Geochemical Tracing of Human Impacts on Coral Reefs

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Coral reefs are under threat from both direct human impacts such as high nutrient loads from erosion of soils and fertilizers as well as from climatic stresses such as cyclones and unusually warm ocean temperatures. In 1997-98, exceptionally warm global sea surface temperatures caused widespread. The effects were compounded by the inability of many coral reefs to regenerate due to algal blooms from high levels of nutrients. As a consequence coral cover has decreased globally by ~30% during the past several decades and in some places such as the Caribbean by up to 90%. The dilemma is that by the time clear-cut evidence is found for ecological impacts, a largely irreversible ‘phase shift’ and large-scale degradation of the reef has occurred. For this reason long-term quantitative records of environmental change are required to decipher man-made impacts from natural variability.

Based on the relatively new technique of high resolution (weekly to fortnightly) laser ablation ICP-MS, continuous scans of the trace element compositions were undertaken on 300-400 year old carbonate coral cores (growth rate of ~1-2 cm per year) from the Great Barrier Reef (GBR) of Australia. During high intensity rainfall events, there are massive discharges of freshwater and suspended sediments into the GBR lagoon. A longstanding and still highly controversial question is how has the water quality changed within the GBR lagoon since European settlement? Ba/Ca ratios in corals, a tracer of suspended sediment load, reveals two distinctive patterns. During the 1770’s when Captain Cook first explored the east coast of Australia, there is only limited evidence for flood-plume related suspended sediment fluxes entering the inner GBR. However, immediately following European settlement in 1870, there is a sustained increase in the Ba/Ca ratios during flood events. This is indicative of a significant increase in suspended load being delivered to the inner GBR, coincident with the first grazing activities by European settlers in the river catchments of the GBR. These results therefore provide unequivocal evidence for substantially increased fluxes (x4 to x8) of suspended sediment and hence nutrient fluxes to the inner GBR reef. Sediment fluxes are modulated by land-use intensity and climate, principally droughts. Following the drought of 1968/69, the suspended sediment load increased x3 during the subsequent 1970 flood, presumably due to enhanced erosion of the highly denuded catchments.

This study provides both a ‘natural’ pre-European baseline as well as a quantitative measure of anthropogenic fluxes against which reduction of sediment loads to the GBR can be targeted. This is essential if coral reefs are to survive the lethal combination of direct anthropogenic impacts and rapid climate change.

Experimental determination of near-solidus peridotite trace partition coefficients

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Mid-ocean ridge basalts (MORBs) represent the accumulation of polybaric fractional melts produced by decompression melting of mantle peridotite as it ascends along an adiabat. Incremental removal of melt enriched in Na, Fe, and Ca during ascent alters the bulk composition of the peridotite, and the resultant change in phase chemistry together with decreasing pressure and temperature, has a profound effect on trace element partition coefficients (Ds). The trace element partitioning behaviour of certain elements in a fertile spinel- or garnet-bearing peridotite are significantly different from those for a refractory peridotite at the top of the melting column. In order to evaluate the effect of continual melt removal on Ds we have performed near-solidus partitioning experiments for 20 trace element at 1500°C, 3.0 GPa on the fertile MORB-pyrolite solidus, and at 1315°C, 1.5 GPa on the refractory Tinaquillo Lherzolite solidus. Garnet lherzolite melting at 3.0 GPa produces melts that are depleted in HREEs relative to LREEs, HFSEs relative to REEs, and U relative to Th. Melts with significantly high Ce/Y and Li/Yb and low Zr/Sm ratios are characteristic of the presence of garnet in the MORB source. At 2.8 GPa garnet is lost from the MORB pyrolite source (Robinson & Wood, 1998) and clinopyroxene becomes the principle trace element-bearing phase in the residue. The resultant melts from spinel peridotite become enriched in HFSEs over REEs, and less depleted in HREEs relative to LREEs. As pressure decreases towards the top of the melting column, REEs become increasingly compatible in clinopyroxene. Our models demonstrate that the majority of a melt’s trace element budget is added at the base of the melting column. The composition of fresh MORB glasses form the Mid-Atlantic Ridge show that where melting begins in the garnet facies, this ‘deep’ trace element signature endures shallow level mixing and plagioclase fractionation.

References

Robinson JAC & Wood BJ, (1998). *EPSL*, **164**, 277-284.