Whodungit? Coprolite chemistry reveals diet, digestive processes and digestive tract microbes of extinct animals

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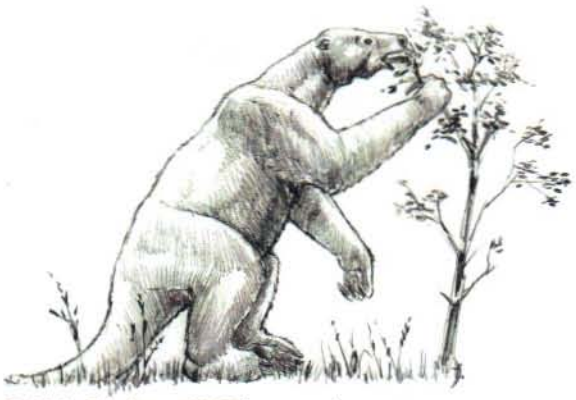
Coprolites are an important, but often overlooked, source of palaeobiological information. Since William Buckland first identified "bezoar stones" associated with ichthyosaur skeletons as fossilised faeces, coprolites have been widely studied in terms of their size, shape, and contents. Recently, the chemistry of the organic components of coprolites has also been investigated.

Biomarkers are molecules that can be attributed to a biological source on the basis of their chemical structure. Recent studies have shown that a variety of lipid biomarkers can be preserved in coprolites, where they may provide unique information on the diet, digestive processes and digestive tract microbial community of the producer. For example, an 11000 year old coprolite from the ground sloth *Nothrotheriops shastensis* was found to contain large amounts of a compound known as epismilagenin, which is interpreted to have been formed by digestive processing of *Yucca* or *Agave* leaves.

To better understand findings from coprolites, it is essential to study faecal lipids from modern analogues. Animals with different digestive systems were found to have different faecal lipid signatures. Faeces from ruminants (e.g. cows, sheep, goats, deer) were consistently found to contain a compound called archaeol, which wasn't found in the faeces of herbivores with a different digestive system, e.g. horses, elephants, rhinoceros. Archaeol is believed to derive from methane-producing microbes and so archaeol recovered from coprolites may represent evidence that the depositor of the coprolite was a methane producer. Eventually, it might even be possible to estimate the amount of methane emitted by an extinct animal, since very recent studies on modern cattle have shown a correlation between the amount of methane emitted and the amount of archaeol in the faeces of an animal.



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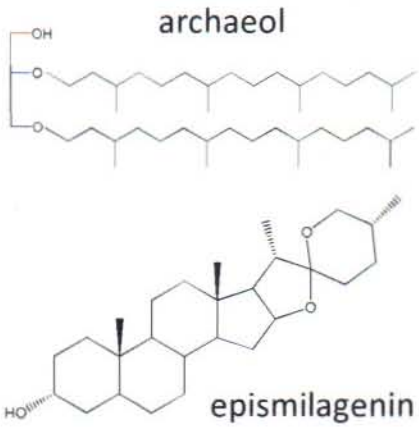

Dead in the Water: an Investigation into Eocene Fish Mass Mortality Events

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Fossil fish from the Green River Formation of southwest Wyoming have been collected by palaeontologists and amateur collectors since the early 19th century. In Fossil Lake the Eocene fish are found in mass mortality beds that have been reported to contain as many as 500 fish per square metre. The carbonate rocks split easily along sub-millimetre laminations and have yielded millions of fossil fish over the last two centuries, as well as many plants, insects, reptiles, birds and small mammals. Flora and fauna are found so well-preserved and in such abundance that this lagerstätten is one of the best known from North America. To date, theories for the cause of death of the Fossil Lake fish mass mortality assemblages have been based on scholarly assumptions rather than definitive evidence. Here we discuss the major mechanisms of fish mass mortality and assess their probability of having been a causative agent in Fossil Lake. A thorough sedimentological investigation of the palaeolake coupled with geochemical analyses indicated no environmental perturbations concurrent with the regularly occurring, possibly cyclical, mass mortalities of the fish. However, it was possible to rule out many hypotheses regarding cause of death using the evidence available, with toxification of the water column by microorganisms remaining as the most likely cause, potentially coupled with related environmental stressors. Further analyses revealed that the sediments contain abundant algal biomarkers, including particularly high concentrations of 4-methylsteranes. These are likely derived from dinoflagellates, indicating an abundance of these protists at time of deposition. This is consistent with harmful algal blooms being a key causal mechanism for the recurrent fish mass mortality events in Eocene Fossil Lake.