pursue research and teaching do not prefer to work in institutions and universities that have limited or no infrastructure facilities. In addition, our research institutions and universities are now facing increasing competition for the limited pool of quality students from universities and research institutions from all over the world. Why would a young person join a university or institute that has poor or no infrastructure facilities? These factors, when taken together, perhaps discourage many young people to pursue academic careers. If this trend continues, I am afraid it might wipe out the research atmosphere in universities. Consequently, the main task ahead for the policy-making bodies is to re-examine the funding process and provide long-term funding to create infrastructure as well as internal funding to invigorate basic research in the universities.

K. MUNIYAPPA

Department of Biochemistry,
Indian Institute of Science,
Bangalore 560 012, India
e-mail: kmbc@biochem.iisc.ernet.in

Lessons learnt from the 8 October 2005 Muzaffarabad earthquake and need for some initiatives

In the Himalayan region, there is no report of the causative fault of an earthquake appearing as a surface rupture. This gave rise to a interpretation that the Himalayan earthquakes were caused by the blind reverse faults. However, for the first time, surface rupture showing a few metres (2–5 m) of displacement has been recorded on the ground after the Muzaffarabad earthquake. Analysis of SAR (Synthetic Aperture Radar) data from the European space agency's Envisat by a group from the Geographical Survey Institute of Japan, has revealed a ~ 90 km long strip indicating details of crustal deformation suffered by the ground as a result of the 8 October 2005 earthquake[1]. This strip of coseismic deformation extends northwest–southeast from Balakot to Muzaffarabad and towards Uri. Prior to the Muzaffarabad earthquake, an active fault of en-echlon pattern trending northwest–southeast and extending ~ 60 km from Balakot to Muzaffarabad and further southeast along the Jhelum river was mapped by Nakata and coworkers from Hiroshima University[2]. The trace of this active fault, lying along the rupture zone defined by the aftershocks, coincides with the alignment of maximum deformation identified in the SAR data map. These observations indicate that the earthquake occurred on the pre-existing active fault mapped earlier by geologists. This underlines the importance of identification and mapping of active faults in the Himalaya and adjoining regions for estimating the future earthquake hazard and risk. The SAR satellite data show details of crustal deformation in the fault zone suffered by the ground as a result of the earthquake. The movement of deformation is measured in centimetres as a function of change in length along the radar LOS (line of site) from the ground position to the SAR satellite. Areas like Muzaffarabad and Balakot that suffered maximum damage also indicate highest values in terms of movement of deformation in the SAR data map. Such mapping of crustal deformation using SAR satellite data can be used for estimating the earthquake-damaged areas and the extent of damage through quick simulation to provide immediate relief and rescue operation.

The Mw 7.6 magnitude Muzaffarabad earthquake occurred in the segment northwest of the Kashmir gap region, having a different tectonic framework from that of the Kashmir–Kangra segment. There is no historical record for the last 500 years, since the Mughal period, that a large earthquake of magnitude $Mw \geq 7.6$ struck the Muzaffarabad region. On this premise it appears that the recurrence interval of a large earthquake with magnitude $Mw \geq 7.6$ m is probably more than 500 years. In the segment of the Himalaya, south of the Great Himalaya and between the Satluj and the Indus rivers, three large earthquakes of magnitude ≥ 7.5 have occurred during the last 450 years. These are east to west, the 1905 Kangra, the 1555 Kashmir and the 2005 Muzaffarabad. The rupture length of the causative fault for the Muzaffarabad earthquake is estimated at ~ 70 km, and that of the 1905 Kangra earthquake with magnitude Mw 7.8 (revised) is ~ 90 km. As the 1555 Kashmir earthquake and 1803 Garhwal earthquake have been assigned magnitudes Mw 7.5 and 7.4 respectively[3], their rupture lengths may range, ~ 60–70 km. Placing the lateral extents and near-approximate locations of the rupture zones of the 1555, 1905 and 1803 earthquakes in the map reveals two unruptured segments of 70–80 km long faults between the ruptured segments in northwestern Himalaya. The unruptured segments capable of generating large earthquakes are (a) western Himachal–eastern Kashmir (Chamba and Doda districts), and (b) eastern Himachal–western Garhwal (Simla, Sirmur and Chakrata districts). Since there is no historical record of a large earthquake say with magnitude $\geq Mw$ 7.5 in the region of unruptured segments, it calls for focused attention in making hazard assessment.

Three-pronged concerted initiatives are proposed (i) Mapping of the active faults and palaeoseismological studies. This will call for easy availability of air photos and high-resolution satellite images. Quantitative measurements of relative displacements using GPS along/across the proven active faults. (ii) There is a need to develop an expertise in application of SAR satellite data for crustal deformation studies across the active fault zones and simulation study for post-earthquake relief and rescue. (iii) Enhanced coverage of seismicity-monitoring in the unruptured segments.

1. Fujiwara, S. *et al.*, *EOS*, 2006, **87**, 73; 77.
2. Nakata, T., Tsutsumi, H., Khan, S. H. and Lawrence, R. D., Special Publication, Research Centre for Regional Geography, Hiroshima University, Japan, 1991, vol. 21, p. 141.
3. Ambreys, N. and Douglas, J., *Geophys. J. Int.*, 2004, **159**, 165–206.

V. C. THAKUR

Wadia Institute of Himalayan Geology,
Dehradun 248 001, India
e-mail: thakurvc@wihg.res.in