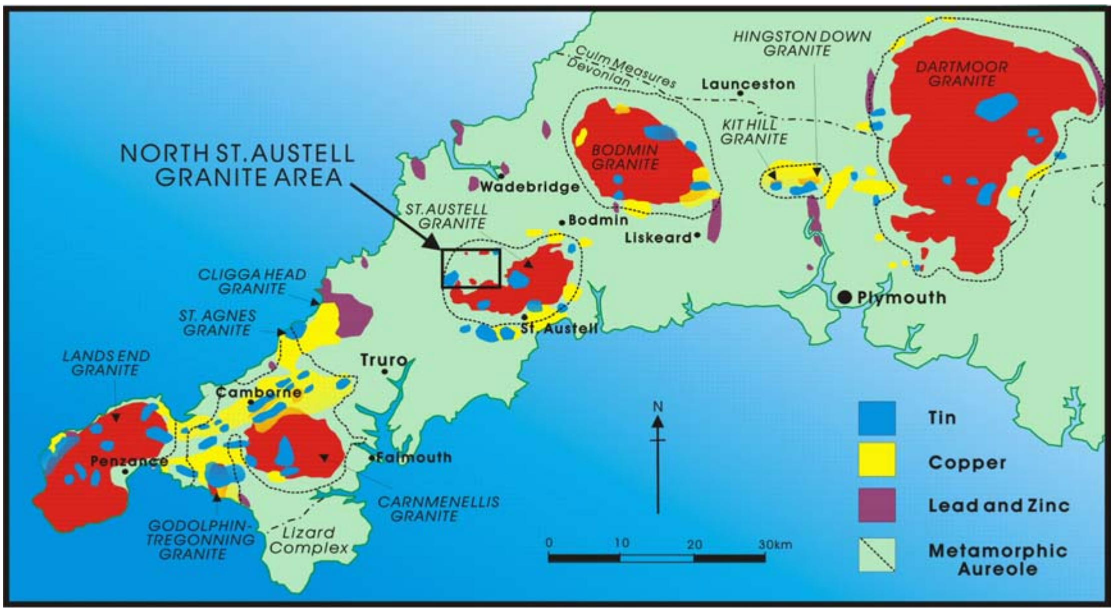
Exploration Case Study
North St Austell Granite Area.

Period 1980s



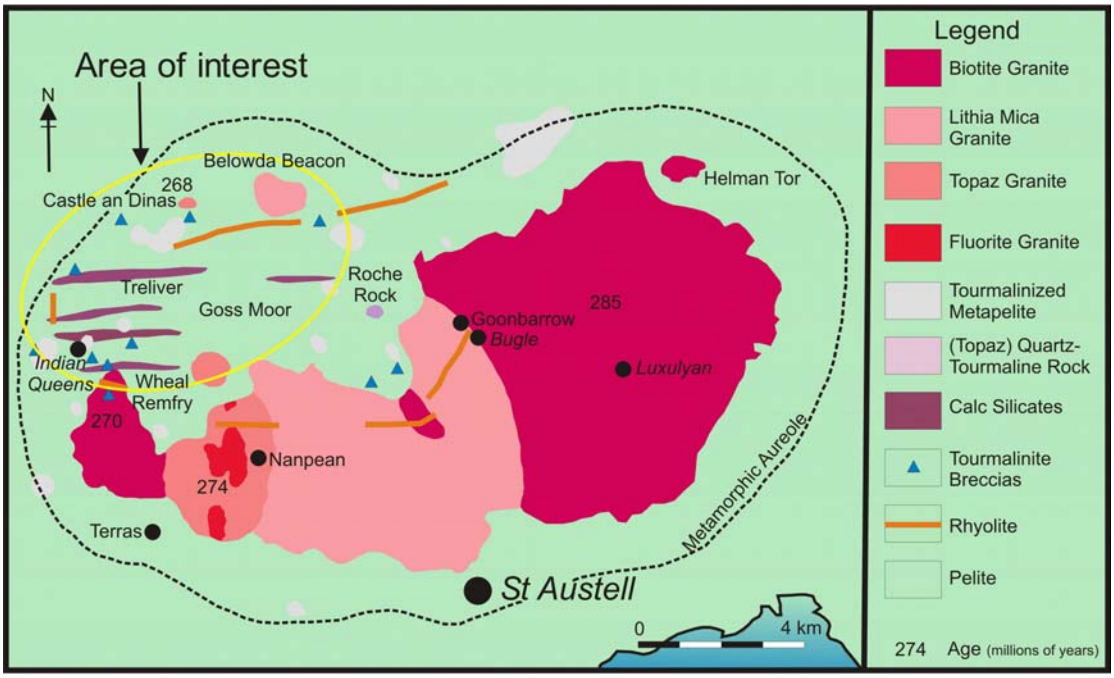
Metal mining distribution (after Dines 1956) showing area of interest.

Target >5 Mt @ 0.5% Sn for open-pit mining.

1.0 Methodology

- Desk study and determination of target area –
- Exploration permit acquisition (land and mineral rights)
- Regional soil geochemistry on 100m grid
- Geological mapping of float
- Detailed soil geochemistry on selected targets on 25 m grid.
- Trenching and geologic mapping
- Target selection
- Diamond drilling
- Petrographic and mineralogical study
- Determination of conceptual model for mineralization
- Initial evaluation.

2.0 Desk study results (based on published data including historic records)



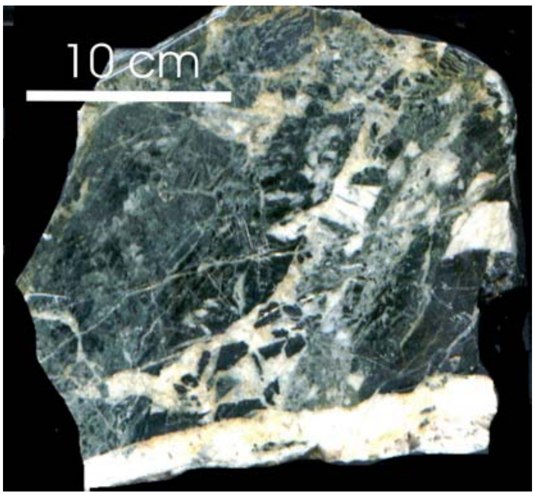
Geological map of the St Austell granite and area of interest

2.1 Regional geological setting.

The St Austell granite is one of six plutons comprising the, upper, exposed portions of the Cornubian batholith. It's kidney-shaped outcrop, relative to the elliptical plan of the metamorphic aureole, the abundance of low angle outcrops along its north-western margin, and the presence of small isolated cupolas to the northwest of the main mass indicate that the present level of exposure is close to the original roof of the pluton. The granite has intruded mainly pelitic (mudstones) sediments with occasional interbedded calcic sequences, which were interpreted as impure limestones. Later rhyolite dykes have intruded, with most probably, contemporaneous hydrothermal breccias. Hydrothermal activity has produced phyllic alteration with greisen-bordered vein swarms, tourmalinization, and argillic alteration.

2.2 Sn Mineralization (from published data and examination of historic specimens and float collected from the field)

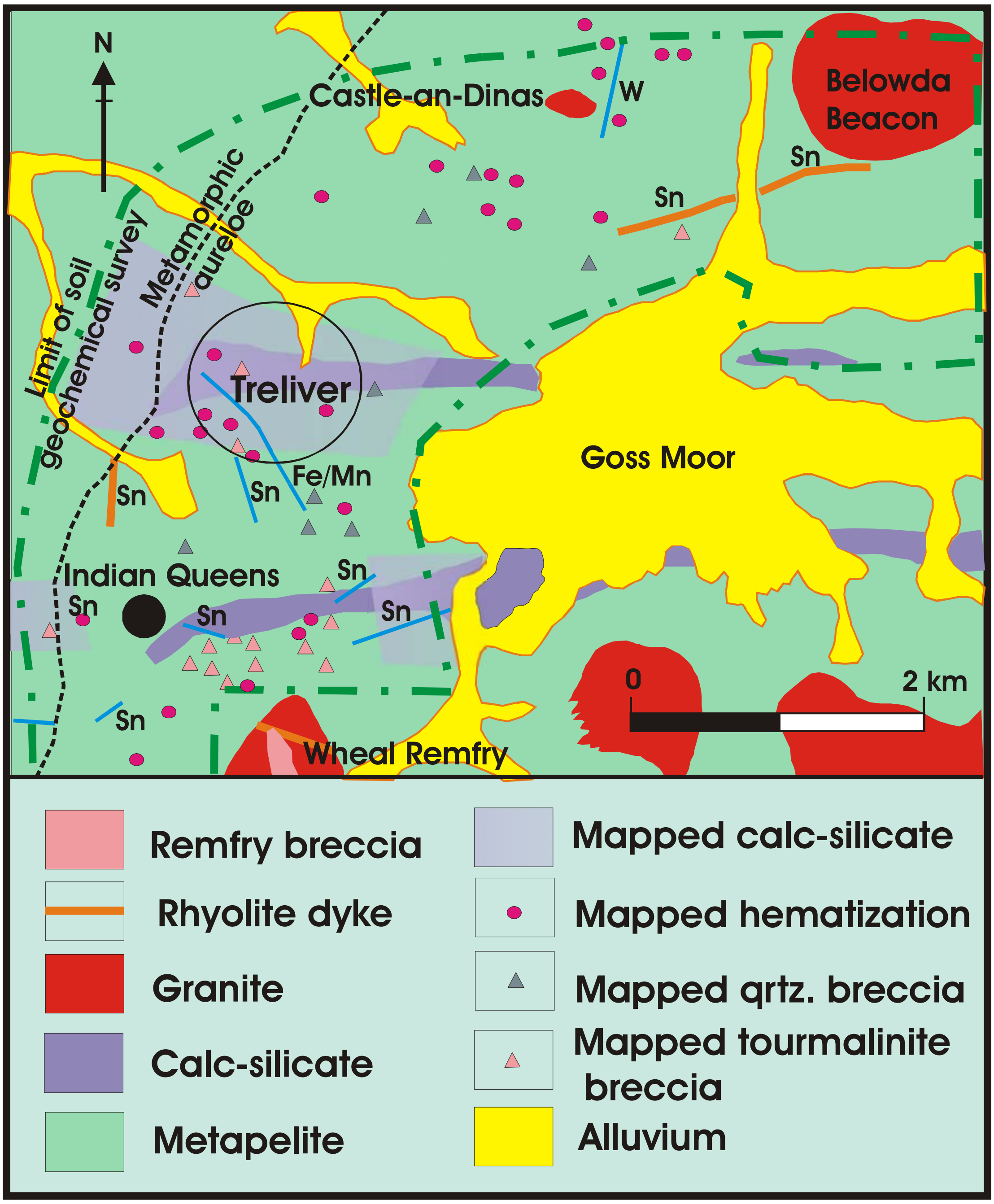
1) Sn and Sn-W lodes and sheeted vein systems – predominant strike direction NE-SW. The association includes single lodes and closely spaced sheeted vein systems. Characterised by borders of phyllic alteration and/or tourmalinization in the adjacent granite.
2) Cassiterite bearing stockworks – these occur just within the granite and within the metamorphic envelope. Characterised by swarms of quartz-tourmaline-cassiterite veinlets. Bordered by greisen when they occur in the granite and by micaceous selvedges where the host is metapelite. In some cases forming ladder veins of quartz-tourmaline-cassiterite in rhyolite dykes.
3) Lodes – ESE-WNW to E-W trending, which run parallel to the southern margin of the St Austell granite in the metamorphic aureole.
4) Hydrothermal breccias – marginal zone characterised by intense net veining and in-situ brecciation. Breccia clasts are autochthonous, angular and scarcely rotated. In the core the breccia contains both autochthonous and allochthonous clasts. The latter include granite, rhyolite and rhyolite tuff and rare calc-silicates. Cassiterite occurs as stringers in metatourmalinite clasts and coarse crystals in matrix.



Hydrothermal breccia


Bedded and replacement ore, Parka Mine

5) Bedded and replacement ore – in bedded ore crystals of cassiterite are aligned parallel with the banding of metatourmalinites or metapelites. Bedded ore occurs in calc-silicate rocks as ‘porphyroblasts’ of cassiterite which have overgrown the banding in tourmalinized calc-silicate rocks.



Geology of the North St Austell Granite Area from published sources and field mapping.

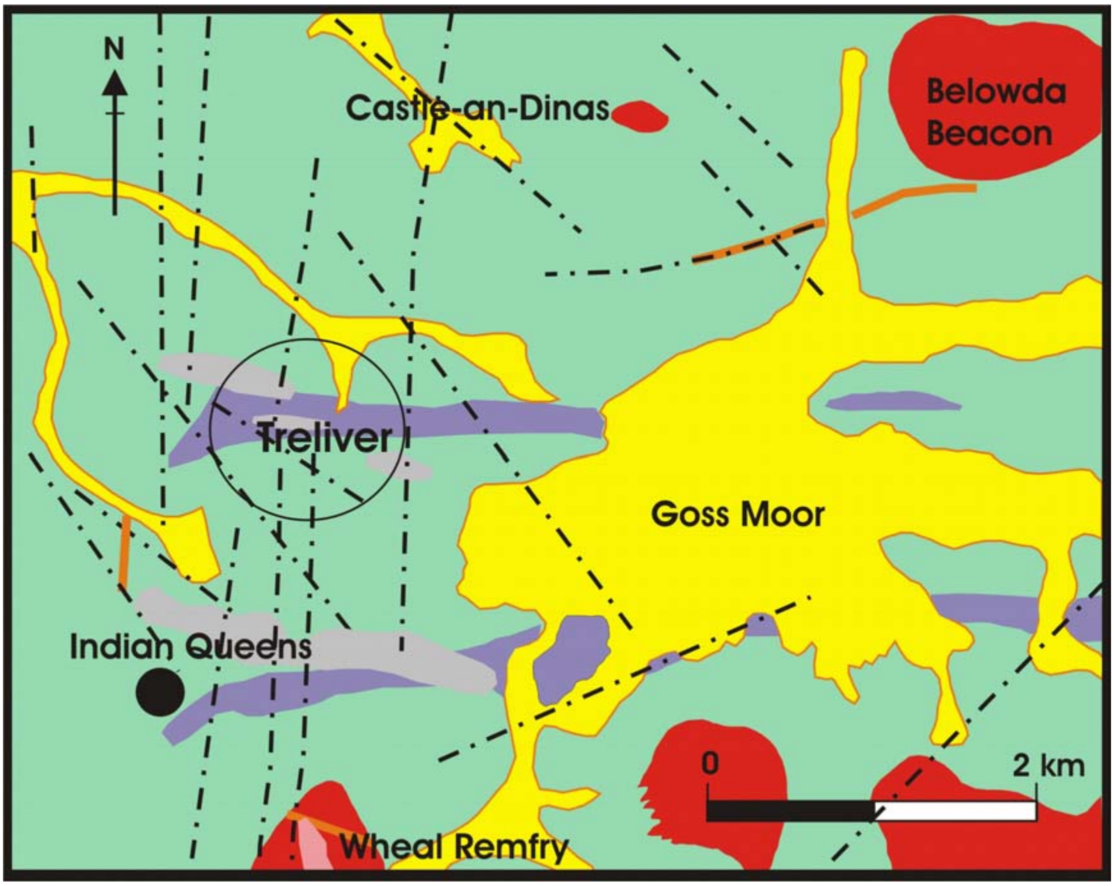
2..3 Geophysical and air photo interpretation.

2.3.1 Areomagnetic – several positive magnetic anomalies. These probably result from magnetite in the calc-silicates skarns or greenstone meta-basic intrusions. Gradients in the magnetic maps suggest the existence of several N-S and NE trending fault zones.

2.3.2 Gravity – gravity data indicates that the roof of the St Austell granite is less than 500m below the main outcrop and Castle-an-Dinas / Belowda Beacon. Positive gravity anomalies may reflect the presence of lithological variations in country rocks as well as irregularities and weak linear features striking N-S and NW-SE in granite roof.

In summary, the geophysical maps indicate N-S, NW-SE and NE-SW features and suggest that the mapped calc-silicates and possibly meta-basites extend irregularly in an E-W belt across the area of interest.

2.3.3 Air photo interpretation indicates arrays of ill-defined linear structures and a family of E-W and N-S trending structures. Tonal traces indicate most probably the calc-silicate units. E-W trending linears may represent joint and extensional fissure fractures, together with N-S and ENE/NE trending ?fault zones may have controlled the tin-bearing fluids after granite emplacement. Local controls over mineralization are dominated by structural intersections (joint/fault, fault/fault, dyke/fault, jointed- competent-lithology/fault). Further movement after emplacement of the granite and mineralization by a younger set of NW trending (Tertiary Age?) may have dislocated and in some places re-activated the older structures containing orebodies.



Air photo interpretation – lineaments and tonal changes

2.4 Historical data.

Within the area of interest the majority of tin deposits were exploited by opencast methods in small shallow pits only resorting to shallow underground works to a maximum of 50-80m below surface during the period between 1700 and 1870. The complex geological setting and no apparent conventional 'lodes' of the fissure type proved difficult to follow for the early miners. Descriptions, when interpreted today, varied between breccias, 'floors' or flats, and stockworks. Early miners were only interested in high-grade ore exceeding several percent metal and exploitation seemed confined to where the host rocks were either weathered or argillized. Descriptions of the ore indicated that it was free of sulphides and the cassiterite easily liberated. In some cases no treatment was necessary before smelting.

3.0 Targets in the North St Austell Granite Area

Area of interest c.40km^2

1) Stockwork veinlet systems
2) Concentrations of bedded ore
3) 'Subsequent', space-filling in permeable hydrothermal breccias
4) Replacement ore in calc-silicates.

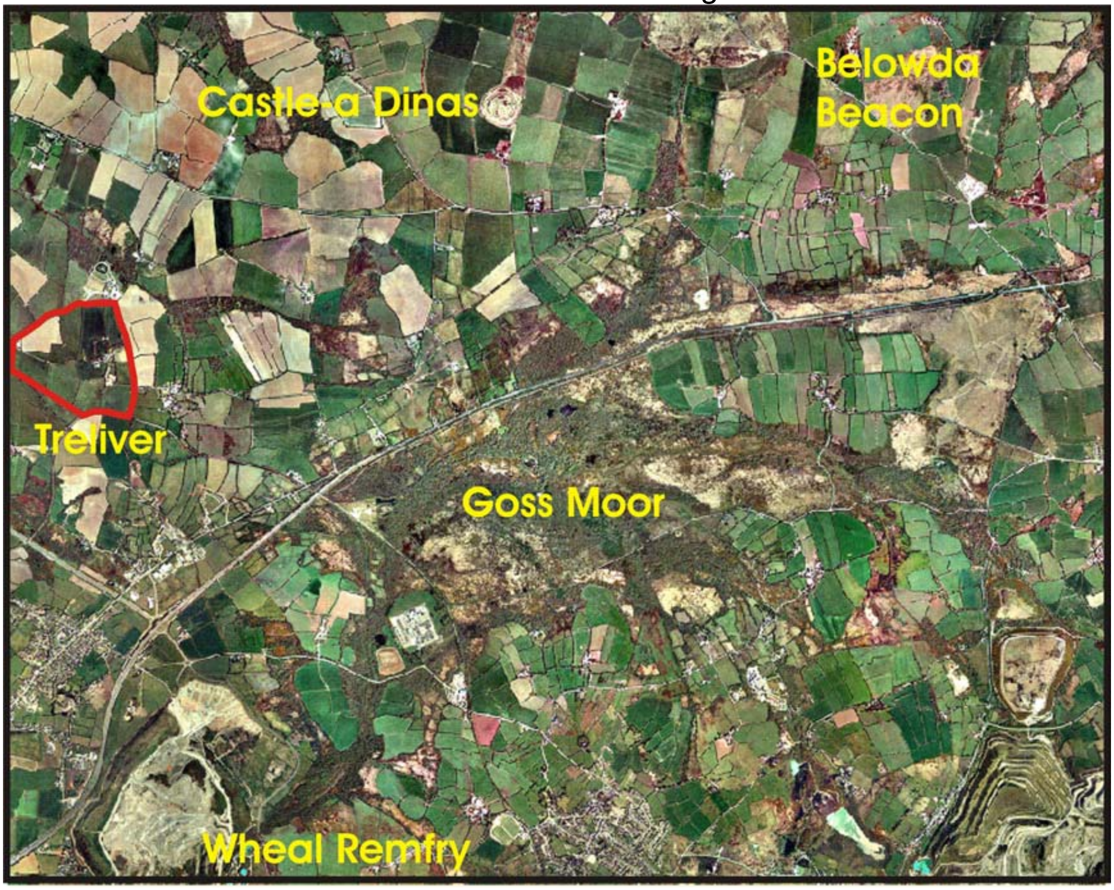
4.0 Exploration rationale

Geologically the area is underlain by the St Austell granite at a shallow depth and it would appear to have topographic highs which can act as loci for Sn mineralization. Linear structures cross-cut the area with an E-W and N-S strike which may control the mineralising fluids and receptive potential host rocks of calc-silicates lie within the area of interest. Due to the geological complexity, poor mine management and lack of exploitation by modern methods post 1900, it is probable that a considerable potential remains in the area. That potential could lie in sections of the orebodies along strike, down-dip, and areas on the footwall and hangingwall; this could include concealed undiscovered ore bodies.

5.0 Physiography

The area is approximately an inverted 'L' shape with longest dimension being 9km E-W and 6.5km N-S. The largest centre of population lies in the SW corner of the area of interest of a small hamlet. Numerous small farming communities characterize the area. There is a fairly high density of 'A' and 'B' class highways and one railway branch line and the main power grid traversing the area. The topography is dominated by the underlying granite stock with the highest points at Castle-an-Dinas (214m) and Belowda Beacon (227m).

Slopes fall away from the granite down to 60-70m in the northern and NW drainage system and at 130m at Goss Moor. Granitic areas to the south have been worked for kaolin. Drainage is poor in the large alluvial tract of the Goss Moor (exploited in the past for placer cassiterite) with other valley systems with an E-W trend. Soils are fairly typical of a temperate climate with a normal profile of a humus rich, dark brown ‘A’ horizon, approximately 50cm deep, underlain by a well-developed ‘B’ horizon with a transition into a less well developed ‘C’ horizon. The ‘B’ horizon is variable in colour from brown, orange and red and often with a high stone content. Anthropogenic activity has in some cases resulted in uneven back-filled ground.



Air photo of the North St Austell granite area

6.0 Geochemical Survey

Orientation study

This was undertaken to define the following:

- sampling tool
- sampling interval
- grid dimensions
- optimum sampling depth
- sample weight
- laboratory preparation techniques

A drainage ditch some 500m long where bedrock mineralization was exposed was used for the study. Bedrock and sidewall soil samples of the ‘A’ and ‘B’ horizon were taken at 5m and 20m respectively All samples were dried and sieved at 250 microns.

- semi-variograms were constructed which showed that the mineralised zones can be correlated up to 25-30m.
- correlation co-efficient calculated from the results of the ‘A’ and ‘B’ soil horizons demonstrated that the ‘B’ horizon was the optimum sampling horizon with sampling depth of 50-60cm.

- field sample weights of c.200gms were considered adequate.
- using comparisons between the combined –250 micron and +250 micron a better correlation or contrast was obtained with the whole sample rather than a sieved sample.
- for regional sampling a 100m square grid was chose with a 25m grid for more detail in anomalous areas.

During soil geochemical sampling float samples would be collected for assay and petrological examination and anomalous soil samples subjected to heavy mineral separation for mineralogical examination by microscopy. Samples were analysed for Sn, As, Cu, and WO_3. Some 2686 samples were obtained during the regional and detailed surveys.

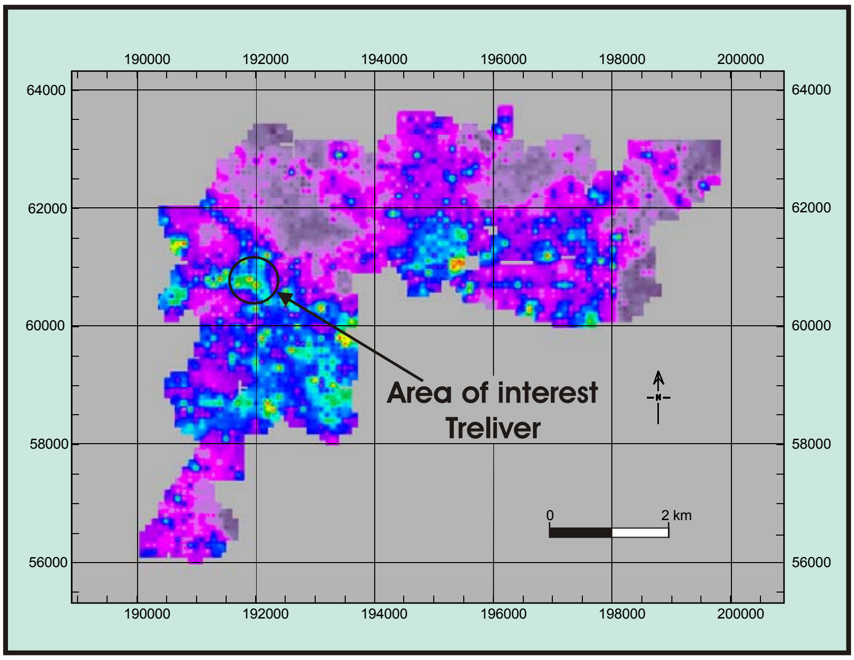
Statistical analysis of the data produced the following:

Element (ppm)	X_{25}	X_{50}	X_{75}	Maximum	Mean	SD
Sn	90	160	290	4700	238	293

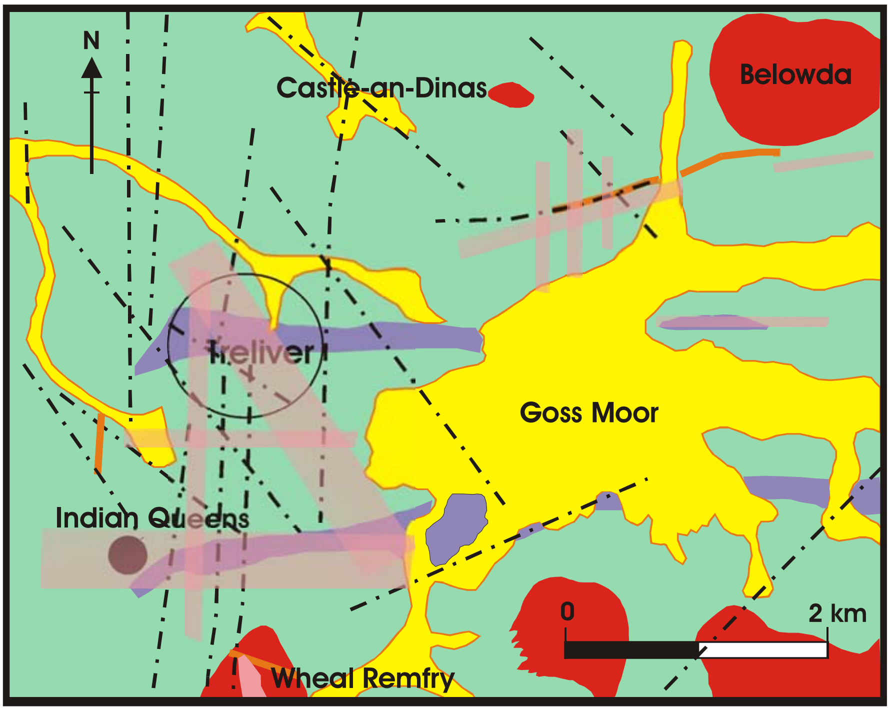
7.0 Soil geochemistry

7.1 Regional survey

Several anomalous areas were detected during the 100 m grid survey with anomalous tin values. These indicated both east-west ad north-south trends. An infill grid of 25 m, which included the Treliver area, further investigated these.



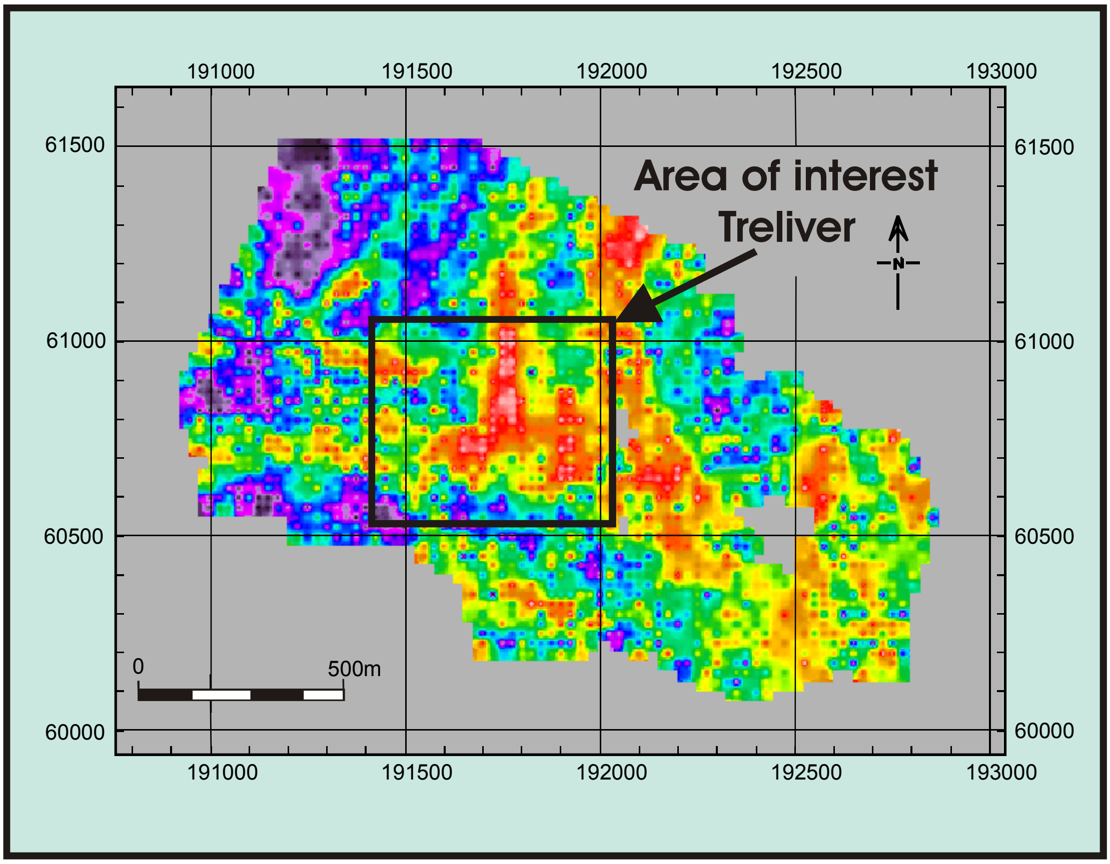
Sn soil geochemistry for North St Austell area – 100m grid.



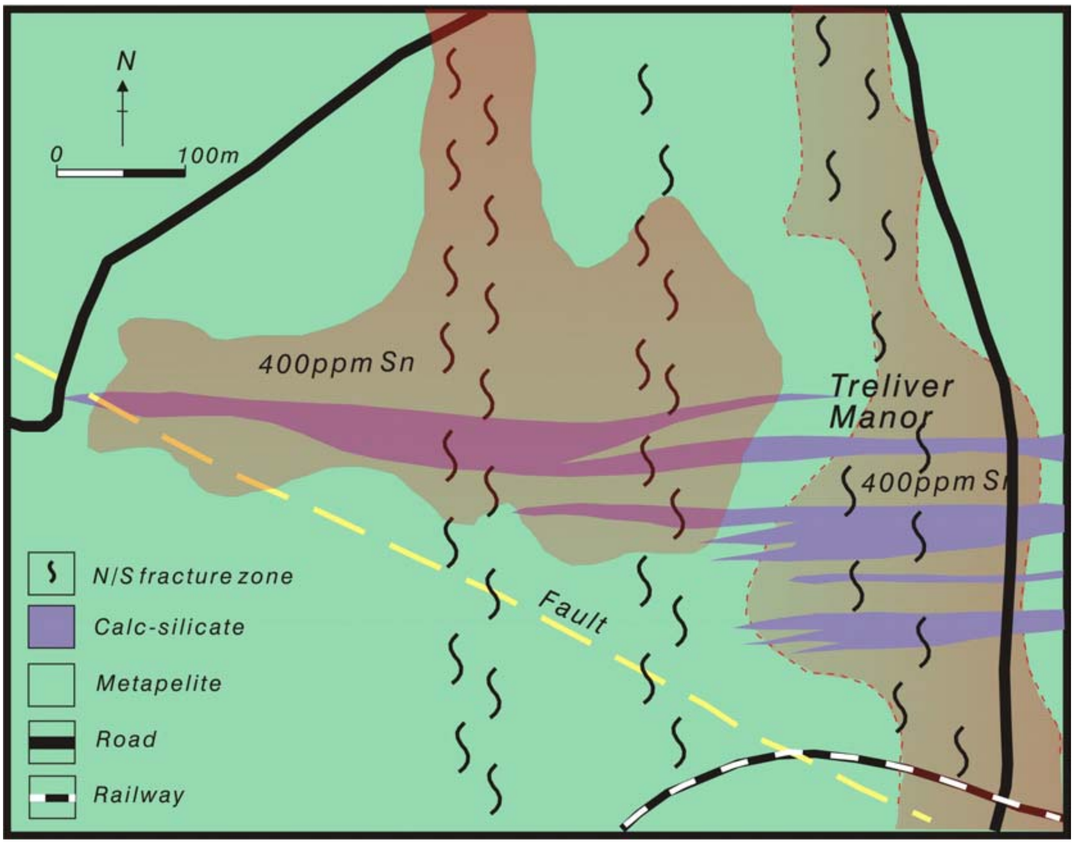
Interpretation of geochemical survey (tin value trends shown in pink) with air photo lineations.

7.2 Detailed survey at Treliver

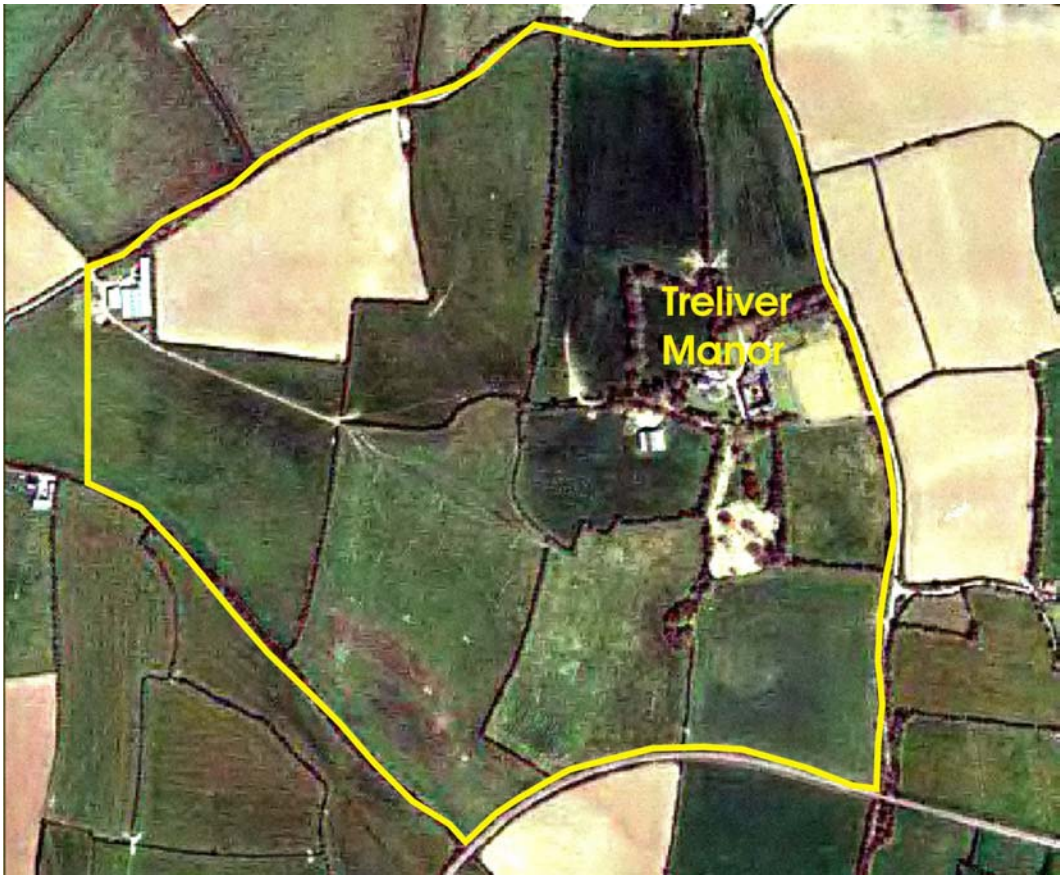
The 25 m infill grid at Treliver confirmed the strong east-west and north-south tin anomalies, these warranted a follow up by trenching and diamond drilling.



Sn soil geochemistry for Treliver area – 25m grid.



Interpretation of the geology and soil geochemistry

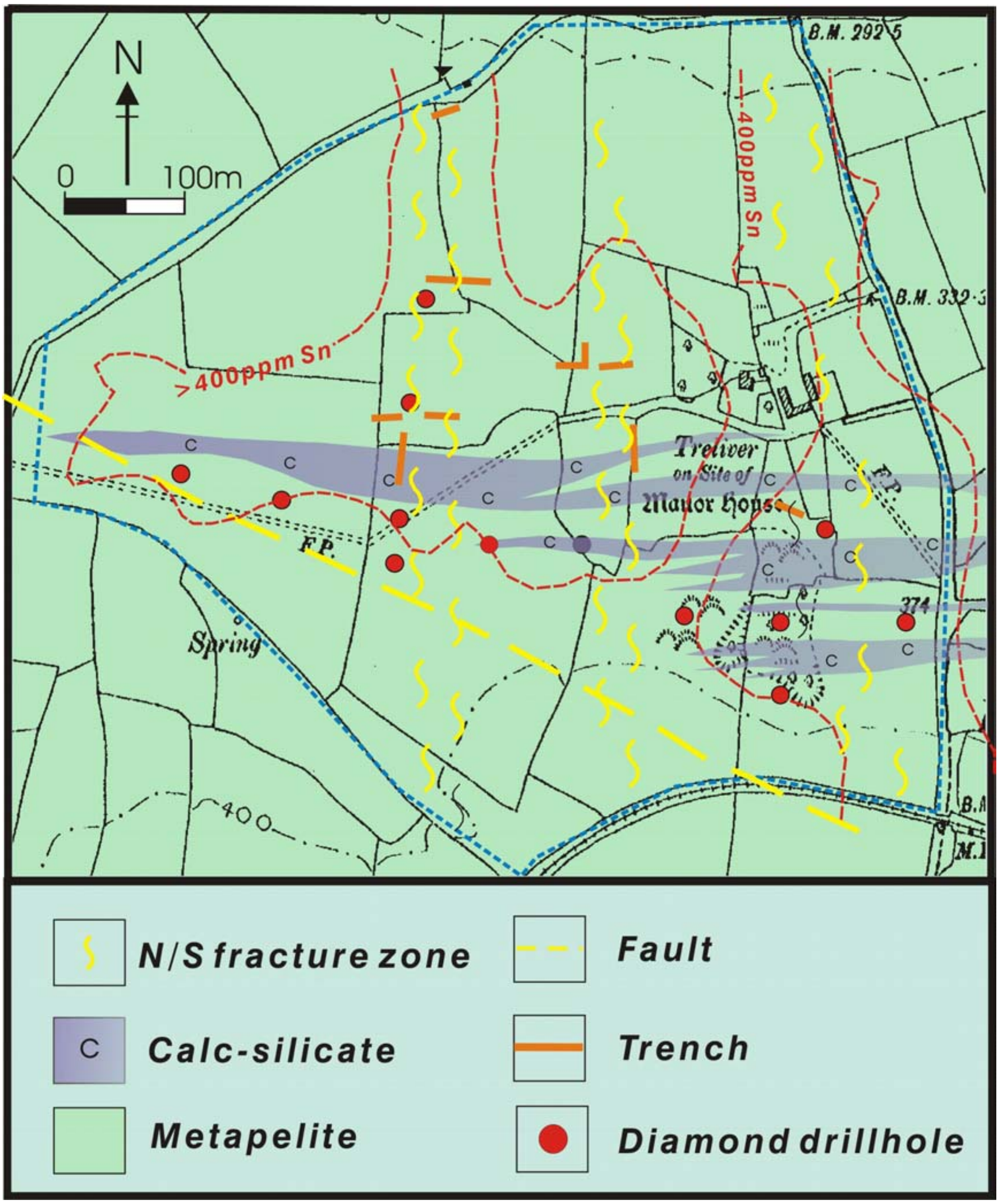


Aerial view of Treliver

8.0 Trenching and scout drilling (Treliver)

8.1 Methodology

Trenching at right angles to the E-W and N-S strike intersected E-W striking tin bearing calc-silicates and N-S striking tourmalinized breccia zones. The trenches were located to traverse Sn geochemical soil anomalies and were between 2 to 2.5 metres deep but the final positions had to be agreed by the land owner. Continuous channel sampling was undertaken on trench sidewalls with sample lengths determined by lithological variation but not exceeding 2.5 m in length. A full geological log was made of each trench. Diamond drilling was undertaken using a Boyles 37 trailer mounted rig starting at HQ (63.5 mm) size and reducing to NQ (47.6mm). Boreholes were positioned to test trench tin mineralization. Boreholes were inclined at minus 55^0 from collar and cased for the first 15-20 m. Core recovery was in excess of 80 percent with losses mainly in the upper part of the hole where the weathering was more intense.



Treliver - trench and borehole positions

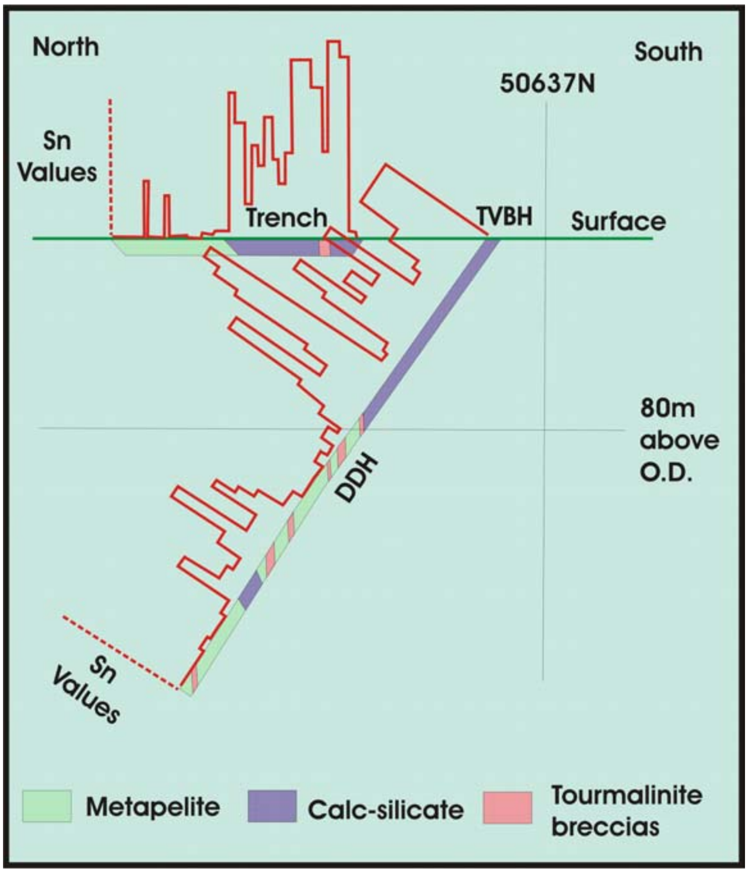
Boyles 37 diamond drill rig

Diamond drillcore after diamond sawing for assay
[broken core is due to the deep weathering profile (c.60m)in the area]

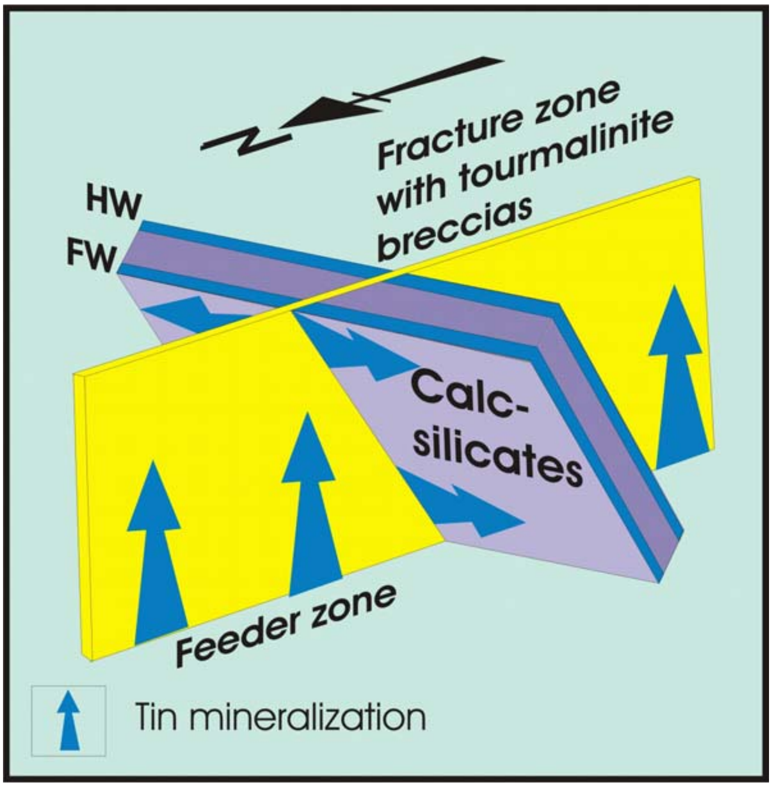
On completion of each borehole two Tropari surveys were made of the borehole to give both azimuth and dip downhole.

8.2 Geology and mineralization

The calc-silicates are contact metasomatised basic or intermediate tuffs. They consist of diopside-actinolite-epidote-plagioclase-axinite-chlorite-sphene-rutile-quartz in varying proportions and in places they are finely bedded. The calc-silicates are highly fractured either by brittle fracture or hydraulic fracture or a combination of both. Examination of the core indicates chevron and similar folding with parasitic folding with minor shear zones and kink bands.
The calc-silicates rocks are a better host to mineralization than the siltstones since they are more competent, allowing greater fracture derived permeability and easier access of mineralizing fluids, and because they are more chemically reactive to the mineralizing fluid. Pervasive tourmalinization is identified in the majority of the boreholes and most noticeably in the metapelite facies where the tourmaline has progressively pervaded and replaced the more argillaceous components, leaving the siliceous bands and producing zebra banded textures. The degree of pervasive tourmalinization increases with depth with a postulated front some 300-500m from the granite-country rock contact. Tourmaline veining and breccias show a strong N-S alignment and range from 1-2 mm stringer veins to 1-2 m breccia/tourmalinite veins. These would appear to occupy N-S extension fractures developed during the emplacement of the St Austell granite.

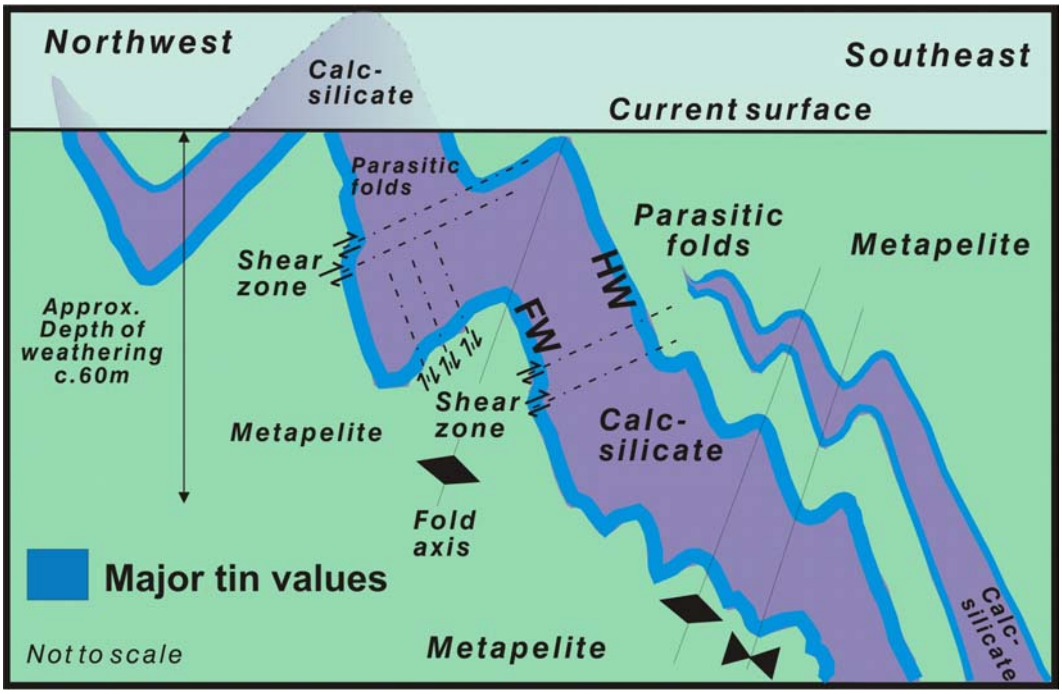


Section showing diamond drillhole and trench data



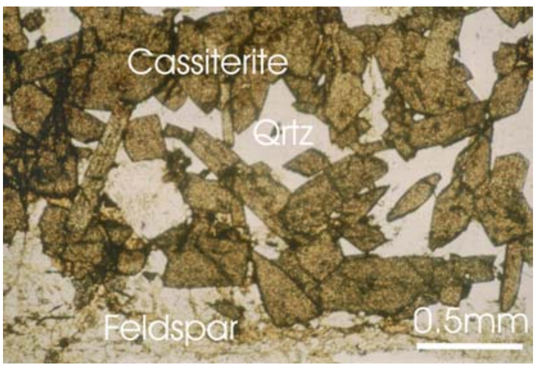
Mineralization model

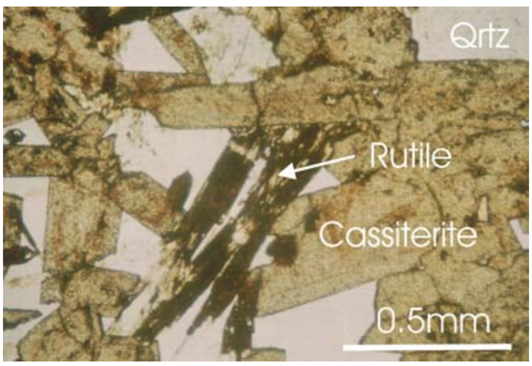
Tin mineralization was probably introduced from the conjugate N-S fracture and breccia zones and is concentrated in fractures in fold 'noses in the calc-silicates.



Stylised vertical cross-section of calc-silicates showing fold styles, axial plane orientation, brittle and semi-ductile deformation and minor structures.

Mineralization is relatively simple, consisting of cassiterite and minor TiO_2 minerals of rutile and sphene. Cassiterite occurs as elongate prismatic grains up to 3.5mm long with average grain size around 100 microns. Cassiterite spaced filled fractures created in the rocks and in some instances was deposited as lens structures parallel to lithological banding. Cassiterite growth was rapid as indicated by the elongate prismatic to acicular crystal forms and the sharp nature of the compositional boundaries in grains. The ore mineralogy is simple with an absence of sulphides and tin bearing silicates.





Photomicrographs of thin sections

9.0.0 Potential

<u>50 m deep pit</u>
Tonnage potential = 3.5 Mt, with waste:ore of 1.7:1, based on:
900 m Strike length x 25m width x 57m dip length x 2.7 density
and an open pit with 45^0 slope

<u>100 m deep pit</u>
Tonnage potential = 7Mt, with waste:ore of 3.5:1
Based on similar assumptions

<u>Economic modelling</u>
A reverse economic modelling exercise shows that the minimum (1983 tin prices) that the minimum average grades of the calc-silicate beds needed to achieve NPV 10 = 0 is
50 m deep pit 0.4 to 0.65 %Sn
100 m deep pit 0.3 to 0.5% Sn

Exploration was terminated due to a dramatic fall in the tin price due to the collapse of the International Tin Council.

10.0 References

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