

Deciphering the tectonic complexity of the Central High Atlas Mountains using mesostructures and calcite mechanical twinning analysis

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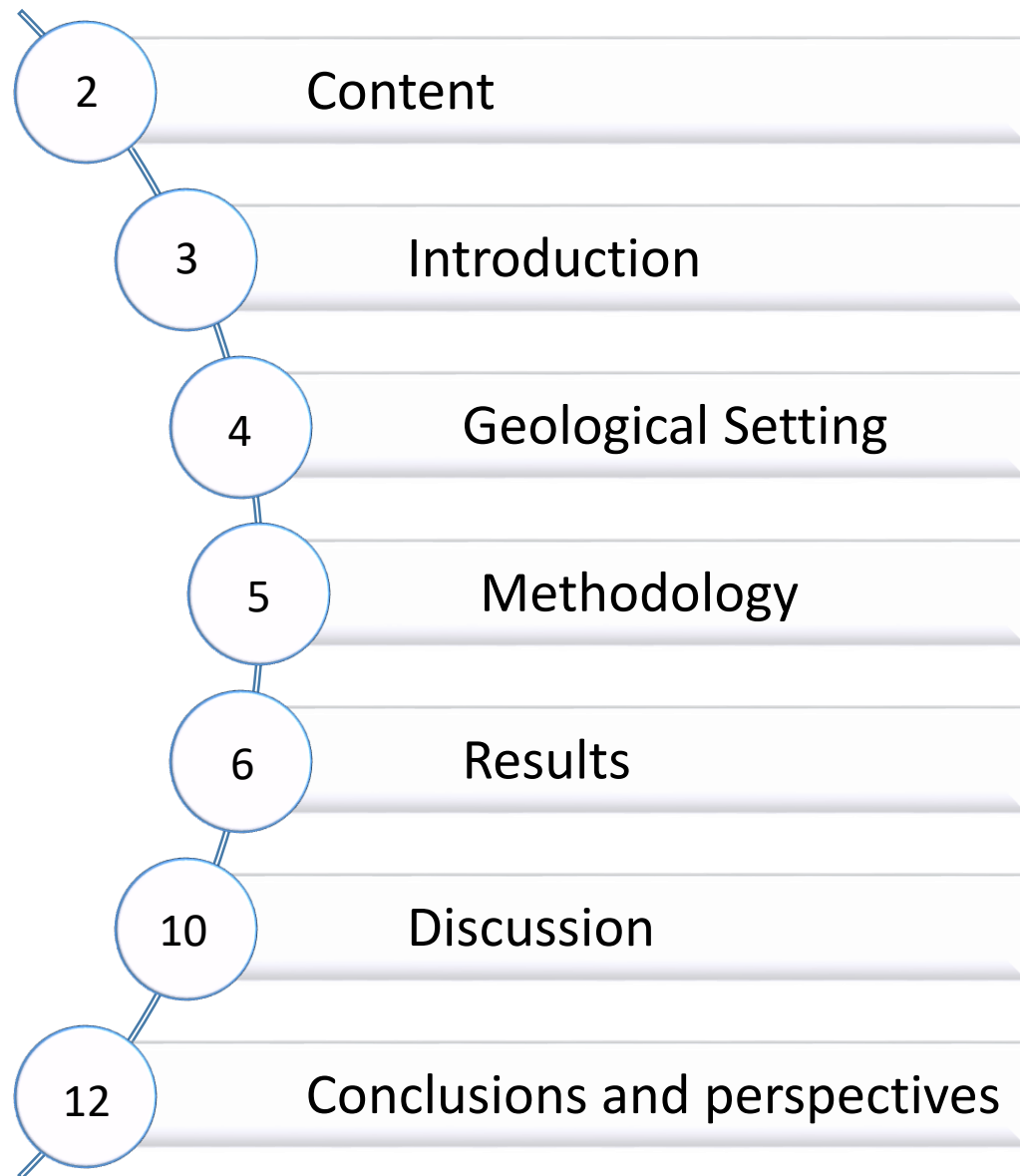
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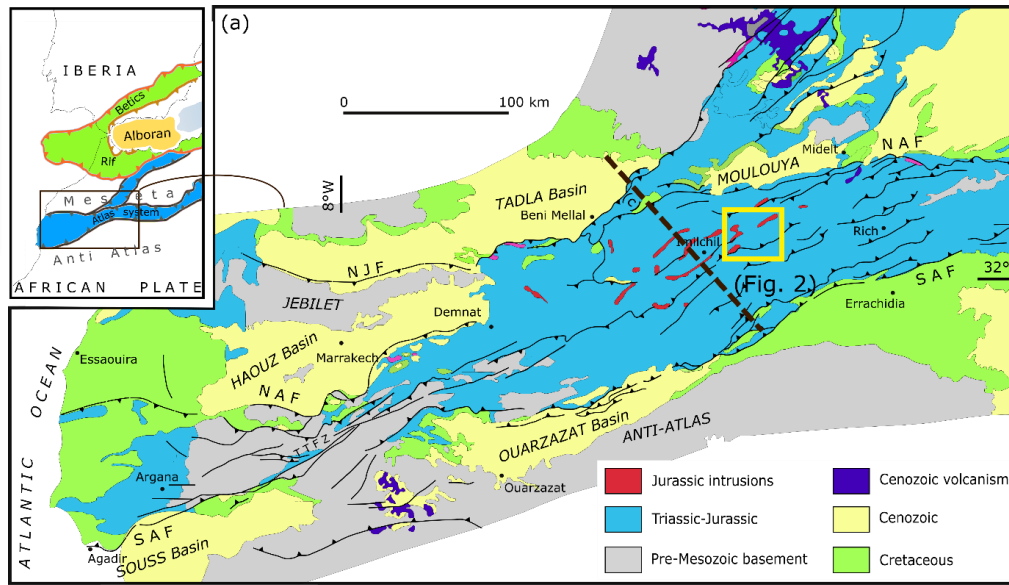
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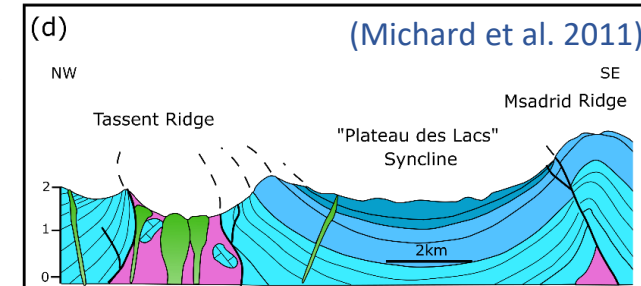
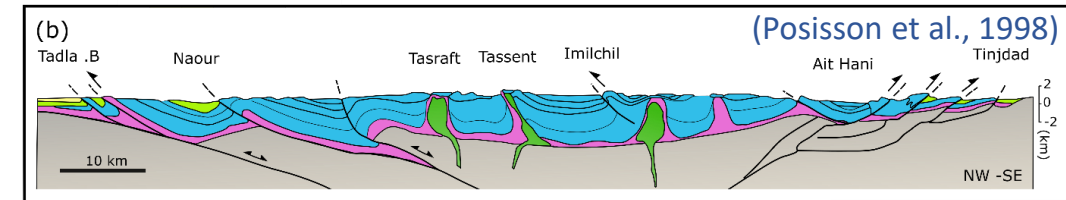
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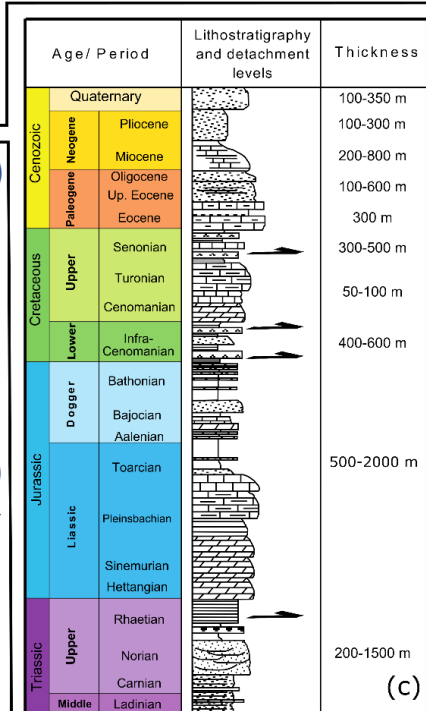
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(modified from Teixell et al., 2003)



(Moragas et al. 2017)



(El Harfi et al., 2006, modified)

Figure 1. Sketch of the structural features of the Moroccan High Atlas belt.

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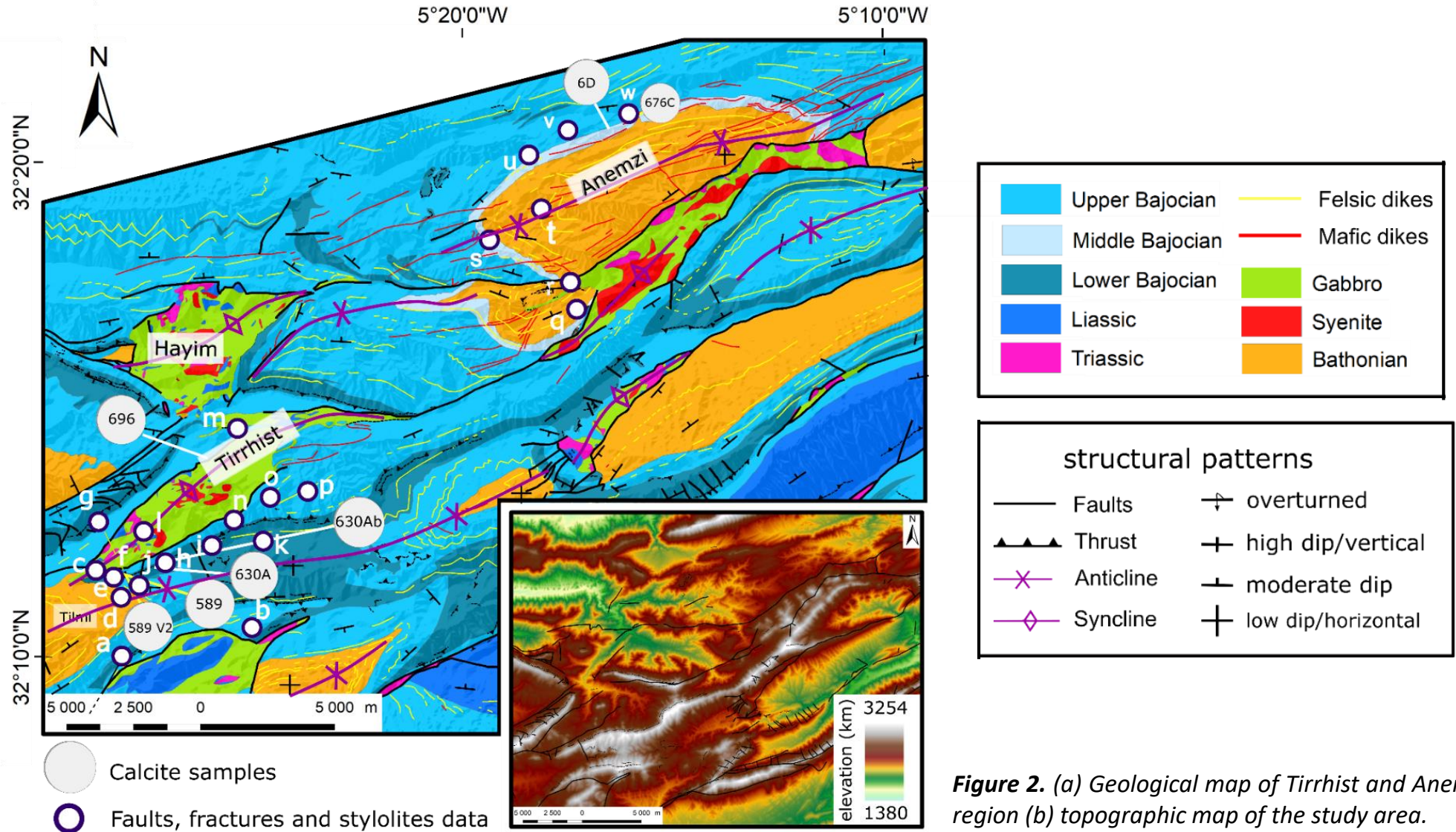


Figure 2. (a) Geological map of Tirrhist and Anemzi region (b) topographic map of the study area.

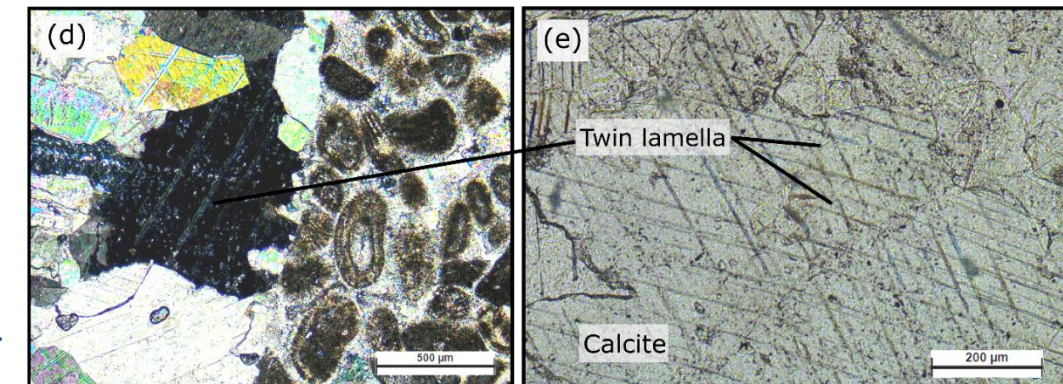
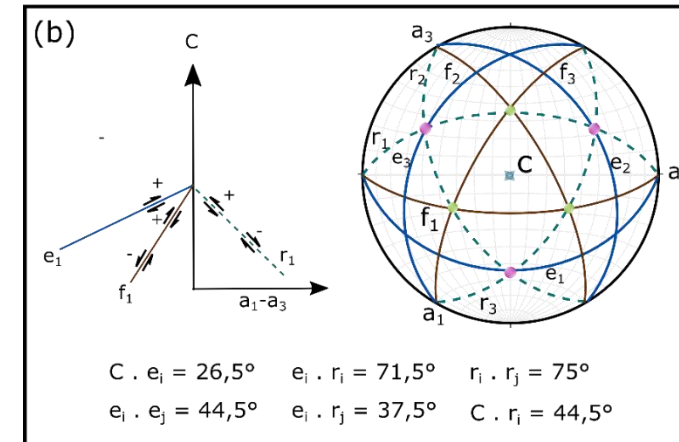
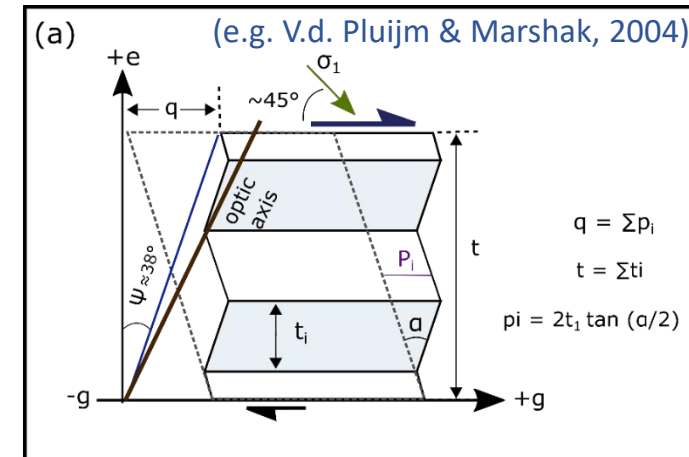
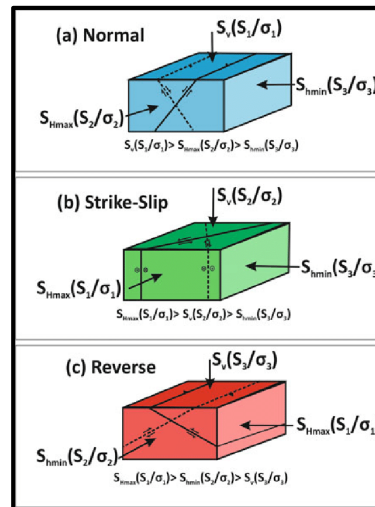
Field investigation

- **Faults**
- **Veins**
- **Stylolites**

Calcite mechanical twinning

- ## ➤ Calcite Stress Inversion Technique (Etechopar, 1984)

Figure 3. Simplified sketch of calcite twins method (e.g. V.d. Pluijm & Marshak, 2004; Amrouch, 2010; Lacombe et al. 2021)



Direct measurement of two
planes' dip and direction
(e-e/e-r/r-r)
(Universal stage / EBSD)

(c)

Indirect determination of the second or/and third twin plan
(Tournet program)

Inverse problem: finding the tensor(s) that fit the inequivalencies

- $\tau_C > \tau_S$: untwinned plans
- $\tau_C \leq \tau_S$: twinned plans

Reduced tensor

$\sigma_1 \sigma_2 \sigma_3$ R $\sigma_{dmax}(\sigma_1 - \sigma_3)$

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Mesostructures: tensile mode fractures (or veins) & pressure-solution seams

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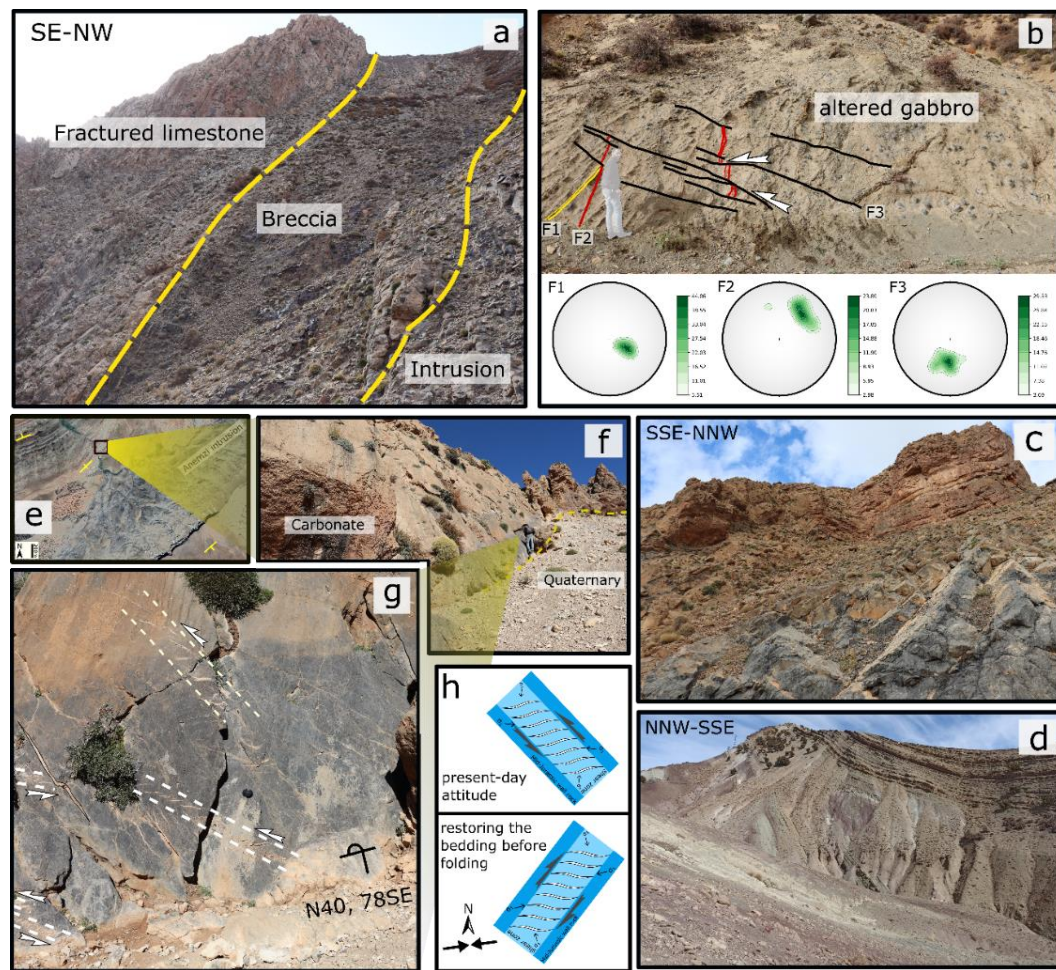
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Figure 4. Field pictures from the studied sectors.

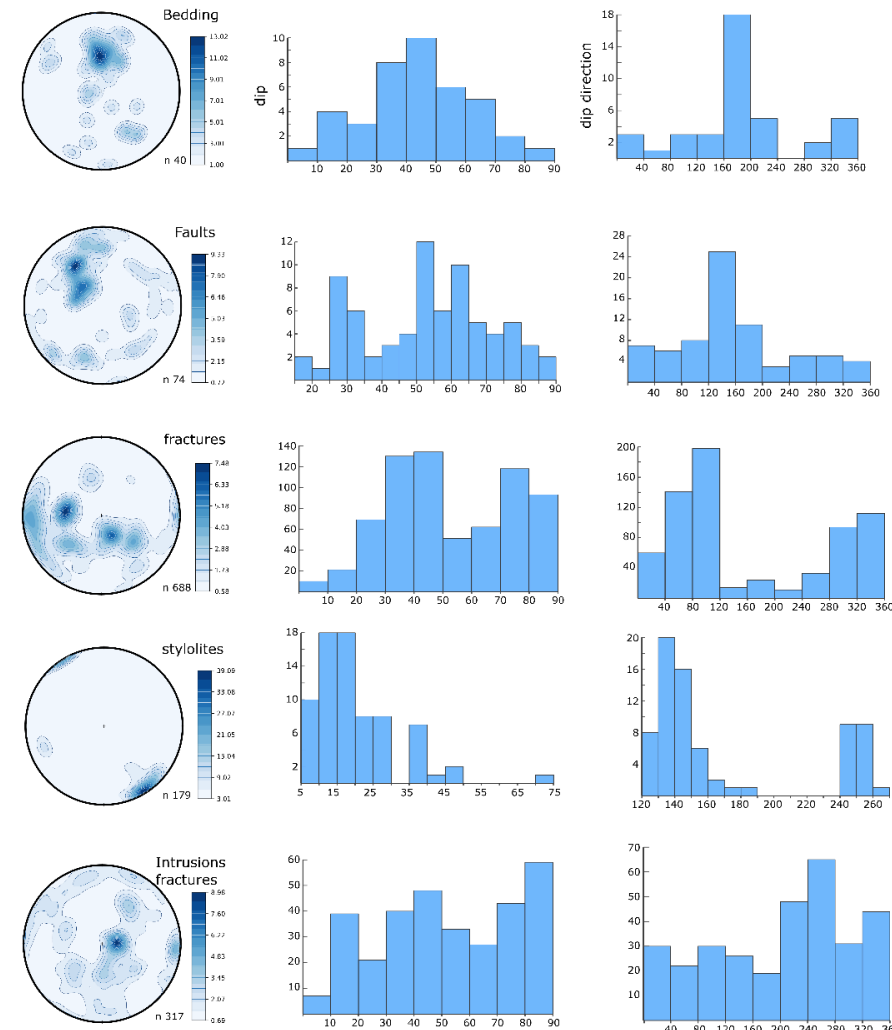


Figure 5. statistical distribution of the measured structural data

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Mesostructures: micro-shear fractures (or veins) & striated fault planes

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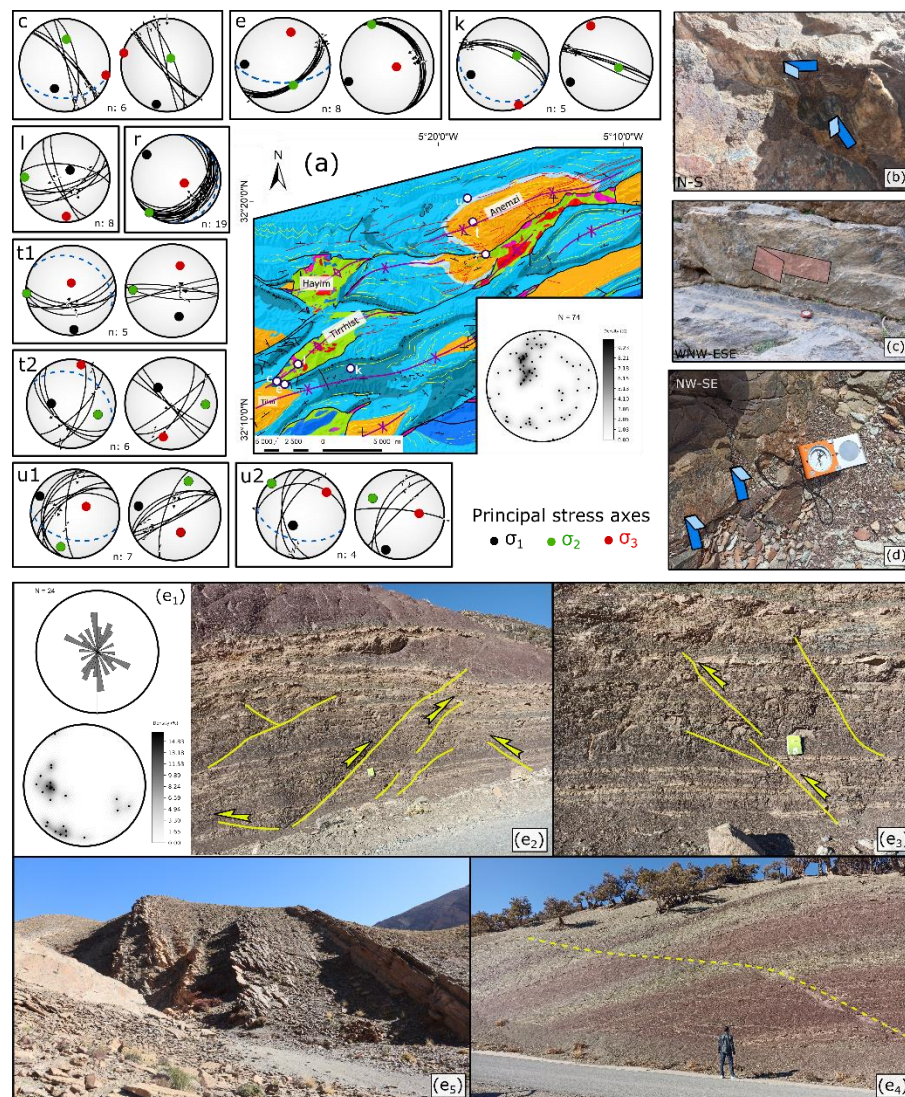
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Figure 6. Striated fault planes stations and the related datasets at the current state and after untilting the bedding

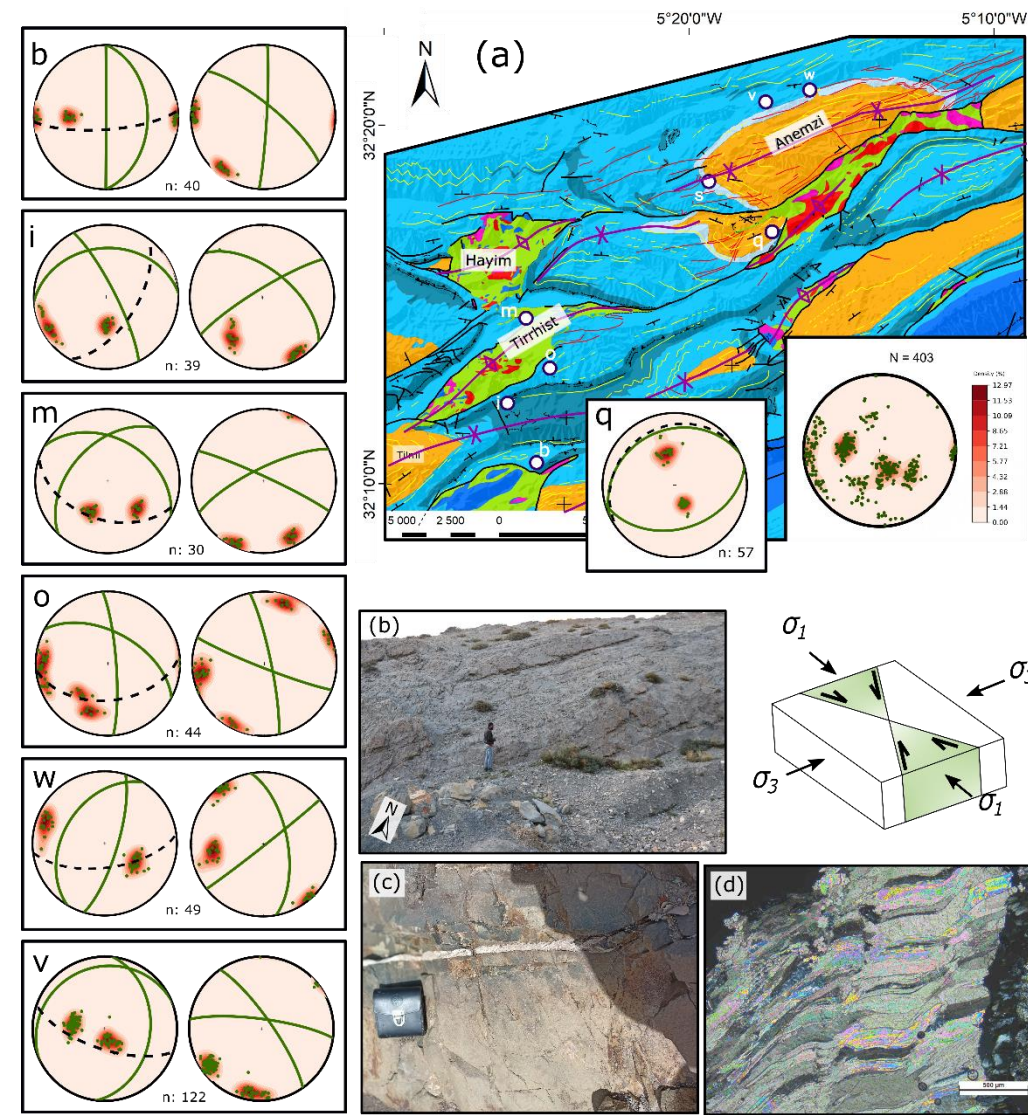


Figure 7. Stations of conjugate micro-shear fractures data and the associated fractures sets at the current state and after untilting the bedding

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Mesostructures: tensile mode fractures (or veins) & pressure-solution seams

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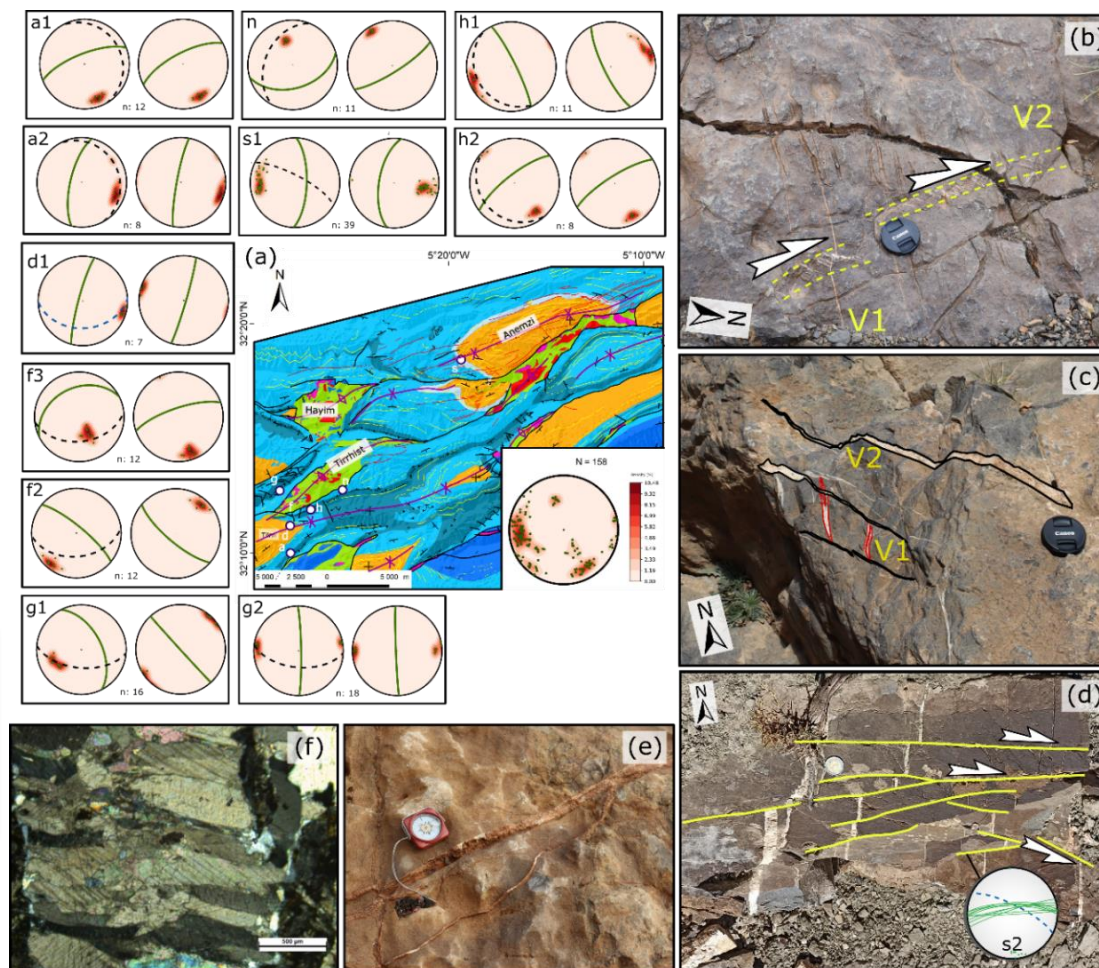
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Figure 8. Tensile mode veins results

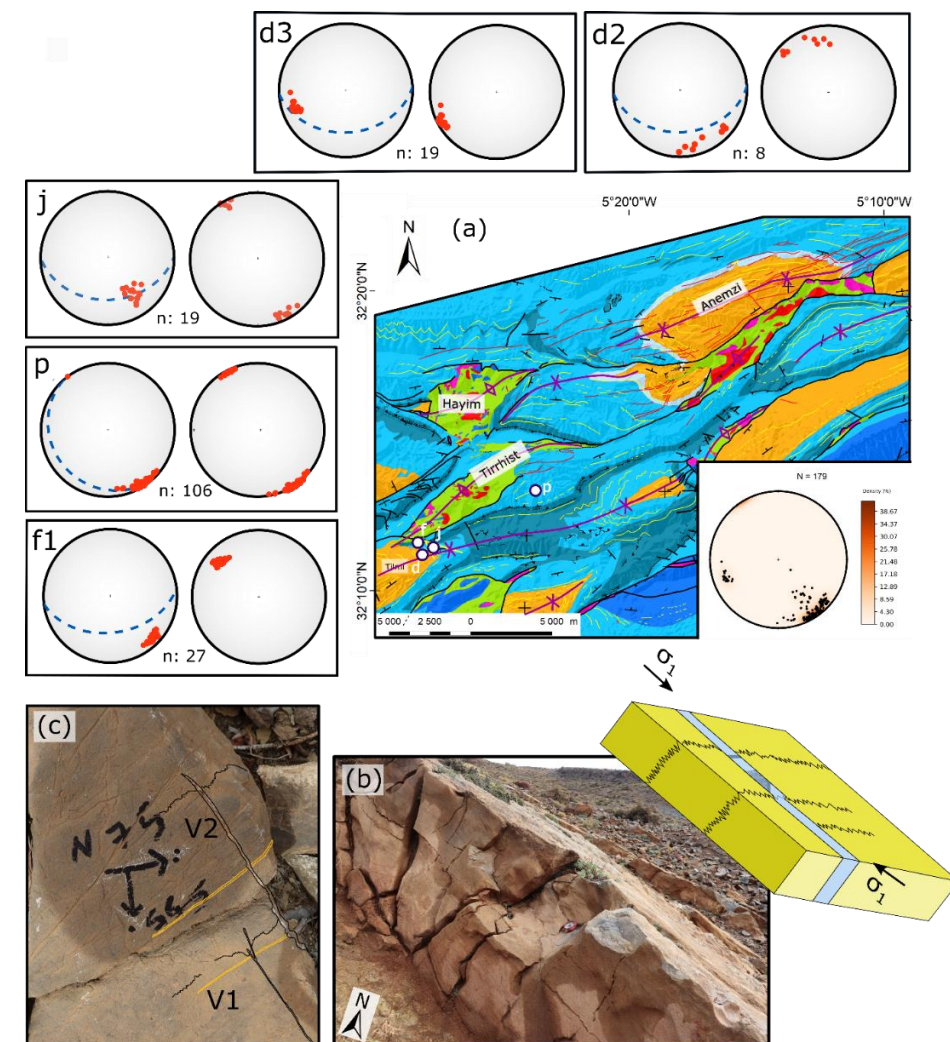


Figure 9. Stylolites (or pressure-solution) datasets.

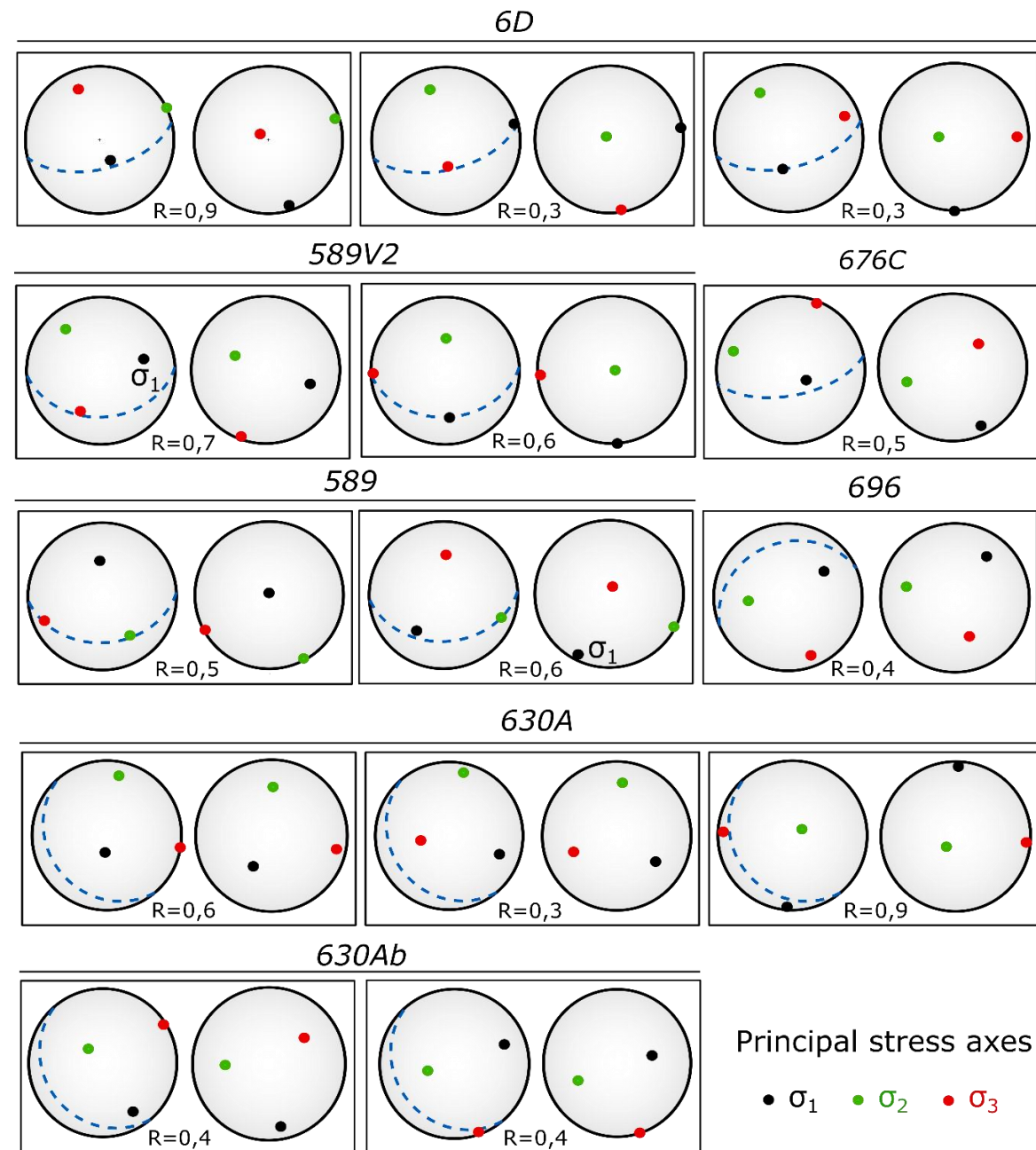


Figure 10. Calcite twins-derived stress tensors

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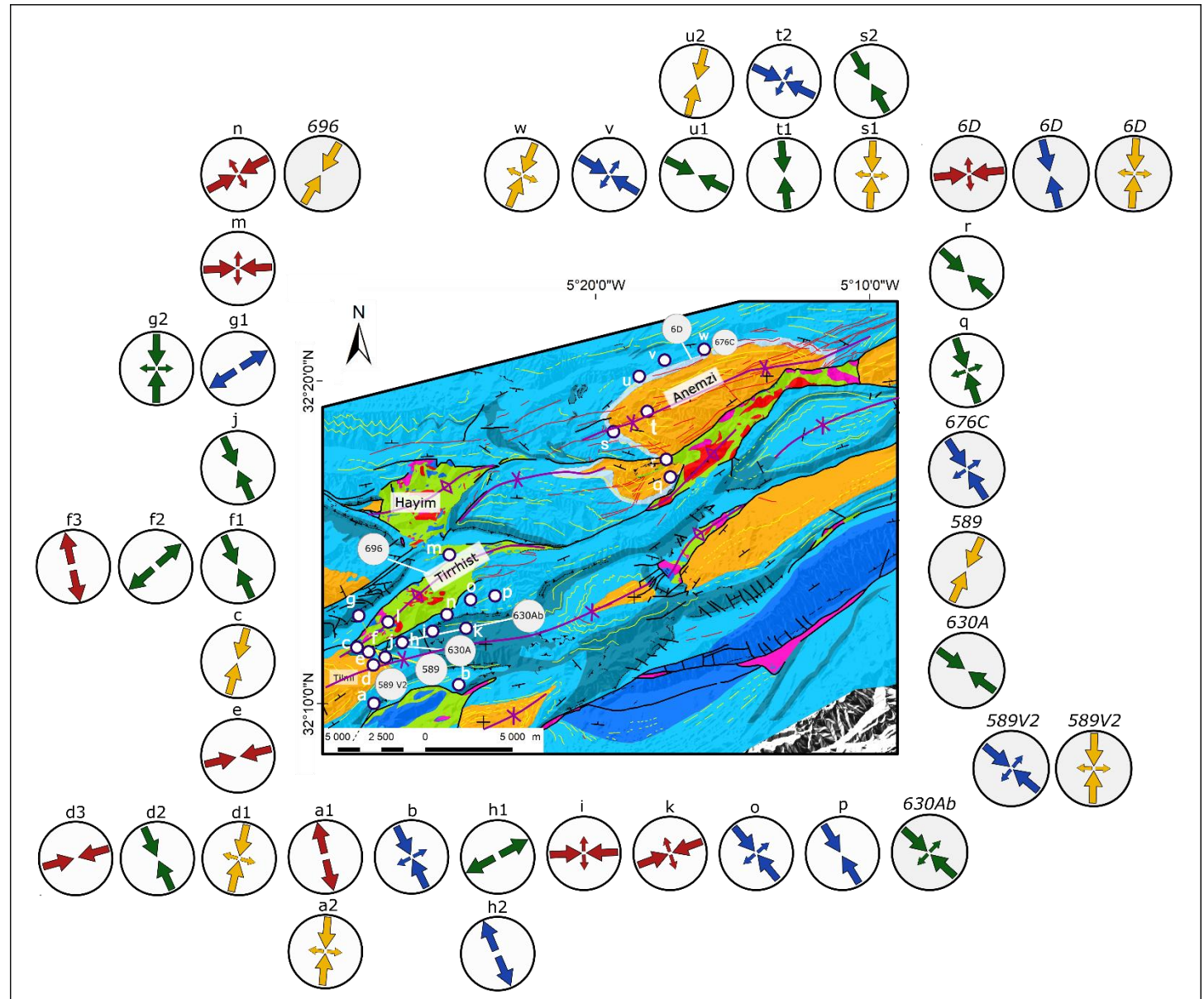
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Figure 11. Interpretation of the aleostress reconstruction based on mesostructures (white circles) and calcite mechanical twinning (grey circles)



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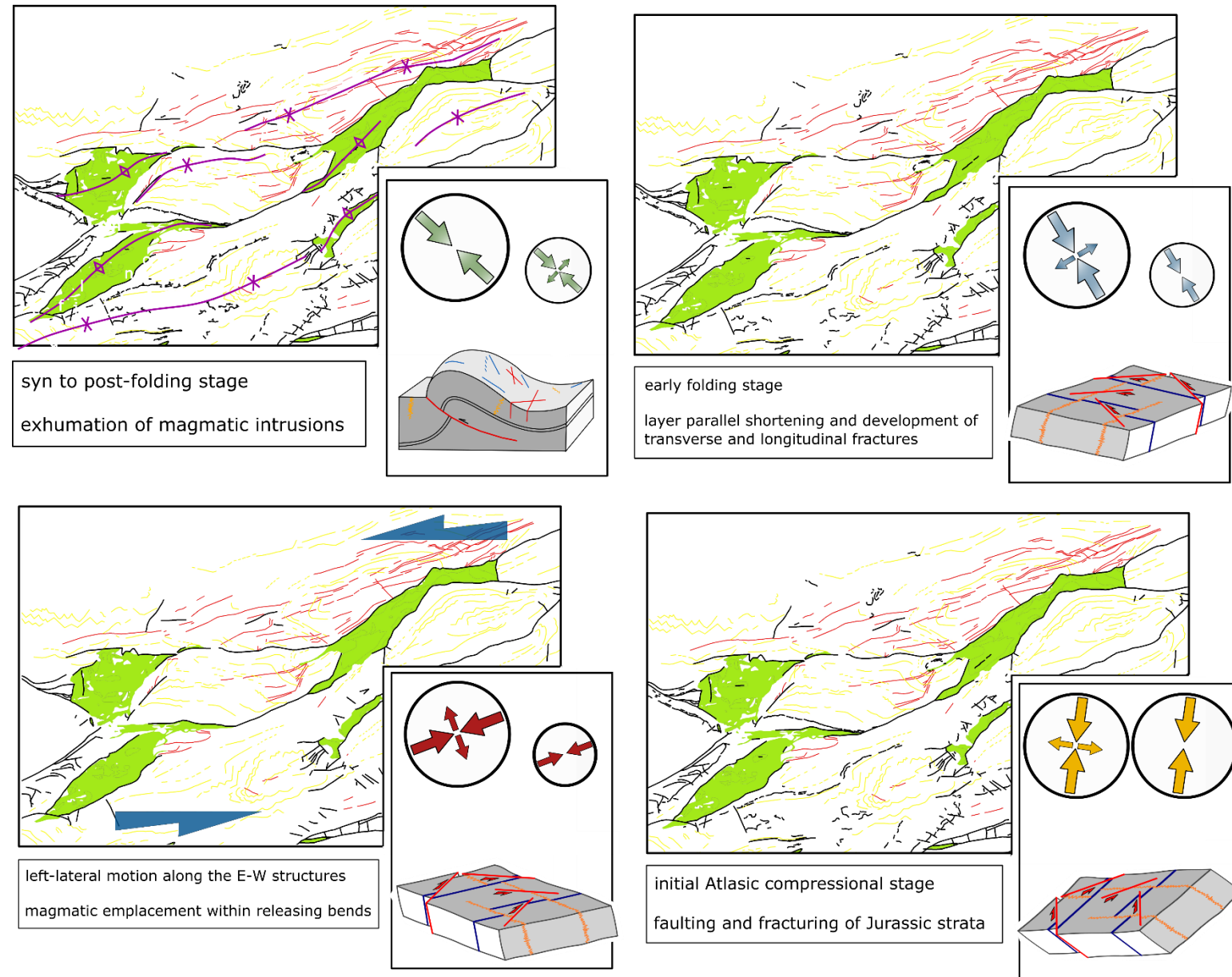
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Figure 12. Conceptual structural evolution model for the study area based on the results of the present study

Content

Introduction

Examining the structural development of the Central High Atlas post-rift basin evolution reveals complex stress history.

Geological Setting

Four main structural stages have been identified: an early compressional event is pointed out characterized by $\sim N70^\circ$ to $N90^\circ$ trending maximum horizontal principal stress. This event is believed to be linked to Middle Jurassic-Early Cretaceous wrench tectonics throughout the Central High Atlas basin, coeval with the emplacement of intraplate alkaline magmatism. Subsequently, the Jurassic layers have been submitted to NNE-SSW and NW-SE compression. These two stress tensors are relatively younger than the E-W compression and are likely ascribed to the Late Cretaceous-Cenozoic Alpine phases. A recent post-folding NW-SE striking compression is highlighted, and it is coherent with the recent Alpine phase that is widely described at the scale of the Atlas orogenic system.

Methodology

Results

A broader-scale paleostress reconstruction and quantification is required to deeply understand the structural history of the range.

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The image is a collage of five photographs. The top-left photo shows a steep, eroded hillside with distinct horizontal sedimentary layers. The top-right photo shows a similar hillside with more varied rock colors, including reddish-brown and grey. The bottom-left photo shows a person in a red jacket crouching next to a rock outcrop, examining its layers. The bottom-right photo shows a person in a red jacket standing next to a large, reddish-brown rock formation. The bottom-center photo shows a wide, flat landscape with a herd of animals in the distance under a cloudy sky. A large, semi-transparent dark rectangle is overlaid in the center, containing the text "THANK YOU" in white, bold, sans-serif capital letters.

THANK YOU