The nature of orogenic lithospheric mantle: constraints from geochemistry of postcollisional mafic-ultramafic rocks in the Dabie orogen

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Oceanic and continental arc volcanic rocks are a window into crust-mantle interaction in oceanic subduction zones, with involvement of the asthenospheric mantle. They are assumed to originate from partial melting of altered peridotite in the overlying mantle wedge, with trace element geochemical signature inherited from aqueous fluids released from subducting oceanic crust. While this process-product link has been a common percept in geochemistry, it is intriguing whether there is the similar relationship in continental subduction zones. Ultrahigh-pressure (UHP) metamorphic rocks are a typical product of continental deep subduction to mantle depths, but arc magmatism is absent above continental subduction zones. While the subducted continental crust can be reworked as postcollisional granitoids, it is unclear whether the overlying subcontinental lithospheric mantle (SCLM) was involved in postcollisional mafic magmatism.

Postcollisional mafic-ultramafic rocks from the Dabie orogen were studied for their zircon U-Pb ages and Lu-Hf isotopes, whole-rock major-trace elements and Sr-Nd-Pb isotopes as well as whole-rock and mineral O isotopes. The results provide insights into the nature of orogenic lithospheric mantle in the continental collisional orogen. The zircon U-Pb dating gave consistent ages of 125 ± 3 to 129 ± 1 Ma for magma crystallization. Few residual zircon cores have U-Pb ages of 234 ± 5 Ma and 739 ± 9 Ma, respectively, in agreement with tectonothermal events for UHP metamorphism and protolith formation in the Dabie orogen. The mafic-ultramafic rocks have high contents of MgO (up to 18.0 wt.%), Cr (up to 1546 ppm) and Ni (up to 349 ppm), but low contents of SiO_2 (41.0-51.9 wt.%), and show the arc-like patterns of trace elements distribution and the enriched signature of Sr-Nd-Pb-Hf isotopes. These geochemical features indicate their derivation from partial melting of the orogenic lithospheric mantle that is fertile in lithochemistry and enriched not only in LILE and LREE but also in radiogenic isotopes. The orogenic lithospheric mantle is suggested to be generated by metasomatic reaction of the overlying SCLM-wedge peridotite with hydrous felsic melts derived from the subducted continental crust during the Triassic continental collision, with the enriched signatures imparted by the felsic melts. In this regard, the crust-mantle interaction is implicated during the continental deep subduction, with the postcollisional mafic-ultramafic rocks as its derivatives. On the other hand, significant differences in elemental and isotopic compositions between different mafic-ultramafic intrusions suggest that the orogenic lithospheric mantle is geochemically heterogeneous, with the possible presence of hornblende-rich and pyroxene-rich lithologies in mantle sources. This difference is attributed to differences in the compositions of subducted crustal-derived melts with a tectonic affinity to the South China Block, but the same SCLM wedge of the North China Block was involved in the crustal metasomatism. Therefore, the compositional variations in the orogenic lithospheric mantle are recorded by the geochemical compositions of postcollisional mafic-ultramafic intrusions.

A spatially-structured model for Proterozoic ocean biogeochemistry

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The picture for Proterozoic ocean biogeochemistry from marine proxy data and simple box models has been of an anoxic and ferruginous ocean prior to 1.85 Ga, with a switch to either oxic or euxinic conditions then responsible for removing iron from the deep ocean and halting Banded Iron Formations ~1.85 Ga [1]. However, recently-gathered geochemical data from what remains of the Proterozoic ocean margins reveal a more complex picture with some euxinic intervals prior to 1.85 Ga, and a largely ferruginous ocean with only some sulphidic intervals and/or sulphidic waters at intermediate depths post-1.85 Ga [2],[3].

Here we use a spatially-structured biogeochemical model GENIE to propose a scenario consistent with proxy data, and also consistent with constraints from both oxygen demand and ventilation, and ocean mixing and Fe, S residence timescales. A robust feature of scenarios that avoid global euxinia is a vertical redox gradient from an oxygenic mixed layer, through euxinic mid-depths in shelf or upwelling regions, to a suboxic deep ocean. A suboxic (rather than fully anoxic and ferruginous) deep ocean is consistent with evidence from hematitic cherts [4]. This model makes two testable predictions: (i) that the "ferruginous" water column state inferred from iron-speciation proxy data arises from iron transport in a marginally suboxic or anoxic region underlying euxinic region, and (ii) that feedback processes must exist to balance the deep ocean on the edge of anoxia.

Nitrogen cycling in the mixed aerobic/anaerobic surface/mid-depth regions results in relatively high levels of denitrification and nitrification with small marine nitrogen reservoirs and short residence times.

[1] Canfield (1998) *Nature* **396**, 450-453. [2] Kendall (2010) *Nature Geoscience* **3**, 647-652. [3] Poulton (2010) *Nature Geoscience* **3**, 486-490. [4] Slack (2007) *EPSL* **255**, 243-256.

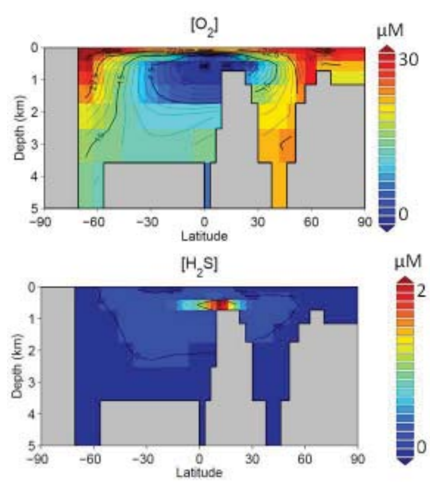

Figure 1: Meridional sections for $[O_2]$ and $[H_2S]$ with localized euxinia and suboxic deep ocean.