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Decoding Clastic Sedimentary Systems: Report

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Sedimentology plays a key role in hydrocarbon exploration as it helps in identifying and interpreting sedimentary environments, which in turn helps in locating potential hydrocarbon reservoirs. Also, for a better understanding of the surface processes of the earth, interdisciplinary study of allied branches of geosciences is necessary.

The Department of Geology, Aligarh Muslim University, Aligarh (India) under the aegis of the Indian Association of Sedimentologists organized Training-cum-Field Workshop on "Decoding Clastic Sedimentary Systems" during February 20-25, 2024.

Here, we present a detailed report of The Training-cum-Field Workshop. The workshop aimed to impart training to students, research scholars, early career researchers and industry professionals on various aspects of clastic sedimentary systems including sequence stratigraphy, basin analysis, prospect evaluation, exploration of unconventional resources, depositional environment and paleocurrent analysis of siliciclastic rocks, etc. The workshop included classroom lectures covering wide ranging topics in sedimentology to enhance the knowledge of clastic sedimentary systems of the young students and experienced professionals. It also comprised tutorials and hands-on exercises on sequence stratigraphy, paleocurrent analysis, thin section study of siliciclastic rocks and drone-based topographic change detection exercise. A two-day dedicated field training was conducted in nearby sedimentary basins as part of the workshop.

Figure 1: View of the dais during the Inaugural Function of the Training-cum-Field Workshop "Decoding Clastic Sedimentary Systems" on February 20, 2024. (L-R): Prof. Rashid Umar (AMU), Prof. Kr. Farahim Khan (Chairperson, Department of Geology, AMU, Aligarh), Prof. Q.H. Ansari (Dean, Faculty of Science, AMU, Aligarh), Chief Guest - Dr. Kalachand Sain (Director, Wadia Institute of Himalayan Geology, Dehradun), Guest of Honour - Prof. Partha Pratim Chakraborty (University of Delhi) and Prof. M.E.A. Mondal (Convenor, AMU).

110 participants from different institutions across India attended the workshop. Outstation participants included students from MS University of Baroda, Kumaun University (Nainital), University of Calicut, Birbal Sahni Institute of Paleosciences (Lucknow), IISER Kolkata, University of Kerala, University of Lucknow, Indian Institute of Petroleum and Engineering (Visakhapatnam), KJ Somaiya College of Science and Commerce (Mumbai), Central University of Kerala, University of Delhi, IISER Mohali, ONGC and Aligarh Muslim University. Due to limited logistic resources in the Bayana town of Rajasthan, only 45 early bird registered participants (first come-first serve) out of the 110 participants, were selected for the fieldwork program. Remaining participants attended the lecture series and the dedicated workshop on sequence stratigraphy.

Eight renowned experts of sedimentology and allied fields rendered their services as resource persons for the workshop. The experts included ***Dr. Kalachand Sain*** (Director, Wadia Institute of Himalayan Geology, Dehradun), ***Prof. Partha Pratim Chakraborty*** (University of Delhi), ***Dr. Sandip Kr. Roy*** (Retired Petroleum Geoscience Expert from Petronas, Malaysia), ***Mr. Riyasat Husain*** (Retired

TPL Specialist 1 Geology from Kuwait Oil Company), ***Prof. Uma Kant Shukla*** (Banaras Hindu University), ***Prof. M. Masroor Alam*** (ZHCET, AMU), ***Dr. Arvind Kumar Singh*** (Birbal Sahni Institute of Paleosciences, Lucknow) and ***Dr. Yunus Ali P.*** (IISER Mohali). The workshop received fundings/sponsorships from industry, alumni and individuals that include Oil and Natural Gas Corporation Limited (ONGC), Council of Scientific & Industrial Research (CSIR), M/s Syed Akhtar Ali Group, Owais Metal and Mineral Processing Ltd (OMMPL), Rawbare, Techno Consultant, Mr Rizwan Ahmad and Mr. Syed Sifat Ali.

Figure 2: Audience during the Inaugural Function of the Training-cum-Field Workshop "Decoding Clastic Sedimentary Systems" on February 20, 2024.

The inaugural function of the workshop was held on February 20, 2024 which was followed by three lengthy but productive technical sessions highlighting important aspects of sedimentology, field geology and use of remote sensing/technology in geosciences. Dr. Kalachand Sain, a renowned geophysicist and Director of the Wadia Institute of Himalayan Geology (Dehradun) and Prof. Partha Pratim Chakraborty of the University of Delhi (Delhi) served as the Chief Guest and Guest of Honour, respectively, of the inaugural session on February 20, 2024.

Dr. Kalachand Sain delivered a plenary talk on "Energy Resources and Energy Security in India". Addressing the gathering, Dr. Sain said that energy is the main driver for socio-economic development of any country. He further added "As the world grapples with the carbon footprint in the current climate change scenario, efforts are being made to find alternatives to fossil fuels". He highlighted that despite the potential of renewable/green energy sectors such as solar, wind, ocean current or wave or tidal, geothermal, hydrogen, hydro, biofuels, and waste-to-energy, no significant advancement has been made and currently 80% of the global energy requirement is met by fossil fuels – a trend that is likely to continue for a few more decades.

Dr. Sain also emphasised that to meet the United Nations' target of carbon neutrality by 2050 and net zero carbon emission by 2070, research on Carbon Capture, Utilisation and Sequestration (CCUS) needs to be strengthened. He remarked that India produces only 30% of its energy requirement indigenously with no major oil/gas fields discovered in recent decades. Therefore, venturing into difficult terrains such as the fold thrust belts or foreland of the Himalaya, sub-volcanic regions in central-western India, and offshore, deep and ultra-deep waters for exploration is the need of the hour. He also said that the unconventional energy resources like submarine gas-hydrates, shale gas/oil, and coal bed methane (CBM) have great potential in India.

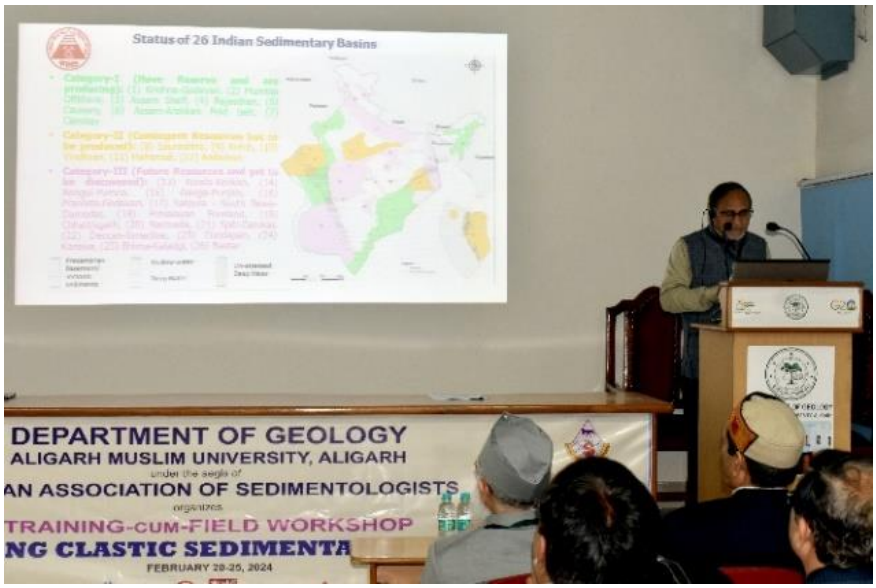

Figure 3: Dr. Kalachand Sain (Director, Wadia Institute of Himalayan Geology, Dehradun), Chief Guest of the inaugural function of the Training-cum-Field Workshop, delivering plenary talk on "Energy Resources and Energy Security in India".

Dr. Kalachand Sain said that science-technology-innovation interface is crucial to tap these resources in an economically affordable and environmentally safe manner.

Figure 4: Prof. Partha Pratim Chakraborty (University of Delhi), Guest of Honour of the inaugural function of the Training-cum-Field Workshop, delivering keynote talk on "Siliciclastic depositional systems: Processes and Products (with special emphasis on rock record)".

Prof. Partha Pratim Chakraborty, the Guest of Honour, stated that it is a unique form of training/workshop that includes fieldwork along with classroom-based lectures and tutorials. Prof. Chakraborty took five lectures (including two practical exercises) including "Siliciclastic depositional systems: Processes and Products (with special emphasis on rock record)", "Thin section study of quartz arenite, feldspathic arenite, arkose, lith arenite, etc." and "An introduction to Sequence Stratigraphy: A state-of-the art technique for Basin Analysis". He explained the nuances of sequence stratigraphy and its importance in petroleum industry. He said that sequence stratigraphy provides a comprehensive understanding of the depositional history of sedimentary basins and plays a pivotal role in the petroleum industry, particularly in the exploration and production of hydrocarbons. Throwing light on the history of sequence stratigraphy, he said it was proposed by the Exxon Group as a branch of stratigraphy that peeps into a sedimentary succession in spatio-temporal framework. Prof. Chakraborty said "sequence stratigraphy helps in identifying the depositional environments that are most likely to contain hydrocarbons. It allows us to understand the distribution and connectivity of reservoirs, which is crucial for efficient extraction". He explained that it also aids in the prediction of reservoir quality and emphasised that by understanding the sequence of events that led to the formation of a particular sedimentary layer, we can predict the porosity and permeability of potential reservoirs. He further added "sequence stratigraphy provides valuable insights into the migration paths of hydrocarbons and this knowledge is essential for locating traps and seals, which are key elements in the accumulation of hydrocarbons".

Prof. Chakraborty, in his concluding remark, highlighted that sequence stratigraphy is an indispensable tool in petroleum industry which not only enhances our understanding of sedimentary basins but also guides us in efficient exploration and production of hydrocarbons. He also conducted practical exercises on paleocurrent analysis and fundamentals of sequence stratigraphy.

Mr. Riyasat Husain (Petroleum Geoscience Consultant & Former TPL Specialist 1 Geology, Kuwait Oil Company) delivered a talk on "Basin analysis to prospect evaluation - Protocol for hydrocarbon exploration" explaining that the protocol for hydrocarbon exploration involves a systematic process starting from basin analysis, moving to prospect evaluation, and finally employing an integrated approach for a comprehensive evaluation. He said that this process helps in identifying potentially prospective hydrocarbon provinces and specific plays within them and that the ultimate goal is to locate and extract hydrocarbons in the most efficient and environmentally friendly manner. He also gave another talk on "Exploration of unconventional resources" in which he explained that exploration of unconventional resources involves a wide-ranging approach that includes understanding the geologic and petrophysical aspects, engaging advanced recovery methods, and leveraging the latest technologies for enhanced field development planning.

Another leading sedimentologist of the country, Prof. Uma Kant Shukla (Banaras Hindu University) presented an eye-catching talk on "Validation of Fluvial Models in the Himalayan Foreland Basin, India". He explained that validation of fluvial models in the Himalayan Foreland Basin involves a comprehensive approach that includes understanding gravel progradation, conducting sedimentary facies analysis, and employing other sedimentological models. He clarified that such process helps in understanding the complex interplay between tectonics, climate, and fluvial processes in shaping the basin.

Dr. Yunus Ali P. (IISER Mohali) gave a scintillating presentation on "Remote Sensing of fluvial systems, especially on the rapid river incision and sediment budget in Rishiganga following a major ice-rock avalanche" and practically demonstrated "drone-based topographic change detection" using a highly sophisticated drone camera.

Mudstones are important component of sedimentary record, preserving information about paleo-environmental conditions, paleoclimate and evolution of life on Earth. Dr. Arvind Kumar Singh (Birbal Sahni Institute of Paleosciences, Lucknow) gave a stimulating talk on "Mud and Mudstones: a repository of information on low energy environment and its processes" in which he explained that mud and mudstones serve as a significant repository of information on low energy environments and their processes. He highlighted that the fine-grained

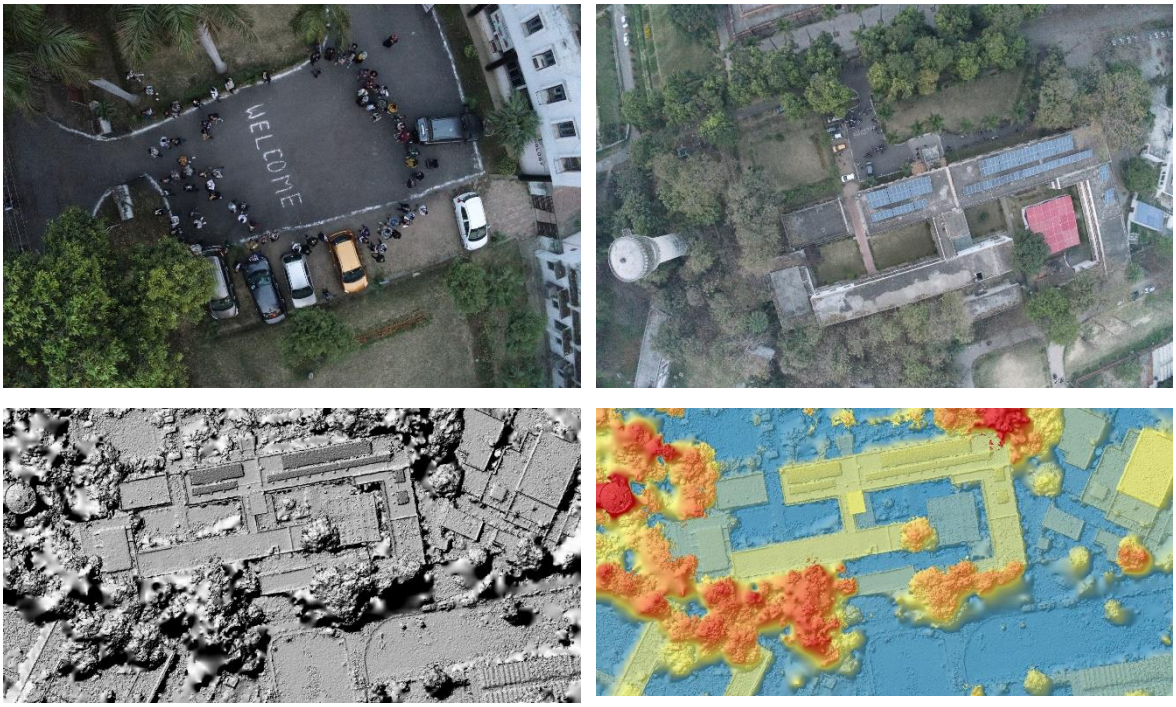

Figure 5: Demonstration of "drone-based topographic change detection" by Dr. Yunus Ali P. (IISER Mohali) during the Training-cum-Field Workshop on February 20, 2024. The photographs were captured using a high-quality camera mounted on a highly sophisticated drone. The bottom photographs are processed images.

Figure 6: Prof. Partha Pratim Chakraborty, Prof. Uma Kant Shukla and Dr. Arvind Kumar Singh leading from the front and explaining the nuances of conducting fieldwork in sedimentary basins to the participants during the Training-cum-Field Workshop on February 21-22, 2024.

nature of mudstones allows it to capture and preserve detailed sedimentary structures and microfossils, making it a valuable record for geologists studying Earth's geological history. Later, he conducted hands-on practical exercises on sedimentary rock classification.

The field training was led by Prof. Partha Pratim Chakraborty (University of Delhi), Prof. Uma Kant Shukla (Banaras Hindu University) and Dr. Arvind Kumar Singh (BSIP, Lucknow) alongside Prof. M.E.A. Mondal (AMU; Convenor) and Dr. Iftikhar Ahmad (AMU; Organizing Secretary). This fieldwork provided participants with hands-on experience and a deeper understanding of clastic sedimentary systems. It aimed at studying the geological features of the area and understanding their formation and significance in the context of clastic sedimentary systems.

Considering the continuous stress due to exhaustive technical sessions and fieldwork, and understanding the significance of mental health of the participants, the 4th Day of the Training-cum-Field Workshop (i.e., February 23, 2024) commenced with a brief tour of the Aligarh Muslim University campus during the pre-lunch session. The participants were overwhelmed on seeing the architectural and cultural heritage of the campus. The campus excursion was followed by a technical session encompassing lectures on sequence stratigraphy, clastic geochemistry, and geo-engineering during the post-lunch session

Figure 7: Group photograph of field party at a sedimentary outcrop of Bayana Basin (Delhi Supergroup) near Bayana Town in Bharatpur (Rajasthan).

Figure 8: Glimpses of the participants enjoying the museums, architectural and cultural heritages of the Aligarh Muslim University, Aligarh during the campus excursion on February 23, 2024 as part of the Training-cum-Field Workshop.

Figure 9: Lectures, practical exercises and interactive sessions on sequence stratigraphy conducted by Dr. Sandip Kr. Roy during the dedicated 2-day workshop on sequence stratigraphy on February 24-25, 2024 as part of the Training-cum-Field Workshop "Decoding Clastic Sedimentary Systems".

Sequence stratigraphy is a method developed to support geoscientists in the geologic interpretation of subsurface data. During the last leg of the 6-day event, the Training-cum-Field Workshop on "Decoding Clastic Sedimentary Systems" also featured a two-day (February 24-25, 2024) dedicated workshop on sequence stratigraphy by a renowned specialist of the subject, Dr. Sandip Kr. Roy. The workshop covered the basic terminologies of surfaces, systems tracts, sequence sets, and stratigraphic hierarchy, and their definitions. The method was described and applied in training sketches and datasets to later be used to interpret subsurface data in non-marine, shallow marine, and deep marine depositional settings.

The 6-day workshop came to conclusion with a valedictory session on the evening of February 25, 2024 (Sunday). The Chief Guest of the session, Dr. Sandip K. Roy, said he is overwhelmed on the active participation from the students during the workshop on sequence stratigraphy. He said that this workshop was a unique one which encompassed almost all fields and aspects of clastic sedimentology. He congratulated the Department of Geology, AMU, Aligarh for successfully and flawlessly organizing the workshop. Prof. Kr. Farahim Khan (Chairperson, Department of Geology, AMU) said such workshops that includes classroom teaching coupled with field training are rare and is the need of the hour to inculcate basic understandings of the subject of geology. He congratulated the organizing committee and the volunteers for their meticulous effort and making the workshop a grand success. Prof. M.E.A. Mondal, Convenor of Training-cum-Field

Figure 10: Few glimpses from the valedictory session. (Row 1; L to R): Dr. Sandip K. Roy (Chief Guest of the session) expressing his views about the workshop; and Prof. Kr. Farahim Khan (Chairperson, Department of Geology, AMU) speaking on the efforts of the organizing committee and thanking the resource persons, sponsors, participants, etc. for making the workshop a grand success.

Workshop, said that the workshop provided the participants with an opportunity to apply theoretical knowledge to practical scenarios, thereby enhancing their skills and understanding in these areas. Dr. Iftikhar Ahmad, Organizing Secretary of the Training-cum-Field Workshop, presented a detailed report during the valedictory session and said that the workshop served as a platform for the participants to gain a comprehensive understanding of clastic sedimentary systems and sequence stratigraphy. He further added that the event was successful in fostering a collaborative learning environment and promoting the exchange of ideas among the participants. Participants also shared their feedback and thanked the Department of Geology, AMU and Indian Association of Sedimentologists for giving them opportunity where they learned theoretical as well as practical aspects of clastic sedimentology. The valedictory session concluded with certificate distribution followed by a group photograph.

Figure 11: Few glimpses from the valedictory session (Row 1; L to R): Dr. Iftikhar Ahmad (AMU, Organizing Secretary) presenting a brief report of the workshop; and audience during the session. (Row 2; L to R): Prof. M. Masroor Alam (ZHCET, AMU) and Ms. Vedashree Athalye (KJ Somaiya College of Science and Commerce, Mumbai) sharing their experience with the audience. (Row 3; L to R): Mr. Abhinav Jain (BSIP) and Ms. Dilisha Saboor Kidwai (AMU) sharing their feedback.

Figure 12: Few glimpses of certificate distribution to the participants by Dr. Sandip K. Roy (Chief Guest of the Valedictory Session) and Prof. Kr. Farahim Khan (Chairperson, Department of Geology, AMU). (Row 1; L to R): Mr. Abhinav Jain (BSIP), Ms. Vedashree Athalye (KJ Somaiya College of Science and Commerce, Mumbai) and Mr. Kumail Ahmad (BSIP). (Row 2; L to R): Mr. Rohit Gupta (AMU), Ms. Sidrah Iram (Indian Institute of Petroleum and Energy) and Mr. Muhammad Fayez Rizvi (AMU). (Row 3; L to R): Ms. Sneha Saraswat (AMU), Ms. Dilisha Saboor Kidwai (AMU) and Mr. Pranav Vidhushekharan (KJ Somaiya College of Science and Commerce, Mumbai).

Figure 13: Group photograph post-valedictory session.