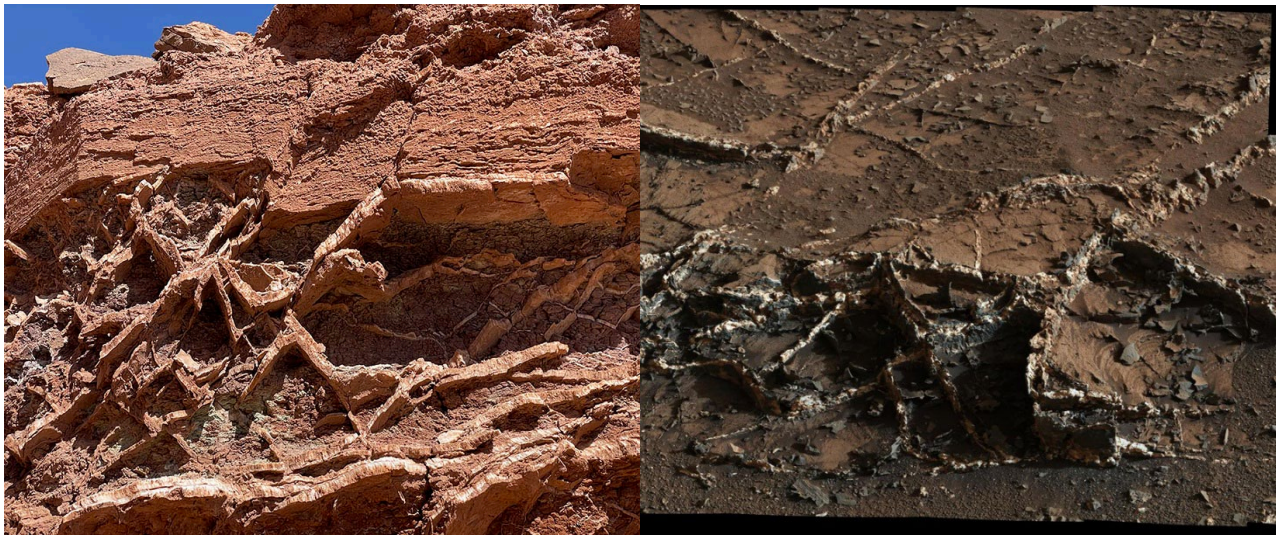
Semi-arid alluvial and coastal plains on Earth and Mars

(Proposer: Prof.ssa Anna Breda, Prof. Matteo Massironi)

The study of depositional environments on Earth as analogs for the study of Mars, offers valuable information on the geology, climate, and the possibility that life may have existed or still exists on the Red Planet. In particular, semi-arid alluvial and coastal plains are among the most promising analogues of Martian environments of the Noachian-Hesperian epoch, when the planet underwent a dramatic climatic transition from warm, humid conditions dominated by clay mineral formation to arid and semi-arid conditions characterized by evaporite precipitation.

This project aims to investigate semi-arid alluvial plain deposits on Earth and compare them with the sedimentary environments observed by the Curiosity rover in Gale Crater on Mars. The terrestrial sedimentary successions selected for this study are the Permian sequences of Southern Alps (Italy) and the Cretaceous (Cenomanian) sequences of southern High Atlas (Morocco). Both these sequences are characterized by fluvial sandstones, siltstones and evaporites and exhibit sedimentary structures strikingly similar to those observed in Gale Crater, offering valuable insights into ancient Martian environments.



On the left, veins of sulphates in the Cretaceous succession of the southern High Atlas in Morocco; on the right, veins of sulphates in the Gale Crater on Mars (image credit: NASA).

The research will conduct detailed stratigraphic and structural analyses of these terrestrial analogues, emphasizing fluvial and coastal deposits in arid to semi-arid paleoclimates. Particular attention will be given to evaporitic pedogenetic levels and evaporitic veining associated with subsequent tectonic fracturing mirroring features observed in Gale Crater. The compositional analysis of sulfates of terrestrial case studies will be performed using X-ray diffraction, chemical analysis and hyperspectral techniques. This data will be crucial for understanding the mineralogical composition and formation conditions of these deposits. The results will be directly compared with data acquired by Curiosity's onboard instruments, including ChemCam and CheMin, to draw parallels between terrestrial and Martian environments.

By integrating field observations, laboratory analyses, and comparisons with Martian data, this project aims to reconstruct the environmental and climatic variations that occurred on Mars during the Noachian-Hesperian transition. The study will focus on:

- Detailed sedimentological logging and facies analysis;

- Structural mapping of fracture networks and evaporitic veins in field and Digital Outcrops;
- XRD, chemical and hyperspectral analysis of sulfate minerals;
- Comparative analysis with Curiosity rover data from Gale Crater and related 3D and Virtual Reality reconstructions.

This multidisciplinary approach will provide new insights into the depositional and diagenetic processes that shaped both terrestrial and Martian sedimentary environments. By elucidating the similarities and differences between these analogous systems, we can better understand Mars' geological history and its potential for past life. The project's findings will contribute significantly to our understanding of Mars' climatic evolution and help interpret future data from ongoing and planned Mars missions, including the Perseverance rover and the Mars Sample Return campaign.

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