THE ORGANIC GEOCHEMICAL RECORD OF ENVIRONMENTAL CHANGE AT THE K/T BOUNDARY. I. Gilmour and M.A. Sephton, Planetary Sciences Research Institute, The Open University, Milton Keynes, MK7 6AA, United Kingdom. (I.Gilmour@open.ac.uk).

Introduction: The effects of an impact at the Cretaceous-Tertiary (K-T) boundary and, in particular, whether these were sufficiently severe and widespread to explain the extinction patterns observed remains controversial. The majority of evidence for biotic perturbations comes from the fossil record of marine sites combined with stable isotope evidence. Studies of the marine foraminiferal record across the K-T boundary have identified negative shift in $\delta^{13}C$ of 1-2% which has been interpreted as evidence for depressed marine bioproductivity. Differences between the carbon isotopic values of planktonic and benthic foraminifera suggest that the ocean ecosystem did not fully recover from for more than 3 million years after the mass extinction [1]. On land the K-T boundary sequences of the Western Interior of North America provide the most complete sequences of non-marine sediments available for study and their palynology has provided evidence of an ecological catastrophe following the impact [2]. Organic carbon at marine sites shows changes in $\delta^{13}C$ values on a millimetre resolution scale though no consistent changes are observed between the upper Maastrichtian and lower Palaeocene records [3]. Thus far few studies have been made of organic carbon in non-marine K-T sequences.

Organic Geochemistry: The presence of molecular biomarkers preserved in sedimentary organic matter provide ‘chemical fossils’ that can be used to reconstruct paleoenvironments. Specific biomarker molecules can be highly indicative of certain sources. For example, steranes are derived from sterols that are found in most higher plants but are rare or absent in prokaryotic organisms while long-chain unsaturated ketones derive from Prymnesiophyte algae and dinoflagellates. The organic matter (OM) preserved in sediments falls into two categories: organic compounds that can be extracted by solvents (extractable OM) and that which cannot (kerogen). Studies of the carbon and nitrogen isotopic composition of the latter have been interpreted as evidence for marine algal blooms in the lowermost Danian [3, 4].

The Marine Record: Comparatively few organic geochemical investigations have been undertaken of K/T boundary successions. In part, this reflects the lithologies available for study, many of which are organic poor. However, when suitable material is available, evidence for a variety of environmental perturbations have been found. For example, molecular studies of the lowermost Danian at the Geulhemmerberg K/T site indicated the presence of a highly abundant long-chain ketone diagnostic of non-coccolithophorid Prymnesiophyte algae [5]. Further studies from the same group found that organic molecular markers, restricted to the basal section of the boundary clay at El Kef and Geulhemmerberg, indicated a short, intense period of fermentation of massive amounts of organic matter on the seafloor (J de Leeuw et al, unpublished data). This provides some of the best evidence so far for mass mortality following the impact event [6].

The Terrestrial Record: We have used, coupled carbon and nitrogen isotope measurements together with molecular level isotope analysis of biomarker molecules [7] to assess environmental conditions at two non-marine K-T boundary sites in the Western Interior of North America to examine the effects of the Chicxulub impact on freshwater ecosystems. Measurement of the carbon isotope compositions of individual molecules greatly increases the usefulness of biomarkers as indicators of specific sources.

The two sites chosen for study Raton Pass (New Mexico, USA) and Brownie Butte (Montana, USA), were selected to represent two different paleogeographical and paleoecological settings at the time of the impact.

Results. Saturated hydrocarbons (n-alkanes) isolated from Berwind Canyon and Brownie Butte indicated a major input from higher plants in samples from the Cretaceous. In samples overlying the top of the boundary clay higher plant input was reduced and n-alkanes from algae/bacteria are present with $\delta^{13}C$ values in the range of $-20\%_{0}$ to $-40\%_{0}$ and that which cannot (kerogen). Studies of the carbon and nitrogen isotopic composition of the latter have been interpreted as evidence for marine algal blooms in the lowermost Danian [3, 4].

These results indicate the onset of highly anoxic conditions with methanogenic bacteria living in anaerobic conditions and methanotrophic bacteria living above the oxic/anoxic interface. As at El Kef and Geulhemmerberg the anoxic environment was most likely brought about by a massive increase in the amounts of organic matter as a consequence of the mass annihilation of higher plant material.

The distribution and carbon isotope composition of n-alkanes returns to Cretaceous values a few centimetres above the boundary. As noted previously [2] the severity of the biotic crisis in the terrestrial environment appears to have been restricted to a mass mortality, as opposed to a mass extinction, with much of the higher plant flora existing at a reduced level in the immediate post-impact environment and then recolonising relatively rapidly.
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Figure 1. Mass chromatograms (m/z 191) showing the distribution of hopanes across the K/T boundary at Berwind Canyon, New Mexico.