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

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Crustal melting is a characteristic process at convergent plate margins, where crustal rocks are heated and deformed. Miocene leucogranite sheets and plutons are found intruded into the high-grade metasedimentary core (the Greater Himalayan Sequence, GHS) across the Himalayan orogen. Previously-published Himalayan whole-rock data suggest that these leucogranites formed from a purely meta-sedimentary source, isotopically similar to those into which they now intrude. Bulk rock analyses carry inherent uncertainties, however: they may hide contributions from different contributing sources, and post-crystallization processes such as fluid interaction may significantly alter the original chemistry. In contrast, zircon is more able to retain precise information of the contributing sources of the melt from which it crystallises whilst its resistant nature is impervious to post-magmatic processes. This multi-isotope study of Oligocene-Miocene leucogranite zircons from the Bhutan Himalaya, seeks to differentiate between various geochemical processes that contribute to granite formation. Hf and O isotopes are used to detect discrete changes in melt source while U-Pb isotopes provide the timing of zircon crystallisation. Our data show that zircon rims of Himalayan age yield Hf-O signatures that lie within the previously reported whole-rock GHS field, confirming the absence of a discernible mantle contribution to the leucogranite source. Importantly, we document a decrease in the minimum εHf values during Himalayan orogenesis through time, correlating to a change in Hf model age from 1.4 Ga to 2.4 Ga. Nd model ages for the older Lesser Himalayan metasediments (LHS) that underthrust the GHS are significantly older than those for the GHS (2.4-2.9 Ga compared with 1.4-2.2 Ga), and as such even minor contributions of LHS material incorporated into a melt would significantly increase the resulting Hf model age. Hence our leucogranite 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. This is the first time that an evolutionary trend in the chemistry of Himalayan crustal melts has been recognized. Thus these new data show that, at least in the Himalaya, accessory phase geochemistry can provide more detailed insight into tectonic processes than bulk rock geochemistry.