Magma components of the Gangdese batholith, southern Tibet: Decoded by zircon Hf and O isotopes

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The Gangdese batholith, southern Tibet is the largest of the Transhimalayan batholiths produced by the Neo-Tethyan subduction. Zircon U-Pb age data show that the emplacement of the Gangdese batholith occurred during ca. 200 and 40 Ma, and can be divided to the Jurassic, Cretaceous and Paleogene stages. Zircon Hf isotope data indicate that, in addition to the juvenile mantle signature observed in both of Mesozoic stages, the Paleogene Gangdese is characterized by significant Hf isotopic shift suggesting the involvement of old continental crust in the magma source, which we interpret as a result of Himalayan sediment subduction related to the advancing India. Here we report new zircon O isotope data measured by Cameca 1280 that, combined with published zircon Hf isotope data, identify four magma source components of the Gangdese bathoilth. These are (1) a depleted mantle [$\varepsilon_{Hf}(T) \approx +20$; $\delta^{18}O \approx +4.6$], representing the depleted mantle wedge of the Gangdese arc magma system; (2) an enriched mantle [$\varepsilon_{Hf}(T) \approx +8$, yielding crustal model age of ~600 Ma; $\delta^{18}O \approx +5.5$], resulting from subduction zone enrichment; (3) an old continental crust [$\varepsilon_{Hf}(T) < -5$; $\delta^{18}O$: up to +8.5], only in the Paleogene stage owing to the sediment subduction; and (4) a new component revealed in the Cretaceous and Paleogene stages that has high Hf and O isotope ratios [$\varepsilon_{Hf}(T) \approx +13$, yielding crustal model age of ~350 Ma; $\delta^{18}O$: up to +7.5]. The forth component, marked particularly with its high O isotope ratio, is interpreted to be derived from hydrothermally altered Neo-Tethyan oceanic crust and/or subducted arc-derived sediments.

Dynamic carbon cycle in the Ediacaran Yangtze Basin

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Extraordinarily large fluctuation in the Neoproterozoic carbon isotope records implies strong perturbations of global carbon cycle. Rothman *et al.* [1] proposed a two-box dynamic model with intertwined pools of inorganic carbon (IC) and dissolved organic carbon (DOC) to explan the unusual carbon isotope excursions and their link to the early animal evolution. Decoupled carbon isotopes of sedimentary carbonate and organic carbon from the fossil-rich Doushantuo Formation (635–551 Ma) in the Yangtze area of South China may be explained by this dynamic model.

The Doushantuo Formation in the Yangtze area is divided into four lithostratigraphic members up section. Member I of ~6 m cap dolostone was the fast deposition in a nonsteady-state carbon cycle during the aftermath of Marinoan glaciation, which explains the irregular track of ε (isotope fractionation between carbonate and organic carbon) vs. $\delta^{13}C_{carb}$ plot. At member II of ~70 m with alternated organic-rich shale and dolostone, stable $\delta^{13}C_{org}$ values and $\delta^{13}C_{carb}$ fluctuations over 10‰ suggest a large DOC reservoir in the depth of the Yangtze basin during the earlier Ediacaran [2]. Bristow & Kennedy [3] and Jiang *et al.* [4] disagreed a large DOC reservoir on global scale. However, a large DOC pool is enough to influence the overlying IC reservoir in basin in a redox-stratified ocean [5]. The intercept of $\delta^{13}C_{carb}$ axis (-30.5‰) suggests that most DOC should be derived from the degradation of photoautotrophs. After the osciliation of sea-level at member III of ~70 m dolostone with imbedded chert and alternating limestone-dolostone, stable $\delta^{13}C_{org}$ values and variable $\delta^{13}C_{carb}$ values (~5‰) occurred in overlying 10~20-m-thick black shale (member IV) suggesting a still existing DOC reservoir in the deep water. Furthermore, an intercept of -40‰ indicates a large amount of DOC should be mostly derived from the degradation of heterotrophic organisms.

[1] Rothman *et al.* (2003) *PNAS* **100**, 8124-8129. [2] McFadden *et al.* (2008) *PNAS* **105**, 3197-3202. [3] Bristow & Kennedy (2008) *Geology* **36**, 863-866. [4] Jiang *et al.* (2010) *EPSL* **299**, 159-168. [5] Li *et al.* (2010) *Science* **328**, 80-83.

DOI: 10.1180/minmag.2013.077.5.3