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Lake sedimentological and plant ecological development across the Early Danian hyperthermal, Boltysh Impact Crater, Ukraine

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Past hyperthermals and associated negative carbon isotope excursions (CIEs) are inferred to have had significant impact on marine environments; however the formation and changes of terrestrial ecosystems across hyperthermals are less well constrained due to the lack of complete and high-resolution data. The Boltysh impact crater, Ukraine, which formed at the Cretaceous/Palaeogene (K/Pg) boundary at the northern margin of the Tethys Ocean, contains a >400 m thick unique and detailed lacustrine rock record of the Early Danian Dan-C2 hyperthermal. Based on a borehole (hole 42/11) drilled in the central part of the crater, we use a combination of sedimentological, palynological and carbon isotope data to 1) characterise and reconstruct lake formation and associated plant ecosystems, and 2) to assess lake sedimentological and ecological response to climatic variabilities during warming.

Based on detailed facies analysis, 3 major gradual stages of lake formation are identified, indicating a strong relationship to carbon isotope shifts and associated climatic trends. Initial pre-excursion sedimentation was controlled by crater morphology and crater rim erosion transporting high amount of sediment into a shallow fresh water lake. During the negative excursion, sediment supply was increasingly characterised by inflow-evaporation ratio variabilities which affected seasonal stratification patterns and longer-term lake levels. An inferred increase in atmospheric pCO_2 during the CIE, together with increasing mean annual temperatures, was likely responsible for periodic increases in bioproductivity. Palynological analyses demonstrate a gradual shift from mesic humid dominated vegetation to winterwet savannah-type vegetation at this stage, associated with an increase in mean annual temperatures and decrease in moisture availability. The positive excursion (recovery) and post-excursion stage is characterised by increased abundance of temperate mesic humid taxa. This cooling trend is associated with a gradual increase in sediment supply and return to fresh water conditions, reflecting increased drainage of the crater environment following the hyperthermal.

Subordinate 21ky precession-paced moisture availability oscillations (MAOs) associated with rapid regime shifts from wet mesic humid to drier savannah biomes correspond to fluctuations in lake facies and lake levels during the negative excursion and suggest that a combination of climate and vegetation cover largely controlled clastic sediment supply at this stage. Smaller scaled regular variations in lamination style during each wet phase of the MAOs suggest a sub-orbital variability in weather conditions, sediment supply and lake stratification on probably annual to subannual scale and further implies changing magnitudes in seasonality. Gradual facies changes prior to CIE inception together with lamination variability suggests that the Dan-C2 event did not initiate large-scale sedimentological changes, but amplified and promoted sedimentary response to orbital controlled climate change.