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Zircon U–Pb ages and Hf isotopic evidence for Eoarchean crustal remnant, crustal growth and reworking in NW India and implications on supercontinental cycles

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In situ U-Pb and Hf isotopic analyses were carried out on detrital zircons from the southern and northern segments of the Mesoproterozoic Delhi Supergroup in NW India. The oldest zircon has a U-Pb age of 3671 ± 15 Ma with an $\varepsilon_{Hf(t)}$ value of +0.1 and model Hf age of 3.92 Ga (T_{DM2}). These data unravel, for the first time, the existence of a 3.67 Ga old crust in NW India, with possible crustal growth as early as 3.92 Ga. Further, wide variation in $\varepsilon_{Hf}(t)$ values for 3.28-2.99 Ga and 2.58-2.34 Ga zircons clearly suggest crust-mantle mixing during these time intervals. Hafnium model ages underline that the crust involved in the mixing process was, on average, not older than 3.65 Ga, synchronous with the obtained 3.67 Ga ages for the oldest zircon. Juvenile crust was obviously derived at 2.86 - 2.71 Ga from a depleted mantle source, as evident by the depleted mantle-like $\varepsilon_{Hf(t)}$ values (+7.2 - +5.6). Formation of juvenile crust ceased after 2.71 Ga and crustal reworking of pre-existing heterogeneous crust was the predominant process for the formation of the extensive 2.66 to 2.34 Ga magmatism (mostly subchondritic $\varepsilon_{Hf(t)}$) in NW India. Large variation in $\varepsilon_{Hf(t)}$ values for Paleo- to Mesoproterozoic zircons indicates that not only substantial amount of older crust was reworked, but also that the juvenile crust was formed during 2.11 - 2.01 Ga and 1.60 - 1.37 Ga.

The major peak clusters in the detrital age distribution of the Delhi Supergroup correlate well with periods of supercontinent assembly, reflecting involvement of Indian block in Superia to Rodinia supercontinent cycles. Three major clusters that were associated with assembly of supercontinents extend vertically into both positive and negative $\varepsilon_{Hf(t)}$ spaces, suggesting that they involved both relatively juvenile and ancient continental crust. In complete contrast, nearly all zircons with ages corresponding to convergent and breakup settings during supercontinent cycles, have positive $\varepsilon_{Hf(t)}$ values, corresponding with depleted mantle and indicating either greatest capture of juvenile relative to reworked crust or contribution of predominant juvenile crust during the breakup and pre-assembly of supercontinent. On the basis of correlation of detrital zircon age patterns, as well as magmatic and tectonic activities, the northern Indian block was most likely connected to the Cathaysia Block of South China from assembly of Nuna.