Some constraints on the redox budget of subduction zones

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A number of lines of evidence suggest that the sub-arc mantle is 1-2 log units more oxidised than mantle elsewhere, though this conclusion is controversial, and the processes that may contribute to sub-arc mantle oxidation are poorly understood.

A simple analytical model was used to constrain the evolution of sub-arc mantle oxidation state as a function of redox-budget fluxes into, and out of, subduction zones. The model shows that plausible Archean and Proterozoic redox budget fluxes would not have created oxidised sub-arc mantle. Phanerozoic redox budget fluxes, on the other hand, which are dominated by the sulfate component, could increase sub-arc fO_2 by up to three $\log_{10}$ units. The paucity of Cu and Au deposits associated with oxidised magmas in the Precambrian may be explained as a consequence of a lack of subducted oxidised material, rather than simply as a consequence of preservation potential. The redox budget of arc lavas is related to arc characteristics; samples from seven arcs show a significant correlation ($P < 0.0005$) between redox budget, subduction zone convergence rate, and subduction zone age.

Sulfate may be present in altered ocean crust in significant quantities, and even the most conservative model calculations suggest that sulfate is likely to dominate Phanerozoic subduction zone redox budget inputs. However, little is known of the relative stability or solubility of sulfur-bearing phases under subduction conditions, so large uncertainties are associated with absolute fluxes.

Sulfur isotopes provide one way to investigate sulfur sources, and the processes that affect sulfur during subduction. In-situ sulfur isotope measurements of pyrite associated with high pressure mineral parageneses in high pressure mafic rocks from the Eastern Alps and from New Caledonia were performed. The New Caledonia samples contain pyrite with $\delta^{34}S$ in excess of 5‰, while samples from Pfulwe pass in the Eastern Alps contain pyrite with $\delta^{34}S$ up to 15‰. These elevated $\delta^{34}S$ values suggest that sulfur ultimately derived from seawater is preserved in these rocks to depths greater than 60km.

Brief Bio

Katy completed a Ph.D on "Metamorphic Fluid Flow in East Central Vermont" at Cambridge University in 1999. This was followed by postdoctoral work at the University of Sheffield (UK) on kinetically-controlled mineral dissolution and precipitation in the unsaturated zone of mine spoil. She moved to Australia in 2002 to take up a position as a Research Fellow at CSIRO Exploration and Mining, where she worked on greenstone-hosted gold deposits and the thermodynamic characteristics of sulphur-bearing, high ionic strength, mixed solvent fluids. In 2005 she was awarded an Australian Synchrotron Research Fellowship, hosted by the ANU, and used this time to undertake experiments on S- and Cl-bearing silicate glasses and CO_2-bearing solutions. She began a Research and Teaching Fellowship at Curtin in 2007, and was awarded an ARC Future Fellowship in 2012 to work on the redox budget of subduction zones.