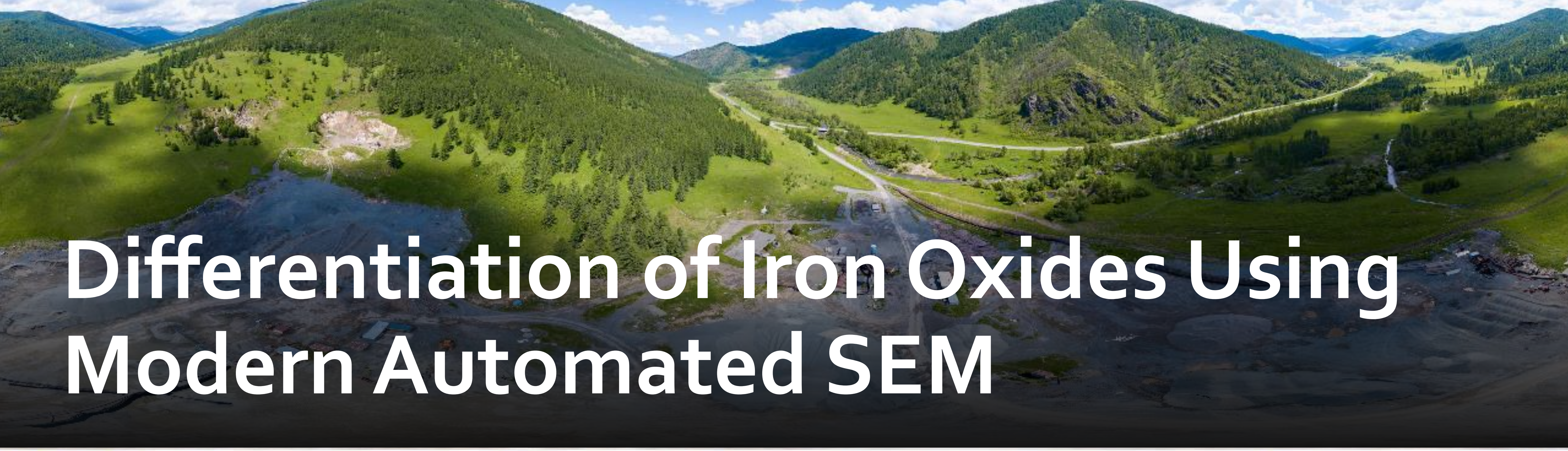


Differentiation of Iron Oxides Using Modern Automated SEM

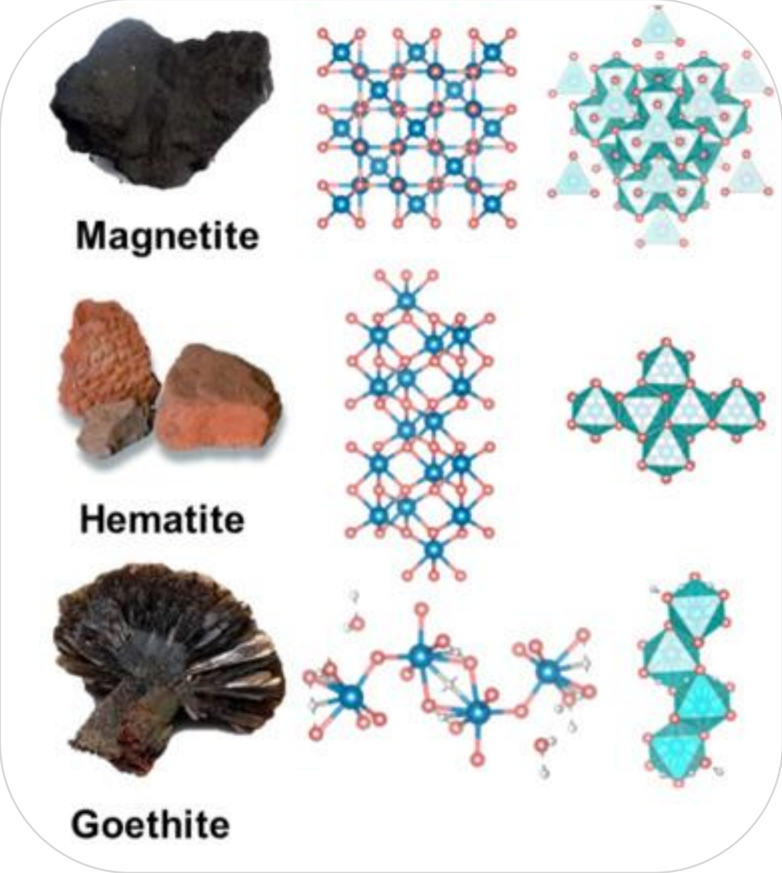




K. Youlton, L. Vonopartis, S. Poelinca , R. Harrison , | 14 October 2025

The Building Blocks of Our Story

- Magnetite (Fe_3O_4): Mixed-valence oxide; magnetic; forms under intermediate redox conditions
- Hematite (Fe_2O_3): Stable under oxidizing conditions; red-brown color
- Goethite (FeO(OH)): Common weathering product
- Others: Wüstite (FeO), Lepidocrocite (γ-FeO(OH)) – less common but important in specific environments



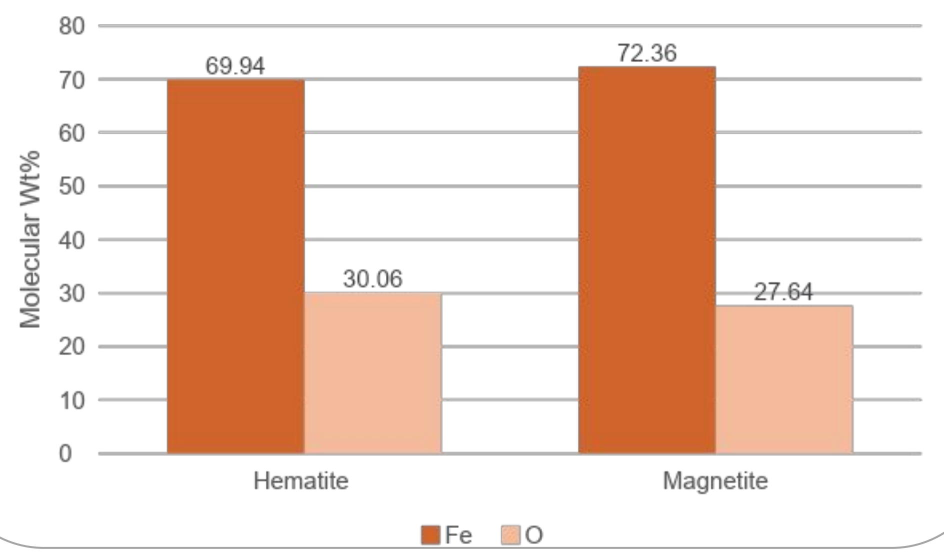
Why Hematite vs. Magnetite Matters

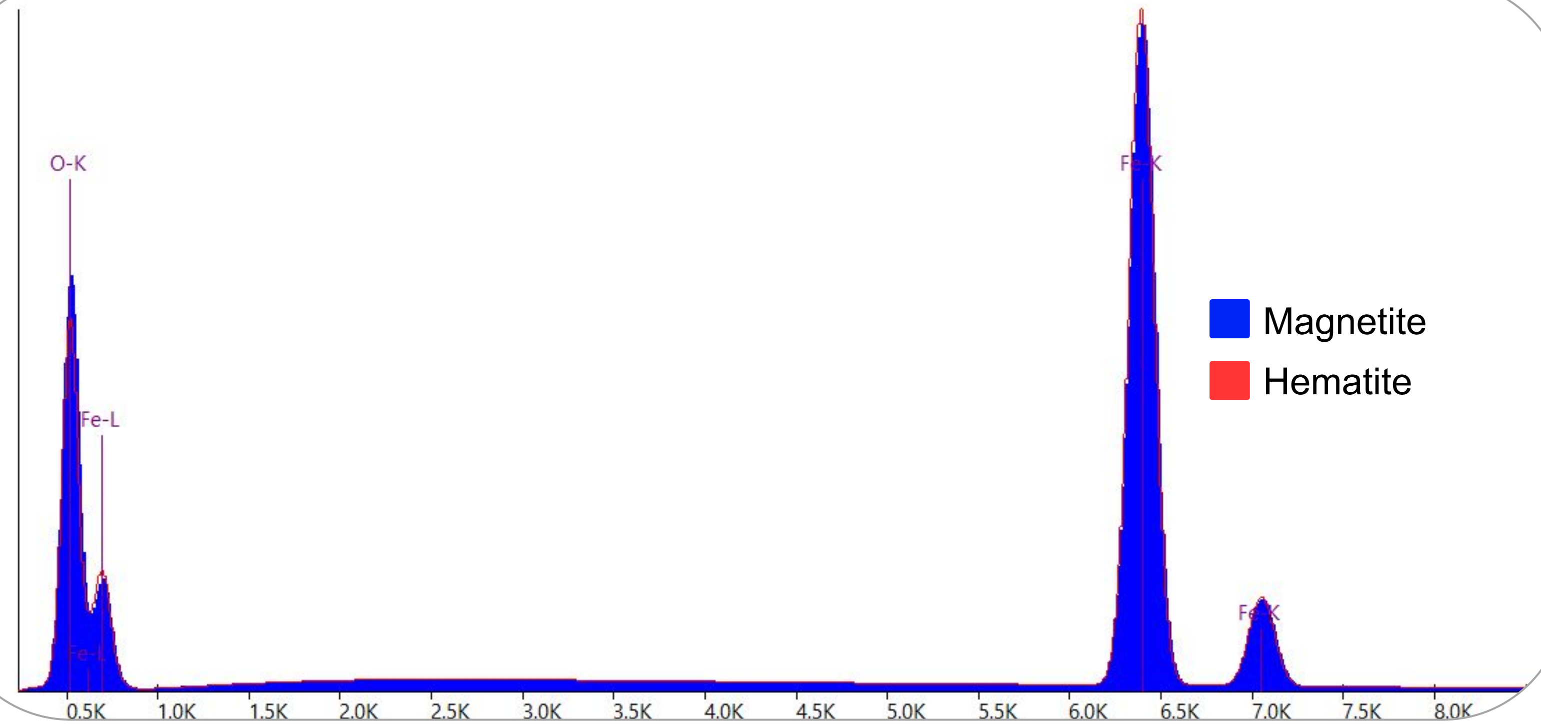
- Indicators of redox conditions and ore-forming processes
- Why it matters: Ore genesis, fluid evolution
- Metallurgical recovery
- Impact on mine planning and resource evaluation

Natural History Museum

The Challenge of Similarity

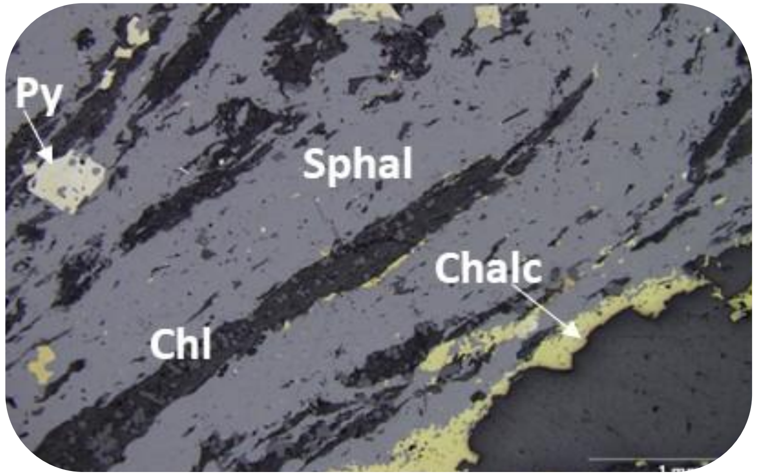
- Similar Fe/O ratios and BSE response
- Historical limitations in AutoSEM workflows

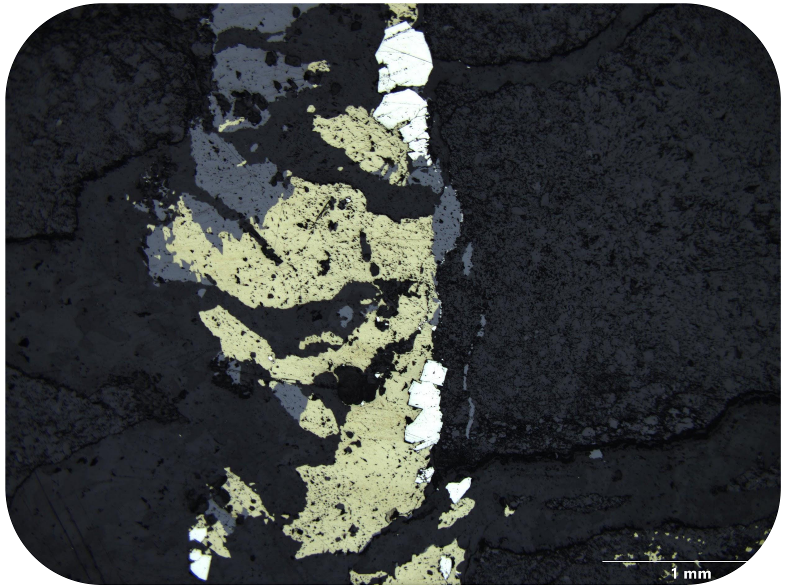


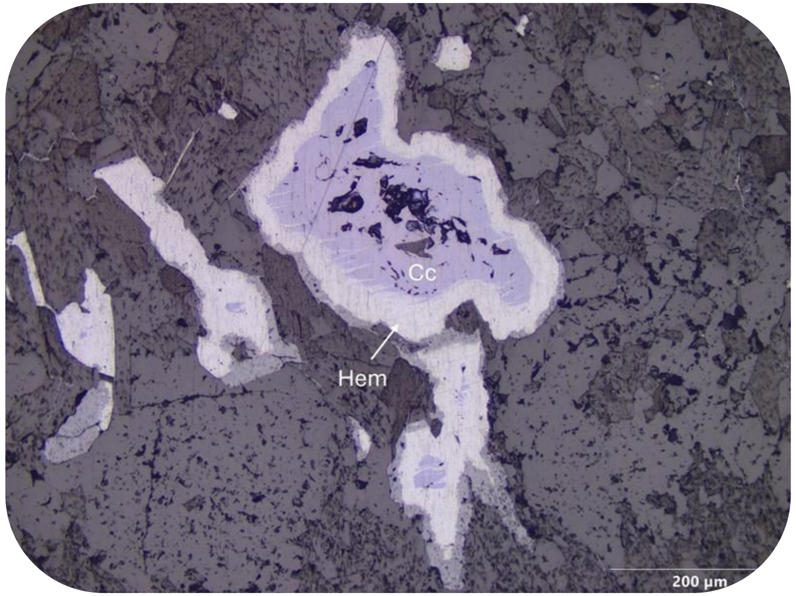


The Ore That Started It All

- Ore body characterisation
- Define the mineralisation zones (oxide, transition and sulphide)

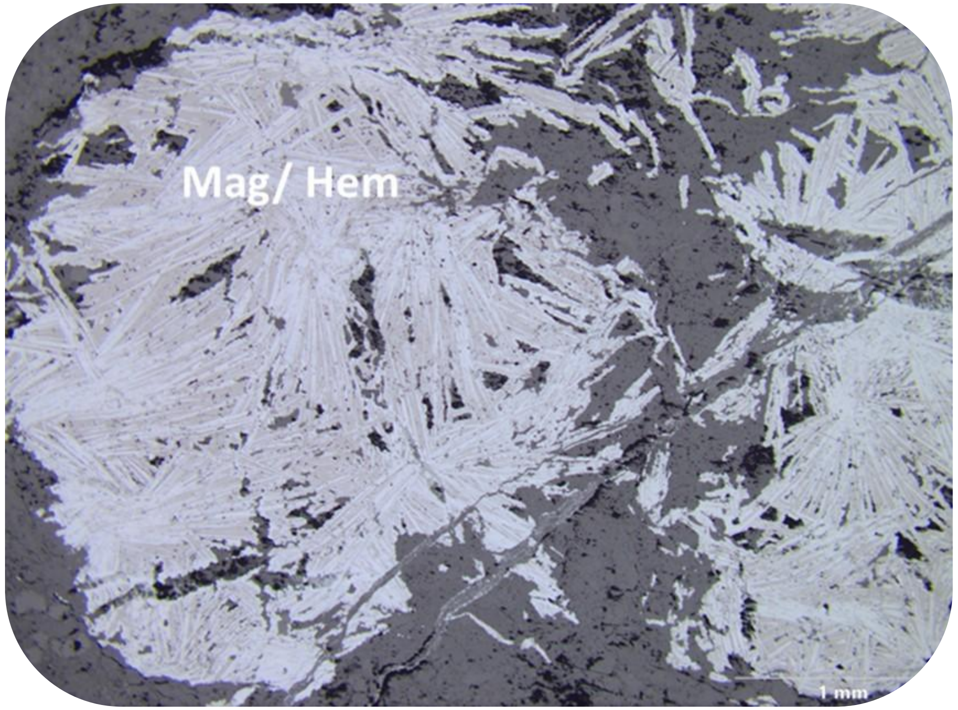






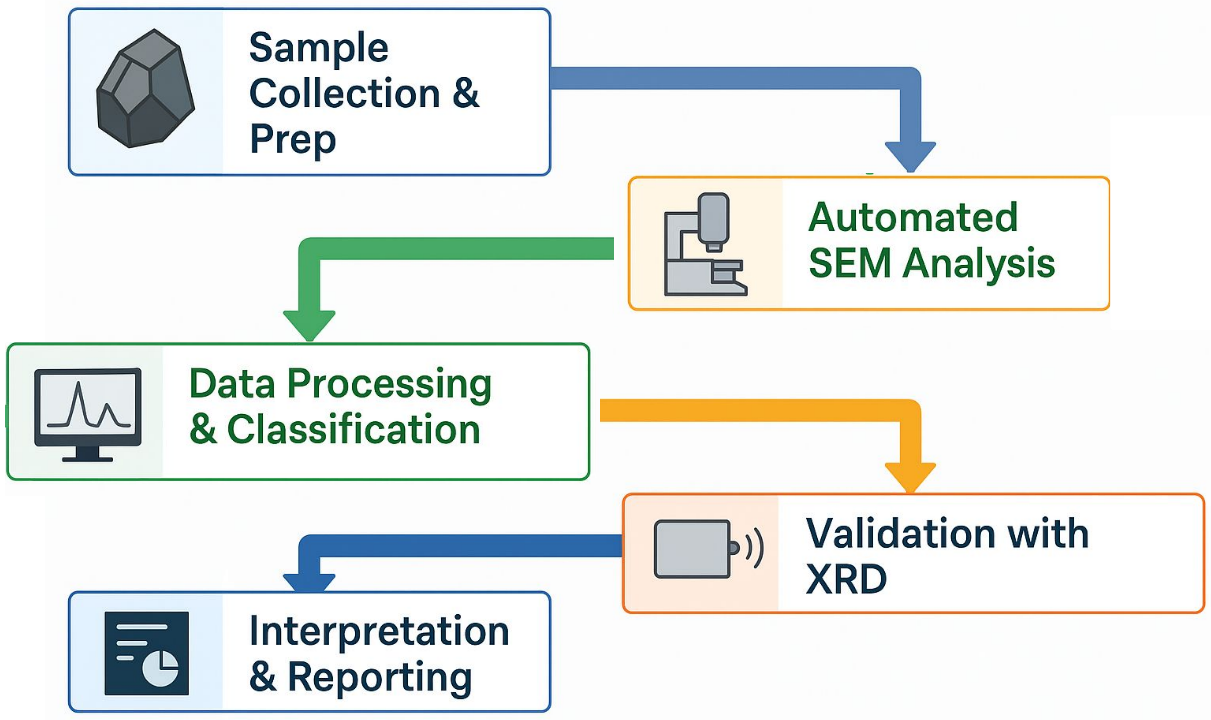
Past Attempts and Lessons Learned

- QEMSCAN, MLA
- BSE stretching + sample prep techniques
- Limitations: Calibration complexity, fine-grained textures



Study Objectives

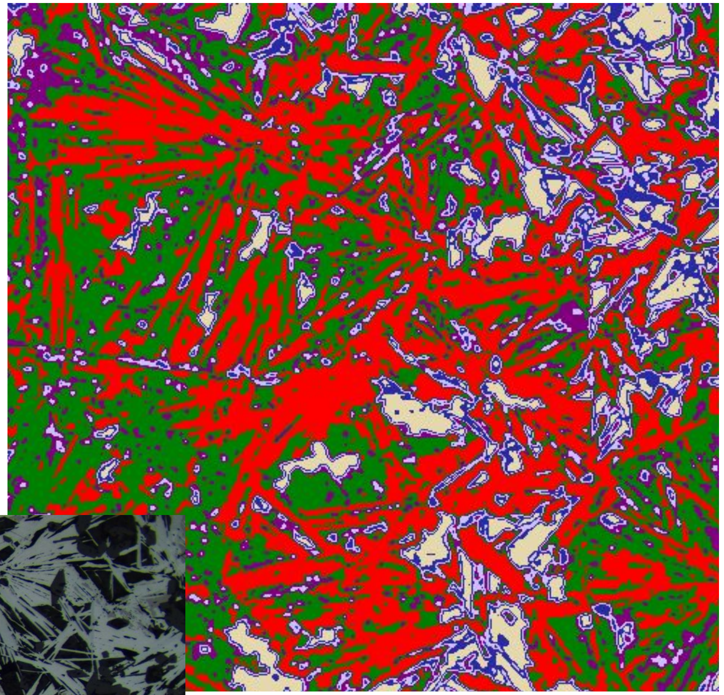
- Goal: Develop a robust AutoSEM workflow
- Validate against XRD
- Deliver insights for geology and metallurgy

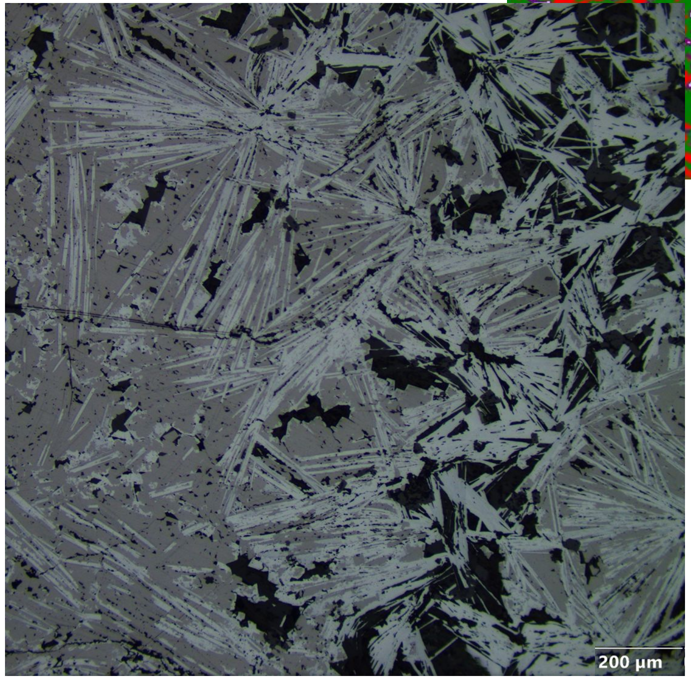


Mapping the Invisible

- Resolution: 1.5 µm pixel spacing
- X-ray counts: 1500 per point
- Output: Mineral maps and textural data

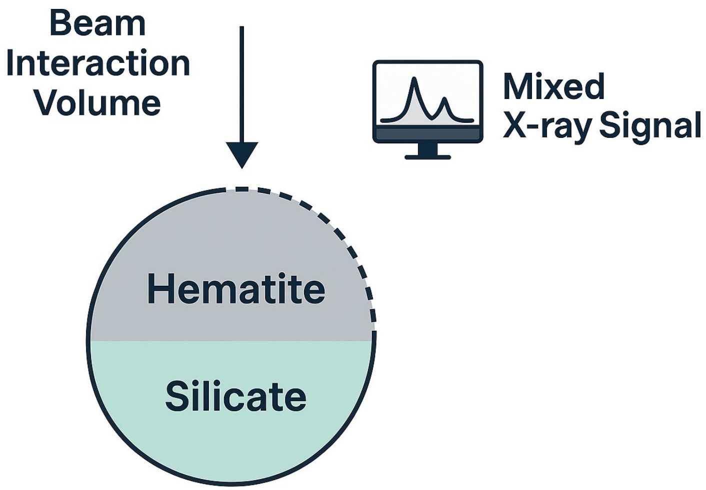
- Fe:O ratios (+- BSE influence)

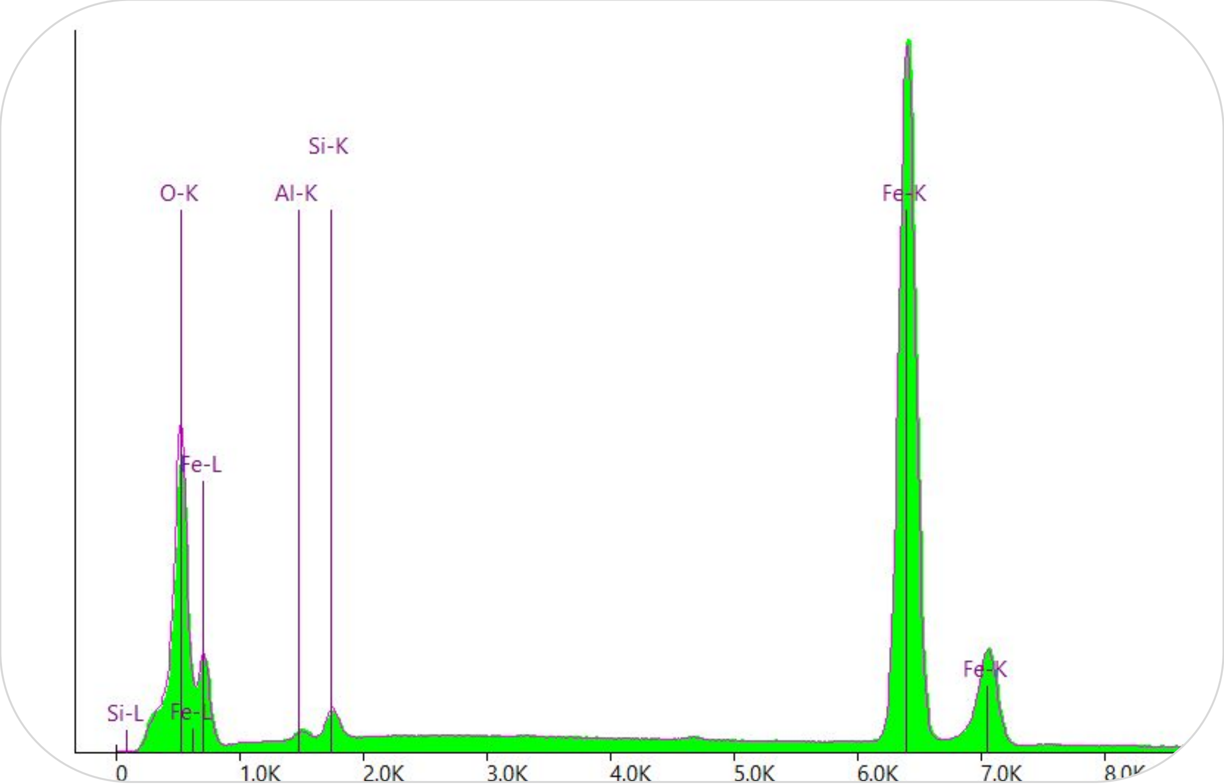




Tackling Impurities

- Impurities >1%: Ti, V, **Al, Si**
- Understanding the difference between **mixed signal effect** (interaction volume) vs inclusions
- Adjusting classification thresholds

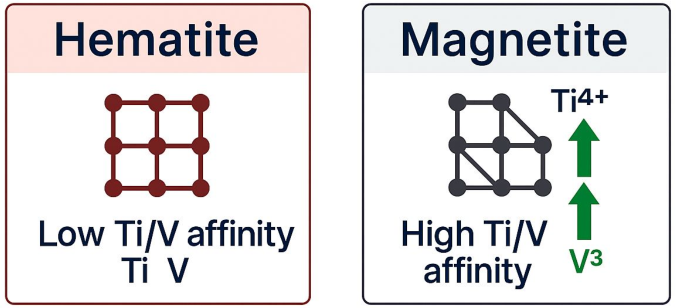




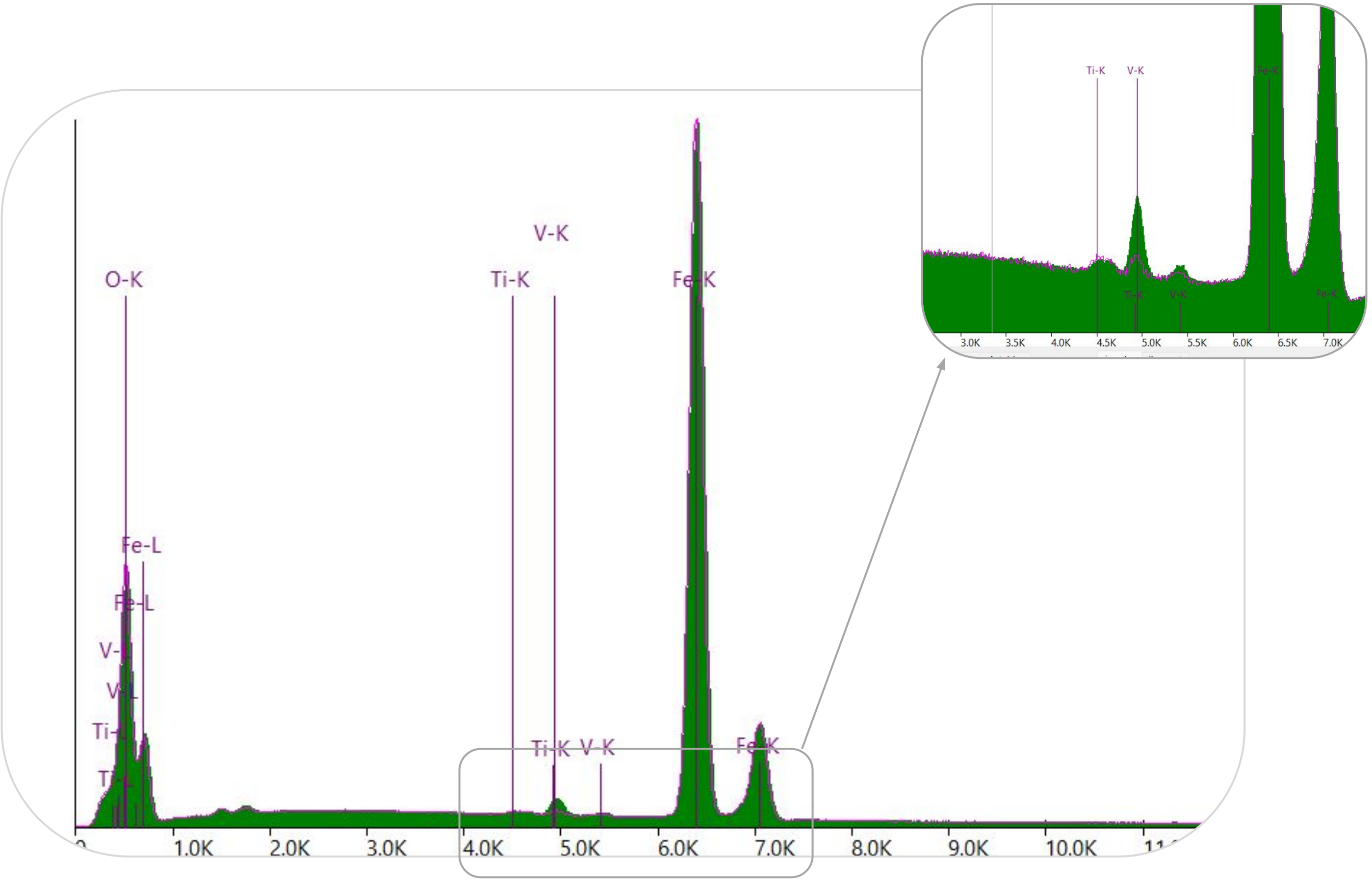
Tackling Impurities

- Impurities >1%: **<u>Ti, V</u>**, Al, Si
- Understanding the difference between mixed signal effect (interaction volume) vs **<u>inclusions</u>**
- Adjusting classification thresholds

Impurity Affinities: Hematite vs. Magnetite

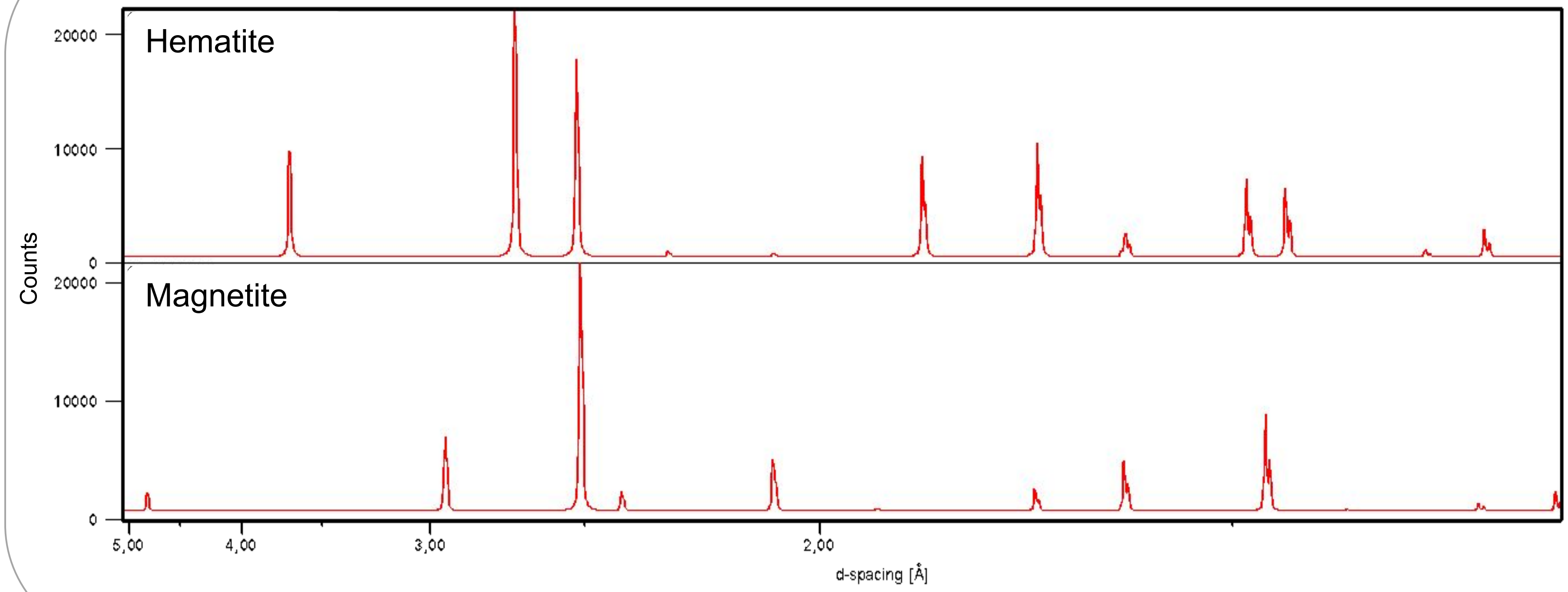


Structural flexibility in magnetite allows significant Ti and V substitution: hematite is more restrictive.



The Validation Partner

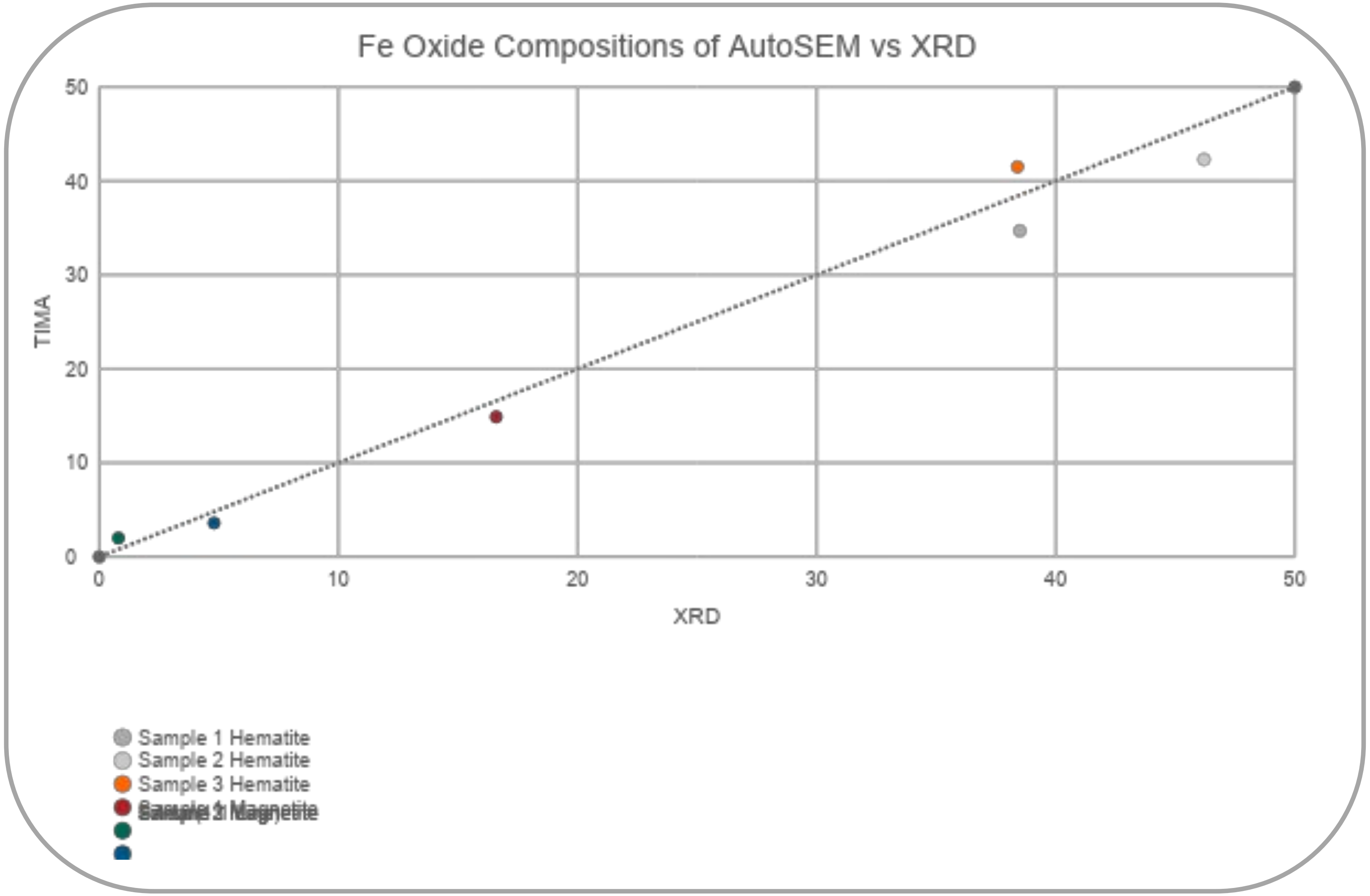
- XRD
- Rietveld refinement



Case Study 1 – Bulk Mineralogy

Mineral	Sample 1		Sample 2		Sample 3	
	TIMA	XRD	TIMA	XRD	TIMA	XRD
Ilmenite	30.0	-	51.4	-	43.1	-
Hematite	38.5	34.7	46.2	42.3	38.4	41.5
Magnetite	16.6	14.9	0.8	2.0	4.8	3.6
Quartz	4.5	-	0.4	-	3.2	-
Titanomagnetite	0.4	-	0.2	-	7.4	-
Chlorite	3.1	-	0.6	-	2.0	-
Apatite	4.9	-	0.0	-	0.0	-
Garnet	1.1	-	0.2	-	0.4	-
Other	0.4	-	0.4	-	0.5	-
Feldspar	0.4	-	0.0	-	0.0	-
Ulvospinel	0.2	-	0.0	-	0.2	-

Case Study 1 – Bulk Mineralogy



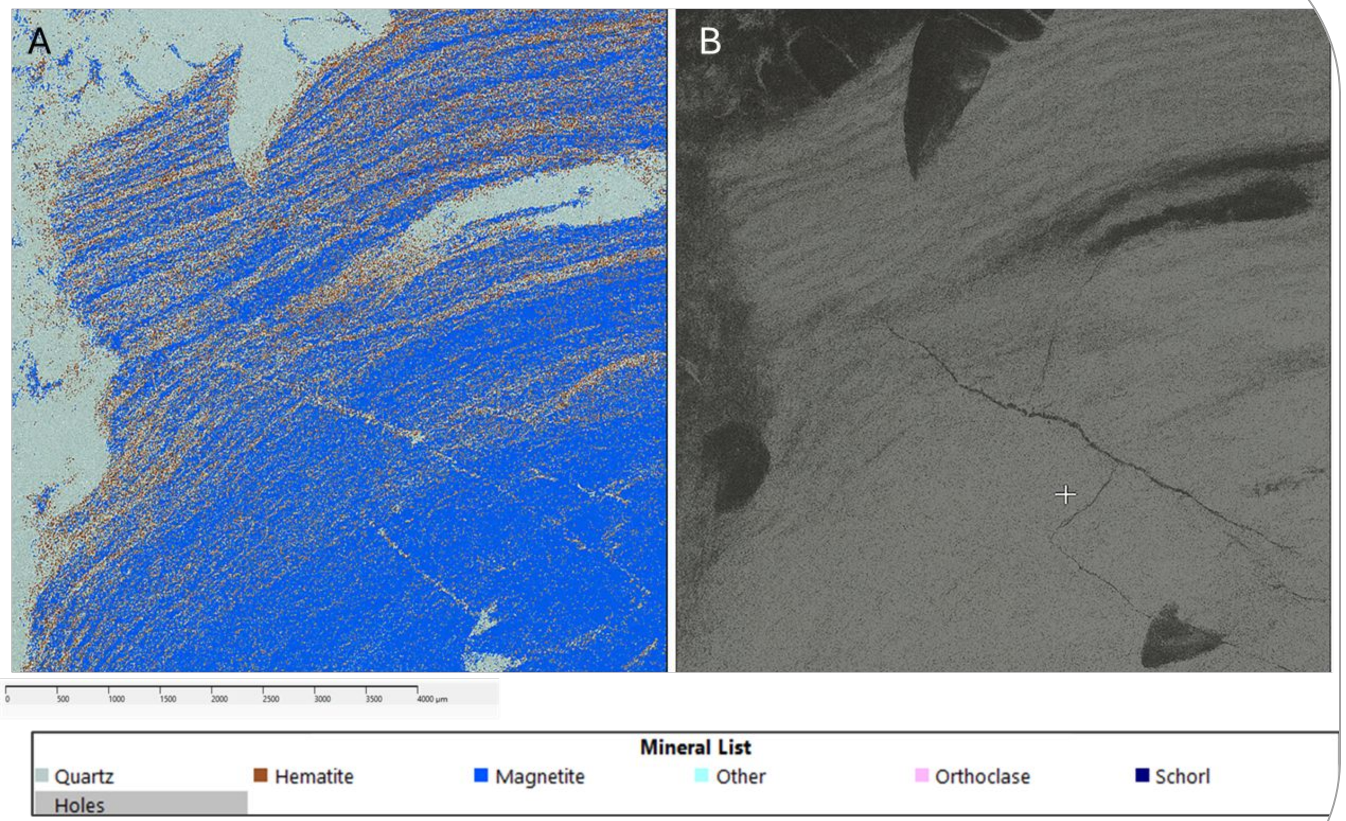
Variability Between Methods

Aspect	AutoSEM (TIMA-X)	XRD (Rietveld)
Sample prep	Polished section, localized analysis	Bulk powder homogenisation
Data Type	Spatially resolved mineral maps (textural + modal)	Bulk mineralogy (whole-sample average)
Detection Limit	Sensitive to trace phases in mapped area	~1-3 wt% for crystalline phases
Quantification Basis	Pixel-based phase assignment via elemental (+BSE) thresholds	Rietveld refinement
Limitations	Localized analysis; sensitive to sample prep	Cannot resolve textures or amorphous phases

SGS

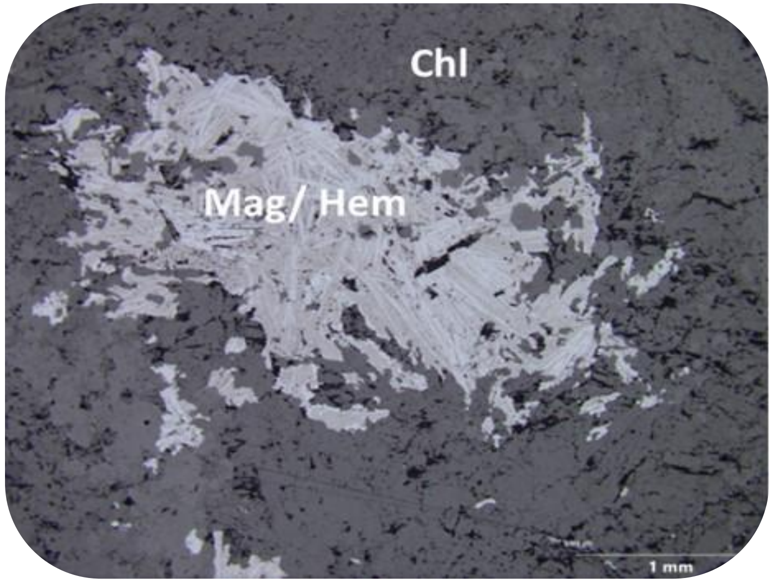
Case Study 2 – Textural Insights

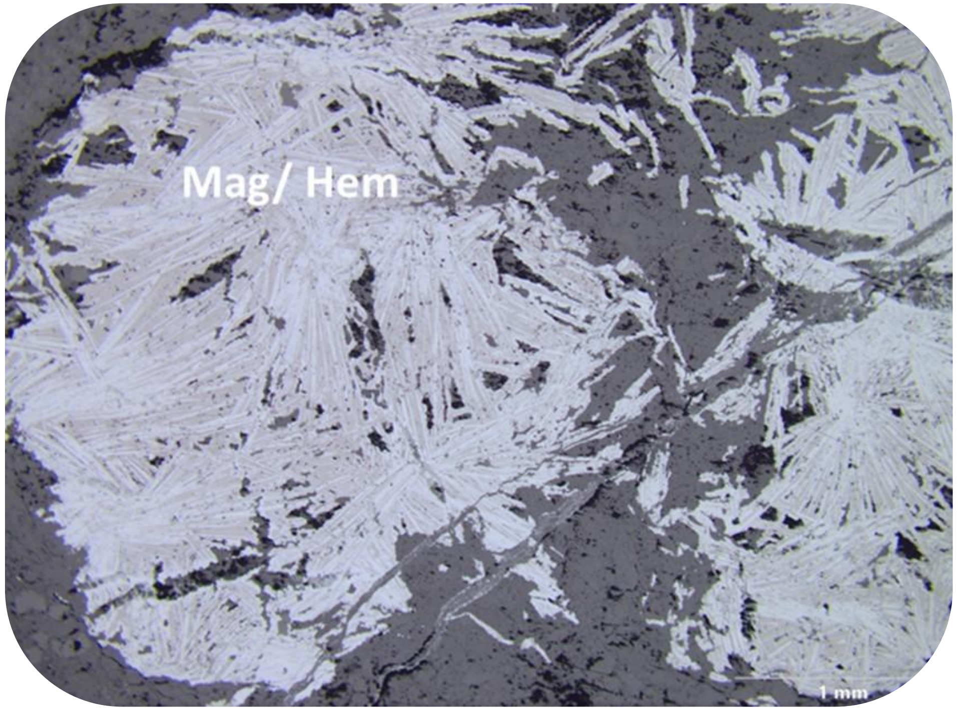
- Polished BIF sections
- Mineral map and BSE image
- Hematite replacing magnetite in oxidized zones



Challenges

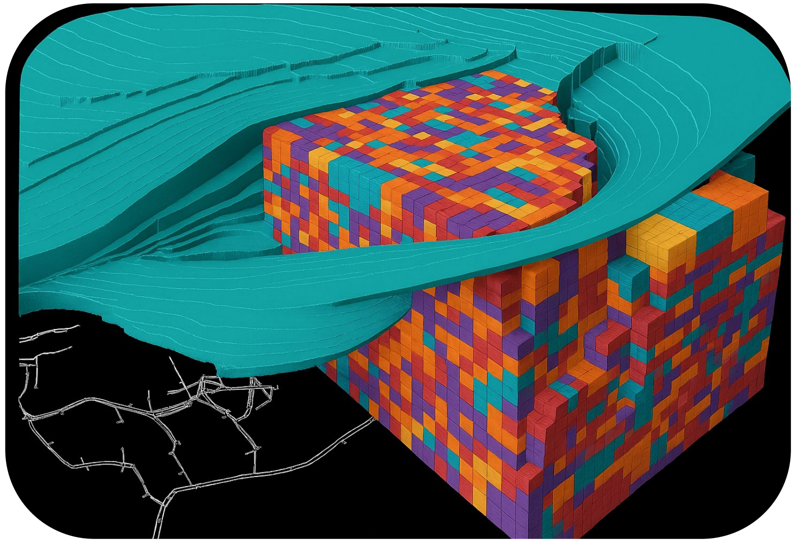
- Boundary phases
- Classification scheme updates required

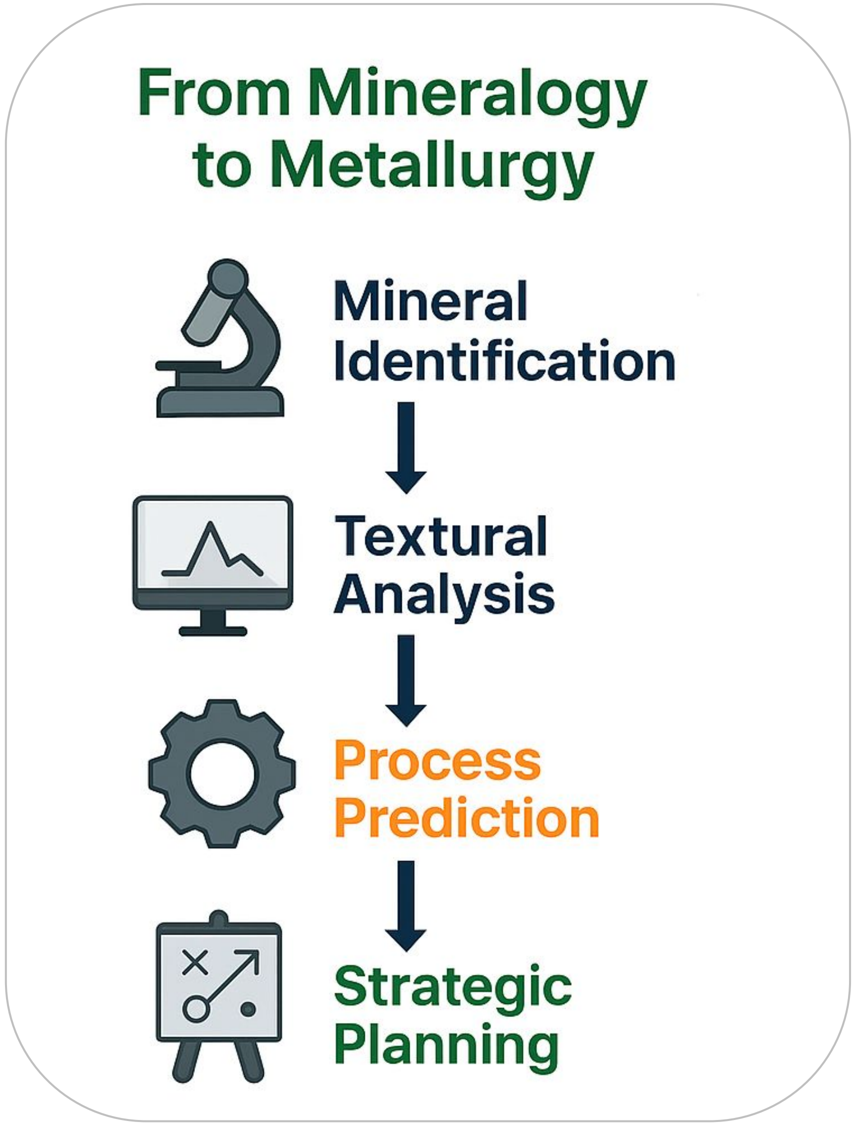


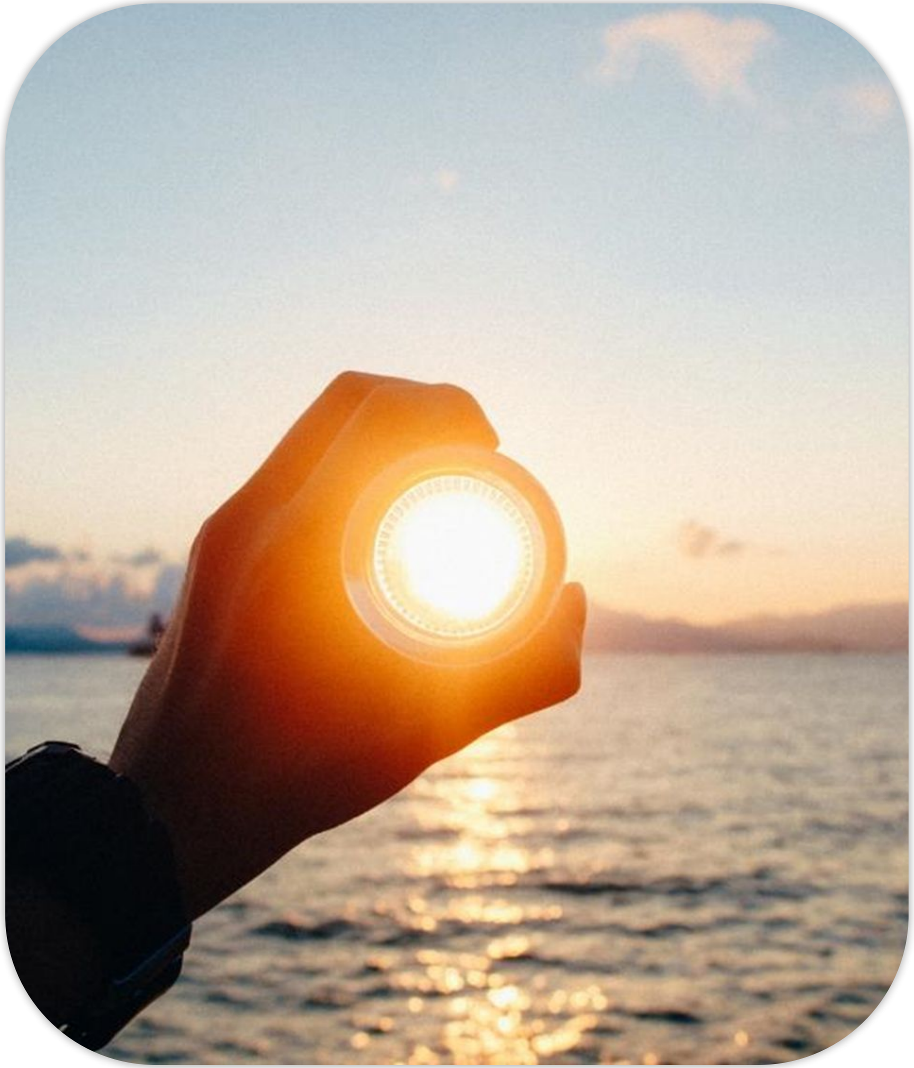


Conclusion

- Modern autoSEM workflow improves phase discrimination
- Improved TAT
- Integration with deportment data
- Enables accurate quantification and textural insights
- Supports geological modelling and metallurgical planning







Thank you!

Do you have any questions?

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