The biogeochemical sulfur cycle during the formation of the Mediterranean Salt Giant
Oxygen and sulfur isotopes of sulfate ($\text{SO}_4^{2-}$) are sensitive to mixing and microbial processes.

- Freshwater inputs
  - $10 \mu\text{M} < [\text{SO}_4^{2-}] < 2 \text{mM}$
  - Sulphid and Evaporite weathering
  - $-20 < \delta^{34} \text{S}_{\text{SO}_4} < -20 \‰$
  - $5 < \delta^{18} \text{O}_{\text{SO}_4} < 18 \‰$

- Sulfate produced by sulfide oxidation
- Microbial Sulfate Reduction only
- Mixing with freshwater

How can sulfur isotopes help?...

Modified from El Kilany (2018)

$[\text{SO}_4^{2-}] \approx 28 \mu\text{M}$

$\delta^{34} \text{S}_{\text{SO}_4} = 22 \‰$

$\delta^{18} \text{O}_{\text{SO}_4} = 11 \‰$

Bottcher et al. 1999
UPPER GYPSUM RECORD:
data available from Onshore and Offshore record
Important informations are also hidden in sulfide-bearing minerals...

**Microbial Sulfate Reduction:**

\[
\text{SO}_4^{2-} + 2\text{CH}_2\text{O} \rightarrow \text{H}_2\text{S} + 2\text{HCO}_3^-
\]

**Pyrite Formation:**

\[
\text{H}_2\text{S} + \text{FeS} \rightarrow \text{FeS}_2 + \text{H}_2
\]


Pyrite grains associated with filamentous microbe fossils

Pyrite grains associated with carbonate rich patina between gypsum laminae

Pyrite (FeS$_2$) analyses
Combining both Sulfide and Sulfate bearing minerals:

Insights from the Vena del Gesso Section

\[ \varepsilon^{34}\text{S}_{\text{net}} \approx \delta^{34}\text{S}_{\text{pyrite}} - \delta^{34}\text{S}_{\text{gypsum}} \]