Once upon a time in Maastricht – clumped isotope climate reconstructions from marine macrofaunal assemblages of the Maastrichtian stage

Ingo A. Müller†, John W.M. Jagt† and Martin Ziegler†
†i.a.muller@uu.nl; †Department of Earth Sciences, Utrecht University, The Netherlands;
‡Naturalhistorisch Museum Maastricht, The Netherlands

Towards the end of the Cretaceous a wide portion of the Eurasian plate was covered by a shallow sea with only few landmarks. The climatic conditions towards the end of the Cretaceous are expected to show a cooling trend from the Campanian to the Maastrichtian stage, accompanied by several carbon isotope excursions (CIE) detected in the Atlantic Pacific and Tethyan Oceans. The observation that these CIEs do not correlate with warming as for instance the Paleocene Eocene Thermal Maximum points on different causes that might relate to tectonic activity and or changes in seawater circulation (e.g. Linssen et al., 2017).

The shallow and still relatively warm water conditions offered a fruitful environment for a wide range of marine organisms of which the fossil remnants are very abundant in the area around Maastricht defining the type locality of the final stage, the Maastrichtian (12.7–14.8 Ma). Various fossil assemblages containing gastropods, brachiopods, echinoids were recovered from different ecozones of the Maastricht. We applied carbonate clumped isotope thermometry to determine ambient temperature changes taking place during the Maastrichtian.

The good preservation of a wide variety of fossils in Southern Netherlands with the recent developments in clumped isotope geochemistry (e.g. Bernasconi et al., 2018) allows us to constrain a much better picture of the climatic conditions during which the sedimentary deposits around present-day Maastricht formed.

Conclusions and outlook
- preliminary 47-T temperature estimates of Maastrichtian fossil assemblages collected at the type locality near Maastricht reveal seawater T estimates of 13.1–20.3 °C with variable δ18O estimates 1.1–3.1 ‰.
- macrofossils probably have longer growth season (more annual seawater T estimates) and show potential of high resolution paleo-climate snapshot
- These T estimates agree with mid palaoealtitude SST estimates derived of planktonic foraminifera δ18O (compiled in O’Brien et al., 2017) and 47-T estimates of “US” Atlantic coast (Meyer et al., 2018)

To do list:
- distinguish primary signals from diagenetic alteration signal (GK3000…mineralogy (XRF+XRD), microscopy, EBSD)
- analyze more replicates (of ~20 μg) to improve precision
- climate variation over Cretaceous-Paleogene (K-Pg) boundary in the sediments around Maastricht

References
O’Brien et al., 2017

Stratigraphy of Upper Cretaceous deposits in the Maastrichtian type area (van den Ham et al., 2016)

Maastrichtian island in the central European Basin-new data inferred from palynofacies analysis and inoceramid stratigraphy. Facies 63:26-61

See references for full details.

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High resolution snap shots

Thromphysa pinna, brachiopod (Gulpen Fm., Lower Mem.)
GK3100:  
47-T 12.4±13.5 °C
δ18OVPDB -1.05±0.03 ‰
δ13CVPDB 7.05±0.03 ‰
Replicates 8

Trigonosema pectiniformis, brachiopod (Gulpen Fm., Lower Mem.)
GK3101-1:  
47-T 11.8±13.5 °C
δ18OVPDB -0.9±0.03 ‰
δ13CVPDB 7.05±0.03 ‰
Replicates 8

Maiote nippon, gastropod
Z477-1:  
47-T 8.2±7.7 °C
δ18OVPDB -1.91±0.08 ‰
δ13CVPDB 1.59±0.02 ‰
Replicates 9

Olyssopyr gi. penyiformis, echinoid
(Gulpen Fm., Lower Mem.)
GK3020-2:  
47-T 13.6±7.7 °C
δ18OVPDB 0.7±1.3 ‰
δ13CVPDB 2.2±0.9 ‰
Replicates 9

Nerita rugosa, gastropod
Z735:  
47-T 10.7±8.8 °C
δ18OVPDB -0.71±0.04 ‰
δ13CVPDB 1.1±0.03 ‰
Replicates 4

Pectenus/pondybile (Maastricht Fm., Lower Mem.)
Z475-L:  
47-T 15.9±9.0 °C
δ18OVPDB -1.09±0.03 ‰
δ13CVPDB 7.05±0.03 ‰
Replicates 6

Okoia pyriformis, gastropod
Z474-3:  
47-T 11.7±7.7 °C
δ18OVPDB -1.2±0.03 ‰
δ13CVPDB 3.0±0.06 ‰
Replicates 6

Grouper - nuculanus, gastropod
Z477-3:  
47-T 14.7±4.9 °C
δ18OVPDB 1.24±0.15 ‰
δ13CVPDB 2.6±0.17 ‰
Replicates 4

Gastropods from the Atlantic coast of modern US (from O’Brien et al., 2017)

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References
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