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## A Sulfuric Acid Speleogenesis in the Northern Pyrenees (France)?

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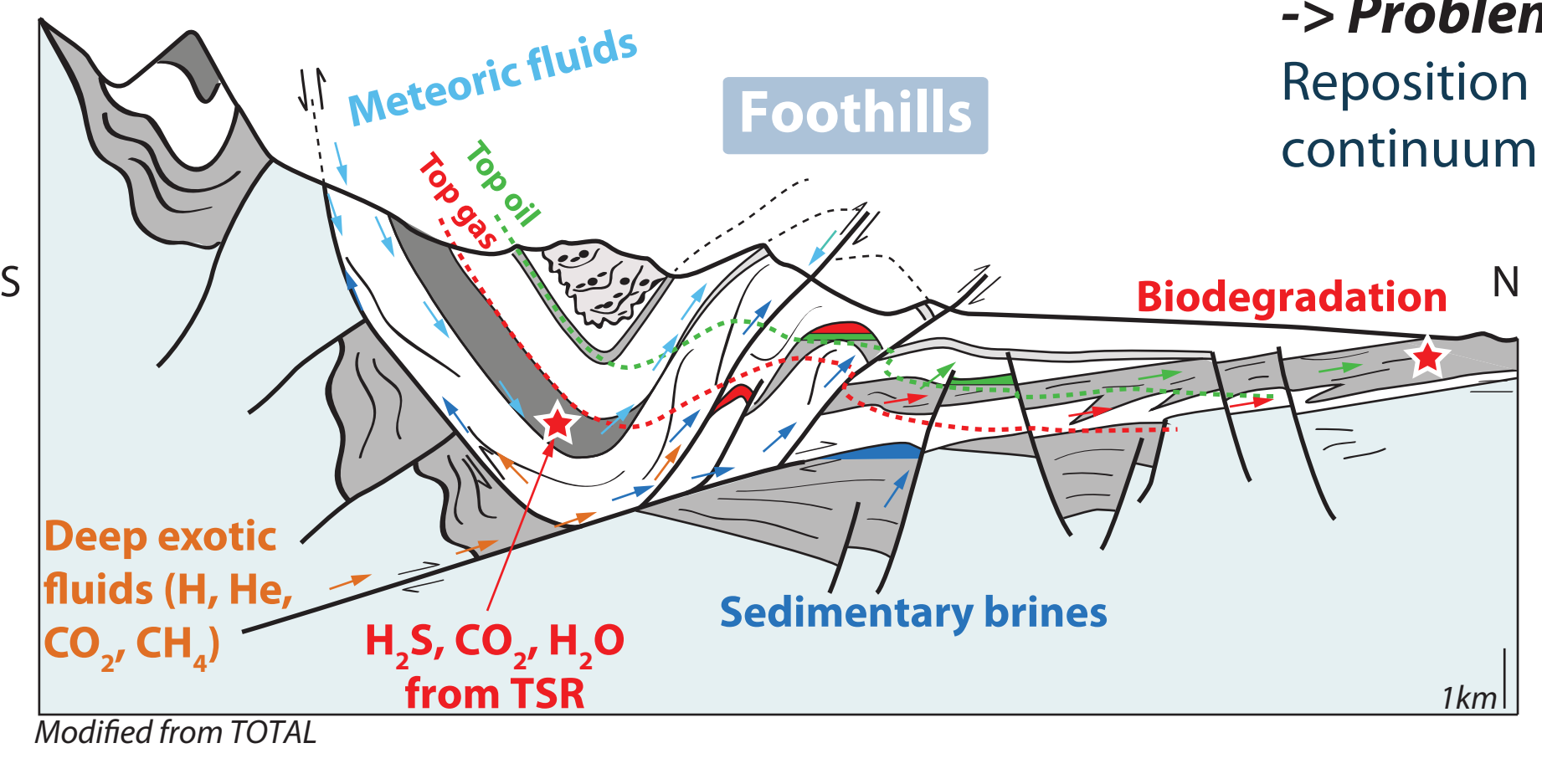
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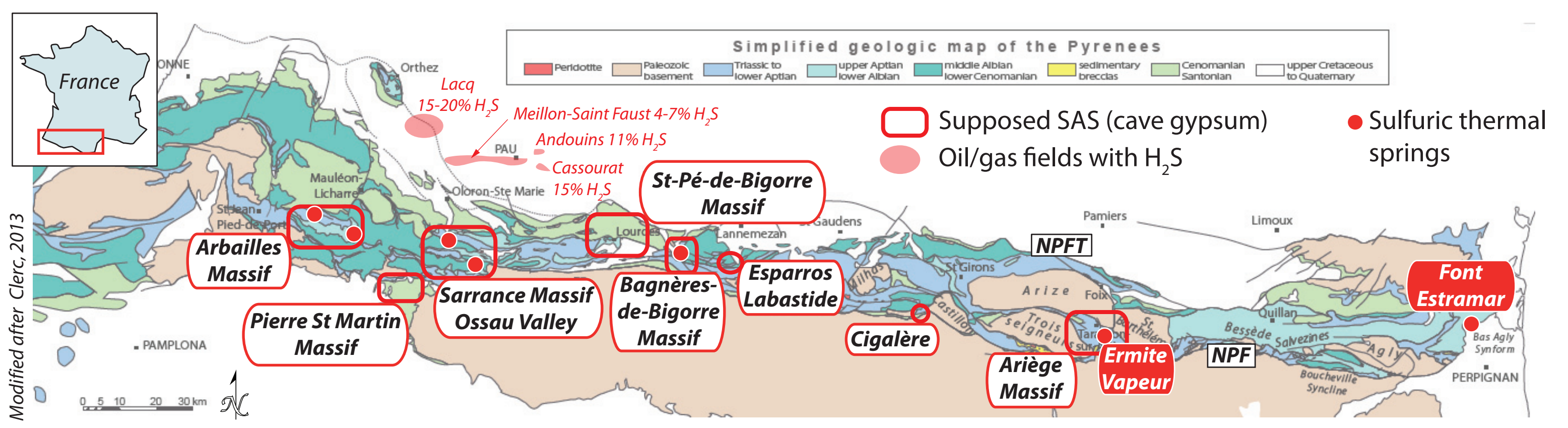
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## 1- Introduction: hypogenic caves in the Northern Pyrenees?

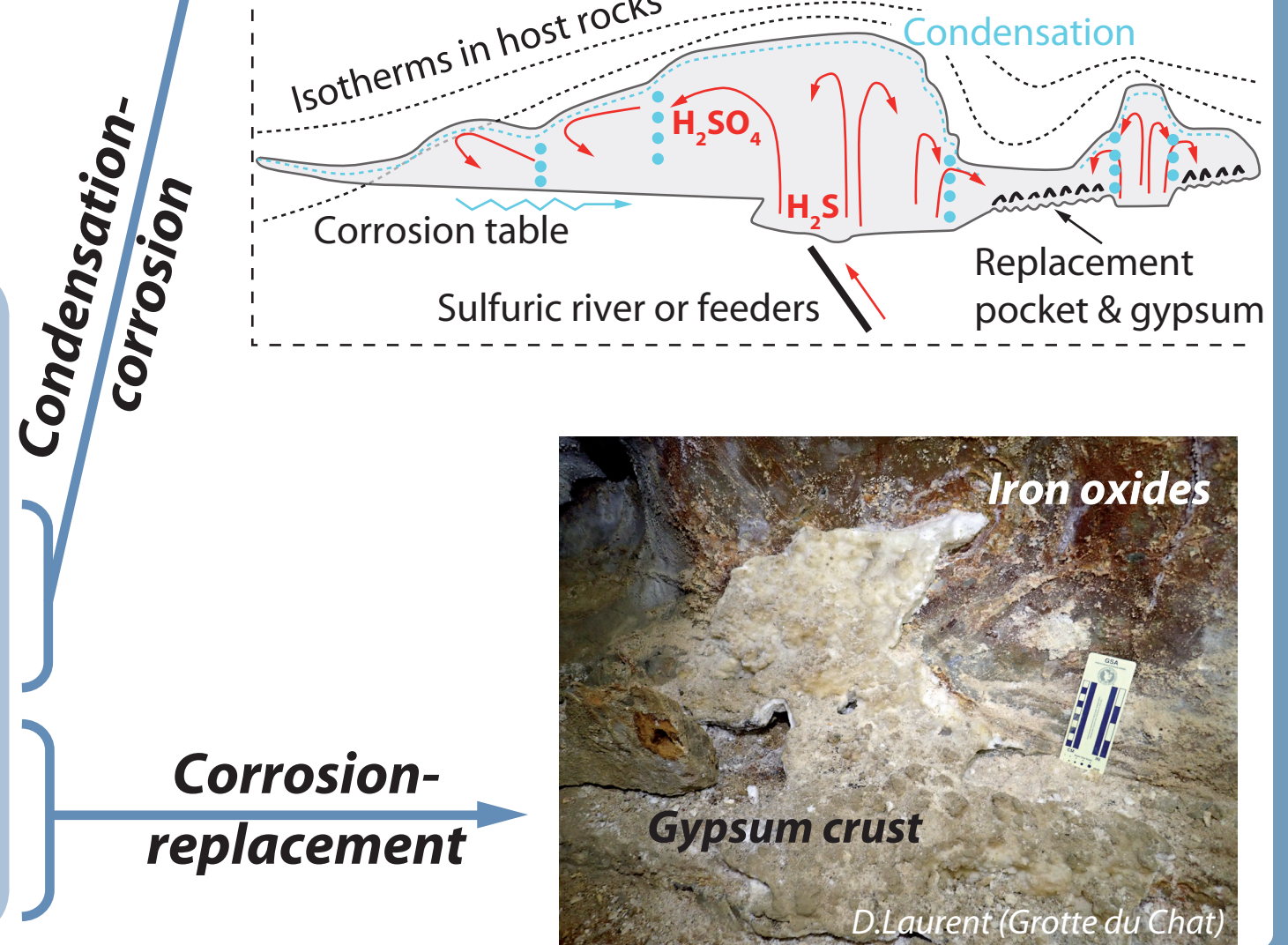
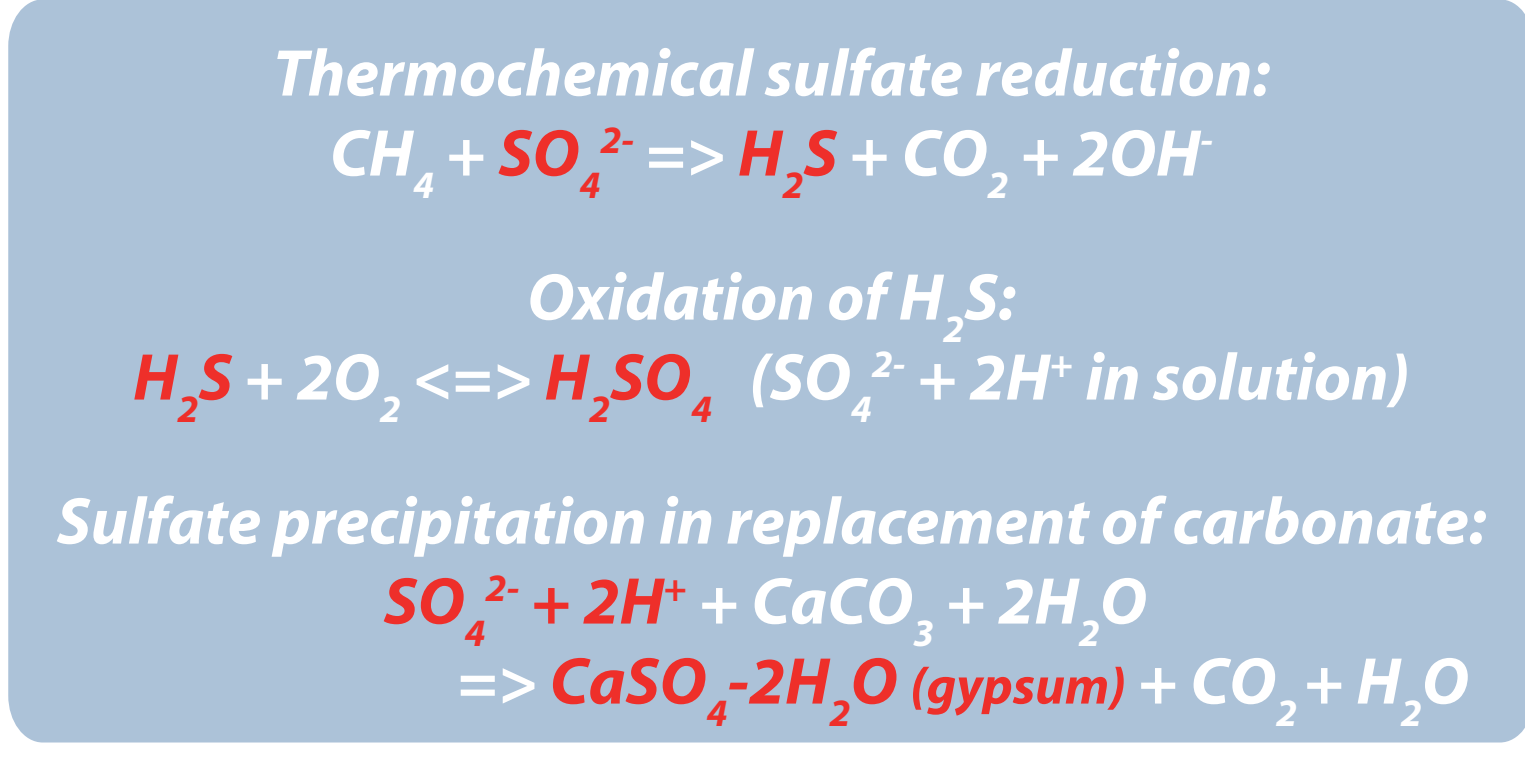
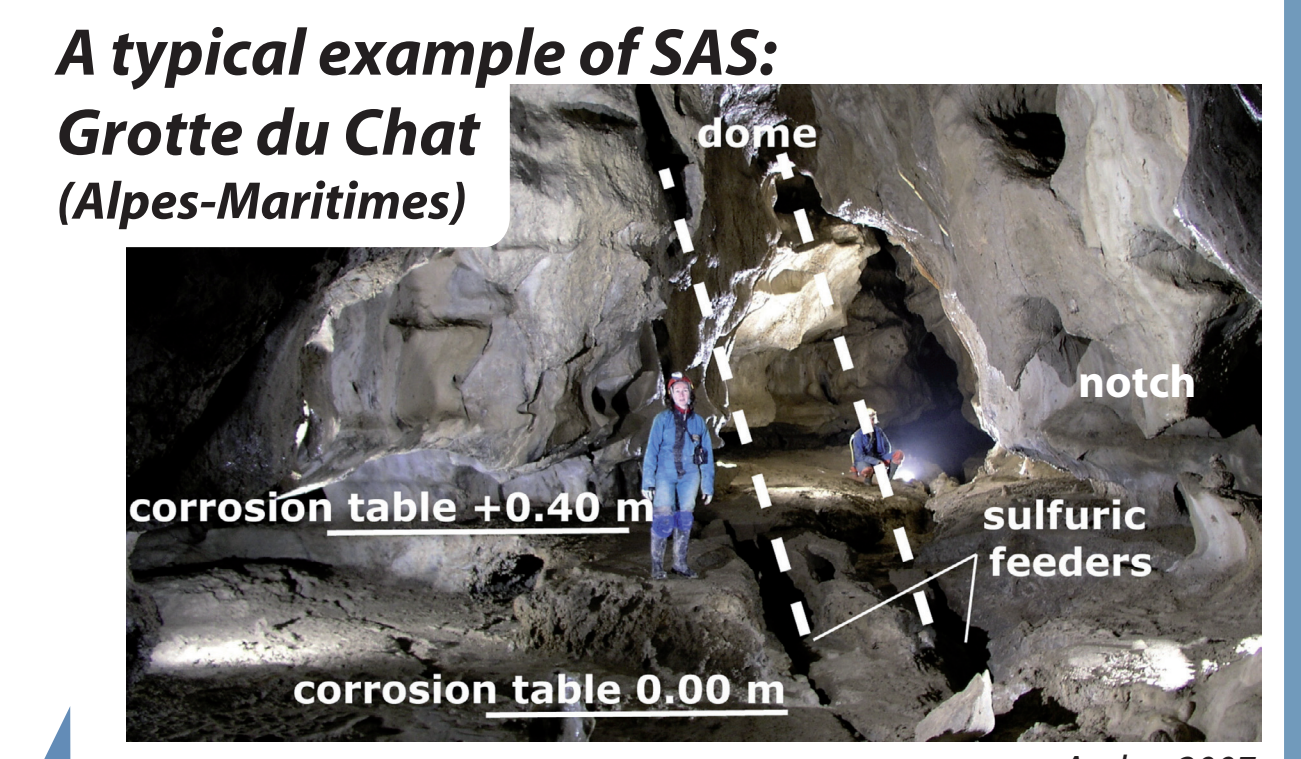
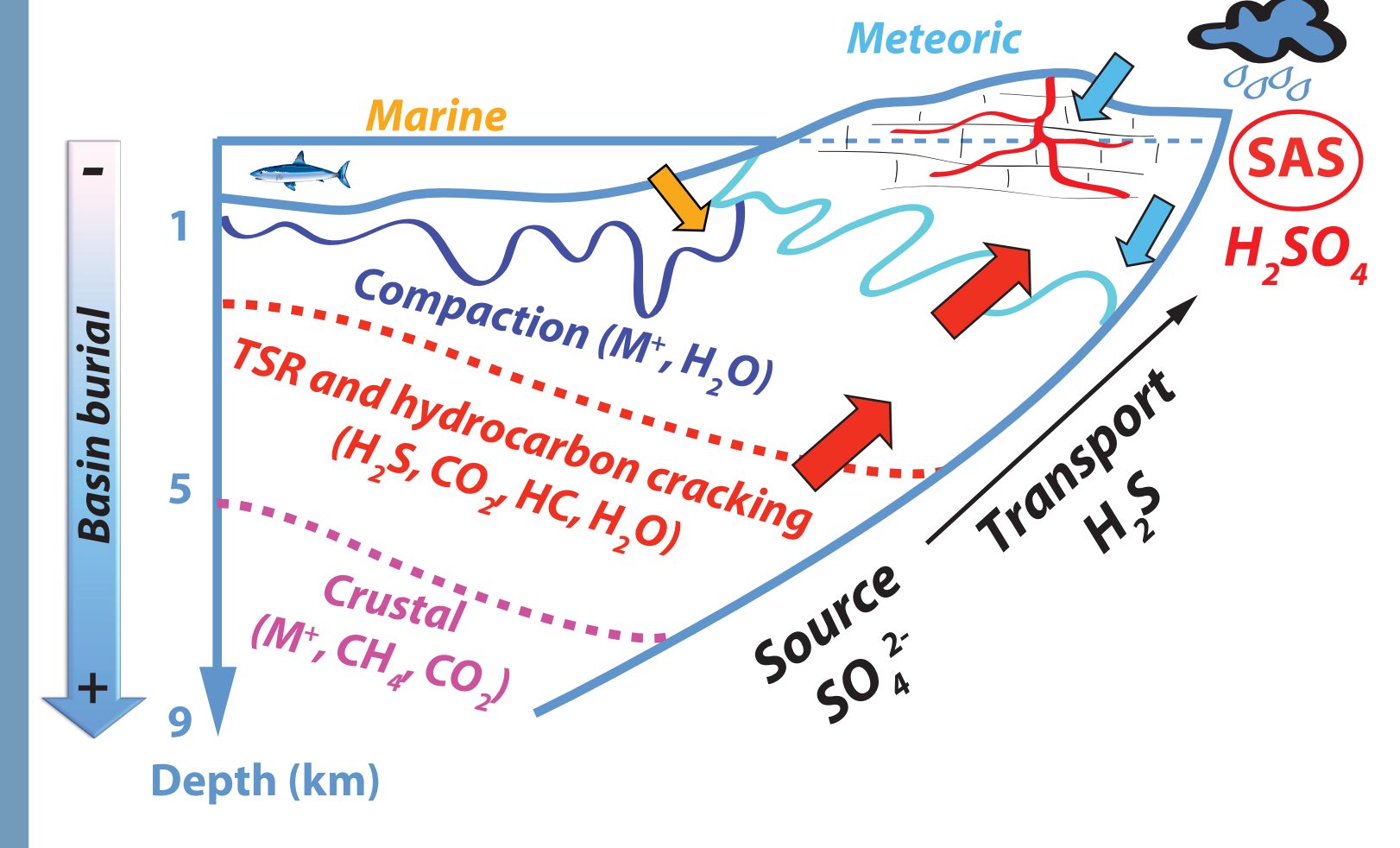


-> **Problematic (in Total «Fluid» program):**  
 Reposition Sulfuric Acid Speleogenesis (SAS) in the continuum of fluid-rock interactions in the foothills.

- > Main questions:**
- **Timing** of karst formation (hyper-extension, compression...)?
  - **Controlling factors** of karst development (structural, geochemical...)?
  - **Nature and origin of fluids** involved in the dissolution (CO<sub>2</sub>, H<sub>2</sub>S, meteoric...)?
  - Link with petroleum and ore deposits?



## 2- Thermochemical Sulfate Reduction (TSR) and SAS



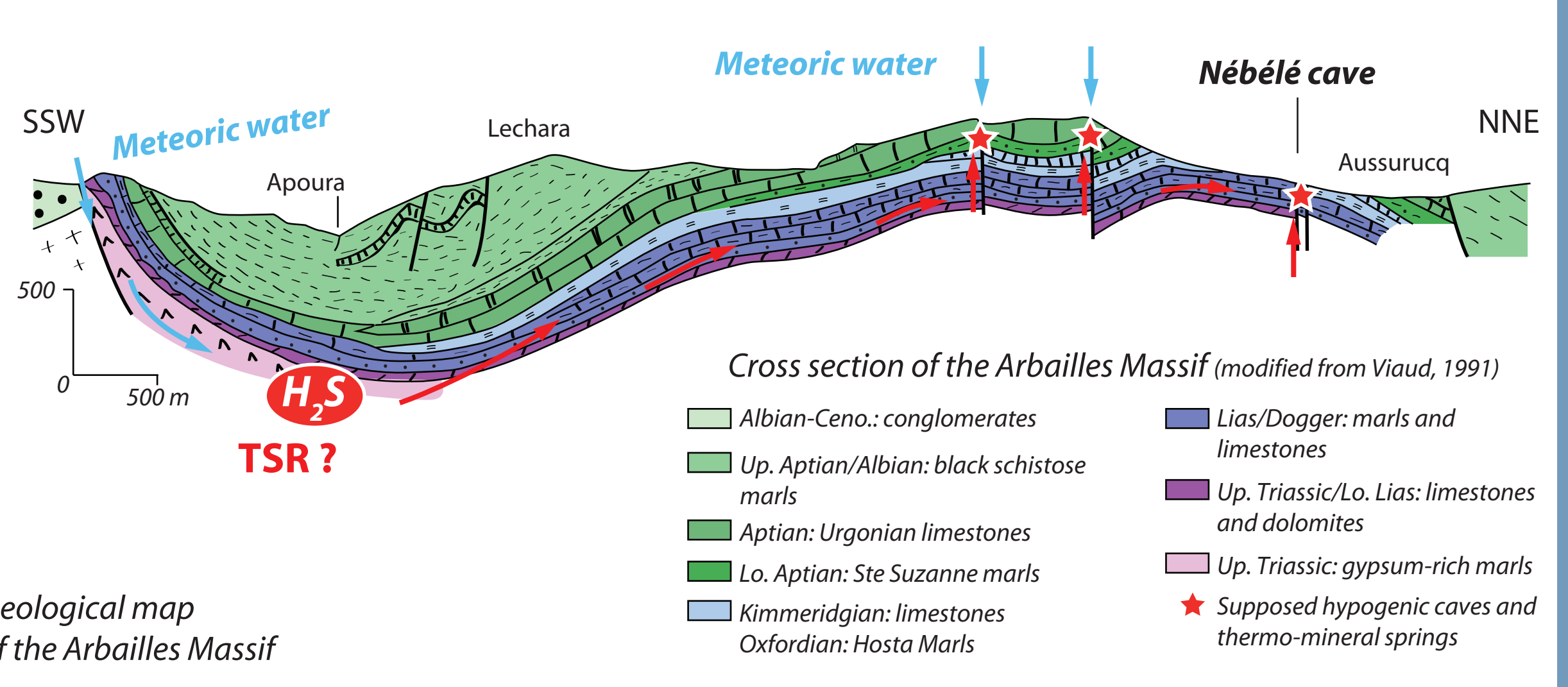
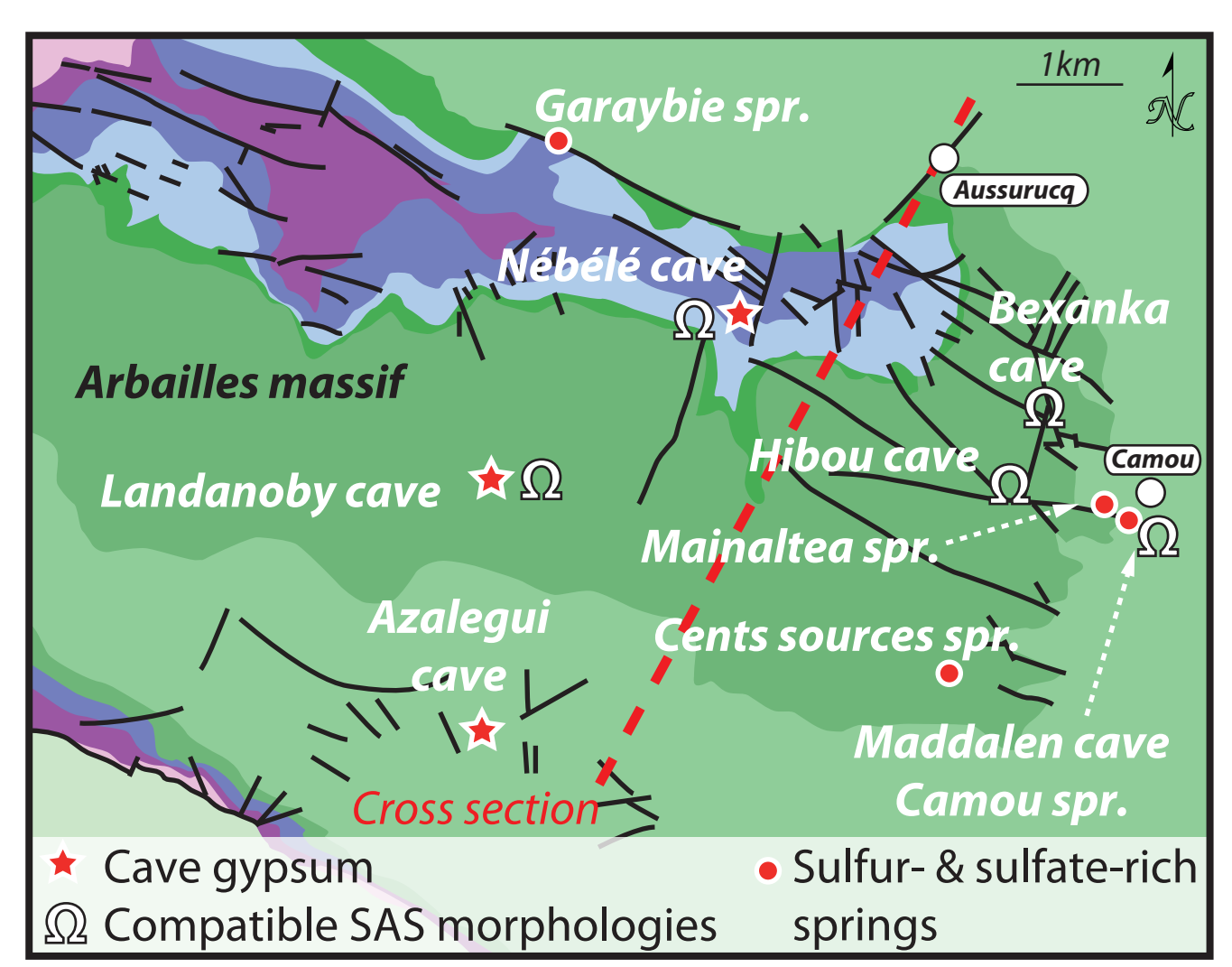
## 3- Field evidences of cave sulfates in the Arbailles massif: SAS or evaporite leaching?

**The Arbailles Massif, a good candidate for SAS...**

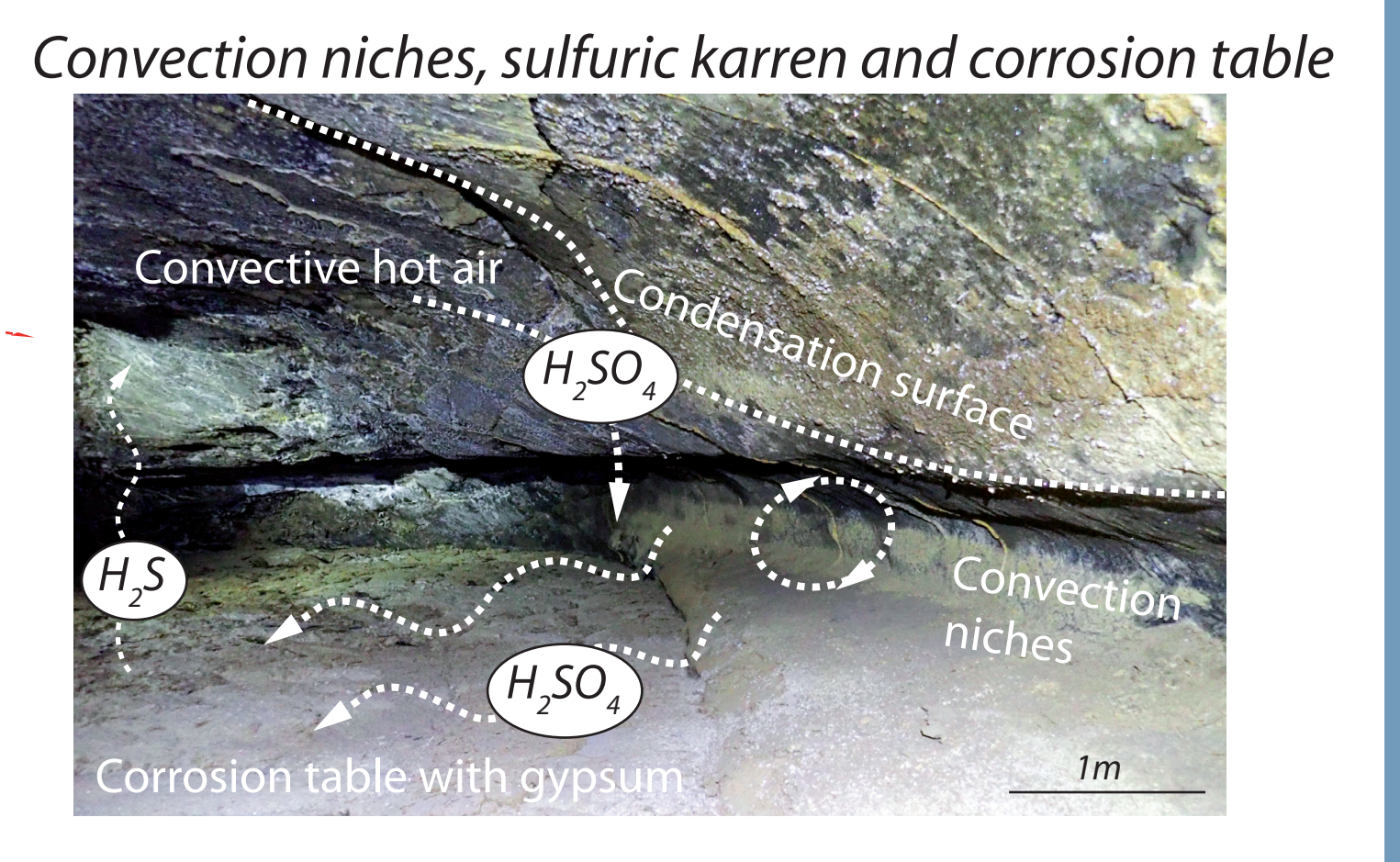
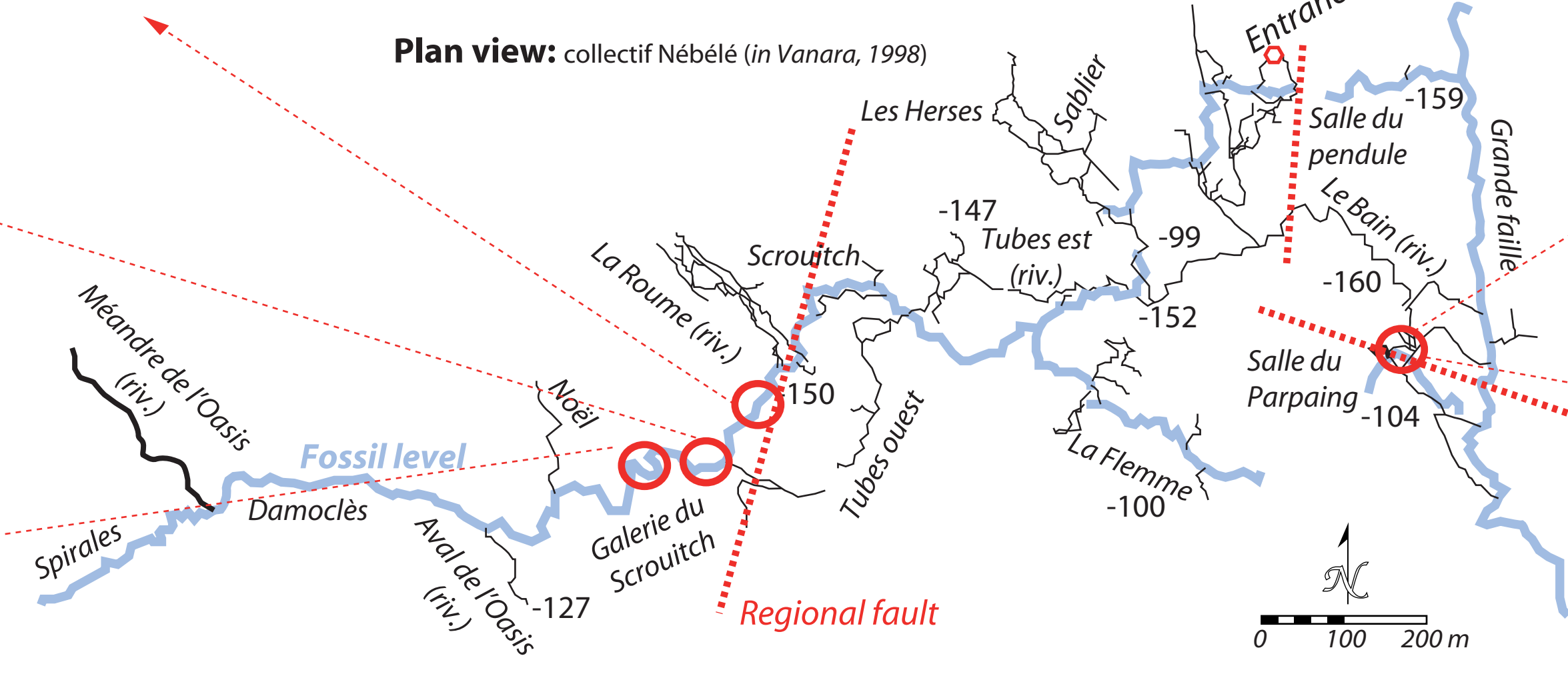
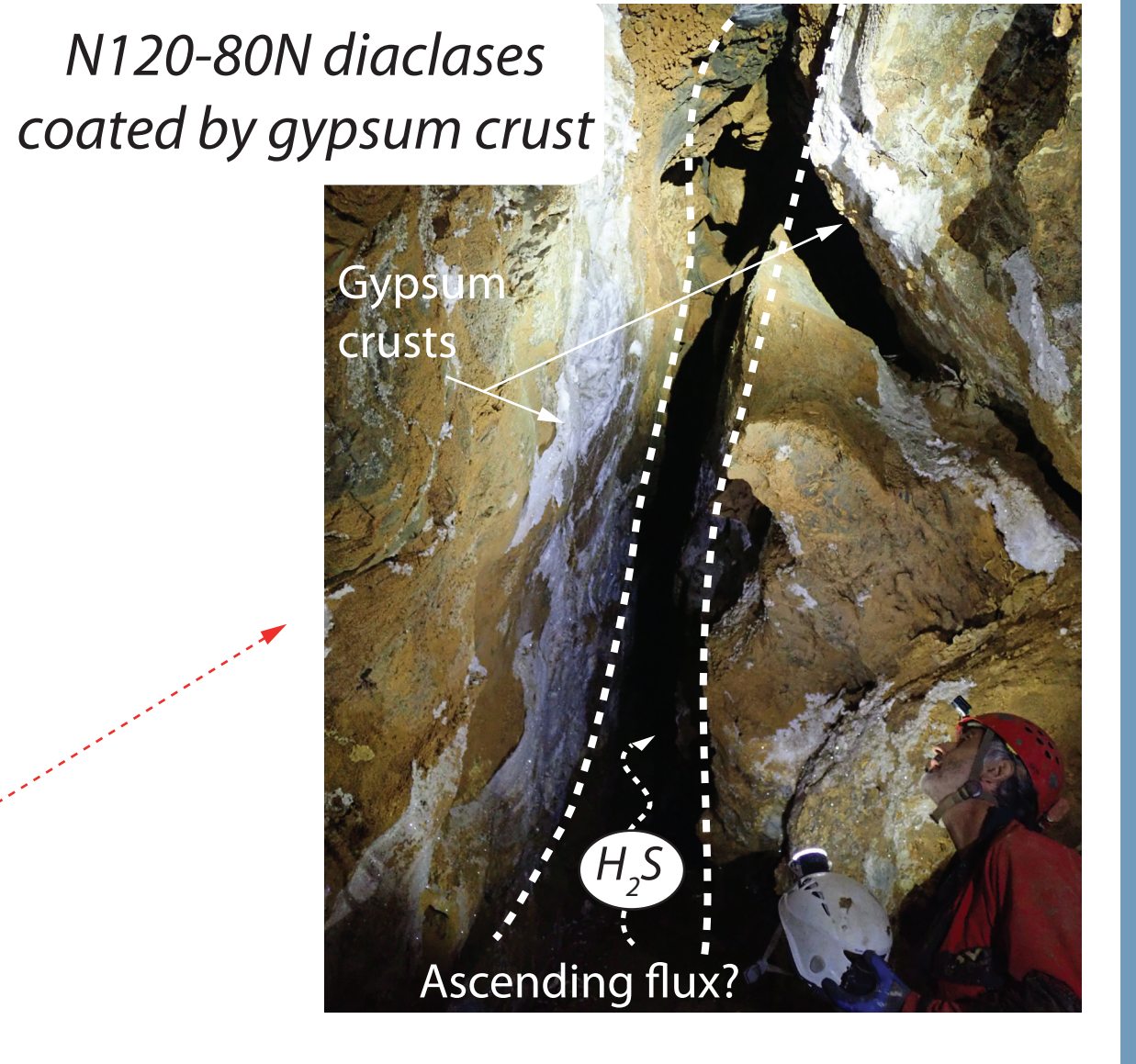
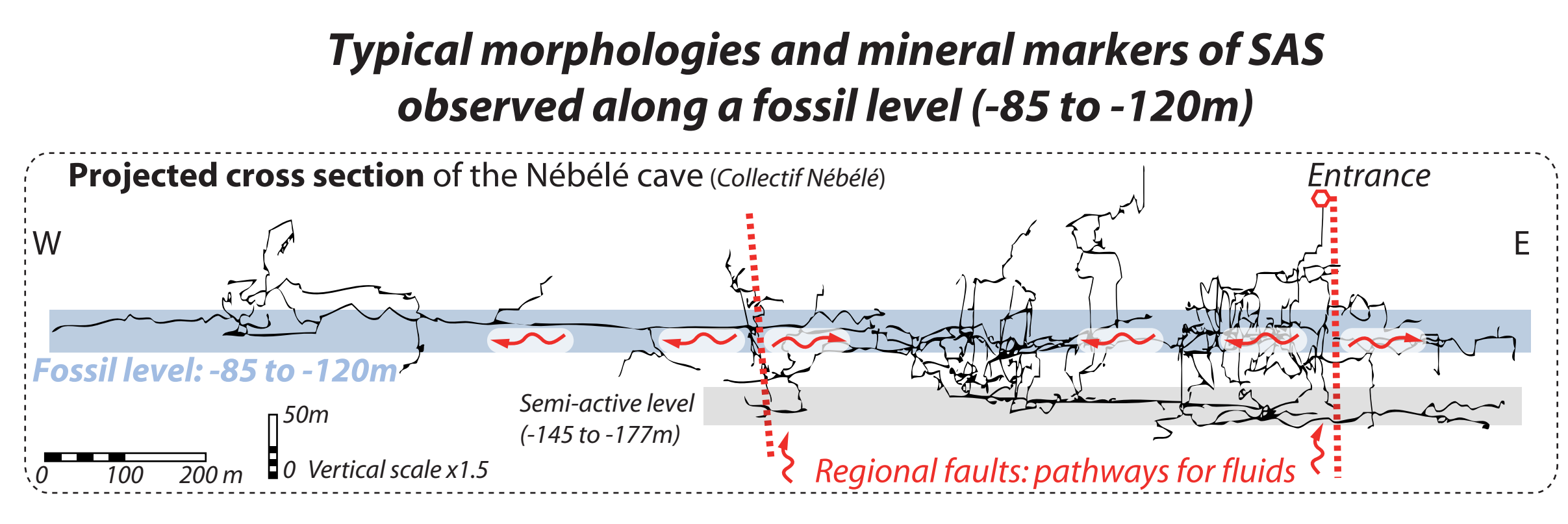
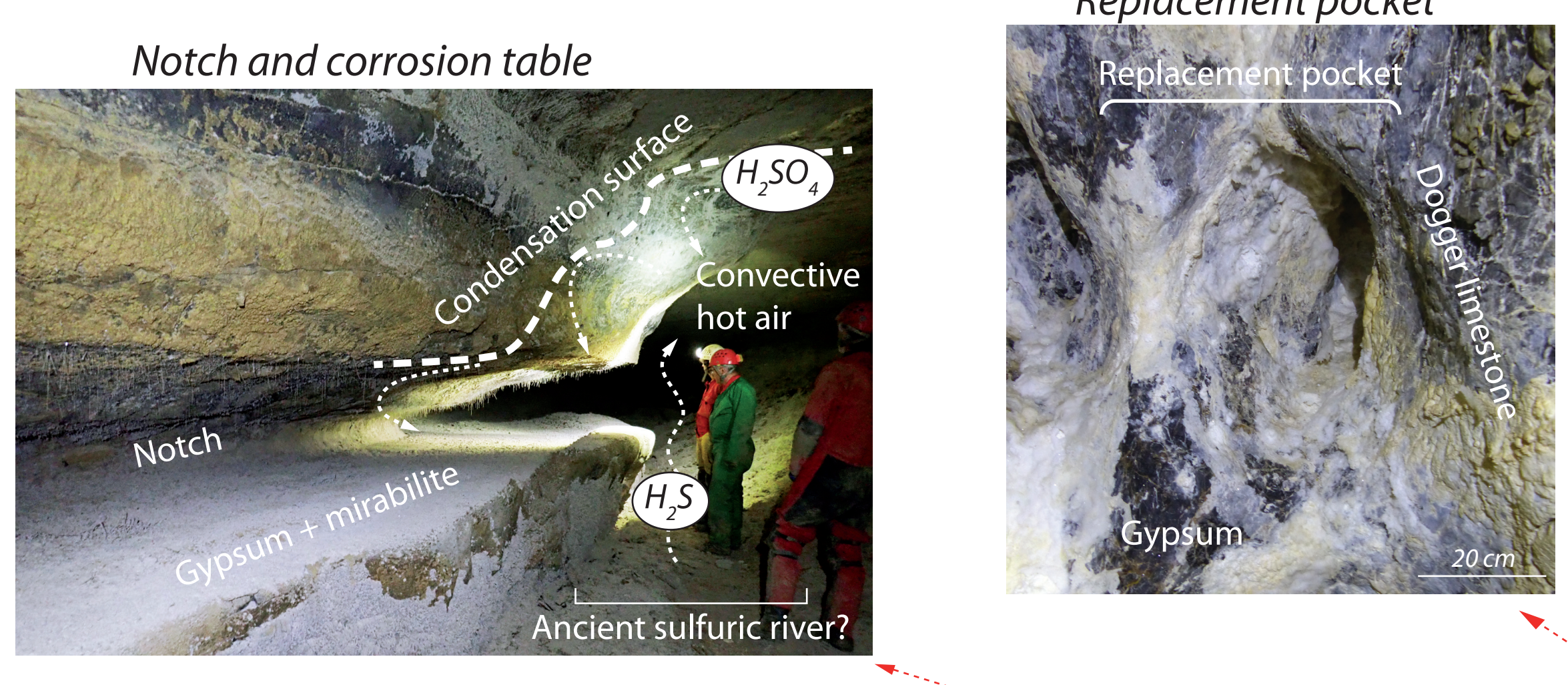
- > Numerous caves in Aptian and Dogger limestones
- > Caves located close to regional faults connected to Triassic evaporites
- > Current thermo-mineral springs = sulfate/sulfur-rich deep fluids circulation
- > Gypsum precipitation in karst systems
- > Relative proximity with oil seeps and hydrocarbon fields

**... But several processes may be responsible for cave sulfate precipitation:**

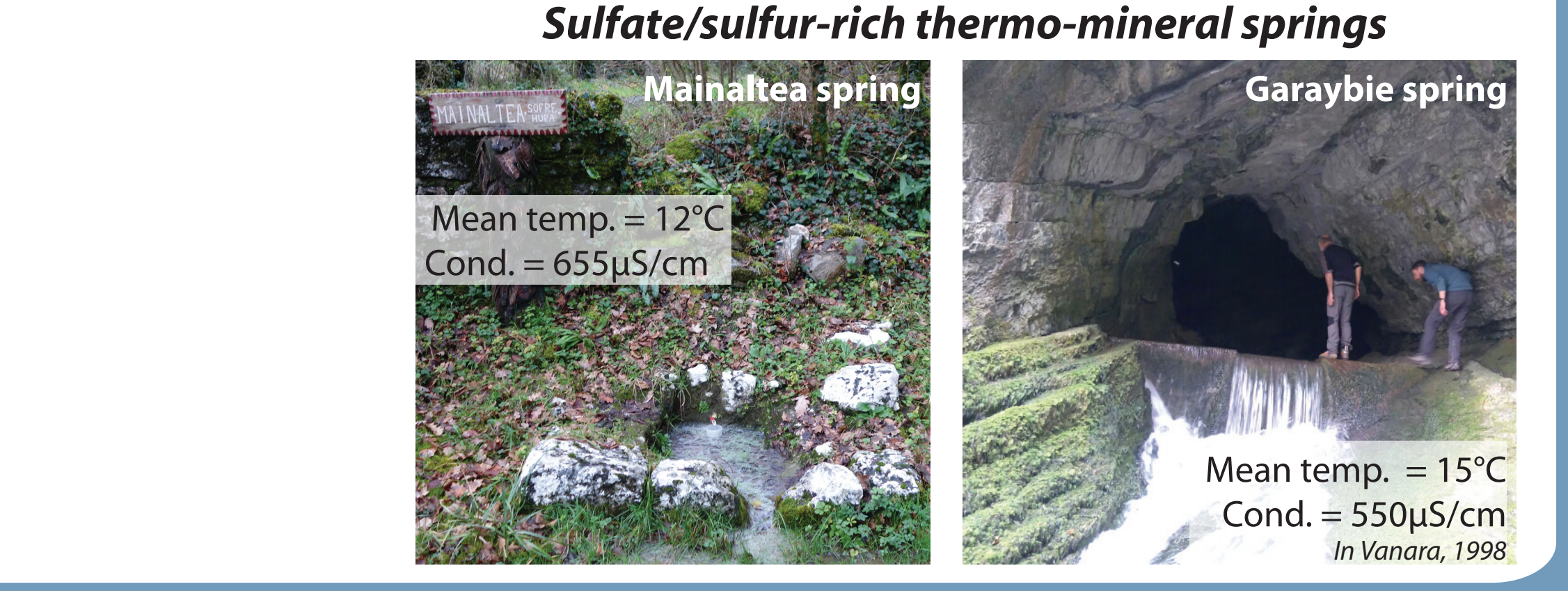
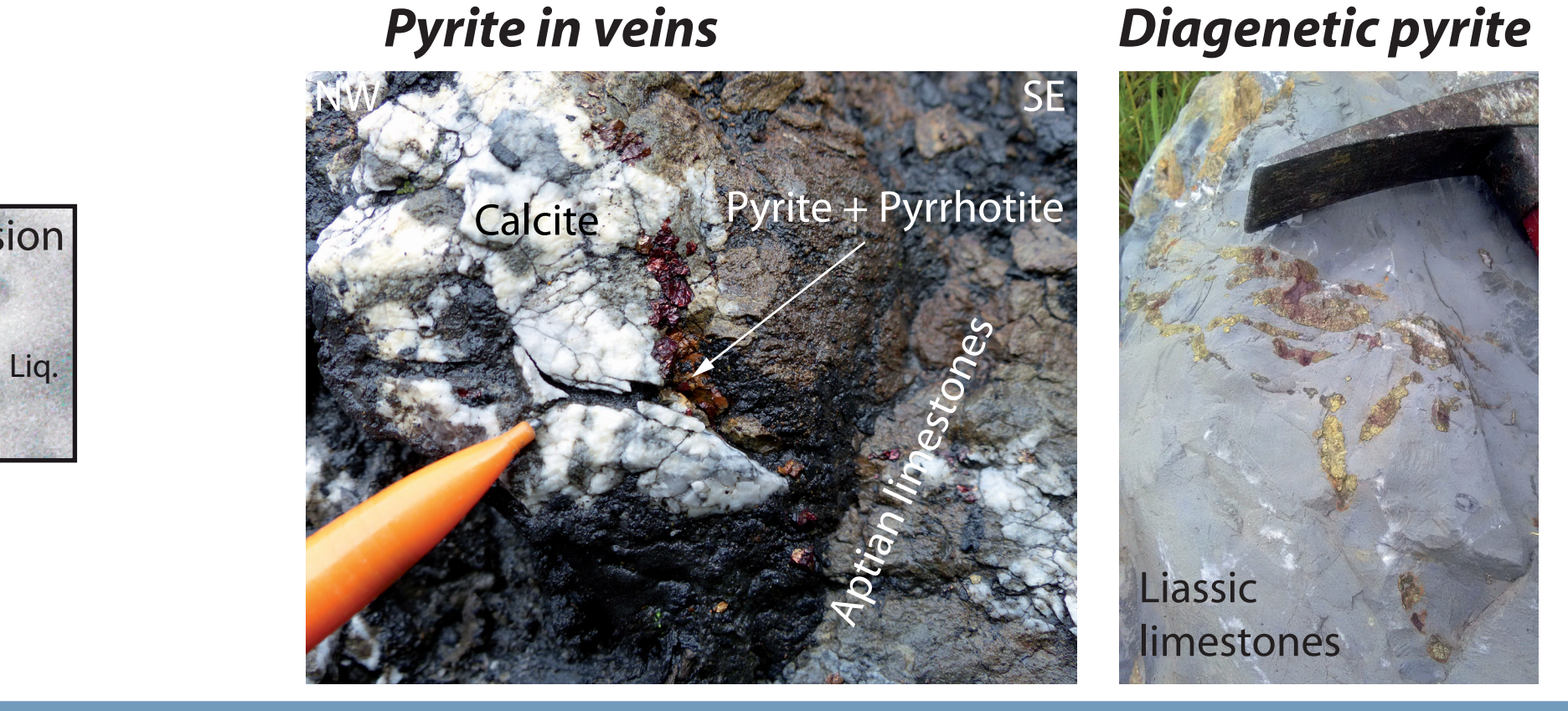
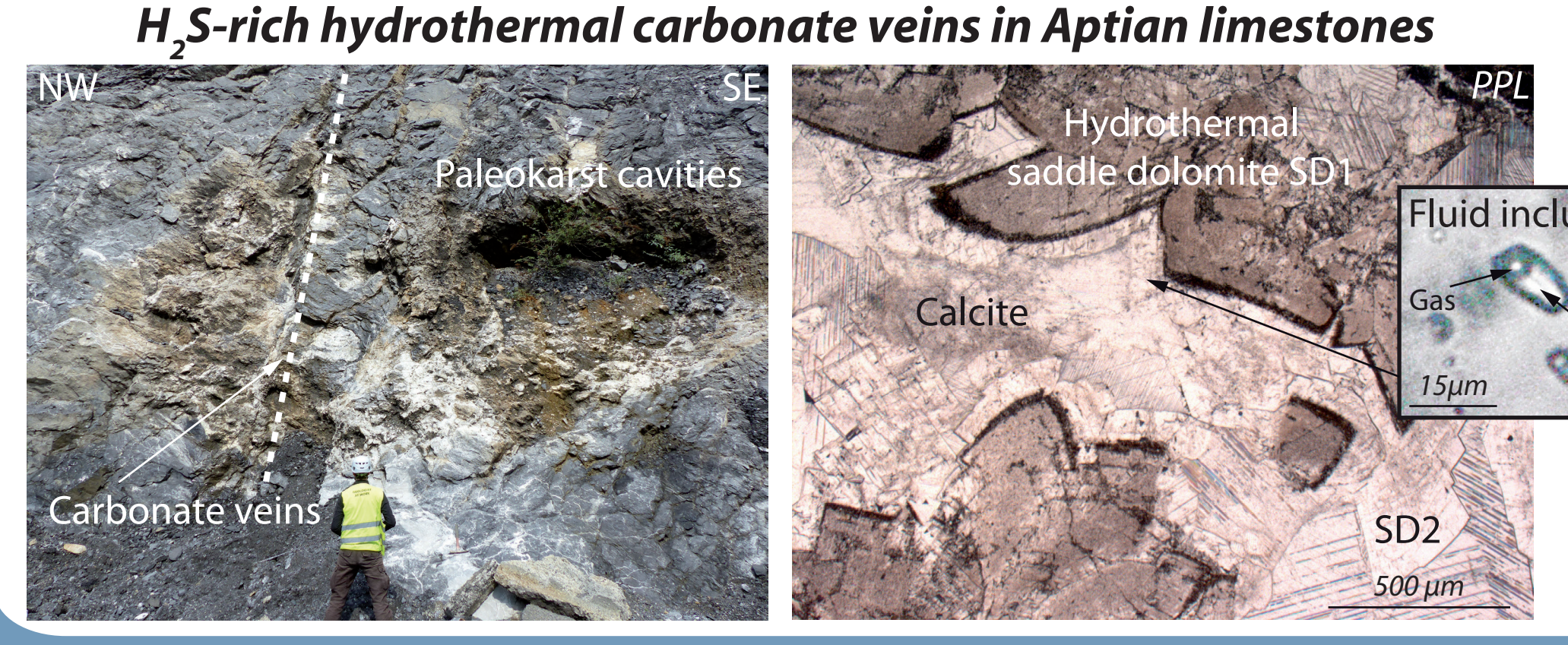
- > SAS
- > Pyrite oxidation
- > Leaching of sulfate-rich sediments (evaporite, carbonate...)
- > Decomposition of organic matter (guano...)



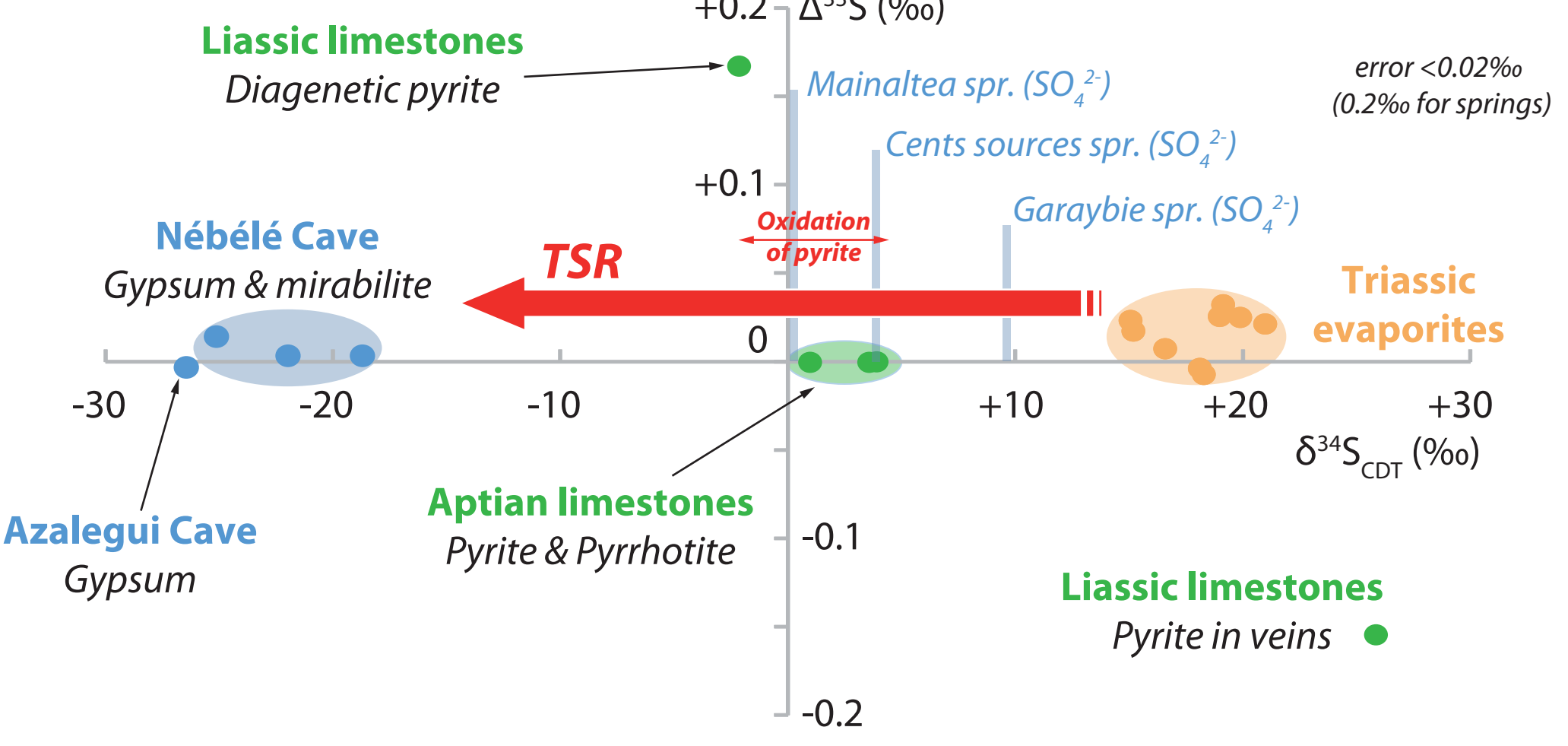
### Example of the Nébélé Cave



### Potential sources of sulfur in the sedimentary basin



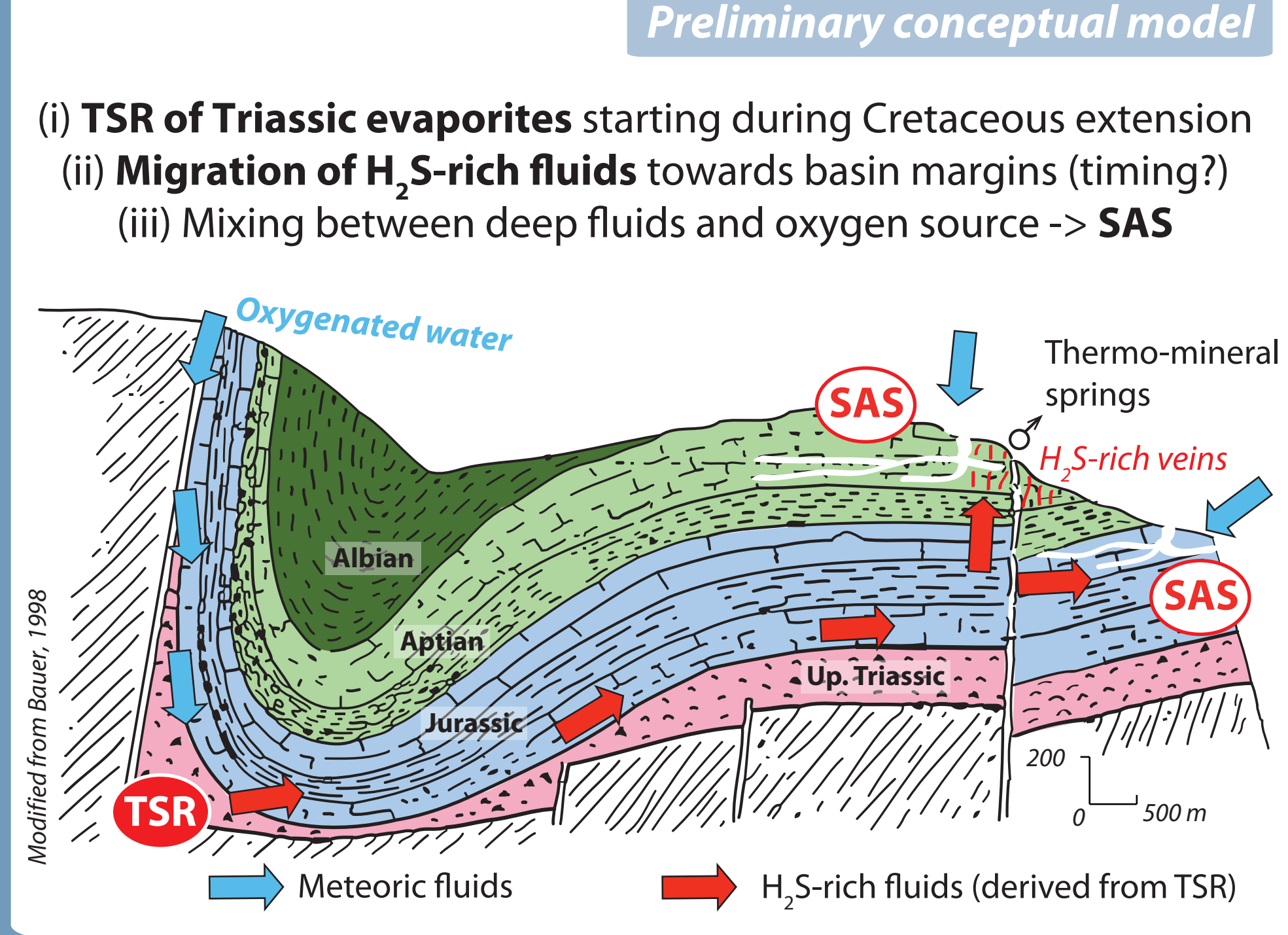
## 4- Sulfur isotopes: origin and processes



**Cave sulfates are not linked to evaporite leaching or pyrite oxidation:**

- such processes do not involve significant δ<sup>34</sup>S fractionation
- very few pyrites in sediments
- > High δ<sup>34</sup>S fractionation between Triassic evaporites and cave sulfates
- > **Evidence of TSR and H<sub>2</sub>S-rich fluid migration**

## 5- Conclusions: 1<sup>st</sup> hypothesis and Perspectives



## 6- Collaborations

- P. & S. Degouve (GSHP Tarbes)
- M. Douat (ARSIP, ICE Himalayas)
- Collectif Nébélé
- P. Sorriaux & CDS09/SCHS
- CDS64
- Data base Karsteau
- Karsteau
- ARSIP
- CDS 64
- Centre National de la Recherche Scientifique
- Centre de Recherches Petrolières de Tarbes