Investigating the processes of exceptional fossil preservation: the case study of Jurassic crustaceans from la Voulte-sur-Rhône

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The fossil record is far from delivering an accurate picture of past biodiversity. Although some localities yield exceptionally preserved fossils (incl. soft tissues or entirely soft organisms) with fine-scale morphological details, the fidelity of such preservation might be questioned. Precise and reliable biological and paleoenvironmental reconstructions based on these objects require better constraining the processes that lead to such exceptional preservation.

Here, we report the mineralogical study of exceptionally preserved crustaceans fossilized within carbonate-rich concretions from the Jurassic Konservat-Lagerstätte of La Voulte-sur-Rhône (Ardèche, France). Semi-quantiitative imaging of element spatial distribution was performed using SEM-EDS and synchrotron-based XRF. Mineralogical species were precisely identified using XRD and Raman spectroscopy.

Combining these techniques allowed identifying the mineralogical phases composing the fossils (Ca-phosphates, Fe-, Zn-, Pb-sulfides, Ca-sulfates, Fe-oxides and Ca-, Mg-, Fe-carbonates) and the surrounding matrix (Fe-carbonates, K-rich clays and detritic silicates), and documented their complex textural relationships. These results allowed proposing a new taphonomic scenario for these exceptionally preserved fossil crustaceans: phosphates and sulfides precipitated first, in an anoxic environment. Iron sulfides were later oxidized in sulfates and iron oxides. This change in the redox environment appears to have been related to inflows of detritic material.

Of note, tissues of different original biochemistry captured different stages of this taphonomic scenario. This highlights the importance of precisely documenting fossilization processes to identify potential biases and better assess the quality of the fossil record.