

Lorraine, France) and pentacene molecules adsorbed on aperiodic Cu surface (K. Pussi, Lappeenranta University of Technology, Finland). Further excitement is from aperiodic oxides that grow as two-dimensional quasicrystal on periodic single-element substrates – two-dimensional oxide quasicrystals, such as dodecagonal BaTiO₃ and SrTiO₃ on Pt(111) surface, reported by Stefan Forster (Martin-Luther-Universität Halle-Wittenberg, Germany), Wolf Widdra (Martin-Luther-Universität Halle-Wittenberg and Max-Planck-Institut für Mikrostrukturphysik, Germany) and Junji Yuhara (Nagoya University).

Quasicrystal materials have several applications, many of them related to technologies for most urgent issues such as the environment. One of them is hydrogen absorption in Ti-based quasicrystals. This issue is important from the point of view of hydrogen-based fuel for automobiles, etc. Rohit R. Sahi (Motilal Nehru National Institute of Technology,

India) talked about the effect of nanocrystallinity and composition of the quasicrystal phase on hydrogen storage capacity. Several of the applications depend upon the surface properties of the quasicrystals. A prime example is a self-lubricating, low-friction and wear-resistant coating, discussed by Jean-Marie Dubois (Université de Lorraine, France). Other examples are hydrophobic coatings by Ming-Sheng Leu (Industrial Technology Research Institute, Taiwan), and soft metal abrasive material by Yongjun Chen (Dalian University of Technology, China). Another application of quasicrystals is as a reinforcement in composites, such as in lightweight magnesium alloys or with polymers. The latter can be used for 3D printing and medical implants. A bioactivity study of such a composite was shown to be most suitable for bioimplants by Guillaume Cini (Université de Lorraine). Mechanical property study of another such composite was presented by Thakur P. Yadav (Banaras Hindu

University, India). A study of deformation behaviour of quasicrystal particles in a magnesium matrix was presented by Alok Singh (National Institute for Materials Science, Japan), showing them to be very strong.

Details of the conference and abstracts of all presentations can be found at <https://www.liverpool.ac.uk/conference-onquasicrystals>.

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MEETING REPORT

Shallow subsurface investigations for resource exploration and hazard estimation*

The international workshop which held at ISR, Gandhinagar encompassed five major themes, namely: (i) Exploration of groundwater and minerals; (ii) Geothermal resource mapping; (iii) Air and space-borne geophysical investigations; (iv) Active fault mapping; (v) Seismic hazard assessment (SHA): macro–micro and site specific and societal impact of SHA.

Welcoming the delegates the Director General, ISR emphasized the need for shallow subsurface mapping. Understanding the top 1 km of the earth's crust is critical for sustenance of mankind. In view of the many challenges involved in probing this layer with high resolution,

multidisciplinary investigations are required to decipher useful information about the mineral resources which can bring economic benefits to the society. The keynote address was delivered by Arun Kumar (Western onshore Basin, ONGC). He informed the delegates about the activities of ONGC in resource exploitation. He opined that ONGC has acquired enormous data through geophysical investigations, which contains a wealth of information about the shallow surface. This information can be further used according to the needs of various stakeholders.

During the first plenary session, S. K. Biswas presented a glimpse of the genesis of active faults of Kachchh region and their implications towards seismic hazard. Antonella Pearesan talked about assessing performances of seismic hazard maps, their reliability and comprehensive characterization of expected seismic ground shaking. She opined that after every major earthquake, we need to examine the existing hazard maps, validate

and periodically update them as and when new information is available. Yi-Ching Lo delivered a talk on shallow surface tomography and topography effect on ground motion in northern Taiwan region. V. P. Dimri presented a talk on the investigation of scaling sources of geophysical anomalies for exploration.

The second session was devoted to advantages of time domain electromagnetic methods for resource exploration. S. K. Verma provided an overview and advantages of airborne EM surveys and presented the results of identification of palaeochannels in Rajasthan. Pavan Kumar discussed the ground-based TDEM surveys and presented a case study on the results of delineation of deep aquifers in the Kachchh region of Gujarat. Shakeel Ahmed emphasized the need for airborne resistivity surveys for delineating aquifers in an urban area where ground-based surveys cannot be carried out. Kapil Mohan discussed the efficacy of MT method in delineating geothermal zones. Hirok Chaudhuri

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presented a talk on 'A promising geothermal resource for power generation'. Bibhas Karmakar deliberated on evaluating the gas content in coal bed methane (CBM) and prospective recovery from the Jharia Coalfield, India.

During the third session on shallow surface investigations for hazard assessment, A. P. Singh emphasized the importance of the use of non-invasive micro-tremour investigations in mapping shallow structures. Satyanarayana presented case studies of 2D/3D seismic surveys and brought out their efficacy in mapping shallow sub-surface structures. Bor Shouh Huang presented a talk on high velocity gradients in shallow sediments of the SW Taiwan Plain and its effects on strong ground motion propagation. B. K. Rastogi synthesized the importance of various geophysical investigations in imaging faults, basement and crustal configuration.

Active fault mapping is important for assessing long-term seismic hazard of any region. Initial results from Himalaya and Kachchh region pertaining to a major programme on active fault mapping in various parts of India initiated by the Ministry of Earth Sciences, was presented by C. P. Rajendran, Javed Malik, Girish Ch. Kothyari and Siddharth Prozumwala. Kusumita Arora, in the second plenary session, emphasized that lineament analysis combining airborne LiDAR data along with borehole data provides direct evidence of subsurface faults. N. P. C. Rao presented a talk on ambient seismic noise correlation tomography for characterizing earth structure, hazard monitoring and exploration. Yih-Min Wu presented the results of the performance of a low cost earthquake early warning system (EEW) during the recent ML 6.4 Meinong Earthquake in Taiwan.

The last session of the two-day workshop was on seismic hazard assessment: macro, micro and site specific. V. K. Gahalaut presented a case from the Tehri dam to demonstrate the significant influence of surface processes on increasing seismicity of a region. B. R. Arora delivered a talk on time evolution of seismicity in the Himachal Himalaya following the 1905 – M_w 7.8 Kangra earthquake and its implications on seismic hazard of the region. T. G. Sitharam delivered a talk on seismic zonation schemes at different scales in India. Sumer Chopra presented case studies of seismic micro-zonation and site-specific studies being

completed and carried out in the Gujarat region by ISR. Dinesh Kumar delivered a talk on the evaluation of seismic hazard in the central seismic gap region through a scenario of a moderate ($M7$) and a great ($M8.5$) earthquake, using hybrid technique of simulation. In the concluding talk, D. Srinagesh spoke on the societal impact of seismic hazard assessment.

During the panel discussion on current challenges in resource exploration and hazard estimation and future strategies, S. K. Verma emphasized the need for Heliborne EM geophysical surveys for high resolution subsurface mapping. Such studies can be used in identifying deep groundwater aquifers, major geological discontinuities as well as identifying mineral resources. Shakeel Ahmed talked about the importance of *Unmanned Aerial Vehicles* (UAV) for groundwater mapping in a short duration. Rao spoke on the efficacy of ambient noise studies for 4D mapping of subsurface structures and their role in resource exploration. S. K. Biswas pointed out the need for integration. Kusala Rajendran urged hydrogeologists to focus on the severe urban water problems, and suggested borehole logging studies to understand the groundwater behaviour. Srinagesh stressed the need for integrating all geophysical studies, viz. seismics, MT, electromagnetic, gravity and magnetic for identification of subsurface structures and mineral deposits.

C. P. Rajendran advised researchers to be careful in stating important outcomes of their studies. He also advised that routine work should be discontinued and the scientific community should ask questions that can enhance the quality of the outcome and interpretation. Javed Malik mentioned that the active fault mapping initiated by MoES is an important programme and we should be extremely careful in making any benchmark points. He emphasized on the need to study strike-slip faulting in Himalaya and Kachchh regions and their role in earthquake generation process. Li Zhao spoke about the need for installation of seismographs/accelerometers at small inter-station spacing for better imaging of the subsurface. Vineet Gahalaut suggested that researchers should update and modify earlier proposed concepts (seismic gap, etc.) through collating good data sets, using state-of-art technologies and new interpretation techniques. Kusala

Rajendran spoke about the necessity to study slip-partitioning in Himalaya and the rest of the active regions and their integration with kinematics of a particular region. P. C. Rao emphasized that studies on rupture modelling and inclusion of time and space in modelling is very important and new techniques should be implemented to better understand earthquake generation process. M. Ravi Kumar spoke about the need for a paradigm shift from data oriented research to process oriented research. He stressed that the best minds should work together for making a global impact. B. K. Rastogi conveyed that MoES/DST or other agencies should identify research problems and working groups should be created accordingly for solving the scientific issues.

A. Peresan pointed out that ground shaking models must be critically checked with good data sets. Yih Min Wu from Taiwan talked about an urgent need of gathering more data sets for realistic estimates of hazard parameters. He informed that mobiles can be used for recording ground accelerations. Sitaram stressed the need for interdisciplinary mapping of shallow subsurface. He emphasized that scientists should educate the society by regularly visiting schools and colleges. Srinagesh suggested that a uniform earthquake catalogue should be prepared. Sumer Chopra said that an active fault map of India needs to be prepared. He informed that these days all smartphones have MEMS-based accelerometers, which can be used to record the ground accelerations. Dinesh Kumar advised that seismic hazard maps should be made available to common people. Tulasi Raman talked about a need to calibrate different sites in various parts of India for validity of data as well as models. Singhvi stressed the need for multidimensional studies and implementation of new research projects on a mission mode, understanding the physics of earthquakes, studies on critical zones of India and evacuation strategies in case of natural hazards, in-house making of instruments and usage of social media (whatsapp/facebook) for community awareness.

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