Post-PETM Hyperthermals in the Bighorn Basin, WY

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Recent focus on deep marine records of the early Paleogene has established the existence of smaller amplitude geochemical anomalies that mimic those found at the PETM. For example, Eocene Thermal Maximum 2 (ETM2, also known as H1 and Elmo) is associated with the second largest CIE identified in the early Paleogene record thus far and corresponds to even greater high-latitude temperatures than the PETM. ETM2 is followed closely in time by another event known as "H2". Unlike the PETM, however, these other hyperthermals are not well documented from continental settings. Continental records of these smaller events are important to confirm their global nature, compare their biotic and hydrologic effects to those found at the PETM, and to help resolve the total amount of carbon released during these events.

We carried out meter-scale sampling of paleosol carbonate nodules for geochemical analysis from an ~160 meter interval surrounding the Chron C24r-24n polarity reversal in the McCullough Peaks section of the Bighorn Basin. The McCullough Peaks section has a relatively continuous and well-documented early Eocene stratigraphic record with good magnetostratigraphic control and abundant fossil mammals. Previous low-resolution isotopic results from this section indicated high variability near this polarity reversal and marine stratigraphic records exhibit several CIEs from this same interval, including the CIEs associated with the ETM2 and H2 events.

Results show two distinct negative $\delta^{13}C$ isotopic excursions in the interval surrounding the C24r-24n reversal. A -2‰ shift in average $\delta^{13}C$ of paleosol carbonates occurs ~110 meters below the base of Chron C24n (~800 meters above the PETM) and a second, well-defined, excursion of -2.7‰ occurs ~2.5 meters above the base of Chron C24n. Assuming uniform sediment accumulation rates for the 2 million year interval between the PETM and the base of Chron C24n, the lower excursion occurred ~240 ky before the polarity reversal and the upper excursion peaked ~5 ky after the reversal. Detailed marine cyclostratigraphic records indicate that the ETM2 CIE occurred between 126 – 315 ky before the Chron 24r – 24n reversal and the H2 CIE occurred almost coincident with the reversal. Given their close temporal association, we interpret the lower CIE in our section as ETM2 and the upper CIE as H2.

Our results indicate that CIEs recorded in paleosol carbonate are variably amplified compared to coincident marine CIEs suggesting the later are more reliable for estimating the total mass of carbon released during these events. In addition, ETM2 in the McCullough Peaks section coincides precisely with Biohorizon B (= Wa-4/Wa-5 biozone boundary) which represents the largest early Eocene mammalian turnover in the Bighorn Basin. ETM2 also coincides with an increase in the size and frequency of channel sandstone complexes throughout the basin, signifying regional hydroclimatic changes. In contrast, H2 does not correspond to any obvious biotic or sedimentological changes. These results show that hyperthermals smaller than the PETM can still, but do not necessarily, cause first order hydrologic and biotic changes in continental environments, highlighting the sensitivity and unpredictability of the earth system to transient changes in the carbon cycle.