# Functionally diverse chemosynthetic bacteria in hydrothermal sediment, Santorini, Greece: Geochemical implications

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A chemosynthetic microbial community displaying diverse respiratory processes was identified within iron- and arsenic-rich shallow marine sediment (20-40°C, pH 6.0-6.3) from an area of active hydrothermalism in Santorini, Greece. Marine hydrothermal sediments are host to abundant microbial life that exploits the steep geochemical gradients generated by the confluence of reduced metal-rich fluids and oxidised seawater. However, there is relatively little information on the functional range of prokaryotes in these settings, and their impact on geochemical cycling. Microbial functional diversity in the Santorini sediment was determined by enrichment culturing (from the suboxic to anoxic transition zone, Eh 0 to -138 mV), coupled with phylogenetic molecular techniques. Enrichment cultures were successfully obtained for: (1) Fe(III), $NO_3^-$, $SO_4^{2-}$, and As(V) reducers (with acetate and lactate); (2) anaerobic and microaerophilic Fe(II) oxidisers; and (3) $Na_2S$ and As(III) oxidisers. Most-probable number (MPN) counts for these functional groups ranged from 7.50 x $10^7$ to 2.30 x $10^2$ cells $ml^{-1}$, with relative abundances decreasing as follows: $NO_3^-$, As(V) and Fe(III) reducers; $Na_2S$ and FeS oxidisers; $SO_4^{2-}$ reducers; and As(III) and anaerobic Fe(II) oxidisers. 16S rRNA and specific functional gene analyses, utilising the clone library method, revealed a phylogenetically diverse range of enriched bacteria, including a number of novel organisms, and also sequences with close affinity for bacteria known to occur in deep-sea hydrothermal vent sediments (e.g. *Shewanella* sp., *Thiomicrospira* sp., *Desulfovibrio* spp., and *Marinobacter* spp.). Phylogenetic bacterial and archaeal sediment communities were dominated by δ-Proteobacteria, Chloroflexi, Bacteroidetes, Chlorobi, and Crenarchaeota. Dominant bacteria displayed closest affinities to known iron and sulphur respirers. In particular, community analyses of the oxidised orange surface sediment (Eh 0) were found to be dominated by an enriched anaerobic, nitrate-dependant Fe(II) oxidiser. Overall, results demonstrate the potential for bacteria to respire inorganic substrates important within the Santorini sediment, namely forms of iron, arsenic, sulphur and nitrogen. Moreover, solid-phase and pore water geochemical data allow correlation between the microbial community structure and the sequence of down-core biogeochemical (redox) zonation.

# Behaviour of PGEs in sills from the Jurassic Ferrar Large Igneous Province, Antarctica

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The Jurassic Ferrar Large Igneous Province, exposed in a > 3000 km long belt along the margin of the East Antarctic craton, comprises numerous sills, dikes and lava flows as well as the layered mafic Dufek intrusion. Uniform crust-like trace element and isotope data indicate a single magma source within the subcontinental lithospheric mantle characterised by crustal enrichment due to Palaeozoic subduction along the Panthallasia margin of Gondwana. However, the thermal source for the voluminous melt generation is still under debate as the crust-like isotope signatures obscure the detection of a possible mantle plume involvement.

In addition to mineral and bulk-rock chemical data for basaltic andesites and andesites from sills in northern Victoria-land, a subset of 23 samples has so far been analysed for platinum-group elements (PGE) to further describe the genesis of the Ferrar magmatic rocks. The abundances of Ir, Ru, Rh, Pt and Pd were determined by ICP-MS using isotope dilution (except Rh) after sample preparation by NiS-fire assay at the University of Karlsruhe, Germany.

The studied rocks exhibit the common phase assemblage of tholeiitic differentiation sequences composed of varying amounts of pyroxenes, plagioclase, oxides and mesostasis. Most of the wide compositional variations (2-13 wt% MgO) are attributed to low-pressure differentiation after magma intrusion at upper-crustal levels. Compositional differences between rocks that are not affected by in-situ differentiation are ascribed to distinct conditions during pre-emplacement differentiation assuming an identical primary magma.

The PGE totals range from ~ 4 to 40 ppb. The single element abundances exhibit good correlations with the MgO contents of the distinctly evolved samples and are thus interpreted to result mainly from in-situ differentiation as well. While the IPGE (Ir, Ru) are highly compatible during differentiation of the Ferrar magmas, the PPGE (Rh, Pt, Pd) show bimodal variations. They decrease in cumulates, but either increase or decrease in differentiates. The distinct PGE fractionation behaviour results in strongly fractionated primitive mantle-normalised patterns for all analysed samples with considerable enrichment of the PPGE over the IPGE.

Compared to tholeiitic rocks from other magmatic provinces, only the Ferrar rocks exhibit coupled enrichment of Pd, Pt and Cu even in most evolved samples. The decrease of Pt and Pd in some of the more evolved samples does not necessarily signify sulphide fractionation, but may indicate the formation of other PGE-compounds. The inferred sulphur-undersaturated conditions during pre- and post-emplacement differentiation processes are in agreement with the elevated melting degrees as well as the refractory nature of the proposed subcontinental lithospheric mantle source.