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3D representation of biominerals integrating microscopy and photogrammetry: implications in geoarchaeology

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Biomineralisation is a natural process by which living organisms, plants and animals form minerals. Biominerals embed a wide array of information of notable significance for both the geosciences and archaeology. Their preservation in relation to the geochemical depositional environment is critical for their archaeological interpretation. Often biominerals are affected by the conditions of their burial environment over time, displaying alterations of their morphological characteristics. The three-dimensional (3D) representation and visualisation of biominerals may contribute towards a deeper understanding of their surface morphology and potential weathering. Even though Earth-related 3D surface reconstruction is widely used in geomorphology, its use within the field of geoarchaeology and especially for the microscopic record has been limited.

In the present study, we propose the integration of microscopy and photogrammetry for the non-destructive imaging and 3D representation of the surface of microscopic biominerals of plant and animal origin. The specimens include wheat phytoliths and teeth of rodent species. Archaeobotanical assemblages suggest that the wheat T. monococcum is the earliest domesticated cereal with a central role in human economies over the millennia. The study of micromammals, often identified by their preserved teeth, may provide important information pertinent to both the palaeoecology and relative dating of archaeological sites.

The overall three-dimensional morphology reconstruction was based on digital photogrammetry principles. Overlapping images were collected from two separate sources, Scanning Electron Microscope (SEM) and a pocket size electronic microscope. Throughout related work, similar experiments merely provide visualisations of 3D specimen models. The photogrammetric reconstruction of the 3D models is limited due to the imaging environment including illumination parameters and non-rigid camera-lens geometry. Thus, the underlying challenges of such an attempt are to build a geometrically reliable 3D model and subsequently provide quantitative structures where relative or absolute metrics can be estimated, since there is a lack of strict scaling or precise coordinate reference system. Towards this end, we provide the first findings of a metric-oriented approach, through microscope camera calibration and novel geometric distance unit set-ups towards a robust measurement methodology.