Pyrite in the Golden Marmot target, Brucejack Au-Ag deposit, British Columbia: Variations in texture, relationship to Au, and comparisons with the Valley of the Kings

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I. Research Motivation

- Pyrite is the most common sulphide mineral in hydrothermal mineral deposits; the textural and compositional variations exhibited by pyrite can provide critical information about the evolution of a hydrothermal system.
- Despite its abundance and long-recognized utility as a powerful geochemical tracer, the intragrain microtextural and compositional characteristics of pyrite have only recently begun to be linked with specific ore forming processes such as boiling (Román et al, 2019).
- This project seeks to elucidate our understanding of the relationship between pyrite and gold mineralization on the Brucejack Property.

II. Geological Setting

- The high-grade Brucejack low- to intermediate-sulphidation epithermal Au-Ag deposit, is part of the Sulphurets mineral district in the Golden Triangle area of northwest British Columbia (Fig 1 and 2). The deposit, well-known for its spatially discrete occurrences of bonanza-style electrum mineralization (>1000 g/t Au over 0.5 to 1 meter drill core intervals), is located on the western side of the Stikine Terrane (Stikinia), a paleo-island arc terrane thought to have experience a similar tectonomagmatic evolution to the modern-day Philippines (Monger et al., 2002).
- Within the Sulphurets mineral district, the Kerr-Sulphurets-Mitchell and the Brucejack deposits are found on the eastern flank of a regional scale, north-plunging anticlinorium named the McTagg Anticlinorium. The 183 Ma Brucejack deposit, which is thought to have formed from a complex multistage magmatic-hydrothermal system underneath an active centre, is mostly underlain by volcano-sedimentary rocks of the Lower Jurassic Hazelton Group (Board et al., 2020).

Figure 1:Geological Map showing the major terranes that make up the British Columbia Canadian Cordillera. The location of the Brucejack deposit within the Golden Triangle area, which hosts to major Au, Ag, and Cu deposits, in west-central Stikinia is highlighted (modified after British Columbia Geological Survey 2018)

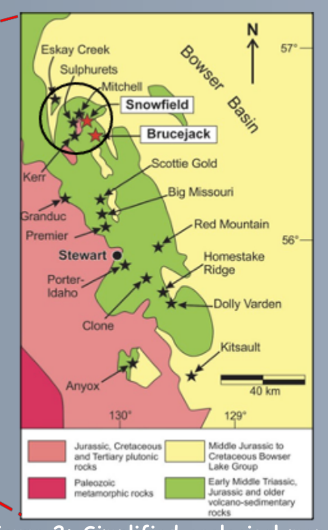

Figure 2: Simplified geological map of the Stewart-Eskay Creek district, showing the location of the major deposits, including the Sulphurets mineral district (circled region) (from McLeish et al, 2013)

III. Methods

- Seven surface drill holes were sampled from the Golden Marmot Target during the summer of 2022, as part of an Honours BSc thesis research project currently underway at the University of Saskatchewan.
- A total of twenty-five samples were selected for petrographic study using polished thin sections.
- Six representatives samples were selected for further study using scanning electron microscopy (SEM) and electron dispersive X-ray spectroscopy (EDS).

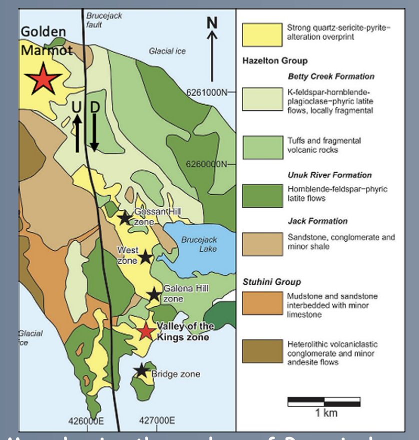

Figure 3: Map showing the geology of Brucejack property and the location of the main mineralized zones. Golden Marmot is located ~5km north of the Valley of the Kings zone (modified after Tombe, 2015).

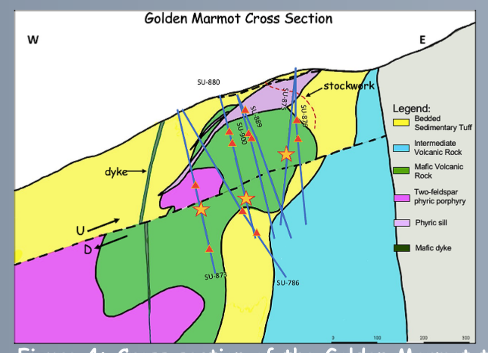

Figure 4: Cross section of the Golden Marmot target showing where the pyrite samples for this study were collected (star = visible gold mineralization, triangle = pyrite sample collected).

IV. Results and Interpretations

A. Petrographic Analysis

Six different pyrites are observed:

- Fine-grained crowded framboidal pyrite (py1) and partially recrystallized euhedral pyrite (Fig. 5A).
- Very fine-grained subhedral to euhedral disseminated pyrite (py2) and large anhedral pyrite blebs (Fig. 5B).
- Coarse- to medium-grained locally porous brecciated pyrite (py3) (Fig 5C).
- Medium-grained disseminated euhedral pyrite (py4) which hosts predominantly of silicate inclusions with smaller amounts of ± electrum, ± sulphides, and ± oxides (Fig. 5D).
- Medium-grained subhedral to anhedral pyrite (py5) with electrum nucleating on grain margins; often inclusion free (Fig 5E).
- Pyrite with an inclusion rich core. Inclusions are predominantly chalcopyrite ± electrum. Electrum locally nucleates along grain margins. Grain cores are mantled by euhedral, largely inclusion-free outer zones (py6) (Fig 5F).

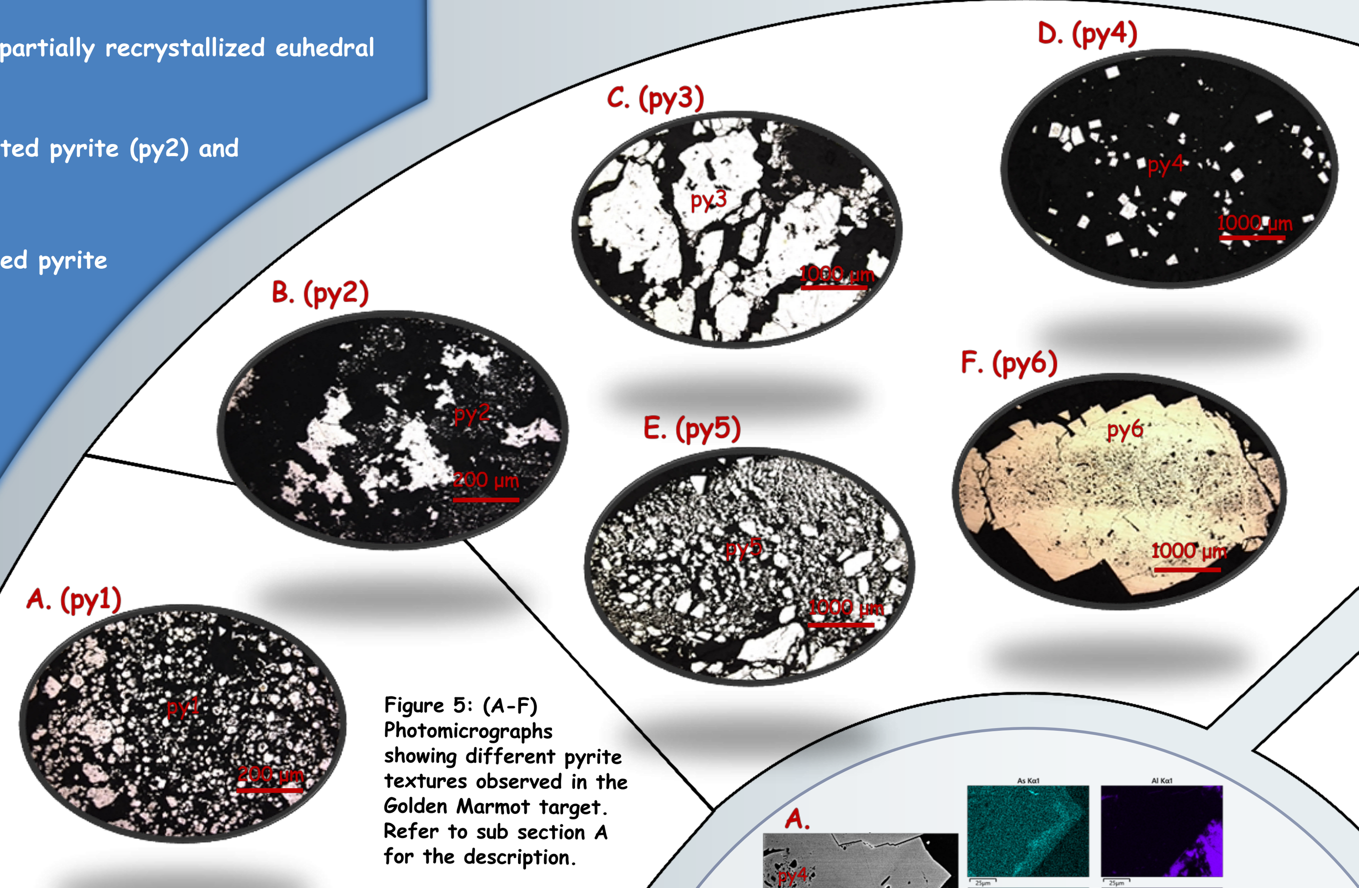

Figure 5: (A-F) Photomicrographs showing different pyrite textures observed in the Golden Marmot target. Refer to sub section A for the description.

B. Electrum and Pyrite Features

- Electrum and pyrite grain (py5) in quartz-carbonate vein (Fig. 6A).
- Electrum infilling fractures and nucleating along grain margins of a weakly corroded core pyrite (py6) (Fig. 6B).
- Electrum nucleating along pyrite (py4) grain margins (Fig. 6C); pyrite grain showing zoning patterns.
- Pyrite 6 (Fig. 6E and Fig. 6F) and pyrite 4 (Fig. 6D) of different morphology and size displaying a distinct reoccurring zoning pattern with inclusion-riddled cores and rare inclusion-free zones.

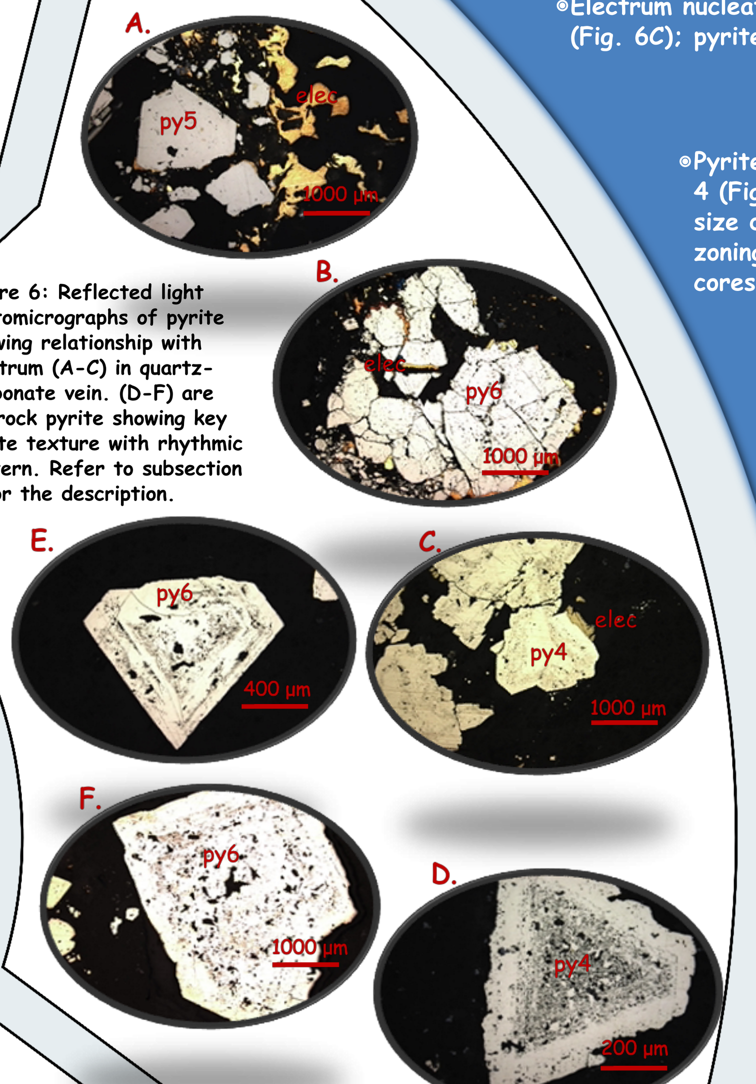

Figure 6: Reflected light photomicrographs of pyrite showing relationship with electrum (A-C) in quartz-carbonate vein. (D-F) are wallrock pyrite showing key pyrite texture with rhythmic pattern. Refer to subsection B for the description.

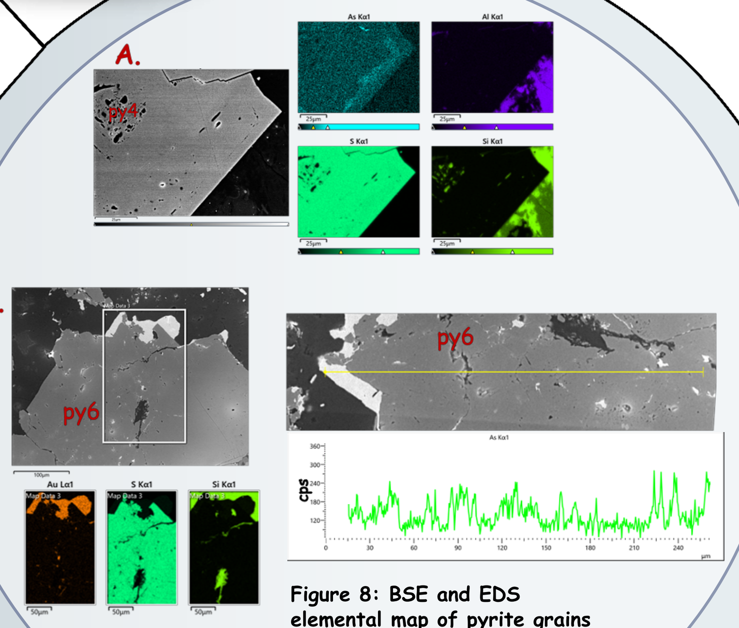

Figure 8: BSE and EDS elemental map of pyrite grains (py4 and py6) (Fig. A-B). EDS line scan for py6 (Fig. B). Refer to subsection C for explanation

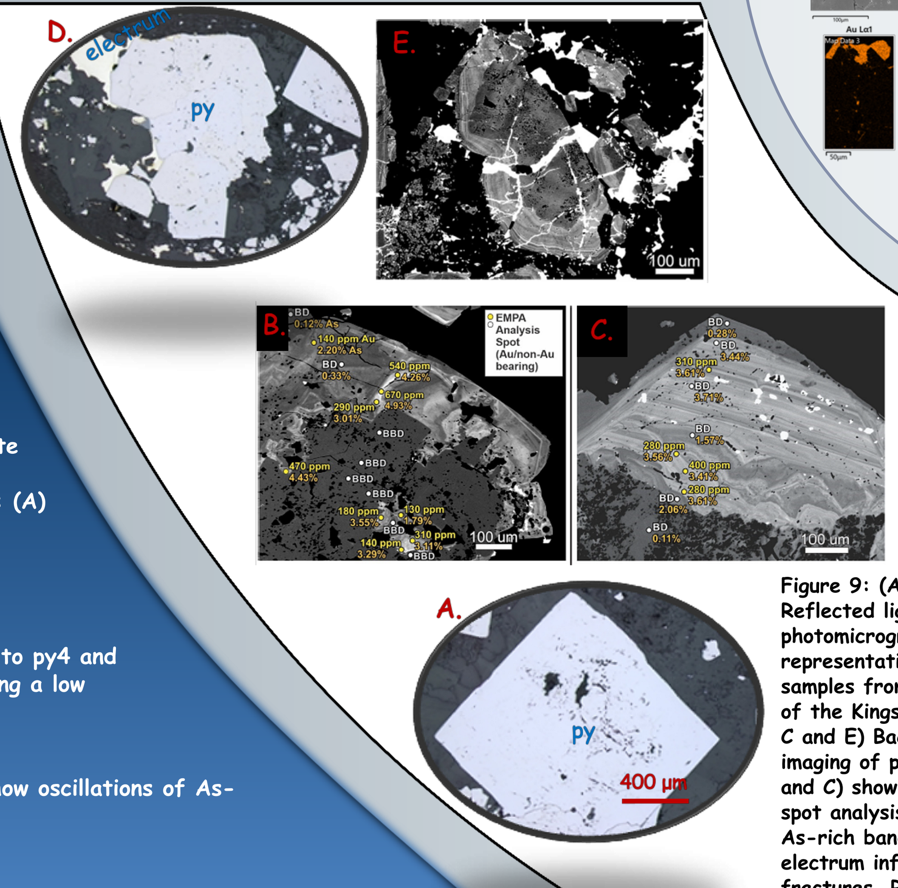

Figure 9: (A and D) Reflected light photomicrograph of representative pyrite samples from the Valley of the Kings (VOK). (B, C and E) Back scattered imaging of pyrite. (B and C) show EMPA-WDS spot analysis. (E) shows As-rich band and electrum infilling py6 fractures. Refer to subsection D for explanation (modified after McLeish 2017, 2022)

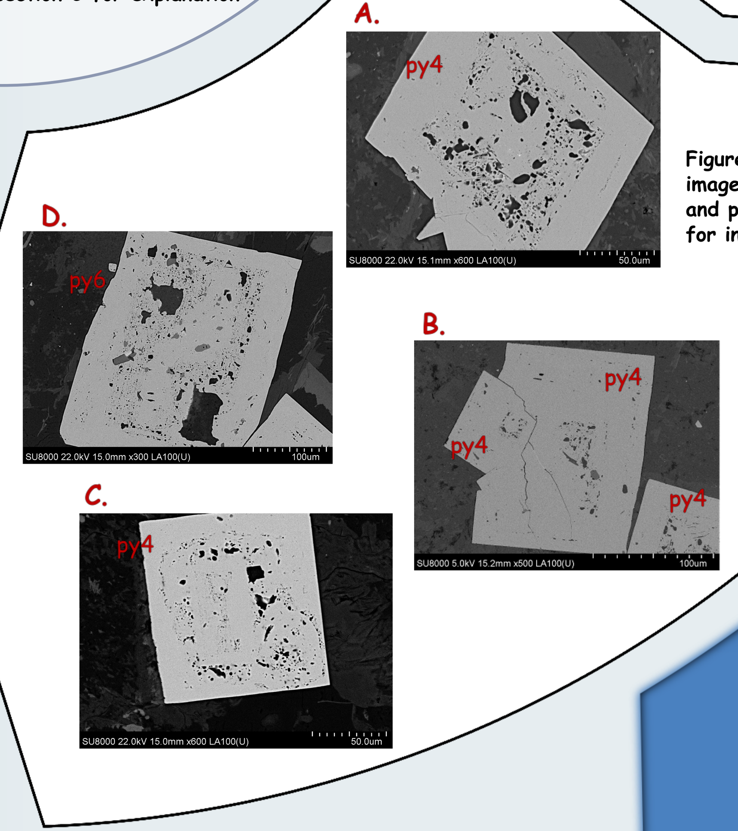

Figure 7: Backscattered electron image (BSE) of pyrite grains (py4 and py6). Refer to subsection C for interpretation.

C. BSE and SEM-EDS Analyses

Preliminary observations on pyrite from Golden Marmot target have been made using the Hitachi SU8010 FE-SEM at the WCVM Imaging Centre at the University of Saskatchewan, in back-scattered electron (BSE) mode and using Energy Dispersive Spectroscopy (EDS).

- BSE images of euhedral to subhedral py4 and py6 emphasizes the consistent rhythmic pattern of zoning surrounding a coroded core (Fig. 7 A-D).
- BSE imaging and EDS elemental map of py4 (Fig. 8A) clearly shows the presence As-rich one towards the margin of the grain.
- BSE imaging and EDS elemental map shows electrum nucleating along the edges of py6 grain (Fig. 8B). EDS line scan elemental analyses of this grain reveals oscillatory pattern marked by sequences of As-bearing and As-poor bands.

Further BSE images and compositional data will be obtained using the Cameca SX-100 electron microprobe at the Saskatchewan Research Council.

D. Comparison with the Valley of the Kings (VOK) zone

- In Golden Marmot (GM), the following pyrite textures are observed which are strikingly similar to those documented in VOK pyrite: (A) shows a distinct reoccurring pattern of corroded core pyrite. (D) shows electrum nucleating on weakly corroded core pyrite.
- In VOK, BSE imaging of pyrite (equivalent to py4 and py6 on GM) shows a oscillatory zoned haloing a low arsenic core (Fig. 9B-9C).
- In GM, initial elemental analyses of py6 show oscillations of As-bearing and -As-poor ones.
- In the VOK, EMPA-WDS spot analysis (Fig. 9B-9C) indicating high (>100) ppm of Au within the sequences of white As-rich oscillatory band.
- Hence, there is likely invisible Au in GM pyrite, within the As-rich spike zones and given the similar textural characteristics of pyrite.
- These similarities suggest that the GM exploration target and the VOK experience a common history of hydrothermal evolution.

V. Paragenetic Sequence

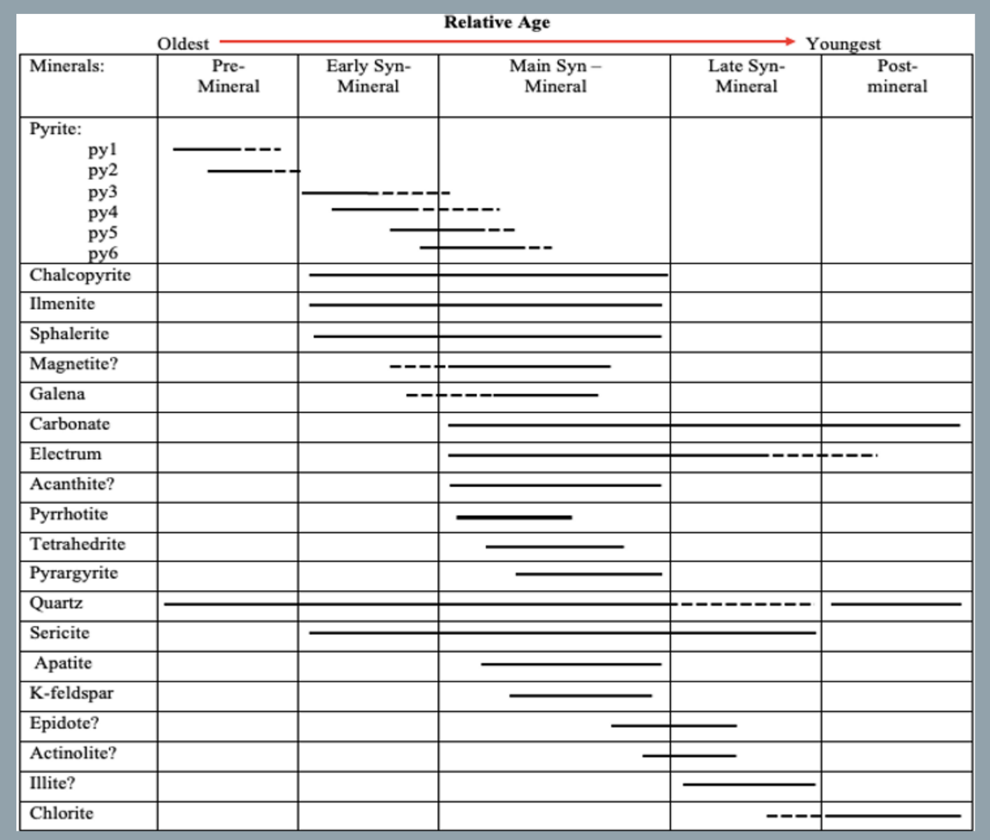

Figure 10: Paragenetic sequence of the GM target based on petrographic observations, and cross-cutting relationships. Solid line indicates a more certain paragenetic timing, whereas dashed line indicates a possible presence of that mineral.

VI. Summary and Implications

- There are at least six texturally unique types of pyrite found in the Golden Marmot target.
- Common alteration that are observed are as follows: strong sericite alteration, pervasive phyllic (quartz-sericite-pyrite) alteration, propylitic (carbonate-chlorite) and local chloritization of amphibole.
- At Golden Marmot, BSE imaging and SEM-EDS line scan elemental analyses does suggests oscillatory zoning of As-bearing and As-poor bands in py4 and py6 do exist.
- At VOK, BSE imaging of pyrite (considered to be equivalent to py4 and py6 on GM) emphasize the complex oscillatory zoning and spot analyses indicate high amount of invisible gold within the As-rich band. One can suggest, that py4 and py6 on GM might also contain a high amount of invisible gold.
- Although there are differences in size and morphologies of the growth zones between VOK and GM, the overall patterns exhibited by pyrite are strikingly similar.
- Geochemical fingerprints of pyrite are a potential powerful vector to epithermal mineralization.
  - Sykora et al (2018) reported the occurrence of distinct pyrite textures that are connected with porphyry-and epithermal-type compositional anomalies by studying the supergiant Lihir porphyry-epithermal Au deposit in Papua New Guinea.
  - The oscillatory arsenian/auriferous pyrite along the rims of pyrite grains is a characteristic signature of epithermal type mineralization at Brucejack.

VII. Acknowledgements and References

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- List of references can be found using the QR code.