Mineralogical and chemical characterization of pyrite-sphalerite bands from metamorphosed volcanogenic massive sulphide deposits

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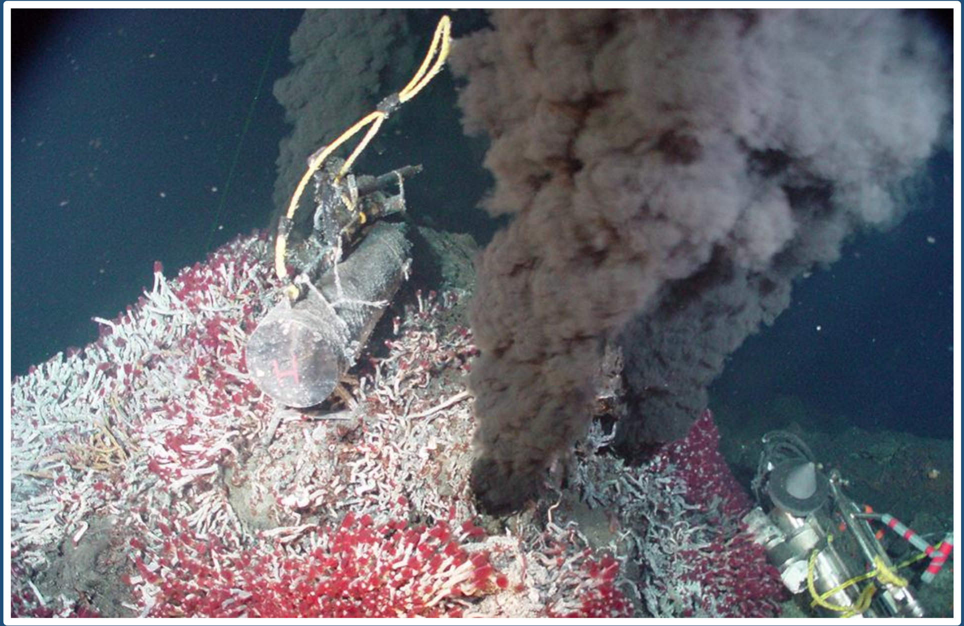

Figure 1: Active hydrothermal vent on the ocean floor ("Black smoker"; https://oceanservice.noaa.gov/facts/vents.html)

Volcanogenic Massive Sulphide (VMS) Deposits

VMS deposits are polymetallic mineral deposits that are an important source of copper, zinc, lead, gold, and silver. These deposits formed throughout Earth's history in various tectonic settings with modern analogues on today's ocean floor (black and white smokers; Fig. 1; Galley *et al.*, 2007). VMS deposits form lens-shaped accumulations of sulphide minerals on or below the seafloor due to mixing of hot, ascending hydrothermal fluids with ambient seawater.

Figure 2: Massive sulphide ore body in the metamorphosed Ming mine, Newfoundland

Research Objective & Impact

Many VMS deposits are metamorphosed and deformed after formation undergoing pressure and temperature changes that impact the distribution of sulphides. The origin of pyrite-sphalerite bands (Fig. 3) in metamorphosed VMS deposits is debated. **The objective of this research is to constrain the origin of the pyrite-sphalerite bands with specific focus on the role of metamorphism and deformation using microscopic, microstructural, and structural methods.** For this study, massive sulphide samples from six metamorphosed VMS deposits including Kidd Creek (Ontario, Canada), Flin Flon (Manitoba, Canada), LaRonde-Penna (Quebec, Canada), Ming (Newfoundland, Canada), Mount Morgan (Tasmania, Australia), and Kristineberg (Sweden) were collected to address the research objective.

This research will have implications for the interpretation of ore genesis in VMS deposits. Additionally, the current increase in global metal demand requires an increase in metal recovery in which this research can assist as well.

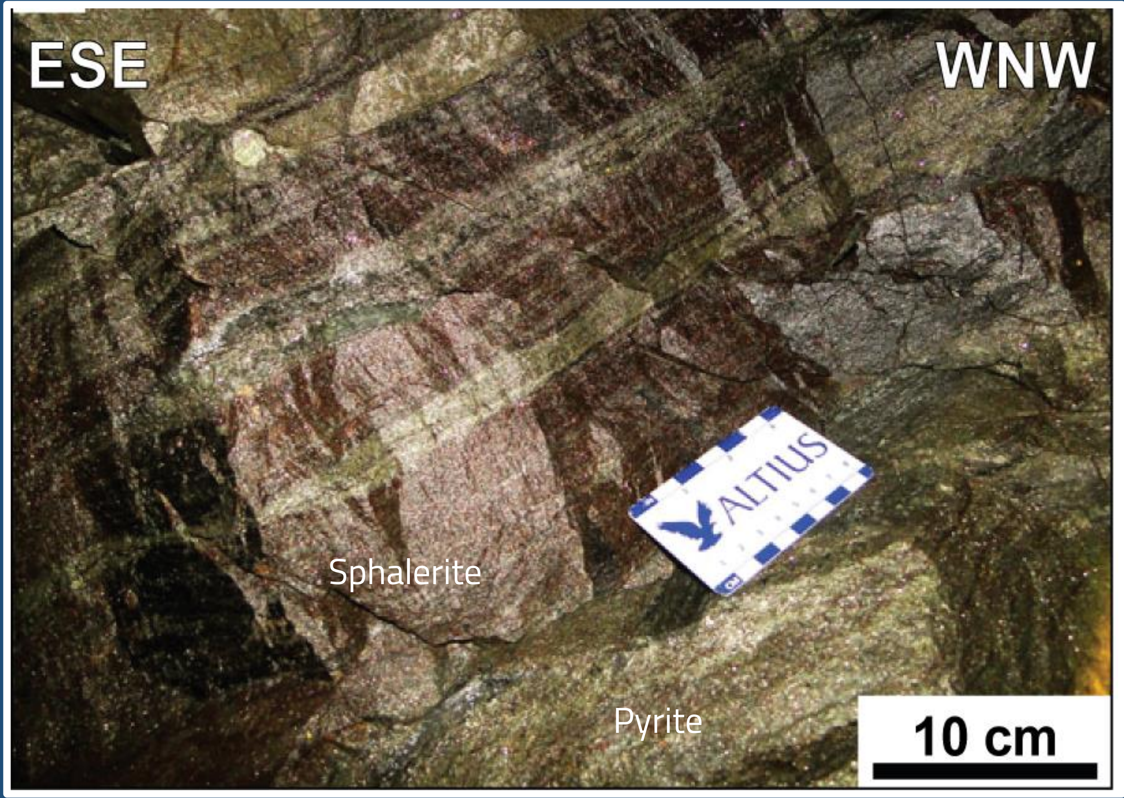

Figure 3: Pyrite-sphalerite band in the deformed Ming mine, Newfoundland (Brueckner *et al.*, 2014)

Figure 4: World map showing the sample locations for this study (https://www.pngaaa.com/detail/250504)

Metamorphism of VMS Deposits

The VMS deposits examined in this study were metamorphosed at ~300 to 500 ˚C and ~3 to 5 kbar. Metamorphism has led to the formation of characteristic textures, as seen in the following Scanning Electron Microscope (SEM) images:

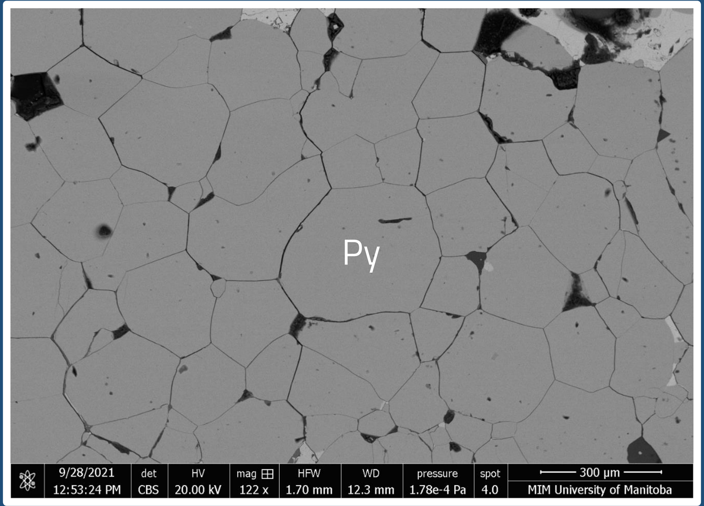

Figure 5: Annealed texture of recrystallized pyrite (Py) with 120˚ triple junctions

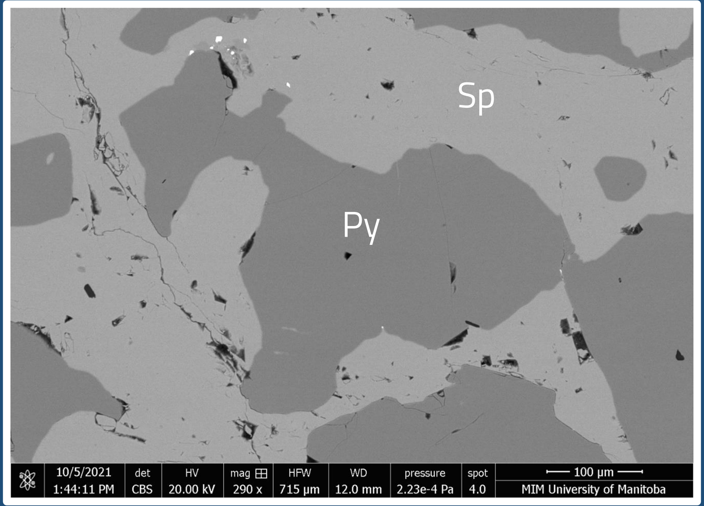

Figure 6: Caries texture of pyrite (Py) in sphalerite (Sp)

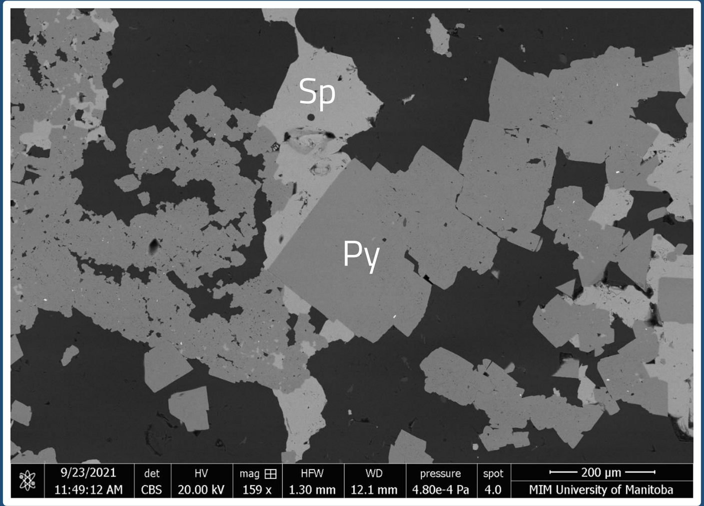

Figure 7: Different generations of recrystallized pyrite (Py) partly overgrowing sphalerite (Sp)

References

Brueckner, S.M., Piercy, S.J., Sylvester, P.J., Maloney, S. & Pilgrim, L. (2014): Evidence for Syngenetic Precious Metal Enrichment in an Appalachian Volcanogenic Massive Sulfide System: The 1806 Zone, Ming Mine, Newfoundland, Canada; *Society of Economic* Geologists, Volume 109, pages 1611-1642.

Galley, A., Hannington, M. & Jonasson, I. (2007): Volcanogenic massive sulphide deposits: in Goodfellow W.D. (ed) Mineral Deposits of Canada: A synthesis of major deposit-types, district metallogeny, the evolution of geological provinces, and exploration methods; *Geological Association of Canada*, Mineral Deposits Division, pages 141-161.

Further Work

Figure 8: EBSD used for microstructural analyses in pyrite (https://htcao.weebly.com/home/electron-backscatter-diffraction-ebsd-training)

Electron Backscatter Diffraction

Electron backscatter diffraction (EBSD; Fig. 8) will be used to analyze the microstructure of pyrite grains. This will determine if pyrite in the identified textures (Figs. 5 to 7) formed during deformation or not. If the former case occurred, crystal orientation in pyrite should show a preferred orientation in all analyzed grains; however, if the latter case is true, pyrite crystal orientation is random.

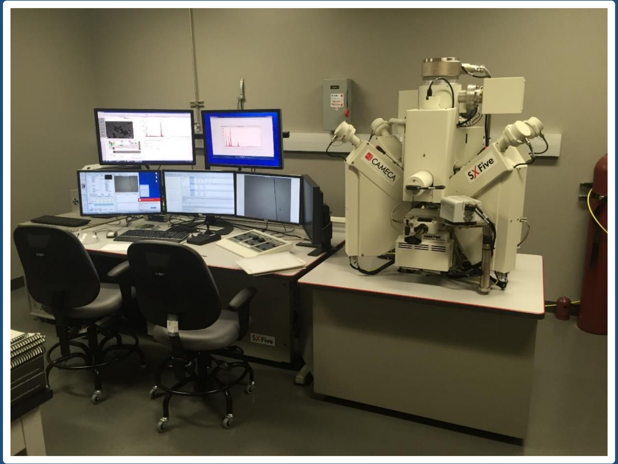

Figure 9: EPMA used for compositional analyses of pyrite and sphalerite (https://mcf.tamu.edu/instruments/electron-microprobe/)

Electron Microprobe Analysis

Electron microprobe analysis (EPMA; Fig. 9) and laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) will be used to perform an in-depth analysis of the chemical composition of pyrite and sphalerite grains. This will determine if compositional changes in pyrite prevailed during metamorphism and deformation or if metals were chemically remobilized during metamorphism and deformation.