MEETING REPORT

Natural resources management, environment and employment*

In tune with the objective of broad basing of geoscience instruction, the participants at this Refresher Course included not only teachers in geoscience, but also in civil engineering, environment, and economics. The course was strongly interactive, and all participants were required to make individual presentations, which were moderated by experts. The highlight of the course was the Roundtable Discussion on 'Natural Resources Management, Geoscience Instruction and Jobs', with Arun Nigavekar, Chairman, UGC, as Moderator – it explored various ways and means of addressing the serious situation in geoscience instruction.

The themes of the course were chosen to address the twin objectives of broad-basing and employment orientation of geoscience instruction: Internet-based geoscience instruction (T. Harikrishnan and Prabhakar Pathak), Geomorphology (V. S. Kale), Meteorology (A. A. L. N. Sarma), Coastal resources management (R. Shankar and I. Radhakrisna), Land-use planning (M. Anjireddy), Remote sensing, GIS and GPS (I. V. Muralikrishna and D. P. Rao), Agriculture (S. P. Wani and M. V. Rao), Geophysical approaches (K. R. Ramanujachari, S. Murali and B. S. R. Murthy), Water resources management (V. V. N. Murthy, U. Aswathanarayana, G. Krishnarao, B. Venkateswararao and C. L. N. Sastry), Soil resources management (Hema Achuthan, Prabhu Prasadini and Saibaba Reddy), and Mineral Resources Management (P. K. Ramam, V. Malleswararao, G. V. Krishnarao).

In connection with the course, the following public evening lectures and colloquia on geoscience topics were organized: U. Cordani (Mahadevan Memorial Lecture), International Cooperation in teaching and research in geosciences; R. N. Bastia, East Coast gas deposits; P. Ramarao, Paradigm of knowledge-driven economic development; Harsh Gupta, Ocean development, and geosciences; Colloquium on 'Are large scale water transfers necessary? (Discussants being U. Aswathanarayana and V. K. Jyothi); Colloquium on 'How to use R&D. In geosciences to create new jobs' (Discussants being B. L. Deekshatulu, U. Aswathanarayana, V. Divakararao and Prakash Rao).

There were two whole-day field excursions: one to Kothapalli watershed to study water and soil issues, and another to Robosand plant in Ankireddypalle to study no-waste technologies in the mineral industries.

The following is the consensus of the Roundtable Discussion.

Geoscience instruction in India is facing a serious crisis – instances are known of well-established university geology departments with more than a score of senior teachers having just a couple of M Sc students. This lack of demand for geoscience studies is a direct consequence of the paucity of employment opportunities for traditionally-trained geoscience graduates. In actuality, there has been a major shift in the employment market, but the geoscience instruction failed to respond to it, presumably because there are no in-built adaptive mechanisms to do so. The present situation is evidently unsustainable, and innovative ways and means have to be found to ameliorate the situation.

A practical way to make the geoscience education in India (and other developing countries) employment-generating, relevant to the needs of the country, modern flexible, affordable and of good quality, is to make it end-use oriented (rather than subject discipline oriented, as before) and broad-based (as earth system science). The end-use orientation can be achieved by designing course ensembles built around potential job clusters. The new kinds of jobs (e.g. poverty alleviation projects, via micro-enterprises based on value-adding processing of natural resources) have a strong environmental relevance, and tend to lie at the interfaces of several traditional scientific disciplines. The broad basing of geoscience has a number of dimensions, such as customized inputs of fundamentals of physics, chemistry, mathematics and life sciences, integration of geology, geophysics, geochemistry and geobiology, and linkage with cognate subjects, such as meteorology, pedology, land-use planning, oceanography, etc. The key words are synergy and flexibility.

The following are the basic elements of the strategy to enhance the employment opportunities in geosciences through broad basing of geoscience instruction:

(i) Identify broad-spectrum geoscience jobs (say, 30–50) based on existing and emerging technologies, social, environmental and industrial requirements (e.g. drinking water, integrated wasteland management, beneficial use of mine tailings and effluents, soil health), and also those that are needed to maintain India's global position in cutting-edge sciences and technologies (e.g. space science, exploration for hydrocarbons on the seabed, geotechniques). Experience shows that the candidates who have skills in remote sensing, GIS and GPS, and computers have the least difficulty to get jobs. Hence all geoscience instruction should include these skills in their framework, as there is a demand for them.

(ii) Design about 100 course ensembles for the above jobs. Some courses may be planned at two levels – undergraduate and post-graduate.

(iii) Design possible curricular structures (say, a four-year resource engineering course, a two-year M Sc/M Tech Course in Natural Resources Management/Earth and Space Sciences, Certificate/short term courses to impart special skills such as Remote Sensing and GIS, Evening courses and Distance education, etc.). Synergy is promoted through the linking of geoscience with other cognate subjects. For instance, the University of Hyderabad is contemplating the establishment of a School of Earth and Space Sciences (which incidentally will have access to super-computing facility in the University, and which will be linked to the National Remote Sensing Agency and the National Geophysical Research Institute, both based in Hyderabad) not only to extend the frontiers of knowledge (e.g. assimilation and validation of hydrologic

*Based on the Refresher Course for earth science teachers conducted by the Indian Academy of Sciences, at Hyderabad from 3 to 15 November 2003.

data), but also to provide employment in the inter-disciplinary areas of earth, space and information sciences (e.g. simulation and optimization of transportation networks). That the recently instituted M Sc course in Natural Resources Management offered by the Mysore University, succeeded in attracting a significant number of students, is an indication of the viability of the proposed approach.

(iv) From the 'smorgasbord' of courses, a geoscience department may choose appropriate course ensembles and specializations, and course structures to suit their academic and financial, resources, and biophysical and socio-economic situations. Those undergraduate departments of geology, which have only one or two teachers and are sub-viable, should be either merged to constitute viable units capable of offering instruction in employable knowledge and skills or abolished, as their continuance serves no useful purpose.

(v) It has been found that even though some universities have departments of geology, geophysics, meteorology, etc., they tend to work as separate entities, with hardly any coordination among them. A mechanism has to be designed to facilitate the offering of the multi-disciplinary courses by the departments jointly.

(vi) The need for the geoscience courses to have strong linkages with industry cannot be overstated. Experts from the industry should be persuaded to give short-term courses in the universities, which could be made use of by a number of universities in a region.

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FROM THE ARCHIVES

CURRENT SCIENCE

Vol. XII] JULY 1943 [NO. 7

Astronomical research in India: I

Astronomy is the oldest of the natural sciences, its beginnings being traceable to the remotest periods of recorded human history. There is ample indication in ancient Sanskrit literature of the interest with which the subject was studied in India from the earliest times, while the later writings of Aryabhatta, Varahamihira, Brahmagupta and of Bhaskaracharya, which have come down to us, show that astronomy was actively studied in India at a time when the lamp of learning lighted by the ancient Greeks had burnt out, and Europe was passing through the dark ages. The vicissitudes of Indian history in the later centuries of the present millennium were not favourable to the development and expansion of cultural interests. Some indication that active interest in astronomy nevertheless did not altogether disappear in India is furnished by the astronomical instruments of an earlier era which have been preserved to us, and by the curious structures known as Jaisingh's observatories which are still to be seen at Delhi, Benares and Jaipur.

During the three hundred and odd years which have elapsed since Galileo first directed his little telescope towards the heavens, the progress of astronomical science has been of the most spectacular character. This progress has largely been the result of the success achieved in making bigger and better telescopes. A study of the fascinating autobiography of John A. Brashear—the American who loved the stars and made great telescopes for observing them—may be warmly recommended to any one who is interested in the development of astronomical research in India. It brings home to the reader the extent to which the progress of astronomical science in a country depends on the existence in it of skilled opticians who can grind, polish and figure great lenses and mirrors up to the most exacting requirements. Without telescopes, interest in astronomy must languish, and without an active interest in astronomy, there obviously can be no telescopes in a country. That was the vicious circle, which Brashear sought to break in a spirit of genuine altruism. The immense interest in astronomical science and the generous support accorded to it by wealthy men in the United States of America must, to no small extent, be credited to the influence of Brashear's life and work. The making of great lenses and mirrors is practical optics on an engineering scale, and it is no accident that Brashear was a mechanical engineer before he became a maker of telescopes. The mounting and driving of telescopes is also mechanical engineering of a very exacting nature. In a modern observatory, the ton-loads of material making the telescope and its accessories move with the same accuracy and smoothness as the hands of a wrist-watch go round its dial. Optics and engineering are the handmaids of observational astronomy without whose services she cannot live and flourish... .

As some of the outstanding results of astronomical research which have influenced the orientation of scientific thought, we may mention the discovery of the finite velocity of light by Romer, of aberration by Bradley, of the laws of planetary motion by Kepler, of the dark lines in stellar spectra by Fraunhofer, of helium in the sun by Lockyer, of the magnetic field in sunspots by Hale, and of the recession of the nebulae by Hubble. When we examine the structures of modern physical and chemical thought, we find that they are laid on foundations built out of the results of observational astronomy. *Vice versa*, observational astronomy calls to its aid all the resources of the experimental physicist, while astronomical thought and speculation have as their basis the well-established laws of experimental physics and chemistry.

It will be evident from what has been said that the organization of scientific research in India must be considered radically defective unless and until adequate provision is made for astronomical study and research of the highest grade in the country.

C. V. Raman