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Unravelling short-term climate and sea-level changes in a greenhouse world – Evidence from the Cretaceous (IGCP 609)

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Sea level constitutes a crucial geographic boundary for humans, and sea-level changes drive major shifts in the landscape. Within the scope of UNESCO/IUGS IGCP project 609 "Climate-environmental deteriorations during greenhouse phases: Causes and consequences of short-term Cretaceous sea-level changes", http://www.univie.ac.at/igcp609/index.html) we use the Cretaceous climate and sea-level history as 'laboratory' to investigate the Earth under different climate conditions to infer causes and consequences of eustatic climate and sea-level changes, and to model scenarios for climate extremes and the shift between climate modes (e.g. icehouse to greenhouse, cool to warm greenhouse). Identifying different processes and factors controlling climate and sea-level changes in different scenarios during the Cretaceous is essential to better evaluate global climate models and near future prediction models today.

The Cretaceous, as the last prolonged greenhouse era of Earth history, yields increasing evidence for significant (20–110 m amplitude) short-term eustatic sea-level fluctuations that follow Milankovitch cycles (4th-order – mainly 405 ka, and 3rd-order, mainly 1.2, 2.4 Ma ranges), and, thus, imply globally synchronous forcing [1, 2, 3]. Provided chronological linking, these cyclic climate – and corresponding sea- and lake-level – fluctuations play an important role for Cretaceous high-resolution marine chronostratigraphy with substantial potential for marine to non-marine correlations.

Though glacio-eustasy is considered to be the main process controlling short term eustatic sea-level fluctuations – which is certainly true for icehouse conditions – the presence of large continental ice shields is highly unlikely for the warm greenhouse to hothouse conditions during the mid-Cretaceous [1, 4, 6]. Alternatively, aquifer-eustasy may have played a significant role during these times, by storing water as groundwater (and in lakes) on the continents [1, 5, 6]. Lake-level changes (non-marine sequences) give information on significant groundwater-table changes and corresponding continent-ocean water distribution imbalances that should lie within the longer Milankovitch band, but out-of-phase with sea-level change [4, 5].

Processes and feedback for sea-level change are highly complex, resulting from various combinations of climate and solid-Earth mechanisms leading to changes in either ocean water volume or capacity of ocean basins ("container volume"). Operative timescales of the mechanisms, their (sea) water volume equivalents and the corresponding orders of magnitude in eustatic sea-level change remain controversial. However, ongoing progress in Cretaceous climate change and integrated stratigraphy, as well as progress in our understanding of solid-Earth processes and their different effects on both regional and global sea-level fluctuations, has led to changing ideas concerning Cretaceous climate and sea-level change, including new approaches, proxies and hypotheses.

To predict future regional and global sea-level change, a better understanding of the past (e.g. Cretaceous) record of sea-level fluctuations is essential, especially considering a shift from icehouse to greenhouse conditions.

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