

## Deformation Mechanisms, Processes and Fabric Analysis in Earth Materials from the Global to the Nano scale – Methods and Applications– A Report of the IASGT Workshop-2024 held at IIT Kharagpur, India

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A workshop, “Deformation Mechanisms, Processes and Fabric Analysis in Earth Materials from the Global to the Nano scale – Methods and Applications”, was held during 26–28 February 2024 at the Indian Institute of Technology (IIT) Kharagpur. The workshop was organized by Prof. Manish A. Mamtani (Department of Geology and Geophysics, IIT Kharagpur) under the aegis of the International Association for Structural Geology and Tectonics (IASGT), affiliated to the International Union of Geological Sciences (IUGS). It was interesting to note the intriguing philosophy of IASGT which is specified in its logo. The logo reads “ex solo ad solem, *Vadudeva-kudumbagam*” (the first phrase taken from Latin and the second from Sanskrit) which translates to “from the earth to the sun, the world is one family”. A synopsis of this could be seen in the IASGT workshop, where internationally renowned structural geologists, from different countries, delivered 17 lectures during the 3 days with the idea of sharing their knowledge with young participants. A total of 200 participants attended the workshop with 80 females and 120 males; a large number of them were research scholars and M.Sc. students, apart from scientists and professors, from various institutes, colleges and universities of India (a few also from abroad). 71 abstracts were accepted for publishing in the Abstract Volume and were presented as

posters providing a unique platform to young scientists to discuss their research with globally acclaimed geoscientists. The IASGT workshop-2024 was financially supported by the Alexander von Humboldt Foundation (Germany), IUGS, German Research foundation (DFG) and Geological Society of India (Regional Centre Kharagpur) and industry partners - Rio Tinto India Pvt. Ltd., DHR Holding India Pvt. Ltd. (Leica Microsystems), Oxford instruments India Pvt. Ltd., Carl Zeiss India (Bangalore) Pvt. Ltd., Censico International (Agra, Indian agents for Buehler, USA), and IR Technology Services Pvt. Ltd.

Scales have significance in Structural Geological investigations. Whilst some researchers work on continent deformation and regional tectonics, others investigate phenomena at the grain boundary scale. Although field data form the foundation of Structural Geology investigations, the understanding of rock deformation processes is substantially enhanced on data from experiments, rock mechanics, microstructural investigations, numerical modeling and other laboratory based techniques viz. Magnetic fabric measurement, X-ray micro CT, SEM-EBSD, AFM, etc. This was highlighted in the introductory lecture (Structural Geology is a “Game of Scales”) by Prof. Manish Mamtani, Convener, IASGT workshop-2024. The workshop covered the aspects related to Exhumation, Continental



Group Photograph taken during the IASGT Workshop - 2024 held at IIT Kharagpur, India from 26-28 February 2024.

deformation, Microscale process, Rheology Geodynamics, Kinematics, Nanostructures, Magnetic methods, Fracture quantification, Porosity/ Permeability and reservoir quality prediction, Numerical modelling of microstructures, Geophysical data inversion and glaciology. These covered through lectures – (1) Exhumation processes and tectonics – theory and examples (Rodolfo Carosi, Italy) (2) The significance of quartz deformation for the rheology of the Earth's crust (Michael Stipp, Germany) (3) Structural geology and reservoir rocks – the importance of structural diagenesis (Christoph Hilgers, Germany) (4) The experimental study of the rheology of mantle rocks (Dan Frost, Germany) (5) Using EBSD analysis to decipher the geological history of rocks and minerals: overview and case studies (Sandra Piazzolo, UK) (6) Anisotropy of anhysteretic remanence magnetisation (AARM) – principles and application in structural geology (M.Irene B. Raposo, Brazil) (7) Strongly anisotropic ferrimagnetic rocks and their implications for structural geology: case studies from Scandinavia (Agnes Kontny, Germany) (8) Interpreting magmatic processes, continental deformation and plate tectonics from anisotropy of magnetic susceptibility: fundamentals and challenges (Jiri Zak, Czech Republic) (9) Structural Geology, lessons from geology applied to ice sheets (Paul D. Bons, Germany) (10) Numerical simulation of rock deformation microstructures (Enrique Gomez-Rivas, Spain) (11) Continent-continent collision: 4D structures, rheology and geodynamic implications (Marco Herwegh) (12) Virtual 3D models from outcrop scale to thin section and beyond (Eugenio Fazio, Italy) (13) Architecture and kinematics of “Low angle normal fault”: Examples from the Alpine-Himalayan belt (Chiara Montomoli, Italy) (14) Fracture network and spatial arrangement quantification and the role of chemical/mechanical interaction across scales (Stephen Laubach, USA) (15) 2D&3D structural geology from regional geophysical datasets (Mark Jessell, Australia) (16) Mechanical anisotropy: how do crystal-scale processes in rocks control large scale dynamics (Maria-Gema Llorens, Spain) (17) Microstructures as deformation-related geothermo(barometers) (Jorn H. Kruhl, Germany).

Besides the lectures, there were two interactive sessions on “Deformation microstructures” with Michael Stipp and “Digital mapping” by Eugenio Fazio on day-1 and day-2, respectively. In the first session, the aspects of characterization of deformation conditions and microstructures were elaborated, while in the second, digital geo-structural mapping of crystalline complexes was detailed. Opportunities like these help young researchers keep up with the changes in the

field of geoscience research in general, particularly in structural geology. Both sessions went beyond the stipulated time, which is a proof of the active participation of youngsters and other scientists.

One of the highlights of the IASGT-workshop was the emphasis given to posters. The posters dealt with interesting topics that included fractal-fracture models with flow simulations, polyphase deformation in various regions, fabric analysis using various tools (AMS, micro-CT, SEM-EBSD, TEM), paleostress analysis using dykes, characterization of shear zones, relation between tectonics and Indian monsoon and many more. The abstract volume is freely available (Open Access) on Research Gate (<https://doi.org/10.13140/RG.2.2.10013.12008>) for the scientific community.

A team of referees was constituted by the Convenor to judge the five best posters. The best poster awards were presented to posters entitled: (I) Investigating relative roles of increasing structural distance from fault zone and mechanical anisotropies in localizing fractures: Insights from fracture characterization and attribute study, Ramgarh thrust, Sikkim Himalaya by Ammu J.K. and Kathakali Bhattacharyya (II) Polyphase deformation history of the Gyangarh-Anjana batholith in the Sandmata Complex (Aravalli Craton, northwestern India): Structures, zircon-monzonite ages, and tectonic significance by Manisha Sahu, Anwesa Banerjee, N. Prabhakar, J. Amal Dev, Suranjan Ghosh, Hetu Sheth, J. K. Tomson (III) Data processing of TEM images in tectonically deformed rocks by Rohit Ghosh, Anindita Sarkar, Jenny Ash, Ahin Roy, Manish A. Mamtani (IV) Spatial variations of fracture network patterns in Neo-Archean granites: implications in understanding late stage Precambrian brittle tectonics by Sirshendu Kumar Biswas, Juhi Sultana, Tridib Kumar Mondal, Md. Sakawat Hossain (V) The role of Dauphiné twin boundaries in misorientation distribution across random high-angle grain boundaries in quartz: insights from Electron Backscatter Diffraction (EBSD) and Atomic Force Microscopy (AFM) analysis by Soham Dey, Sandro Chatterjee, Sushree Ritu Ritanjali, Ritabrata Dobe, Rabibrata Mukherjee, Sumantra Mandal, Saibal Gupta.

The certificate presentation for best posters was followed by IASGT General Assembly that was chaired by Prof. Manish A. Mamtani (President, IASGT). Matters related to membership, funds, future road map of IASGT were discussed during the General Assembly. The workshop was well-attended and the deliberations during the 3 days will contribute to the global progress of Structural Geology in this century.



Best Poster Award Ceremony during the IASGT General Assembly on 28-February-2024 at the end of the IASGT Workshop-2024