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HyMap Airborne Imaging Spectroscopy for Mineral Potential Mapping of Cupriferous Mineralization in Semi-arid Region Based on Pixel/Sub-pixel Hydrothermal Alteration Minerals Mapping – A Case study

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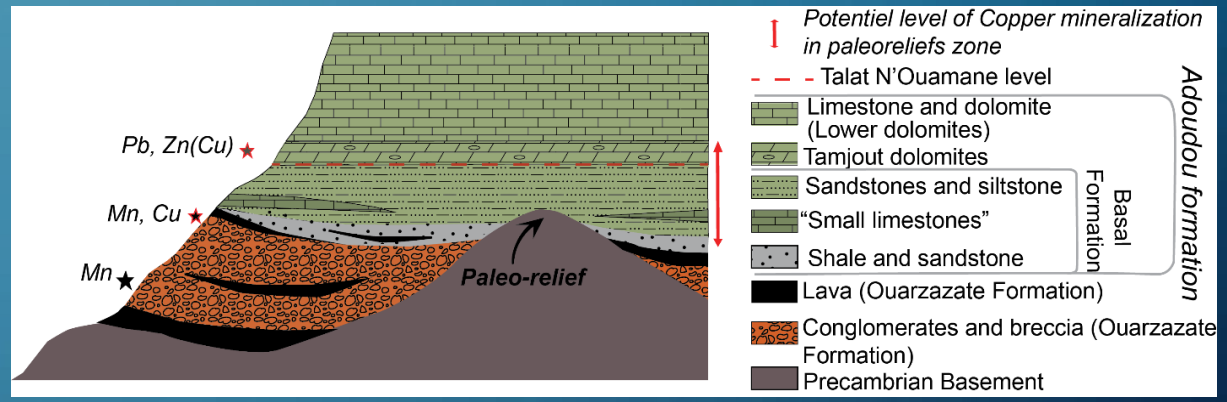
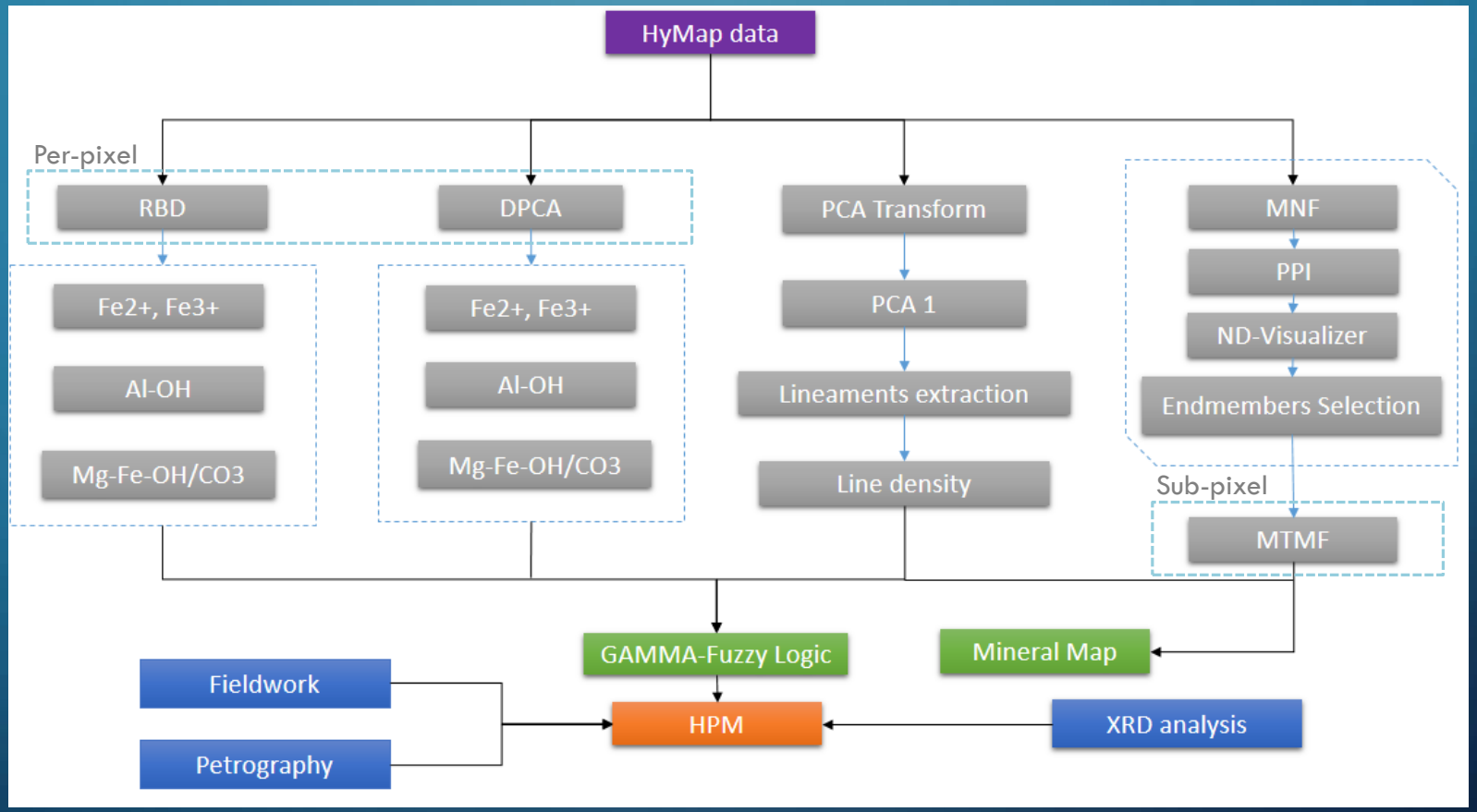
- The project aims to develop a mineral potential map of eastern Kerdous inlier (Amlen Valley Shear Zone), Moroccan Anti-Atlas.
- Schematic diagram showing the spatial link between copper-rich mineralization of the western Anti-Atlas and the paleorelief (modified from Pouit, 1966).
- Álvaro et al. (2014) demonstrated that polymetallic hydrothermal activity is spatially correlated with the paleorelief of the Precambrian basement.
- The eastern Kerdous region has experienced old mining activity represented by the existence of the abandoned Idikel Manganese mine.
- The Idikel mine deposit is interstratified in a mainly conglomerate series (200 m thick) (Choubert and Faure-Muret, 1973).
- Thus, several genetic models assume the hydrothermal origin of the mineralization.



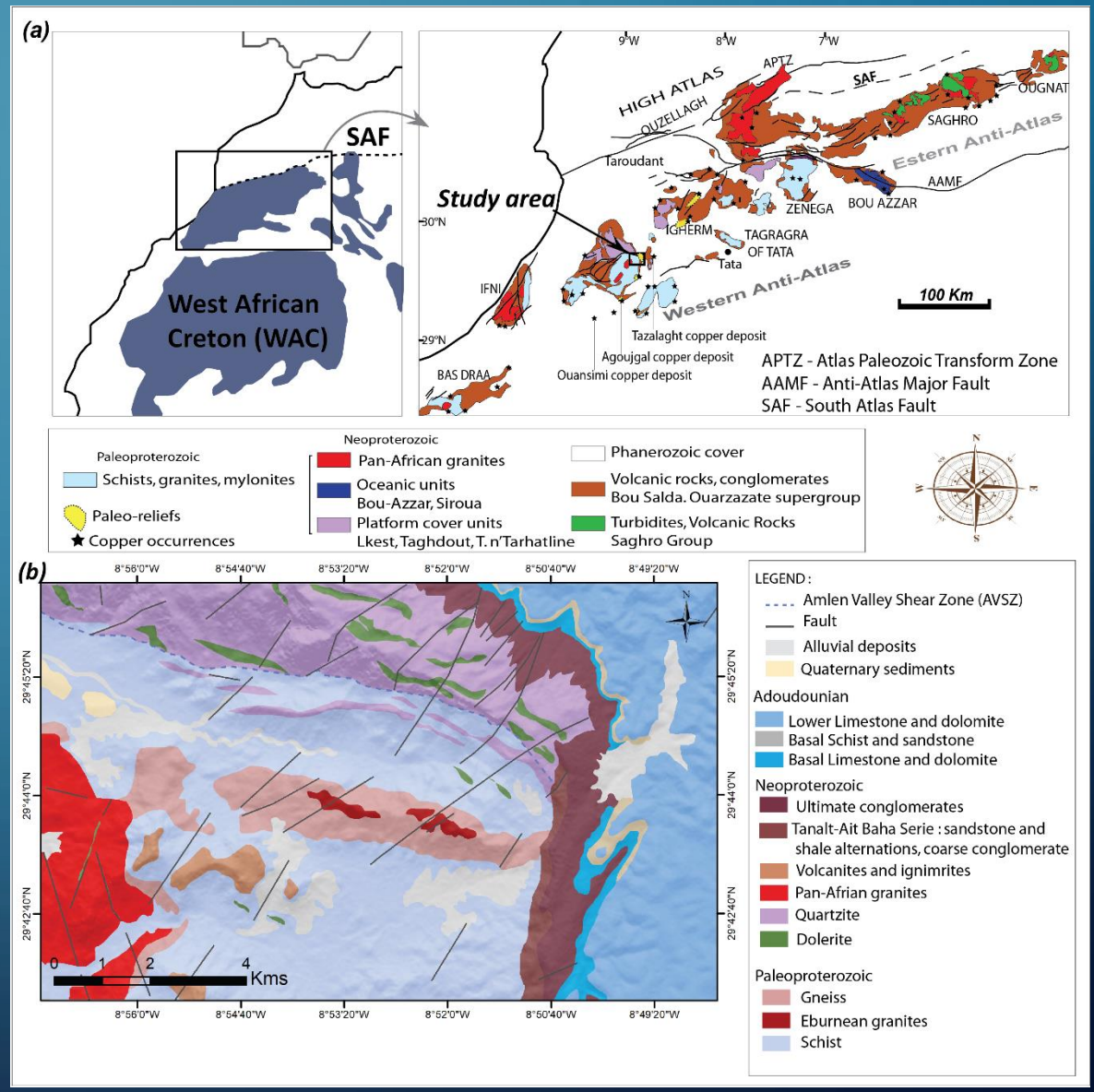
METHODOLOGY



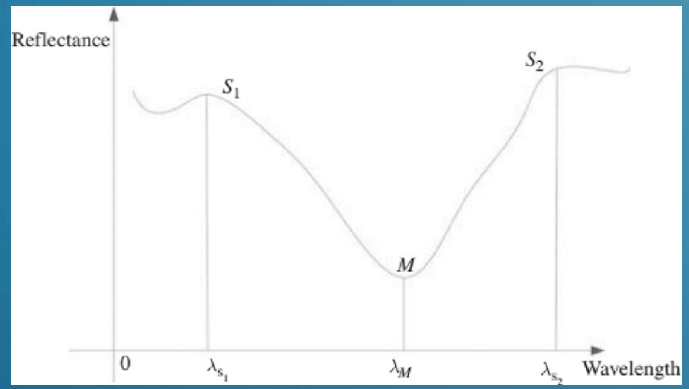
The applied methodology flowchart for HyMap data processing.

STUDY AREA

Geological location of the study area; (a) shows the location of the study area on the general map of the Anti-Atlas and surrounding regions, modified from (Gasquet et al., 2008); (b) shows the lithological map of the East Ameln Valley (based on the Tafraout 1/100000 geological map).

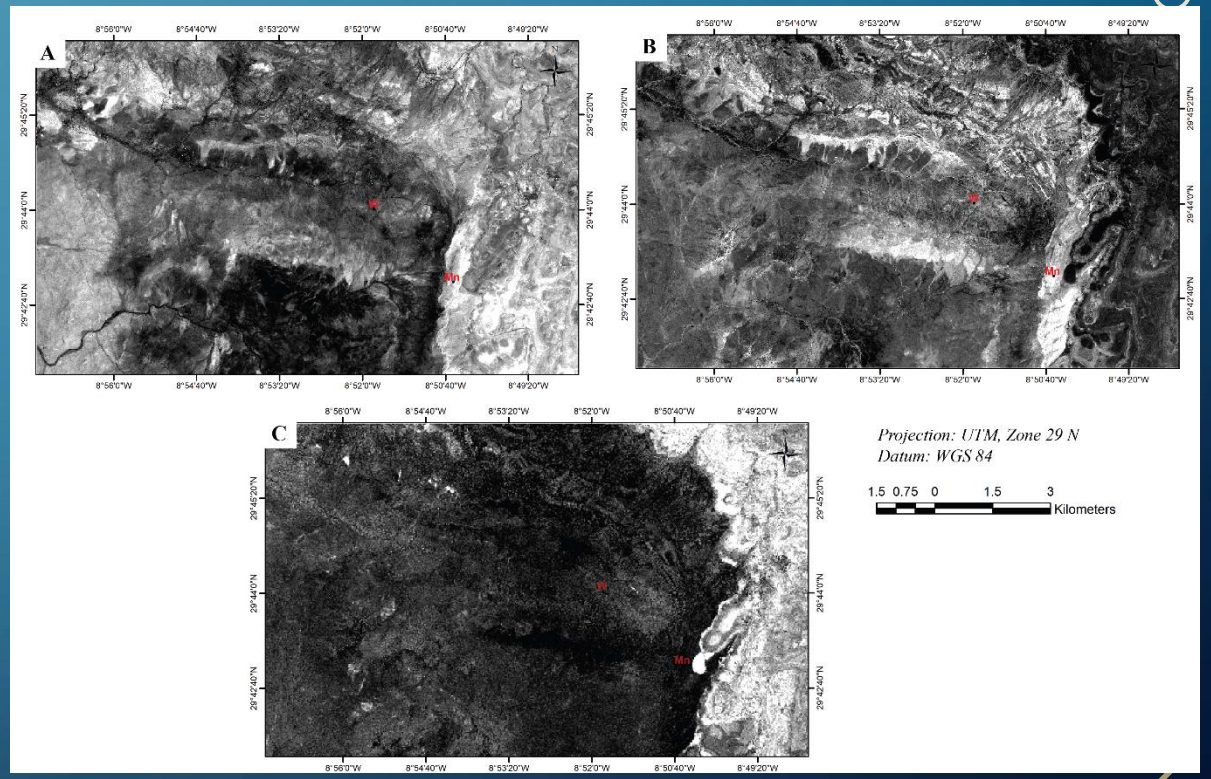


Relative absorption band depth (RBD)



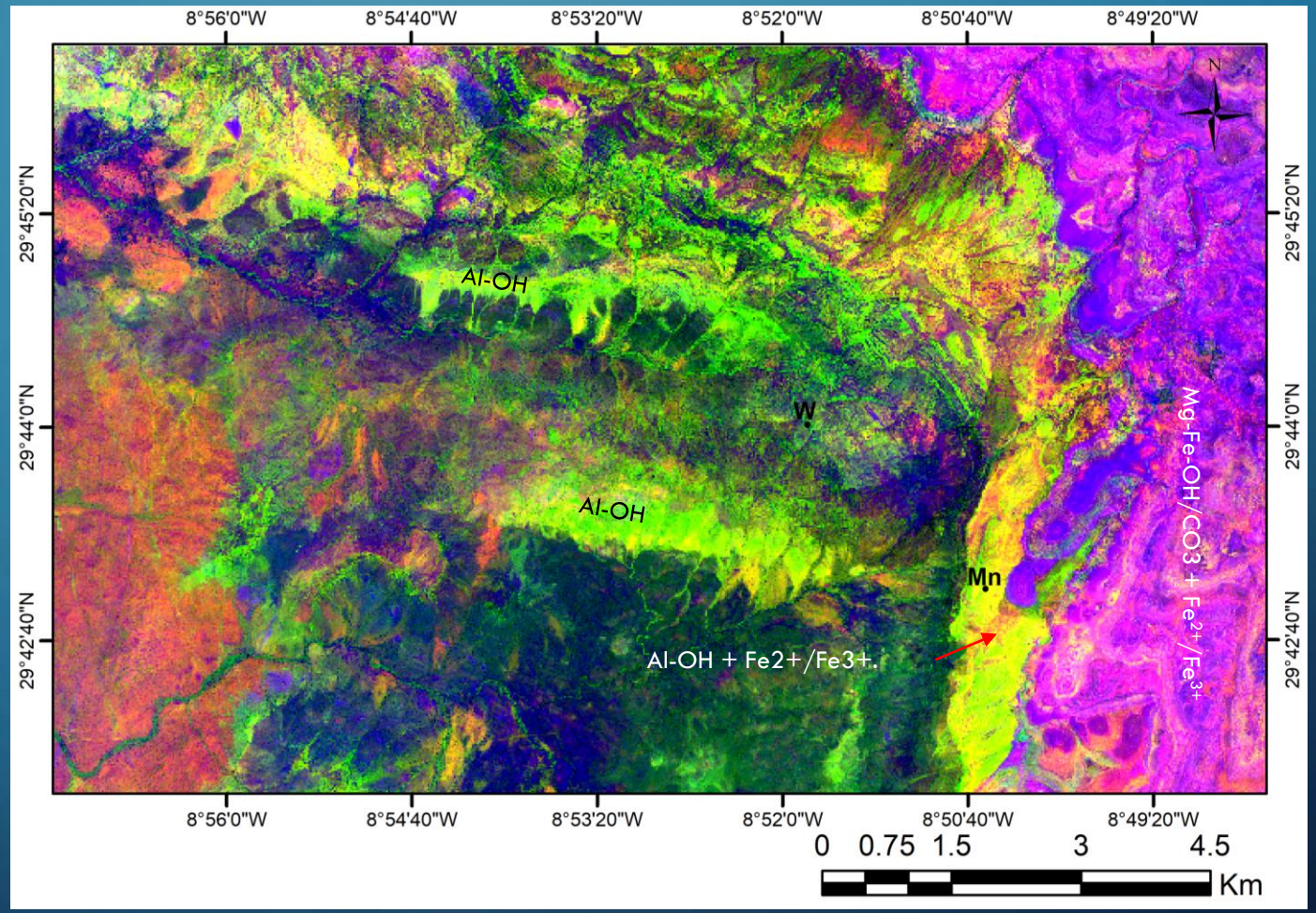
RBD1, RBD2, and RBD3 were developed to map Fe3+-Fe2+, Al-OH, and Mg-Fe-OH/CO3 minerals, respectively.

- RBD1 = ((B21 + B51 / B31)) * (B21 / B4)
- RBD2 = (B101 + B111) / B108
- RBD3 = (B111 + B120) / B114



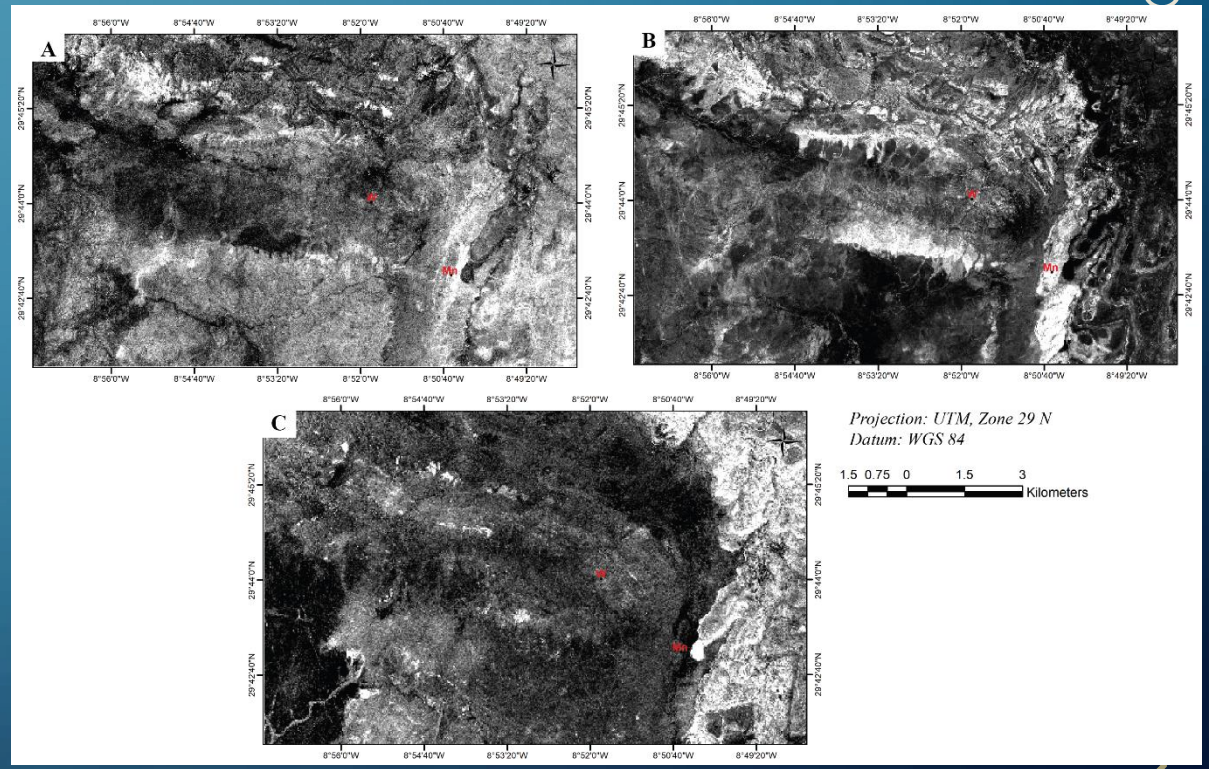
(A) The RBD1 image reflects Fe2+/Fe3+ by the bright pixels.
(B) The RBD2 image reflects Al-OH by the bright pixels.
(C) The RBD3 image shows Mg-Fe-OH/CO3 by the bright pixels.

The RGB FCC image of HyMap using RBD1, RBD2, and RBD3.



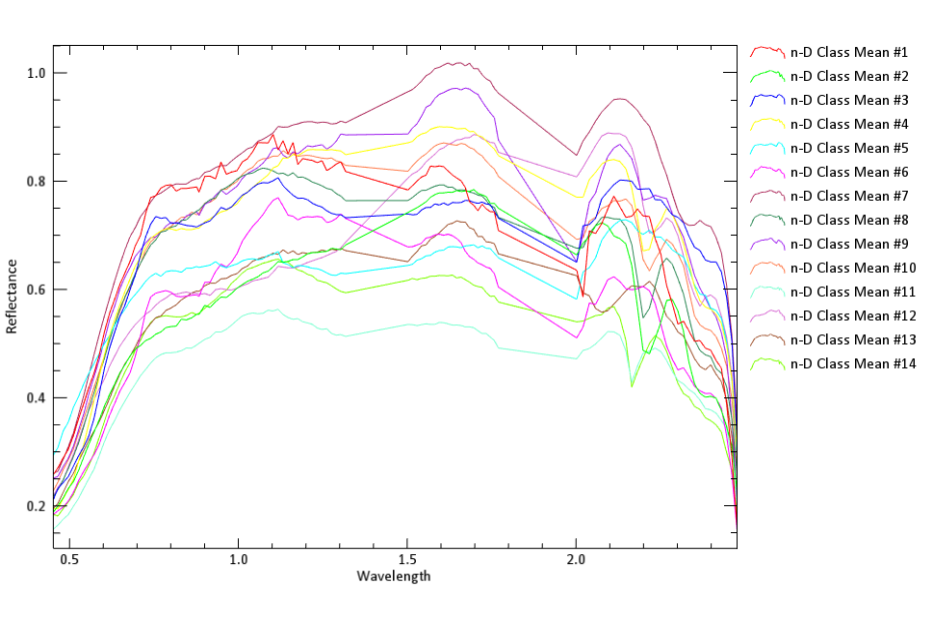
Directed Principal Component Analysis (DPCA)

- Bands 21, 31, and 51 were used to map Fe2+/Fe3+ alteration.
- Bands 101, 108, and 111 were selected for DPCA to map Al-OH alteration.
- Bands 111, 114, and 120 were selected to map Mg-Fe-OH/CO3 alteration.



(A) PC3 image shows Fe2+/Fe3+ alteration as bright pixels.
(B) PC2 image displays Al-OH alteration as bright pixels.
(C) PC3 image shows Mg-Fe-OH/CO3 alteration as bright pixels.

HYDROTHERMAL ALTERATION MINERALS IDENTIFICATION

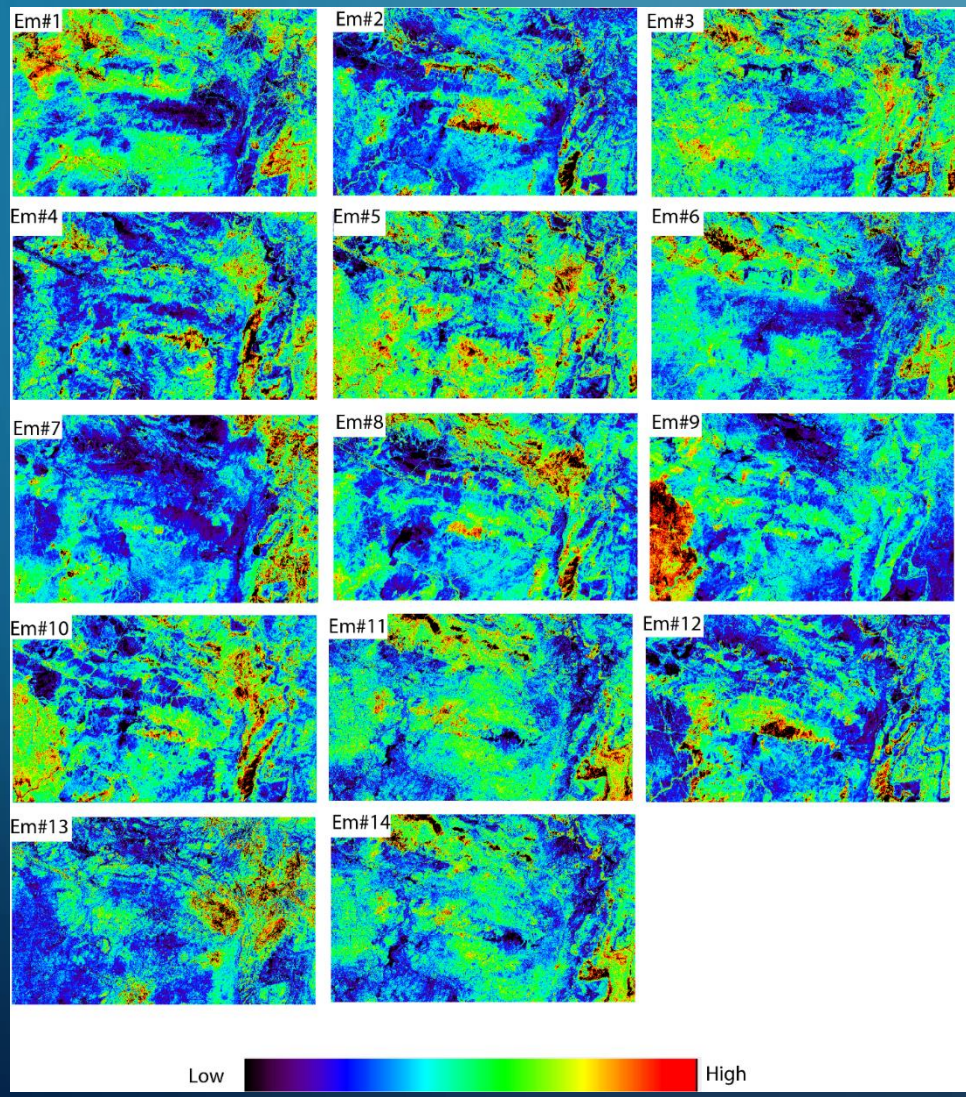


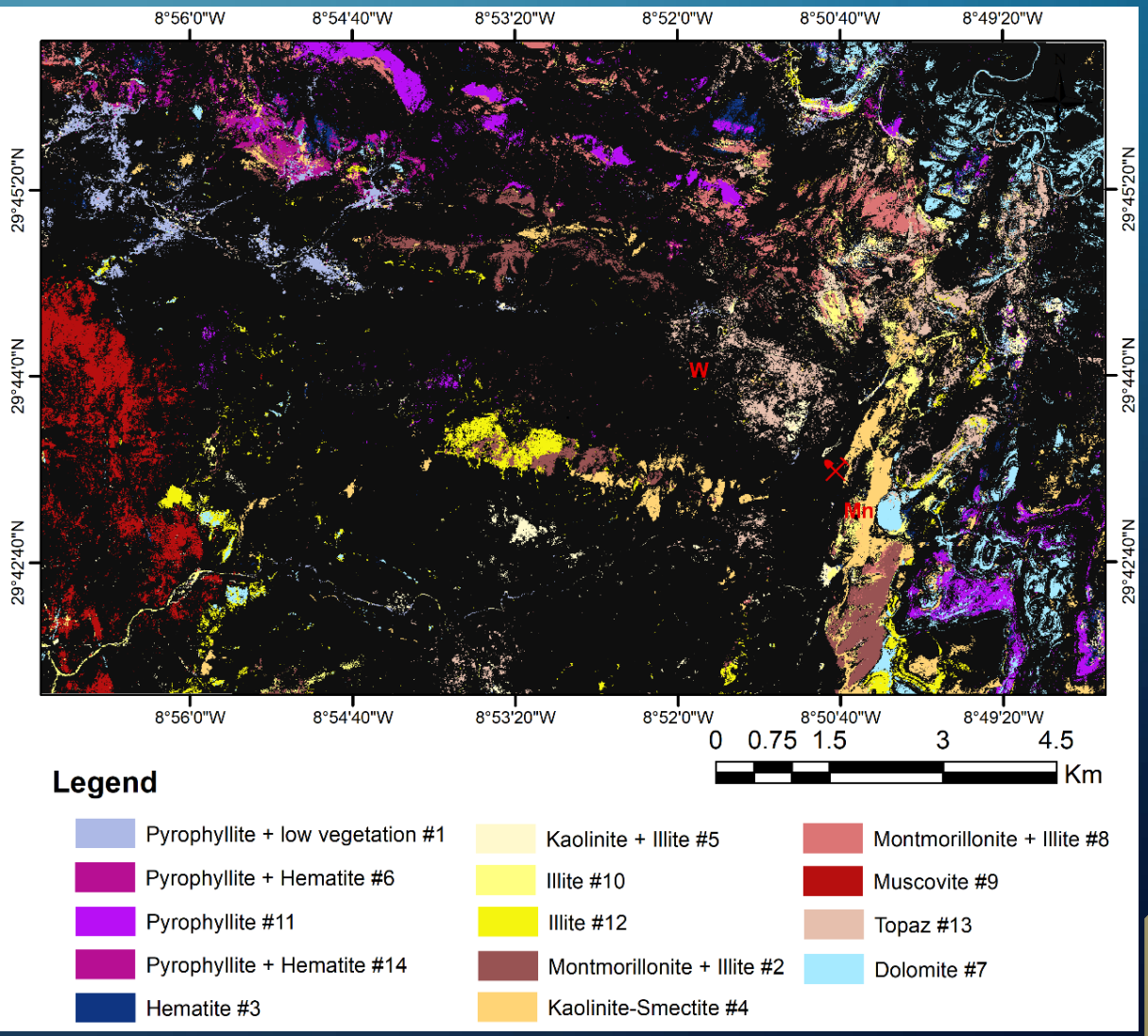
Endmembers spectra derived from the n-dimensional visualization technique applied to the VNIR and SWIR bands of HyMap.

Identified minerals with their corresponding match scores.

Endmember\Score	Total score	SAM	SFF	BE
Em#1: Pyrophyllite + Low Vegetation	0.720	0.800	0.545	0.836
Em#2: Montmorillonite + Illite	0.836	0.848	0.730	0.955
Em#3: Hematite	0.767	0.842	0.696	0.773
Em#4 : Kaolinite-Smectite	0.780	0.887	0.593	0.882
Em#5 : Kaolinite + Illite	0.701	0.751	0.605	0.755
Em#6 : Pyrophyllite + Hematite	0.651	0.770	0.301	0.891
	0.619	0.727	0.466	0.673
En #7 : Dolomite	0.702	0.759	0.696	0.673
Em#8 : Montmorillonite + Illite	0.835	0.865	0.749	0.891
Em#9 : Muscovite (Granite)	0.696	0.765	0.505	0.827
Em#10 : Illite	0.749	0.790	0.755	0.718
Em#11 : Pyrophyllite	0.764	0.775	0.630	0.909
Em#12 : Illite	0.797	0.885	0.622	0.909
Em#13: Topaz	0.812	0.902	0.660	0.900
Em#14 : Pyrophyllite + Hem	0.733	0.815	0.555	0.973
	0.644	0.732	0.581	0.627

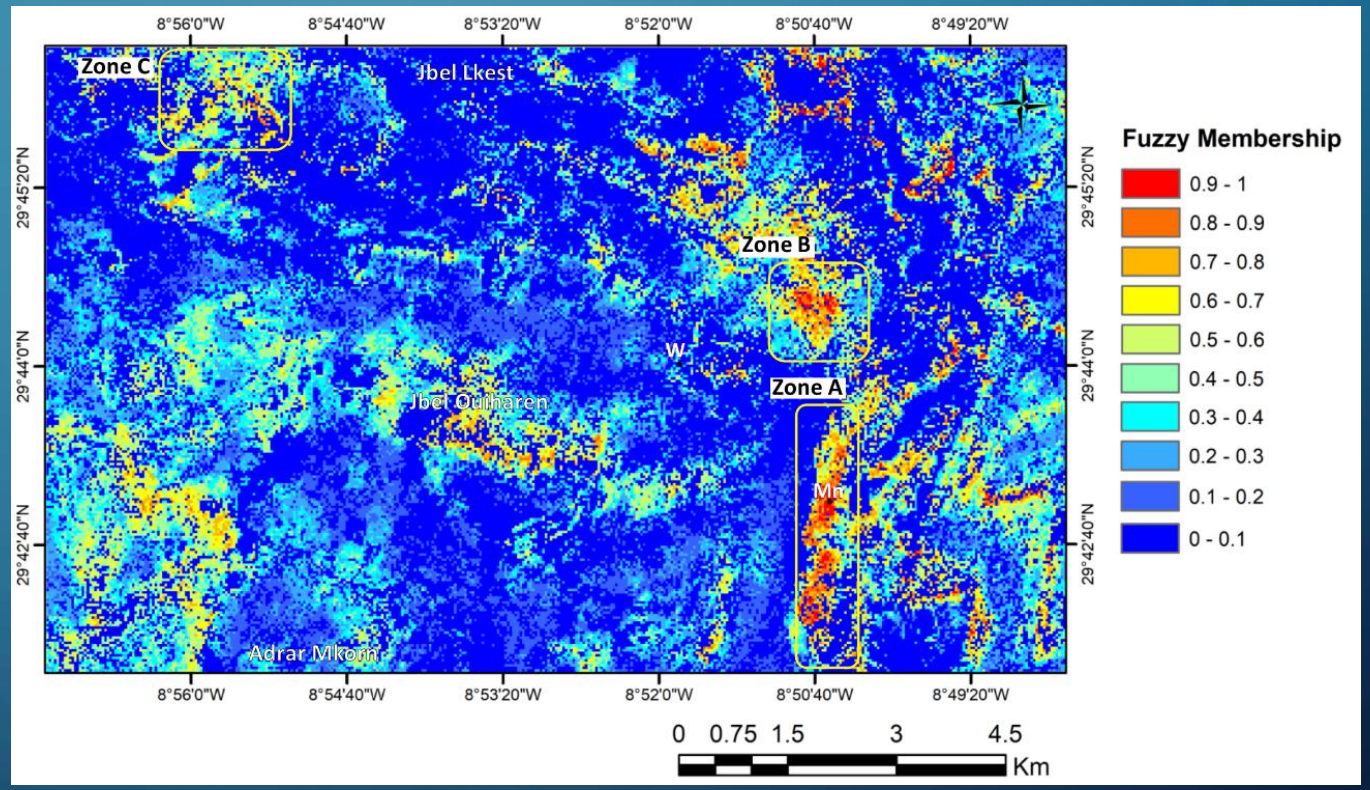
HYDROTHERMAL ALTERATION MINERALS MAPPING





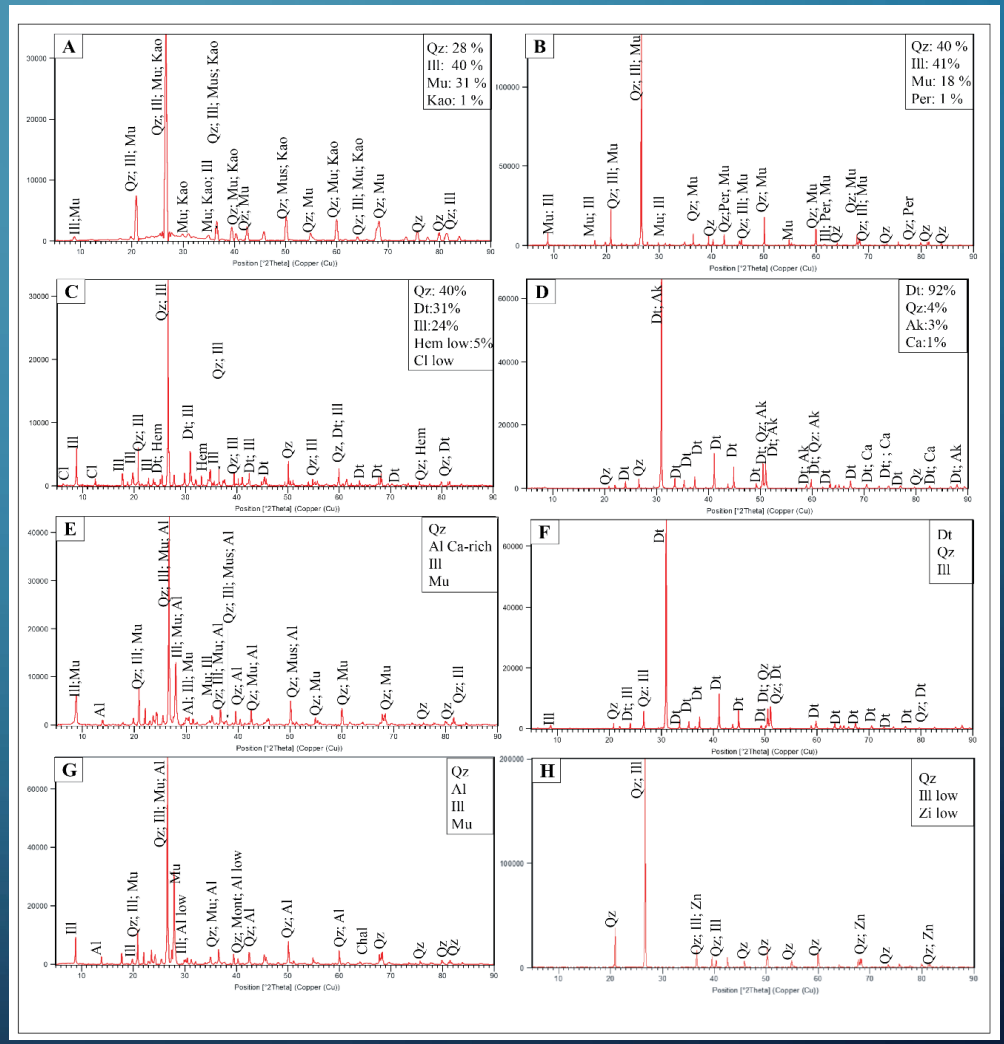
MINERAL POTENTIAL MAPPING

The Mineral Potential Map (MPM) generated from the Fuzzy Logic Model (FLM) for the study area. The areas with high mineral potential are marked by yellow rectangles



VALIDATION

XRD patterns of representative samples collected from the hydrothermally altered zones. (A, B, and E) argillic/phyllic alteration zone; (C and F) dolomitization zone; (D and G) phyllic alteration zone; (H) silicophyllic alteration zone. Abbreviations: Qz: Quartz, Ill: Illite Hem: Hematite Dt: Dolomite, Kln: Kaolinite, Cl: Clinochlore, Ak: Ankerite, Al: Albite, Ca: Calcite.



CONCLUSION

- The results of this research demonstrate that the use of fuzzy modeling to integrate thematic layers (RBD, DPCA, line density, and MTMF) derived from HyMap imagery is a relevant approach for generate a high-resolution mineral potential map. It provides an accurate map of high-potential areas in the Ameln Valley region. The lithological units of ultimate conglomerate and quartzites show three locations of high suitability for mining exploration campaigns.
- The close spatial association between NE-SW and NW-SE lineaments and alteration zones highlights an important tectonic control on mineralization in the study area. The used methodology for HyMap image processing in this study can be applied to other regions with similar geological conditions in the Western Anti-Atlas metallogenic province.

Reference: Hajaj, S., El Harti, A., Jellouli, A., Pour, A. B., Himyari, S. M., Hamzaoui, A., ... & Hashim, M. (2023). HyMap imagery for copper and manganese prospecting in the east of Ameln valley shear zone (Kerdous inlier, western Anti-Atlas, Morocco). *Journal of Spatial Science*, 1-22.

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