Cell enumeration in extremely nutrient-poor sediments

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This expedition explored extraordinarily slowly accumulated sediments of the South Pacific mid-ocean gyre, farther from continents and productive oceanic zones than any other site on Earth. It provided an opportunity to study the nature of life in the most oxidized and food-limited sediments of Earth's ocean. These sediments are relatively rich in cosmic debris and a direct terrestrial analogue for slowly accumulating energy-poor sedimentary environments on other planetary bodies (e.g. wet subsurface sediments of Mars).

So far most cell enumerations have been carried out in shelf sediments which contain variable but significant amounts of organic matter. Such sediments usually have cell abundances that range from 10^9 to 10^{10} cells cm^{-3} at the surface and decrease with depth to about 10^5 cm^{-3} around 100 to 1000 mbsf. The sediments retrieved during this cruise have much less organic matter and also lower cell numbers. Due to the low cell abundances, ranging from $10^6 cm^{-3}$ at the surface to 10^3 cm^{-3} at 10 mbsf, it is necessary to extract the cells from the sediment and concentrate them prior to counting, using novel technique (KALLMEYER, subm.). The sediment is treated with a mixture of different detergents, solvents and complexing agents, followed by separating the cells from the sediment particles by density centrifugation. The cell extracts are then filtered and stained with SYBR Green I®, a highly dsDNA specific stain.

The cell counts show that there is a microbial community in these sediments despite the fact that there is basically no organic matter available. The cell abundances are the lowest ever encountered in the marine environment. These very low cell counts imply that current estimates of subseafloor biomass are far too high, because the abundance of cells in this extensive habitat is approximately three orders of magnitude lower than current estimates of average cell concentrations in subseafloor sediments.

Establishing high precision trace element maps of the main dust source areas of eastern and south-central Australia

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Continental-scale geochemical mapping relies on precise and accurate chemical analyses of surface samples. Eggins *et al*. (1997) demonstrated that appropriate analytical protocols can yield high precision (typically better than 1-2% rsd) and accurate trace element data for >40 elements by inductively-coupled-plasma mass spectrometry (ICP-MS).

Here we present such a high-precision geochemical dataset (40 trace elements) for the source areas of dust that is transported across the Eastern Australian seaboard. These source areas (river floodplains, palaeo-lakebeds, dunes, playas) have generally similar relative trace element abundances, typical of upper continental crust. However, the new ICP-MS data document geochemical provinces on the sub-catchment scale. The geochemical provinciality is largely inherited from the main erosion source lithologies and translates into provenance resolution of ca. 50 x 50 km.

When modern far-travelled (up to 4,000 km) mineral dust of known provenance (from ground observation) is compared to the surface geochemical map, we find excellent agreement with the source area for many elements (McGowan *et al*., 2005). Mismatching elements are those affected by: (i) density sorting (Zr, Hf, HREE); (ii) reprecipitation (Be, Sr) and (iii) air pollution (first and second order transition metals, Tl and Pb). Comparison of ^{210}Pb activity between known source areas from the geochemical map and far-travelled dust demonstrates clearly that the enrichment in metals like Pb, Zn and Cu happens during atmospheric transport through the coastal East Australian pollutant plumes (Marx *et al.*, 2005).

For the purpose of dust provenancing, for which Zr, Hf and HREE are unsuitable, it is sufficient to digest surface sediments in closed beakers at 130°C. However, we also demonstrate that only high-P digestion at 200°C yields complete sets of accurate data for all elements. This factor will severely increase the effort and cost of any rigorous surface geochemical mapping project.

Reference

Eggins *et al*. (1997), *Chem. Geol.* **134**, 311-326.
McGowan *et al.* (2005), *Geomorphology* **69**, 208-211.
Marx *et al*. (2005), *Earth Planet. Sci. Lett.* **239**, 336-351.