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3D identification and quantification of multi-phase diagenetic carbonate mineralogy using μ -computed tomography: roadmap to original isotope geochemistry of altered archives

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Marine biogenic carbonate deposits are important climate archives as environmental conditions during mineral genesis are recorded chemically in the crystal lattice. When exposed to diagenetic alteration metastable carbonate phases as aragonite are prone to transform into more stable calcite, Mg-calcite or dolomite resulting in the loss of the original geochemical information. As diagenetic alteration is often heterogeneous, numerous carbonate archives are characterized by multi-phase compositions, including potentially unaltered remains of primary formation. Consequently, high-spatial-resolution identification of adjacent carbonate mineral phases is of key interest to constrain diagenetic fronts, as well as the degree and pattern of a carbonate archive alteration, and the deciphering of relevant geochemical proxy information.

The aim of the present study is to contribute to the localization of potentially unaltered localities within heterogeneous carbonate samples, enhancing the retrieval of original geochronological and proxy information. Using natural tropical fossil coral samples as an example, we present an approach for the 3D-identification of multiple carbonate phases using μ -computed tomography scans with a resolution on a μm scale. The straightforward discrimination of aragonite, calcite, and dolomite from CT-imaging is principally hampered by the similar X-ray densities of these carbonate phases. To overcome this problem, reference material blocks for each of the three carbonate minerals were scanned together with the carbonate sample. Using the AVIZO 2019 software package in combination with a self-developed Tool command language (Tcl) script each of the carbonate reference blocks within the scanned volume was systematically subsampled for its voxel grey values. The obtained data set was statistically analysed and a robust mean voxel grey-value was calculated for each reference mineral. Subsequently, these mean grey values were used for the automated selection of seed points for subsequent image segmentation throughout the entire scanned volume based on a self-developed Tcl script. After seed point definition mineral identification was carried out throughout the volume using the watershed algorithm as a region-based image segmentation method. The final result yielded an approximation of the 3D-

distribution of identified carbonate phases throughout the sample on a μm scale, which represents an excellent starting point for subsampling strategy development.