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Quantification of diagenetic overprint processes deduced from fossil carbonate shells and laboratory-based hydrothermal alteration experiments

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Benthic and nektonic marine biogenic carbonate archives represent the foundation of numerous studies aiming at reconstructions of past climate dynamics and environmental change. However, living organisms are not in thermodynamic equilibrium and create local chemical environments where physiologic processes such as biomineralization takes place. After the death of the organism the former physiologic disequilibrium conditions are not sustained any more and all biological tissues are altered by equilibration according to the surrounding environment: diagenesis. With increasing diagenetic alteration, the biogenic structure and fingerprint fades away and is replaced by inorganic features. Thus, recrystallization of organism-specific microstructure is a clear indicator for diagenetic overprint. Microstructural data, which mirror recrystallization, are of great value for interpreting geochemical proxies for paleo-environment reconstruction.
Despite more than a century of research dealing with carbonate diagenesis, many of the controlling processes and factors are only understood in a qualitative manner. One of the main issues is that diagenetically altered carbonates are usually present as the product of a complex preceding diagenetic pathway with an unknown number of intermediate steps. In this contribution we present and discuss laboratory based alteration experiments with the aim to investigate time-series data sets in a controlled manner. We conducted hydrothermal alteration experiments with modern Arctica islandica (bivalvia) and Notosaria nigricans (brachiopoda) in order to mimic diagenetic overprint. We explore first the potential of electron backscattered diffraction (EBSD) measurements together with statistical data evaluation as a tool to quantify diagenetic alteration of carbonate skeletons. Subsequently, we compare microstructural patterns obtained from experimentally altered shell material with those of fossil specimens that have undergone variable degrees of diagenetic overprint. We intend to come up with a process-oriented understanding of alteration parameters and products as the change in microstructure, texture and mineral phase needs a careful action when it comes to the interpretation of paleoclimate reconstruction data.