# Detrital Apatite Fission-Track Thermochronology of Modern River Sands from the Arunachal Himalaya and its Implications for Exhumation

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The Eastern Himalayan Syntaxis (EHS) is characterized by (i) a northern large strike-slip region, and (ii) fold- and thrust-controlled tectonics in the southern parts. The main syntaxial sequence of highly deformed Namcha Barwa Group felsic gneiss and high-pressure granulite reveals extremely localized erosion and an intense phase of very young and fast fold-controlled exhumation rates up to 10 mm/yr in the core (Booth and others, 2008; Seward and Burg, 2008; Stewart and others, 2008; Cina and others, 2009). Further south, in the Arunachal Himalaya, the Cenozoic foreland Siwalik belt abruptly rises over the Holocene Brahmaputra alluvium along the Main Frontal Thrust (MFT), and is overridden by the pre-Cenozoic Lesser Himalayan sedimentary sequence along the Main Boundary Thrust (MBT). Two windows at Menga and Nacho reveal its extension beneath the Himalayan Metamorphic belt (HMB), which is thrust southeastwards along the folded Main Central Thrust (MCT). The southern metamorphic belt dominantly contains mylonitized Daporijo Gneiss, whereas the inner metamorphics are medium to high grade garnetiferous-kyanite-sillimanite schist/gneiss and granulite of the Higher Himalayan Crystallines (HHC). These are overlain by the low grade or unmetamorphosed Tethyan Sedimentary Zone (TSZ) in the extreme northwest, while the Indus-Tsangpo/Tidding Suture Zone rocks separate this belt/HHC from the Lohit Batholith around the EHS. Many of these tectonic belts may be physically traced around the EHS into the northeastern Mishmi Hills, which dominantly expose the batholith.

Apatite FT detrital thermochronology of the Subansiri, Siang, Dibang and Lohit rivers sands and their tributaries as well as the Siwalik Group (Miocene-Pleistocene) on 1028 grains from 20 samples have been undertaken to decipher the source rocks of these modern sands. Individual AFT grain ages range from 0.2 to 99.3 Ma and reveal the time elapsed since it attained its closure temperature of ~135$^{o}$C. These mixed population of different ages were reduced to individual peaks between 0.2 to 33.4 Ma, using the BINOMFIT software (Brandon and others, 2002), and have been assigned to different sources in the Himalaya, and compared with the bedrock AFT ages from some of the units falling in catchment area of each sample.

In the westernmost parts, the smallest Ranga River drains the Siwalik, the LH sedimentary belt including the Gondwanas, and overthrust Daporijo Gneiss. Sample Z155 from the Ranga Dam has sediments coming from the Daporijo Gneiss and the LH Sedimentary Zone with a P1 Peak of 6.4 Ma from the latter sources, while the 10.7 Ma P2 Peak has a mixed source of the Daporijo Gneiss and the Lesser Himalaya. However, a new P1 Peak of 2.2 Ma in the foothill sand sample Z145 is likely to be derived from the youngest Pliocene Kimin Formation of the Siwalik Group or the reworked older terraces.

The main Subansiri River valley drains a very large area of Tibet covered by the Tethyan Sedimentary Zone. The HHC bedrock within Arunachal has the AFT ages from 2.6 to 2.9 Ma, whereas those of the Daporijo Gneiss are between 6.2 and 7.4 Ma. The 1.9 Ma P1 Peak in sand sample Z93 in the extreme northwest matches approximately that of the bedrock AFT ages from the HHC. It is likely that the 3.7 Ma P2 Peak has a source in the leucogranite intrusion within the HHC as well as the Tethyan sediments; a few older AFT ages are also sourced within this belt. The picture of sediment source in this river is clearer when we compare peak ages of sample Z80(S), where the 1.9 Ma P1 Peak is certainly coming from the HHC and the LH windows, whereas the 4.9 Ma P2 Peak grains are contributed from the Daporijo Gneiss and Lesser Himalayan Sedimentary belt. In the sand sample Z185, collected from Gaurkamukh, the youngest P1 Peak is diluted to 3.7 Ma, possibly due to an admixture of youngest apatite ages from different sources and various tributaries of the Subansiri River. The 7.9 Ma P2 Peak grains might have apatite contributed by the Daporijo Gneiss. Although there is no exposed bedrock with ~20 Ma age, it is likely that 19.5 Ma peak is from un-reset Cenozoic foreland-basin Siwalik sediments.

In the Kurung-Kamla Rivers, the important tributaries of the Subansiri, the bedrock AFT ages range from 2.2 to 3.5 Ma for the HHC. However, the river sand sample Z169 from Kurung, having inputs from the HHC and the TSZ, has two peaks: P1 and P2 of 2.4 and 8.9 Ma, respectively. The P1 Peak may have its source from the HHC, while the P2 Peak is presumably from the TSZ. Bedrock AFT ages from the Daporijo Gneiss of the LH metamorphic belt range from 5.0 to 8.0 Ma. A single sample from the LH window has an AFT age of 2.0 Ma, however these ages vary from 4.7 to 8.5 Ma in the LH sedimentary belt. Sand sample Z113 from the Kamala River has two peaks, with P1 of 5.0 Ma containing 88.8% of the bulk population, and a P2 Peak of 12.0 Ma. This means that majority of the grains are coming from the Daporijo Gneiss but have a mixed population. The 12.0 Ma P2 Peak may be assigned to the Lesser Himalaya.

The Siang River, the main tributary of the Brahmaputra River, has the largest drainage system in Tibet and Arunachal Himalaya, and drains the EHS. The northernmost sand sample SP43 from Tuting has an AFT age range between 0.2 and 28.0 Ma with a P1 Peak of 1.2 Ma (88.1%, n=46), which is likely to be derived from the HHC complex of the EHS, whereas the older P2 Peak of 10.8 Ma possibly has its source in the Lohit Batholith. Sand sample SP 34, collected downstream from the Siyom-Siang confluence, has an AFT P1 Peak of 1.7 Ma with its source in the HHC, as is evident from four bedrock ages between 1.3 and 1.8 Ma; the P2 Peak is 14.1 Ma with a possible source within the batholith. Sand from Rotung along the Siang has only one peak of 1.9 Ma (Sample SP 87), whereas sample SP 86 from Pasighat has P1 and P2 Peaks of 2.1 and 31.5 Ma; the latter bears strong similarity to the AFT peak from the Middle Siwalik Formation (sample SP86A) from Pasighat, whose youngest P1 Peak of 8.0 Ma constrains its minimum depositional age and is distinctly older than the Upper Siwalik peak of 4.3 Ma from Kimin in the Ranga valley (Sample Z 143).

In the Siyom River valley, a tributary of the Siang River, the 4.4 Ma single P1 Peak of sample Z30 in the westernmost parts (100%, n=36) may have a mixed source of the HHC as well as the TSZ. This argument is based on the bedrock AFT age of ~2.9 Ma from the HHC. Sand sample Z62 from the middle stretch did not yield any peak but individual grain ages range from 2.1 to 12.9 Ma. This implies that the sample has a mixed source of different units including the Lesser Himalayan package.

Two mighty rivers, the Dibang and Lohit, mainly drain the Lohit Batholith in Mishmi Hills, besides the Tidding Suture Zone, the HHC and other tectonic units of adjoining Tibetan region in the northeast. Two sand samples from Amboli and Etalin along the Dibang have P1 Peaks of 2.9 and 2.6 Ma respectively, whereas the older peaks between 8.2 and 15.4 Ma are sourced from the Lohit Batholith. Along the Lohit, the northernmost sample SIV has grains as young as 0.7 Ma with a P1 Peak of 0.00 Ma and others between 5.7 and 26.3 Ma, indicating recent fault activity within the source area. In two samples further south (samples SIII and SV), older peaks between 7.8 and 33.4 Ma appear to be derived from the Lohit/Gangdese Batholith, while the 0.2 Ma Peak in the southernmost sample at Parasuram indicates Holocene movements along the frontal Mishmi Thrust.

**References**

Booth, A.L., Chamberlain, C.P., Kidd, W.S.F. and Zeitler, P.K., 2008, Metamorphic and geochronologic constraints on the tectonic evolution of the eastern Himalayan syntaxis, Namche Barwa, Geol. Soc. Amer. Bull., 121(3-4), 385–407.

Brandon, M.T., 2002, Decomposition of mixed grain-age distributions using BINOMFIT, On Track, 24, 13–18.

Cina, S.E., and others, 2009, Gangdese arc detritus within the eastern Himalayan Neogene foreland basin: Implications for the Neogene evolution of the Yalu–Brahmaputra River system, Earth Planet. Sci. Letts., 285, 150–162.

Seward, D. and Burg, J.P., 2008, Growth of the Namche-Barwa Syntaxis and associated evolution of the Tsangpo Gorge: Constraints from structural and thermochronological data, Tectonophysics, 451, 282–289.

Stewart, R.J., and others, 2008, Brahmaputra sediment flux dominated by highly localized rapid erosion from the easternmost Himalaya, Geology, 36, 711–714.

Cite as: Jain, A.K., Pebarn, J., Lal, N., Singh, S. and Kumar, R., 2010, Detrital Apatite Fission-Track Thermochronology of Modern River Sands from the Arunachal Himalaya and its Implications for Exhumation, *in* Leech, M.L., and others, eds., Proceedings for the 25th Himalaya-Karakoram-Tibet Workshop: U.S. Geological Survey, Open-File Report 2010-1099, 2 p. [http://pubs.usgs.gov/of/2010/1099/jain/].