The Severn Tin Deposit

Mineralogy, Microstructures and Petrogenesis

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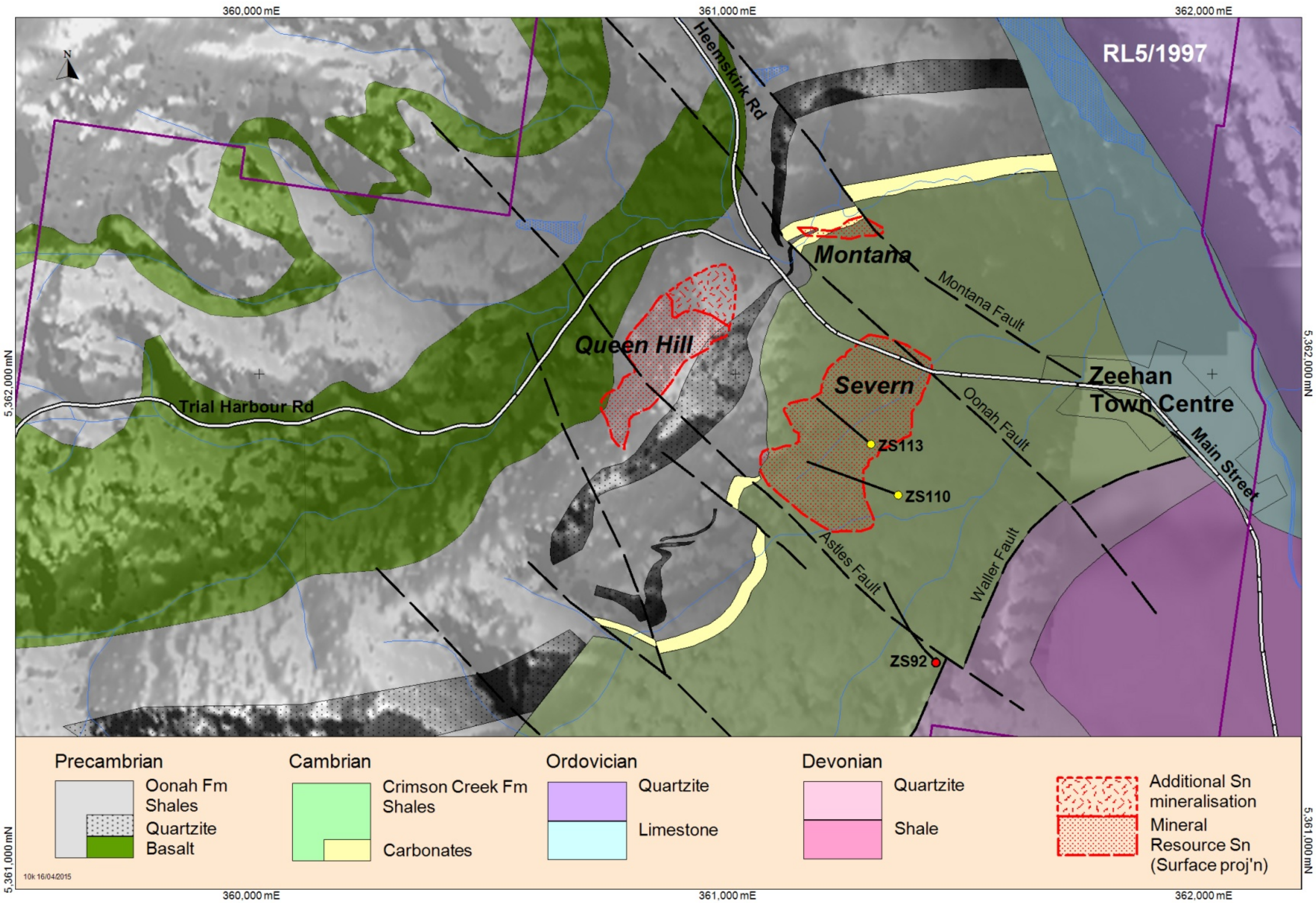
360,000 mE
361,000 mE
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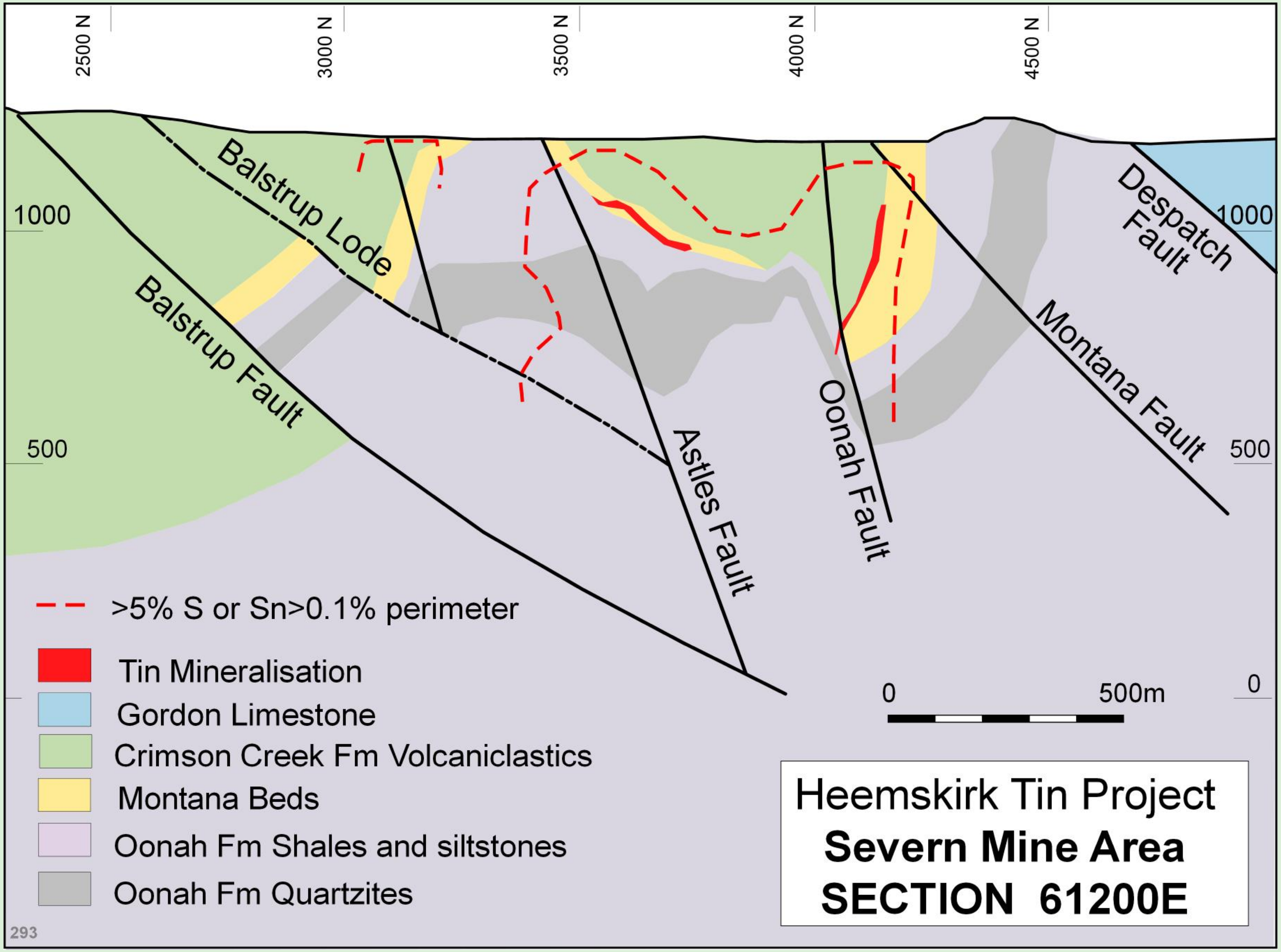
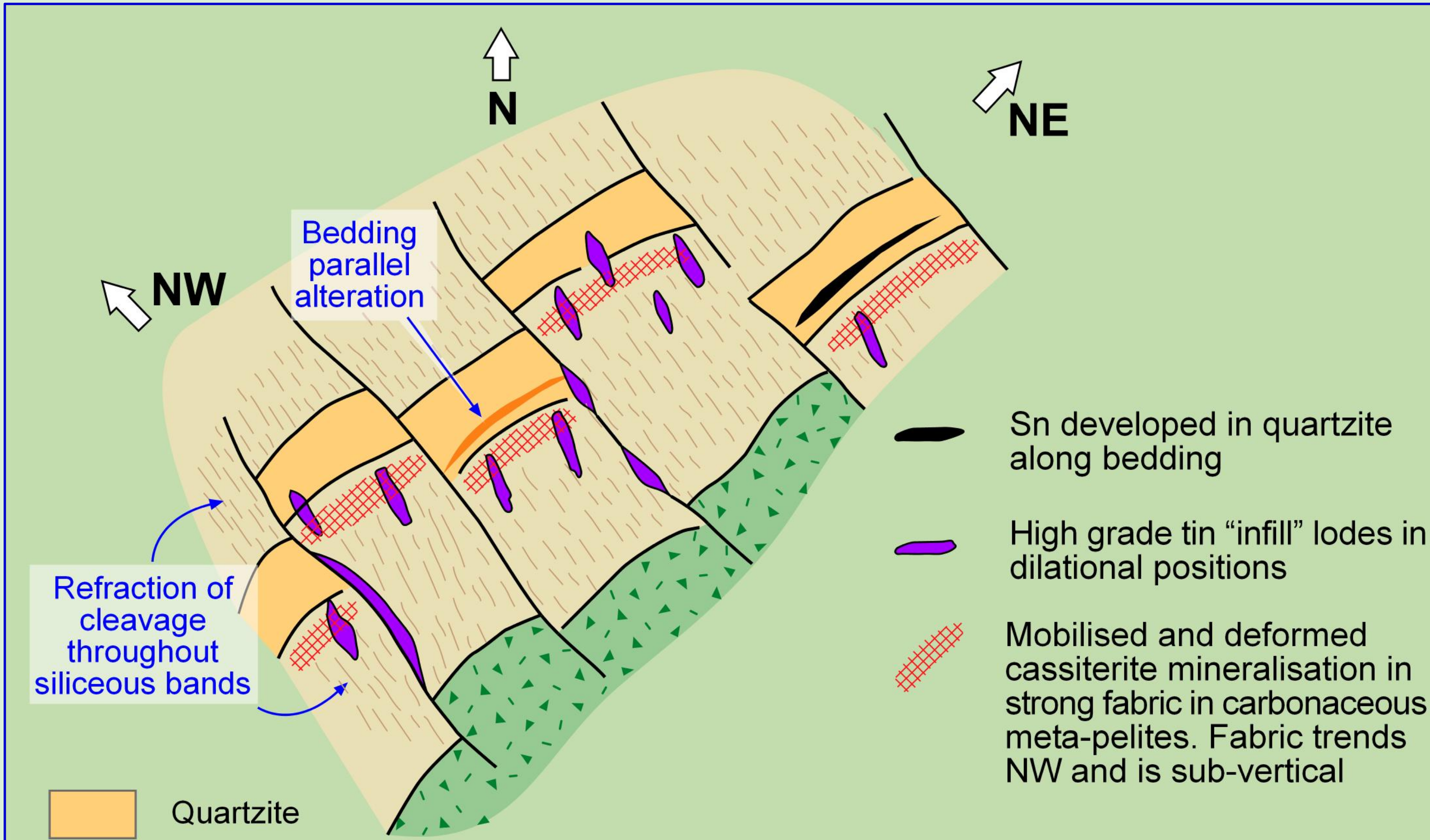
N
RL5/1997
Heemskirk Rd
Montana
Montana Fault
Queen Hill
Severn
Oonah Fault
Zeehan
Town Centre
Main Street
Trial Harbour Rd
ZS113
ZS110
Astles Fault
Waller Fault
ZS92
Precambrian
Oonah Fm
Shales
Quartzite
Basalt
Cambrian
Crimson Creek Fm
Shales
Carbonates
Ordovician
Quartzite
Limestone
Devonian
Quartzite
Shale
Additional Sn
mineralisation
Mineral
Resource Sn
(Surface proj'n)
10k 16/04/2015



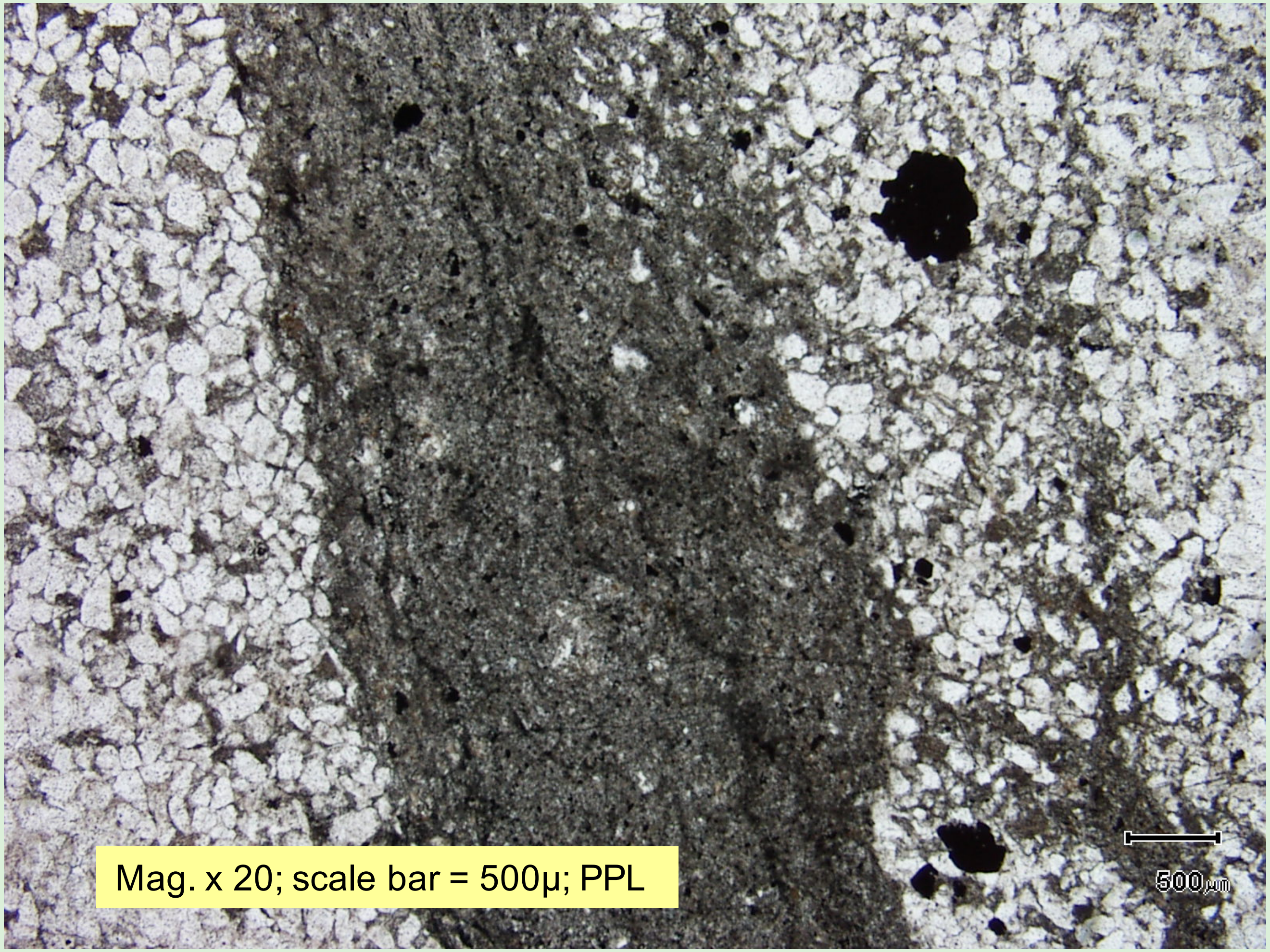
Heemskirk Tin Project
Severn Mine Area
SECTION 61200E



SEVERN DEPOSIT
Schematic "Cartoon" Showing the Various Interpreted Locations of Tin Mineralisation,

Evidence of high fluid flow in the fractured Oonah Quartzite along with anomalous Sn

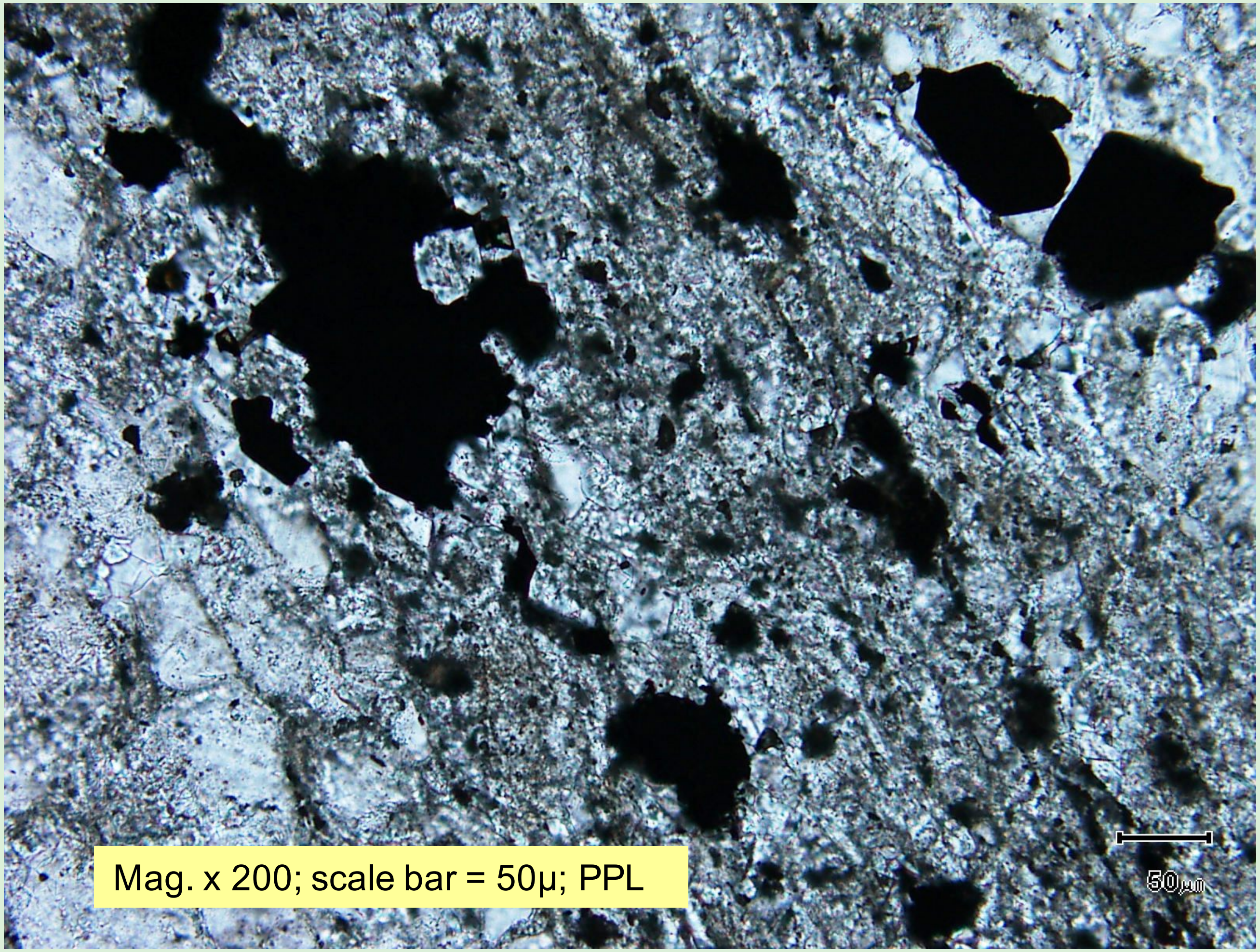
A muscovite-rich bed within the Oonah Quartzite has been replaced by topaz and other minerals including cassiterite, stannite, chalcopyrite and REE minerals.



Mag. x 20; scale bar = 500µ; PPL

G65 - 289.6m

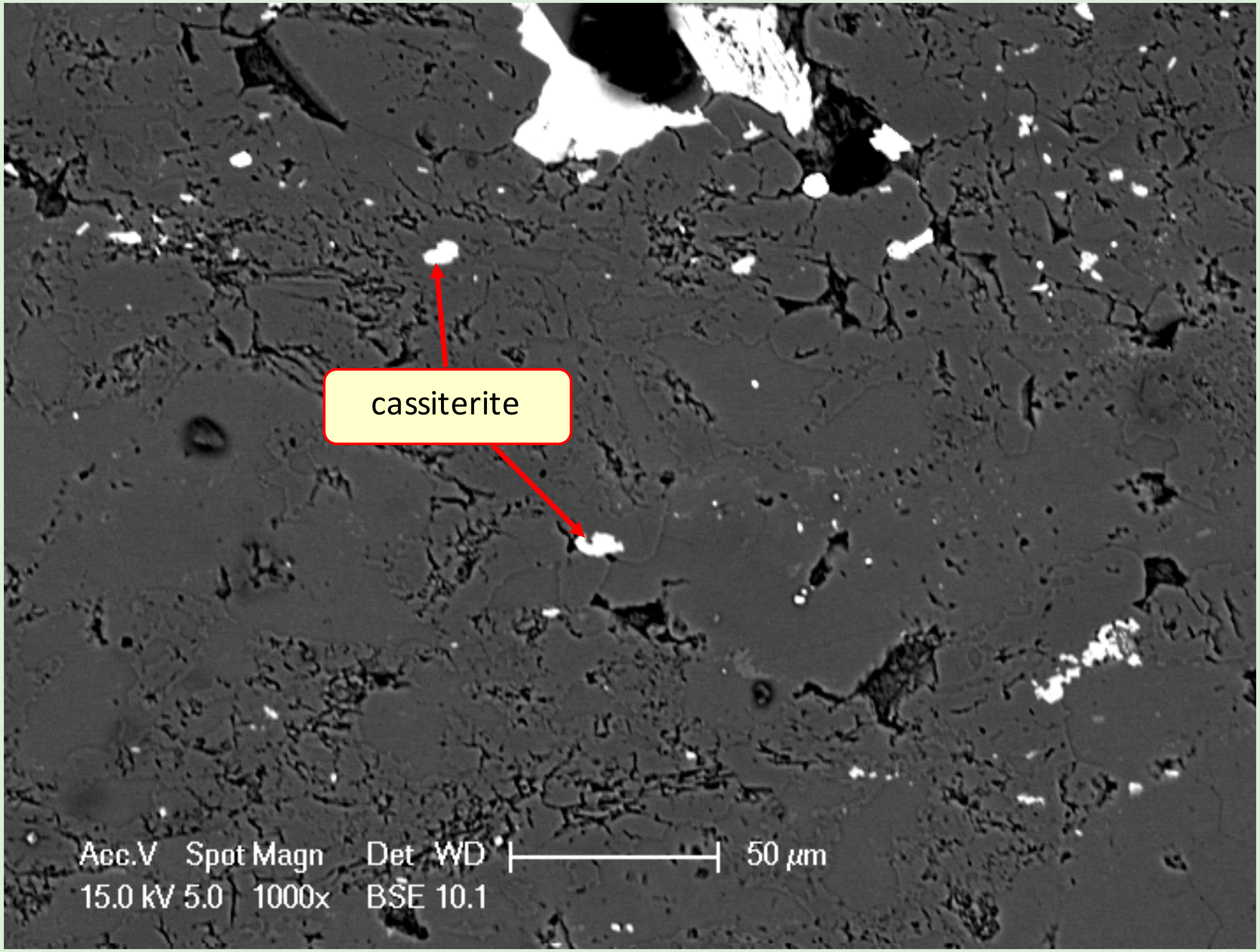
A general textural view of the topaz-rich alteration which is easily observed with high relief topaz, tourmaline and florencite (a LREE enriched Al-phosphate) associated with abundant sulphides and cassiterite.



Mag. x 200; scale bar = 50μ; PPL

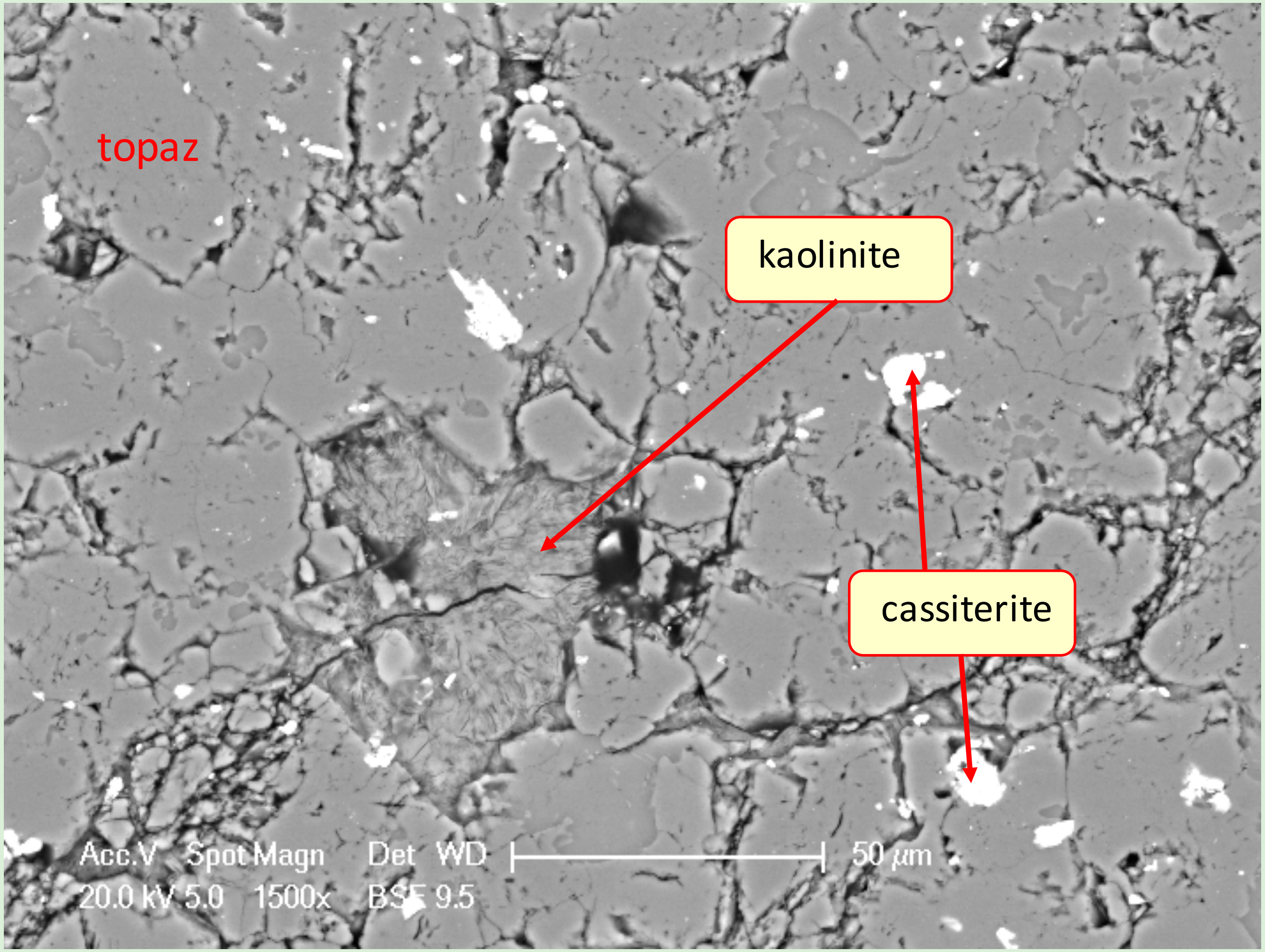
ZS110 - 398.7m

This BSE image shows fine grained cassiterite (white) sitting within a topaz gangue. The topaz has replaced fine grained metamorphic white mica that had developed within silt beds.



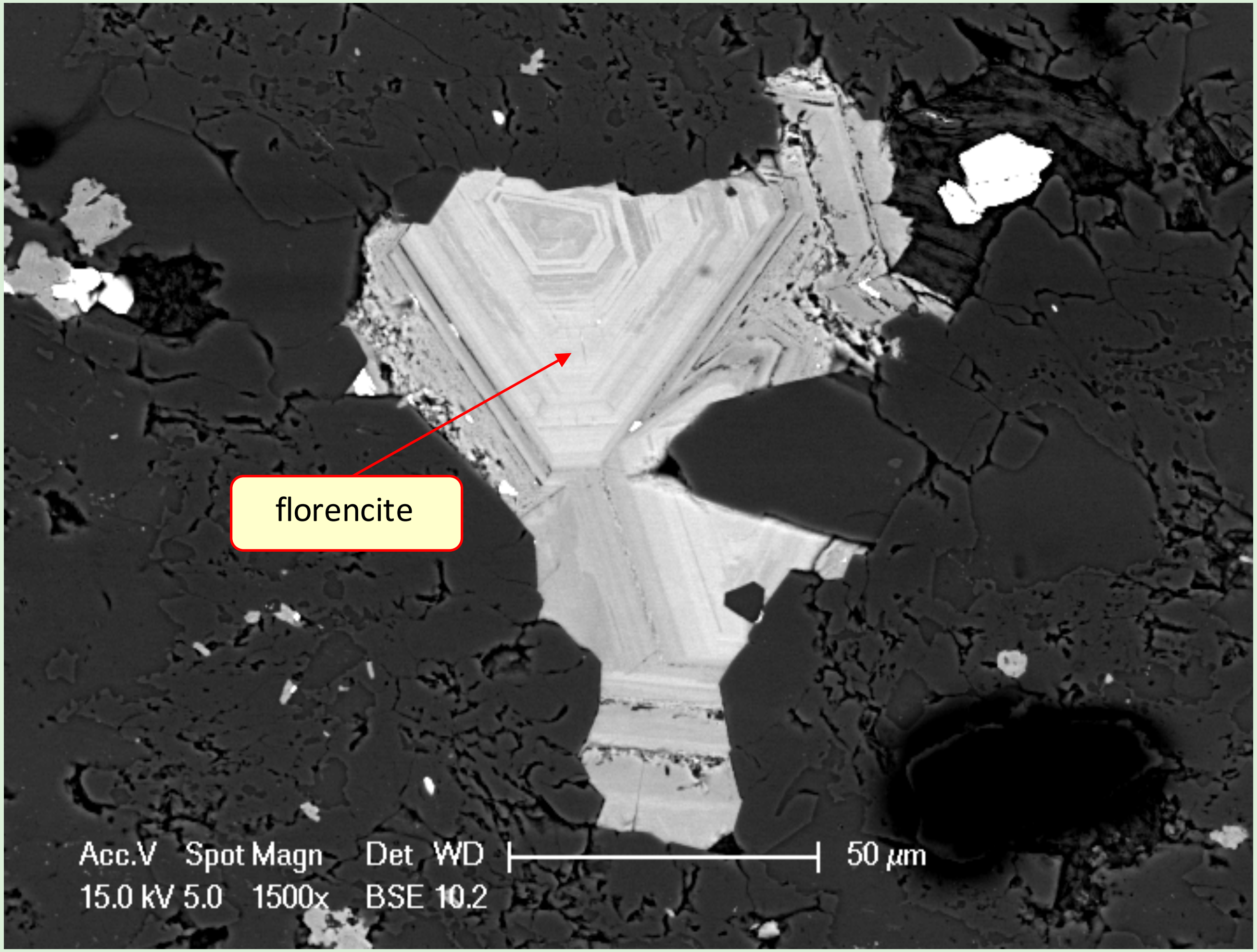
ZS110 - 398.7m

This BSE image shows the general texture of the clay, topaz and cassiterite-bearing alteration in this sample. The bulk of the groundmass is topaz which has replaced former white mica.



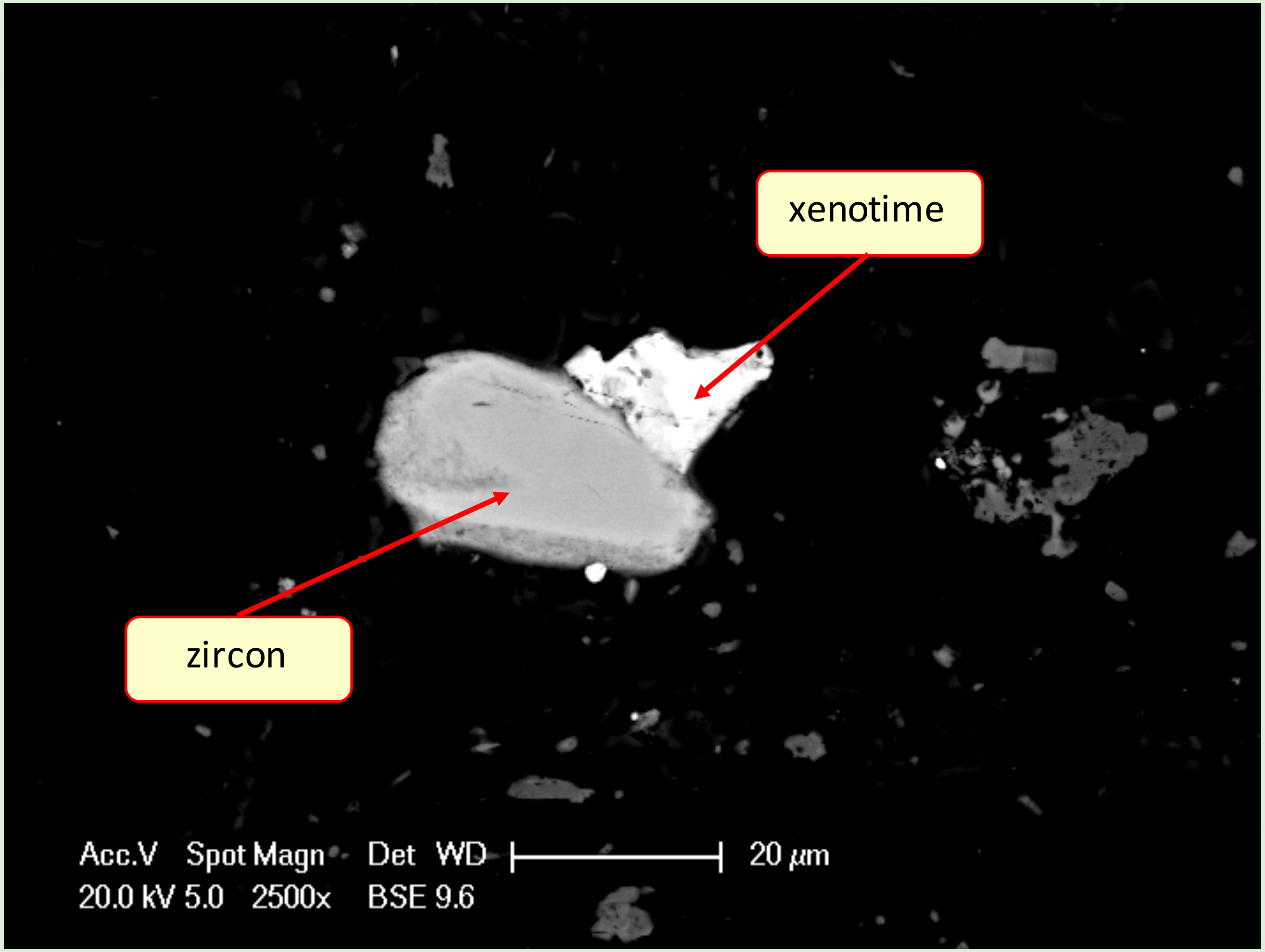
G65 - 289.0m

This BSE image shows a strongly zoned florencite grain which develops in a possible “cavity” in a topaz gangue. This LREE enriched Al phosphate may be part of a zonation adjacent to the main ore-body.

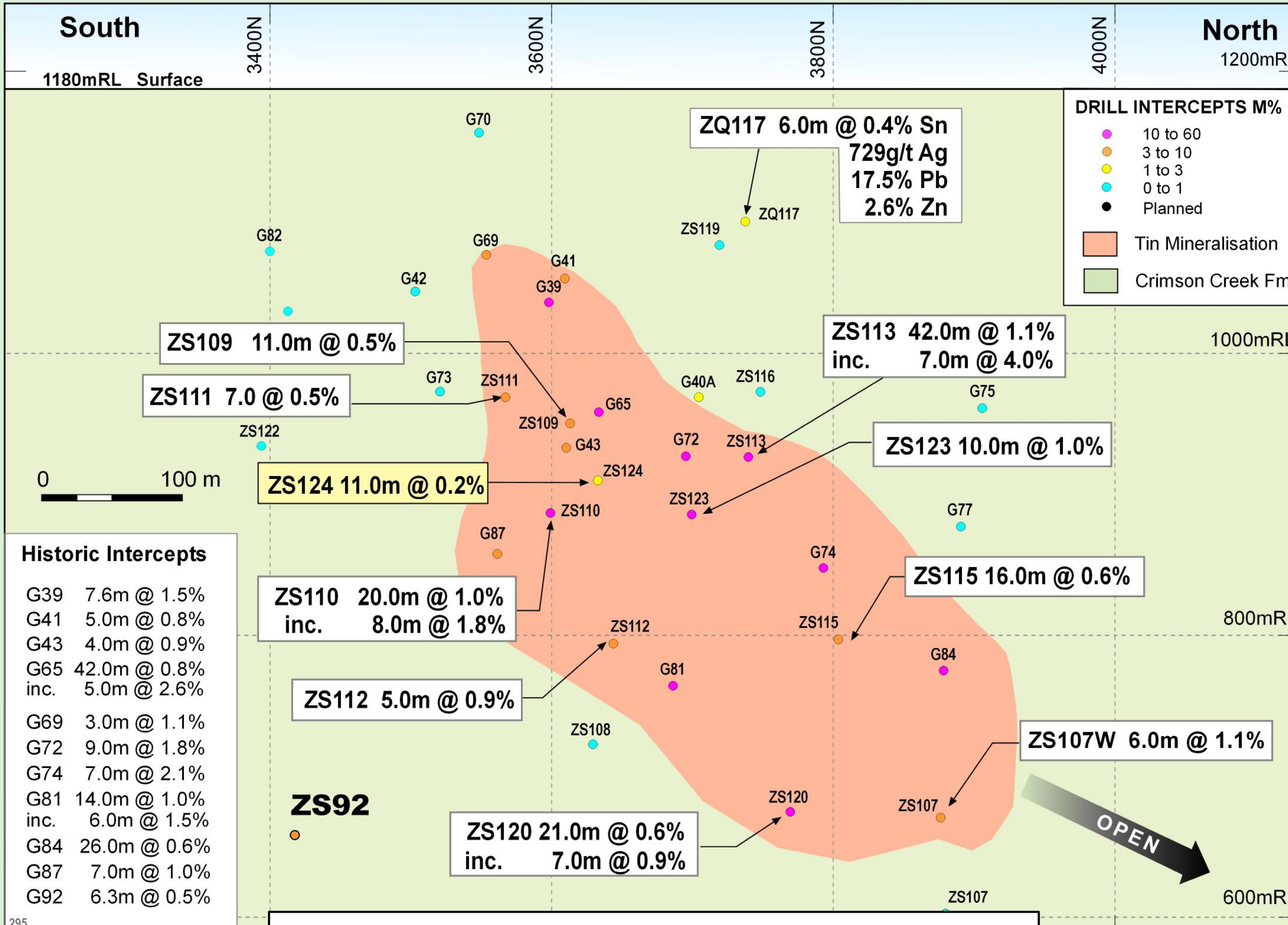


ZS110 - 398.7m

This BSE image shows a small grain of hypogene xenotime attached to a detrital zircon grain. Hypogene xenotime has also been observed nucleating on monazite.



G65 - 289.0m



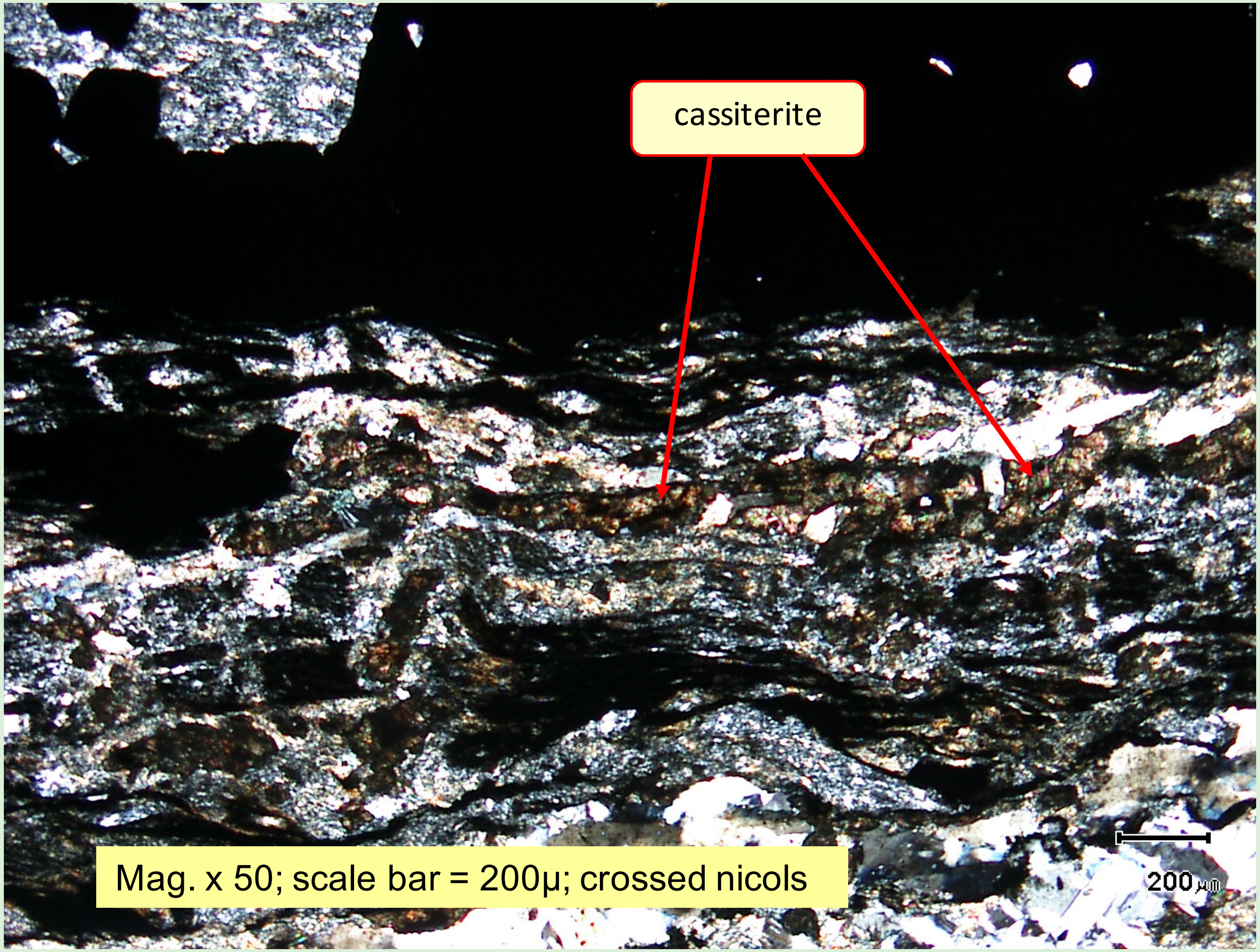
Severn Mine – Longitudinal Section

An extremely high strain carbonaceous meta-pelite.

The fabric trends to the north west with this fabric being almost parallel to layering.

ZS110 - 357.0m

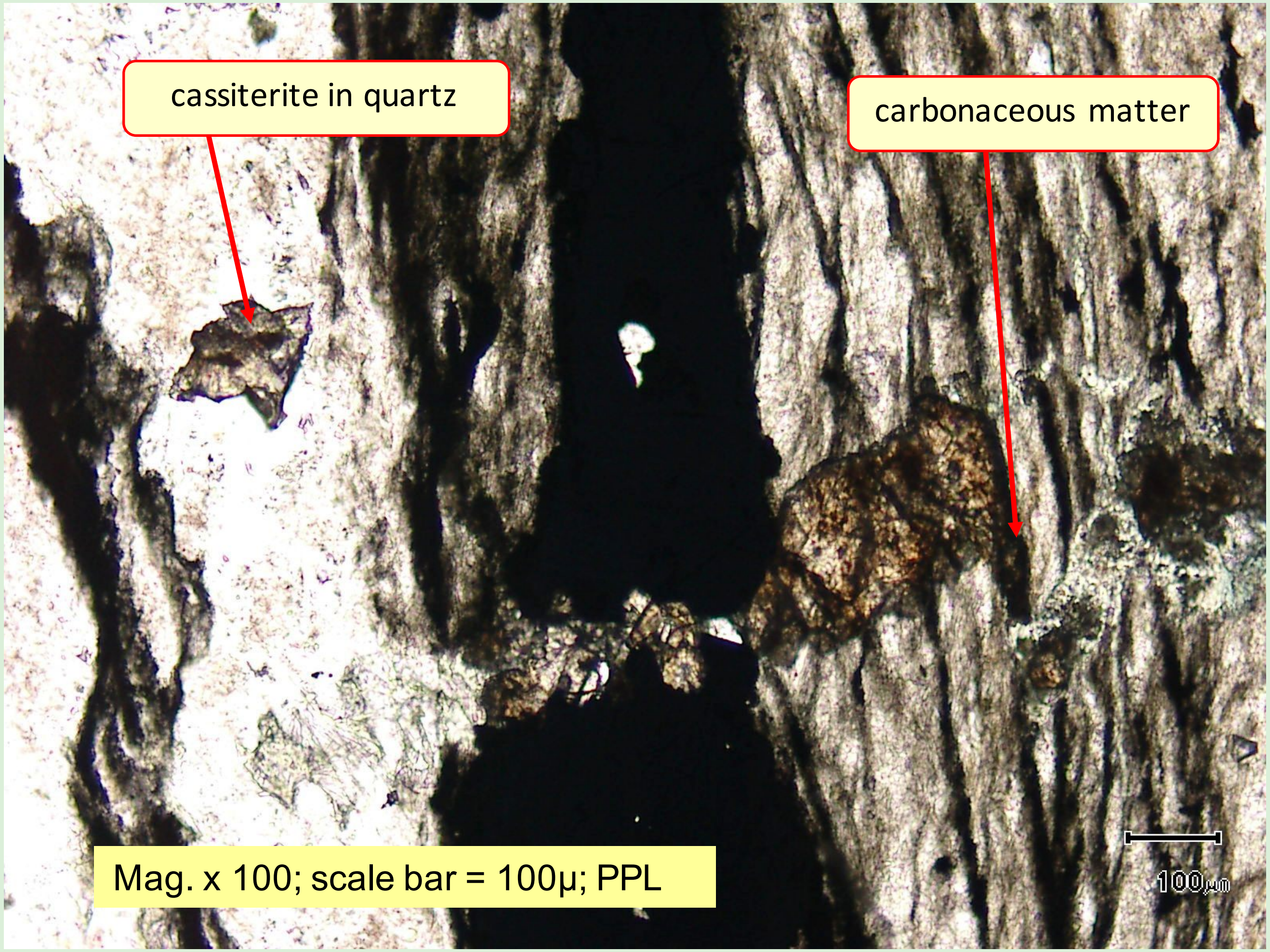
The slide shows the strong fabric containing disrupted and boudinaged cassiterite aggregates which parallel that fabric.



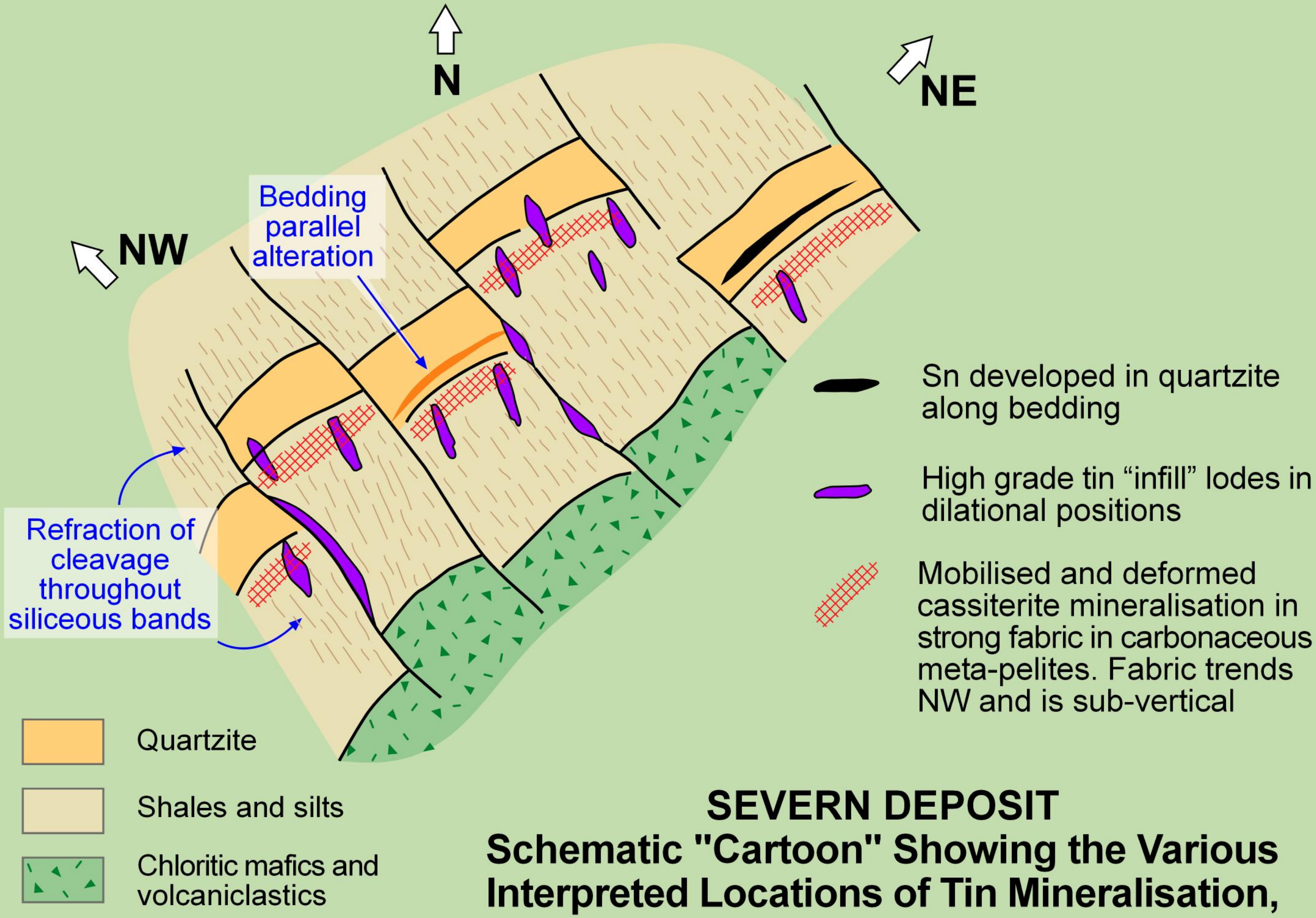
Mag. x 50; scale bar = 200µ; crossed nicols

ZS110 - 342.8m

Note the cassiterite vein cutting the pyrite, the cassiterite being dismembered in the quartz veining and the apparent cessation of growth of cassiterite by a carbonaceous shear.



ZS110-342.8m



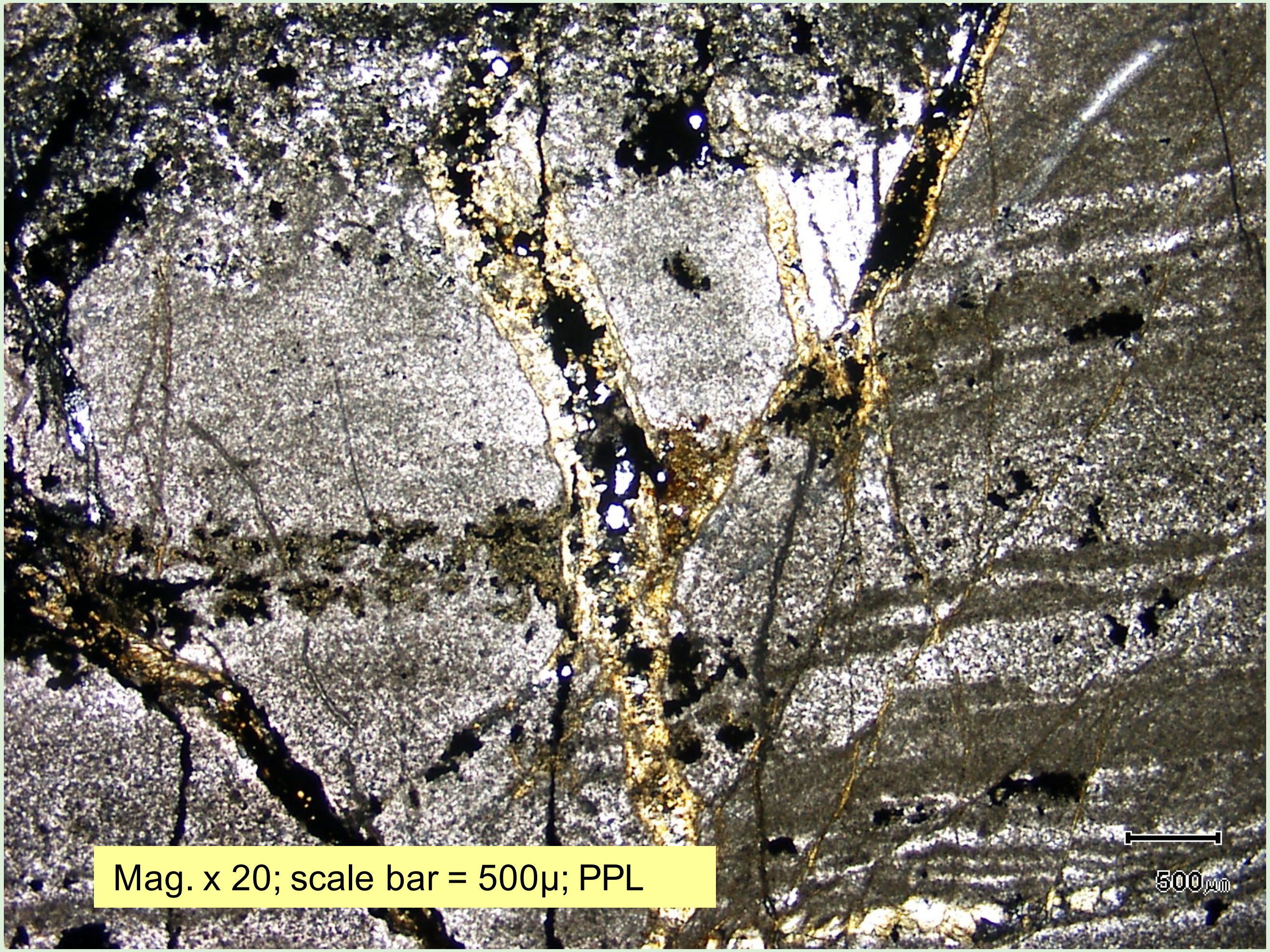
SEVERN DEPOSIT

Schematic "Cartoon" Showing the Various Interpreted Locations of Tin Mineralisation,

A strongly veined carbonaceous meta-pelite. Some of the veins exhibit a pale selvedge which has developed due to a decrease in chlorite adjacent to the veining. Elsewhere, (veins perpendicular to core axis) veins exhibit a darker selvedge with an increase in chlorite content adjacent to veins.

ZS107W - 527.5m

Banded chlorite-quartz-anatase-carbonate rock (altered mafic tuff?) which is cut by pyrite-pyrrhotite veining, tourmaline veining and alteration, quartz veining and siderite veining. Vein emplacement is complex.

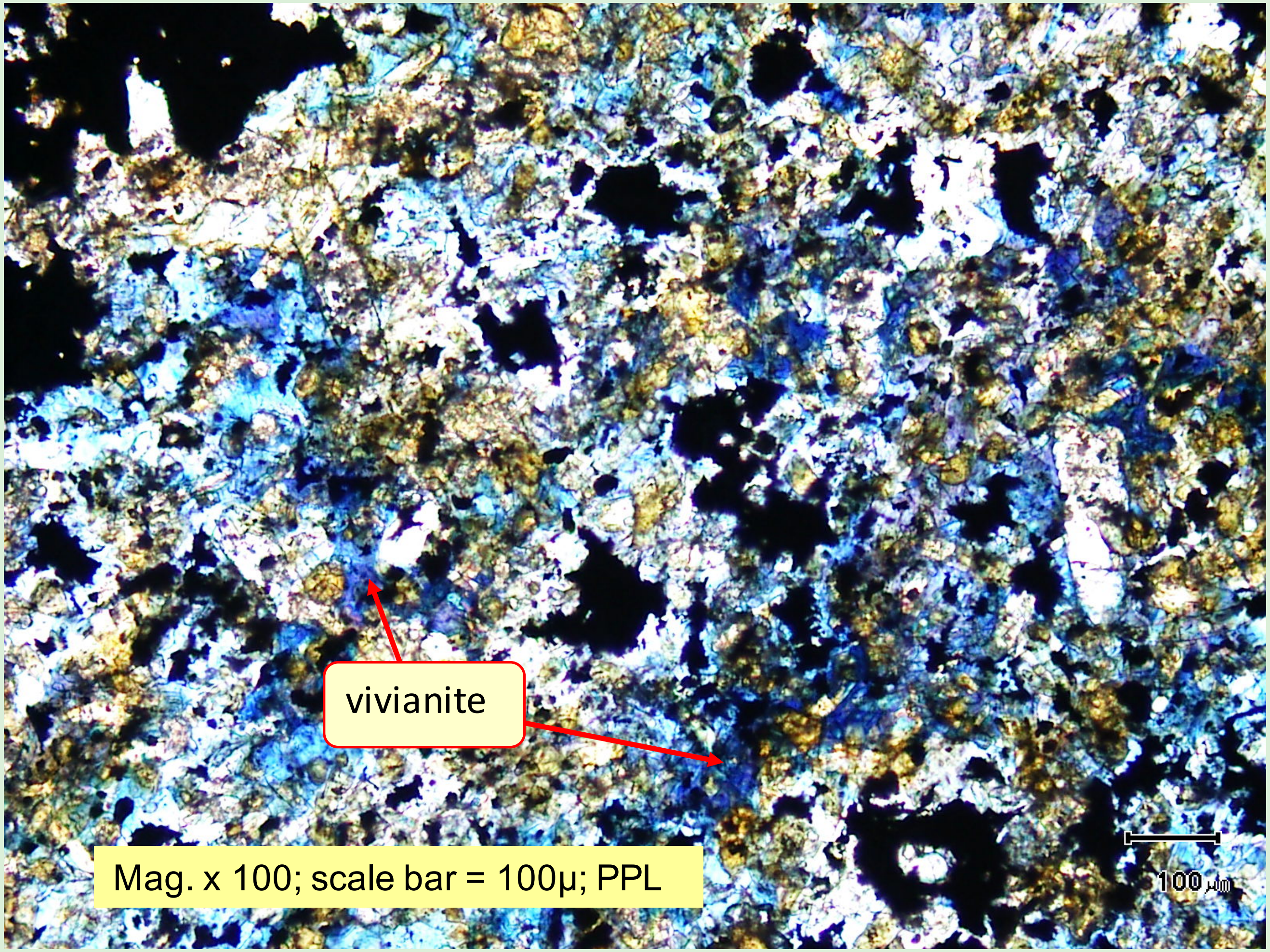


Mag. x 20; scale bar = 500µ; PPL

ZS120-516.3m

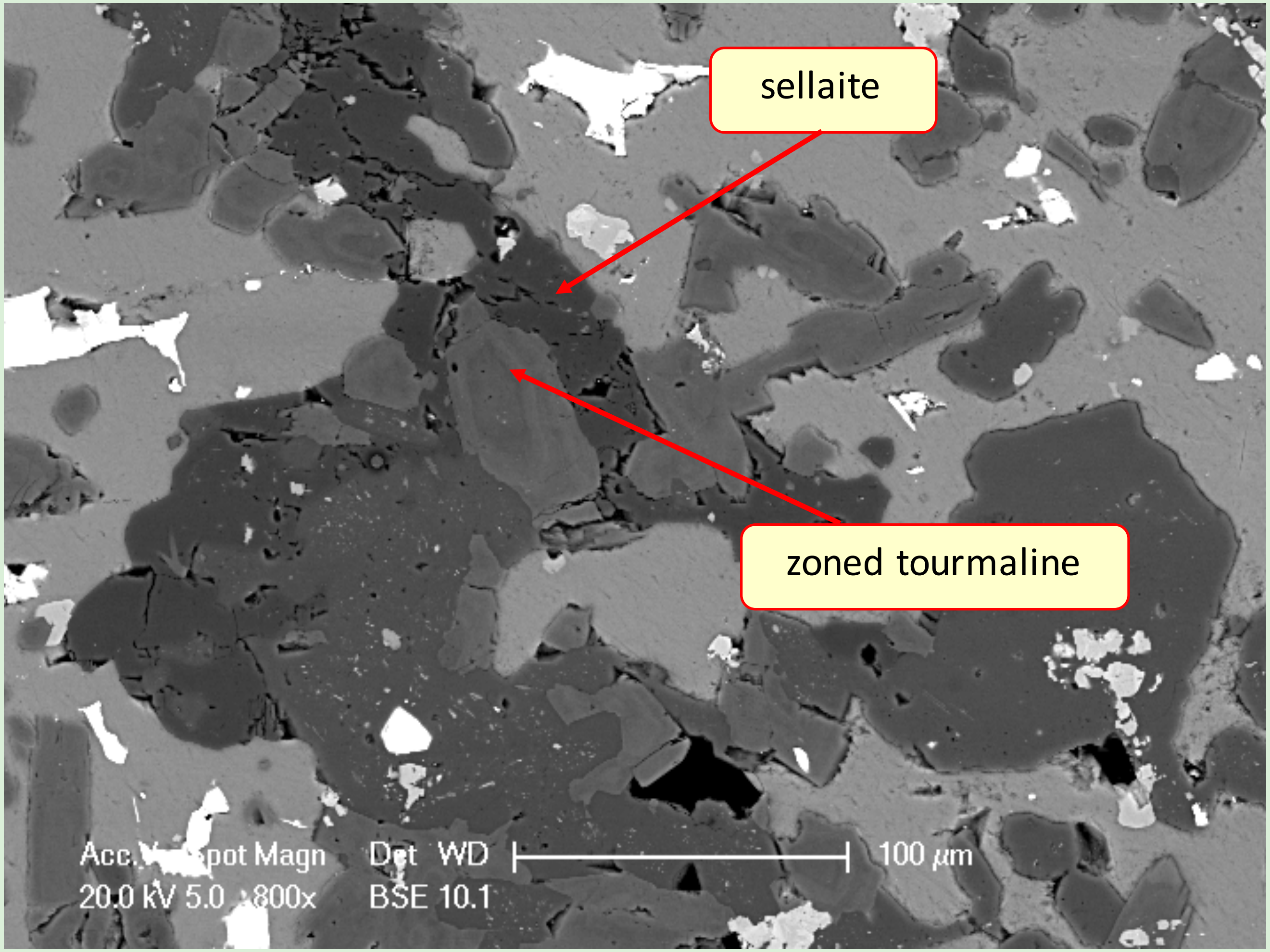
Tourmaline-vivianite-sellaite textures in a deep tin intersection in hole ZS120.

Possible mineralisation flanking high grade infill structures.



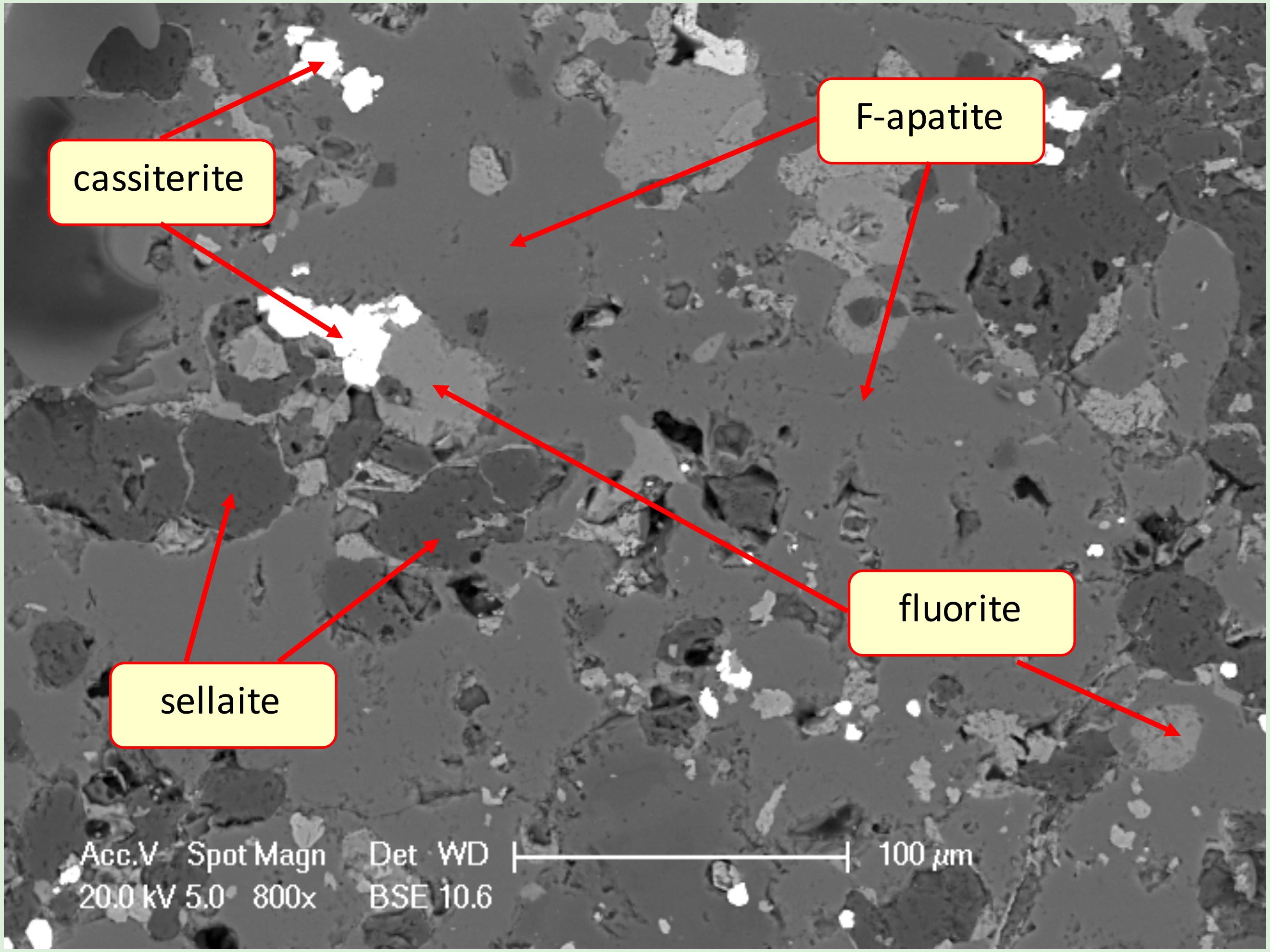
ZS120-535.3m

This BSE image shows sellaite (MgF_2) and extremely zoned tourmaline (F-rich), both of which are associated with quartz and sit within a groundmass of vivianite.



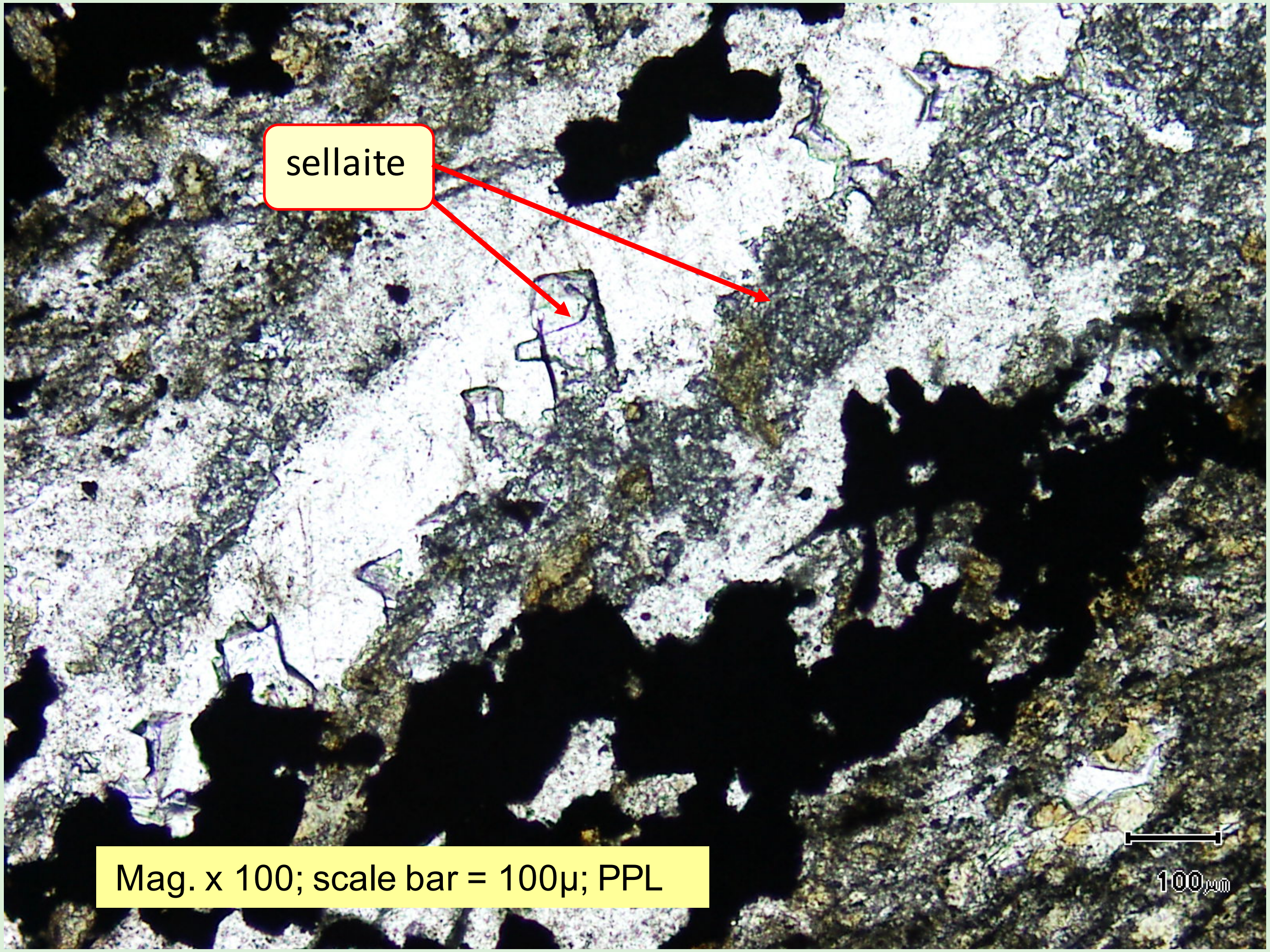
ZS120 - 535.3m

This BSE image shows sellaite, fluorite and cassiterite sitting within a groundmass of F-apatite (~6% F). Fluorite selvedges and cross-cuts the sellaite.

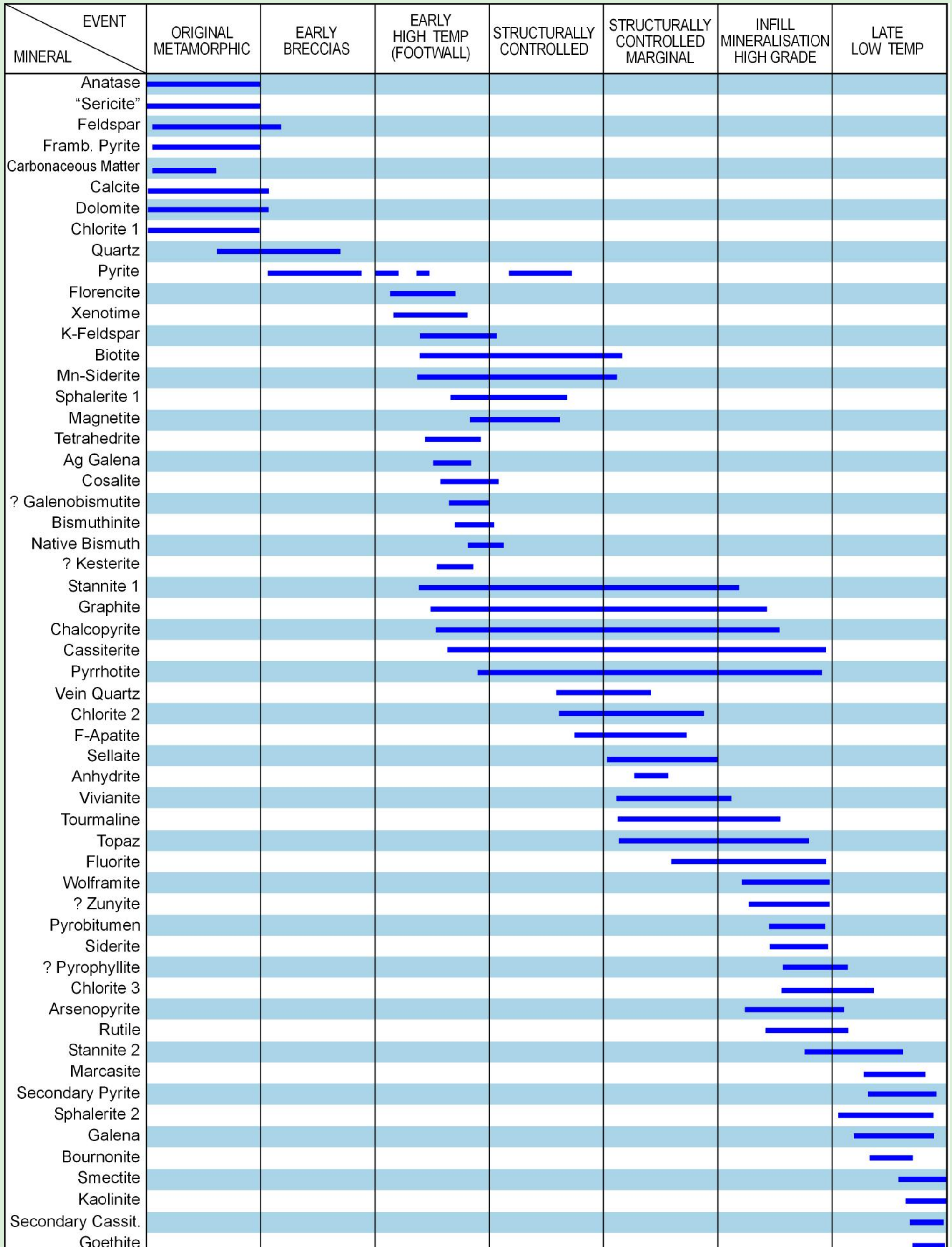


ZS120 - 554.55m

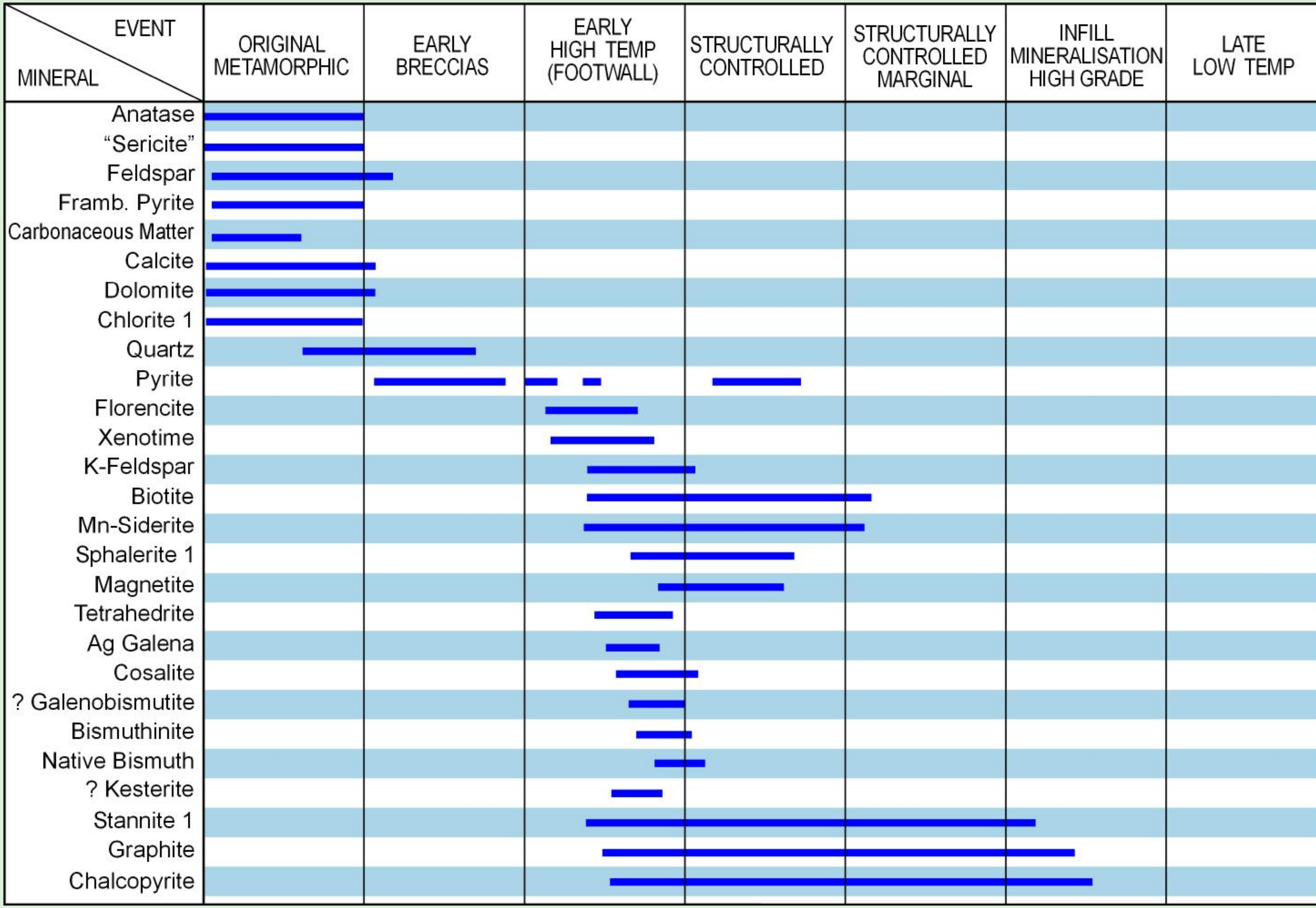
Sellaite develops within a carbonaceous meta-pelite which develops within a small infill domain.



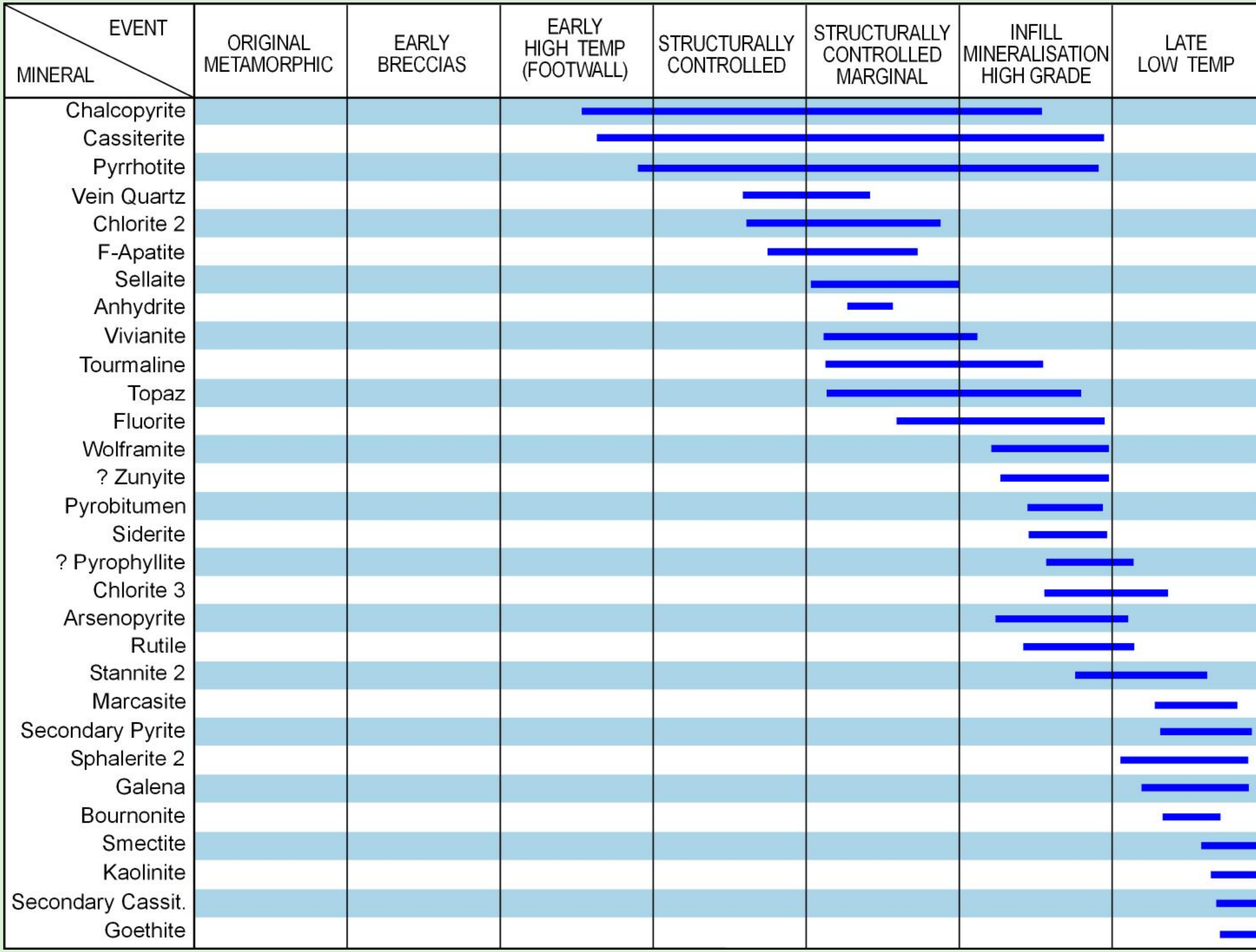
ZS120 - 557.3m



Preliminary Paragenetic Sequence Queen Hill - Severn Tin Mineralisation



Preliminary Paragenetic Sequence - Queen Hill to Severn Tin Mineralisation - Part 1

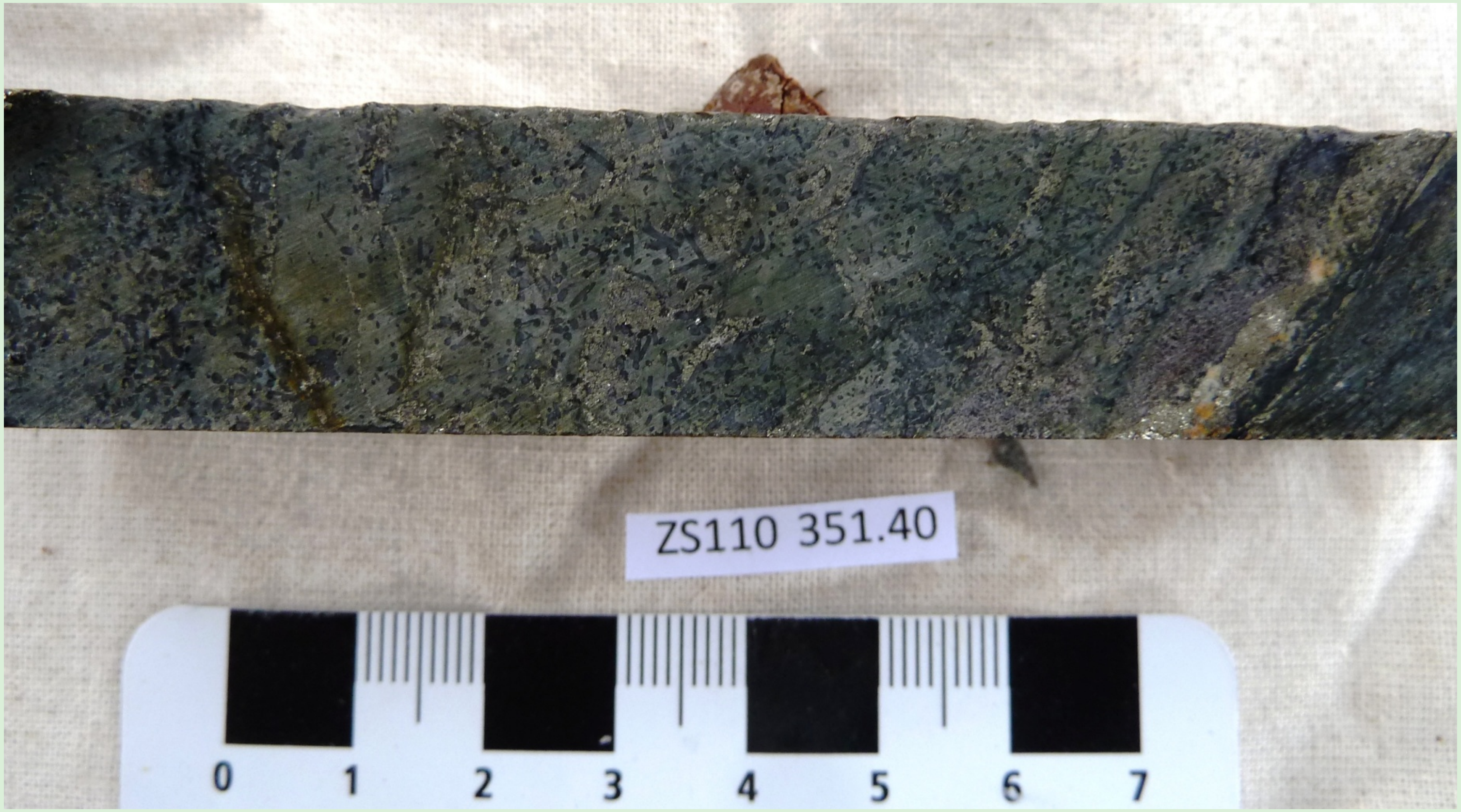


Preliminary Paragenetic Sequence - Queen Hill to Severn Tin Mineralisation - Part 2

The sample was initially considered to contain tourmaline idioblasts during logging.

It consists of secondary siderite replacing predominantly tourmaline with concomitant development of idioblastic quartz which can contain cassiterite and pyrrhotite.

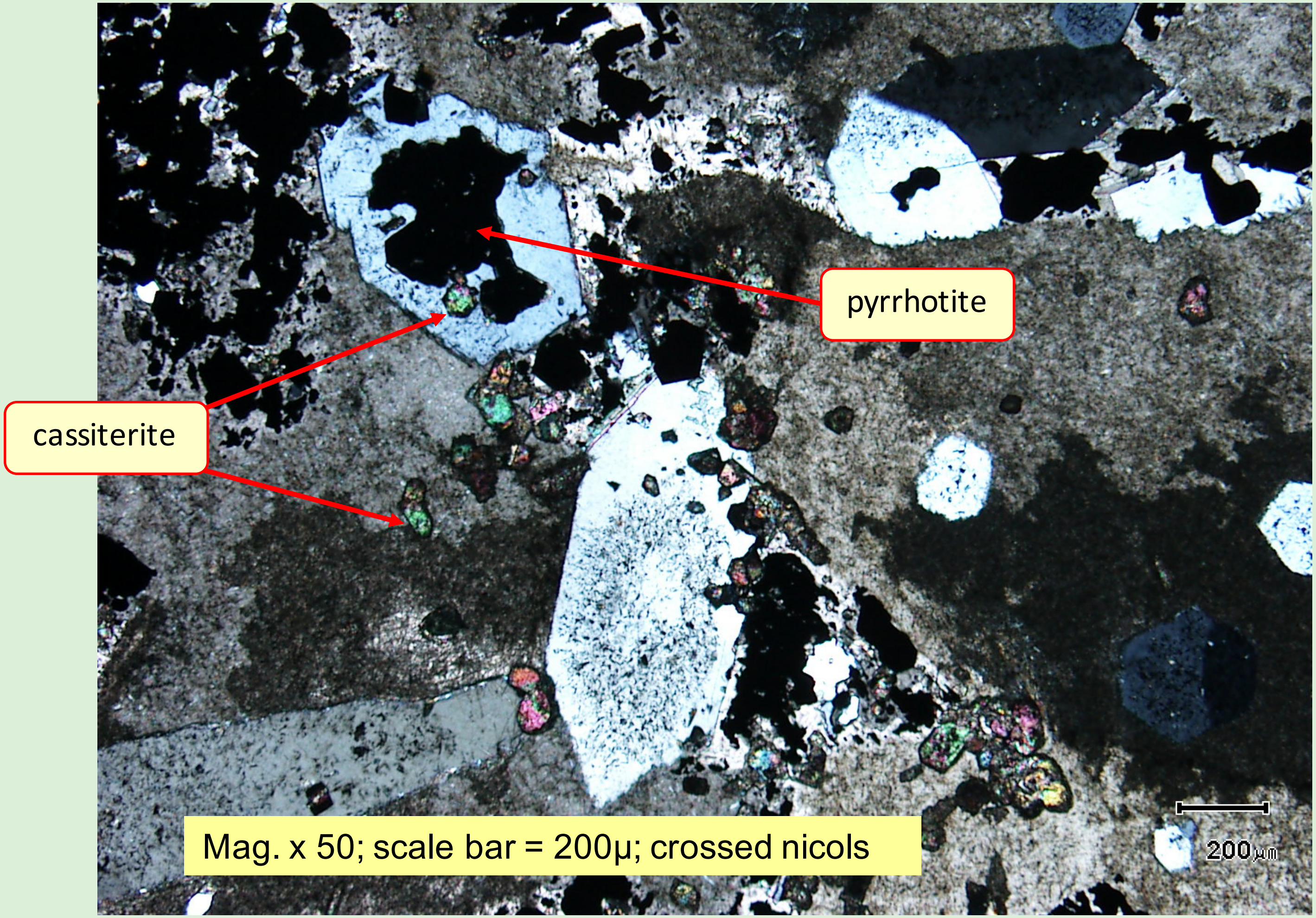
No pyrrhotite is present in the groundmass.



ZS110-351.40m

Note the cassiterite in both the quartz and the groundmass.

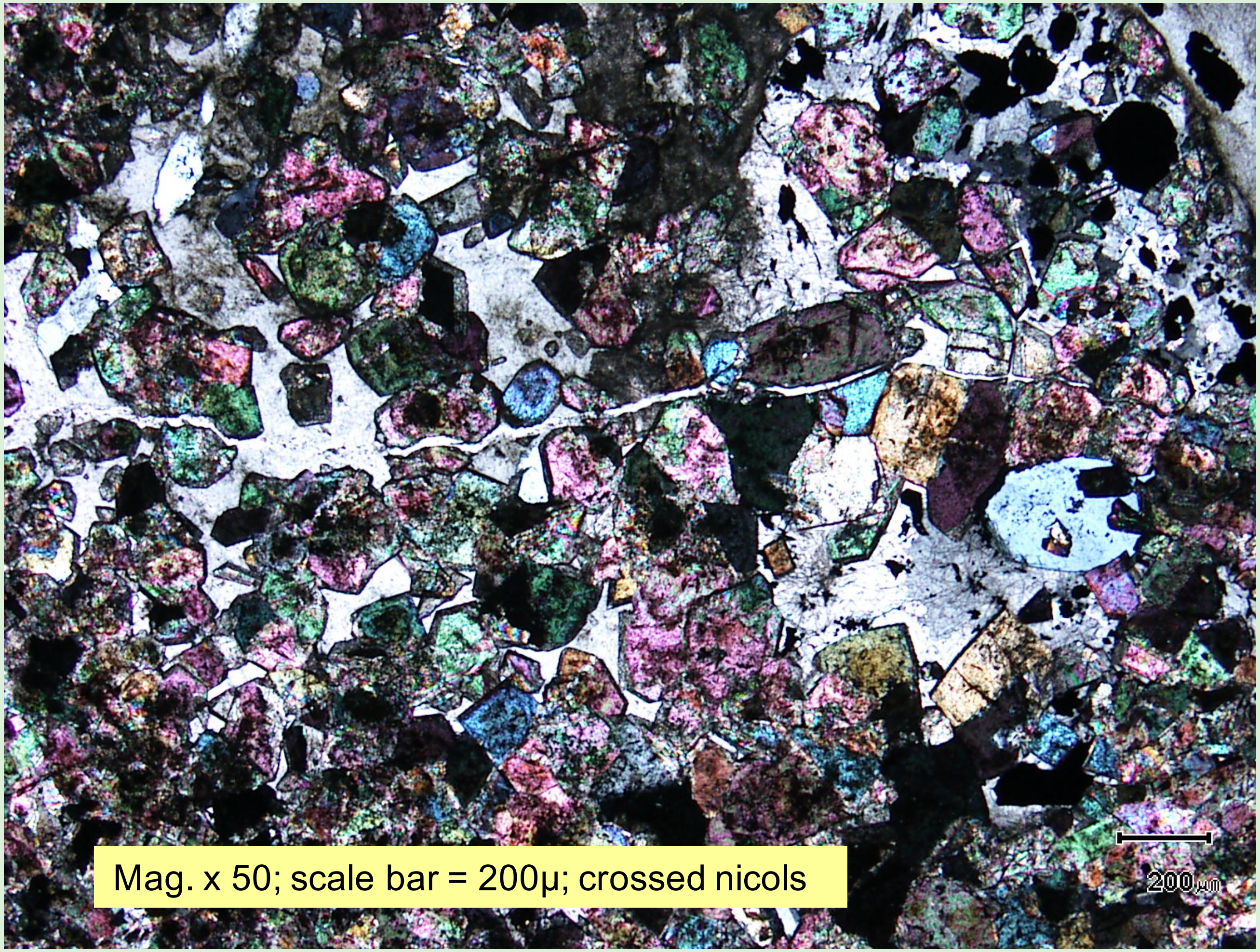
Pyrrhotite is only located within the idioblastic quartz.



ZS110-351.40m

An exceptionally cassiterite-rich domain.

The cassiterite grains are often in excess of 100µ.

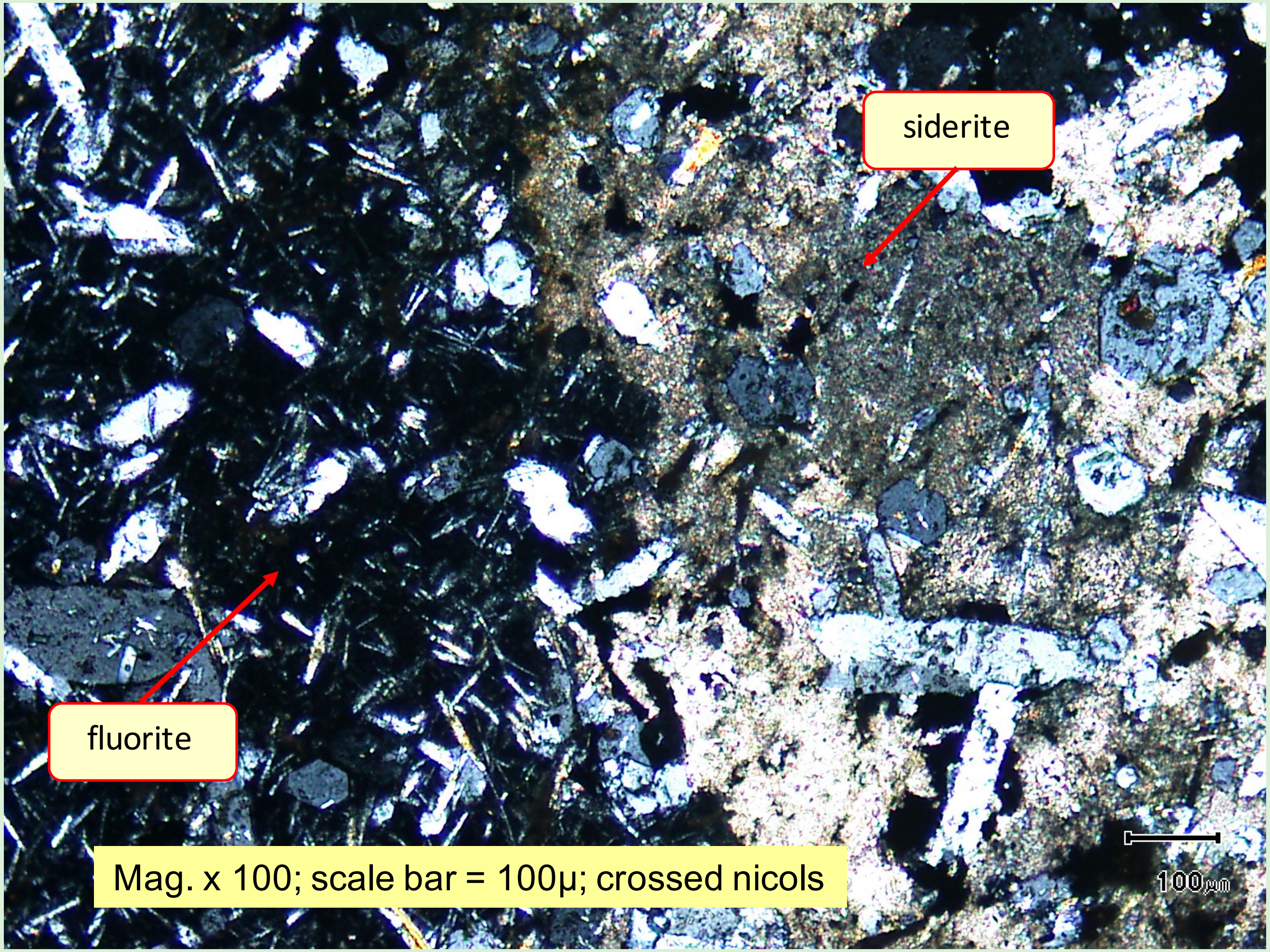


Mag. x 50; scale bar = 200µ; crossed nicols

ZS110 - 351.4m

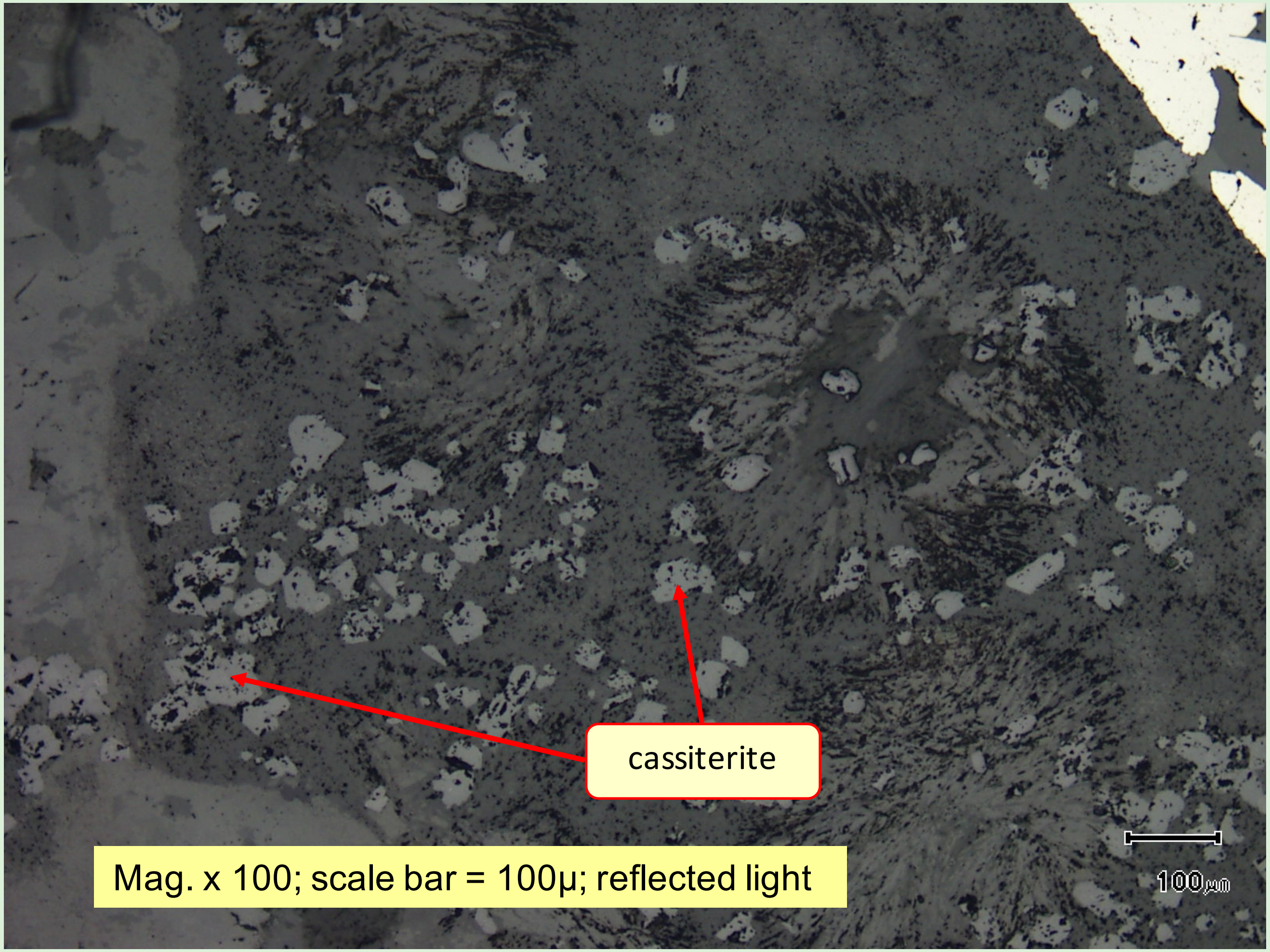
Fluorite being replaced by siderite, a common replacive texture at Severn.

Acicular tourmaline is preserved in both fluorite and siderite.



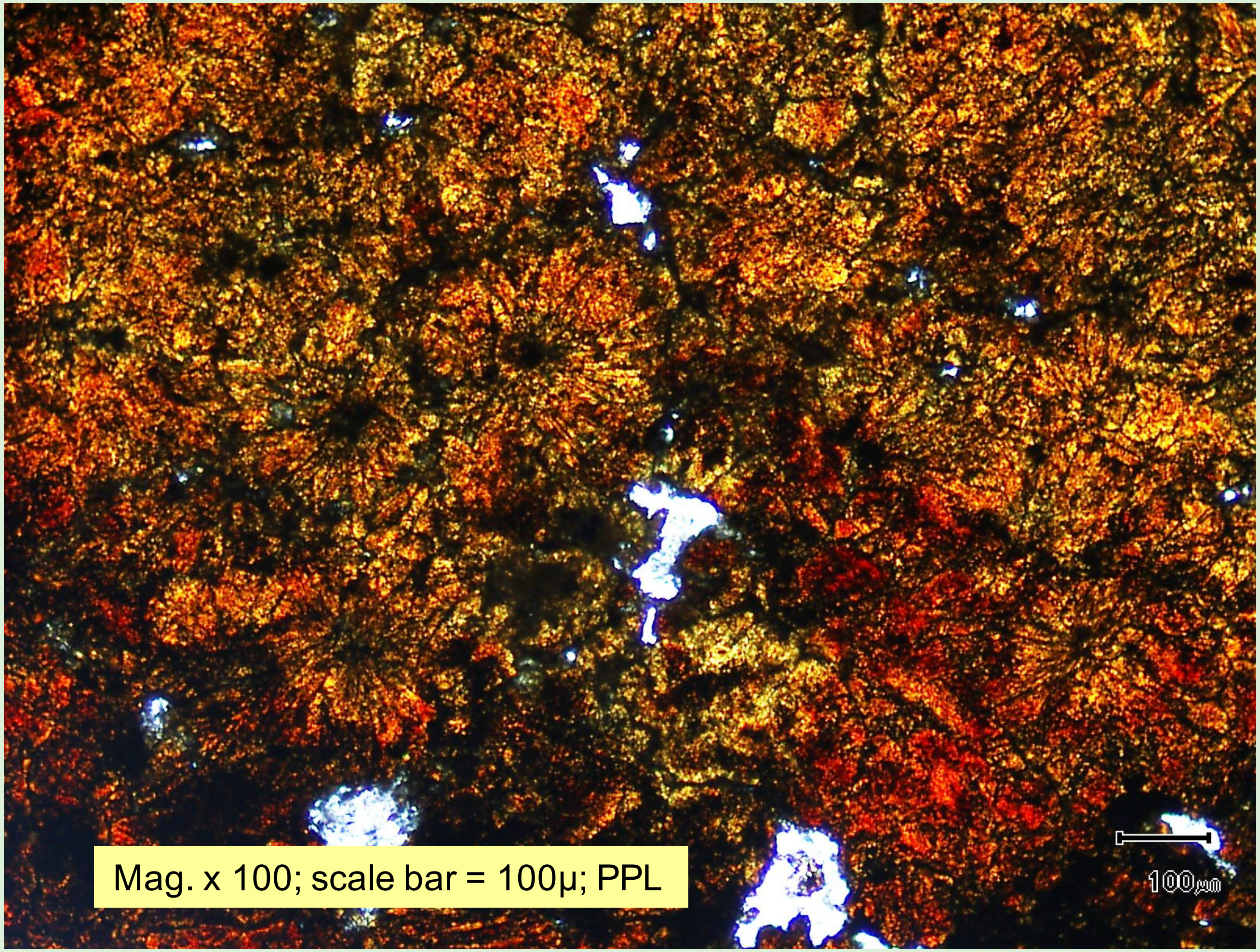
ZS113W-287.5m

Abundant cassiterite developed within goethitic, sericitic altered tourmaline.



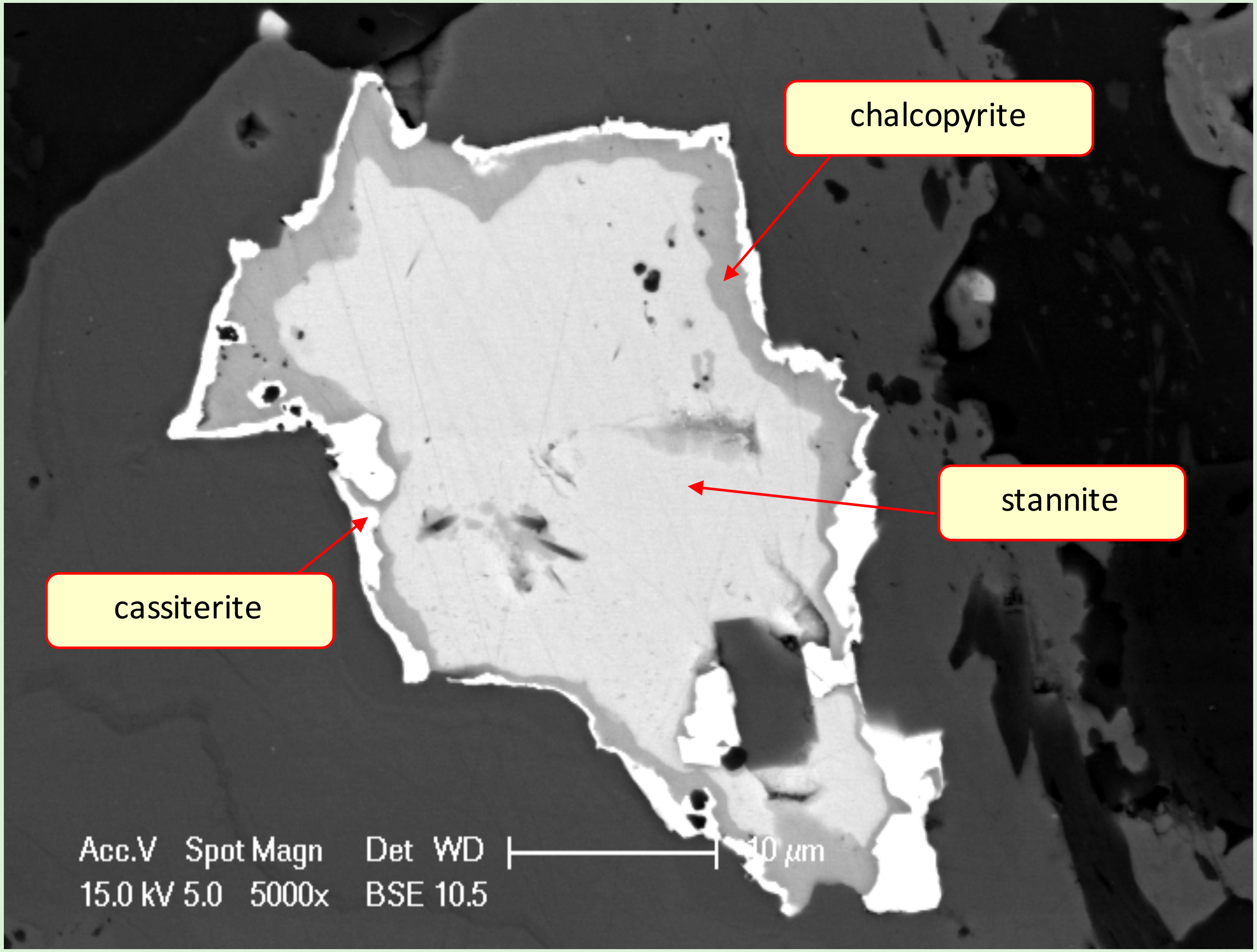
ZS113W-275.0m

Here, radiating sprays of sphalerite have not been deformed and may be replacing acicular tourmaline.



ZS110 - 255.2m

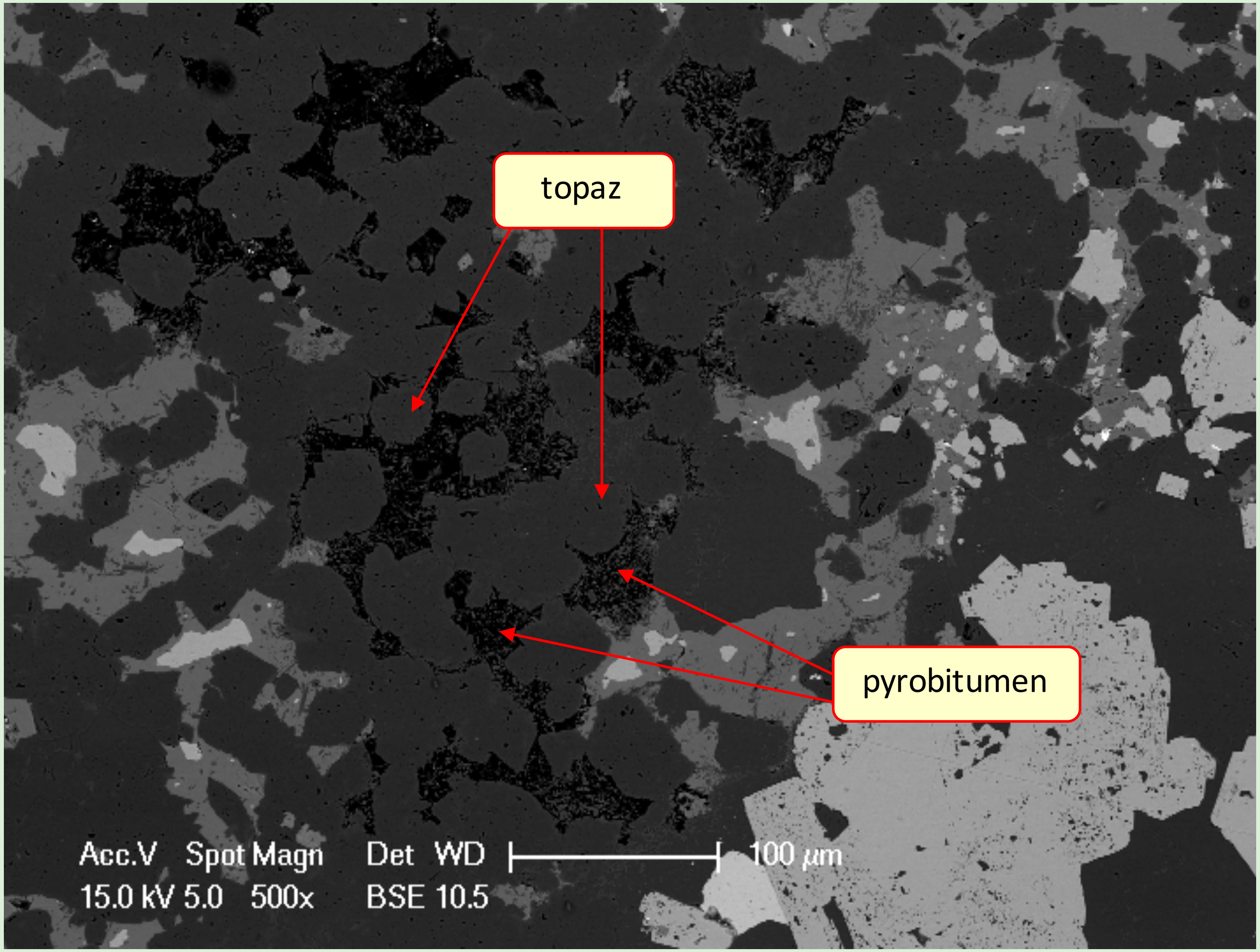
This BSE image shows a stannite grain which is being replaced by cassiterite + chalcopyrite. The aggregate sits within siderite and stannite hosts acicular tourmaline. The breakdown of stannite to chalcopyrite plus cassiterite is common in the Severn ore-body.



ZS110 - 341.15m

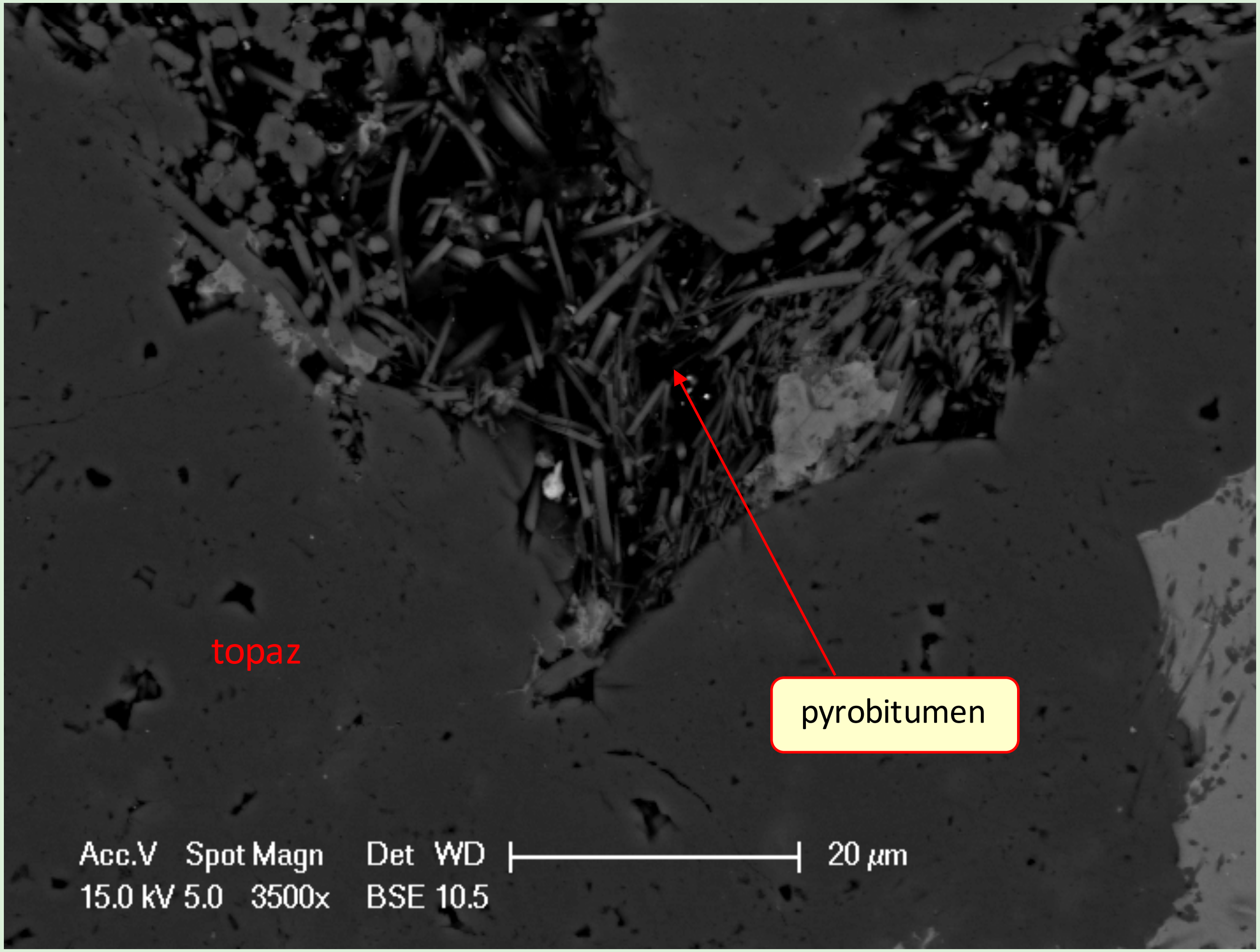
This BSE image shows lower magnification view of the pyrobitumen which encapsulates topaz. The bright white material is cassiterite.

Acicular tourmaline also develops in topaz.



ZS110 - 341.15m

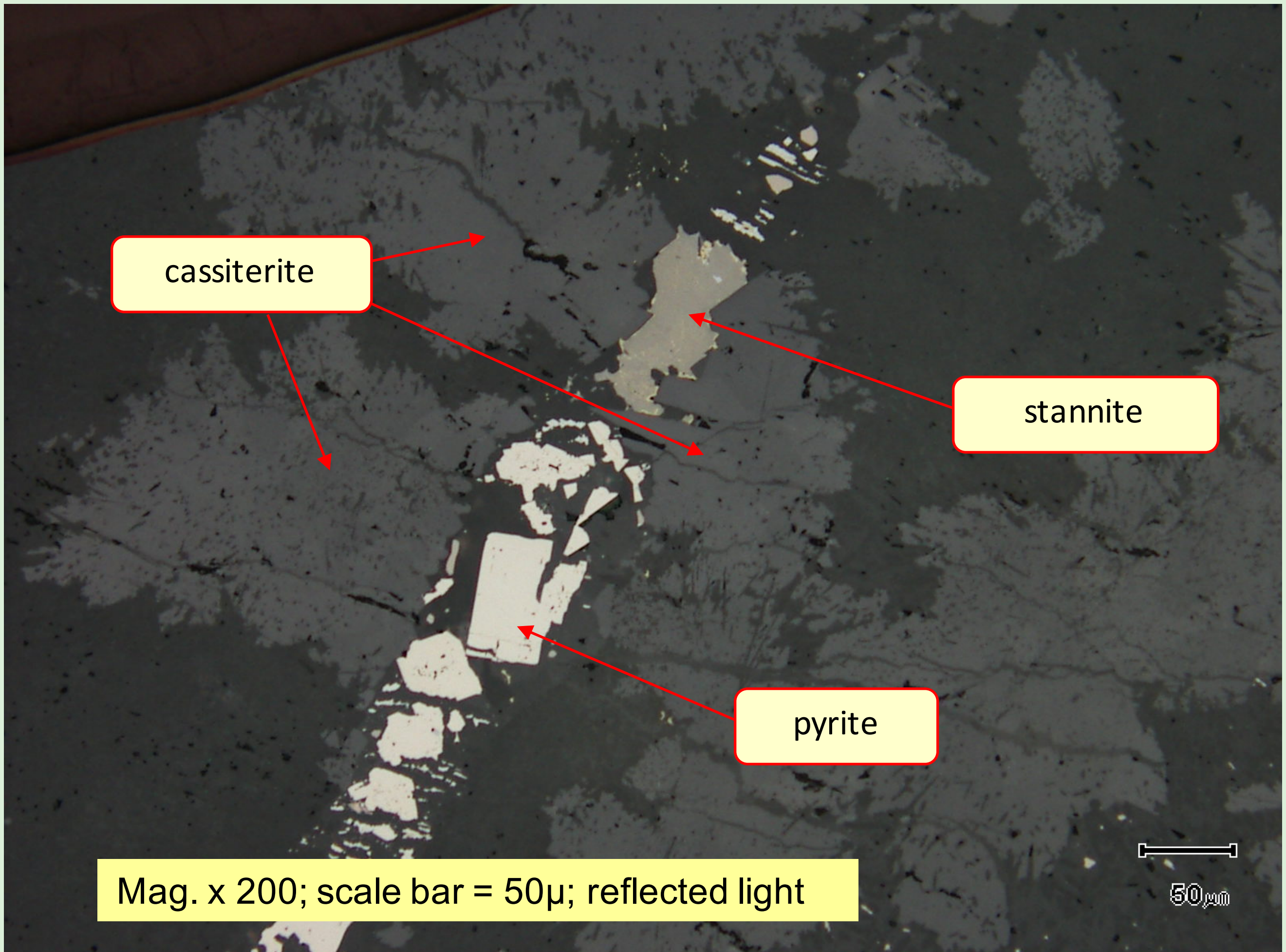
This BSE image shows the remarkable texture of cassiterite (bright white) sitting within pyrobitumen which is choked with acicular inclusions of tourmaline. These aggregates develop interstitial to topaz grains.



ZS110 - 341.15m

Again, stannite is developing within pyrite-carbonate veins where they cut cassiterite.

This is a further generation of stannite.



G92-542.9m

Rimming, replacement and infill

- Sericite replaces tourmaline (G72-294.3m) and relict “rosettes” of pseudomorphed tourmaline are present (abundant elsewhere). Elsewhere siderite, sphalerite and topaz can replace tourmaline rosettes (e.g. ZS113W-275.0m). “Sericite” (presumably fine grained muscovite) is a dominant mineral in many samples (e.g. ZS107W-536.1m and ZS107-547.6m). As mentioned, it replaces tourmaline and fluorite, with the precipitation of new cassiterite.

- Idioblastic (crystalline) quartz crystals can be enclosed or “cemented” by either siderite or intergrowths of fluorite + tourmaline (e.g. G65-261.7m). The latter are present as acicular grains within the fluorite. Siderite can replace tourmaline and presumably fluorite (e.g. ZS110-351.4m). The release of a fluid enriched in F may cause the destruction of other mineral phases. This fluid may also stabilise other minerals that are F-rich (topaz, sellaite) and mobilise Sn. Calcium from the breakdown of fluorite may be incorporated into the replacing carbonate.

- Topaz can contain inclusions of cassiterite (e.g. G84-433.33m). There are many textures which show various minerals as inclusions with those minerals being absent from the groundmass (see ZS110-351.4m where pyrrhotite is found in idioblastic quartz but not in the groundmass).

- Siderite can rim and replace iron sulphides and chalcopyrite can rim cassiterite. Tourmaline can selvedge pyrrhotite. Cassiterite can develop as crude layers which can be cut by chalcopyrite. Stannite can be broken down and replaced (where does the Sn go?) and deformed galena can be mantled by crustiform sphalerite.

- The presence of high strain, often mylonitic, fabrics developed in vein quartz, micro-shears and axial planar carbonaceous shears are invariably associated with breccia “blowouts”, infill growth and areas of general very low strain. For example, undeformed idioblastic quartz crystals (doubly terminated), basal section idioblastic topaz crystals, rosettes of tourmaline and tabular tourmaline crystals all indicate infill in a low strain domain.

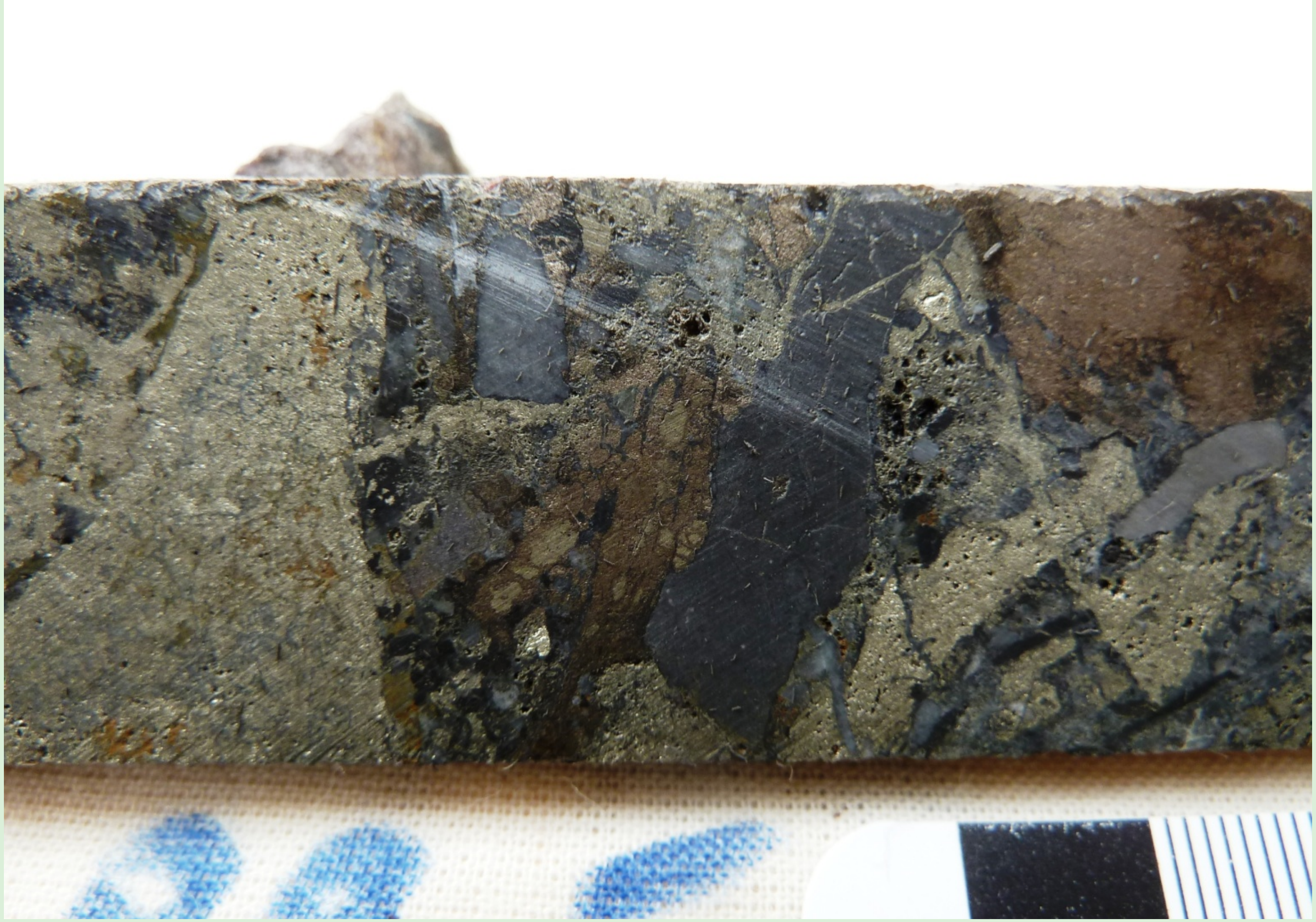
Crackle breccias develop at the margins of mineralisation in many drill-holes.

A meta-tuff has been intensely altered with abundant pyrite present. This crackle breccia develops on the margin of breccia body containing milled and shingle breccias.

ZQ96 - 82.8m

A possible “shingle” breccia developed via collapse during volatile introduction.

The large pyrite clast on the LHS is micro-brecciated with this brecciation occurring prior to shingle breccia development. Clasts are hydrothermally altered and silicified with many containing abundant fine pyrite.



ZQ96 - 88.5m

A well developed crackle breccia which is cut by later sulphide veining.

The breccia contains anomalous base metals but no tin.

ZS107W - 522.7m

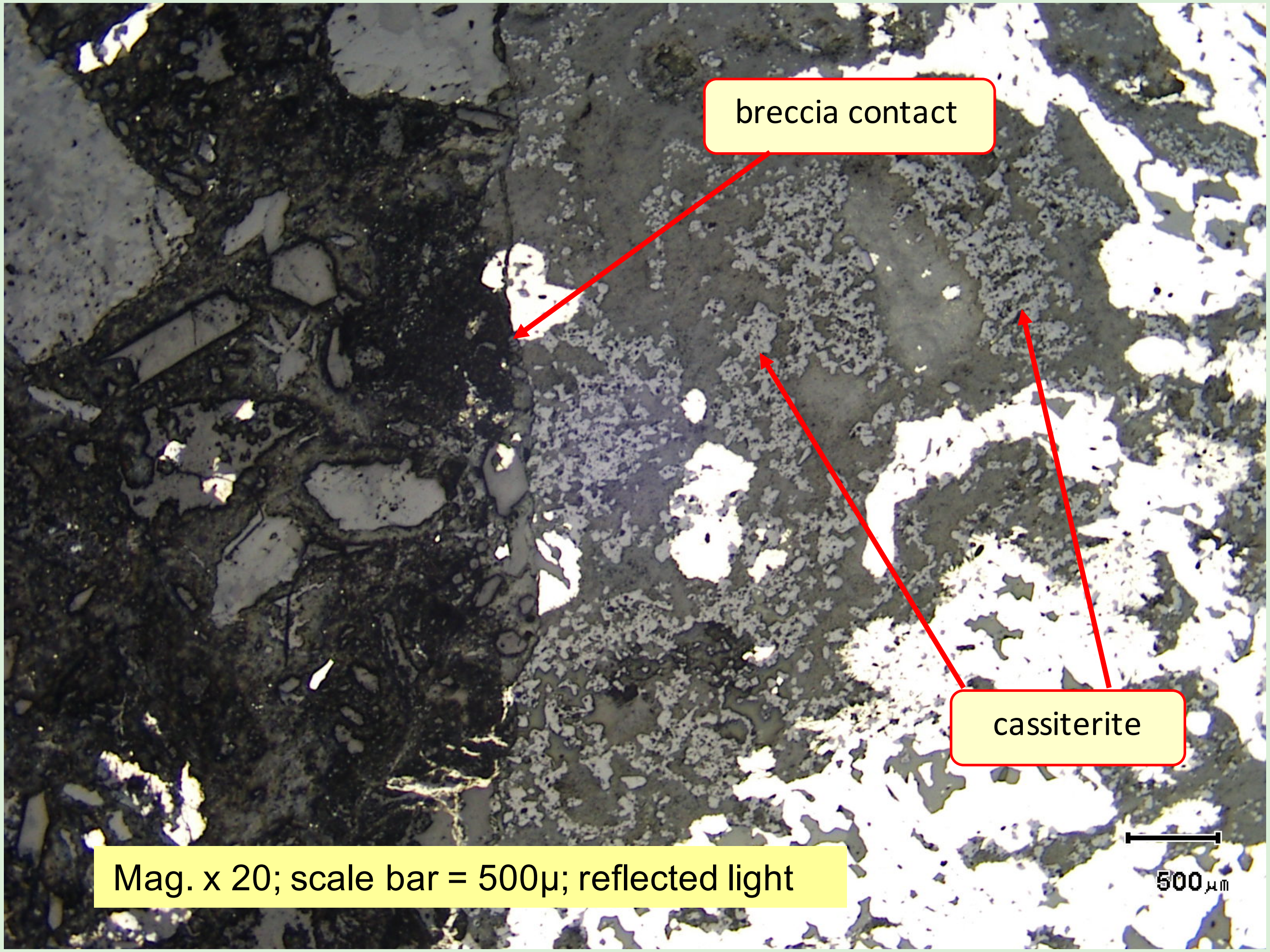
This quarter core slab photograph shows an interpreted shallowly dipping , fluidised, sulphidic injection breccia which cuts massive pyritic, tin-rich mineralisation.

ZS113W - 275.0m

Contact of injection breccia (shallow SE dip) with cassiterite-rich breccia or lode.

There is no cassiterite in the injection breccia (LHS).

Note the two differing domains in the reflected light photomicrograph.



ZS113W-275.0m

Summation

- The tin and base metal mineralisation is associated with fluids that were enriched in B, F, Si, Sn, As, Zn and Pb. It is most likely that mineralisation was introduced over a significant time period with varying stocks responsible for providing pulses of aqueous and hydrothermal fluids. The earliest fluids were Si-rich.

- Breccias are common and dilational positions within the overall Queen Hill and Severn domain are ideal exploration targets. The intersection of D_1 and $D_{2/3}$ folds forms an ideal position for creation of dilational positions. Hangingwall lodes need to be understood.

- There are geochemical differences between the Queen Hill and Severn mineralisation. Severn is generally Cu-rich (0.1%-0.4% Cu) and contains no Pb + Zn with Queen Hill containing anomalous Pb-Zn but no Cu.

- Axial planar shears ($D_{2/3}$?) and fault structures contain tin mineralisation and have been used as “channel-ways” for mineralising fluids.

- Infill textures are common and a significant amount of high grade tin mineralisation is associated with infill structures. These may trend NW. They are high grade and form shoots which plunge steeply to the NE.

- “Infill” lodes are best developed in more siliceous meta-sediments with the fabric perpendicular to bedding. Strain increases towards the “infill” lodes.

- Do chlorite-rich altered mafic sills and volcanics act as an “aquiclude” to mineralising fluids? Tin-bearing veins cut possible altered mafics (for example, ZS120-516.3m). If this happens there may be “pooling” of mineralisation below the mafic. Similarly, footwall fluid movement takes place.

- Drill-hole G92 intersected significant mineralisation of the “Severn-style” (9.5m @ 0.372% Sn), that is Cu anomalous and no Pb + Zn. This zone may represent the structural top of another Severn ore-body.

- Shear mineralisation contains deformed and boudinaged tin mineralisation. This can be cross-cut by late tourmaline-Sn veining.

- Topaz, with cassiterite + stannite + chalcopyrite, develops in the footwall to mineralisation with this mineralisation parallel to bedding. Fluids move along the contact of more micaceous beds with porous quartz-sandstone.

- The Severn and Queen Hill Mineralisation is not strictly replacive, and is not stratiform or stratabound. Crackle fracturing, crackle breccias, milled breccias and “shingle” breccias can be observed. Mineralisation can develop within the Oonah Quartzite, Oonah Shales/Silts and up into the Crimson Creek Formation. Mineralisation can develop 100m-150m above the Oonah Quartzite, i.e.mineralisation can develop over a significant stratigraphic and structural level.

- In some areas, mineralisation is interpreted to cut across the various faults (Oonah, Astles, Montana). What does this suggest?
- Cassiterite is generally coarse grained (0.1mm-0.8mm).
- The North West Connection (NW) – structure and fluid movement
  The North East Connection (NE) – lithotypes, viz. Crimson Creek, Oonah Quartzite and Oonah shales and silts (highly carbonaceous)
- Potential for structural repetitions of “Severn-style” mineralisation (e.g. G92)