Chemical evolution of Himalayan leucogranites based on an integrated zircon O, U-Pb, Hf study

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Crustal melting and leucogranite intrusion are common features of most collision zones around the world. In the Himalayas, multiple Miocene leucogranite plutons and sheet complexes intrude the Greater Himalayan Series (GHS) across the orogen, in particular at upper structural levels towards the South Tibetan Detachment.

Previously-published Himalayan whole-rock data show that the leucogranites formed from a meta-sedimentary source (e.g. Deniel et al., 1987; Guillot and Le Fort, 1995). However the bulk rock approach carries inherant uncertainties. Post-crystallization processes such as fluid-rock interaction can have a large effect on whole rock chemistry and bulk analyses may mask more subtle influences from (differing) contributing sources. Zircons have been shown to retain precise information of the contributing sources of the melt from which they crystallise due to the resistant nature of the zircon structure to post-magmatic processes (Appleby et al., 2010).

This study focuses on detailed geochemical investigations of zircon to differentiate between varying geochemical processes in granite formation. O and Hf isotopes are used to detect discrete changes in source while U-Pb analyses yield the timing of zircon crystallisation. This study of Oligocene-Miocene (35-12 Ma) leucogranite zircons from the Bhutan Himalaya presents the first application of this novel technique that links Hf and O isotope data to the U-Pb age in zircons, to anatexis in the Himalayan orogeny.

The dataset shows that the majority of zircon rim analyses yield O-Hf signatures that lie within the previously-reported whole-rock GHS field, suggesting no discernable mantle source has contributed to Himalayan leucogranite formation (Fig. 1). In contrast zircon cores inherited from earlier orogenic episodes reveal a significant mantle component during Paleozoic and Precambrian events.

A change in Hf isotope composition through time during Himalayan orogenesis is documented, with a tendency for younger (17-12 Ma) leucogranites to yield significantly lower εHf values. The maximum εHf stays constant at -11 through all samples, however the minimum value drops as low as -23 in the youngest leucogranites (Fig. 2). This correlates to a change in Hf model age from 1.4 Ga to 2.4 Ga. These data suggest either a change of source within the GHS over time, or an increasing contribution from older Lesser Himalayan (LHS) material in the melt. LHS Nd model ages are significantly older than those of the GHS (2.4-2.9 Ga compared with 1.4-2.4 Ga; Ahmad et al., 2000), and even minor amounts of LHS material incorporated into a melt would significantly increase the Hf model age of the resulting leucogranite. If this inference is confirmed, it would have large implications for tectonic models of the Himalaya.

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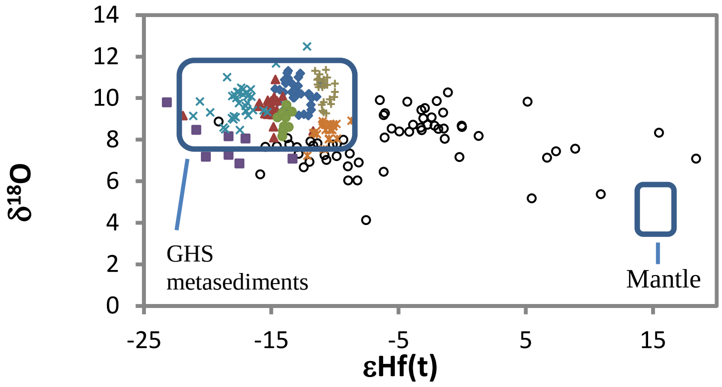

Figure 1. Graph of oxygen and hafnium isotope data for leucogranite zircon rims. Each colour/shape represents one sample. The vast majority of samples lie within the GHS (whole-rock) metasediment field, suggesting there is no mantle interaction with Himalayan melts. Open circles represent zircon core values. Data for GHS field from Harris and Massey (1994) and Massey et al. (1995). Mantle values from Vervoort and Blichert-Toft (1999) and Valley et al. (2005).

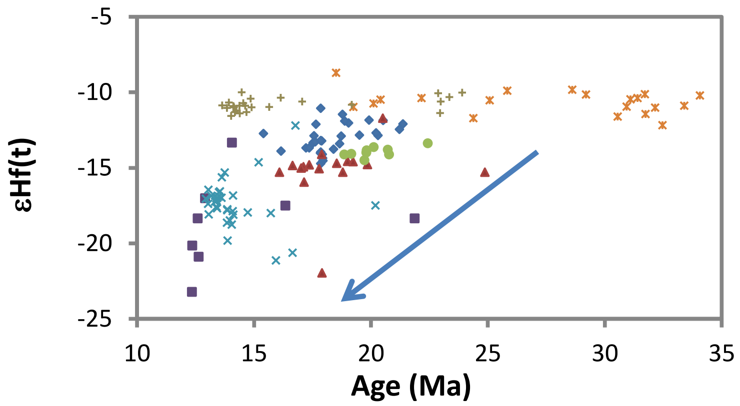

Figure 2. Plot of Hf isotope composition against age for leucogranite zircon rims. Each colour/shape represents one sample.

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