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

S. Krause[1], V. Liebetrau[1], K. Engelkes[2], S. Büsse[3], H. Jurikova[4], G. Nehrke[5], S. Gorb[3], A. Eisenhauer[1]

[1]GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany, [2] Center of Natural History, Hamburg University, Germany
[3]Zoological Institute, Kiel University, Kiel, Germany, [4]GFZ German Research Centre for Geosciences – Helmholtz Centre Potsdam, Germany, [5]Alfred Wegener Institute, Bremerhaven, Germany

Introduction

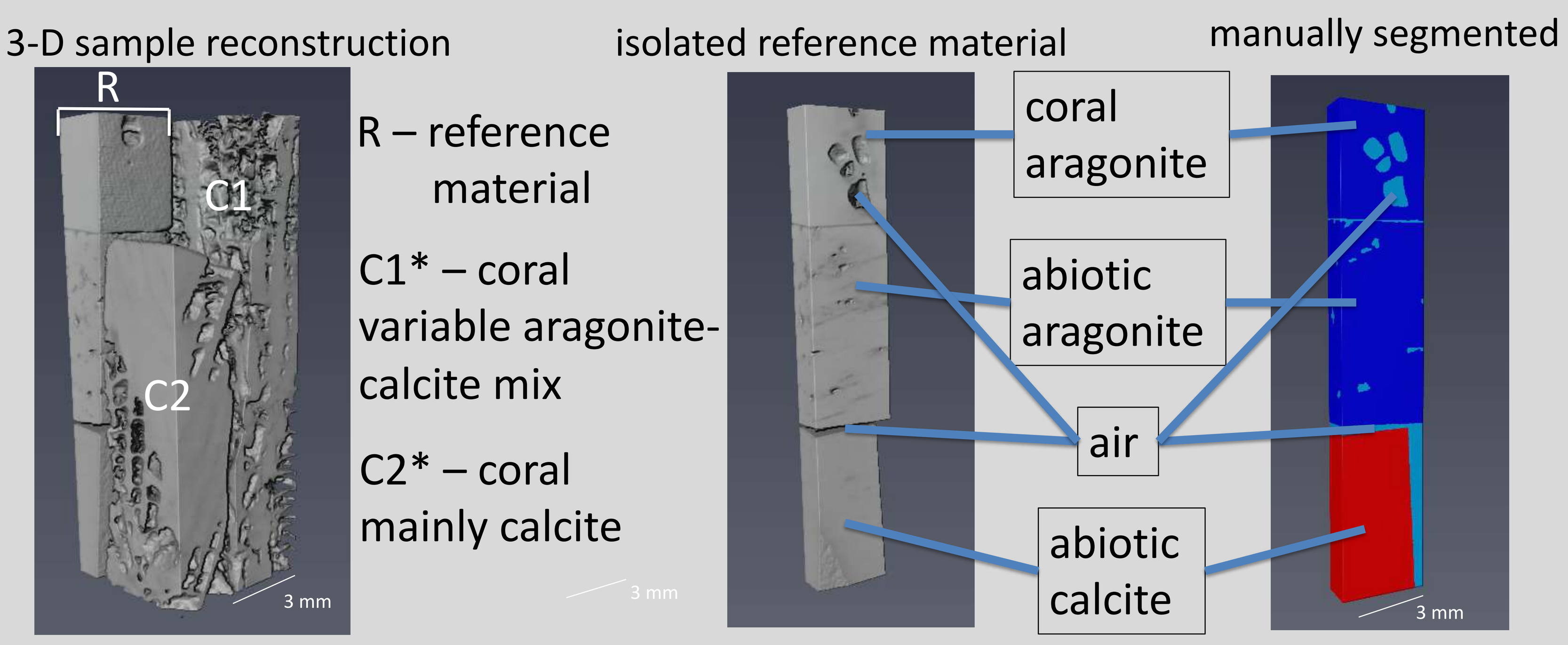
Computed tomography (CT) is a versatile, non-destructive technique for 3-D object analysis, theorethically allowing for the discrimination and quatification of individual mineral phases within a given sample.

A novel approach

Here, we introduce a novel approach to constrain individual mineral phases of a given sample using the distribution of aragonite and calcite in two diagenetically altered tropical corals as an example in combination with refernce material.

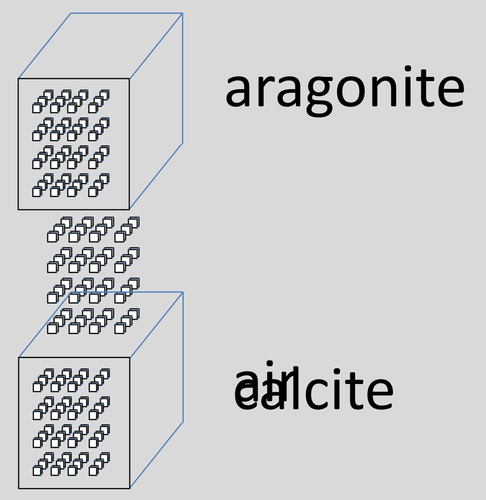
Work flow

1. Sample imaging and manual reference material segmentation



*Used corals originate from Zanzibar, last interglacial

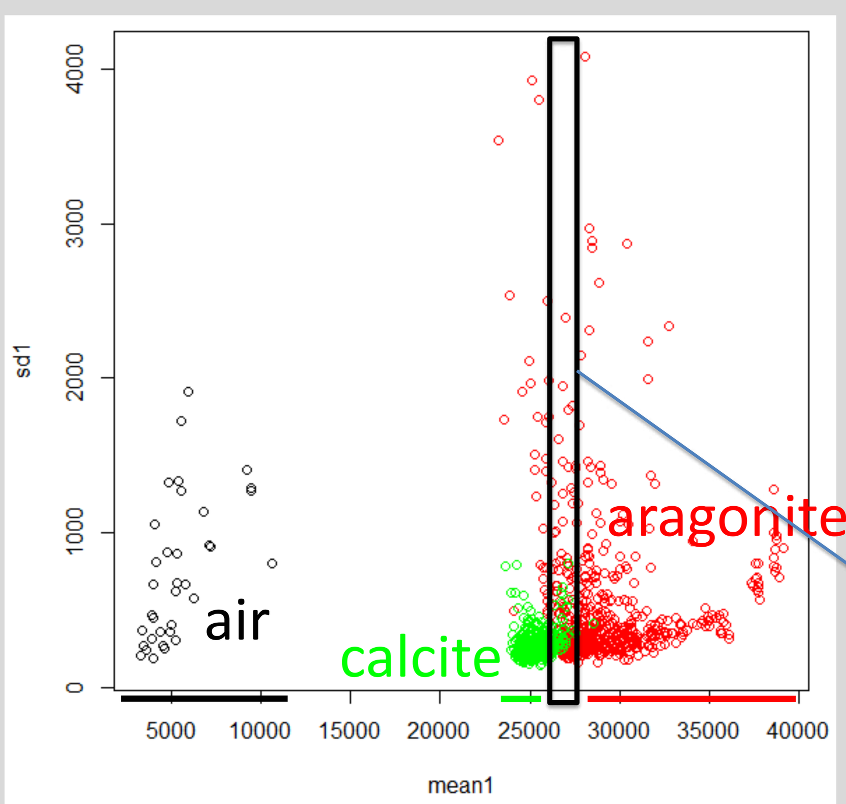
2. Calculation of mean radiodensity variability thoughout each segmented reference material and surrounding air



Automated multiple calculations of mean radiodensity* were carried out for defined volumes with regular intervals (e.g. volume of 25x25x25 voxel step size 50 µm) for aragonite, calcite and air

*Script for automated multiple mean values calculation developed by S. Krause, K. Engelkes, S. Büsse

3. Definition of min-max intensity values for each material



Plot of mean values vs SD of radiodensity for each reference material and air to identify reliable min-max radiodensity boundaries

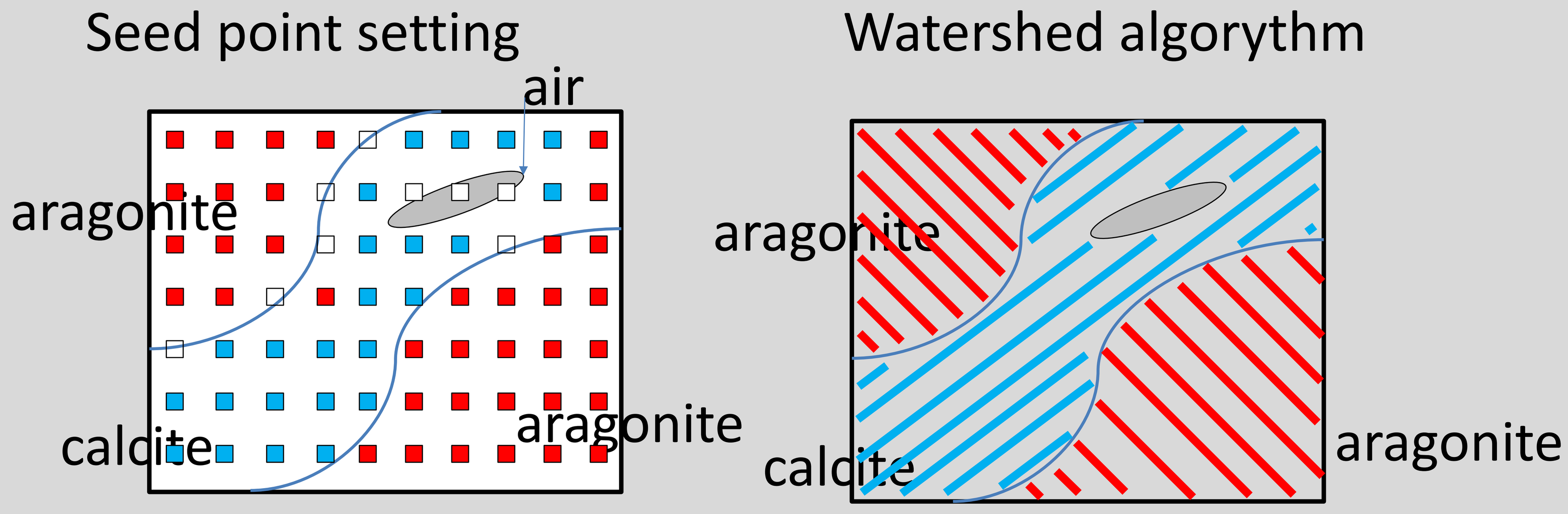
Due to material heterogeneity and scan settings approx. 10% of overlapping mean radiodensity of aragonite and calcite in this sample

Real-life problems using CT

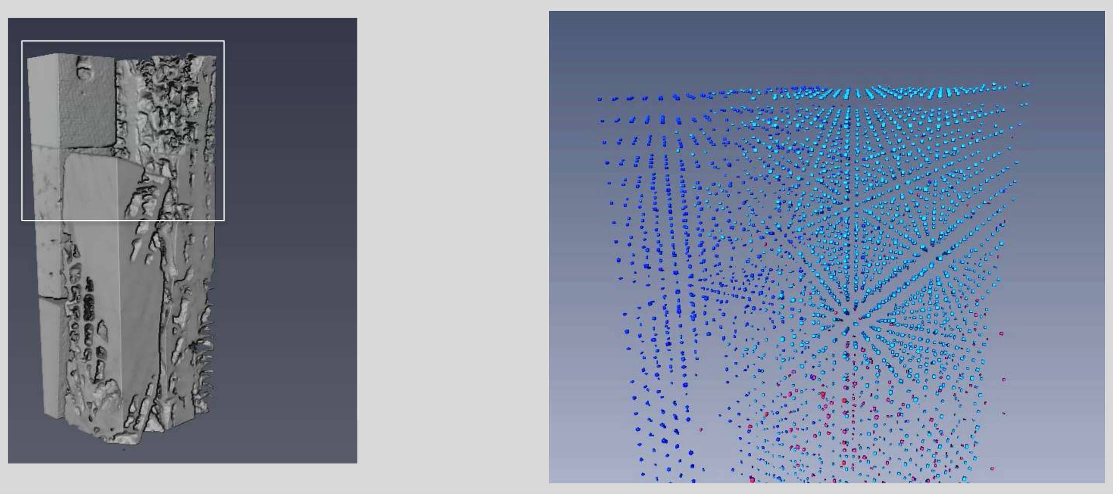
A reproducible, straight-forward mineral identification and quantification is hampered by the natural mineral heterogeneity and individual X-ray source aging of signal-to-noise ratio of CT-scanners.

4. Seed point setting and watershed algorythm

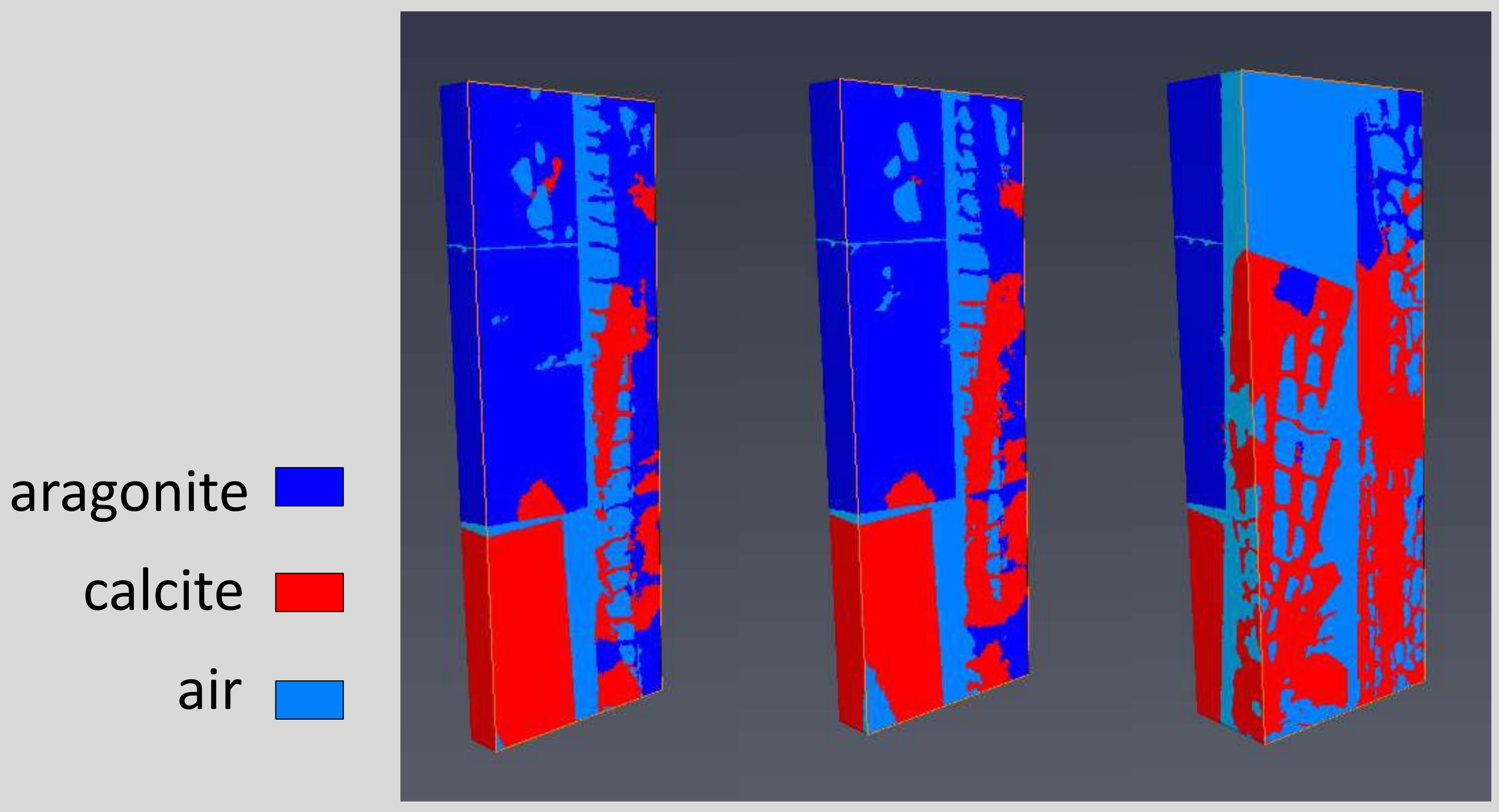
Small volumes (e.g. 25x25x25voxel) of the entire sample are probed for their mean radiodensity value. In case it falls within the definition for a pre-defined mineral, a seed point for it is set. Subsequently, seed points are propagated with the watersheld algorithm.



Example of seed point setting in the sample



Final mineral reconstruction of the sample



approx. 10% of aragonite in the reference material was classified false positive as calcite, no false positive calcite classification of refernce material

Achievements

- **Robust non-destructive reconstructio of multi mineral phases , suitable for sample pre-investigation**

Current limitations

- **Approx. 10% of ragonite is not correctly assiged**