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The Mg isotope composition of foraminifers: a new proxy for palaeoseawater composition

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The application of Mg/Ca (magnesium/calcium) ratios in foraminifera test calcite as a proxy for seawater palaeotemperature is prevalent within the palaeoclimate community. However, the process by which foraminifera incorporate Mg into their test is still relatively unknown. In order to better understand this process, we measured Mg isotope values within the foraminiferal calcite to determine the amount of isotopic fractionation during biomineralisation. Previous studies have shown a reduction in Mg/Ca concentrations of a factor of 1000 and the Mg isotopic ratio of approximately 4‰ from that of present day seawater (δ^{26}Mg -0.88 $\pm$0.05‰ (Mg isotope composition)). The offset in δ^{26}Mg does not obey the thermodynamic rules associated with the precipitation of inorganic calcite and is variable amongst different species. These species specific offsets have been observed in planktic and benthic foraminifera and are thought to originate from the processes involved in the incorporation of Mg from seawater into the test. Therefore, the identification of the magnitude of these vital effects would enable the calibration of data to produce a corrected Mg isotope seawater curve. Magnesium is a fundamental element of the carbon cycle and fractionates proportionally to temperature, meaning that it is important to understand its behaviour over time. Fluctuations in ocean seawater chemistry during the Cenozoic are considered to be the result of changing surface processes. Thus, the establishment of magnesium isotopes within foraminifera as a reliable proxy for seawater composition and surface processes has been an area of intense interest in recent years

Here, we present Mg isotope and Mg/Ca evidence from planktic foraminifera for the past 40 Ma, calibrated for species specific vital effects using modern species to normalise the values to present day seawater. The modern samples show similar finding to previous studies, with all samples deviating from modern day seawater values. This deviation in isotopic fractionation was applied to ancient samples for the last 40 Ma, to calibrate for species specific vital effects. The new record shows significant increase in δ^{26}Mg from 16-25 Ma to values similar to those observed in silicate rocks, suggesting the weathered minerals have already undergone fractionation prior to deposition and uplift onto the continents. An increase in fractionation from 40 Ma to present, suggests a shift in $CaCO_3$ deposition from shallow waters to deeper water environments, causing significant decrease in dolomitisation, consequently changing the δ^{26}Mg of seawater. We show that careful application of species specific calibrations can be used to remove vital effect from a dataset to produce an accurate sea surface temperature and Mg isotope curve to reconstruct seawater composition and surface processes.