was stressed by M. Agrawal (BHU). Success stories of VIS who have gone on to careers in science in different parts of the world were shared by B. P. Mandal. In the next session, the manner in which VIS can participate in hands-on activities as well as serious experimentation was demonstrated, and the importance of scaffolding mechanisms was explained. Shruti Pande shared some simple on-line tools that aid basic science learning. Parimal Das emphasized the need for more such camps. In the concluding session, O. N. Srivastava enlightened the audience on the development of Braille, and highlighted modern technologies that can help science education for VIS.

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MEETING REPORT

Luminescence dating*

Chronology plays an important role in determining the timing of geological and climatic events that shaped the earth's surface processes, particularly during the Quaternary period, as this lays the foundation of understanding our recent past and predicting possible future scenarios. Considering that the major focus in Quaternary research is on the earth's surface processes, climate change and human–cultural interactions, it is thus pertinent to secure the chronology of these events identified using various proxies. Hence improving the numerical ages and techniques for Quaternary sediments and artifacts is crucial for Quaternary research. In the Indian context, over the last few decades, the luminescence dating technique has made a significant contribution towards providing secure chronology on dunes, fluvial deposits, glacial/paraglacial sediments, coastal deposits and to some extent on archaeological materials. Luminescence dating exploits the trapped charges that accumulate from the ionizing radiation delivered by the naturally occurring radioactive elements to the mineral crystals. Similar to other dating methods, age may be estimated if the total number of trapped charges in the crystal is known – which is a function of the ambient radiation dose; and is divided by the dose rate – dictated by the concentration of radioactivity surrounding the datable sample. However, the technique involves various assumptions, preconditions and measurements to arrive at a reasonable estimate of time. For example, the samples should be adequately bleached before burial, linear radiation dose-response of the sample in a natural environment, secular equilibrium in radioactivity, near-reasonable estimation of sample-water content history and lastly, the models used in computing the ages.

If the protocols are not standardized for all laboratories in the country, there may be discordance in the ages. In view of this, a workshop was held to encourage standardized protocols and adoption of a consistent methodology by all the laboratories.

Inaugurating the workshop, the Director, Birbal Sahni Institute of Palaeosciences (BSIP), Lucknow welcomed the participants and touched upon the significance of precise chronology for the Quaternary deposits, including the Anthropocene. The workshop provided a platform for researchers (both experts and end-users) who participated from various laboratories and institutions across the country, to discuss the problems, possible solutions, and latest research innovations in luminescence dating. The themes included sample-specific problems encountered, standardization of the protocols for dose and dose-rate measurement, format for reporting luminescence ages and data repository, formation of a national body (either formal or informal); and inter-laboratory calibration. Session-I was devoted for highlighting and discussing the sample-specific problems encountered in obtaining accurate and precise luminescence chronology. It included extracting quartz from feldspar-dominated samples, separation of mica from the sediments generated from crystalline-dominated Himalayan rocks, poor sensitivity of the Himalayan quartz samples, problems associated with dating young (~200 yrs) tsunami/cyclone sediments, widespread scatter in the equivalent dose (D_e) distribution of Himalayan sediments, and poor growth curves of sediments from regions like the Andaman. Discussion was also held on the current methodology of preheat plateau test, which involves giving laboratory dosage to bleached samples and estimating D_e at different temperatures. Due to the dominance of physical weathering, the Himalayan samples (usually quartz) show feldspar contamination. Hence the use of double single-aliquot regeneration (SAR) (post-IR blue optically stimulated luminescence (OSL), was suggested to avoid the luminescence contribution from feldspar. Another major problem encountered, particularly for the Himalayan and Andaman quartz, is the poor luminescence sensitivity. Therefore, various studies deviate from the conventional threshold values/ratios of 10% recycling ratio and 5% recuperation criteria so as to have reasonable number of aliquots. It was suggested that any such study-specific deviations must be included in text or supplementary materials as mandatory information, so that the results are replicated by various laboratories. Also, for defining minimum (reasonable) number of aliquots, it was proposed that a statistically rigorous procedure should be evolved to obtain reliable age estimate. A template for reporting tables and figures in a manuscript was formulated and users were encouraged to utilize it in all future communications. This includes (a) OSL shine-down curve (inset: infrared stimulated luminescence (IRSL) shine-down curve); (b) preheat plateau test with three values, viz. (i) measured (M)

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to given dose (G) ratio (M/G), (ii) recycling ratio, and (iii) recuperation signal (another axis); (c) dose–response curve or growth curve, and (d) at least two typical examples of dose distributions suggesting the best and worst luminescence behaviour. For reporting of the luminescence ages, the convention of reporting ages as kilo years or kilo annum (ka) is to be strictly followed.

The second crucial part of luminescence dating is the dose rate that is primarily dependent on U, Th and K concentrations. Currently, for dose rate estimation various laboratories use different instruments such as gamma spectrometer (NaI:Tl scintillation detector and high-purity geranium detector), alpha counter (ZnS:Ag) – NaI:Tl gamma spectrometer combination, and X-ray fluorescence (XRF)/flame photometry – inductively coupled plasma mass spectrometry combination, where results obtained differ in terms of accuracy and therefore may be incomparable. Suggestions were made to calibrate the instruments by standards so that dose rates may be compared from different laboratories. Three standards, viz. (i) mixed ores of U and Th and K dichromate with radioactively inert materials such as artificial quartz; (ii) sediment samples (with suitable mixing of U, Th and K) from Atomic Minerology Department, Hyderabad; and (iii) natural sediment samples to be collected by BSIP are to be prepared and sent to various laboratories for calibration.

For reporting of the luminescence ages, there is no such 'before present', like in radiocarbon ages, where BP means before 1950 CE. If at all BP is used, it indicates the sample collection date. Also, it was emphasized (as mentioned above), that key information such as the IRSL decay curves of quartz, preheat plateau test data, dose–response curve and dose distribution should be reported either in the manuscript or in the supplementary material.

It was also unanimously decided to formulate an Indian Association for Luminescence Dating, which will organize regular conferences and training workshops on luminescence dating. In this regard the first workshop is to be organized during December 2019 at National Geophysical Research Institute, Hyderabad. The workshop concluded future plans to improve the consistency of luminescence data/technique.

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