

## HIMALAYAN TECTONICS (THE HIMPROBE RESULTS)

A workshop on "Himalayan Tectonics (The HIMPROBE Results)" was organized during October 16-17, 2003 at the Department of Earth Sciences, Indian Institute of Technology Roorkee, sponsored by Deep Continental Studies Programme of the Department of Science and Technology (DST), New Delhi. There were about 40 participants who are actively involved in the Himalayan tectonics. The workshop was inaugurated by Dr. H. K. Gupta, Secretary, Department of Ocean Development.

There were five main sessions and a final concluding session. Each session was conducted by a Chairperson and a Reporter. The first session was on *Karakoram Mountains*, which contained six presentations and was opened by briefing on HIMPROBE programme and how it was conceived and implemented in the first phase by K. R. Gupta, followed by the work of A. K. Jain and his associates who talked about the tectonics of Karakoram Shear Zone along with the age constraints of the metamorphic terrains. R. M. Manickavasagam presented data on metamorphic grades including P-T estimation supported by the garnet zoning data of the metamorphics along Tangtse-Lukung section. This talk was followed by Patta and associates, who presented data on Rb-Sr biotite ages from metamorphics and also from granitic bodies lying in the Karakoram shear zone and indicated that the rocks were at a depth of ~10 km around 10.5-12 Ma ago. B. R. Aiyar and his associates explained the period-dependent strike direction in terms of possible decoupling between lithosphere and sub-lithosphere mantle and post-collision rotation of the Indian Plate on the basis of long-period MT data. The work of Goikarn and associates was presented by Nandini Nagarajan on wide band MT survey between Baialacha La and Panamik and Pang and Phobang, and came up with a strong signature of molten layer below the Ladakh Batholith. Data was also presented from Una-Mandi section which brought out the tectonics of the near surface lithosphere.

It was recommended by the Chairperson of the first session (O. N. Bhargava) and the Reporter (S. Singh) that similar multidisciplinary-multi-institutional programmes should be launched in other sectors of the Himalaya and also to develop a dedicated team akin to the one at IIT, Roorkee. He also recommended that more data of long-period MT with closer sites may be acquired to constrain the structures below TMC and Ladakh Batholith. Further, it was recommended that MT data between Mandi-Baialachala may be acquired to complete the geotranssect.

The target of presentations in the second session was the *Himalayan Suture Zone*. The session started with the presentation by Hakim Rai, who discussed the geology and tectonic evolution of the Shyok Ophiolite Melange Belt in three parts. Like A. K. Jain, he also opined that there was no strike slip movement along the SSZ in recent geological past. He also opined that the Shyok Suture and Indus Suture are of same nature. However, T. Ahmad and coworkers disagreed with his observations and indicated that they have two distinct geochemical signatures. Later, Sunil Bajpai and coworkers discussed the fossil finds from part of Ladakh Molasses (Basgo Formation) near Taiuche village. Their most important finding was the discovery of non-marine ostracods, particularly the Chinese genus *Dongyingia* which suggests a Late Oligocene age for Basgo Formation. This is at variance with earlier assignment of Maastichtian and Eocene ages. Sandeep Singh and coworkers presented SHRIMP U-Pb ages of zircons for Ladakh Batholith which is to be ~60 Ma with a depth of emplacement of about 9-10 km on the basis of Al-Ti hornblende geobarometry. Although other dates of ~105 Ma and some dates around 20 Ma were also found by earlier workers and T. Ahmad, but the bulk of magmatism took place at ~60 Ma. Later R. G. S. Sastry discussed the implications of gravity data at 1-2 km station spacing for the Keylong to Panamik sector and deduced typical horst and graben tectonics at ~30 km depth for the Upshi-Panamik section, where this structure is most profound between SSZ and ITSZ.

It was recommended by the Chairperson of the second session (M. Joshi) and the Reporter (M. L. Shaima) that there should be some way to resolve the controversy of one suture or different sutures along with more age data on other units of Ladakh Batholith. They also mentioned that a detailed gravity modeling is required with integration of data with MT and seismic profiling.

The third session was dedicated to *Himalayan VHP Terrain* which had five papers on fso-Moran Crystallines (TMC), the UHP terrain in Ladakh and incorporated latest investigations on metamorphic petrology, P-T estimates, geochronology and one AMS study in Ladakh. Data clearly distinguish mineral phases of prograde path of eclogitization and development of coesite with garnet (H. K. Sachan) and subsequent changes either due to metasomatism (P. K. Verma) or retrogression (R. M. Manickavasagam, H. K. Sachan and M. Joshi). Sr isotopic data does support metasomatism (T. Ahmad) as the eclogites have, with much

higher and variable Sr ratios expected in basic rocks of positive  $\epsilon_{\text{Nd}}$  values. The geochemistry of eclogites suggests that they are more of an OFB and not having any affinity with Panjal volcanics of Kaghan area (Sandeep Singh). There has been unanimity of opinion that Indian continental lithosphere got subducted to ~ 100 km in the initial stages and subsequently exhumed at ~ 55 Ma as per available published data. SHRIMP U-Pb zircons from adjoining country rocks (Sandeep Singh) reveal a much younger metamorphic growth at ~ 48 Ma during subduction.

Chairperson (A. K. Jain) and Reporter (T. Ahmad) put forward that there are still few questions like what controls exhumation/uplift of the Indian continental lithosphere from ~ 100 km depth, role of serpentinization and how they are related with other parts of Himalaya, when did eclogitization take place and whether there is some temporal relationship with collision tectonics in the Himalayan concomitants or not, if possible to draw more precise P-T path for the Tso-Moran Crystallines and the nature of subduction, e.g., how fast it is taking place and what is its residence time, eclogite-blue schist connection and whether the exhumation has taken place in single or multiple stages. He recommended that future studies should summarize the results with more data on geochemistry of eclogites along with multi-isotopic inputs for Geochronology, source characterization and protolith identification.

The fourth session, which was held on the second day, was on *Tectonics of Great Himalaya* and the first presentation was by S. K. Parcha who presented his work on the refinement of boundaries within the Cambrians of the Tethyan Himalayas and related his work to Kumaun, Spiti and Kashmir Himalaya, emphasizing mainly on Middle Cambrian to Early-Late Cambrian time. This talk was followed by O. N. Bhargava's talk which shared his work on Jutogh and Vaikunta thrust sheet and clearly brought out refolded structures and their relationship with the metamorphics and the Chur granites. He finally posed a question whether various units of the Jutogh Group are thrust separately or represent a package transported as a unit<sup>9</sup>. Further Soumyajit Mukherjee presented a mathematical model for combined ductile shear and channel flow for Higher Himalayan Crystallines on the basis of the thin section studies from Zaskar Himalaya.

The fifth session was on *Deep Crustal Structure* having five presentations during pre-lunch session and two presentations during post-lunch session. Pre-lunch session was started with the presentation made by Nandini Nagrajan on geophysical 2-D and 3-D modeling of the MT profile using Gokain's data across Ladakh and compared it with that of S. Tibet. This was followed by S. Kareemunnisa and

coworker's presentation on electrical conductivity and after shock activity of Chamoli Lesser Himalaya. H. C. Tewari presented seismic structure of Jammu-Kashmir region while M. L. Sharma estimated spectral strong motion on the basis of strong motion data from Himalaya. After that M. P. Singh and coworker presented crustal image of northwest Himalaya on the basis of broadband seismic data.

Chairperson of pre-lunch session (B. R. Arora) in his retrospect and prospect of results emerging from studies launched under HIMPROBE, highlighted the anomalous geophysical characters of crust beneath Tso-Moran Crystallines (TMC). The conductance of the zone is estimated to be > 20,000 S, much higher than found anywhere in Tibet. This may require fresh look into the causes of high conductance. In addition to fluid or partial melt, the possibility of graphitic or carbon films may also be looked into. The possibility of suture zone bore holes for heat flow measurement should be done to resolve the source of anomalous nature of the crust. It may also be worthwhile to constitute a small task group to integrate multiple data sets and develop tectonic model for TMC that is consistent with petro-physical data. He also mentioned that to distinguish magmatic association with compressional and extensional tectonics, AMS measurements may be initiated. He is of the opinion that since a number of geodynamic factors were presented during this session, no one-to-one correlation should be made between NW and Tibet Himalaya. Hence, comparison of geophysical data and encouraging interpretation should be done with care.

However, during post-lunch session Paramesh Baneijee presented GPS results from NW Himalaya indicating ~ 11 mm/yr slip rate of Karakoram causing eastward motion of southern Tibet and westward motion of NW Himalaya towards Nanga Parbat. The shortening of the order of ~ 40 mm/yr, which has been observed from this region, is attributed to accumulation of ~ 15 mm/yr to Himalayan boundaries and ~ 5 mm/yr to the Indian Shield along Narmada. Later K. Suryaprakasham and coworker presented tomographic studies of the Indian Peninsula and demarcated the lithospheric boundaries at 250, 410 and 660 km depths, however, diffusion at 660 km has been observed which needs to be explained and understood properly. Similar approach has been used to show a lithospheric model along the geotranssect, which is presently very tentative according to the presenter and the study is still continuing to strengthen it.

Chairperson of the session (H. C. Tewari) and Reporter (R. G. S. Sastri) recommended the continuation of GPS studies and the possibility to integrate it with tomographic studies. He was also of the opinion that the role of micro-

seismic activities should also be looked into the accommodation of the stress and strain which may be good for determining the exact amount of stress in the Indian Subcontinent.

During the concluding session each Chairperson along with the Reporter presented the summary of each session along with the recommendations. ONB and SS were of the opinion that all the studies carried out under different disciplines may be synthesized to present an integrated picture; there is also a need for electromagnetic studies below Ladakh with MT and LMT. MJ and MLS raised the question of two sutures or one suture, which is separated by Ladakh Batholith, the attitude of two sutures and the situation at deeper levels. They also mentioned that there was need for more palaeontological findings from molassic sediments along with more specific data from the different magmatic phases of the Ladakh Batholith. AKJ and TA specified the need for more sample collection from different terrains for constraining the age by fossil records as well as much constrained geochronological data on zircon. PKV and SB indicated that there was need for studies to arrive at more realistic structures, to constrain the structural sequence for modelling, reversal of shear indicators and also

combined channel flow and ductile shear model. They also mentioned that there was lot of scope in looking back at Himachal Himalaya with the new approach. However, BRA and RGSS were of the opinion that due caution should be exercised in any comparison on one-to-one basis. There is also need of revisiting the DSS data along with borehole data of ONGC.

Chairperson of concluding session (D.N. Avasthi) and Reporter (S. Singh) made recommendations for future studies emphasizing on the work done by IIT Roorkee Group. MT, LMT and similar studies can be taken up along another geotranssect which could be Roorkee-Badrinath section, which may not be a complete section like Hoshiarpur-Leh-Panamik section. There is also a need of absolute gravity measurement in different folded areas of Himalaya. It was also pointed out that the set of new data now available should prompt Indian geoscientists to reassess the geodynamics of the development of the Tibetan - Himalayan orogeny.

*Department of Earth Sciences,  
Indian Institute of Technology Roorkee,  
Roorkee - 247 667  
Email: sandpfes@iitr.ernet.in*

SANDIIBP SINGH

## NEW OIL FIND IN RAJASTHAN

According to press reports (*The New Indian Express*, Bangalore, 20 January 2004 and the *Times of India*, Bangalore, 20 January, 2004), Cairn Energy of U.K. has struck oil in a well 60 km north of its Saraswati oil field in the Barmer district of Rajasthan.

Initial estimates of the find range from 450 million barrels to 1,100 million barrels. Preliminary reserve estimates indicate a range of 50-200 million barrels of crude oil. It appears that ONGC has a 30% right to any development area resulting from a commercial discovery in the block. Cairn Energy in recent times has shifted its focus from North Sea to the Subcontinent (Bangladesh and India).

It is earnestly hoped that this new oil find in Rajasthan will be commercially exploitable in a short time and will open up further vistas of Rajasthan emerging as a prime fuel provider to the nation.

M.S. RAO

We regret very much to record the passing away of Professor Adusumilli Bhaskara Rao on 27<sup>th</sup> November 2003.