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Closure of Tethys and early stages of Himalayan evolution: constraints from the detrital record, Ladakh, India

D. Jenks (1), Y. Najman (1), L. Godin (2), R. Parrish (3), M. Horstwood (3), O. Green (4), P. Bown (5), E. Garzanti (6), and H. Willems (7)

(1) Lancaster University, Dept of Environmental Science, Lancaster, United Kingdom (d.jenks@lancaster.ac.uk), (2) Dept. Geological Sciences, Queen's University, Kingston, Ontario, K7L 3N6, Canada, (3) NERC Isotopic Geosciences Lab. Keyworth, NG12 5GG, UK, (4) Dept. Earth Sciences, Oxford University, Parks Road, Oxford OX1 3PR, UK, (5) Dept. Earth Sciences, UCL, Gower St, London WC1E 6BT, UK, (6) Dept. Scienze Geologiche e Geotecnologie, Universita di Milano-Bicocca, Italy, , (7) Dept. 5 Geosciences, Uni Bremen, Postfach 330440, 28334 Bremen, Germany

Closure of Tethys marks initiation of collision between India and Asia, and the start of Himalayan orogenesis. A clear understanding of when this occurred is paramount to understanding the tectonic and denudational processes that have occurred since collision. A number of methods and datasets have been used to constrain the initiation of collision, from faunal mixing at 65 Ma [1] to the timing at which Indian rocks reached UHP depths at 57 Ma [2], to a reduction in northward drift of the Indian plate at 55 Ma [3]. New interpretations have placed collision as late as 38 Ma [4]. The extent of diachroneity is also disputed, varying from slight [5] to substantial [6]. Two approaches are used here to determine collision, 1) the timing of closure of the Tethys Ocean [7], based on stratigraphic succession, 2) first evidence of Asian derived material deposited on the Indian plate [8], using U-Pb ages of detrital zircon to assess provenance.

In Ladakh, Indian plate passive margin limestones of the Mid-Late Paleocene Dibling Formation [9] are overlain by the youngest marine facies of the region, the marine siltstones of the Kong Fm. and the fluvio-deltaic facies of the Chulung La Fm. [8]. The age of the Kong and Chulung La formations is disputed, ranging from P5/6 (56 Ma) [10] to P8 (50.5 Ma) [8]. The provenance is also debated, considered either to be eroded from ophiolitic material from the Indian plate [10] or containing detritus from the Trans-Himalayan arc of the Asian plate [8,11].

We applied biostratigraphy, and U-Pb dating on detrital zircon, to samples from the Kong and Chulung La Formations to define depositional age and provenance. Biostratigraphy identified Asselines A. placentula grande and A. pomeroli, from the SBZ 10 (50.5 to 52.5 Ma) and SBZ 9 (53 Ma) zones respectively, thereby defining a minimum age of collision at 50.5 Ma, based on cessation of marine facies. However, the possibility that these fossils are reworked will be discussed. U-Pb dating of detrital zircons allows discrimination between Asian provenance (dominated by Mesozoic grains from the Trans-Himalayan arc) and Indian provenance (characterized by Precambrian grains and an absence of Mesozoic grains). Our data from the Kong and Chulung La Formations shows a primary provenance from the Asian plate (arc derived), with dominant grain populations between 55-70 Ma and 90-100 Ma, and a subordinate population of Precambrian grains suggesting an origin on either the Indian (High or Tethyan Himalaya) or Asian (Lhasa Block) plate. Thus collision is constrained by arrival of Asian detritus on the Indian plate during SBZ9-10, 53-50.5 Ma.

Our results and identification of first arrival of Asian material on the Indian plate at 53-50.5 Ma 1) conflicts with the recent view that the commonly quoted 50 Ma collision was between the Indian plate and a small intra-oceanic arc [4] rather than Asia and 2) correlates with data from analogous sediments along strike in Southern Tibet [12,13], eastern Himalaya, implying collision was synchronous along a large portion of the Himalayas. In addition, our new ages from the Trans-Himalayan arc contribute to the existing database which shows a very low proportion of grains dated between 80-90 Ma. This has been interpreted by previous workers as an expression of a reduction in magmatic activity around this time, due to a period of "flat subduction" of the Neo-Tethyan oceanic slab followed by slab roll back and a more vigorous period of magmatism [14].

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