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Controls on fluvial metamorphosis during global warming at the Paleocene-Eocene boundary (56 Ma) in Spain: extreme droughts, extreme floods or both?

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How does global warming change the frequency and intensity of extreme weather events? The response to this question is partly preserved in the geological record. 56 Ma ago, global temperatures increased during the Paleocene-Eocene Thermal Maximum (PETM), leading to a major biotic turnover, but how this event affected the nature of extreme events remains unknown. On several continents, fluvial systems with sinuous channels within fine-grained floodplains suddenly transformed at the P-E boundary into apparently coarser-grained braid plains with frequent lateral migrations, washing their muddy floodplains to the seas. This landscape transformation has been related to aridification and intensification of precipitation allowing transport of coarser material as a result of P-E global warming, with important implications for predicting the consequences of current global change. Here we test this hypothesis by quantifying the magnitude of grain size change and flow depth at a representative P-E locality in Northern Spain. We find that the size of pebbles in transport and flow depth remained similar to, or even smaller than, pre-PETM conditions. This suggests that, if more seasonal and extreme precipitation occurred, they are not necessarily borne out in the predicted deeper flow depths and coarser grain sizes, but rather trigger a shift to multiple active channels. However, an alternative or complementary explanation may rest in pollen data found in coeval marine records and which document a dramatic vegetation shift from permanent conifer forests prior to the crisis into periodic vegetation in brief periods of rain during the hyperthermal episode. Such change induced by long periods of intense droughts, could have enhanced erodibility of channel banks by decreasing root-controlled cohesion of fine-grained floodplains and interfluves, promoting their lateral mobility and the observed fluvial metamorphosis. Thus, although water is regarded as the main agent sculpting fluvial landscapes, the absence of it during extreme droughts rather than its presence during extreme precipitation events, may be a dominant control on fluvial metamorphosis and landscape evolution.