Hera: evidence for multiple mineralization events and remobilization in a sediment-hosted Au-Pb-Zn-Ag deposit, central New South Wales, Australia.

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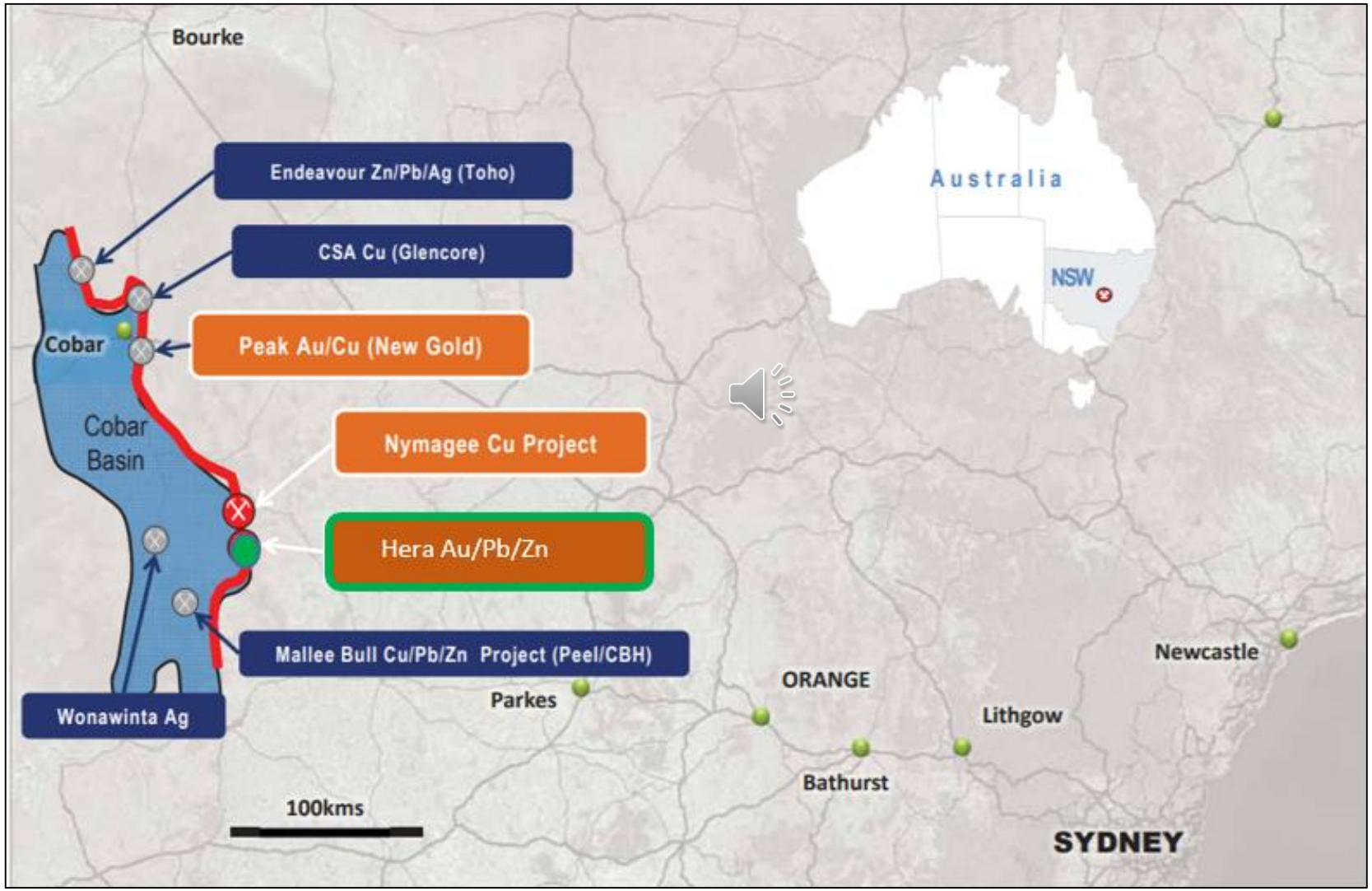
LOCATION: very centre of NSW in eastern Australia

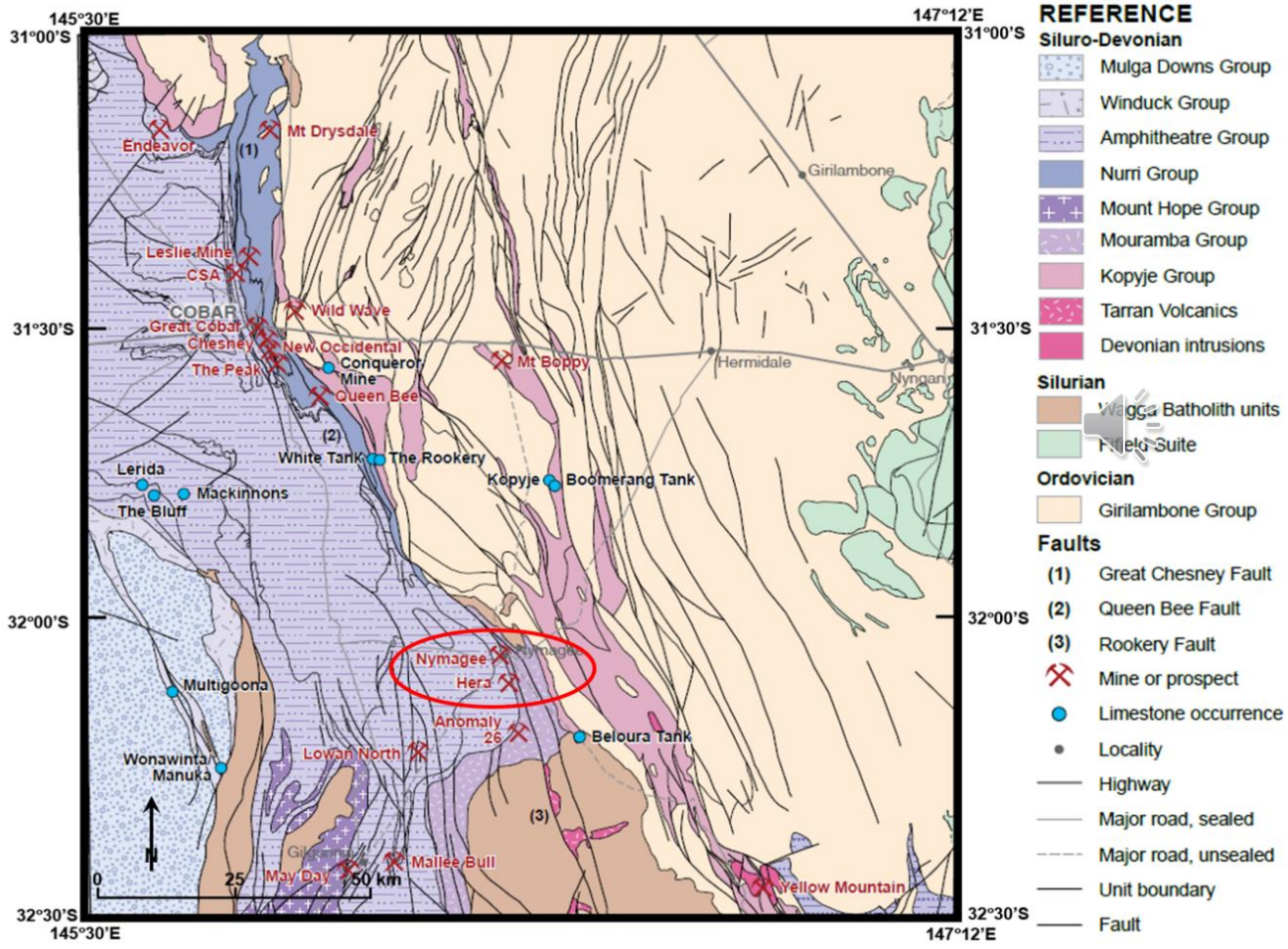


What is the Hera deposit?

‘A Devonian turbidite-hosted low-middle greenschist facies polymetallic Au-Pb-Zn-Ag deposit comprising a number of en-echelon like submassive to massive sulphide lenses with distinct skarnified zones, cross-cutting quartz veins and granite pegmatite dykes’

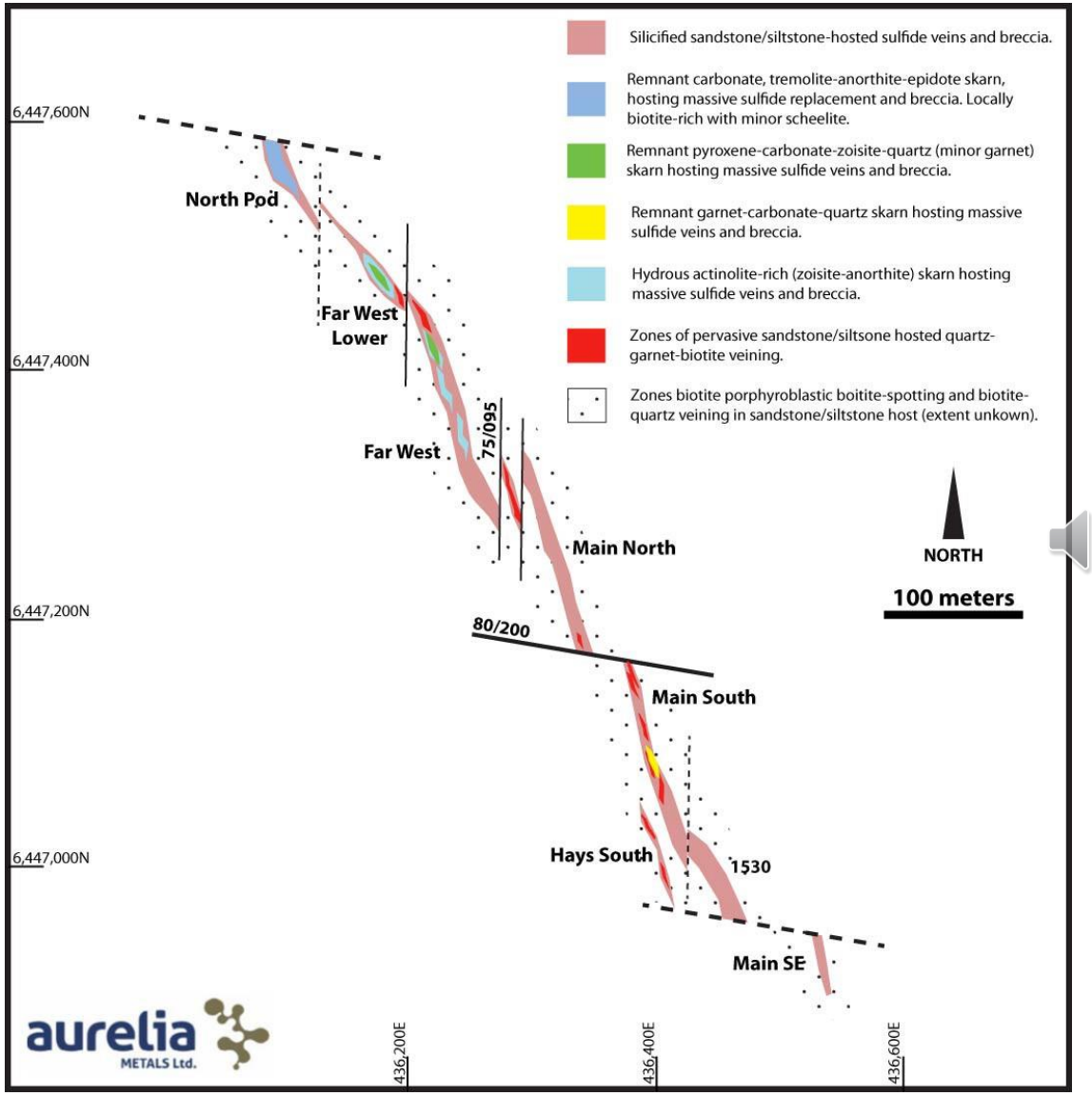
Undepleted resources of 3.6 million tonnes at:
3.3 g/T Au
25 g/T Ag
2.6 % Pb
3.8 % Zn
~ 0.05% W
Anomalous Sb, Cu, As

Regional geological setting



The Cobar Basin is one of the richest polymetallic regions of the Lachlan Fold Belt with numerous historic and working mines, mostly polymetallic turbidite-hosted Cu-Au-Pb-Zn sulphide deposits.

Hera deposit is located along a fault splay of the major Rookery Fault Zone at the boundary of the shallow marine Mouramba Group and overlying turbiditic Amphitheatre Group.

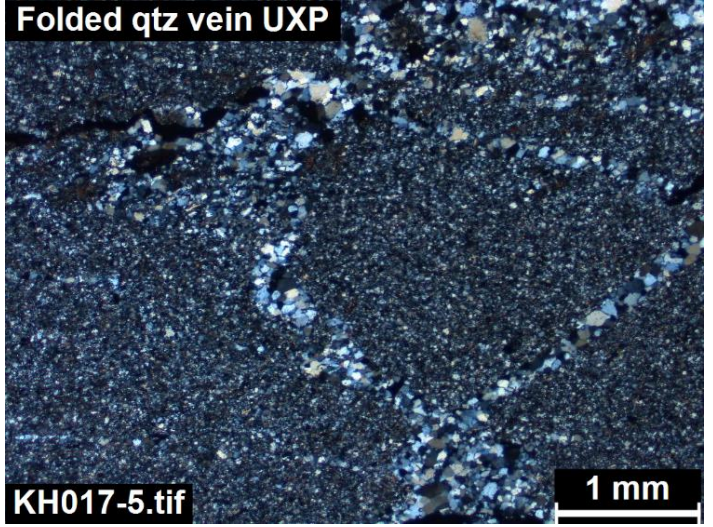


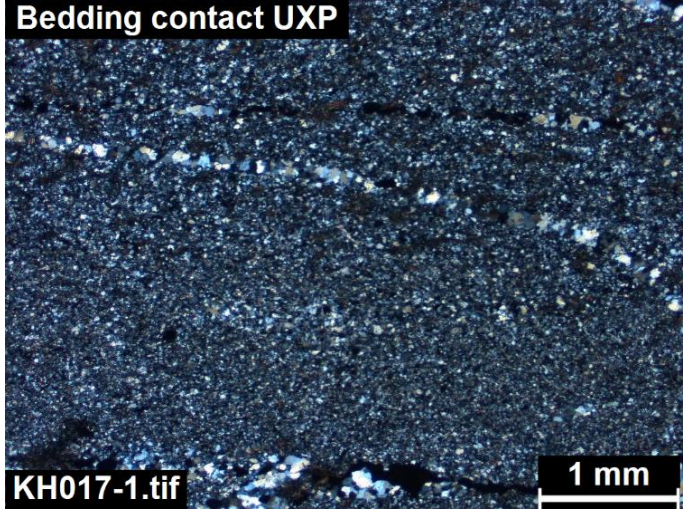
The Hera deposit comprises a number of stacked discrete sulphide lenses with each lense having distinctive metal ratios, sulphide species and alteration assemblages. It is currently mined from 285 to 640 metres below the surface.

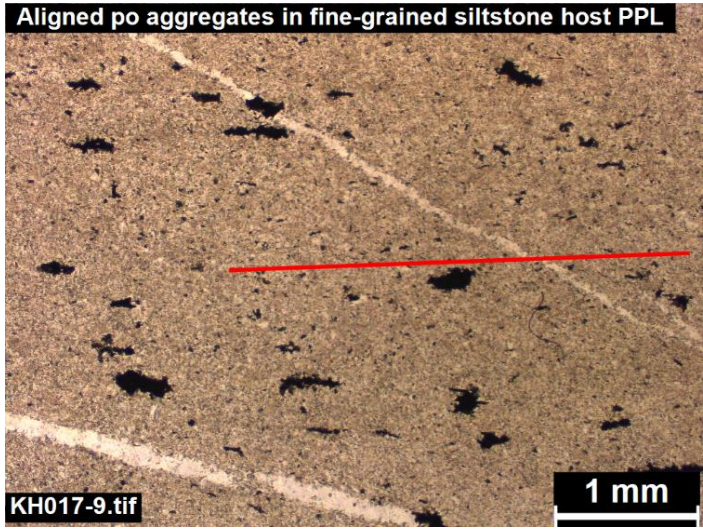
Mineralisation is strongly structurally-controlled and the ore lenses are generally steeply west-dipping striking NNW.

Host turbidite sequence

Previously thought to comprise quartz, muscovite, biotite and chlorite but our work also shows that many beds contain abundant (up to 22 wt%) labradorite-andesine, albite and rare K-feldspar (microcline, sanidine) and importantly, abundant accessory titanite and ilmenite (commonly Mn-rich). Also, common early pyrrhotite defining a strong lineation.

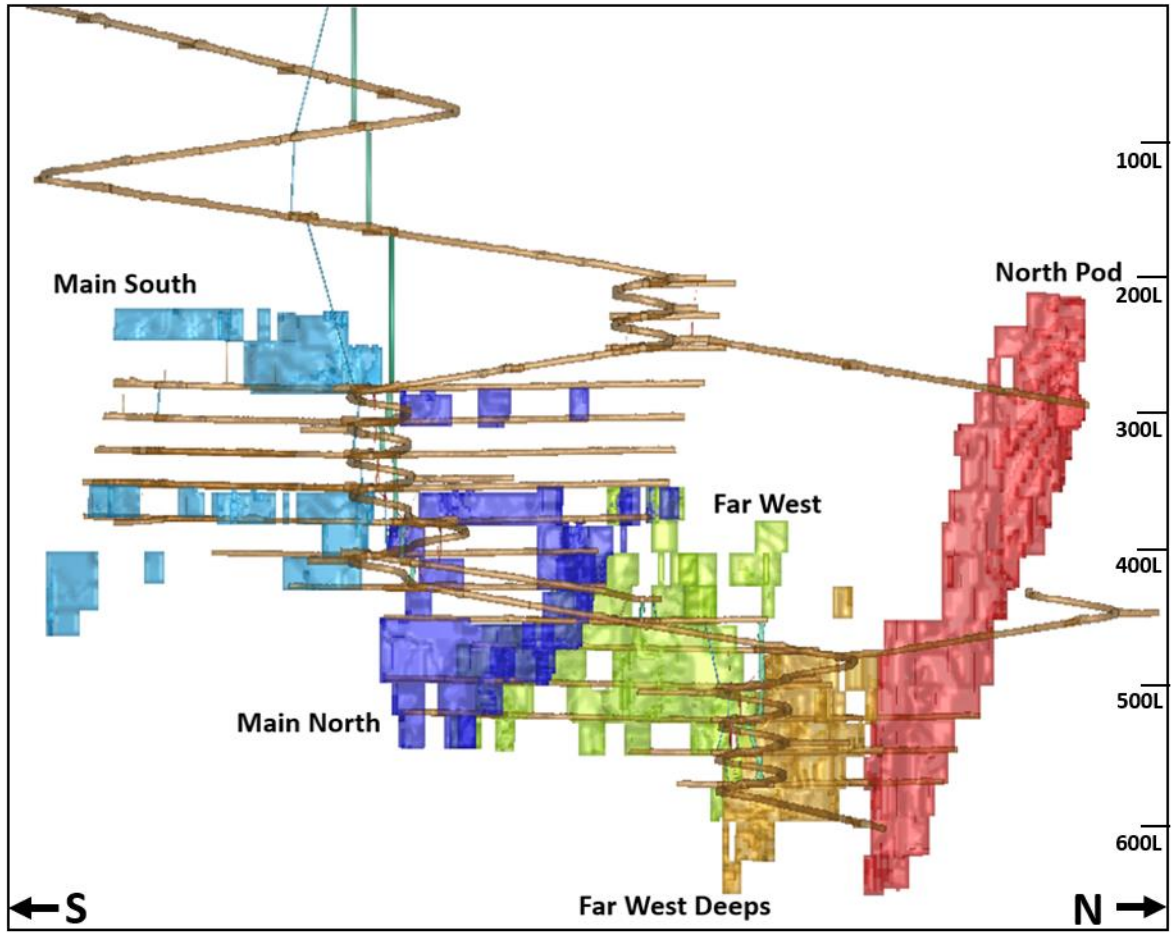






Ore Lenses

Most ore comprises semi-massive to massive sulfides and ‘durchbewegung’ ores (clasts of hostrock in galena/sphalerite matrix) are common.

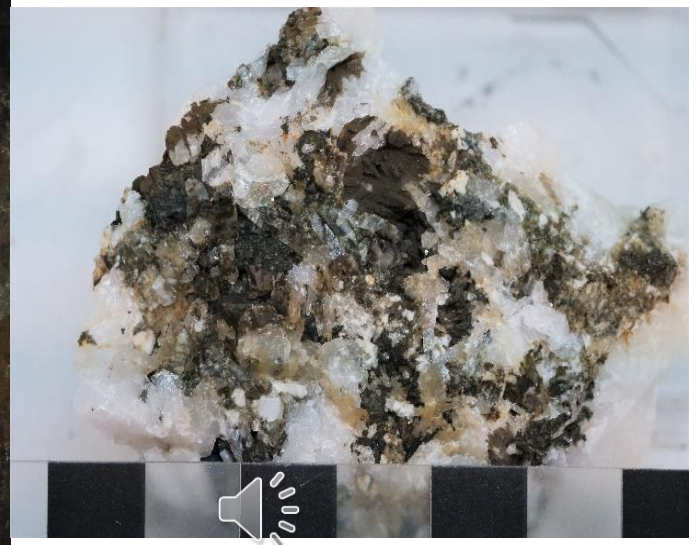


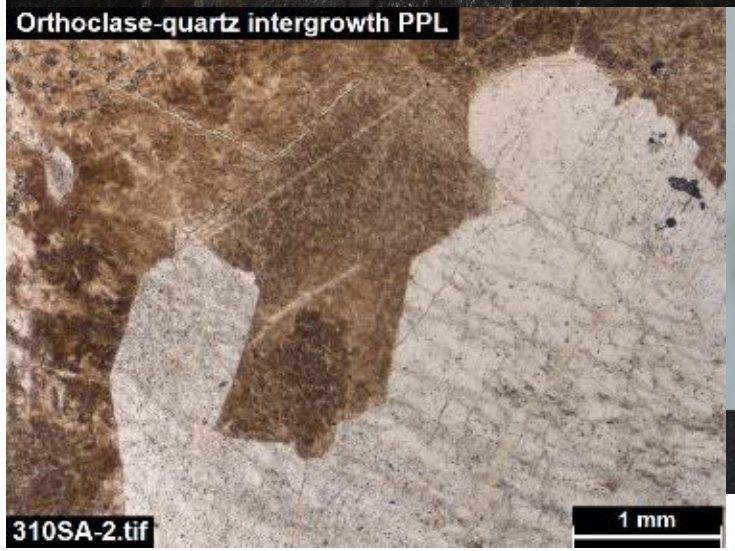
Ore lenses within the Hera deposit excluding areas depleted by mining.

Metal and sulphur correlations based on >13,000 ROM assays

	Pb %	Zn %	Au g/t	Ag g/t	Cu %	S %	Fe %	As ppm
Pb %	1							
Zn %	0.70	1						
Au g/t	0.21	0.19	1					
Ag g/t	0.81	0.57	0.23	1				
Cu %	0.27	0.04	0.05	0.46	1			
S %	0.69	0.58	0.17	0.74	0.58	1		
Fe %	0.17	-0.17	0.02	0.35	0.61	0.66	1	
As ppm	0.05	0.04	0.05	0.03	-0.02	-0.01	-0.06	1

Pegmatite dykes





To date, pegmatite dykes comprising a main assemblage of quartz-microcline-orthoclase-(labradorite-andesine-albite) have been found on levels 285, 310 and 615. They have hypidiomorphic granular textures and in places contain cavities lined with later chlorite, siderite, stilbite-Ca and pyrite.

Quartz veins

Multi-generational quartz veins of varying textures are widespread throughout the deposit. Some contain euhedral coarse-grained pyrrhotite, chalcopyrite, sphalerite, galena and cubanite and in one occurrence, a 0.4 metre cavity was found within a quartz vein and this contained superb glassy semi-transparent adularia crystals up to 15cm.

Wallrock clasts in quartz vein 615NP

Multi-generational quartz veins, 485MN

Sulfide assemblages – sphalerite and galena

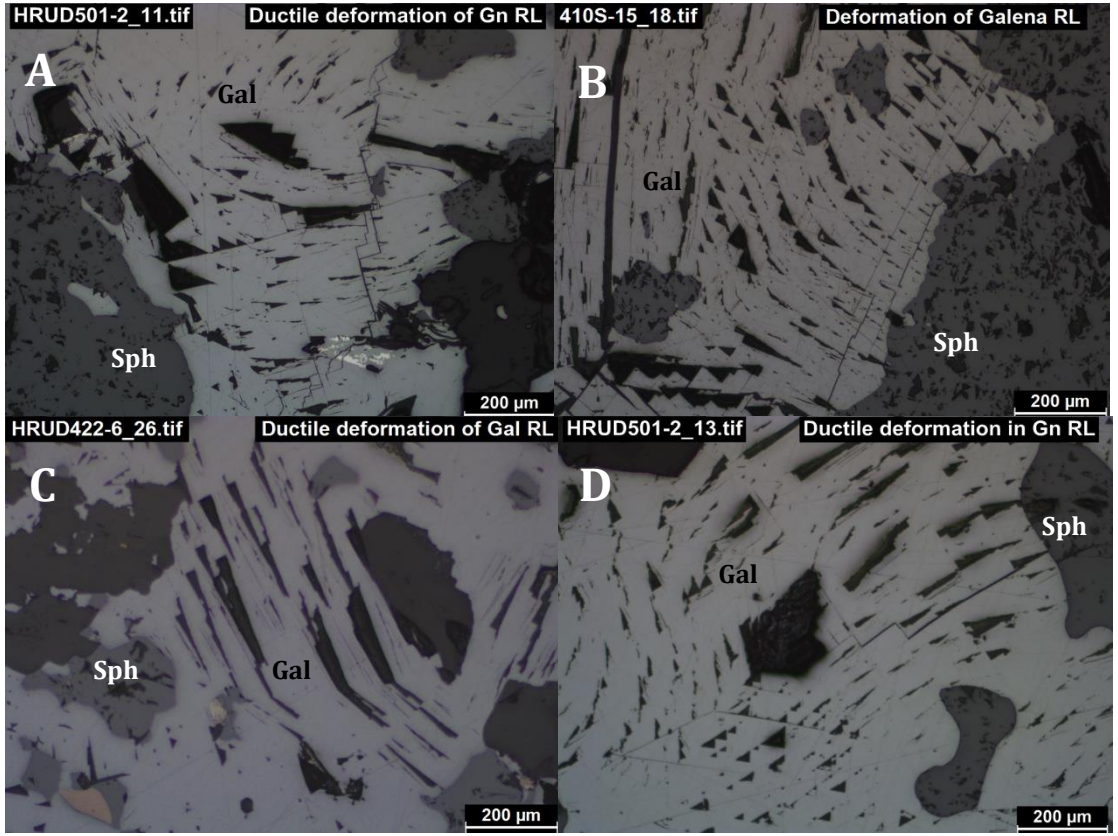


Fig. 7 Ductile deformation of galena from different parts of the deposit. A) Far west ore lens (RL). B) Main South ore lens (RL). C) North Pod ore lens (RL). D) Far West ore lens (RL). Mineral abbreviations: galena (Gal) and sphalerite (Sph)

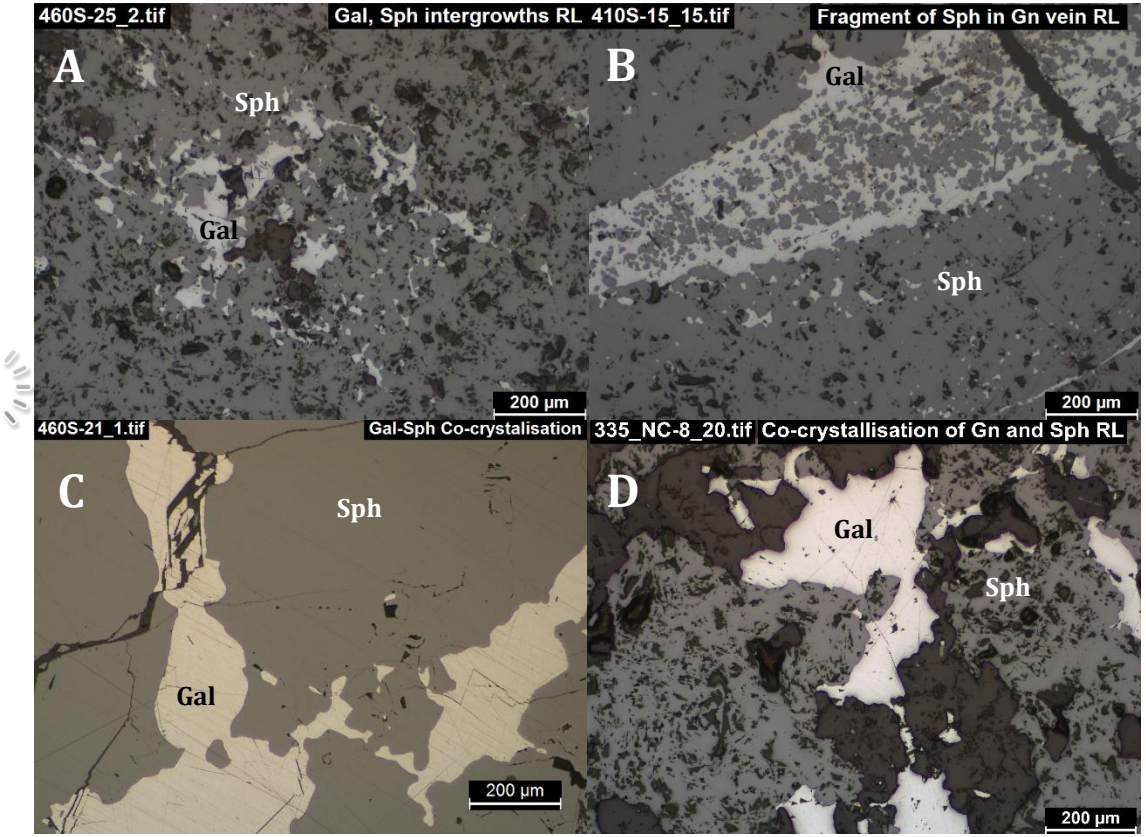
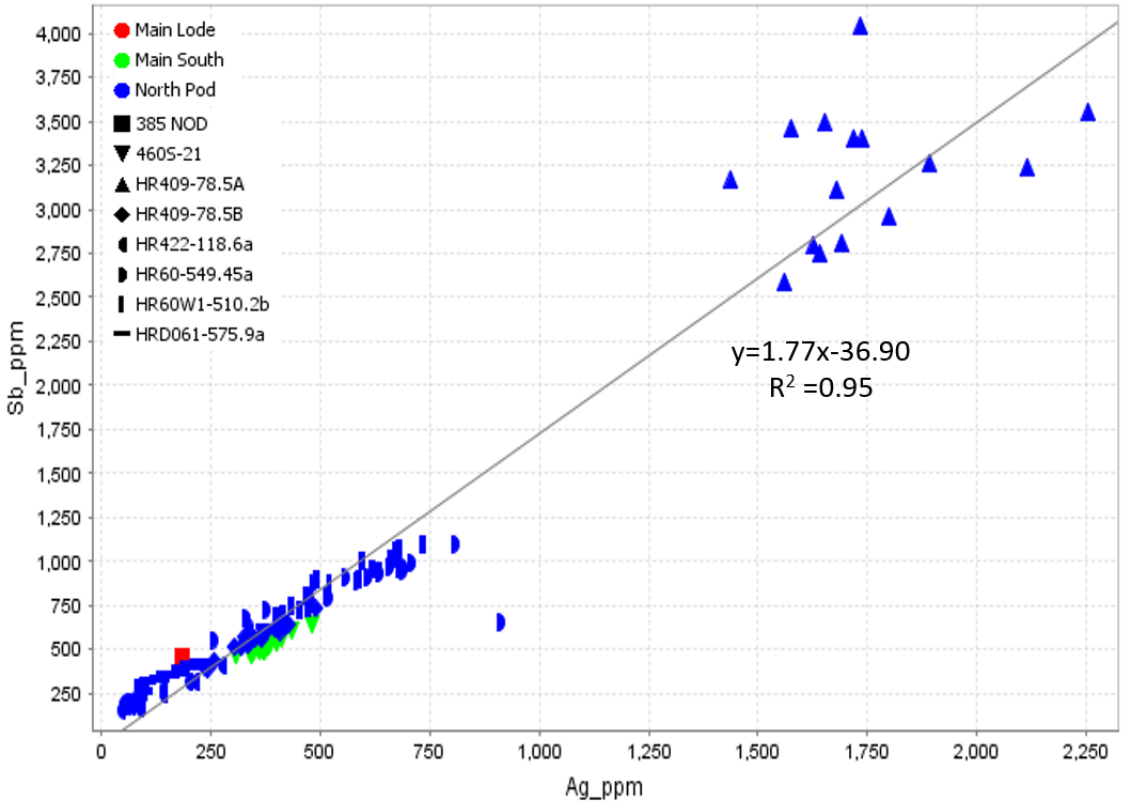
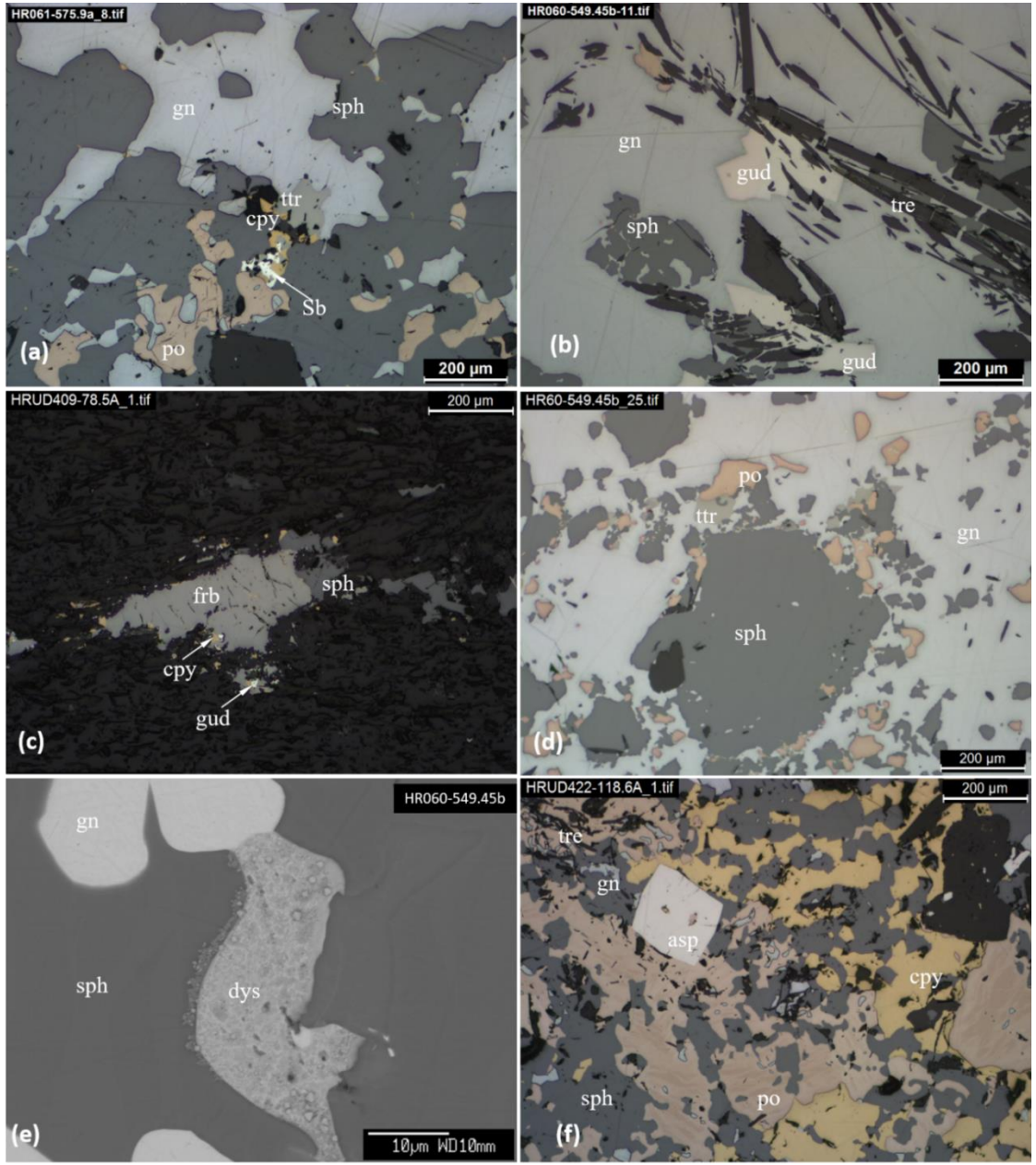


Fig. 5 Sphalerite-galena relationships. A) Sphalerite-galena intergrowths in the Main South ore lens (RL). B) Sphalerite fragments within a later galena vein from the Main South ore lens (RL). C) Sphalerite-galena co-crystallisation textures in the Main South ore lens (RL). D) Sphalerite-galena co-crystallisation textures in the Main North ore lens (RL). Mineral abbreviations: galena (Gal) and sphalerite (Sph)

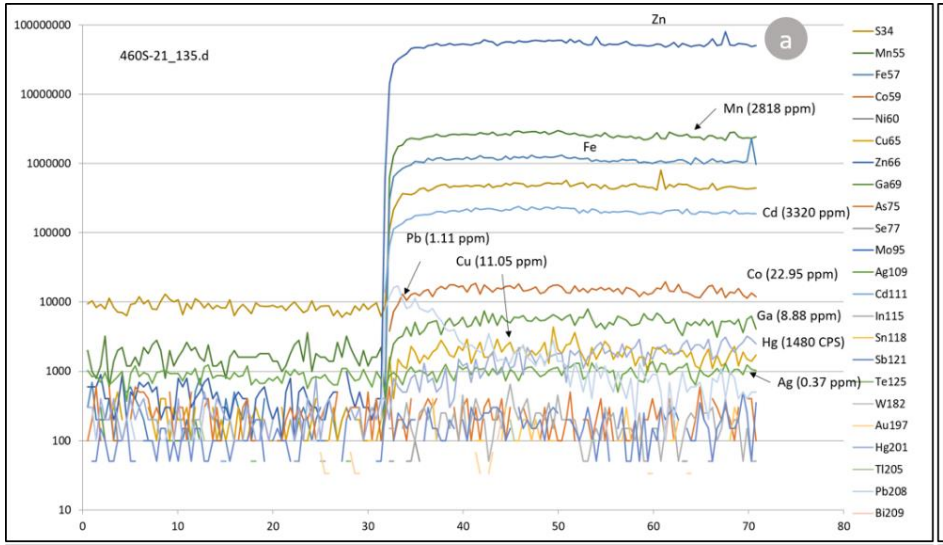
North Pod Mineralisation Unusually Ag, Sb and As rich.

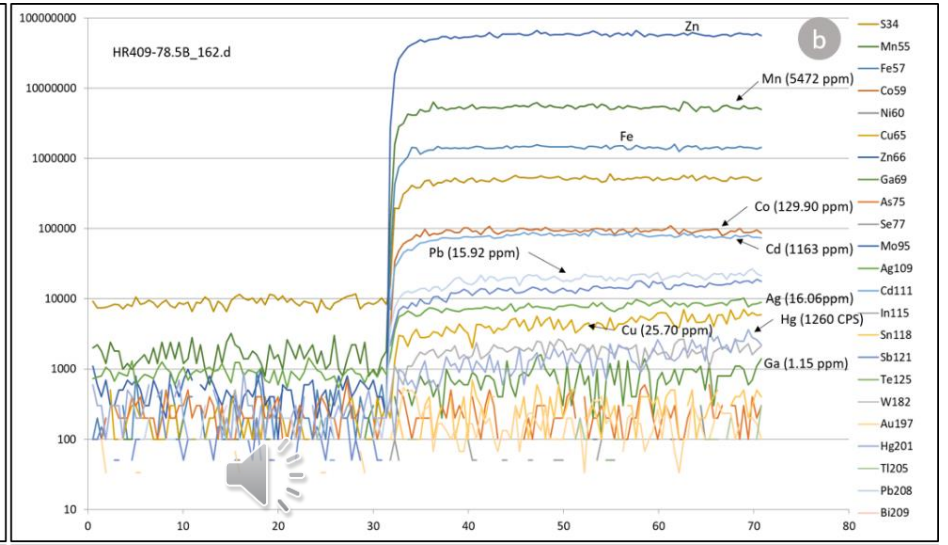


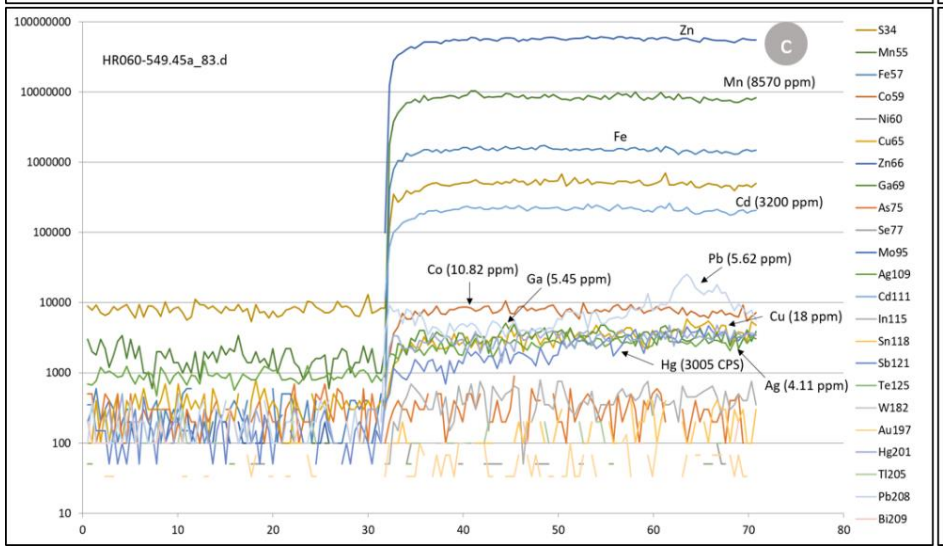
Correlation between Sb and Ag in galena

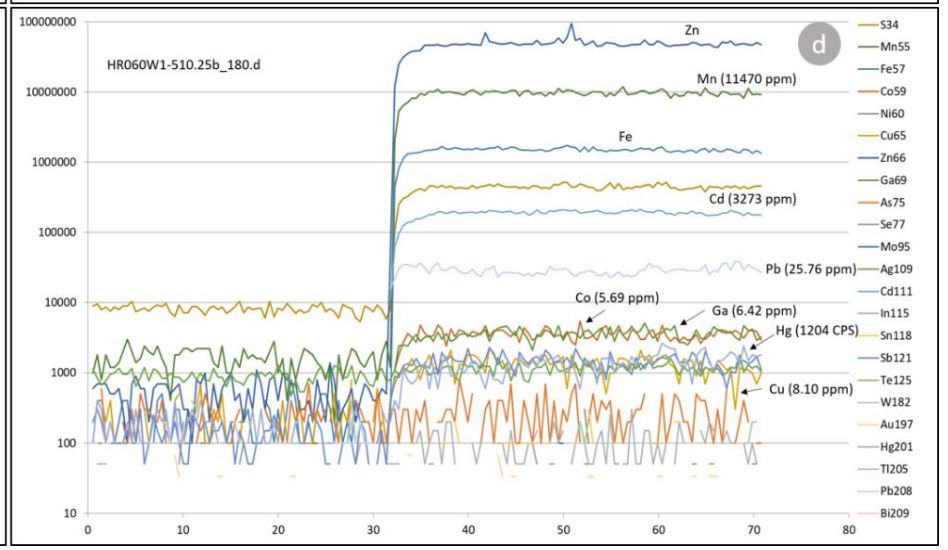


LA-ICP-MS trace element analysis of sphalerite



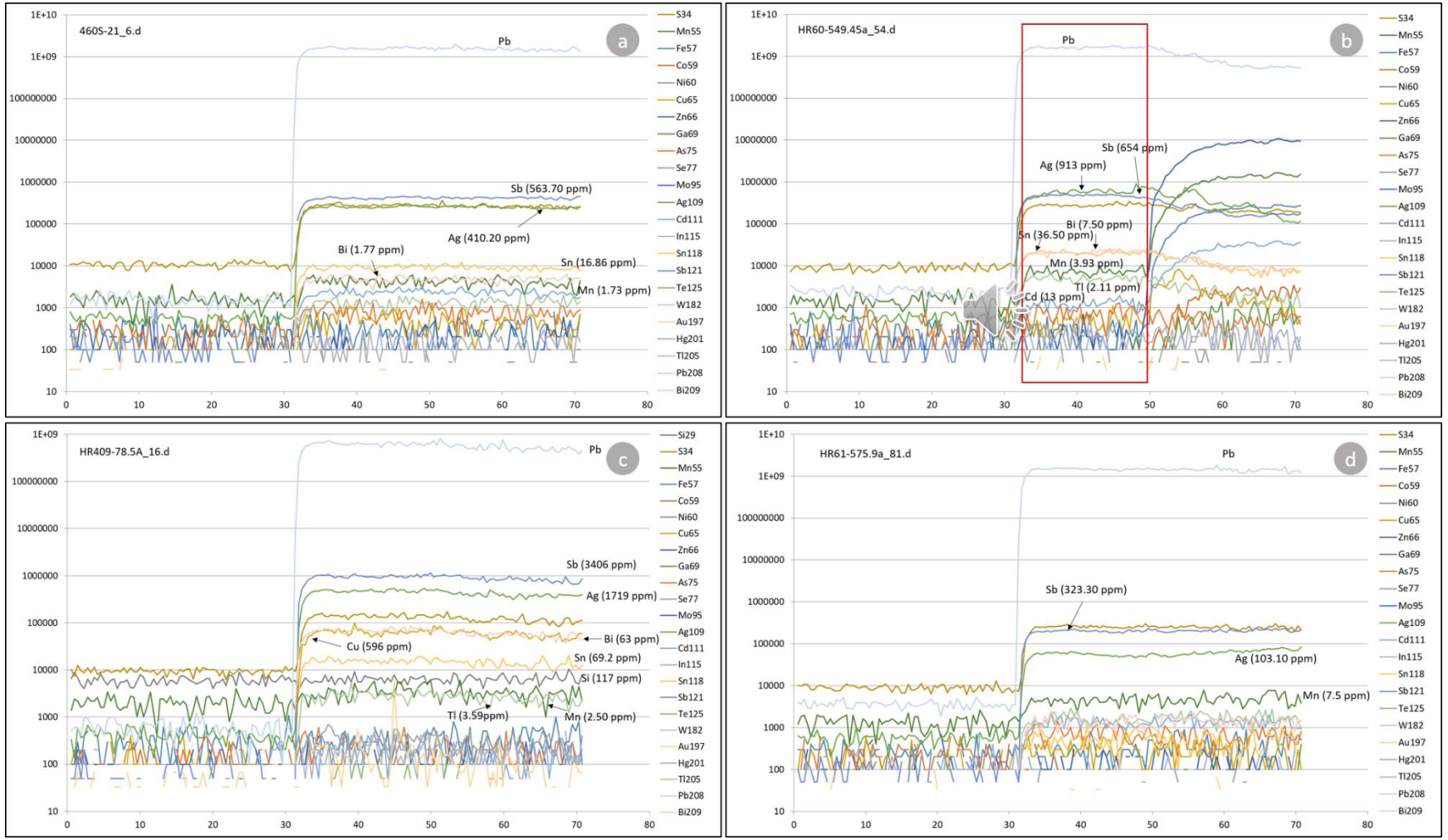






All very Mn-rich with more Mn than Fe!.

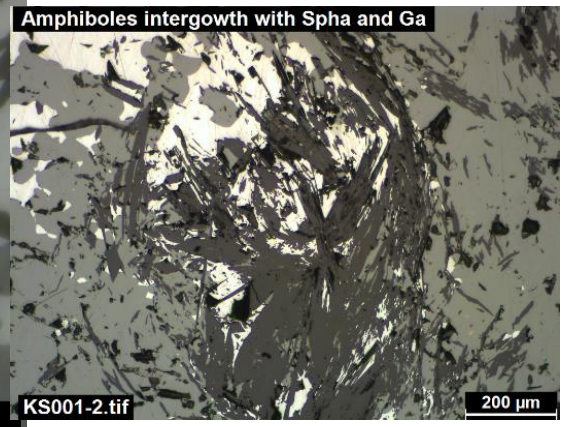
LA-ICP-MS trace element analyses of galena from the North Pod



Significant concentrations of Sb, Ag and Sn

Skarn assemblages

Tremolite is widespread throughout many of the sulphide lenses (commonly intergrown with sphalerite-galena) while ferroactinolite is uncommon. Fluoredenite and edenite are rare and exclusive to quartz veins.



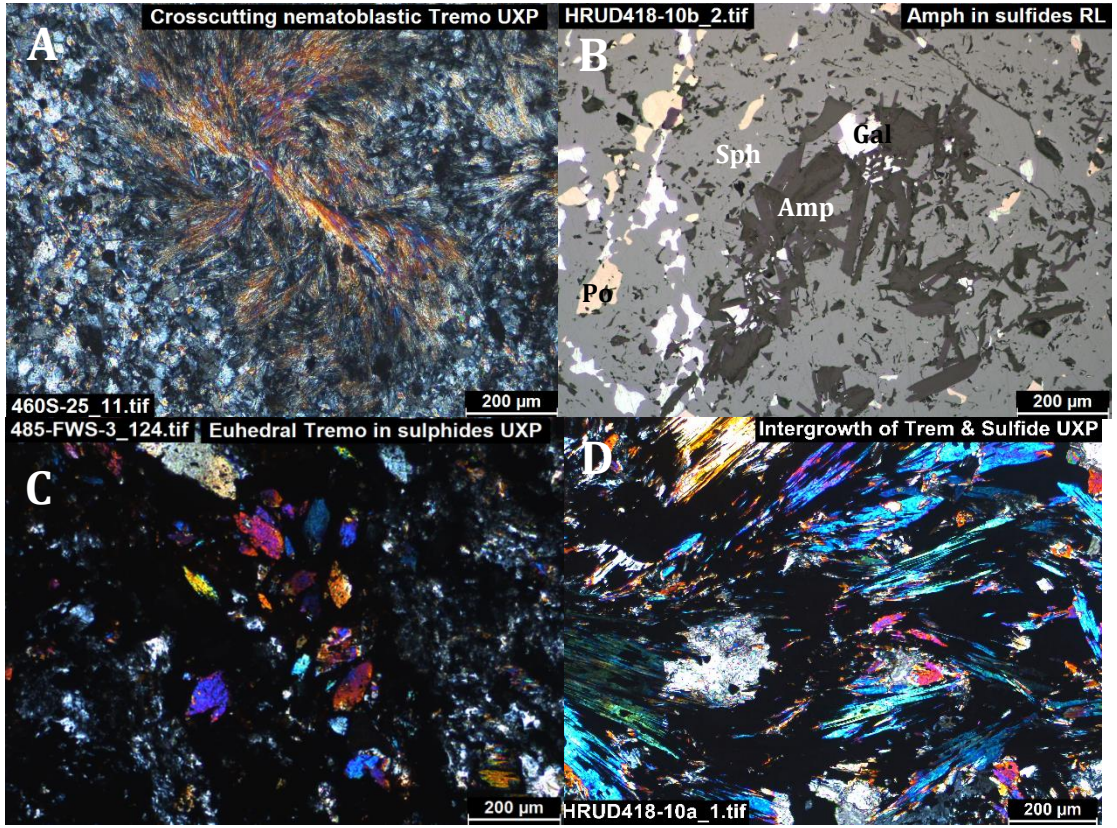
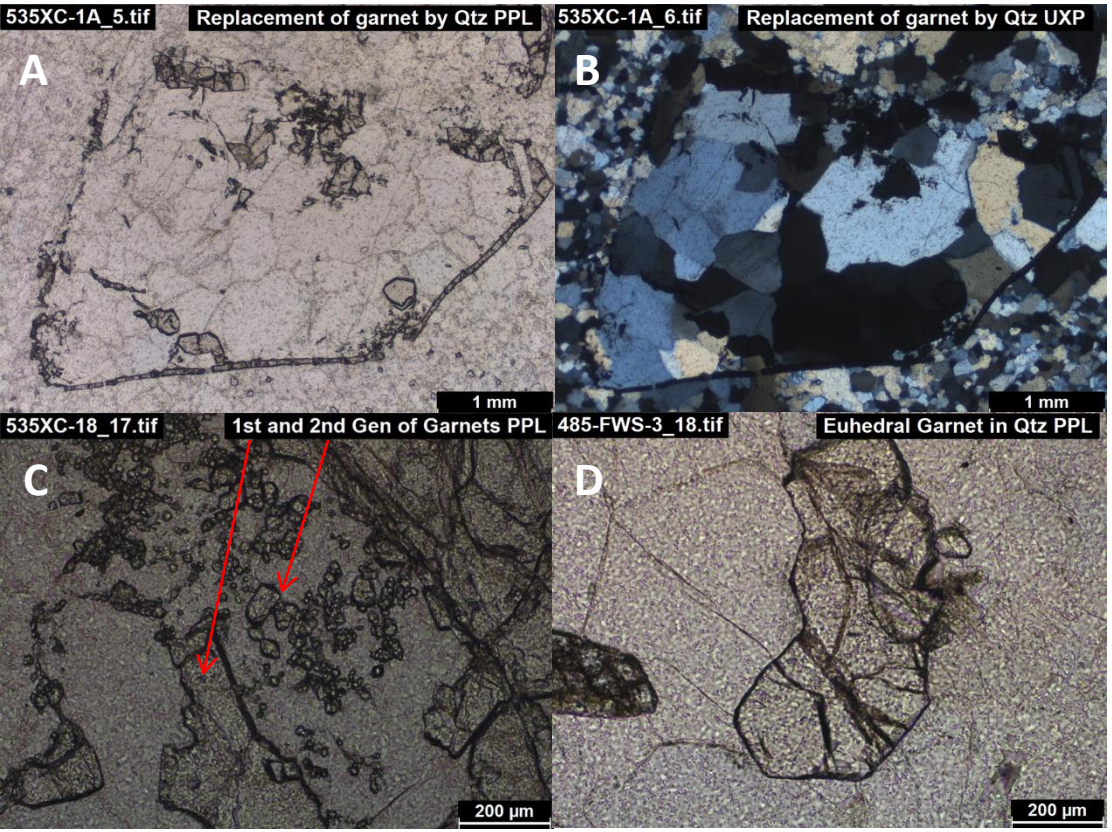


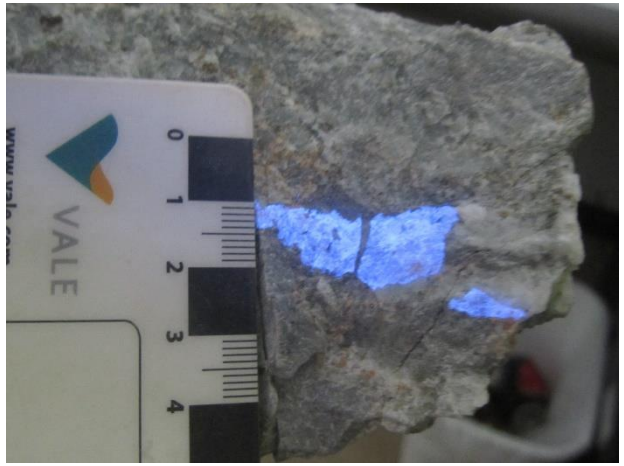
Fig. 13 A) Tremolite (I) crosscutting host rock deep in the Main South ore lens (UXP). B) Tremolite in sphalerite, galena and pyrrhotite in the North Pod ore lens (RL). C) Tremolite (II) in sulphides in the Far West ore lens (UXP). D) Tremolite (I) intergrown with sulphides in the North Pod ore lens (UXP). Mineral abbreviations: galena (Gal), pyrrhotite (Po), sphalerite (Sph) and tremolite (Tremo)

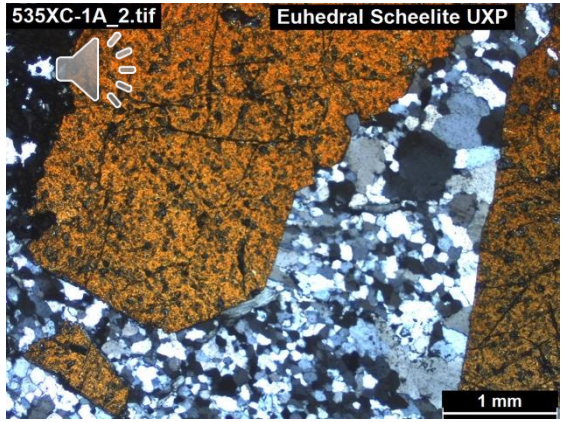
Garnets



Generation I – subhedral to euhedral, larger, commonly partially replaced by quartz and Mn-rich (spessartine)
Generation II – anhedral, much smaller and Ca-rich (grossular)

Scheelite

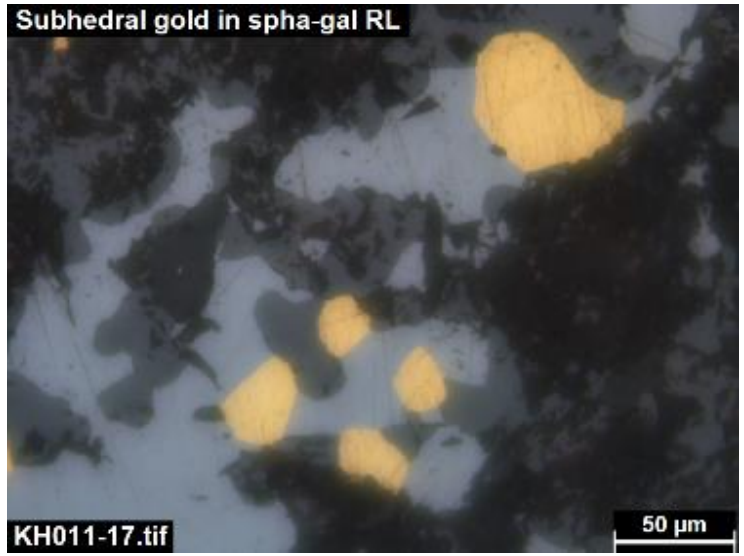


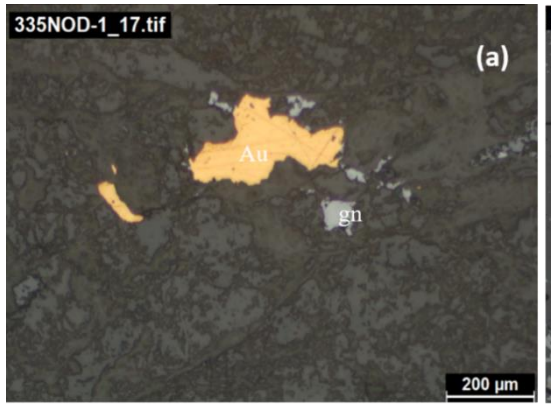


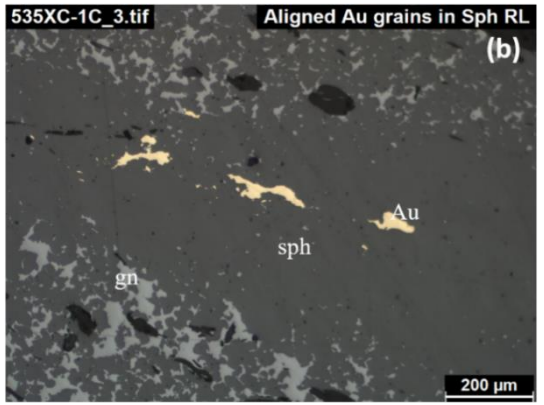
Relatively widespread throughout the deposit but subeconomic (~ 0.05%), best developed within quartz veins and appears to have crystallised at an early stage and increases in abundance with depth to the north.

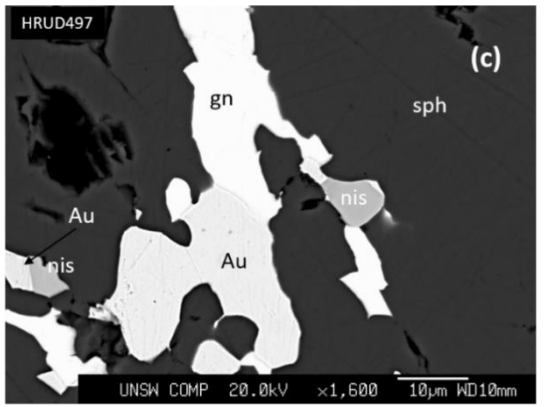
Gold occurrences and associations

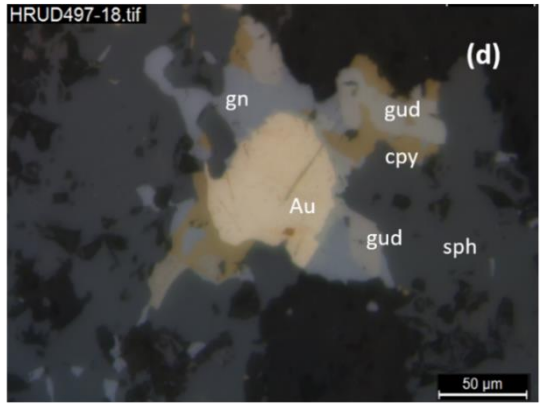
Gold correlates poorly with all other metals and occurs as disseminated grains in the host siltstones, in quartz veins, in narrow quartz-sulphide veins and in massive sulphide ores.

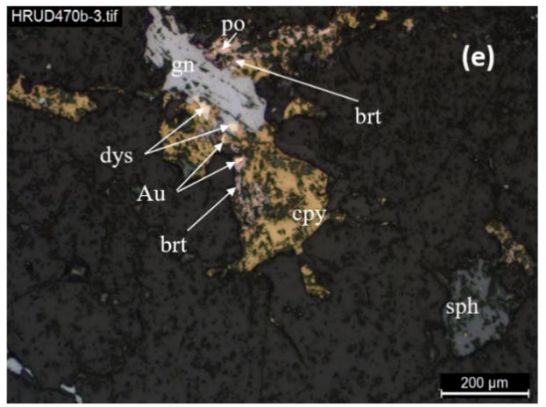


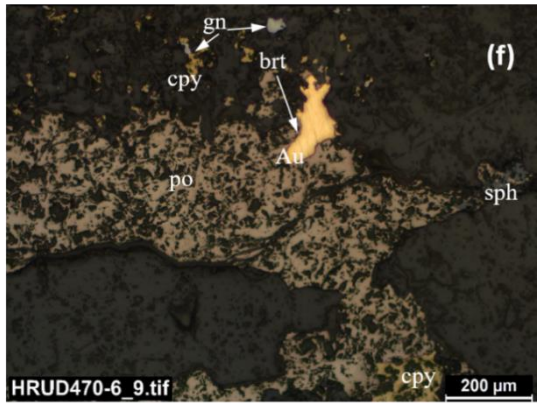


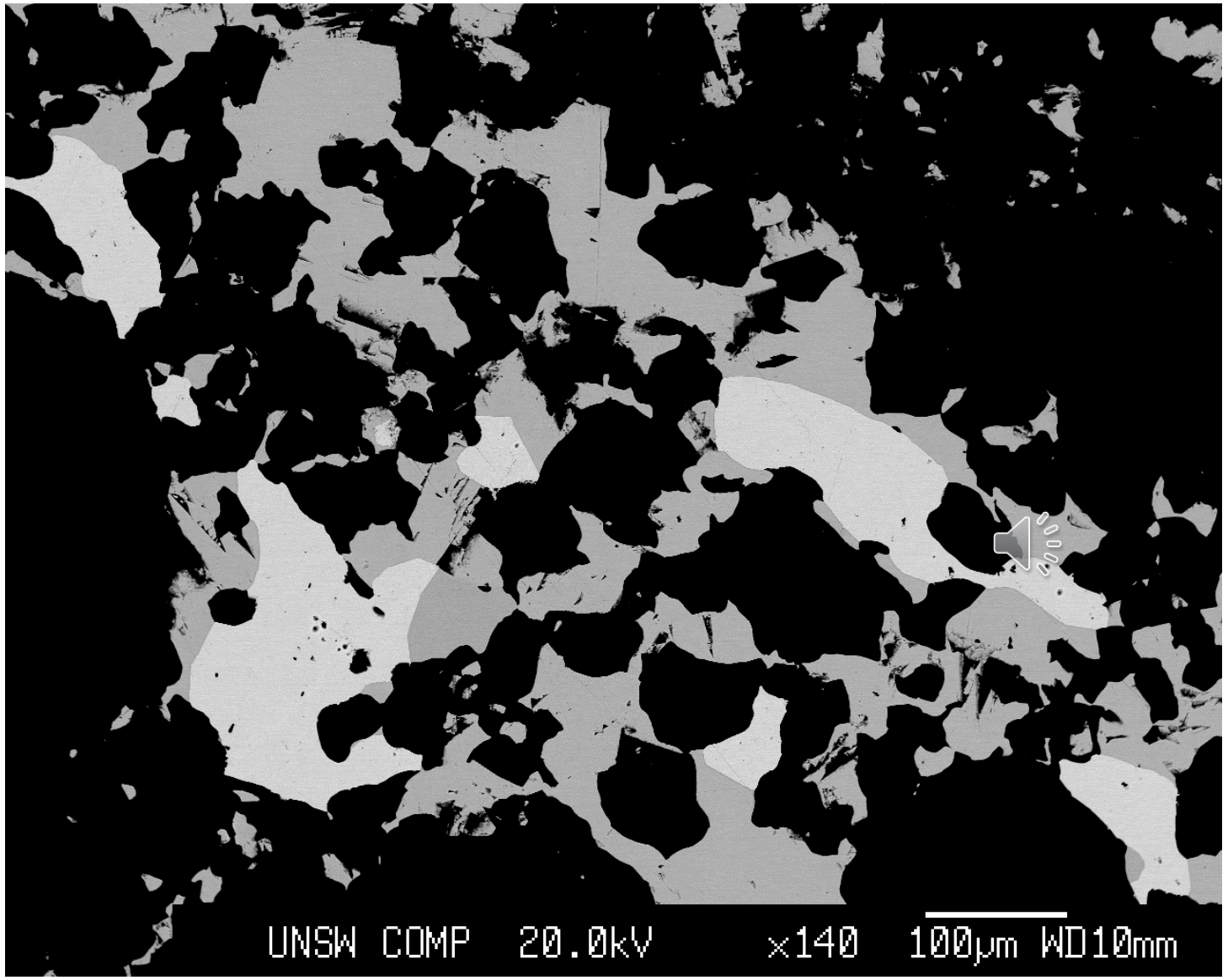






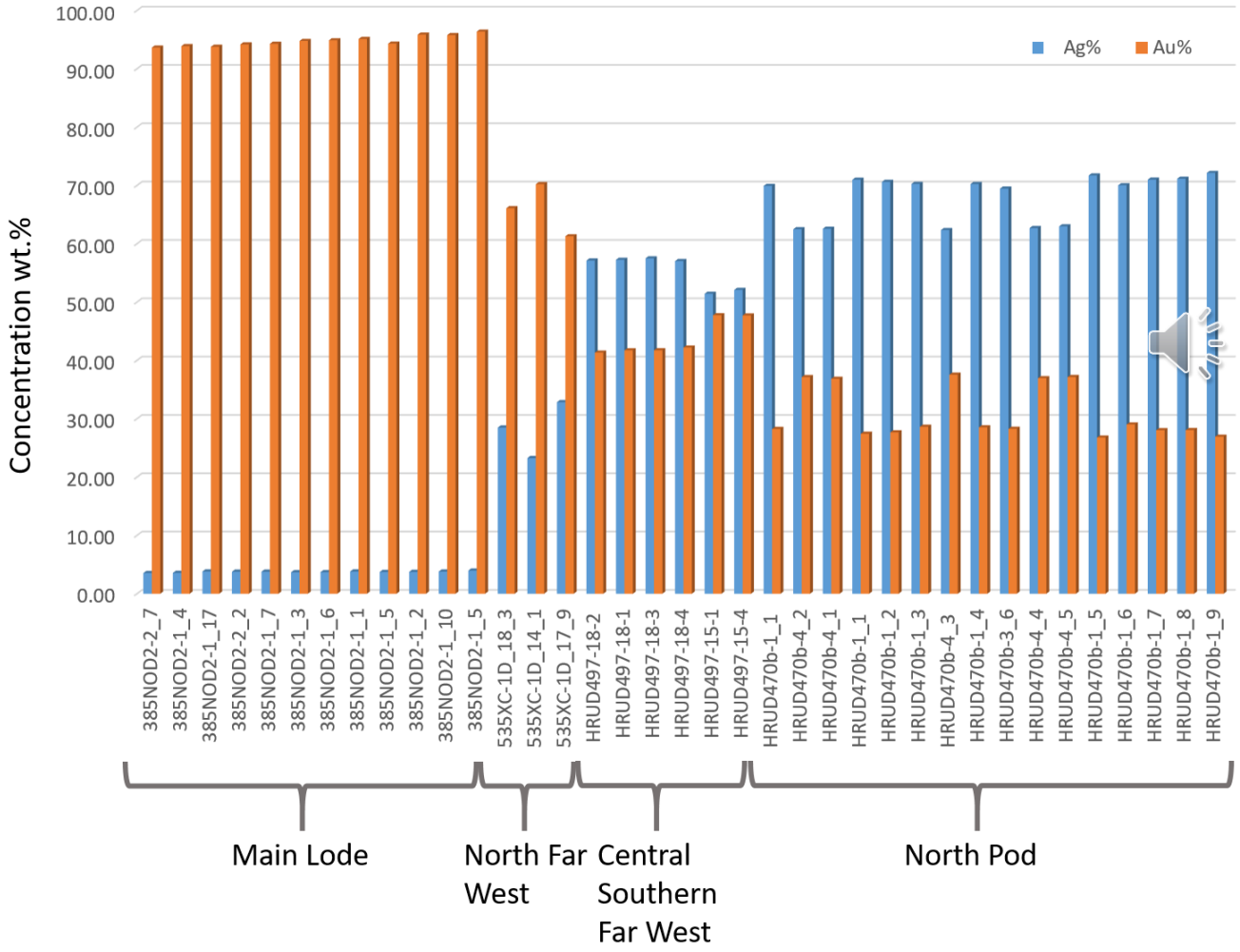


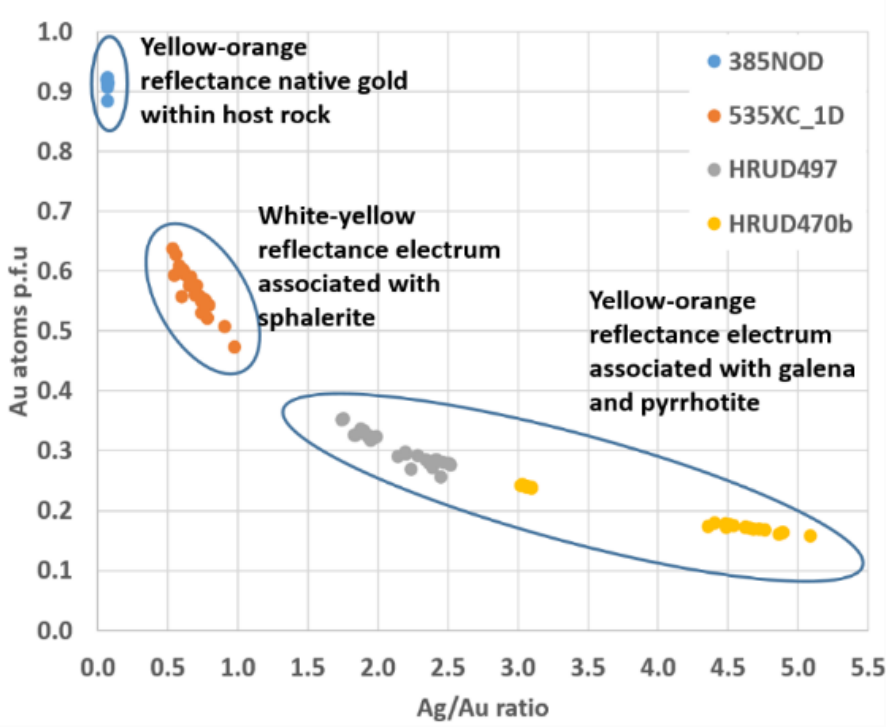




Electrum (brightest grains) rimmed by aurostibite ($AuSb_2$)(mid-grey grains) from 640 Level, North Pod

Gold Chemistry





Sulfur isotopes and Fluid inclusions

North Pod - 535 (3.36), 585 (4.55) and 615 (3.55-4.51)
Overall for the deposit 3.27-4.60
Kershaws (separate subeconomic lense) – 2.38-4.58
Data from David (2005) and Downes and Poulson (2018) – 2.9-7.4
Suggests magmatic source

Limited fluid inclusion data of Page (2011) suggests basinal fluid source and temperatures of 270-365C.

Based on the skarn assemblage of diopside-wollastonite-garnet-tremolite-zoisite, Fitzherbert et al (2017) suggested peak metamorphic temperatures of 450C

Genesis and evolution of the Hera deposit

Typical ‘Cobar-type’ deposits occur along the eastern margin of the Cobar Basin and are epigenetic structurally-controlled polymetallic deposits. However, although Hera fits all of these criteria, it also has:

1) **widespread low-T skarn alteration (tremolite) that is intimately intergrown with the main sulfides**
2) **Higher T skarn assemblages (mostly spessartine-grossular garnet) but also diopside and wollastonite in North Pod, Main and Far West lodes.**
3) **Widespread sporadic scheelite**
4) **Low-Fe sphalerite with low indium but very high Mn**
5) **A distinctive late-stage Ag-Sb-As-Au assemblage**
6) **A wide range in gold associations and chemistry**

Last year, Aurelia Metals discovered the Federation deposit (see paper by Schellen et al in the conference proceedings) only ~ 6 km south of Hera but this is a far more typical 'Cobar-type' deposit being low in Ag, higher in Cu and with a simple sulphide mineralogy of sphalerite-galena-chalcopyrite-pyrrhotite-gold and almost total lack of skarn phases.

So, what is Hera? – it would appear to have originally been a typical 'Cobar-type' deposit that then became a partial exoskarn through infiltration of fluids from an as yet 'unknown' intrusive at depth. However, evidence for this intrusive exits in the mine as cross-cutting pegmatites. These fluids have significantly mobilised some components and were most likely responsible for the introduction of at least Sb and As into the system, particularly within the North Pod. Although granites are well-known in the region, these all predate (428-422 Ma) the hostrocks (419-407 Ma) and muscovite intergrown with sulfides (382 Ma). It may also have an orogenic gold/tungsten component!.