Goldschmidt 2000
September 3rd–8th, 2000
Oxford, UK.

Journal of Conference Abstracts
Volume 5(2), 782

Palaeoenvironmental Interpretation of the Early Postglacial Sedimentary Record of a Marl Lake

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Marl lakes are characterised by their sediment composition (>50%$CaCO_3$)and water chemistry (>100 ppm dissolved $CaCO_3$). They are a) excellent for preservation of calcified lake organisms; b) have rapid sedimentation rates giving good resolution, c) well buffered with respect to H^+, OH^- inputs and d)have continuous stable isotope records of deposited carbonate ($^{13}C/^{12}C$, $^{18}O/^{16}O$). Malham Tarn is a small (60ha) shallow (2.5 m) UK lake situated in the 'cool temperate' climatic zone where several plants and animals are currently at the edge of their range. It is a sensitive location for recording both present and past environmental change. A series of sediment cores were taken to investigate the Postglacial environmental history of the lake. Core 99/1 penetrated clay, marl and peat units. Pollen analysis has shown that peat began forming 8000 years ago. In this presentation we discuss the underlying late Glacial/early Postglacial sediments with reference to climatic change and their fossil evidence with the distribution of biomarker compounds and their $^{13}C/^{12}C$ ratios. The oldest sediments are late Glacial clays with ca 40%$CaCO_3$. They are followed by a thin sequence of varved clays probably representing the Younger Dryas. Above, the clay has increasing amounts of carbonate and gives way to a pure carbonate marl. Within this marl we have found two calcified macrophyte genera, Chara and Potamogeton, which were not found in the underlying clays. They are associated with a benthic molluscan and ostracod fauna. However organic matter occurs throughout the core to the extent of a few percent. Pollen analyses indicate that during the Late Glacial, the area was colonised by Alchemilla/Juniperus scrub. After the Younger Dryas, woodland developed with Salix, Alnus and Pinus parkland. During the period of marl formation, woodland probably expanded with additional Betula and Quercus. The $^{18}O/^{16}O$ isotope record of the carbonate in the clay unit is nearly constant, in the range -7.2 to -8.2‰. In the marl it increases rapidly to about -6.5‰ and remains constant throughout. The $^{13}C/^{12}C$ record in the clay unit is also nearly constant in the range +0.5 to +1.3‰ followed by a small sharp increase to +1.7‰ at the base of the marl and a monotonic decrease to -3.5‰ at the marl-peat transition. The carbonate fraction in the clayey sequence is interpreted as detrital catchment limestone whereas the overlying marl contains a mixture of detrital and autochthonous components. The isoptopere record suggests either that an increase in productivity has occurred, that the detrital carbonate fraction is falling steadily, or both. The Chara, Potamogeton and associated fauna showed rapid and irregular fluctuations within the marl while in contrast the carbonate isotopic record was smooth. Carbonate-depositing epilithon and plankton were not identified and may have contributed to the isotope record however. Moreover the terrestrial re-colonisation with increasing soil development, ^{13}C-deplected CO_2 would enter the lake and lower the $^{13}C/^{12}C$ ratio. The distribution of n-alkanes and fatty acids shows a decrease of input from higher plants from the clays to the marls which was associated with a marked fall in $^{13}C/^{12}C$ of the long chain homologues. The research demonstrated that a) stable isotope data alone did not identify surges in abundance of the benthic flora; b) the oxygen isotope record seems to represent a transition from detrital carbonate to biogenic carbonate and is not necessarily related directly to climatic change; c) there is a time lag between the environmental changes as indicated by $^{18}O/^{16}O$ and stabilisation with respect to the $^{13}C/^{12}C$ record of the biogenic carbonate.