

Geology the Eisenbrey Zn-Cu-Pb Deposit, Rusk County, WI

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Introduction

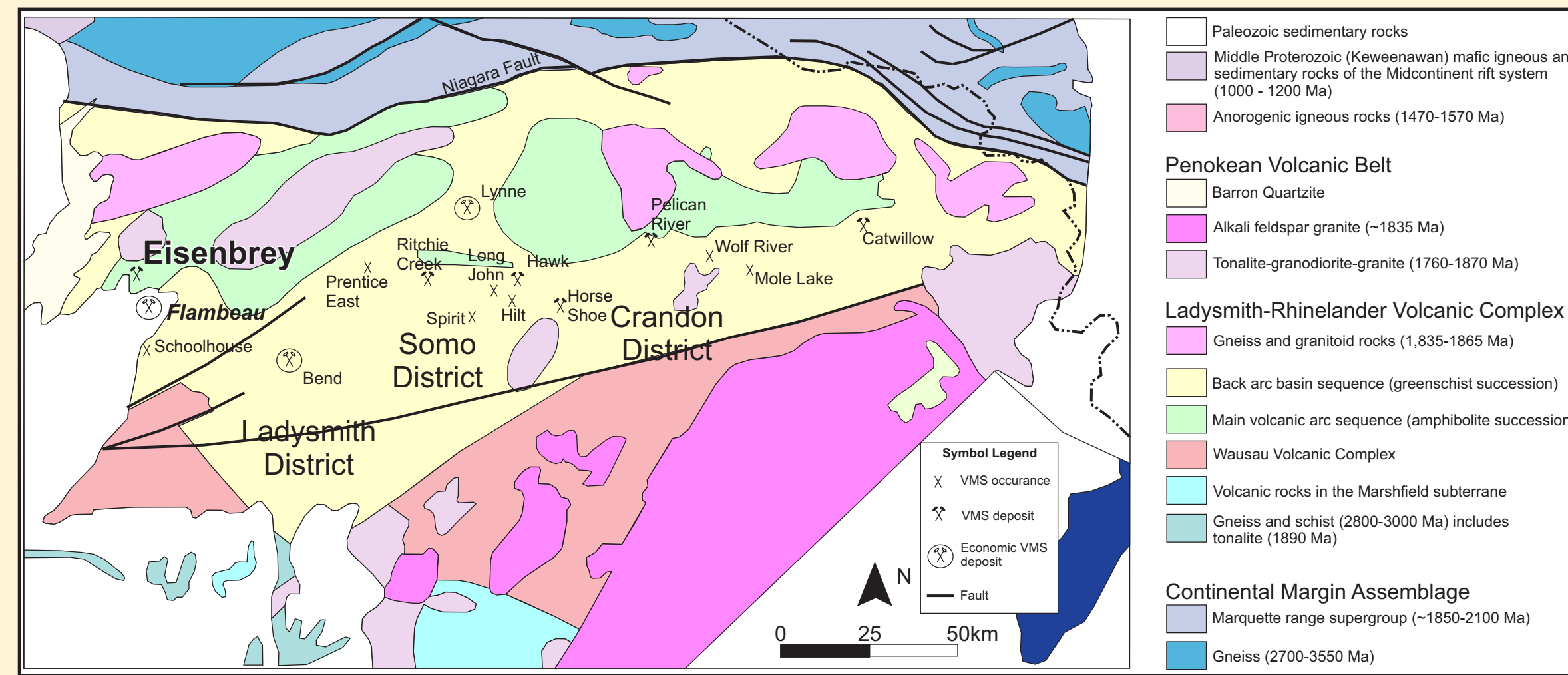


Figure 1: Precambrian geology of northern Wisconsin and Michigan showing the distribution of Cu-Zn-Au mineralization and major ore deposits.

The primary objective of this project is to complete a geochemical and petrographic study of the poorly understood Zn-Pb-Cu mineralization of the Eisenbrey deposit hosted in Precambrian volcanic assemblages (DeMatties, 1994) of the Penokean Orogen. These deposits and their regional geological and economic significance have not been examined in any detail, despite almost 20 years of advancement in the fields of economic and Precambrian geology.

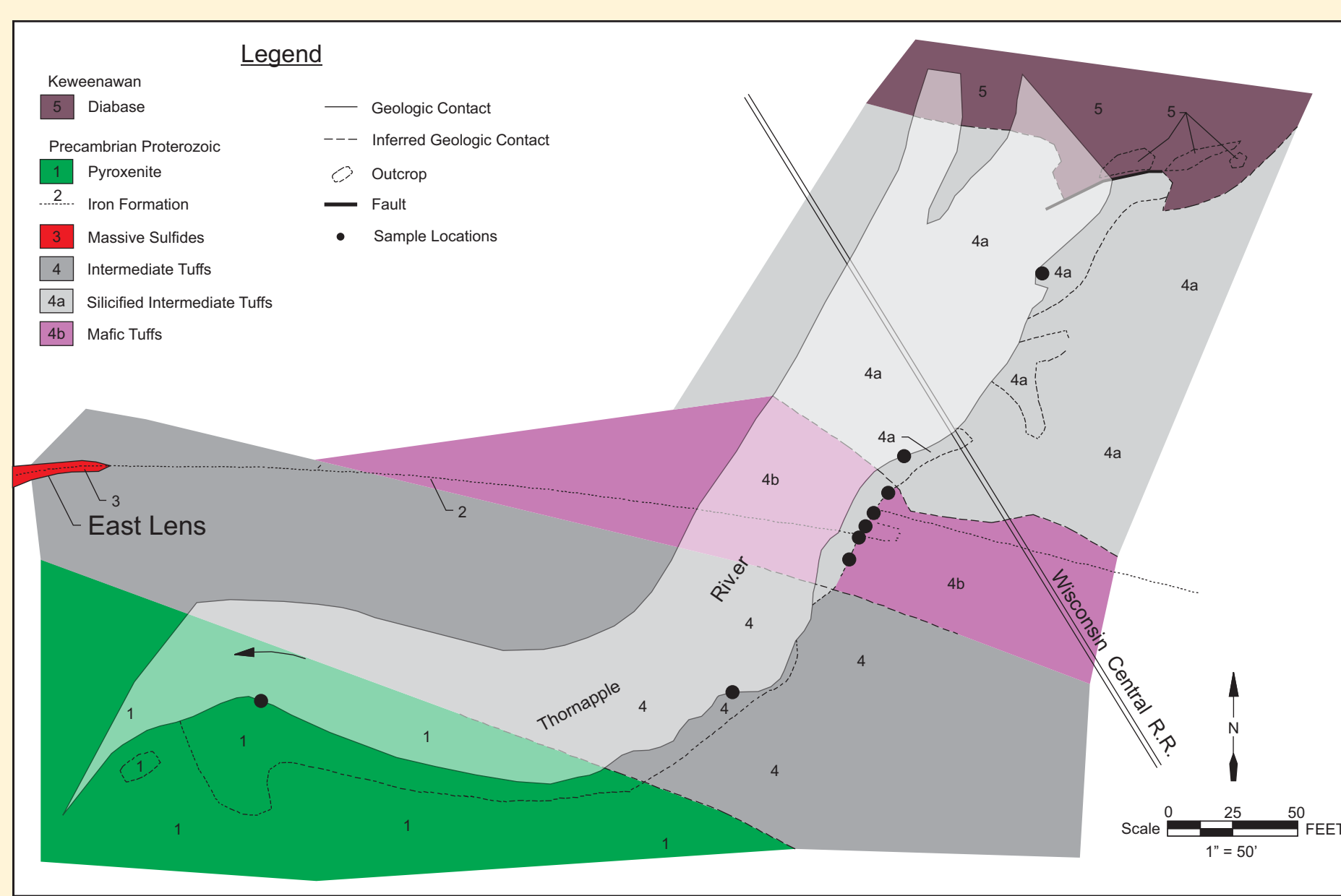


Figure 2: The Eisenbrey Deposit was discovered in bedrock exposed in the Thornapple River near Ladysmith, WI.

Mapping efforts after the discovery of massive sulfide bodies elsewhere in the Penokean Orogen resulted in the 1970 discovery of an outcropping iron formation with anomalous base metal concentrations on the banks of the Thornapple River just 4 miles away from the Flambeau Cu-Au mine near Ladysmith, WI. Complete characterization of this ore body ceased because of the controversy surrounding the extraction of metallic sulfide ore bodies in the state.

Volcanogenic Massive Sulfides (VMS)

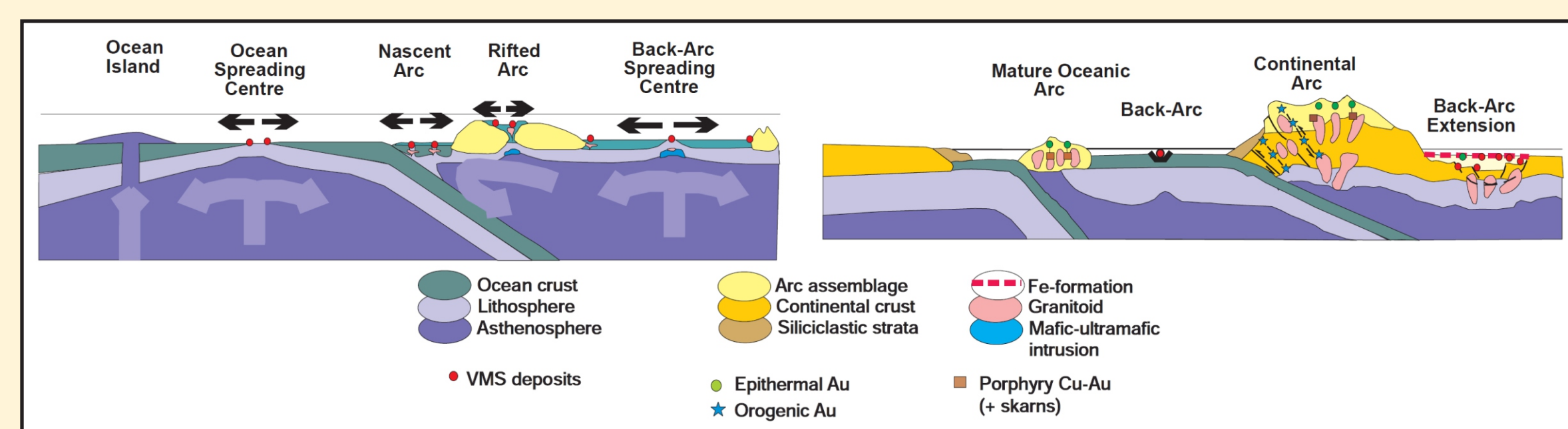


Figure 3: Metallogeny of volcanic arc tectonic settings.

VMS deposits are important sources of base and precious metals such as Cu, Zn, Pb, Au, and Ag. They are associated with extensional tectonic settings. Extensional settings that host VMS deposits are those that are preserved during subduction and orogenesis include rifted submarine volcanic arcs and back-arcs (e.g. Galley et al, 2007).

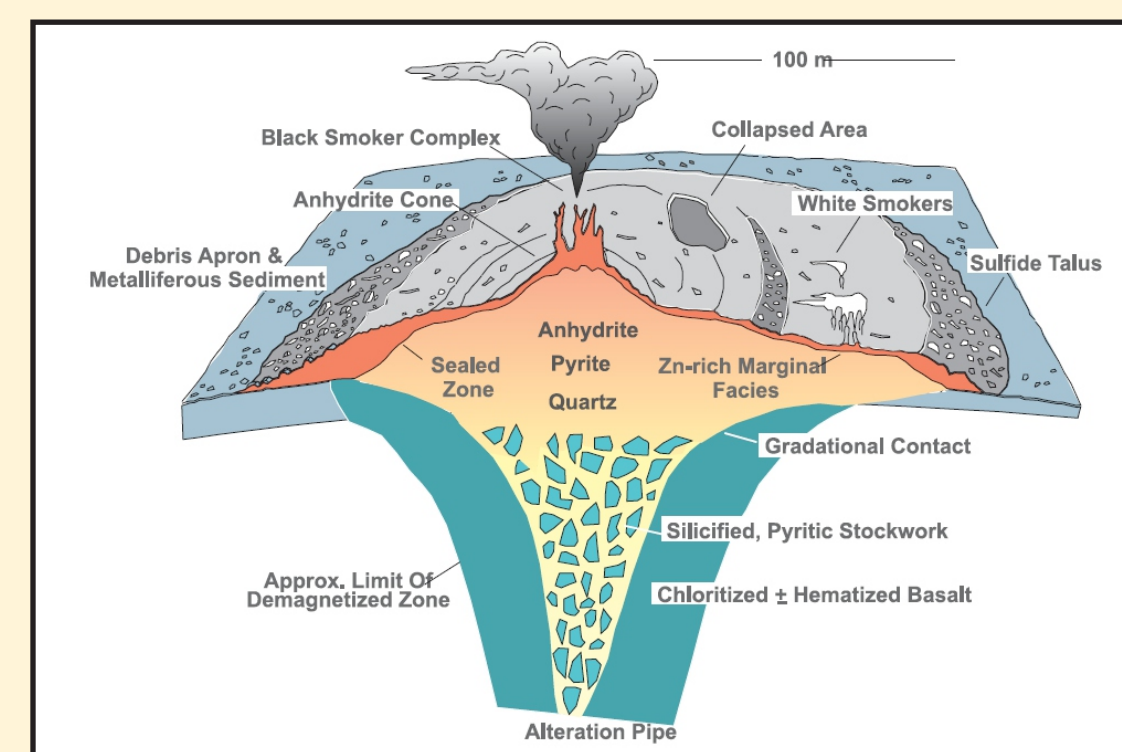
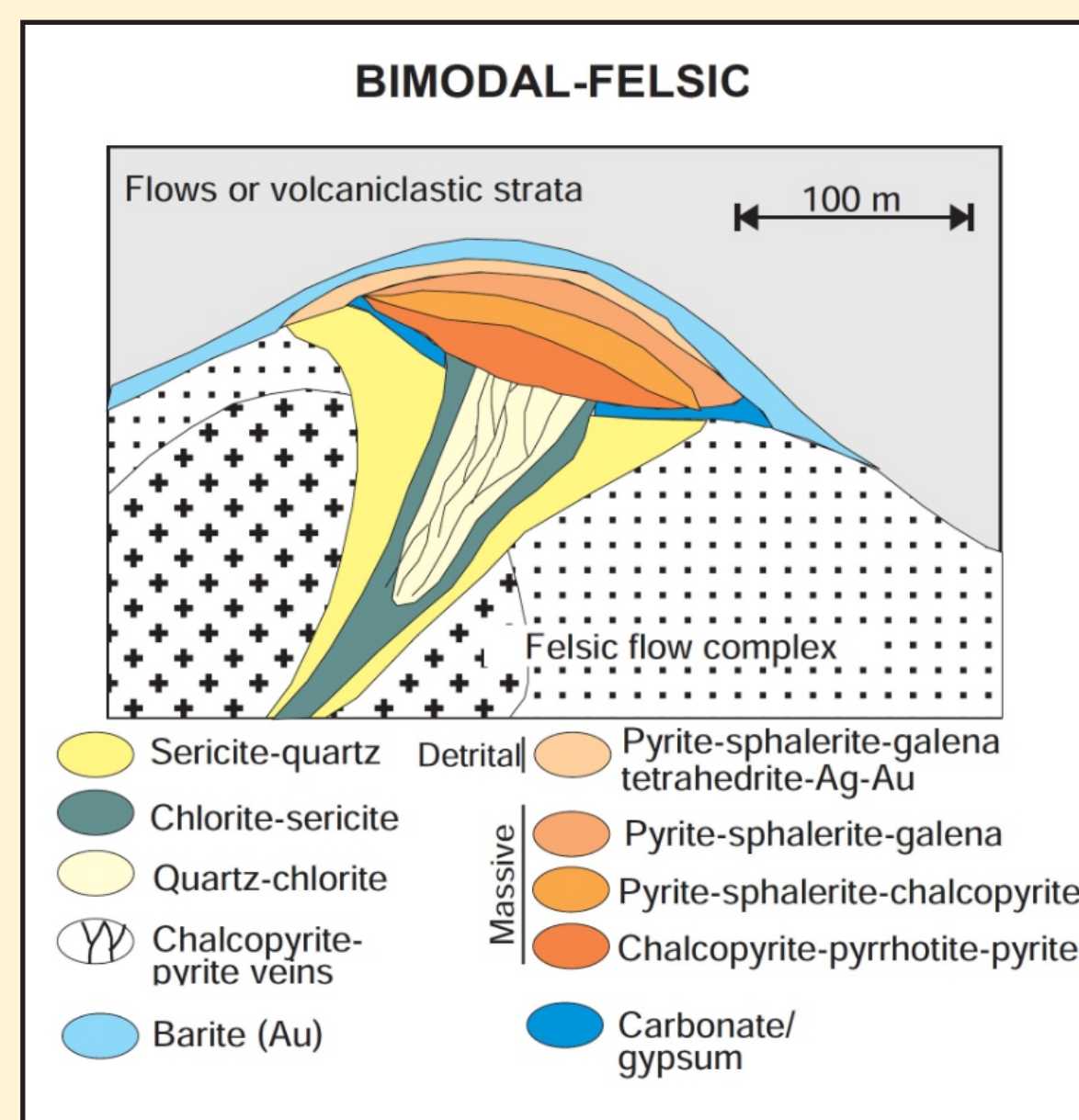


Figure 4: Schematic of a modern hydrothermal vent.

The discovery of hydrothermal vents on modern sea floor corroborated the hypothesis developed from previous research on ancient VMS deposits: they are metalliferous deposits formed by the leaching of elements from the country rocks due to hydrothermal activity.

Figure 5: Ideal model of a Bimodal-Felsic VMS deposit.

VMS deposits can be classified based on the composition and relative abundance of the different strata that host the ore zones (Barrie & Hannington, 1999). Bimodal-Mafic and Bimodal-Felsic are the most common lithostratigraphic classifications of VMS ores in the Precambrian. Eisenbrey is a Bimodal-Felsic VMS deposit based on the ore horizon being hosted in primarily felsic to intermediate volcanic rocks.



Stratigraphy of the Eisenbrey Deposit

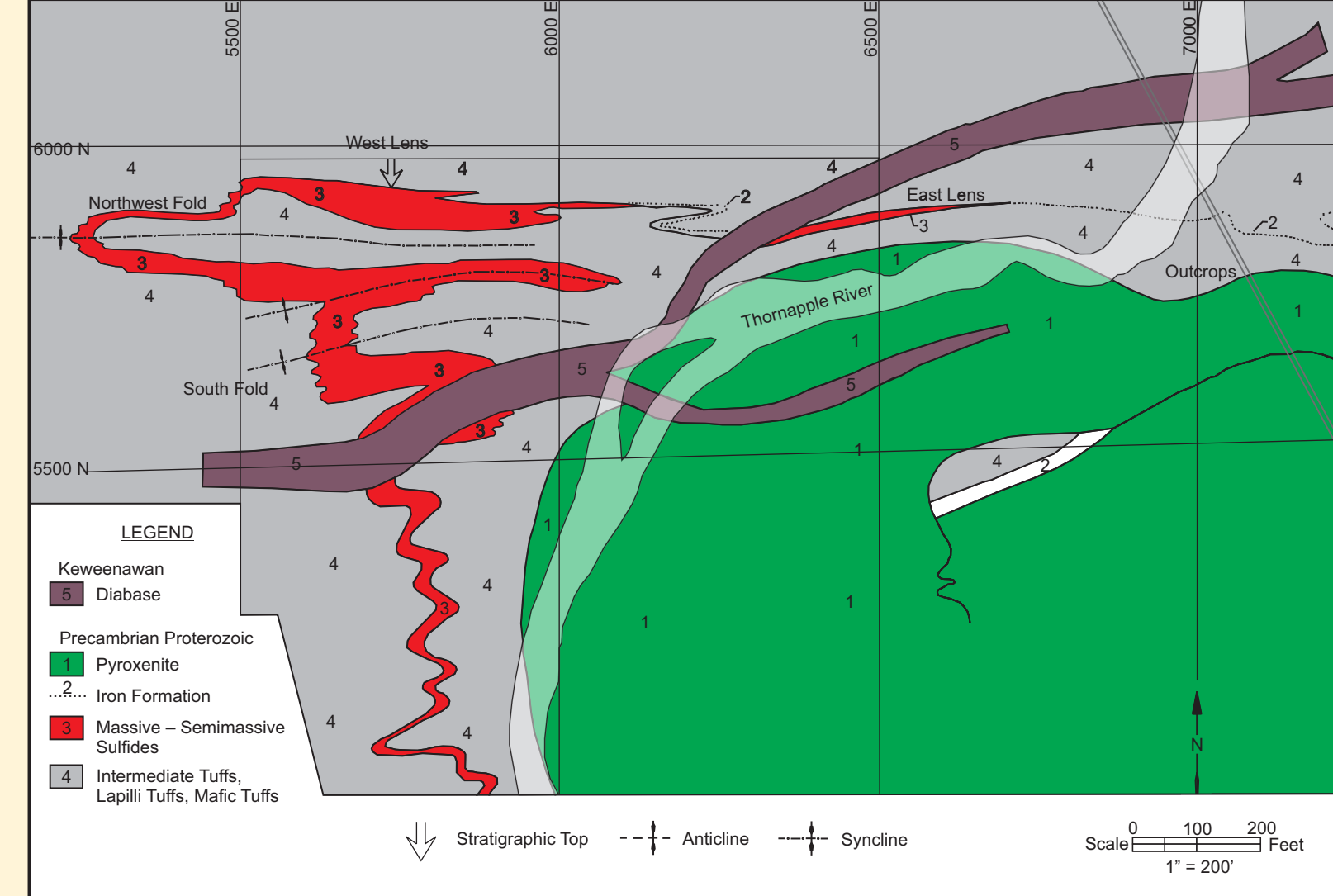


Figure 6: Bedrock Map of Eisenbrey Strata.

The geology of the Eisenbrey deposit was completed through compilations of bedrock exposure, drilling, and geophysical interpretations (May, 1996). The interpreted geology reveals a complexly folded ore horizon hosted in intermediate volcanic rocks with multiple tight folds.

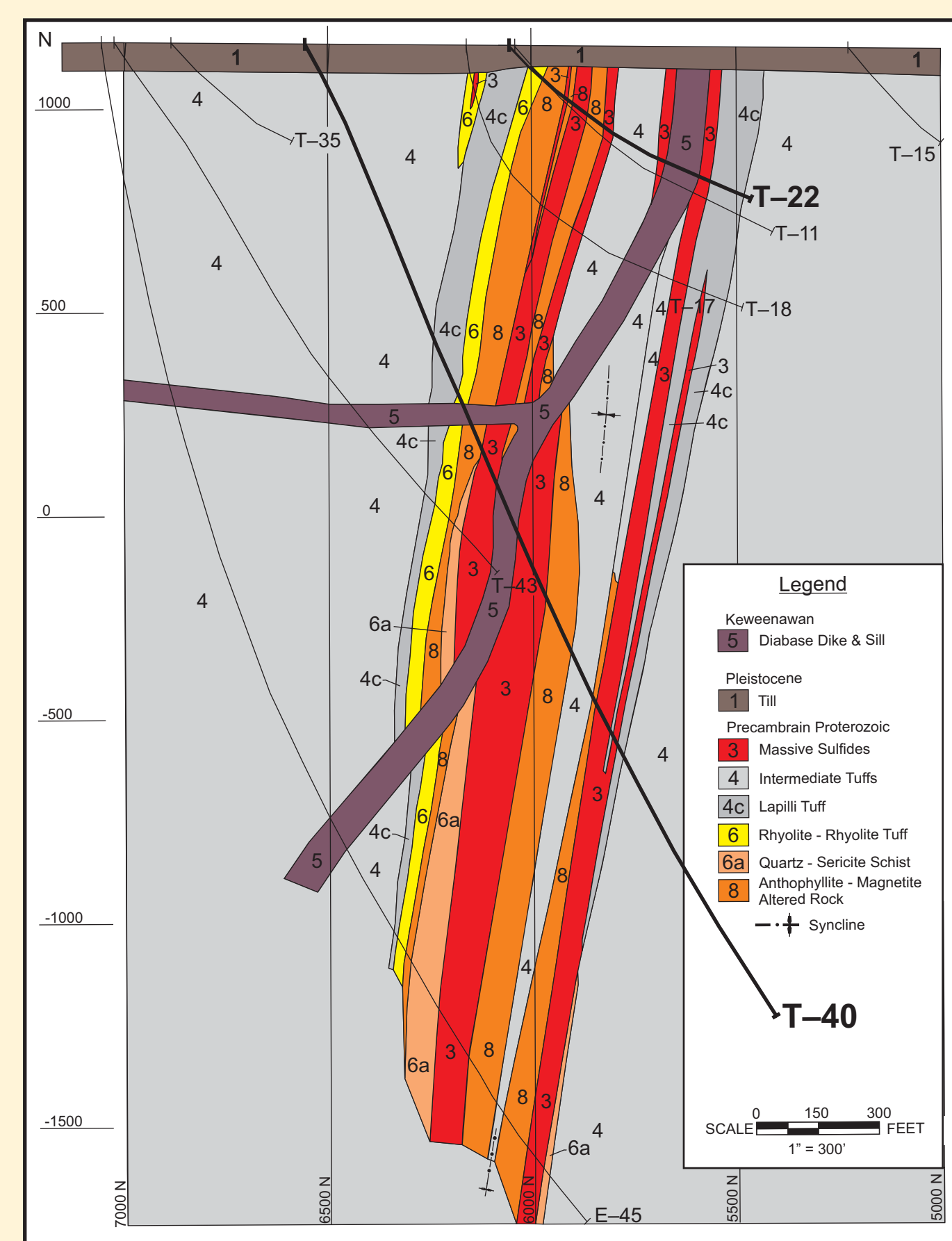


Figure 8: Cross-section of the Eisenbrey deposit.

Drilling has revealed multiple lenses of massive sulfide separated by metadacites and altered volcanic rocks. For this study, drill holes T-22 and T-40 (bold) were re-examined to characterize the rocks and to collect samples for thin section and geochemical analyses.

Figure 9: Altered and unaltered volcanic rocks hosting the Eisenbrey deposit.

A) Relatively unaltered, weakly foliated metadacite with feldspar phenocrysts. **B)** Anthophyllite-magnetite-chlorite schists that represent metamorphosed hydrothermal alteration of volcanic rocks. Geochemical and thin section data to determine their protolith is pending.

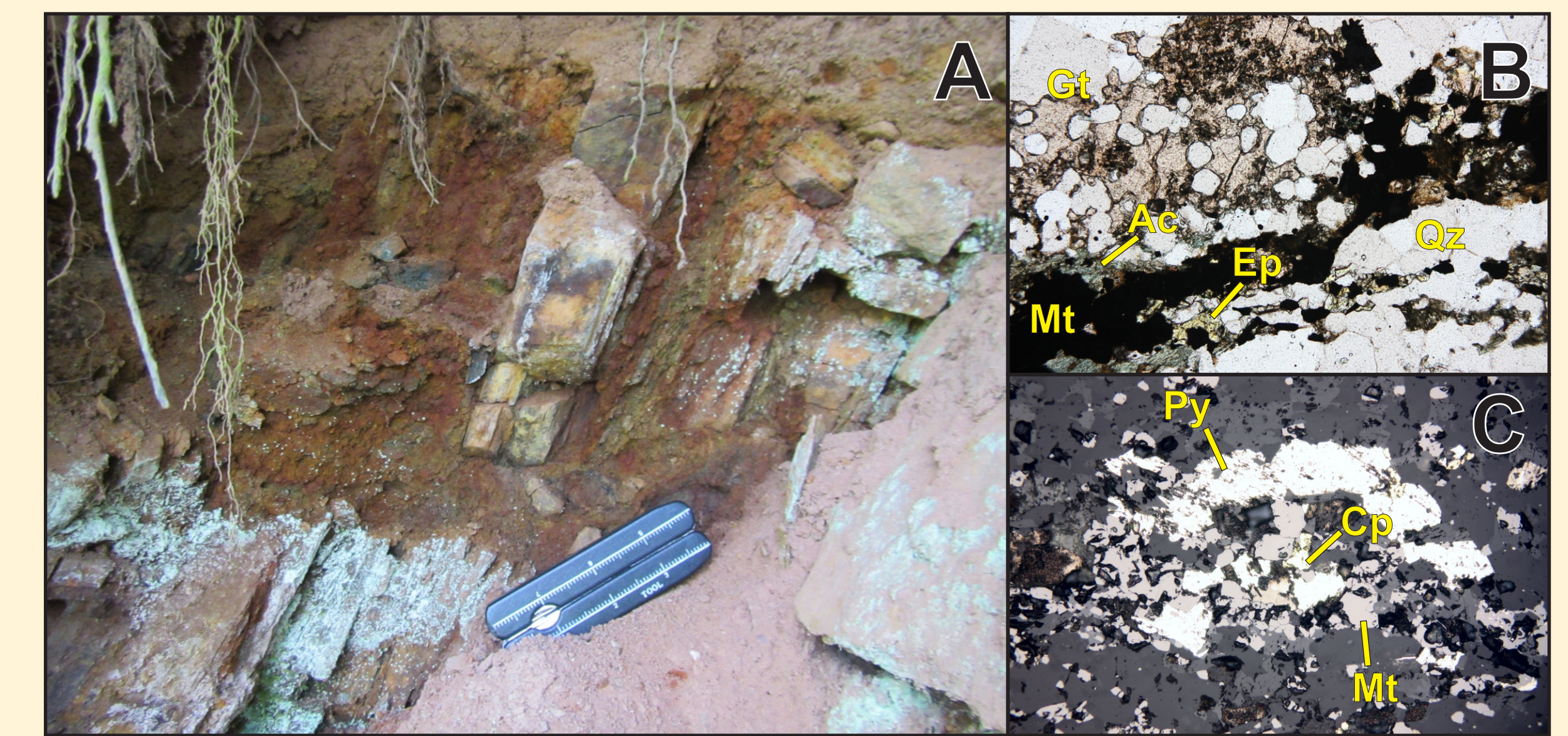


Figure 7: Discovery outcrop of the Eisenbrey ore horizon.

A) Field photograph of metalliferous iron formation exposed in the Thornapple River. **B)** Photomicrograph (pp) showing layers of quartz (Qz), garnet (Gt), epidote (Ep), and actinolite (Ac) with opaque magnetite (Mt). **C)** Photomicrograph in reflected light showing magnetite with pyrite (Py) and chalcocopyrite (Cp).

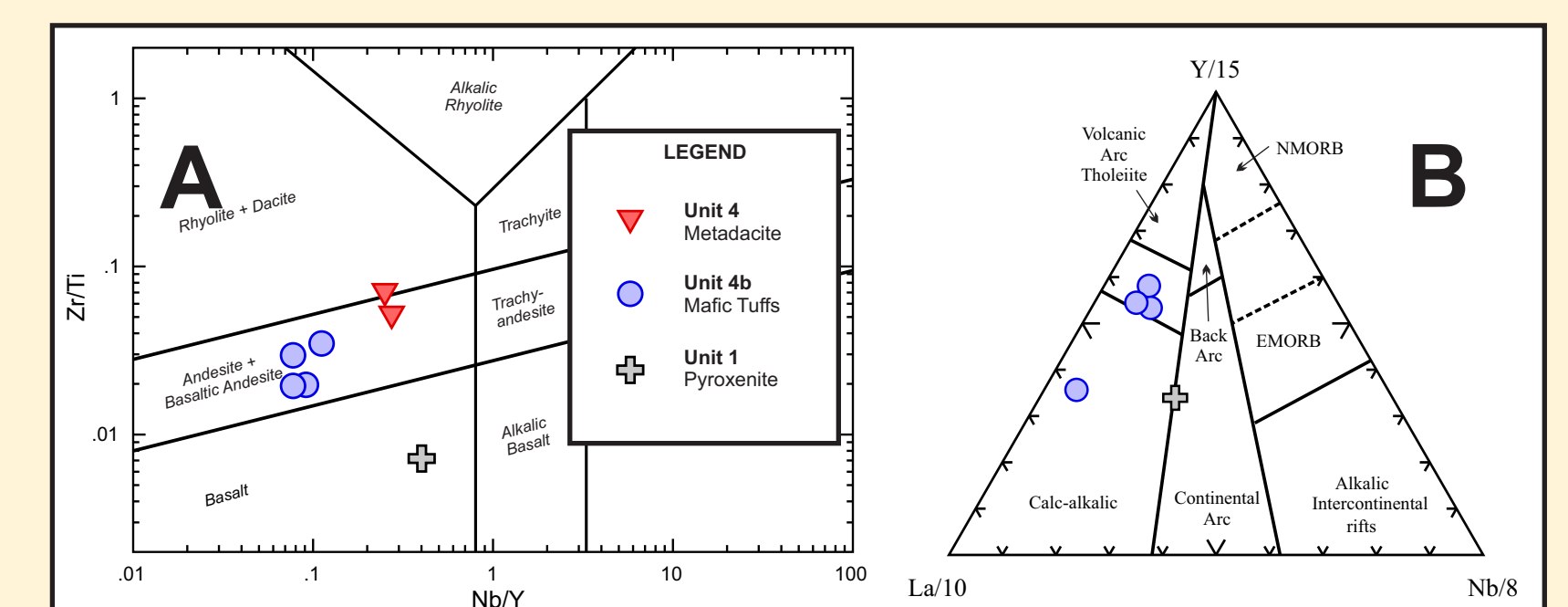


Figure 10: Geochemistry of exposed volcanic strata on the Thornapple River that host the Eisenbrey deposit.

A) Rock classification (Pearce 1996) showing basalt and dacite compositions for the rocks exposed on surface. Interestingly, mafic rocks are associated with the ore horizon at surface were not previously identified in drill core and may have been missed because of intense hydrothermal alteration. **B)** Tectonic discrimination (Canabis & Lecolle 1989) showing a volcanic arc tholeiite affinity for the mafic rocks.

Ore Petrology of the Eisenbrey Deposit

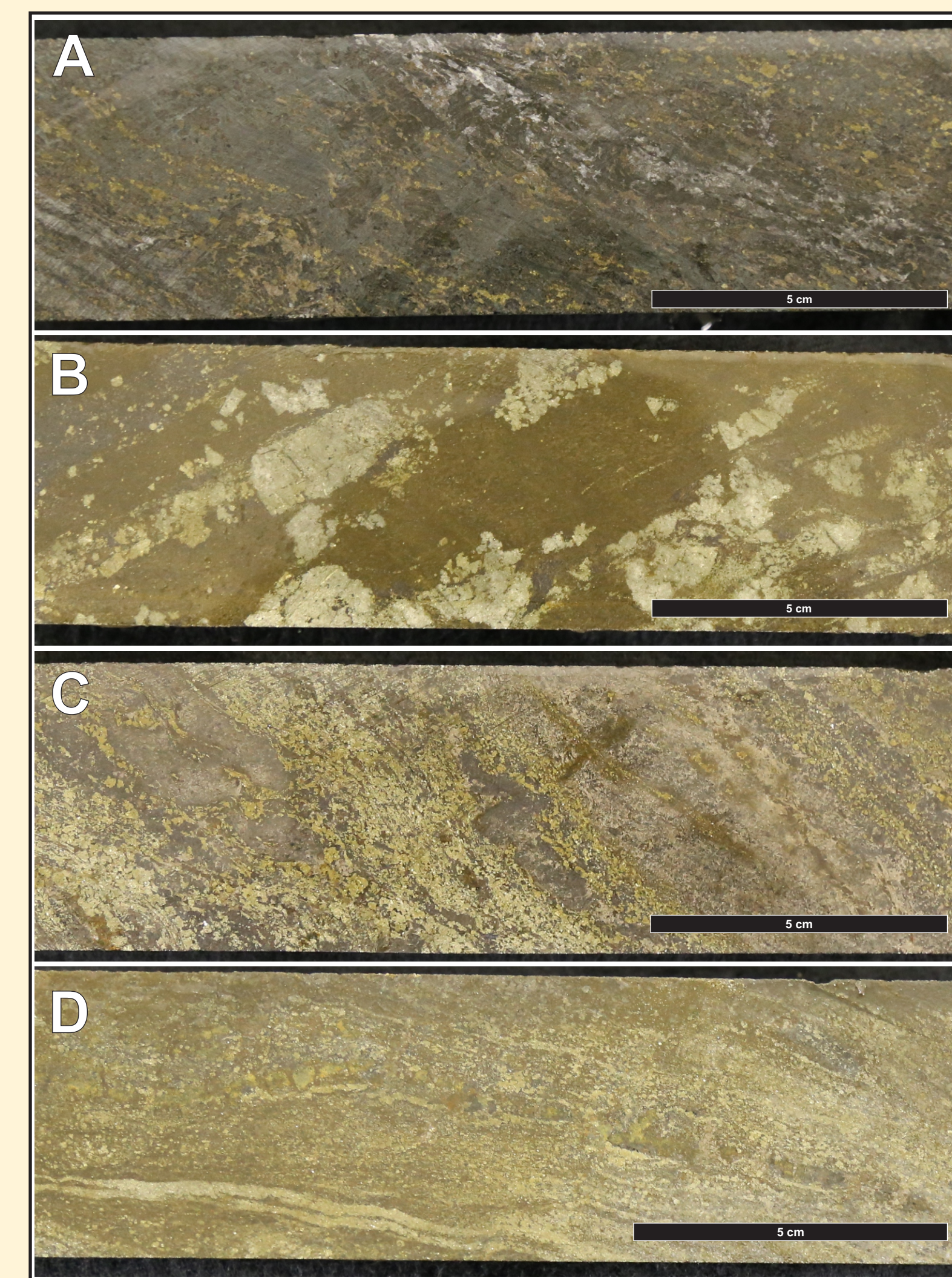


Figure 11: Different ores in the Eisenbrey deposit.
A) Disseminated Pyrrhotite, Pyrite & Chalcocopyrite
B) Porphyroblastic Pyrite in massive Pyrrhotite & Chalcocopyrite
C) Massive Chalcocopyrite + Pyrite with Quartz gangue
D) Banded Pyrite, Pyrrhotite, Chalcocopyrite with minor Sphalerite

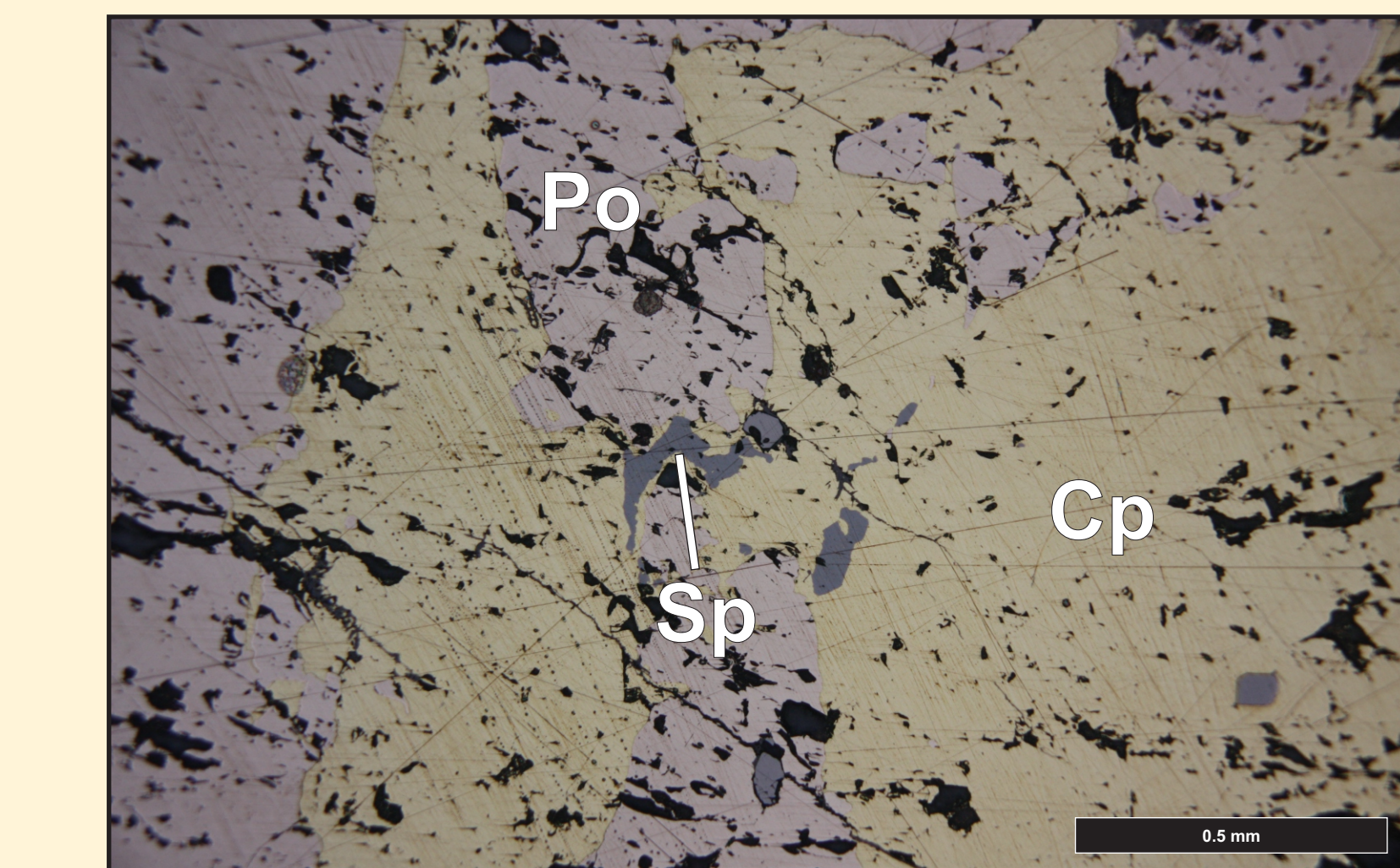


Figure 12: Photomicrograph of polished thin section from the Eisenbrey ore.

The dominant mineral in the Eisenbrey ore is massive anhydrous pyrrhotite (Po) with variable amounts of pyrite, chalcocopyrite (Cp) and sphalerite (Sp). Pyrrhotite as the dominant phase indicates a higher temperature hydrothermal system.

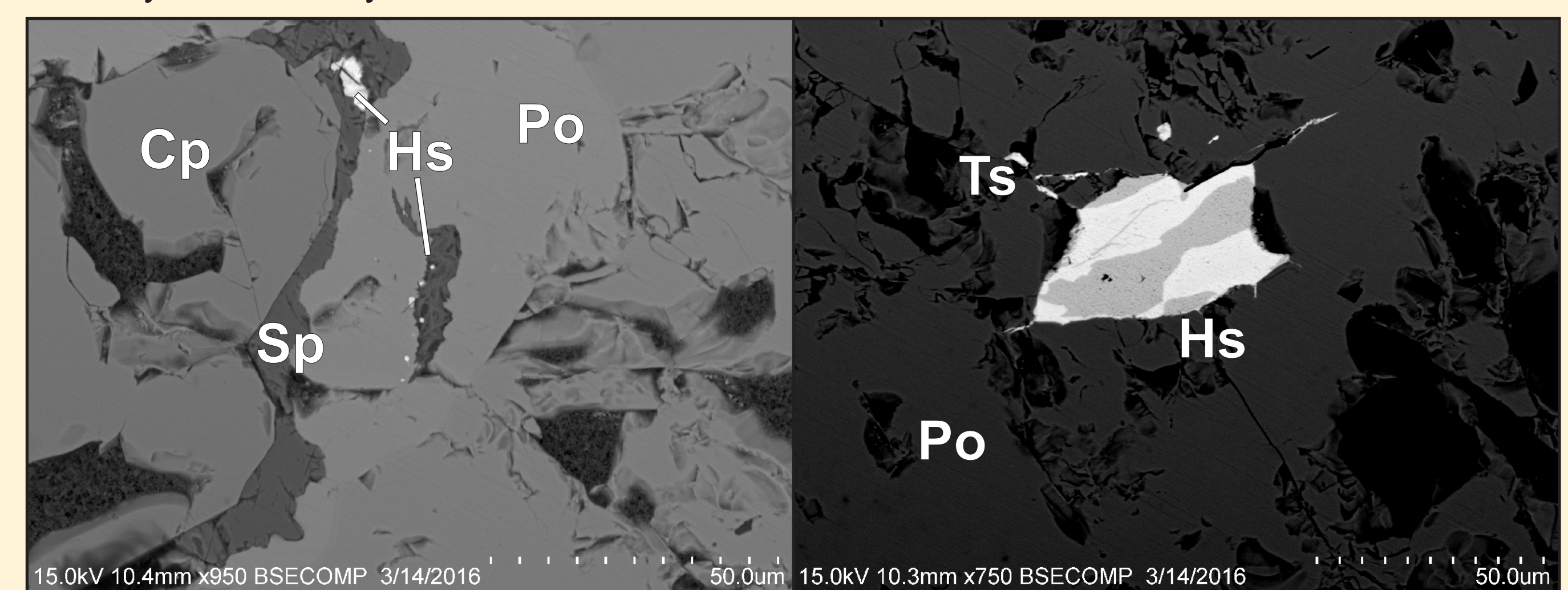


Figure 13: Back-scatter images of the Eisenbrey ore obtained on the SEM. Rare and precious metals in the ore are present as Hesseite (Hs: AgTe) and Tsuimotoite (Ts: BiTe). These minerals were found as micron-scale inclusions in pyrrhotite and often had exsolution textures.

Table 1: Metal grades for ore samples obtained via X-ray Fluorescence analysis.

These results confirm that despite a few Cu-rich samples, the base metal grades for the Eisenbrey ore is low. This also supports a high-temperature hydrothermal fluid temperature at the time of ore formation.

Hole ID	Depth (ft)	% Cu	% Zn	% Pb
T40	1870	0.14	1.40	0.34
T40	1183	1.12	0.16	0.00
T22	226	0.73	0.85	0.08
T40	359	5.27	0.04	0.00
T40	1467	0.49	0.01	0.00
T40	1050	0.90	0.05	0.00
T40	1130	1.45	0.05	0.00
T40	1341	0.21	0.10	0.07
T40	1147	0.73	0.14	0.01
T40	1365	2.13	0.02	0.01
T40	1412	0.49	0.35	0.03
T40	1458	0.94	0.06	0.00

Conclusions

Through the examination of drill core through the strata hosting the deposit, the intense folding interpreted by May (1996) is questionable. Locations of fold axis on cross sections yield little to no exceptional deformation fabric in the rocks, suggesting a homoclinal sequence. In addition, the relationship between massive sulfide and stringer mineralization suggests consistently upright stratigraphy. Instead of folded stratigraphy repeating ore horizons, it may be possible to explain repeating ore horizons through stacked ore lenses.

Preliminary studies of the Eisenbrey ore indicate a high-temperature hydrothermal fluid that precipitated sulfide minerals in a sub-seafloor setting. There is textural evidence in the ores that indicate that there is replacement-style mineralization. Future work will involve more detailed geochemical and textural analysis ores and host strata to better constrain the geodynamic and hydrothermal setting.

Acknowledgements

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