



## Middle–Upper Jurassic seawater temperatures: clumped isotopes from Scottish belemnites

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We present new seawater temperature estimates for the Callovian to Kimmerigian interval (Middle to Upper Jurassic), from clumped isotope analyses of pristinely preserved belemnites from Staffin Bay, Isle of Skye, Scotland. We compare two belemnite genera, finding that generally *Pachyteuthis* give warmer temperatures than *Cylindroteuthis*. Our clumped isotope temperatures for both genera are higher than previous stable isotope temperature estimates across this interval (from this and other localities). Whilst it is possible that there was some slight solid-state re-ordering of the belemnite calcite, these new data suggest that either or both  $\delta^{18}\text{O}_{sw}$  estimates and the fractionation of  $^{18}\text{O}$  into belemnite rostral calcite are different to previously assumed values. Reconstructions of seawater  $\delta^{18}\text{O}$  ( $\delta^{18}\text{O}_{sw}$ ) using a number of published calcite temperature equations generally yield very high  $\delta^{18}\text{O}_{sw}$  values. The results from the present study support previous evidence that belemnites may fractionate  $^{18}\text{O}$  differently to abiotic calcite, and other biotic calcites (e.g. foraminifera, brachiopod). This supports a growing body of evidence that a belemnite-specific  $\delta^{18}\text{O}$  temperature equation needs to be developed.