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Diagenesis in foraminifera and its effect on geochemical proxies

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Oxygen isotope and trace metal compositions of foraminiferal tests are important geochemical proxies for reconstructing palaeo-ocean environments, e.g., temperature and global ice volume[1]. Once buried in sediment, foraminiferal calcite tests may experience various diagenetic processes, which include partial dissolution, inorganic calcite precipitation, and recrystallisation. Dissolution is known to increase planktic foraminiferal δ18O values and decrease trace metal concentrations[2] while inorganic cement on chamber walls may increase both $\delta^{18}O$ and Mg/Ca[3]. As recrystallisation increases low-latitude planktic foraminiferal $\delta^{18}O$ values, biasing reconstructions to colder temperatures, only those from clay-rich hemipelagic sediments that display no signs of recrystallisation under SEM are considered to retain entirely 'original' signals[4]. The impact of recrystallisation on benthic foraminiferal $\delta^{18}O$ values is likely less severe but perhaps still significant[5,6]. The impacts of recrystallisation on both planktic and benthic foraminiferal trace metal geochemistry are poorly constrained.

To assess the impacts of diagenesis on planktic and benthic foraminiferal $\delta^{18}O$ and trace metal geochemistry, we generated a suite of time-series (0-12 Ma) foraminiferal geochemical and textural data from ODP Site 925, and a single time-slice (early Oligocene) from ODP sites 925, 1219 and IODP Site U1331. SEM and EPMA images are used to show the microstructural alteration and evaluate the preservation of primary high-Mg/Ca bands within the foraminiferal tests respectively. We find that even small amounts of clay in the sediment are surprisingly effective at limiting recrystallisation, and benthic foraminifera appear to retain original microstructure better than planktic foraminifera, perhaps as a result of their chemical composition / crystallography. Overall, our results support the suggestion that recrystallisation occurs in relatively closed system conditions[7], and suggest that the presence of well-defined Mg bands in test calcite may provide a means of unlocking previously discredited Mg/Ca sea surface temperature records.

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[7] Staudigel et al. (2022), Geology 50, 760-764.

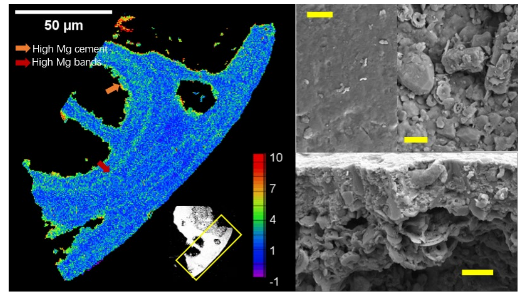

Figure 1: Benthic foraminifera *O. umbonatus* from ODP Site 925 (clay-rich site), with burial depth of 709 mcd and age of 30.5 Ma. Left Panel - EPMA map (Mg/Ca ratio, mmol/mol) Right Panel - SEM images (exterior surface, interior surface, cross-section test wall). Yellow bar represents 5 µm)

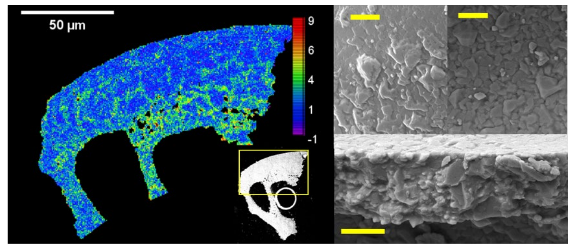

Figure 2: Benthic foraminifera *O. umbonatus* from ODP Site U1331 (clay-poor site), with burial depth of 16.49 mcd and age of 30.7 Ma. Left Panel - EPMA map (Mg/Ca ratio, mmol/mol) Right Panel - SEM images (exterior surface, interior surface, cross-section test wall). Yellow bar represents 5 µm).