Implications of Himalayan Detrital Zircon Spectra of Cambrian–Ordovician Strata

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We present detrital zircon U-Pb age data for eleven Cambrian and Ordovician sandstone samples taken across and along the strike of the Himalaya in Bhutan, Tibet, northern India, and Pakistan, as well as one sample from Cambrian strata of the Indian craton. Detrital zircon age spectra for Cambrian samples of the Himalaya are of particular interest because the Cambrian Period witnessed the final amalgamation of core Gondwana (Cawood and Buchan, 2007). In addition, they are also the only rocks of Phanerozoic age known to occur in all three of the northernmost lithotectonic zones of the Himalaya, comprising sedimentary strata in the Lesser Himalaya (LH) to the south and the Tethyan Himalaya (TH) to the north, as well as protolith for part of the high-grade metamorphic assemblage of the intervening Greater Himalaya (GH). The biostratigraphically constrained depositional ages of the Himalayan strata sampled in this study range from terminal Early Cambrian to Ordovician. Tethyan sample names, ages and locations are as follows. Batal, PV, and Thango: Lower(?) Cambrian, Middle Cambrian, and Ordovician, respectively, Spiti Valley, northern India. MS-2 and MS-5: Cambrian and Ordovician, respectively, Kumaon region, northern India. NY-11: Middle Cambrian, Nyalam region, Tibet. WL-270: Upper Cambrian, Black Mountains, Bhutan. KU2: Middle Cambrian, Zanskar Valley, northern India. MBQ: Ordovician, Nowshera, Pakistan. Lesser Himalaya samples are Tal and Tal–GKM: Lower and Middle/Late Cambrian, northern India.

Eight of the eleven samples show very high p values of paired comparisons (Kolmogorov-Smirnov test). The p values range up to 0.976, and average a high value of 0.418. These very high p values strongly support the assertion of Myrow and others (2009) concerning the detailed correlation of Cambrian strata across the Himalaya to unfossiliferous, relatively high-grade rocks on the slopes of Mt. Everest and adjacent regions. More importantly, the uniformity of the age spectra from the northern Indian margin is remarkable, particularly given the broad geographic range of our samples over a distance of more than 2,000 km.

Myrow and others (2003) presented detrital zircon data from two samples that demonstrated a similarity in age spectra of these lower Paleozoic samples from the LH and TH, with grain ages that span from Archean to Cambrian in both. The data help refute the claim that pre-Permian deposits of the LH contain only Mesoproterozoic and older detritus (DeCelles and others, 2000; DeCelles and others, 2004; Martin and others, 2005; Richards and others, 2005), and instead support the hypothesis that the LH, GH and TH were part of a continuous northern passive margin of the Indian craton from the Neoproterozoic through the Cambrian (e.g., Searle, 1996). Continuity of the three zones is also supported by Cambrian stratigraphy, paleocurrent data and sedimentary facies relationships (Myrow and others, 2003; Hughes and others, 2005; Myrow and others, 2009). A detrital-zircon age spectrum from a Cambrian deposit of cratonic India, sample NAG-2 from the Nagaur Group of Rajasthan, shows large peaks from 0.7 to 1.3 Ga, accompanied by peaks at 1.6–1.7, 1.8, and 2.4–2.7 Ga. The sample lacks grains younger than 737 +/- 9 Ma, but the overall age distribution matches those of Cambrian samples across the Himalaya, including a large proportion of younger (< 1.6 Ga) grains (Myrow and others, 2003; in press).

The presence of the younger grains (< 1.6 Ga) in all these rocks has important implications for tectonic reconstructions and for characterization and mapping of the lithotectonic zones of the Himalaya in general. Specifically, a large fraction of bedrock exposed in the Lesser Himalaya (LH) has depositional ages that are >1.6 Ga, and the old geochronological and geochemical signatures of these rocks have been linked to sediment sources within the Indian craton (DeCelles and others, 2000; Najman, 2006). It is widely accepted that these signatures represent the LH zone, and can thus be used to distinguish it from other zones (e.g., Richards and others, 2005). Greater Himalayan (GH) and Tethyan Himalayan (TH) rocks with younger detrital zircon ages (0.5-1.6 Ga) and less negative ε_{Nd} values are generally considered to have sources in more distal Gondwanan orogenic belts. The younger grains (< 1.6 Ga) of our cratonic sample contradict the idea of a uniquely Indian geochronological signature (> 1.6 Ga grains) for the craton and the hypothesis that the GH and TH are exotic to the LH and the rest of India, and were accreted to the Indian margin during the Cambrian–Ordovician boundary interval (DeCelles and others, 2000; Yoshida and Upreti (2006). A detrital age spectrum from the Tal Formation of the Outer LH suggests continuity of the northern Indian margin and thus rejection of this hypothesis. Recent interpretations of the Krol-Tal Belt as a far-transported unmetamorphosed thrust sheet that roots into the GH or TH (Richards and others, 2005; Yoshida and Upreti, 2006; Célérier and others, 2009) are consistent with the general view that the entire LH consists of strata derived from older (> 1.6 Ga) source rock. However, our stratigraphic and geochronologic data clearly demonstrates that that the Outer LH was part of a proximal facies realm, distinct from the TH zone, and that it was part of a Neoproterozoic–Cambrian succession that would have overlain the older inner LH and extended south onto the Indian craton and north across the Tethyan realm.

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