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Response of pteropods and foraminifera to changing pCO2 and pH: Examples from the Mediterranean Sea

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The seas around the island of Ischia (Italy) have a variable and, on average, lowered pH as a result of volcanic gas vents that emit carbon dioxide from the sea floor at ambient seawater temperatures. These areas of acidified seawater provide natural laboratories in which to study the long-term biological response to rising CO2 levels. Benthic foraminifera are routinely used to interpret the effects of climate change as they have short life histories, are environmentally sensitive and have an excellent fossil record. Here, we examined changes in foraminiferal assemblages along gradients in pH at CO2 vents on the coast of Ischia as they may provide a useful model on which to base future predictions of the consequences of ocean acidification. We show that foraminiferal abundance, diversity and ability to calcify decreased markedly in living and dead assemblages as pH decreases, the result of CO2 percolating through the seawater. These results are in accord with the responses recorded by coralline algae, corals, molluscs, barnacles and echinoderms at the same sites.

Samples from the normal (pH 8.17) environments around Ischia contain a diverse fauna dominated by miliolid foraminifera (e.g., Peneroplis planatus, P. pertusus, Quinqueloculina spp.) while those from areas with reduced pH (7.8 to 7.6) have faunas that are progressively less diverse and composed of <100% agglutinated taxa (e.g., Ammoglobigerina globigeriniformis, Miliammina fusca, Trochammina inflata, Textularia sp. cf. T. bocki). The changes in the benthic foraminifera are quite dramatic and confirm the possibility that events, such as the PETM, could quite easily record a widespread loss of diversity or extinction as a result of ocean acidification.

Over the last 250,000 years the diversity and quality of preservation of pteropods (holoplanktic gastropods) has fluctuated in response to glacial/interglacial cycles. This is almost certainly related to the change in oceanic pH as the best preservation is recorded in glacial cycles when pCO2 was lower than during interglacials. Detailed studies of the pteropods assemblages from marine cores taken near Montserrat (Caribbean Sea) have provided a high resolution database with which to make comparisons world-wide. There are peaks of diversity (and excellent preservation) in Marine Isotope Stages 2 and 6 and these can be found elsewhere in the Gulf of Mexico, Indian Ocean and the South China Sea. Using a "Limacina Dissolution Index" (LDX) it can be seen that this parallels the changing pCO2 (and pH).

Two cores from the Western Mediterranean Sea are being investigated in order to provide the validity of the LDX approach used successfully in the Caribbean Sea. Core B5 – 1, collected south of Mallorca is 494 cm long and may extend back to MIS 6. Preservation of pteropods in MIS 5 is poor to very poor and this would confirm the results from the CAR-MON 2 core in the Caribbean Sea. Core B5 – 1 from the Mediterranean Sea, therefore, contains a record of changes in global pCO2 and fluctuations in oceanic pH as well as a complete record of changes in the pteropod assemblage through time.