

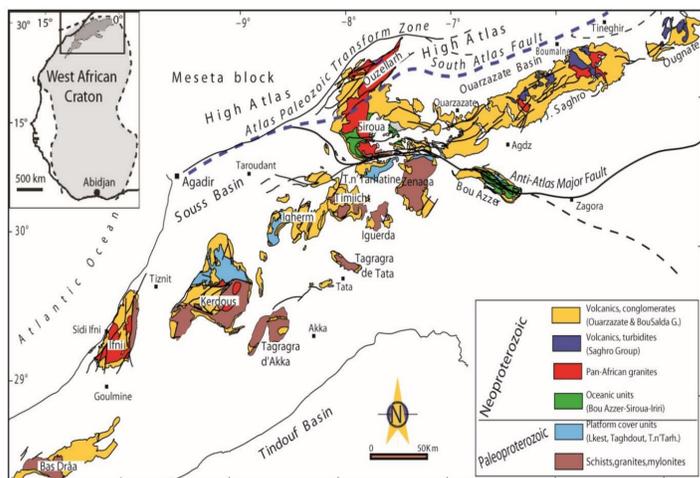
# Structural analysis and hydrothermal alteration using satellite imagery

## Implications for ore prospecting in the Proterozoic Bou Azzer–El Graara inlier (Central Anti-Atlas, Morocco)

Fouzia Anzar<sup>1,2</sup>, Abderrahmane Soulaïmani<sup>1\*</sup>, Mohammed Jaffal<sup>3,4</sup>, Saïd Ilmen<sup>5</sup>, Walid Kassou<sup>6</sup> – Faculty of Sciences Semlalia, Cadi Ayyad University, Marrakech, Morocco

### INTRODUCTION & STUDY AREA

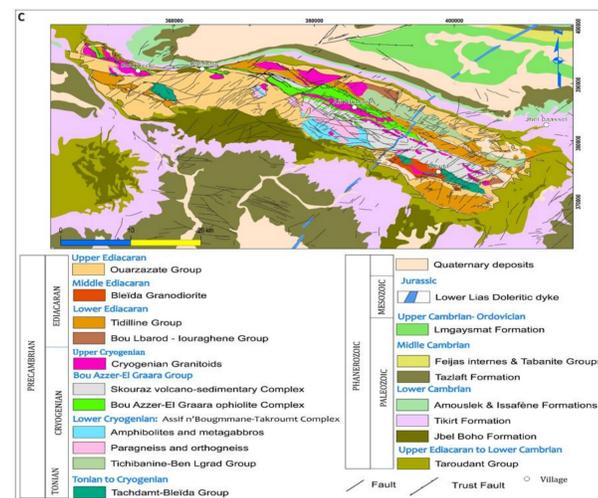
- The Bou Azzer–El Graara inlier is a Pan-African suture zone hosting significant Co, Au and Cu mineralization.
- The study area is located in the Central Anti-Atlas (Morocco) and comprises ophiolites, arc-related terranes and volcano-sedimentary sequences.
- Arid climatic conditions provide favorable settings for satellite remote sensing applications.
- Understanding the relationship between structures, hydrothermal alteration and mineralization is essential for mineral exploration.



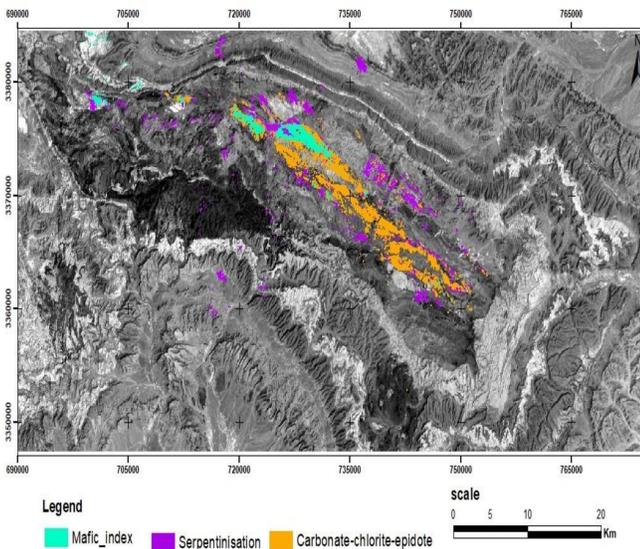
Geological map of the Anti-Atlas with an inset showing its location within the West African Craton (modified after Gasquet et al. 2005)

### METHODOLOGY & ALTERATION

- ASTER VNIR–SWIR data were processed after atmospheric correction to enhance lithological and alteration signatures.
- Targeted band ratios were applied to map iron oxides, Al–OH, Mg–OH and carbonate-bearing minerals.
- Structural lineaments were extracted and integrated to analyze their control on hydrothermal fluid circulation.
- Alteration maps were validated through field observations and available geochemical data



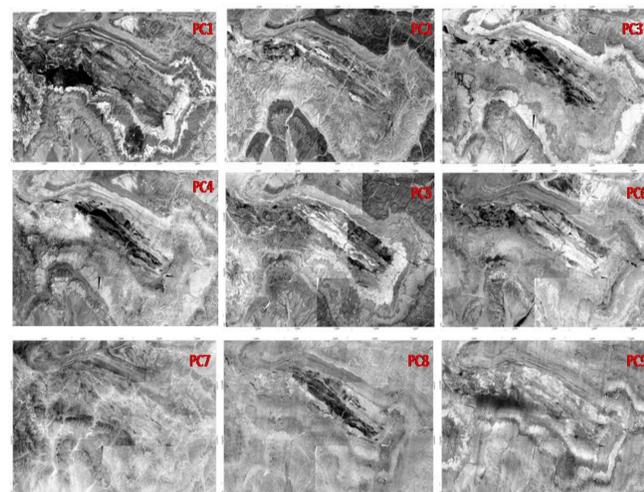
Geological map of the Bou Azzer–El Graara (Combined from: Blein et al., 2013a,c; Admou et al., 2013; Soulaïmani et al., 2013)



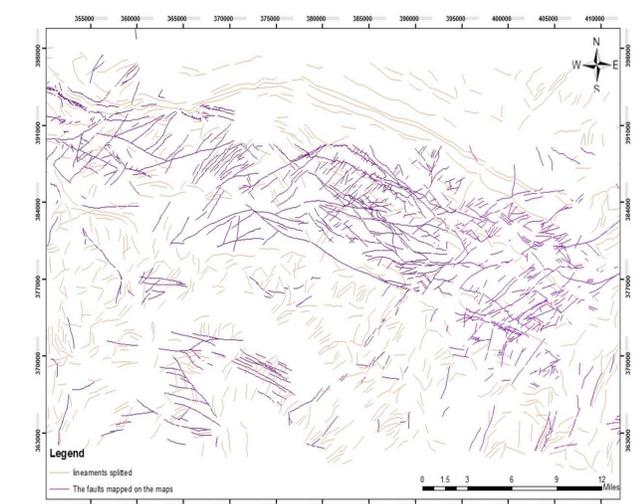
Alteration zone mapping of assemblage carbonates-chlorite-epidote using threshold values of mineralogical indices in the Proterozoic Bou Azzer–El Graara inlier.

### STRUCTURES & MINERALIZATION

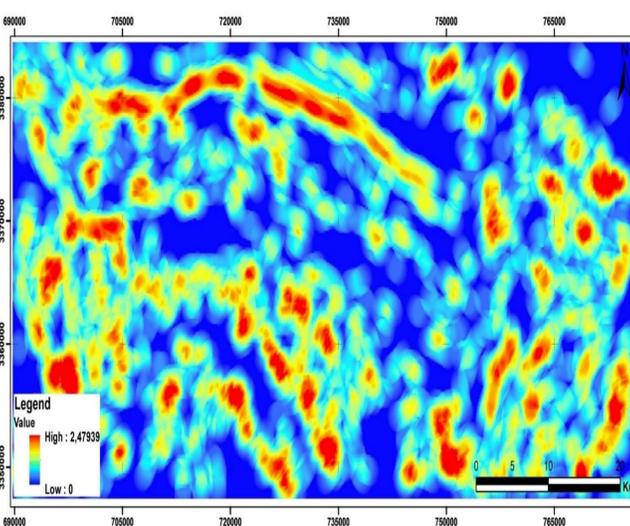
- Lineament analysis reveals dominant NE–SW and E–W fault systems consistent with regional Pan-African tectonics.
- Major structures control hydrothermal fluid pathways and the spatial distribution of mineralization.
- Cobalt mineralization is mainly associated with carbonate–chlorite–epidote alteration zones.
- Gold mineralization correlates with alunite–kaolinite–pyrophyllite and locally sericite-bearing assemblages.



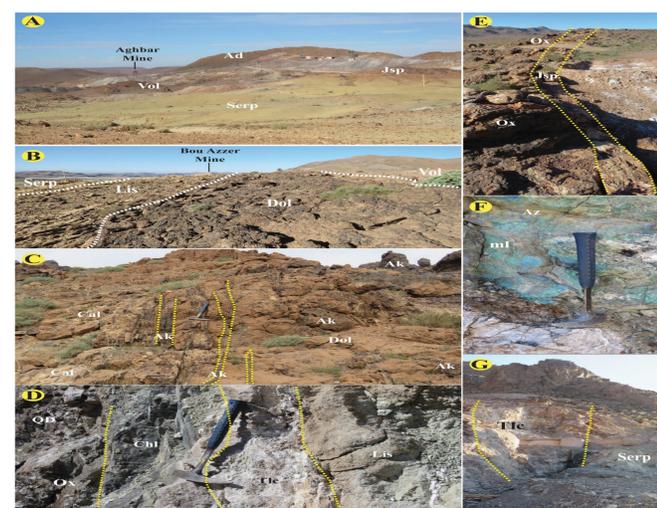
The 9 PCs images generated from the ASTER VNIR and SWIR bands of the Proterozoic Bou Azzer–El Graara inlier.



Fault patterns extracted from the geological maps of the Bou Azzer–El Graara region, Bou Azzer (Blein et al., 2013c), Alougoum (Blein et al., 2013a), Ait Ahmane (Admou et al., 2013) and Al Glo'a (Soulaïmani et al., 2013).



Lineament density map of the Proterozoic Bou Azzer–El Graara inlier



Field photos illustrating hydrothermal alteration

### CONCLUSIONS

- ASTER multispectral data effectively map hydrothermal alteration zones in arid environments.
- Structural analysis confirms a strong tectonic control on hydrothermal alteration and mineralization.
- The integrated approach provides a reliable tool for future mineral exploration targeting in the Bou Azzer–El Graara inlier.