



Age and provenance of the Dras Arc, Ladakh, NW Himalaya: A detrital zircon record of the Nindam Formation

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Many aspects of the Himalaya Orogen remain unresolved, including the timing of final “hard” continent-continent collision and the nature of earlier “soft” collisions involving intraoceanic arcs with either India or Eurasia. The Dras Arc in NW India is a distinct belt of basaltic-andesites and calci-volcaniclastic rocks (Nindam Formation) situated along the Indus Suture. Debates exist as to whether it developed as the forearc basin to the Eurasian margin or as a purely intra-oceanic island arc that may have collided with either India or Eurasia before final continental collision. Detrital zircons from the Nindam Formation volcaniclastic rocks yield U-Pb age spectra with a dominant youngest age population of ~120-84 Ma corresponding with arc magmatism. The youngest detrital zircons in each of the samples becomes progressively younger up through the sequence indicating deposition at the base began at about 100 Ma and continued until ~84 Ma at the top of the sequence. Smaller and slightly older peaks occur at ~135 Ma and ~150-185 Ma and these correspond with reported ages of Neotethyan ophiolites such as Spongtag and Nidar. An ophiolitic source is reflected by the presence of abundant ophiolitic serpentinite and tonalitic clasts near the base and throughout the Nindam Formation, while granitic clasts sourced from the Ladakh/Karakoram batholiths are completely absent, which suggests that the Nindam Formation did not develop as a fore-arc basin to the Ladakh Arc of southern Eurasia but rather a separate intra-oceanic island arc. A distinct “Gondwanan” signature comprised of Precambrian peaks at ~500 Ma, 800-1300 Ma, 1700-2000 and ~2500 Ma occurs in all samples. Gondwanan source rocks occur either side of the Neotethys during the Cretaceous as the Lhasa terrane to the north and India to the south so either of these peri-Gondwanan blocks could’ve shed sediment that was transported as submarine fans into the trench associated with the Dras Arc. Sandstone provenance analysis indicates that the Nindam Formation evolved from an undissected arc to dissected arc over a period of ~15 Ma. The Nindam Formation is distinctly different to the more quartz-rich sediments of the coeval Tar Group and post-collisional Indus Group which have a distinct Eurasian (Ladakh and Karakoram arc) source. We interpret the Nindam Formation to represent the fore arc basin to the Dras Arc which first collided and accreted onto the passive margin of India prior to “hard” continent-continent collision of India and Eurasia.