Environmental changes across the onset of the Messinian salinity crisis: insights from the Piedmont Basin (NW Italy)

Mathia Sabino[a], Daniel Birgel[a], Francesco Dela Pierre[b], Marcello Natalicchio[b], Enno Schefuß[c], Jörn Peckmann[a]

[a]Institut für Geologie, Centrum für Erdsystemforschung und Nachhaltigkeit, Universität Hamburg, D-20146 Hamburg, Germany
[b]Dipartimento di Scienze della Terra, Università degli Studi di Torino, I-10125 Torino, Italy
[c]MARUM – Zentrum für Marine Umweltwissenschaften, Universität Bremen , D-28359 Bremen, Germany

EGU

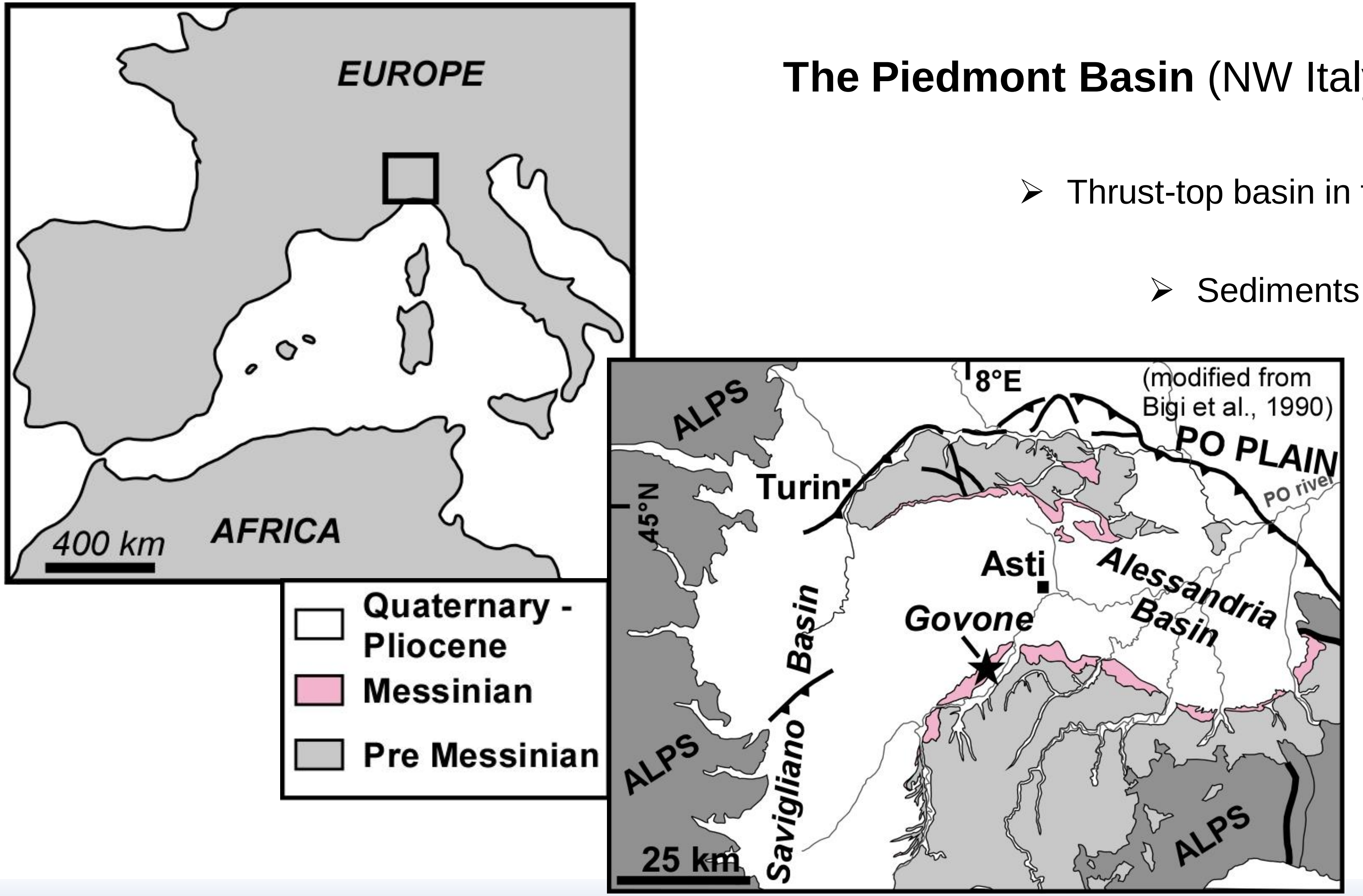
Universität Hamburg
DER FORSCHUNG | DER LEHRE | DER BILDUNG

UNIVERSITÀ DEGLI STUDI DI TORINO

Universität Bremen

The Piedmont Basin (NW Italy)

- Thrust-top basin in the Alpine retroforeland
- Sediments: Upper Eocene to **Messinian**



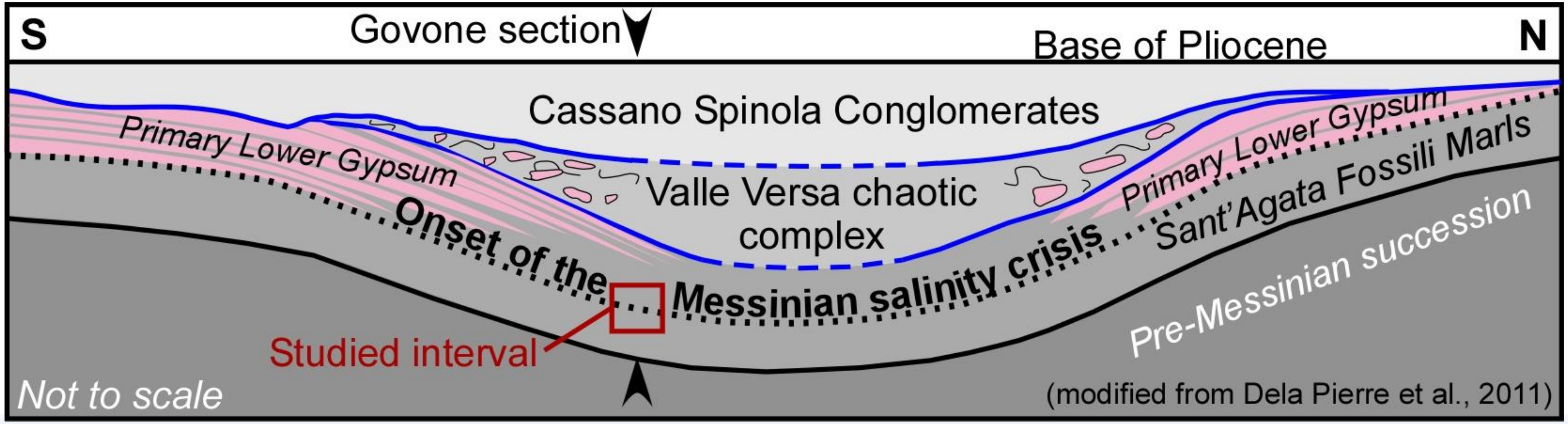
The Messinian stratigraphy

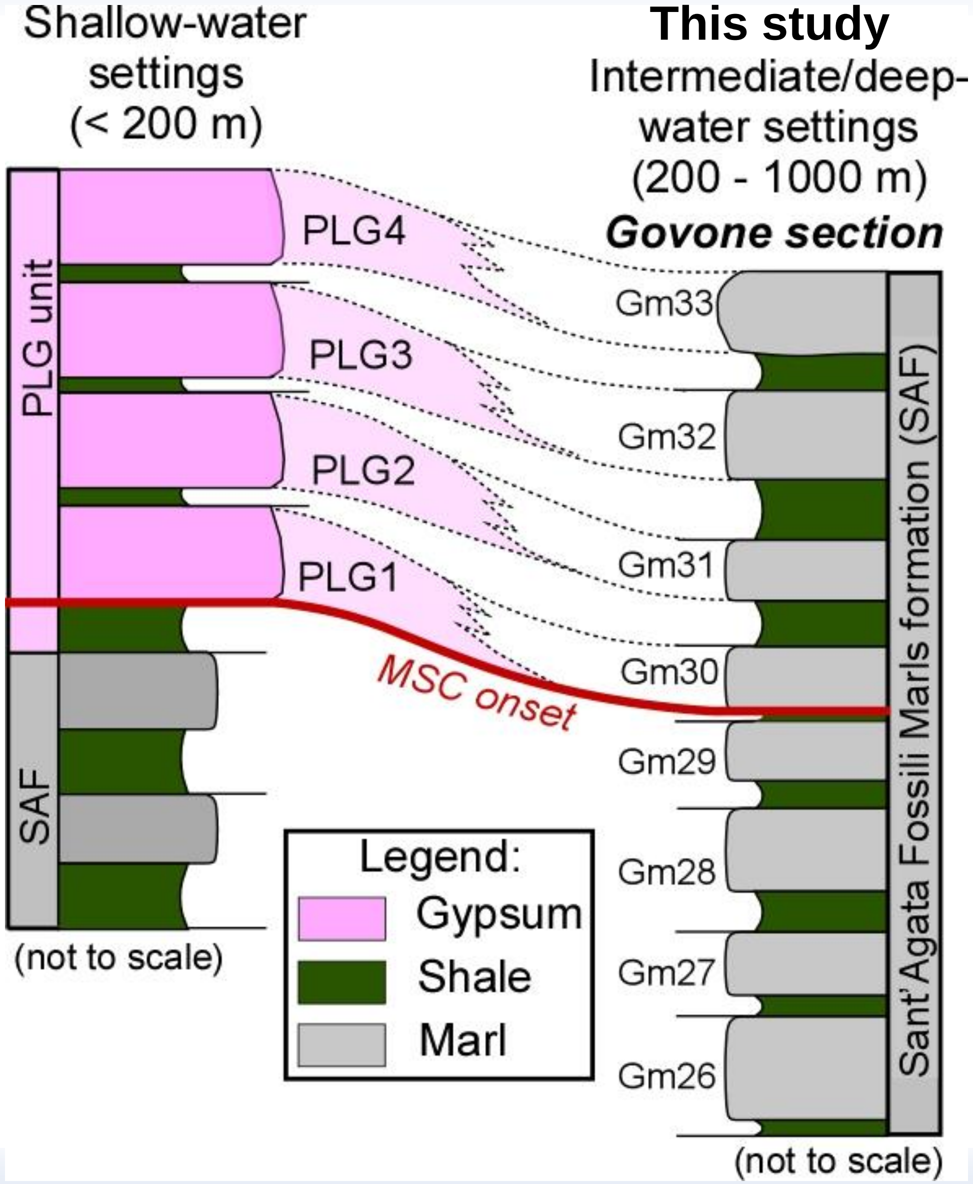
- Sant'Agata Fossili Marls formation → Shales and marls
  - At the top:
    Primary Lower Gypsum (PLG) unit → Shales and primary gypsum

} Deposition paced by **astronomical precession**
Shales: *prec. minima*
Marls/gypsum: *prec. maxima*

- Valle Versa chaotic complex → Resedimented and chaotic evaporites

- Cassano Spinola Conglomerates → Fluvio-deltaic deposits





The Govone section

Intermediate to deep-water settings

Pre-Messinian salinity crisis (**MSC**, > 5.97 Ma):

Planktonic foraminifera assemblages fluctuations (up to cycle Gm27)

- Marls: drier climate (precession maxima)
- Shales: moister climate (precession minima)

After the onset of the MSC?

- **NO lithological changes**
- **Scarcity or absence of fossils**

Paleoenvironmental reconstructions **highly elusive**

Multidisciplinary approach:

Sedimentological analyses

Inorganic geochemistry (33 samples)

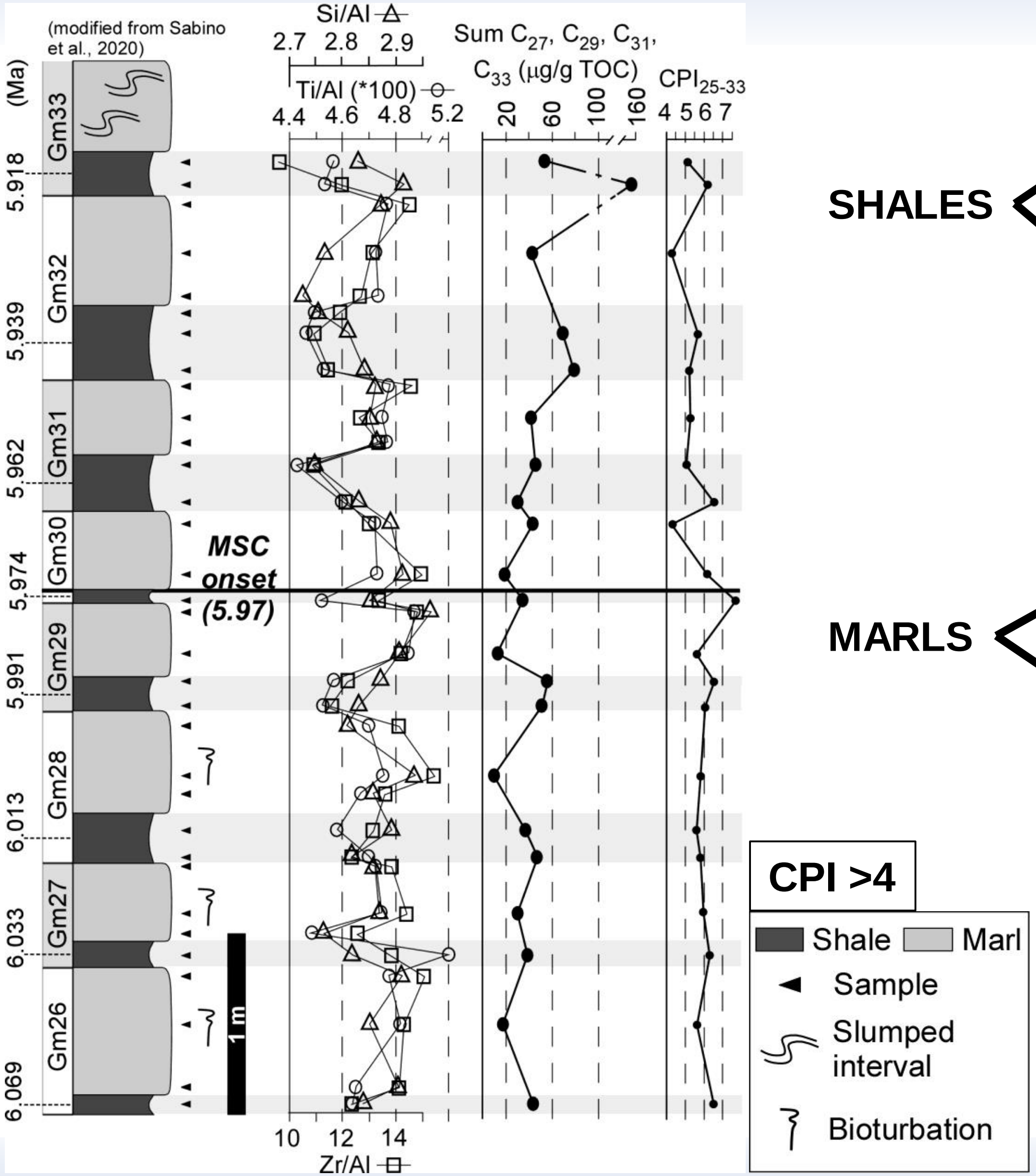
- X-Ray fluorescence analyses: major (**Al, Si, Ti**) and trace (**Zr**) elements

Organic geochemistry (21 samples)

- Lipid biomarker analyses and calculations of indices (Carbon Preference Index, CPI)
- Compound-specific C ($\delta^{13}C$) and H ($\delta^{2}H$, 16 samples) stable isotopes on n-C_{31} alkane

(Modified from Bray and Evans, 1961)

$$CPI=0.5 \times \left(\frac{C_{25}+C_{27}+C_{29}+C_{31}+C_{33}}{C_{24}+C_{26}+C_{28}+C_{30}+C_{32}}+\frac{C_{25}+C_{27}+C_{29}+C_{31}+C_{33}}{C_{26}+C_{28}+C_{30}+C_{32}+C_{34}}\right)$$



SHALES

- reduced aeolian inputs (low element/Al ratios)
- Higher inputs of terrestrial organic matter (high *n*-alkane contents) → Denser terrestrial vegetation cover

→ **Moister climate conditions at precession minima**

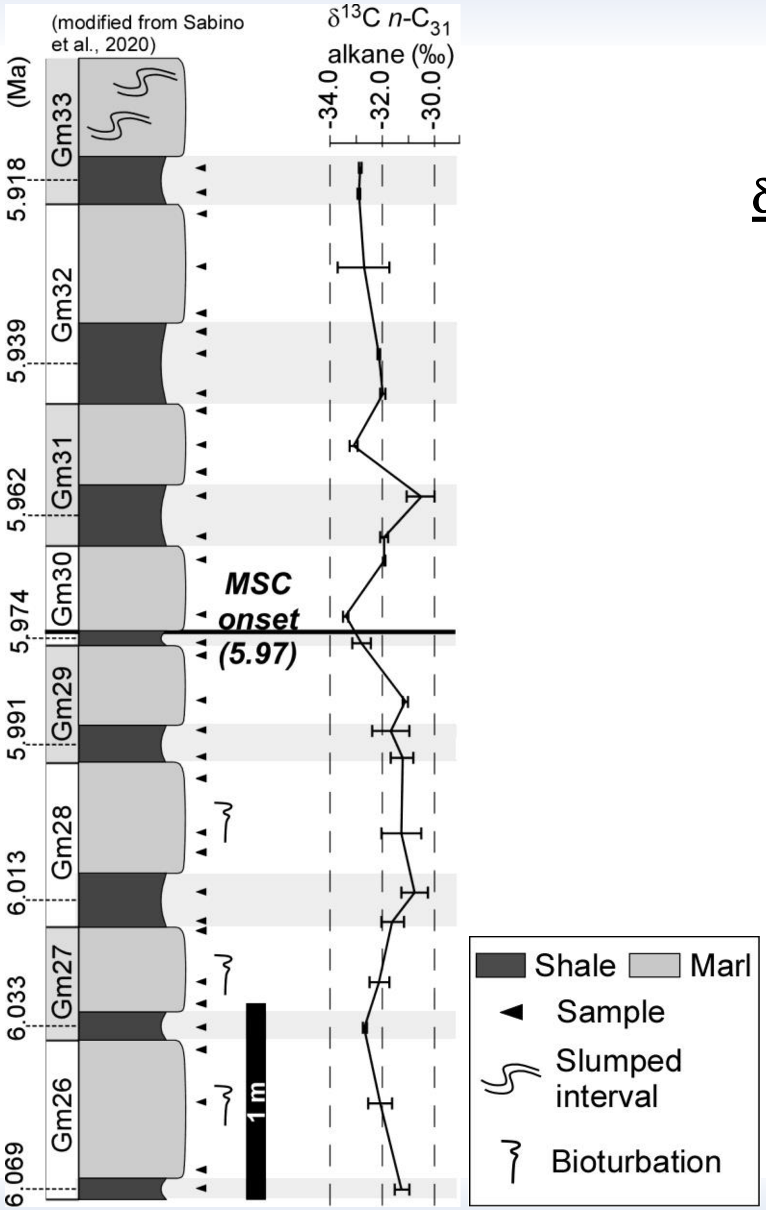
MARLS

- increased aeolian inputs (high element/Al ratios)
- Lower inputs of terrestrial organic matter (low *n*-alkane contents)

→ **Drier climate conditions at precession maxima**

Upward decrease of element/Al ratios
+
Upward increase of *n*-alkane contents

→ **Moister climate conditions in the initial stage of the MSC**



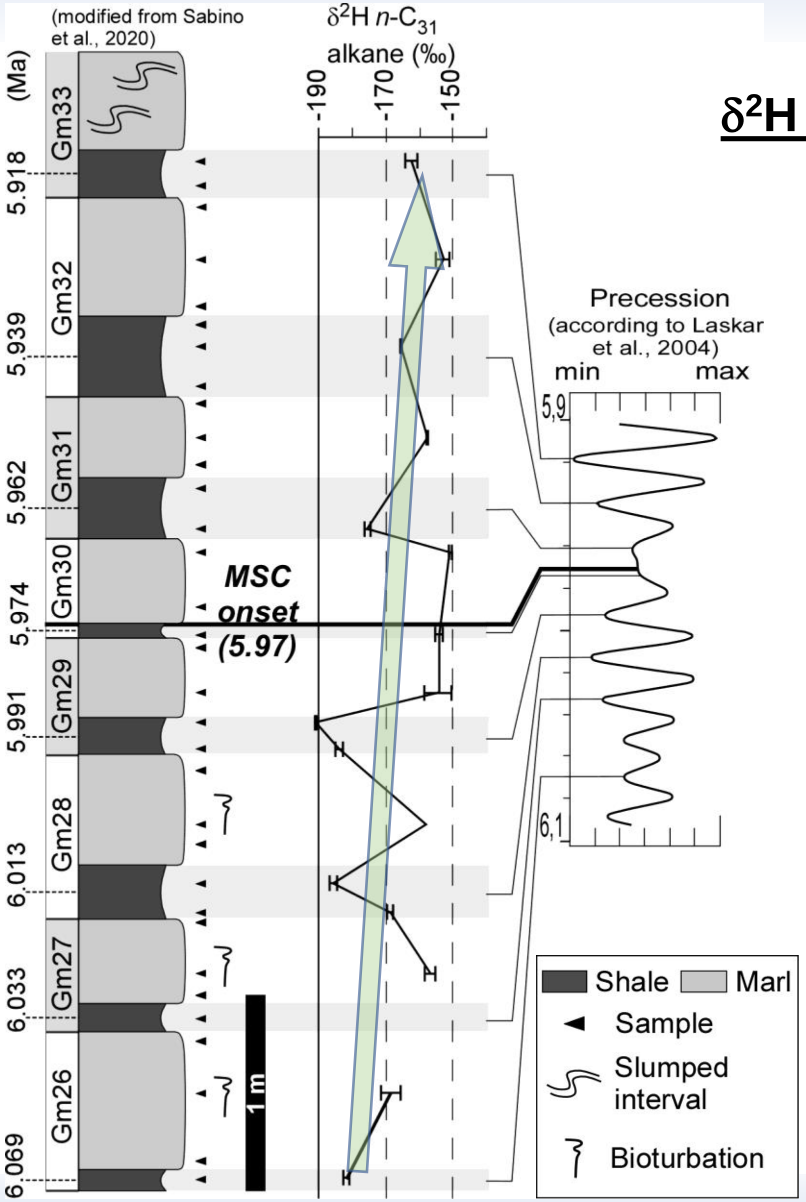
$\delta^{13}C$ isotopes

$\delta^{13}C_{n\text{-}C_{31}}$: **$C_3$ plants dominated vegetation**

- conifers → unimportant contribution to the lipid pool
- **subtropical humid taxa**

No significant change among the lithologies → the overall climate remained **humid, even at precession maxima**

Upward decrease in $\delta^{13}C$ values → Reduced water stress and less fractionation during CO_2 uptake



δ^2H isotopes

Cyclical pattern paced by **precession**

Precession minima
Shales: ^{2}H-depleted

More humid

- ✓ Intensified Mediterranean storm track
- ✓ Increased rainfall
- ✓ Lower evapotranspiration

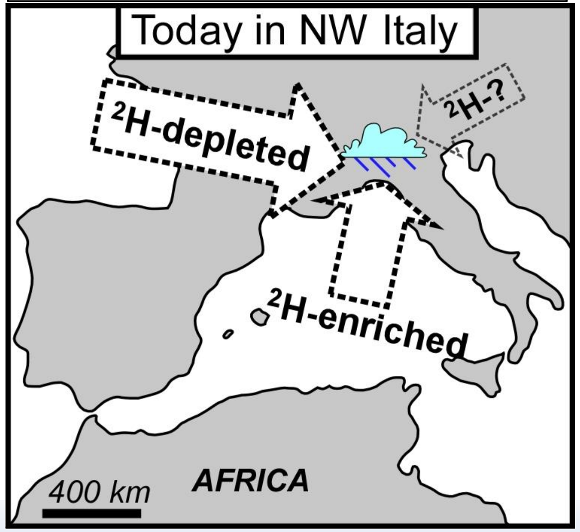
Precession maxima
Marls: ^{2}H-enriched

Less humid

- ✓ Weakened Mediterranean storm track
- ✓ Reduced rainfall
- ✓ Higher evapotranspiration

Upward enrichment of δ^2H values? → **Progressive increase of Mediterranean derived moisture**

Mediterranean storm track: bring ^{2}H-depleted moisture from N. Atlantic



Summarizing…

- *Precession minima*: **more humid** climate and extra ^{2}H-depleted moisture with N. Atlantic origin

- *Precession maxima*: **relatively more arid** climate (C_3 plants still dominated!) and rainfall dominated by ^{2}H-enriched moisture from the Mediterranean

- **Earliest phase of the MSC**: N. Mediterranean evolved towards **moister climate conditions** because of supply of extra ^{2}H-enriched moisture from the Mediterranean

Thank you for the attention!

REFERENCES

Bigi, G., Cosentino, D., Parotto, M., Sartori, R., Scandone, P., 1990. Structural model Italy: Geodinamic Project. Consiglio Nazionale delle Ricerche (S.EL.CA, scale 1:500000, sheet 1).

Dela Pierre, F., Bernardi, E., Cavagna, S., Clari, P., Gennari, R., Irace, A., Lozar, F., Lugli, S., Manzi, V., Natalicchio, M., Roveri, M., Violanti, D., 2011. The record of the Messinian salinity crisis in the Tertiary Piedmont Basin (NW Italy): the Alba section revisited. *Palaeogeography, Palaeoclimatology, Palaeoecology* 310, 238–255.

Laskar, J., Robutel, P., Joutel, F., Gastineau, M., Correia, A.C.M., Levrard, B., 2004. A long-term numerical solution for the insolation quantities of the Earth. *Astronomy & Astrophysics* 428, 261–285.

Sabino, M., Schefuß, E., Natalicchio, M., Dela Pierre, F., Birgel, D., Bortels, D., Schnetger, B., & Peckmann. J., 2020. Climatic and hydrologic variability in the northern Mediterranean across the onset of the Messinian salinity crisis. *Palaeogeography, Palaeoclimatology, Palaeoecology* 545, article 109632. https://doi.org/10.1016/j.palaeo.2020.109632