Utilization of Stable Oxygen Isotopes for Quantification of the Mid-Cretaceous Greenhouse in the Americas

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Understanding the hydrologic cycle during greenhouse worlds is vital for accurate characterization of global climate systems. Investigation of Aptian-Albian greenhouse sedimentary systems allows us to generate important data that can be utilized to constrain models used in forecasting and hindcasting greenhouse conditions. We build on the Aptian-Albian sphaerosiderite $\delta^{18}O$ data set, a groundwater $\delta^{18}O$ proxy, of Ufnar et al. (2002) from the North American Cretaceous Western Interior Basin (KWIB) to improve a mass balance model used to estimate precipitation-evaporation fluxes.

New tropical to equatorial $\delta^{18}O$ data from pedogenic sphaerosiderites and calcite, and early meteoric diagenetic calcite is used in a revised isotope mass balance model. Four different Cretaceous (empirical and modeled) latitudinal temperature gradients for the mid-Cretaceous, and empirically derived $\delta^{18}O$ composition of groundwater are used as constraints in our mass balance model. Precipitation flux, evaporation flux, relative humidity, seawater $\delta^{18}O$, and continental feedback are adjusted to model the empirically-derived groundwater $\delta^{18}O$ compositions to within ± 0.5‰. The model is calibrated against modern precipitation data sets.

Precipitation fluxes generated for all the Cretaceous temperature gradients utilized in the model are greater than modern precipitation fluxes. We utilize saturation vapor density temperature relationship and precipitation fluxes estimated by our mass balance model scenarios, to estimated precipitation rates. Calculated global precipitation rates are all greater than modern precipitation rates and range from 371 mm/year to 1154 mm/year greater than modern. Our model results continue to support our research group's finding that increased rainout are the cause $\delta^{18}O$-depleted precipitation.

Sensitivity testing indicates that temperature, and air mass origin and pathways, significantly affect the oxygen isotopic composition of precipitation. Relative humidity is important in the tropical dry belt and significant reductions in relative humidity are required. Seawater ^{18}O enrichments are necessary in the tropical ocean to simulate proxy data, and are consistent with fossil and geologic evidence for a warmer and evaporatively enriched Tethys. Our results indicate that use of constant seawater $\delta^{18}O$ composition is not appropriate for mid-Cretaceous simulations.

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