EGU2020-13553
https://doi.org/10.5194/egusphere-egu2020-13553
EGU General Assembly 2020

Secular variation in the global carbon cycle during the Mesozoic: a new composite carbonate δ^{13}C reference curve calibrated to GTS2020

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A new δ^{13}C reference curve for the Mesozoic is presented. This has been constructed using in excess of 10,000 published analyses of bulk carbonate sediments extracted from published literature. Available data from sections world-wide were compiled for each stage and the stratigraphic trends visually compared. Data sets used to construct the composite reference curve were those offering patterns that are consistent with other sections and offer the highest stratigraphic resolution (close sample spacing), constrained by biostratigraphic first appearance (FAD) and last appearance datum (LAD) levels, magnetostratigraphy, radiometric dates and cyclostratigraphy. Preference was given to time series that showed the least scatter. Pelagic carbonates proved most suitable for these purposes but data from hemipelagic and shallow-water carbonate sections were included where necessary.

Age calibration was achieved using stage boundary ages, biostratigraphic FAD and LAD datums levels, and chron boundary ages derived from the new GTS2020 timescale. Where possible, data from multiple authors and/or multiple stratigraphic sections were age-calibrated and interleaved to generate composite profiles for each time interval. Data from individual stages were spliced together with offsets being avoided wherever possible; minor offsets in values were corrected where necessary to generate a continuous smooth time series. The uneven geographical spread of published data and suitable lithofacies has resulted in source information being derived from different regions for different time intervals. For example, the Early – Middle Triassic curve is constructed from eastern Paleotethys sections (South China), the Jurassic and Early Cretaceous curves principally from Tethyan areas of Europe and North Africa (Morocco, Portugal, southern France, Switzerland, northern Italy), and the Late Cretaceous curve from the Boreal Sea of northern Europe (England, Denmark). The global significance of the resulting curves requires further testing.

The stratigraphic positions and recalibrated ages of positive and negative δ^{13}C excursions that define carbon isotope events (CIEs) are presented. These reflect major perturbation in the global carbon cycle. Changes in the production and burial of organic matter on land and in the oceans, plus the balance between carbonate versus organic carbon deposition, are the principal mechanisms driving the observed long-term stratigraphic trends and short-term excursions.

These are linked to palaeogeographic and palaeoceanographic change, with climate and sea-level fluctuations driven by orbital forcing, tectonics, and volcanic events. The emplacement of large igneous plateaus (LIPs) and associated volcanism likely played a major role in driving many of the palaeoenvironmental perturbations reflected in the carbon isotope stratigraphy.

The most prominent CIEs characterise the Early Triassic with amplitudes exceeding 5‰ $\delta^{13}C_{carb}$ (VPDB), with other notable excursions in the mid-Carnian, mid-Norian and Rhaetian. The Toarcian negative CIEs are the stand-out feature of the Jurassic, but multiple lower amplitude CIEs occur throughout, notably in the Hettangian, Bajocian Callovian and Oxfordian. The most prominent Cretaceous CIEs in the Valanginian, Aptian and at the Cenomanian/Turonian boundary are linked to Oceanic Anoxic Events.