The continental record of the **Eocene-Oligocene Transition** in the Eastern Ebro Basin. Decoding the paleoclimatic signature from sediments and **clay mineralogy.**

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The context of the EOT.

The **Eocene-Oligocene Transition (EOT)** represents one of greatest shifts of the global climate as recorded in deep sea isotope records.

The impact of the EOT in the terrestrial realm has been associated to a dramatic faunal turnover (“Grande Coupure”), and cooling and aridification in some, but not all nonmarine records. It appears that the response to global cooling on continents presents a significant regional variability.

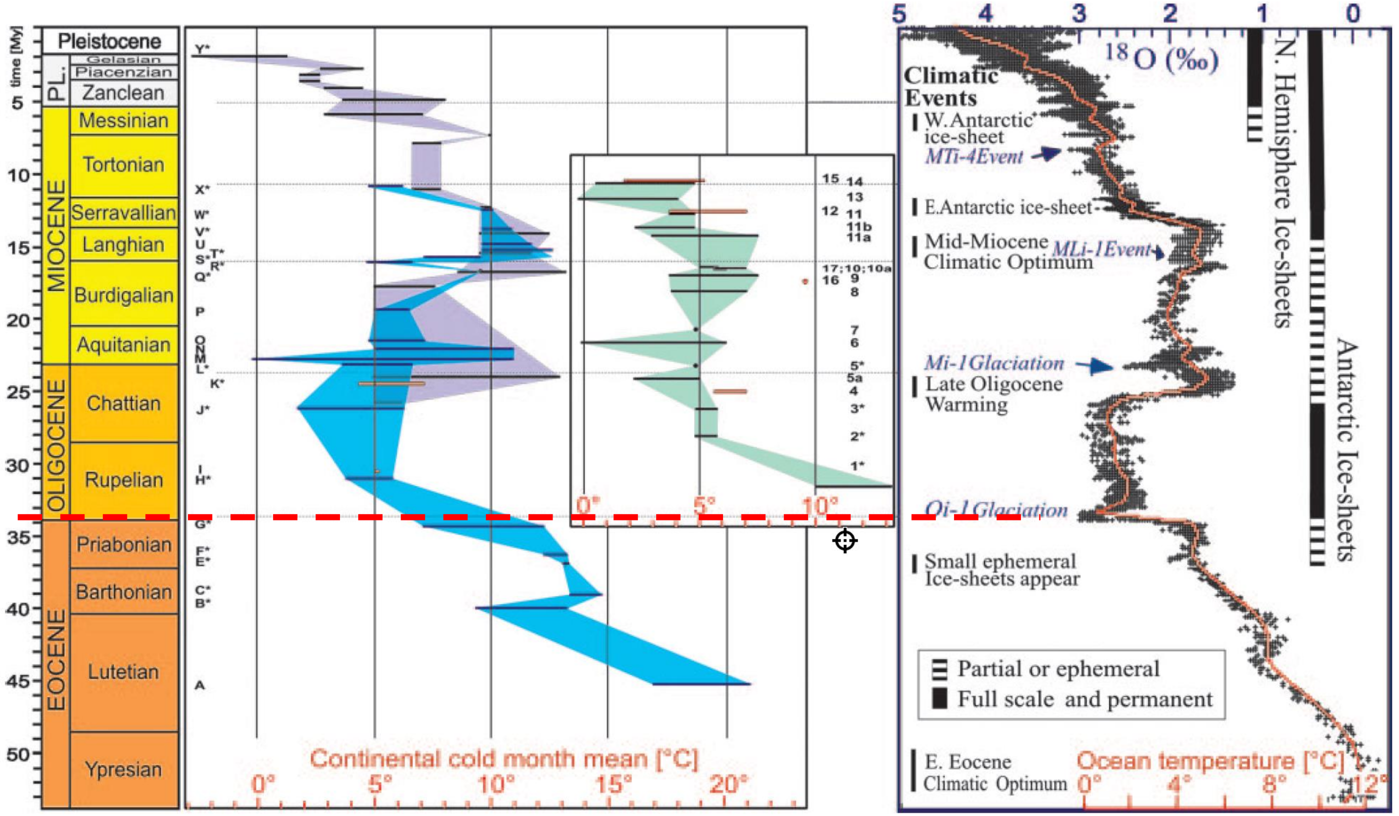

Fig. 3. Continental temperature curves (CMM) for Central Europe during the last 45 My in comparison with the global marine oxygen isotope record of Zachos *et al.* (1) adapted to the International Commission on Stratigraphy 2004 time scale (12). For code numbers and bar colors, see Fig. 2.

Mosbrugger et al., PNAS 102, 2005

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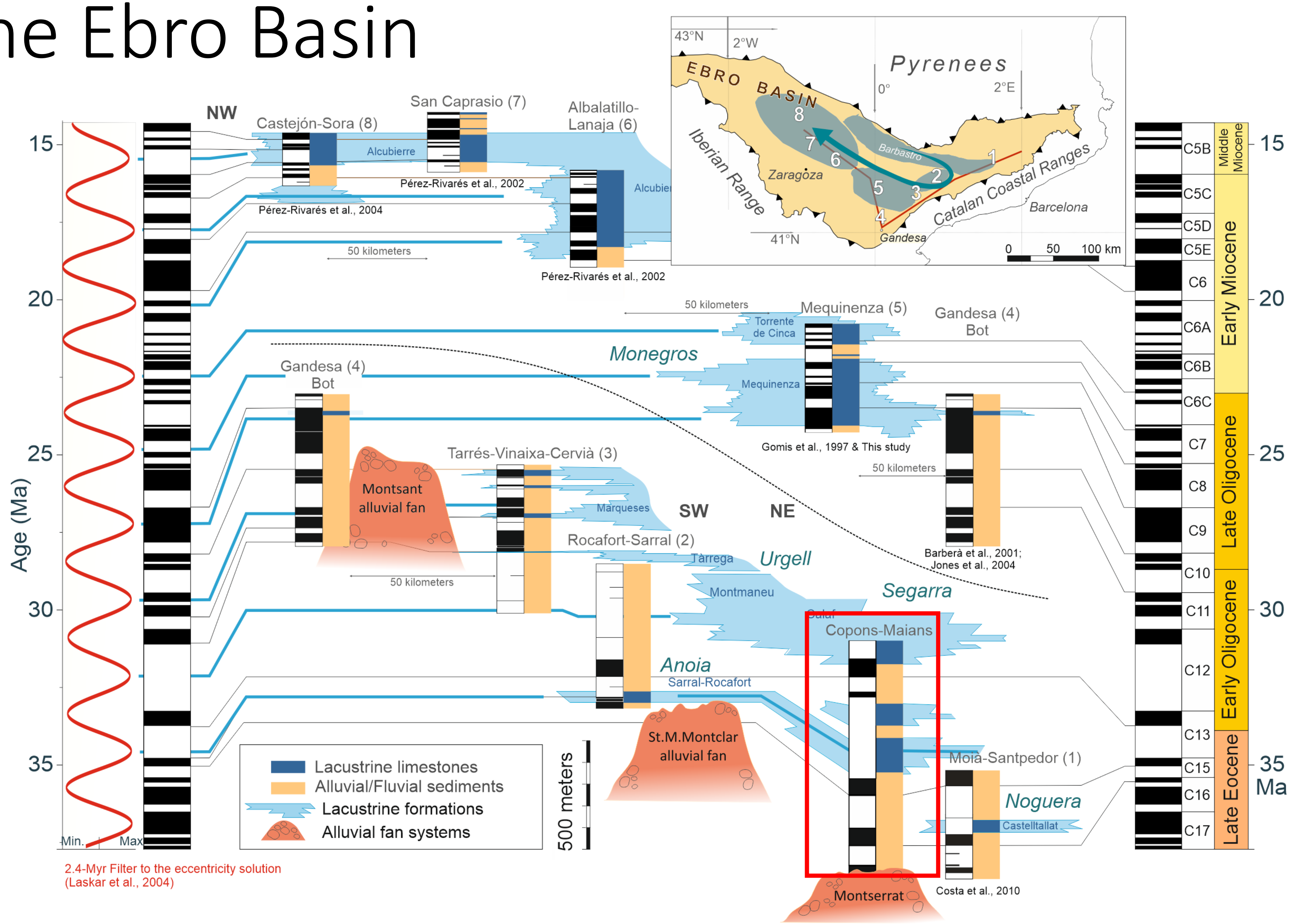
The EOT in the Ebro Basin

The Ebro basin underwent an internally drained basin since the late Priabonian. A rim of alluvial fans along its margins fed a central saline to fresh-water lake. Cycles of lake expansion were correlated with times of 2.45myr long eccentricity màxima (Valero et al, 2014).

Study section



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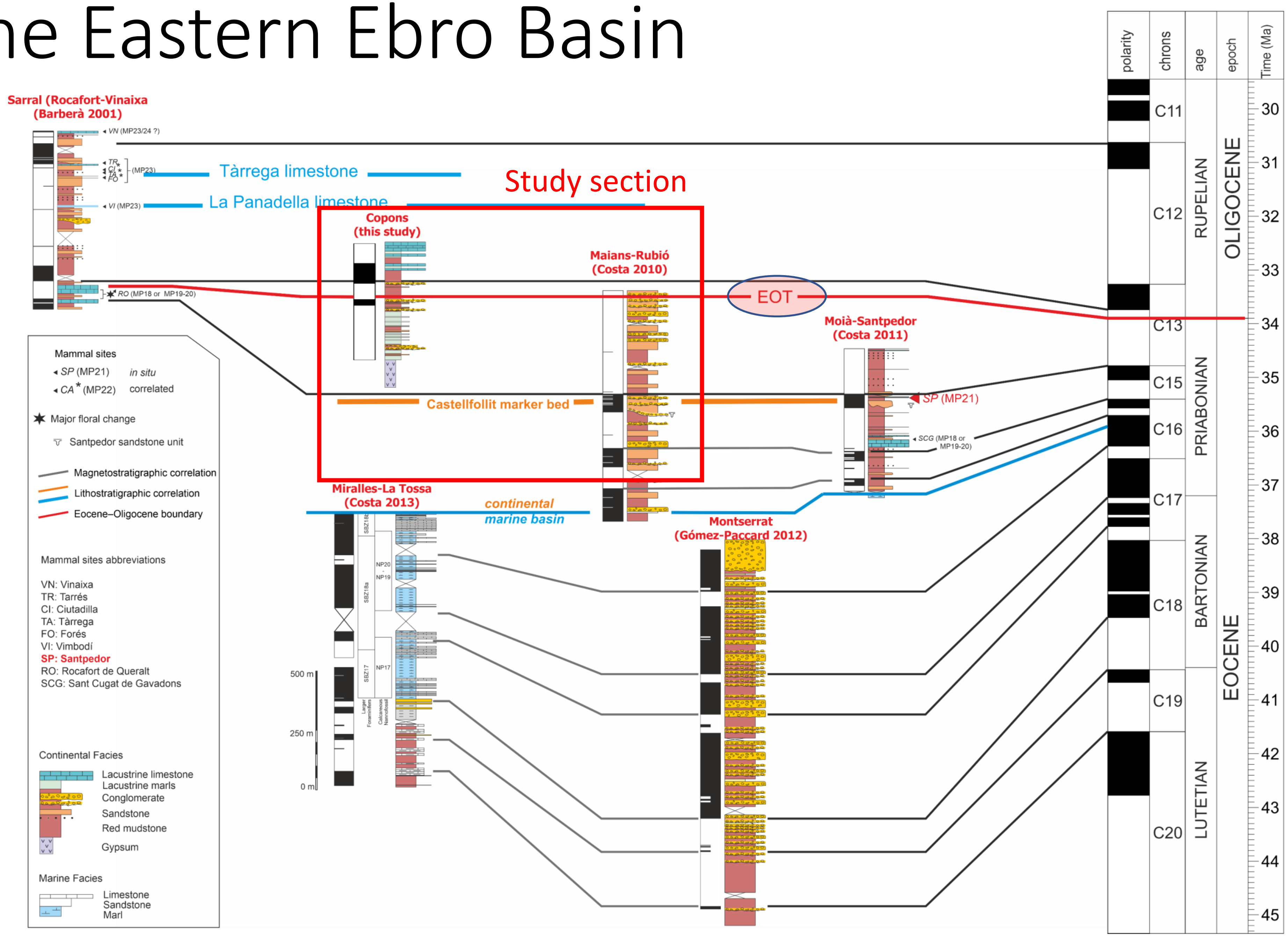
The EOT in the Eastern Ebro Basin

The **EOT** in the Eastern Ebro basin is now **magnetostratigraphically** constrained, located in a distal alluvial/shallow lacustrine succession.

This chronology challenges biostratigraphic studies (Vianey-Liaud et al. 2019) that suggest occurrence of "Oligocene faunas" in a lower stratigraphic position (→ see GarcesEGU2021, for further details)



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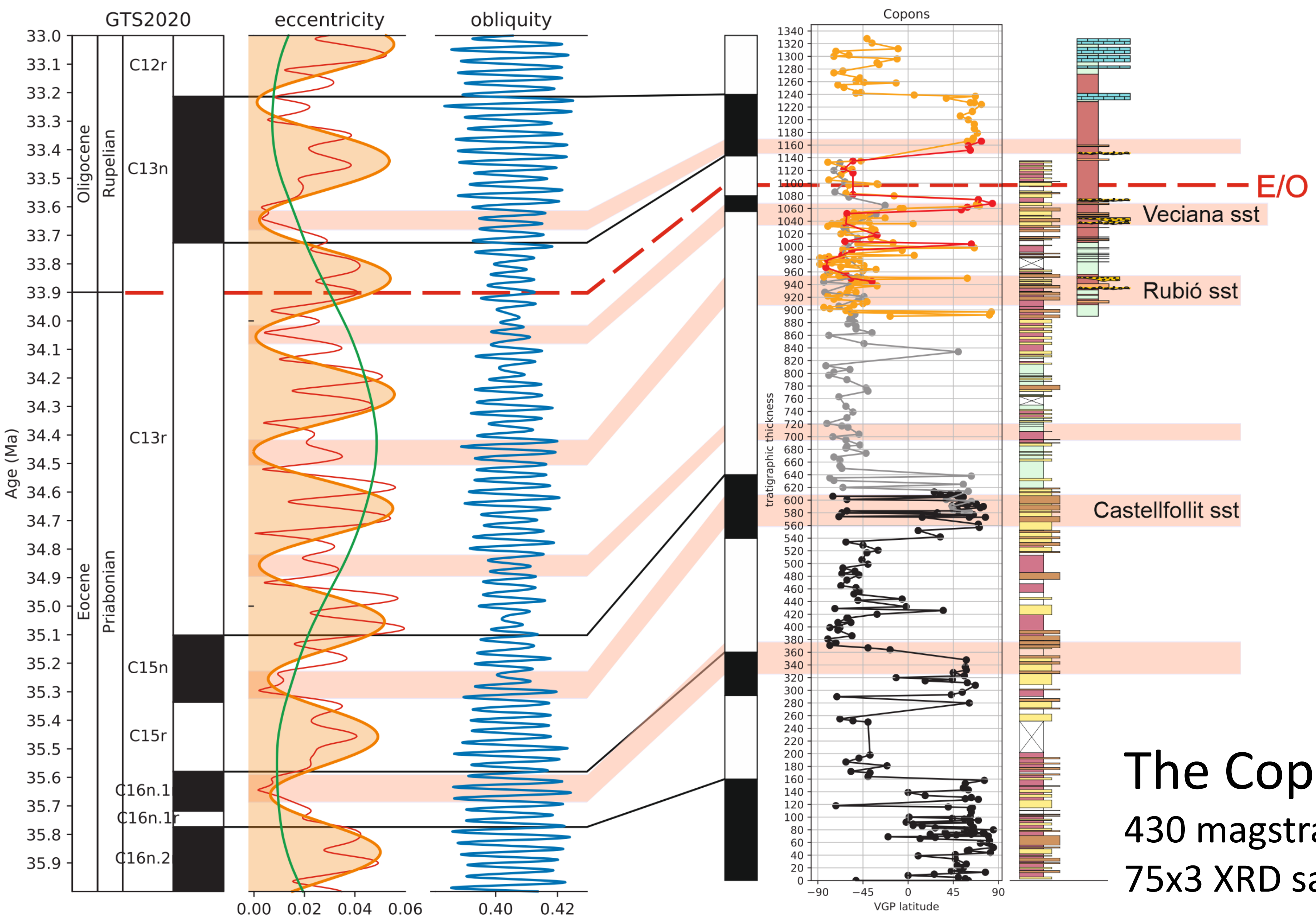
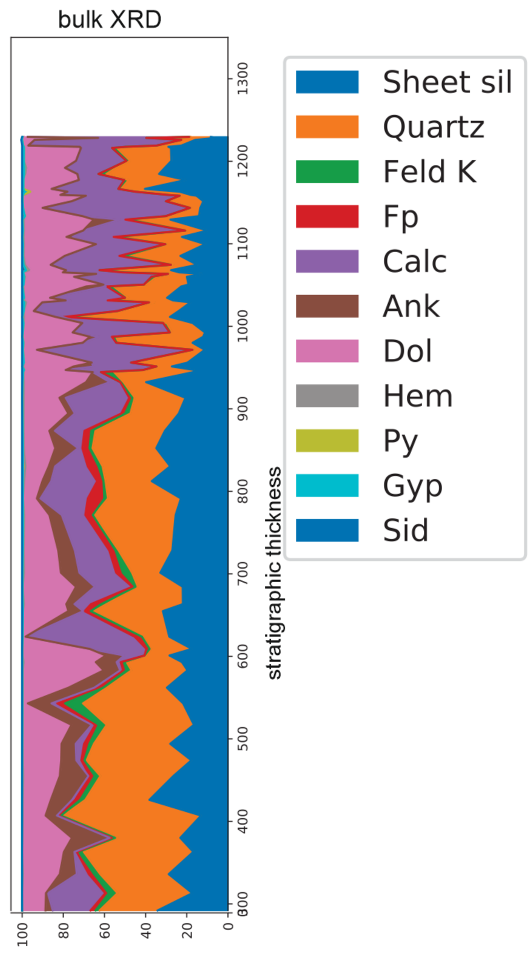
Age Model



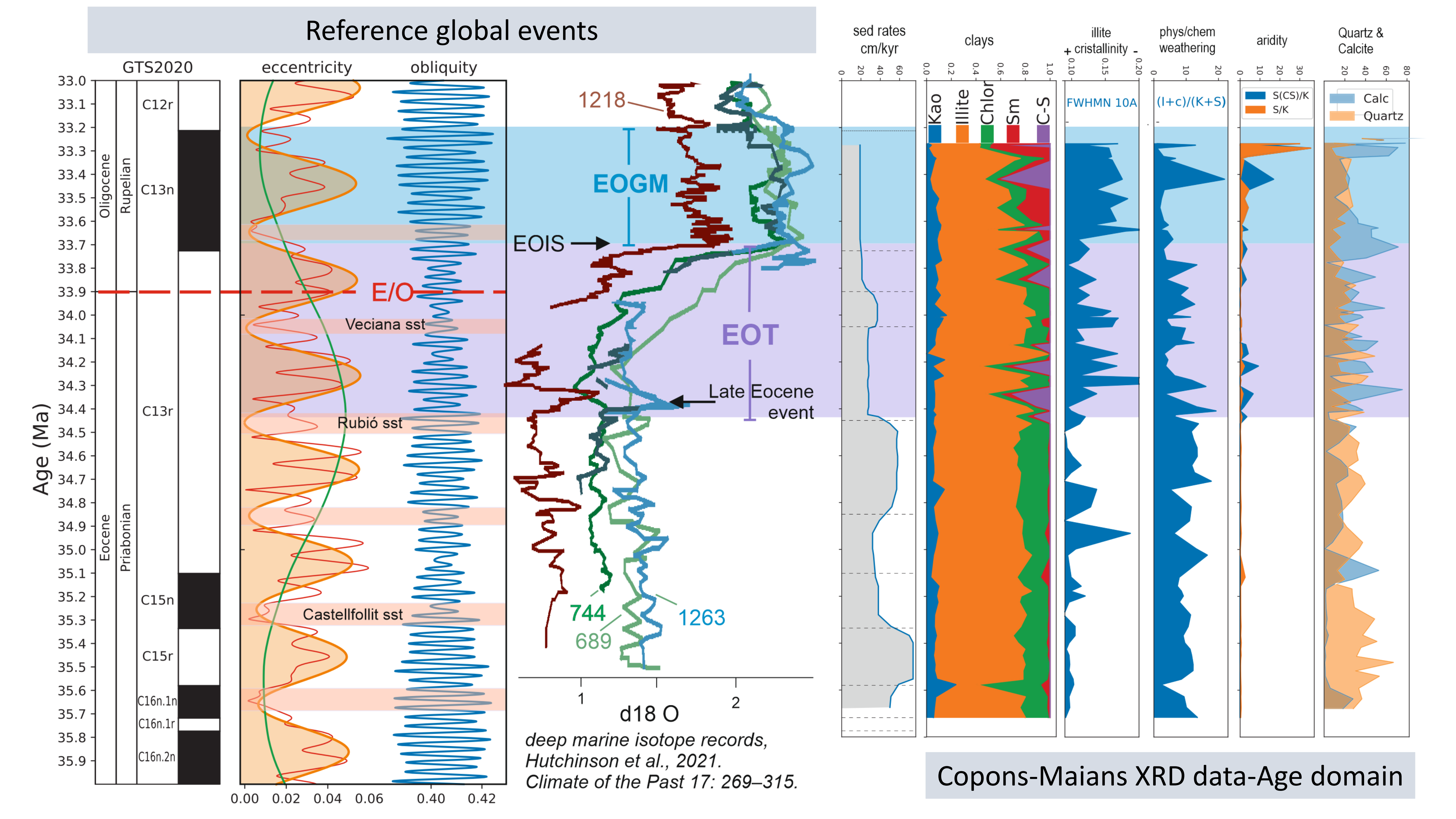
Bulk XRD data



The Copons-Maians section.

430 magstrat samples

75x3 XRD samples


Reference global events
GTS2020
eccentricity
obliquity
Age (Ma)
Oligocene
Rupelian
Eocene
Priabonian
C12r
C13n
C13r
C15n
C15r
C16n.1n
C16n.1r
C16n.2n
E/O
Veciana sst
Rubió sst
Castellfollit sst
1218
EOGM
EOIS
EOT
Late Eocene event
744
689
1263
d18 O
deep marine isotope records, Hutchinson et al., 2021. Climate of the Past 17: 269–315.
sed rates cm/kyr
clays
Kao
Illite
Chlor
Sm
C-S
illite + cristallinity -
FWHMN 10A
phys/chem weathering
(I+c)/(K+S)
aridity
S(CS)/K
S/K
Quartz & Calcite
Calc
Quartz
Copons-Maians XRD data-Age domain

Highlights on the EOT in the Copons-Maians section:

- Bulk composition shows:
  - Relative increase of detrital Calcite against Quartz → Increase of physical alteration, decrease dissolution of carbonate rocks. → aridity
- Clay composition
  - Independent from sedimentary facies.→ Composition inherited from the source (detrital signal)
  - Increase of Smectite → formed in soils in the source under alternating wetting/drying conditions →increased seasonality.
- Two-step increase in Illite alteration (decreasing crystallinity):
  - starting at 34.4Ma (late Eocene event),
  - peaking during the EOGM (Glacial Maximum).
- Sediment accumulation trending to lowering rates (multiple causes to be discussed)

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Conclusions.

Observations compatible with increasing cooling and aridity:

- Relative increase of detrital Calcite against Quartz
- Increase of Smectite against Kaolinite.
- Increase of aridity indexes (S/K), (S+CS)/K

Unanticipated observations (← seasonality?):

- Decreasing illite crystallinity (FWHMN 10A)
- Decreasing Physical against Chemical weathering index (I+C)/(S+K)

Tricky observations:

- Sediment accummulation trending to lowering rates (←lowering average Qw?)

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Supplementary material

See next slides for additional material and figures from reference papers

- ❑ Clay compositional trends in depth domain
- ❑ Tiepoints for age model
- ❑ Clay composition correlation matrix
- ❑ Bulk composition correlation matrix

- ❑ Reference papers:
- ❑ Rennes Basin (Tramoy et al., 2016)
- ❑ The deep marine stable isotope record (Hutchinson et al., 2021)
- ❑ The EOT at Saint Stephens Quarry, Alabama (Katz et al., 2008)
- ❑ The EOT at Massignano section (Jovane et al., 2007)

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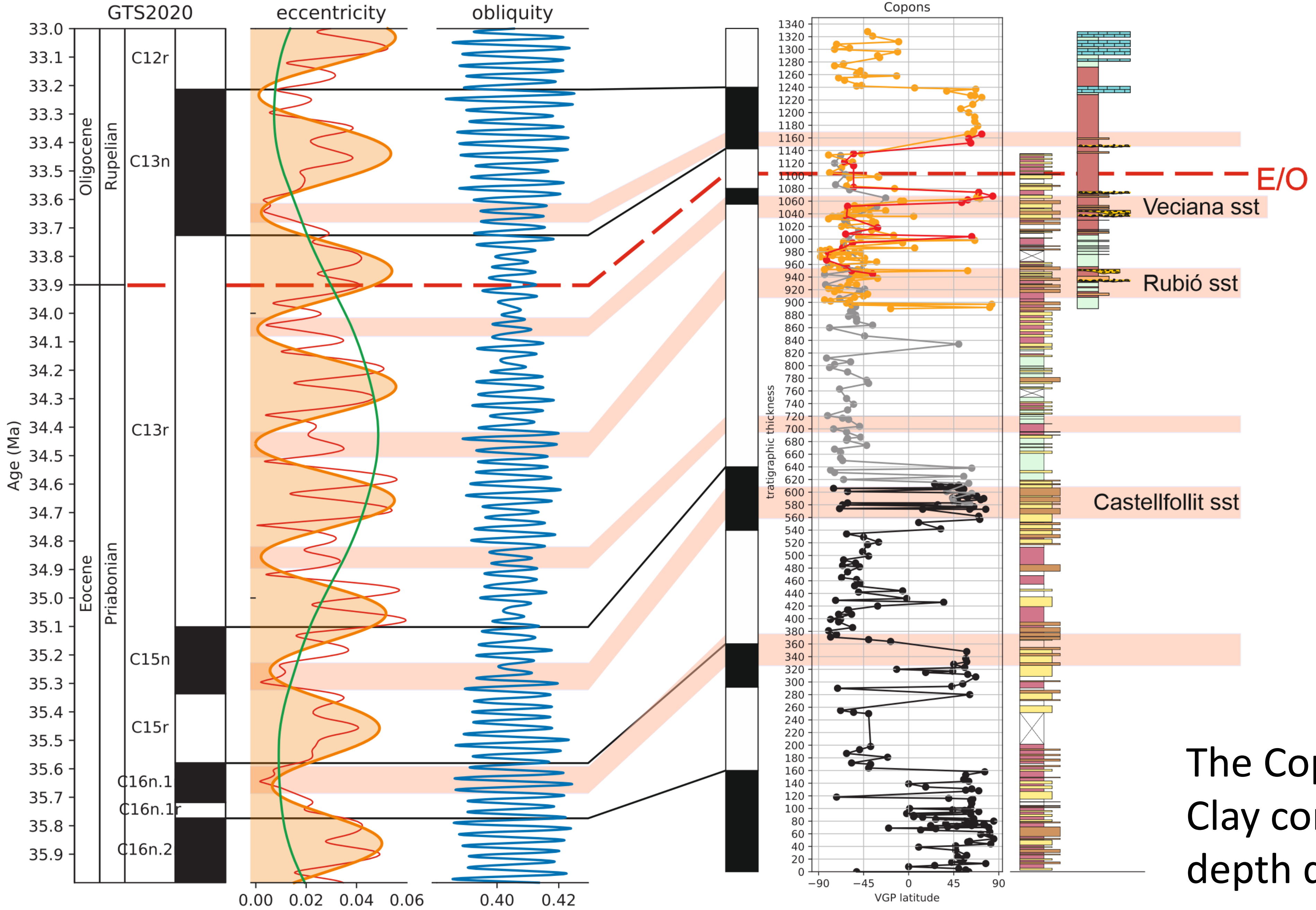
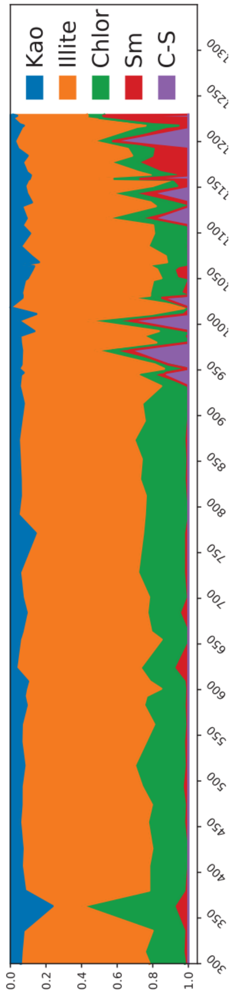
Age Model



Clay XRD data



The Copons-Maians section. Clay compositional trends in depth domain.

Age constrains

- Tie points used for depth-to-age transformation.
- (ecc1, ecc2, ecc3: consecutive eccentricity mínima within C13r correlated with alluvial proggradion events)

	chron	age	level (m)
0	C16n.1r	35.774	161
1	C16n.1n	35.718	291
2	C15r	35.58	360
3	C15n	35.336	540
4	C13r	35.102	630
5	ecc1	34.85	710
6	ecc2	34.45	940
7	ecc3	34.05	1050
8	E/O	33.9	1070
9	C13n	33.726	1142
10	C12r	33.214	1240

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Clay composition
Correlation matrix

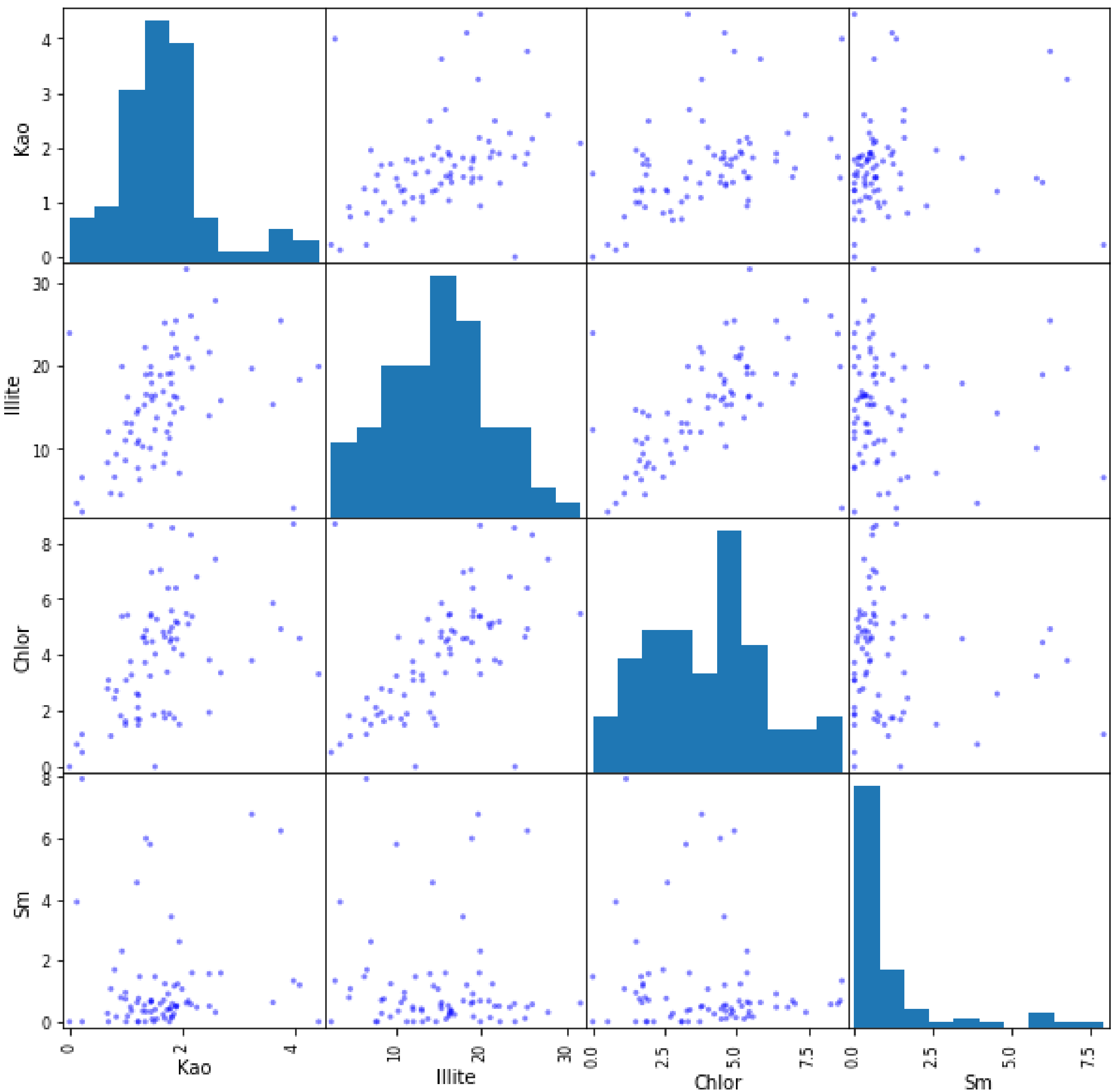
Positive correlations:

Illite vs Chlorite

Illite vs Kaolinite (poor)

No correlation:

Smectite vs any other component



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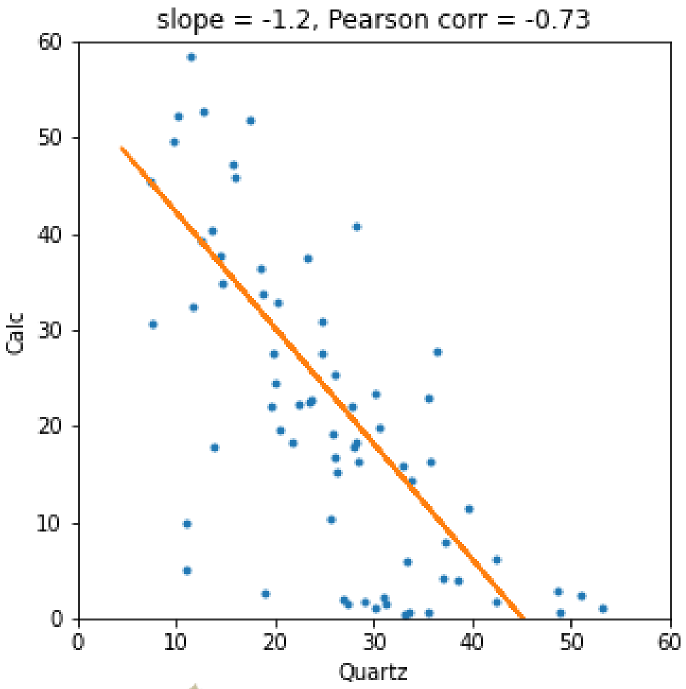
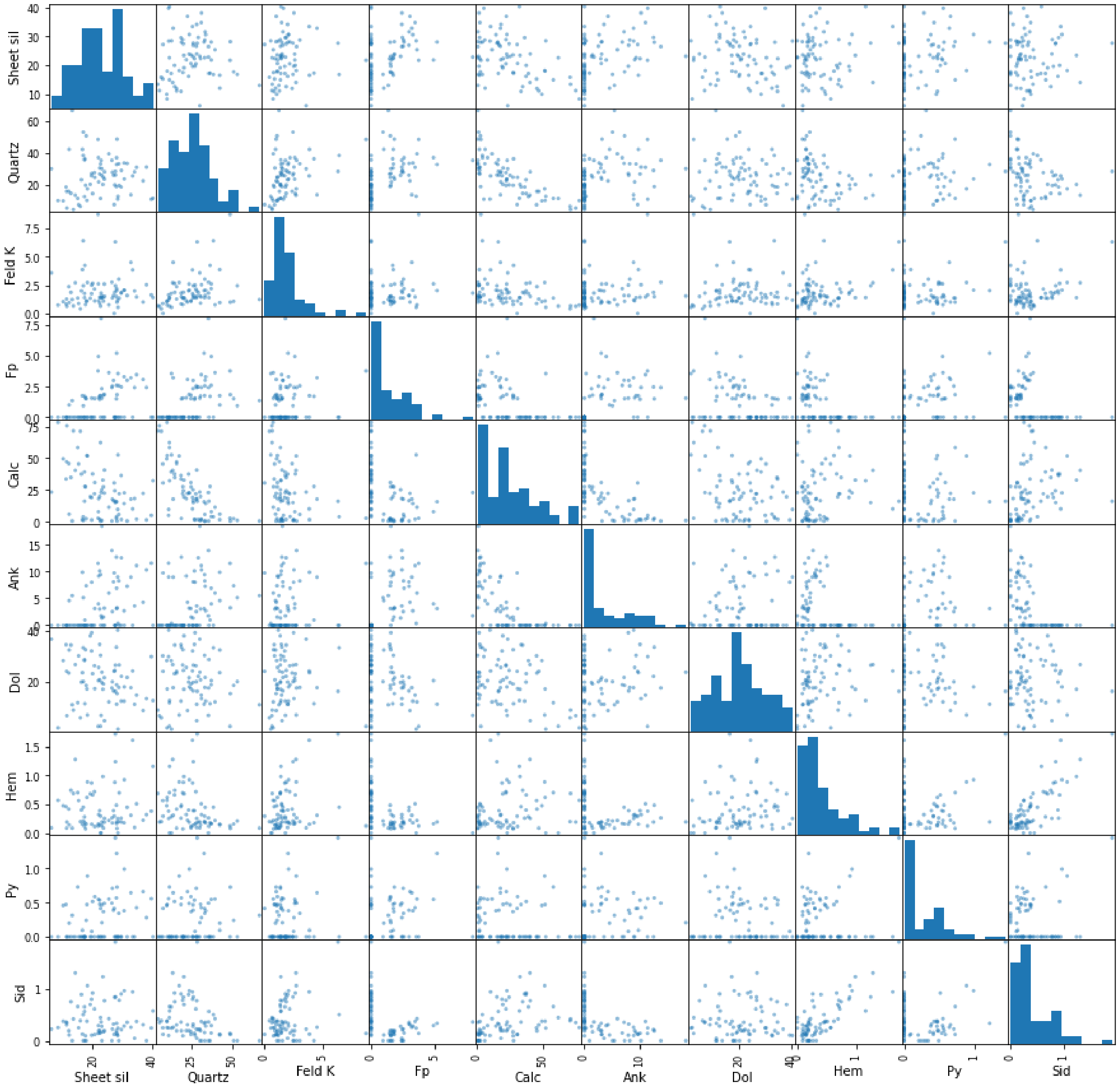
Bulk composition
Correlation matrix

Only Calcite and Quartz reveal a negative correlation → Dissolution effect





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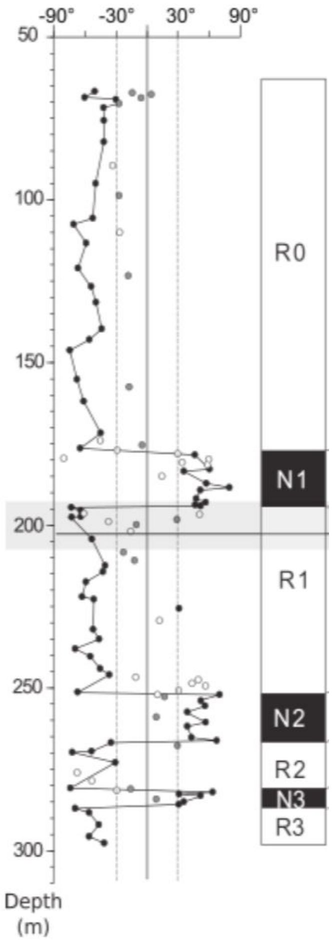
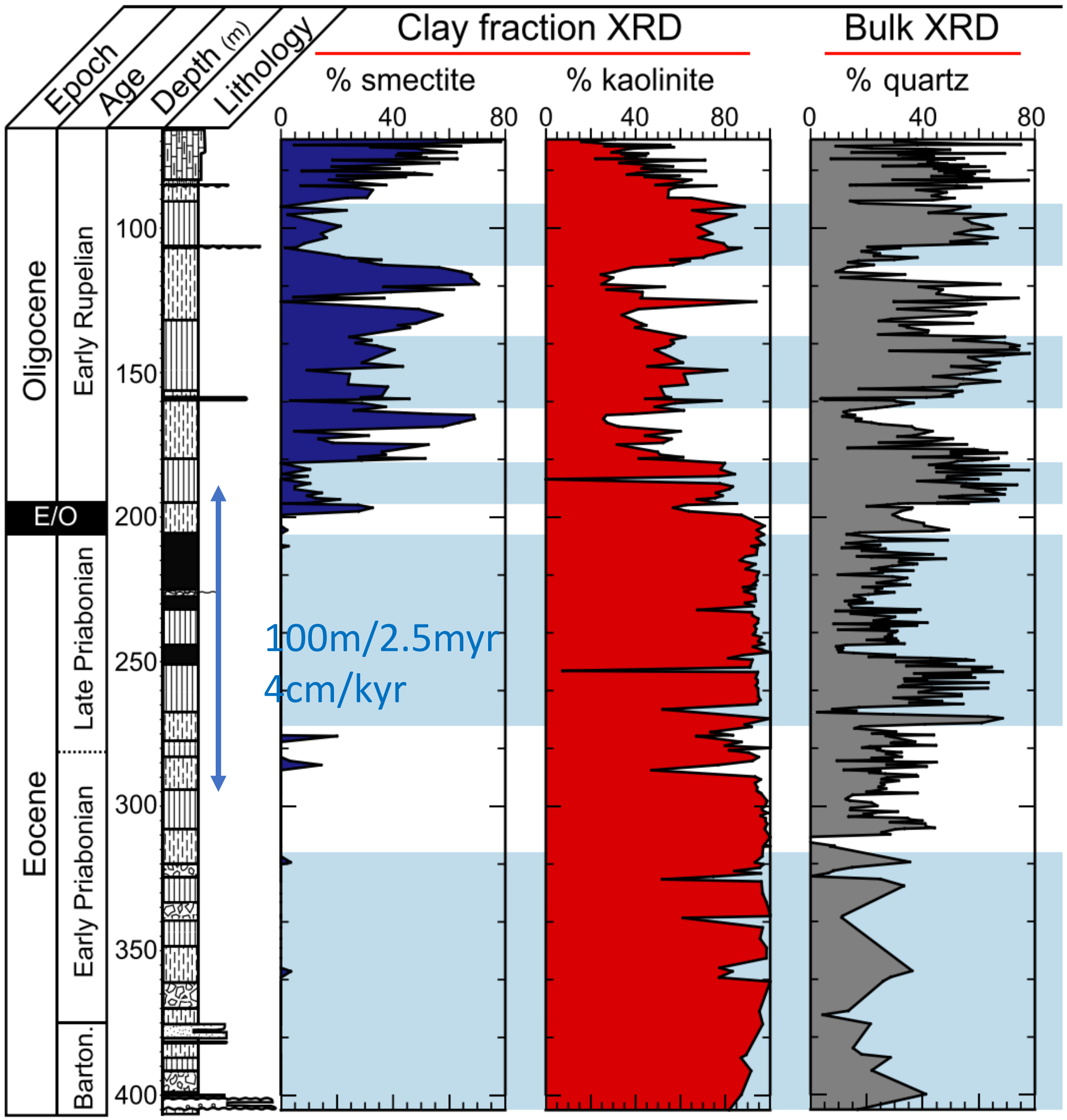
Rennes basin

- CDB1 borehole

Tramoy, R., Salpin, M., Schnyder, J., Person, A., Sebilo, M., Yans, J., Vaury, V., Fozzani, J., and Bauer, H., 2016, Stepwise palaeoclimate change across the Eocene-Oligocene transition recorded in continental NW Europe by mineralogical assemblages and δ15Norg (Rennes Basin, France): Terra Nova 28: 212–220.





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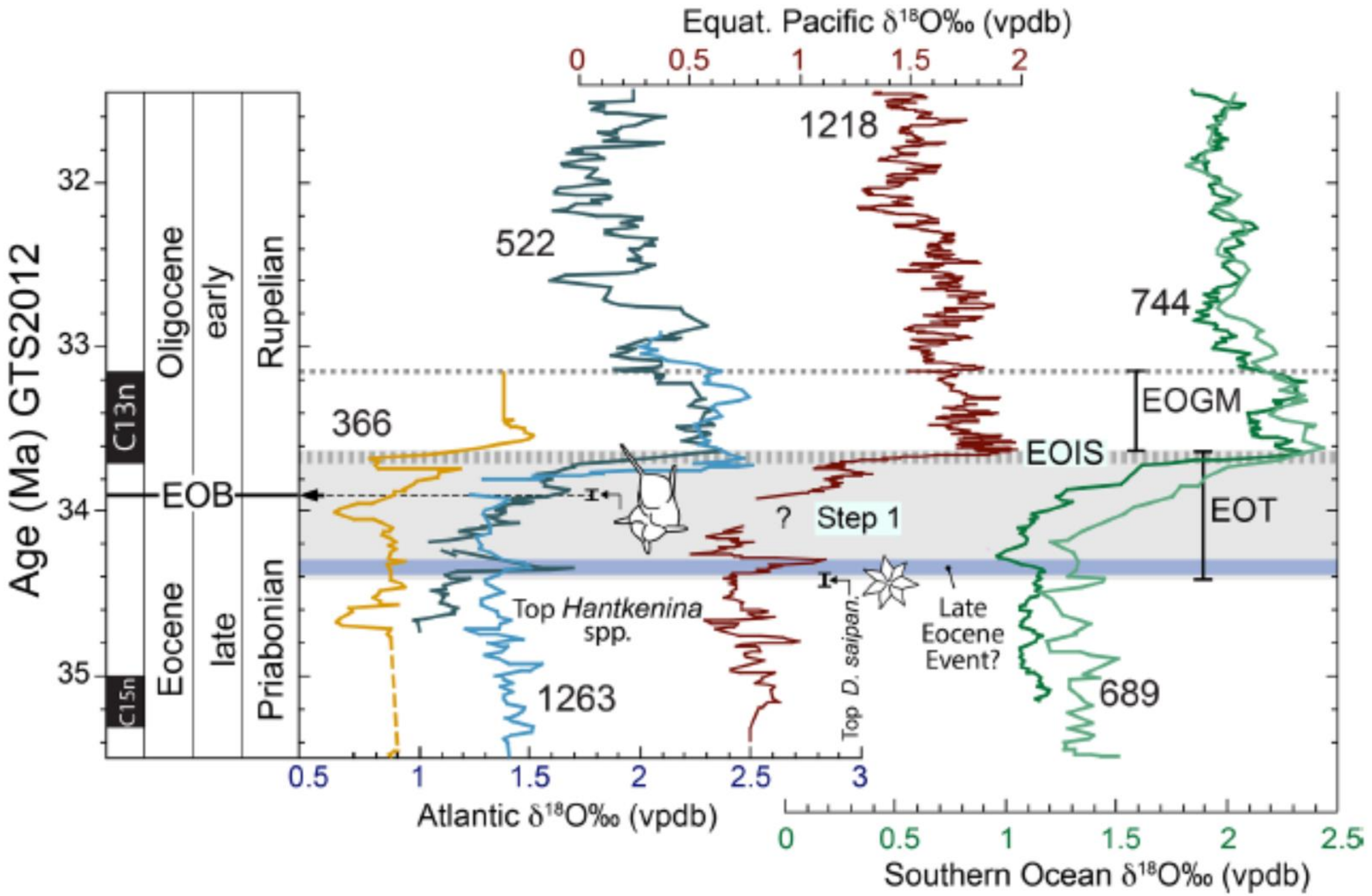
The deep marine stable isotope record

Hutchinson, D.K., Coxall, H.K., Lunt, D.J., Steinthorsdottir, M., De Boer, A.M., Baatsen, M., Von Der Heydt, A., Huber, M., Kennedy-Asser, A.T., Kunzmann, L., Ladant, J.B., Lear, C.H., Moraweck, K., Pearson, P.N., et al., 2021, The Eocene-Oligocene transition: A review of marine and terrestrial proxy data, models and model-data comparisons: Climate of the Past, v. 17, p. 269–315, doi: 10.5194/cp-17-269-2021.



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Saint Stephens Quarry, Alabama

Position of “ghost subchron” C13r.1n between EOT-1 and the E/O boundary

C13r.1n

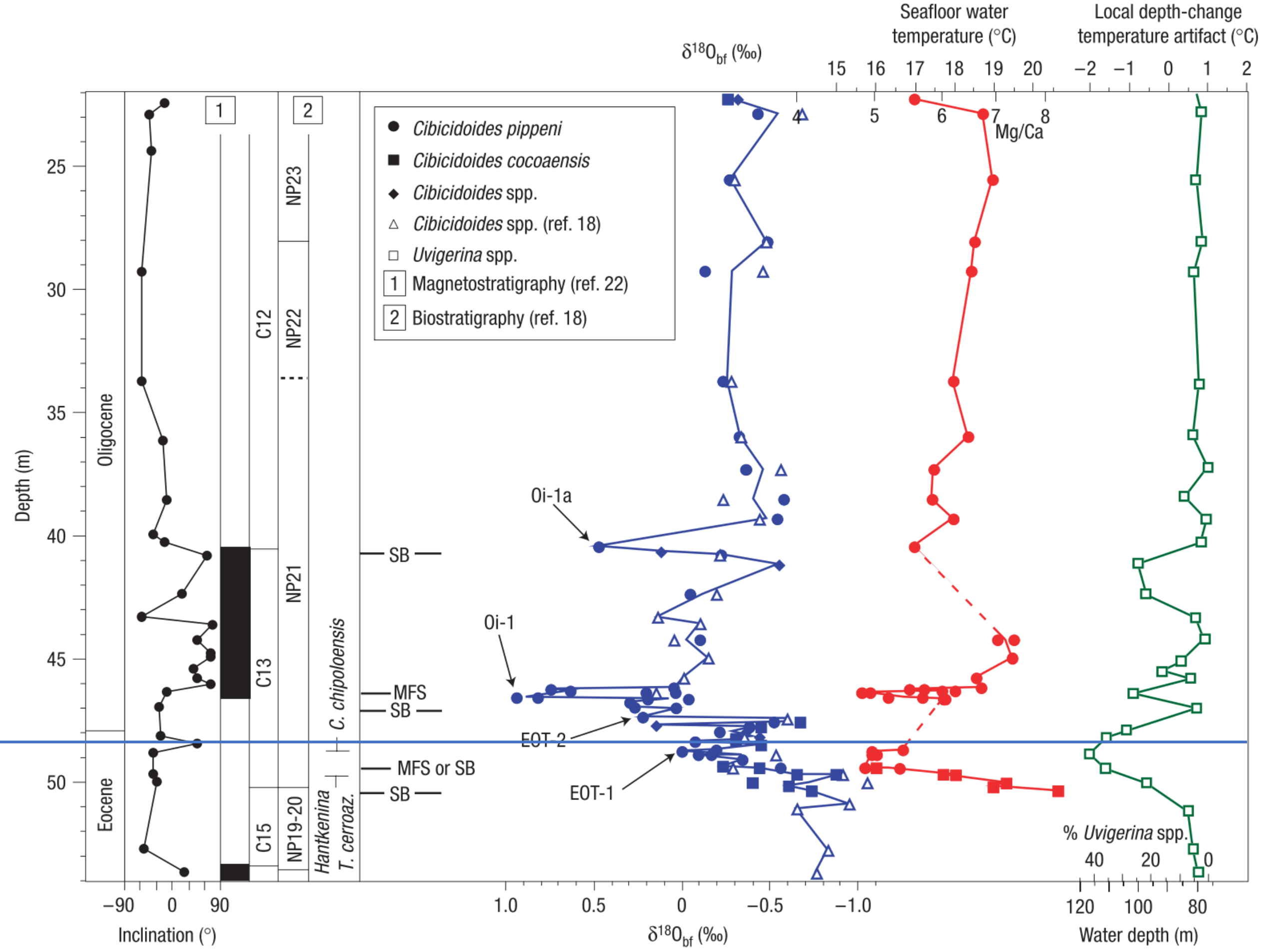

Figure 1 SSQ proxy data for ice volume, temperature and sea level. $\delta^{18}O$ and Mg/Ca were measured on benthic foraminifera (see Supplementary Information, Table S2). Multiple analyses of single samples are shown, connected with a line through average values. *Uvigerina* abundances were used to estimate palaeodepth and the local temperature change driven by water-depth changes (see the text). MFS = maximum flooding surface (deepest palaeodepth within a sequence). SB = sequence boundary

- *Katz, M.E., Miller, K.G., Wright, J.D., Wade, B.S., Browning, J. V., Cramer, B.S., and Rosenthal, Y., 2008, Stepwise transition from the Eocene greenhouse to the Oligocene icehouse: Nature Geoscience, v. 1, p. 329–334, doi: 10.1038/ngeo179.*

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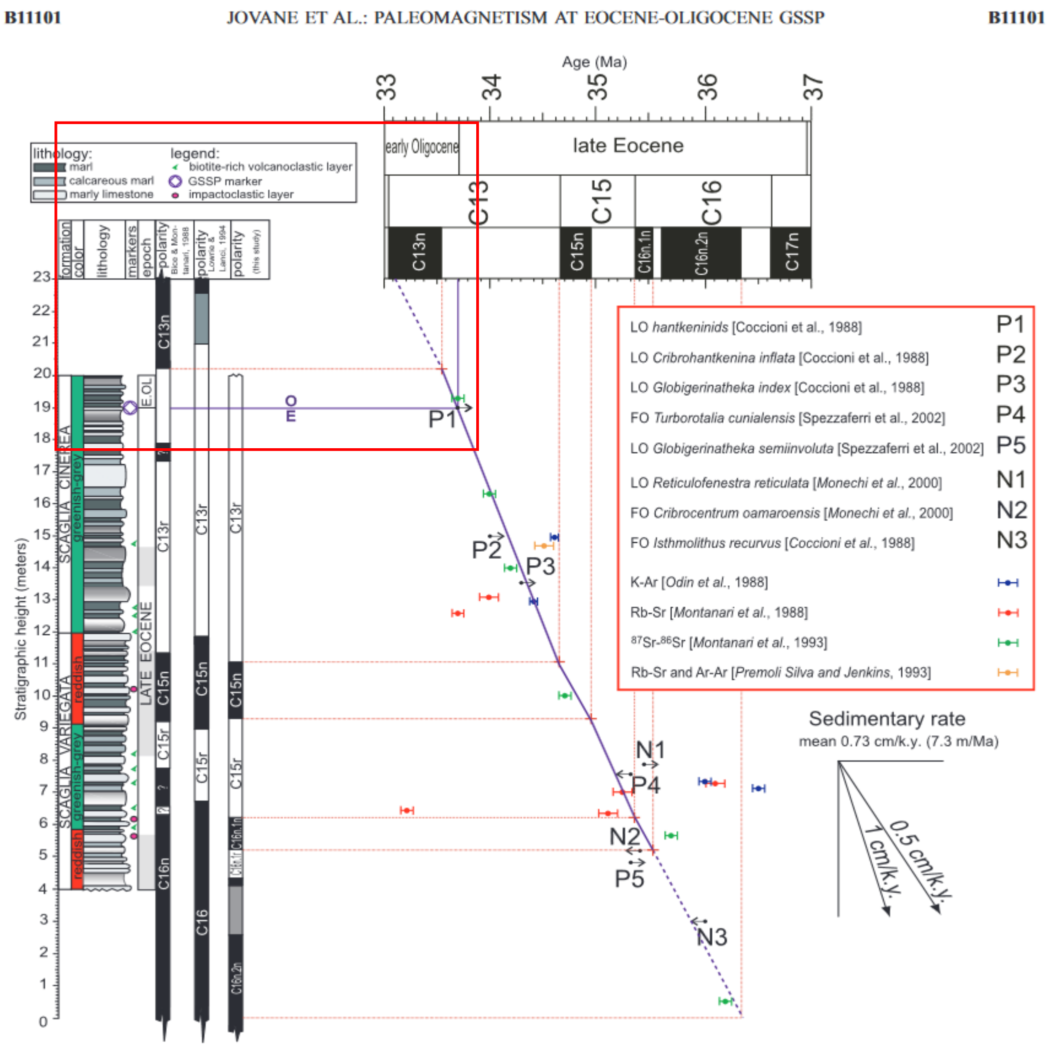
The EOT at Massignano section

- Position of E/O boundary relative to “ghost subchron” C13r.1n



Jovane, L., Sprovieri, M., Florindo, F., Acton, G., Coccioni, R., Dall’Antonia, B., and Dinarès-Turell, J., 2007, Eocene-Oligocene paleoceanographic changes in the stratotype section, Massignano, Italy: Clues from rock magnetism and stable isotopes: Journal of Geophysical Research, v. 112, p. B11101

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