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Land Erosion and Coastal Sedimentation in the Sub-Tropics During Rapid Planetary Warming: Environmental Magnetism of the Zumaia, Spain Paleocene-Eocene Thermal Maximum Record

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Abstract

Climate events in the geological record, like the Paleocene-Eocene Thermal Maximum (PETM), are widely studied because they provide important analogues to the current climate system on Earth (*e.g.* Burke et al., 2018). The PETM is a ~200 ka-long global ~4-5 per mil negative carbon isotope excursion that occurred ~56 Ma; during the PETM, temperatures rose ~5-8°C globally and ~3-4°C in within the sea surface (McInerney and Wing, 2011). Although the magnitude of the PETM is most analogous to present-day warming, the duration of warming and environmental change took place over a much longer time scale compared to warming in the Anthropocene. In addition to warming, the PETM coincides with the largest benthic foraminiferal extinction in the past 60 Ma (removing 30-50% of benthic foraminiferal diversity), the first appearances of many North American terrestrial mammalian taxa, and a change in terrestrial plant communities (McInerney & Wing, 2011). At Zumaia, Spain, a subtropical marine environment close to the western Catabrian-Iberian coast during Paleocene and Eocene time, sedimentological and isotopic observations suggest a dramatic change in the amount and style of physical and chemical weathering at the onset of the PETM. Based on experiments made in other settings and time periods, magnetic properties may also record clues about precipitation and extreme weather events (Maxbauer *et al.*, 2016), but this approach has not been applied to the Zumaia record. Here we present analyses of the magnetic mineral properties, including magnetic grain size, shape, and composition, in sediment samples to describe the iron delivery, (re)mineralization, and preservation that occurred at Zumaia while submerged in a marine depositional environment. Our magnetic measurements— which include magnetic susceptibility *vs.* temperature curves, hysteresis loops, remanent backfield curves, and FORC diagrams— all suggested the presence of a mixture of magnetite and hematite in the samples. Stratigraphic plots of the magnetic data show an increase in magnetic concentration (M_s), magnetic hardness (B_{cr}), and hematite concentration (S_{300}) at the beginning and throughout the PETM. A fluvial detrital proxy (Rb/Al) decreases during the carbon isotope excursion, so we tentatively interpret the increase in hematite to suggest that the mineral was not weathered on land and transported to the site, but rather produced *in situ*. We hypothesize that the environmental magnetism of the PETM record at Zumaia appears to be more sensitive to local redox and bottom water conditions than to surface runoff and hydrologic change on the Iberian-Catabrian coast. With future work, we will test this interpretation by comparing our magnetic record to benthic foraminifera assemblages preserved in the Zumaia section (Alegret *et al.*, 2018). Our magnetic approach also allows us to test the degree to which mineral magnetism in this record is consistent with previous sedimentological and geochemical studies (Schmitz &

Pujalte, 2003; Schmitz & Pujalte, 2007; Alegret *et al.*, 2018). High-stratigraphic-resolution magnetic methods may provide an economical baseline from which to select and complement more expensive and time-consuming geochemical studies.

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