The structure and topology of cytochromes involved in outer membrane electron transport

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Characterisation of Outer Membrane Cytochromes.

Extracellular mineral respiration is dependent on the correct expressionof an outer membrane porin-cytochrome complex, where a large transmembrane porin mediates direct electron transfer between a small decaheme periplasmic cytochrome and an extracellular decaheme cytochromeon the cell surface. [1] Over 30 % of the *Shewanella oneidensis* surface is covered with these outer membrane cytochromes and it has been shown that there are multiple members of the outer membrane cytochrome family are capable of interacting with a broad range of mineral oxides [2,3].

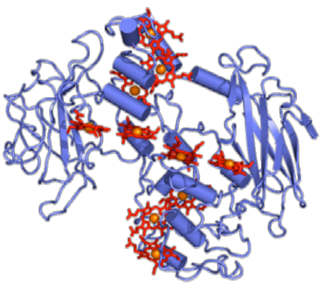

Figure 1: Structure of MtrF, a decaheme outer membrane cytochrome involved in mediating electron transport between *S. oneidensis* and extracellular mineral.

We have resolved the crystal struture of one of these outer membrane cytochrome, shown in figure 1, and this has revealed that these proteins comprise a c-type cytochrome core flanked by two β-barrel domains [4]. This structure provides a base for understanding how these systems interact with both the outer membrane and the extracellular enviroment.

[1] Hartshorne *et al*. (2009) *P.N.A.S.* **106**, 22169-74 [2] Lower *et al*. (2007) *Appl. Env. Microbiol*. **75,** 2931-2935 [3] Shi *et al*. (2009) *Env. Microbiol. Reports* **1,** 220-7. [4] Clarke *et al*. (2011) *P.N.A.S. Accepted for publication*.

Plate- versus plume-driven processes – South Atlantic DUPAL revisited

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The DUPAL anomaly in the South Atlantic is present in intra-plate volcanism associated with the Tristan-Gough, Discovery and Shona plumes, and along adjacent sections of the southern Mid-Atlantic Ridge. Its origin has been variably attributed to either plate-driven processes introducing continental material into the shallow mantle, or plume-driven processes sampling sources in the lower mantle, which cannot be distinguished based on geochemical arguments alone. Here we present an integration of geochemical arguments and dynamic considerations and test the following hypotheses:

(1) South American origin – Previous geochemical evidence suggests that the DUPAL originates from the South American sub-continental lithospheric mantle (SCLM), possibly thermally eroded by the Tristan plume head. However, our mass balance calculation shows that an unrealistic volume of SCLM would be needed for the contamination of thousands of cubic km of upper mantle in a direction unsupported by any obvious mantle flow regime.

(2) South African origin - A mantle flow field induced by the African Superplume has been inferred previously from seismic anisostropy, suggesting mantle flow from beneath Africa and possible contamination of the S Atlantic upper mantle with African plate material. However: (i) off-craton SCLM and lower crustal samples provide no evidence in support of thermally eroded or tectonically detached African plate material being the origin of the S Atlantic DUPAL anomaly [1]. (ii) Erosion of the base of the Kaapvaal craton by the Superplume-related mantle flow is not supported by available constraints on the composition of the Kaapvaal SCLM [1]. In addition, volcanism from upper mantle melting anomalies at Vema and 7 degree Seamount do not support an overall contamination of the S Atlantic shallow mantle [1].

(3) Deep origin – A deep, plume-related origin of the S Atlantic DUPAL is supported by the spatial extent of the anomaly in S Atlantic MORB adjacent to DUPAL plumes. Mixing systematics are consistent with the different plumes showing plume-ridge interaction as a function of distance to the ridge. Extreme isotopic heterogeneity of the S Atlantic DUPAL source is indicated from plume trail samples of the DUPAL plumes. Similarities and differences to Indian and Pacific Ocean DUPAL anomalies are explored.

[1] Class & le Roex (2011) *EPSL* **305**, 92-102.