Carbon isotope stratigraphy: a key tool for the definition of Cretaceous GSSPs and their global correlation

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Abstract

The global carbon cycle constitutes one of the most fundamental biogeochemical systems affecting all surface reservoirs on Earth, with complex interactions that modulate and drive climate change on both short and long timescales. Secular variation in stable carbon isotope ratios determined from fossil carbonate (δ13Ccarb) and organic matter (δ13Corg) provides evidence that the sizes of, and fluxes between, global carbon reservoirs have changed significantly throughout the geological record. A residence time of *c.* 100 kyr for carbon in the ocean – atmosphere system ensures that the rock record has the potential to capture a global high-resolution signal of palaeoenvironmental change affecting the carbon cycle. The geological history of carbon cycle perturbations is revealed in profiles of carbon isotope variation from individual stratigraphical sections, with episodes of major change evidenced by positive or negative carbon-isotope excursions or shifts in the direction or rate of isotopic change (Cramer and Jarvis, 2020). Coincident changes in multiple sections from different sedimentary basins enable the definition of carbon isotope events (CIEs) which, when calibrated using biostratigraphy, magnetostratigraphy and/or geochronology, provide a basis for correlation and dating. Carbon isotope stratigraphy (CIS) offers higher precision than possible using conventional biostratigraphy, potentially down to 10 kyr, and as a result it is being increasingly adopted for the refinement of Cretaceous stratigraphy and as one of the criteria for the definition of GSSPs (e.g., Walaszczyk et al., 2022). A unique feature of CIS is the ability to compare records derived from oxidised carbon (δ13Ccarb) and reduced carbon (δ13Corg, including individual organic compounds), with potential for the reconstruction of changes in atmospheric *p*CO2, and for correlation between marine and non-marine (terrestrial and lacustrine) environments.

The GSSP for the Campanian Stage was ratified in 2022 (Gale et al., 2023), completing the formalisation of GSSPs for all Upper Cretaceous stages. With the exception of the Santonian, all of the stage boundaries are associated with prominent CIEs that offer important tie points for global correlation. The case study of the Campanian (Jarvis et al., 2023) will be used to illustrate how CIS provides a key means for correlation between biotic provinces and enables the development of a robust holostratigraphy that can facilitate global correlation. By contrast, only 2 of 6 Lower Cretaceous stages have ratified GSSPs. The Lower Cretaceous is similarly characterised by a number of high-amplitude CIEs but the current reference curve (Cramer & Jarvis, 2020) is less well resolved, particularly in the Aptian and Albian, and major events do not necessarily coincide with traditional stage boundaries defined using biostratigraphy. The application of CIS to establishing an Aptian GSSP will be investigated to show how chemostratigraphy can provide criteria that enable a more robust

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correlation of key intervals of global palaeoenvironmental change.

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