



## **Late Jurassic (Kimmeridgian–Tithonian) carbon isotope stratigraphy and palaeoclimate data from Helmsdale, northeast Scotland**

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The Late Jurassic (and the Kimmeridgian in particular) is a time when global temperatures are known to have reached a maximum, although detailed isotope records for this greenhouse interval are somewhat limited. The data presented here provide the first relatively high resolution stable isotope ( $\delta^{18}\text{O}$ ,  $\delta^{13}\text{C}$ ) and geochemical (Mg/Ca) investigation of Kimmeridgian–Tithonian belemnites from the Helmsdale Coast, Scotland, UK. Oxygen and carbon isotope values from well-preserved specimens range from  $-2.84$  to  $+0.29\text{‰}$  and from  $-2.25$  to  $+2.82\text{‰}$  respectively. The oxygen isotope data are consistent with palaeotemperatures of up to  $24^\circ\text{C}$  in the Early Kimmeridgian cymodoce zone and down to  $11^\circ\text{C}$  in the Mid Tithonian rotunda–fittoni zones. Furthermore, the oxygen isotope palaeotemperature estimates are strongly supported by the Mg/Ca data, which also indicate a cooling episode (and very similar palaeotemperatures,  $11\text{--}22^\circ\text{C}$ ) at this time. The cooling event is associated with a  $5\text{‰}$  decline in  $\delta^{13}\text{C}$  ratios. This shift towards more negative  $\delta^{13}\text{C}$  values has also been observed on the Russian Platform and in the Tethys, confirming that this was a global event. Such globally synchronous records can provide a valuable tool for stratigraphic correlation. The Helmsdale  $\delta^{13}\text{C}$  data are therefore combined here with other published belemnite isotope data from the Jurassic of Scotland (namely, from the Callovian–Kimmeridgian of the Isle of Skye and the Toarcian–Aalenian of Raasay). The resultant carbon isotope curve provides a detailed record of the Toarcian–Tithonian British Boreal Realm, which can be compared with the Boreal Russian and Tethyan records in order to investigate regional differences in Jurassic carbon isotope stratigraphy.