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Disentangling the history of complex multi-phased shell beds based on the analysis of 3D point cloud data

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Shell beds are key features in sedimentary records throughout the Phanerozoic. The interplay between burial rates and population productivity is reflected in distinct degrees of shelliness. Consequently, shell beds may provide informations on various physical processes, which led to the accumulation and preservation of hard parts. Many shell beds pass through a complex history of formation being shaped by more than one factor. In shallow marine settings, the composition of shell beds is often strongly influenced by winnowing, reworking and transport. These processes may cause considerable time averaging and the accumulation of specimens, which have lived thousands of years apart. In the best case, the environment remained stable during that time span and the mixing does not mask the overall composition. A major obstacle for the interpretation of shell beds, however, is the amalgamation of shell beds of several depositional units in a single concentration, as typically for tempestites and tsunamites. Disentangling such mixed assemblages requires deep understanding of the ecological requirements of the taxa involved – which is achievable for geologically young shell beds with living relatives – and a statistic approach to quantify the contribution by the various death assemblages. Furthermore it requires understanding of sedimentary processes potentially involved into their formation.

Here we present the first attempt to describe and decipher such a multi-phase shell-bed based on a high resolution digital surface model (1 mm) combined with ortho-photos with a resolution of 0.5 mm per pixel. Documenting the oyster reef requires precisely georeferenced data; owing to high redundancy of the point cloud an accuracy of a few mm was achieved. The shell accumulation covers an area of 400 m2 with thousands of specimens, which were excavated by a three months campaign at Stetten in Lower Austria. Formed in an Early Miocene estuary of the Paratethys Sea it is mainly composed of shells of the giant oyster Crassostrea gryphoides along with numerous other bivalves, gastropods and barnacles. More than 10.000 objects were outlined on the digital surface model and characterized in respect to taxonomy, convex up/down position, left/right shell, orientation, fragmentation and several other features. The outlines and attribute data were stored in a georeferenced ArcGIS database. Already the first analyses and visualizations of the obtained data-sets pointed out different degrees of taxon distribution, composition, and taphonomic grade allowing an identification of at least four discrete ecosystem/depositional phases now amalgamated in a single shell-bed.

Based on examples from the present research the presentation will demonstrate enormous potential of high resolution terrestrial laser scanning in paleontology and sedimentology. Representing a pioneering study, lessons have been learned about the benefits as well as the limitations of its application for taphonomic studies.

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