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X-ray synchrotron microtomographic imaging of three-dimensional non- biomineralized fossil arthropods from upper Triassic shoreface clays, Somerset, England.

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The fossil record is biased; it consists primarily of biomineralised tissues that have high preservation potential (e.g. bones shells, teeth). Exceptional faunas are those in which the labile (decay-prone) tissues of organisms are preserved. They provide a more complete record of the diversity and ecology of ancient communities than the 'normal' fossil record and are essential to our understanding of the history of life on Earth.

Exceptionally preserved fossil arthropods have been recovered from Late Triassic (Rhaetian) strata near Frome, Somerset, England. Recent fieldwork has confirmed their taphonomic context is extraordinary. Three-dimensional preservation of non-biomineralised organisms, rare overall, is unknown without an enclosing concretion. Further, the 'Frome arthropods' occur in poorly consolidated clays (from which they can be wet-sieved) that would have afforded no structural support during burial. The host clays are interbedded with fine-grained carbonates and conglomerates - that accumulated in a high-energy shoreface environment (the associated bioclastic material is heavily abraded and fragmented) - and represent the first occurrence of non-biomineralized arthropods in such a setting.

Light microscopy and SEM of two-dimensional, naturally fractured, surfaces reveals the presence of phosphatized musculature. Remarkably, this has not only retained its

three-dimensional shape at both hand specimen and microscopic levels, but appears to be in life position. Other specimens show the gut also preserved *in situ*, although this appears to be infilled with clay minerals rather than replicated in any authigenic mineral, as far as can be determined. The remainder of the body space is filled with fine-grained micritic carbonate and scattered pyrite framboids; the framboids vary in their size and abundance both within a specimen and between specimens.

Due to the small size (approx 2-5mm) and rarity of this material, destructive analysis is undesirable; therefore, high-resolution non-destructive imaging techniques are required. The resolution provided by synchrotron radiation is essential to image individual muscle fibres, carbonate crystals, and particularly the distribution of the 3-10 micron diameter pyrite framboids. The results of decay experiments indicate that the geochemical gradients required for mineral authigenesis, and the replication of labile tissues, vary over scales of μm to mm. The minerals present in these fossils (phosphate versus carbonate plus pyrite framboids) represent authigenesis under markedly different environmental (Eh/pH) conditions. The 'Frome arthropods' provide an opportunity to resolve the distribution of phosphatic and carbonate phases, within the fossil material, at a distinctly finer scale than previously reported, and is thus an opportunity to test models derived from experimental studies.

The distribution of preserved muscle in some Cambrian arthropods has been used to indicate their biological affinities; alternatively, it may result from selective preservation of only specific muscles. The ability to resolve the three dimensional nature of the musculature of the 'Frome arthropods' at a scale of microns, and then compare it to the musculature of extant analogues, is an unprecedented opportunity to address the question of preferential preservation versus evolution of taxonomic indicators.