Ca isotopic constraints on marine carbonate recrystallization rates: Implications for geochemical proxies

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Quantifying carbonate recrystallization rates in marine sedimentary systems is a critical part of the process of applying and interpreting geochemical proxies. Post-depositional processes can alter proxy-based interpretations, in some cases creating considerable interpretive disagreement that confuses our understanding of how the Earth functions. Thus, accurately quantifying rates, and understanding the extent to which assumptions impact such quantification, is necessary to interpret proxy records, especially when comparing records from different sites.

The current study interprets recently published pore fluid Ca isotope (δ^{44}Ca) data from ODP Sites 984, 807A, 1170A, and 1171A using a new analytical solution to the diagenetic equation. The aim of the study is to use the steady state analytical model to evaluate the importance of parameters such as external advection, porosity, temperature, and burial rate on rate quantification and extent of reaction over 1 Ma time scales. Burial rate, which is shown to be important from a mathematical perspective, is often poorly resolved with conventional numerical approaches. In addition, our approach using an analytical solution to the diagenetic equation allows for a rapid exploration of parameter space, which is also difficult to do using time-intensive forward models.

Using this approach, we constrain bulk carbonate recrystallization rates at the silicilastic site (984) to be on the order of 1 to 3% Ma^{-1} over the first 1 Ma; extents of recrystallization at 984 vary from 1 to 4%, primarily depending on burial rate. This rate is ~20 times faster than rates inferred previously using finite difference approaches. By contrast, recrystallization at carbonate-rich sites can be as high as 20 to 40% Ma^{-1}, with integrated reaction over 1 Ma as high as 25%. The consistency of these rates across disparate depositional environments suggest that Ca isotopes generally demonstrate rapid recrystallization of carbonate over 1 Ma time scales. Finally, we use a box model approach to demonstrate the impact of diagenetic recrystallization, at those depth-dependent rates constrained using Ca isotopes, on the interpretation of δ^{18}O-based paleotemperatures.