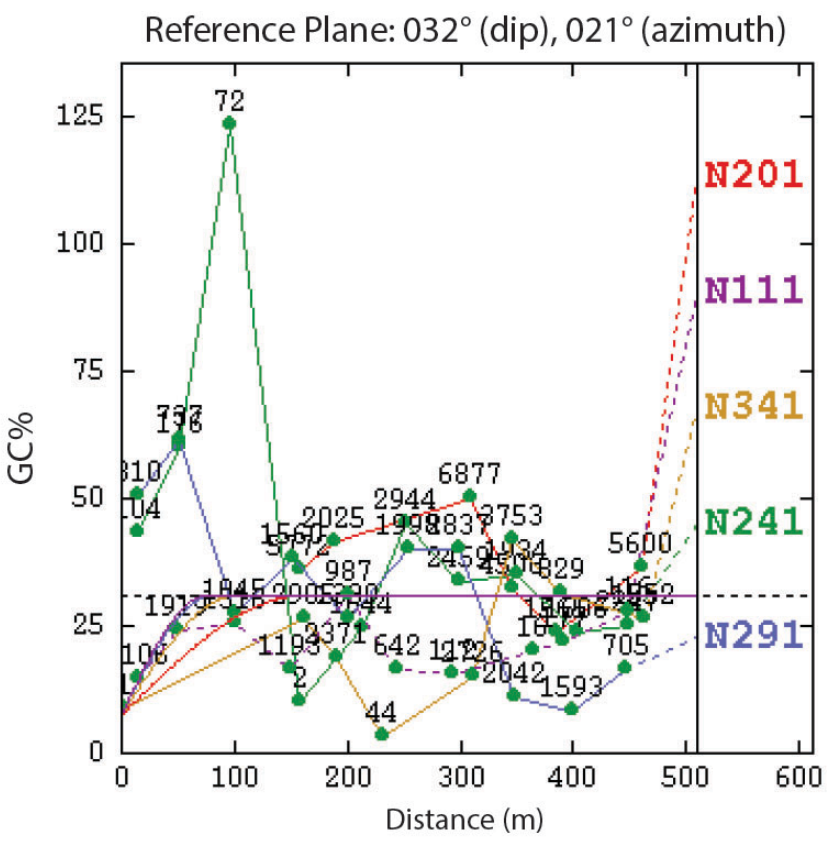




Modelled lodes – Fresh

Modelled lodes - Weathered (Oxide and Transitional) zones





North domain – Semi-variogram model

South domain - Semi-variogram model

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Summary

- Regional polyphase deformation of Neoproterozoic basement – structural template
- Fault offsets of lodes and regional rotation (faulting and folding)
- Rotation effects variography
- Large to jumbo flake associated with some faulting and pegmatitic intrustion

Concluding Thoughts

- Three selected projects illustrating the 3 main different forms of natural graphite
- They are all hosted by high grade metamorphic rocks and are geologically complex despite appearances
- Understanding the structure is key to exploring and estimating a (industrial) mineral resource
- Inadequate structural knowledge means inadequate resource