Open University Geological Society's Field trip to Sikkim, NE India. April 2011

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View of the Kangchenjunga range from the campsite at Tonglu

Our trip leaders were Professor Nigel Harris from the Open University and Professor Talat Ahmad , Vice Chancellor of the University of Kashmir (formerly at the University of Delhi). Here is a brief overview of the area and some of the locations we visited.

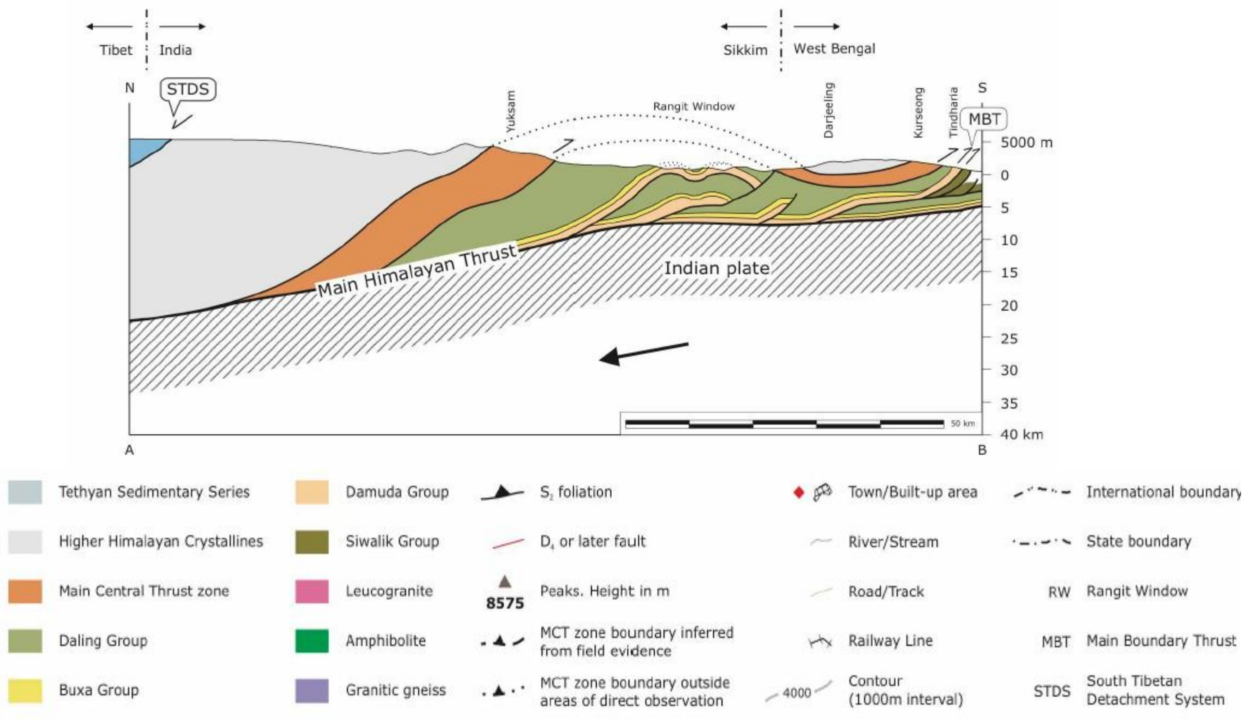
During the Cretaceous, the Indian plate rifted from Gondwana and started its migration north, pulled by the subducting lithosphere of the Tethyan Ocean. By the Eocene, the Tethyan Ocean had closed and the collision between the Indian and Eurasian plates had started. Since then, India has continued to move northwards creating crust beneath the Himalaya and the Tibetan Plateau that is about double the thickness of normal crust.

The Indian state of Sikkim is nestled within the Eastern Himalayan Mountains; bordered to the east and west by Nepal and Bhutan, China to the north and West Bengal to the south.

In geological terms this region lies to the south of the Tethyan Suture Zone which forms the boundary between India and Eurasia. The area is still seismically active and on the 18th September 2011 it was subjected to a M6.9 earthquake. Preliminary data suggests that the earthquake was triggered by shallow strike-slip faulting from within the overriding Eurasian Plate. Ninety four people were killed, several were injured and thousands displaced (http://earthquake.usgs.gov/earthquakes).

Surprisingly, there has not been much detailed

Map of Sikkim



Cross section of the Sikkim-Darjeeling Himalaya based on Acharyya, 1989; Lahiri, 1974;

research carried out on the geology of this region. So, along with the cultural aspects of our trip, we were there to conduct a general reconnaissance of the area for Nigel's new PhD. student. The rocks we observed were within the Lesser Himalayan formations (LHF) and are medium-low grade metasediments. These have been intruded by granites that have been dated between 1.8 & 2.4 Ga and are some of the oldest rocks in the Himalaya. The Lesser Himalaya Formations are bounded by the Main Central Thrust (MCT) to the north and the Main Boundary Thrust (MBT) to the south.

We started our trip by road from Bagdogra to Kurseong. Along this route there is a sharp break of slope on entering the foothills that marks the MBT. To the south lie late Tertiary deposits in the Himalayan foreland basin – these are the Siwaliks. Here, the MBT places sediments of the Damunda group (late Permian) on top of the Siwaliks. The Damunda shales are thinly bedded and interlayered with thin coal seams that suggest cycles of sediment deposition. Further along this route we saw evidence for the start of the MCT zone – small exposures of laminated carbonaceous slates within chorite-grade phyllites.

Just south of Kurseong are outcrops with visible isoclinal and recumbent folding. We also saw chevron folding in the hinge zones all of which indicate strong episodes of deformation in the past. These beds form part of the Darling group which sit near the top of the MCT zone. The rocks are metamorphosed

Professor Harris studying the folding

sandstones. These quartzites are interbedded with pelitic mica layers containing small garnets of approximately 1-2 cm in size. Further up-slope are outcrops of biotite-garnet schists. Above all of this sits the Higher Himalayan Formation Crystallines. In the past these have been mapped as Darjeeling gneiss but it is mostly schist. We stopped only briefly to look at these as the outcrop was at the side of a busy road. Roads in this part of the world are something to behold!

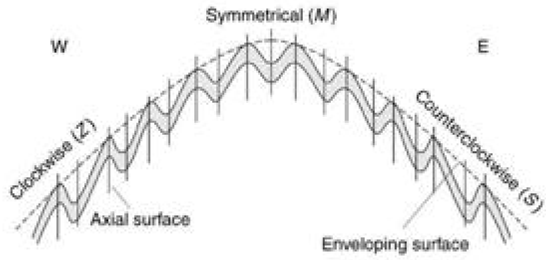
Next stop Darjeeling. Tenzing Norgay (Sherpa Tenzing) is one of the most famous mountain climbers in history being the first, along with Sir Edmund Hillary, to reach the summit of Mount Everest in 1953. After a visit to a tea plantation we made a stop at the outcrop he practiced mountain climbing on, now known as Tenzing Rock.

The outcrop is made up of Darjeeling gneiss, (bands of quartz, feldspar and biotite), from the Higher Himalayan Series and has been dated to the end of the Palaeogene, probably deposited during the early Cambrian and metamorphosed at a depth of approximately 25km. This has later been brought up along the main central thrust (MCT) and has been identified as part of the hanging wall.

The whole rock face is covered in shear zones

z-folds in Tenzing Rock, Darjeeling

and you get a sense of top to right movement from the clearly visible z-folds, indicating we were looking at the overturned limb of an asymmetrical fold; z & s folds are usually superimposed on larger structures.



Small scale folds Source: ***http://ic.ucsc.edu***

A small patch of sillimanite was found but no other minerals apart from the layers of biotite, quartz and feldspar that make up the gneiss.

From a geological point of view, for the rest of the trip our main focus became our search for the index minerals found in rocks of pelitic composition that would identify the barrow zones. These index minerals represent zones of increasing metamorphic grade:
chlorite – biotite – garnet – staurolite – kyanite – sillimanite

The zones occur as these minerals are only stable under certain temperature and pressure conditions. Chlorite is in rocks of the lowest metamorphic grade and sillimanite the highest. High grade metamorphic rocks containing sillimanite are the precursor to re-formation as migmatites or leucogranites provided the pressure and temperature continue to increase. We saw evidence for the beginning of leucogranite formation during our investigations.

We had our first sighting of sillimanite close to our campsite at Tonglu, near the India-Nepal border, at an altitude of 3070m. We were at the southern end of the Singali Trail within the