Editorial

Two Thousand and Twenty-One was a remorseful year for the geological fraternity of Lucknow University. Several esteemed members left us for the heavenly abode. One of them was Indra Bir Singh, an internationally acclaimed clastic sedimentologist who was not only a non-conformist geologist but also a great friend. To perpetuate his memory, his admirers proposed publishing a Memorial Volume and the Palaeontological Society of India readily agreed to this proposal. The guest editorial team approached many Indra Bir's friends and co-workers asking them to contribute articles for this volume. The result is this compendium of fifteen articles, dealing with varied aspects of sedimentology.

Conforming to Indra Bir's own intrinsic nature, the very first articles has a tone of challenge to the existing sedimentation paradigm. In majority studies, the attitude is to interpret apparently uniform sedimentation packages to have formed in a steady manner, without realizing the fact that sedimentation in any basin, is never continuous. Always there exists a depositional time lag between each layer. In their article *Choudhuri et al.* have elaborated and underscored this aspect and challenged the age-old principle of *Present is the key to the Past*. These authors have presented data specifying different rates of sedimentation in fluvial, lacustrine, shallow marine and deeper marine environments and compared them with the modern rates of sedimentation. The study demonstrates existance of several minor depositional puases between each lamina. Therefore each bedding plane represented a time lag. The study indicated the sedimentation break between each bed partly controlled by the prevalent climatic regime. Sedimentation is never continuous, although the magnitude of gap vary. Minor gaps in sedimentation are difficult to identify and these may or may not be represented by traditional erosional features. Such surfaces of omission are identified by rootlets, borings or truncation of burrows or hardgrounds. The authors concluded that 'individual break in time may be minor, but the cumulative figure in a formation will be significant.'

Interpretation of the origin of chert in any rocks always invites controversies. *Banerjee et al.* in their article have discussed the origin of the Mahakut chert breccia in the Precambrian rocks of the Kalagdi Basin. Their study suggests that it is a matrix supported chert breccia and much of it is formed as a result of replacement of stromatolitic/ non-stromatolitic carbonate protoliths. In such rocks, stromatolitic laminations and the oolitic structure have survived but the internal structures have been largely obliterated. Silicification took place during bulk dissolution of carbonates with precipitation of silica in the void spaces. These authors surmised, the Mahakut chert horizon was deposited as a shallow shelf deposit, within the photic zone. The unresolved issues are: volume and source of silica, rate and time of certification and brecciation mechanism, the last one could be due to seismic activity.

Ooids are common in the shallow water carbonates of all ages. *Thorie at al.* indicated that although microbial activity in the Neoproterozoic Kunihar Formation of Lesser Himalaya rocks is represented by the stromatolites and ooids, these have received scant attention of carbonate sedimentologists. Authors have studied ooids in this formation and classified them on the basis of size, cortical microfabric, morphology, and ratio of cortex to nuclei. The ooimmuration of stromatolitic and ooid clasts controlled the preservation of microbial imprints. The cortexes around broken ooids suggested agitation, while the composite ooids represented calmer environment. Micrite in the interstitial spaces formed by the microbial activity, while sparry cement was formed under agitated conditionthis.

The Kachchh Rift Basin consists of sediment packages of Jurassic and Lower Cretaceous representing three megacycles. The sediments of the Late Jurassic megacycle have been accommodated in the Jhuran Formation, a nearly exclusive siliciclastic unit. In this article, *Fürsich et al.* classified the Jhuran Formation into four members, the Lower, Middle, Upper, and Katesar, ranging in age from the late Early Kimmeridgian to the Barremian. These authors have recorded sedimentary dykes at three localities: in the middle and at the eastern cliff of the Jhuran River, at the Nirona dam and in the Jara Mara cliff. These well-spaced, near-vertical to slightly oblique dykes occur in dark-grey fine-sandy argillaceous silt. The sandstones are fine- to coarse-grained and display large bundles of cross beds, characteristic of deposits of the delta-front. The soft-sediment deformation structures, sandstone pillows and large floating slabs formed as result of seismic shock waves while the sandy material has been injected from a lower level. Liquefaction of the micritic matrix was also caused by seismic shocks.

Saha and Shukla studied the Nimar Sandstone of Bagh Group along three sections namely the Bagh Cave section, the Naingaon section, and the Hathni River section where thickness of this unit varies from 10m to 30m. They identified a ferruginous lower Nimar Sandstone and an upper calcareous Nimar Sandstone. Lithofacies analyses include, cross-bedded gravely sandstone, planar cross-bedded sandstone, herringbone cross-bedded sandstone, ripple cross-laminated sandstone, horizontal bedded sandstone, interbedded sandstone-siltstone-mudstone, gravelly mudstone, and bioturbated mottled trace fossil bearing mudstone. Similarly, upper Nimar Sandstone display four lithofacies: sandstone with the tidal bundle, small-scale cross-bedded calcareous sandstone, interbedded calcareous sandstone-siltstone-mudstone, and fossiliferous calcareous sandstone characterized by several ichnogenera. Comprehensive lithofacies analyses indicate a river-dominated estuary to tide-dominated estuary grading into neritic depositional environment.

It is well known that Indian continent moved northward after its break-up from the large Gondwana landmass and remained physically isolated during the Cretaceous Period. *Prasad and Parmar* in their article reviewed the evolution of biota on this northward drifting Indian plate and its biogeographic connections during this isolation time gap. In order to interpret that, authors have examined the fossil records of Upper Cretaceous Lameta Formation, Deccan intertrappeans, and the Kallamedu Formation. They inferred that the fauna of Gondwana affinity confirm a vicariant biogeographic scenario with many of the taxa having sister group relationships with those of Madagascar. Several taxa, and five plant groups are identified as endemic to India and made their way to Laurasia following India/Asia collision, thus supporting 'Out-of-India' dispersal hypothesis. The taxa of Laurasian lineages are interpreted to have dispersed into India using Kohistan–Dras–Oman island arcs as steppingstones, facilitated by a sweepstakes mode of dispersal. This review shows how focused and integrated research can significantly improve our understanding of a research problem and address many ancillary questions.

The tectonic activity along the ENE-WSW trending crustal scale Narmada-Son Fault (NSF) transecting through the central part of the Indian plate all through Cenozoic are well documented in literature. *Chamyal and his co-workers* assembled the evidence of Late Quaternary tectonic activity and near-surface characterization of NSF zone using Ground Penetrating Radar. The NSF in Gujarat is divisible into four segments bounded by cross-faults. Maximum intensity is observed in segment II where all north-flowing streams crossing the NSF zone show significant incision in Deccan Traps and alluvial sediments. The Nandikhadi River shows three significant falls and several rapids in trappean lava flows. Basaltic exposures in this river provide good data for defining the NSF zone, the tectonic activity along which has affected the Quaternary sediments. The sedimentation pattern shows significant control of the tectonic activities that are well exposed and studied in segments I and II. Active tectonic uplift along NSF has produced steep mountain front escarpments and abundant north-flowing parallel drainages that have provided an appropriate physiographic setup for alluvial fan sediments to be deposited in segments I and II. GPR and field data all along its length show that the NSF is a high angle south-dipping reverse fault that conforms to available seismic data.

Multi-storied sandstones characterize the Middle Siwalik rocks but In Jammu area mudstones are also interlayered. In their article, *Irfan et al*. made use of textural and facies characteristics for interpreting the depositional environment. The sandstones belong to silty- sandstone facies while the mudstones represented very silty-sandy-mudstone facies. The sandstones display planar-beds, trough cross-beds, and tabular cross-beds. Laminated mudstone and mottled mudstone facies are also prominent. Scour-fill facies is formed as result of erosion of mud and filling of sand in the scours. The mottled mudstone facies contain carbonate nodules and formed during pedogenesis. These authors described various statistical parameters to infer riverine domain for these sediments in which floodplain facies dominated. Study of the flow pattern suggested southerly flowing rivers during the deposition of Middle Siwalik in the Jammu area in northwest Himalaya.

Although fossil muroid rodent record of the Neogene Indian terrestrial subcontinent is well documented and is based mainly on isolated molars, the incisors have rarely been studied. *Singla et al*. in their paper presented a detailed analysis of enamel microstructure and assigned the rodent incisors from the middle Miocene Siwaliks of Ramnagar (J&K) to murine, cricetine and rhizomyine. Those from the late Miocene deposits of Kachchh (Gujarat) are assigned to murine, ctenodactyline and sciurine . Early and late Pliocene Siwalik rodent incisors have been assigned to murine, gerbilline and rhizomyine . These studies reveal that the Siwalik cricetid incisors differ from those of other murine incisors in possessing surface ornamentation. A few murines with thin modified radial enamel suggest a diet of hard substances and those with thick outer enamel indicate digging and burrowing behaviours.

Patel et al. in their article enumerated their studies on the Lahuradewa lake sediments that provided evidence for the earliest rice cultivation in the central Ganga plains at ~8.3 ka BP using depth profiles of phytoliths and paddy field diatoms. Other than the conventional chronology based on ^{14}C dates the changes in the *lake* biogeochemistry was determined by measuring TOC, N and S concentrations and their stable isotopes ($\delta^{13}C$, $\delta^{15}N$ and $\delta^{34}S$). A few ^{14}C dates measured on AMS were found to be in excellent agreement with earlier reported radiometric ^{14}C dates. Using various isotopic concentrations and their variations defined the depositional history of the lake and its subdivisions into four phases: pre-agricultural or peat zone, early-agricultural, deteriorating monsoon and the modern phase. These authors surmised that pre-agricultural phase sequestered capacious amounts of atmospheric C and N by developing Botrycoccus algae, which produces natural hydrocarbons.

Aharon et al. in their article studied a manned submersible, a 25-cm-long sediment core at upper bathyal depth in the Gulf of Mexico from a mound underlain by methane hydrates. Their study show that intense methane seepage has decimated, but not obliterated, the benthic foraminiferal community that includes many facultative anaerobes, dominated by two species of *Bolivina*. The remnant community has continued to exist at this site for over 2000 years. They observed a shift from a much higher foraminiferal density to persistent low values in the lowermost part of the core. Planktonic and benthic foraminiferal tests yield $\delta^{13}C$ and $\delta^{18}O$ profiles that are inversely correlated and exhibit anomalously negative carbon and positive oxygen isotope values. These isotopic anomalies are attributed to anaerobic oxidation of ^{13}C-depleted biogenic methane and intake of ^{18}O-rich fluids released during hydrate dissociation. Three lines of evidence attest to the complexity of reconstructing methane flow from foraminiferal records, and therefore stable isotopes cannot be used as a tool to confirm whether *Bolivina* may live and thrive in anoxic waters.

Sonam and Vikrant in their paper reviewed the present status of geological studies in the Ganga alluvial plains which has been scrutinized by several workers over few decades and have attracted a diverse field of geoscientific research in the last few years. In contrast to decadal studies,the recent decade has incorporated hydrological data in geomorphic studies leading to a new set of process-based study. This has resulted in the application of physical models to understand the evolution and dynamics of fluvial systems in the alluvial plains. These authors have used Digital Elevation Models (DEM) data for watershed modelling leading to new insights into this highly dynamic sediment dispersal system emphasizing the importance of quantitative data. The authors provide a systematic review of these quantitative advances and highlight the emergence of a new research area for geomorphic inquiry at a modern time scale with a major emphasis on the quantitative understanding of cause-effect relationships.

Singh and his collaborators studied the dynamic behaviour of Gangotri glacier in the Himalayan region which produced the landforms showing the long-term effects of climate change. This glaciers during the last few decades, show decrease at the rate of 10-15 m/y (2015-2021). A combination of geochronology, sedimentology and mineral magnetism studies were integrated with other proxies to build up the Late Quaternary stratigraphy in this region. The geochronology suggests glacier terminus around 3.7 km down during ~200-300 yrs. B.P from its position in 1992. This region exhibits stratified as well as unstratified glacial and non-glacial landforms. The sedimentary analysis indicated a combination of depositional environments responsible for geomorphic features. The carbon isotopic analysis indicated that the GGR is characterized by mixed type of vegetation. The mineral magnetic analysis reflects warm episodes having well oxygenated ponding conditions that ended with restricted cold climatic events.

In their exhaustive review article *Singhvi et al.* have provided an overview of the development of luminescence dating in India which saw a great spurt in the use of this technique for unravelling the Quaternary history. The focus of this article is primarily towards application aspects. The article summarizes all important contributions and their import on the chronology of the Indian Quaternary sequences. Future outlook is also discussed in brief.

Late Neoproterozoic carbonate deposits are well documented from the Krol Belt in the Lesser Garhwal Himalaya. *Mazumdar* in this article described Krol A and Krol B with characteristic thinly laminated succession of micritic limestone/ marl and red/green shales. In contrast, Krol C and D were found to be thick sequences of limestone and dolomite showing deep subtidal to supratidal/karstic depositional features. Krol C and D carbonate rocks show fenestral void filling/ fascicular optic type fibrous dolomitic fabric. These rocks show dedolomitization features, cloudy centre clear rim dolomite, Baroque dolomite, chert-dolomite association, oolites, cemented algal mat fragments and anastomosing microstylolites. Both early and burial diagenetic textures are observed in these carbonate rocks. The petrographic studies has helped in fine-tuning the diagenetic evolution of the Krol carbonates, including early and burial dolomitization pathways.

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Sivapriya et al. Studied twenty-eight surface sediment samples along 4 transects of the shelf area off Vetharanyam, Nagapattinam district, Tamil Nadu within a water depth ranging from 4 m to 14.8 m were studied for ostracod diversity, distribution, and their relation with the environment. The sediment characteristics such as calcium carbonate, organic matter, and sand-silt-clay ratio were determined and correlated for the observed Ostracoda population. The predominant and widely spread sediment types in the area are sandy silt and silty sand. Micropaleontological studies indicated thirty Ostracoda taxa. About 5955 Ostracod specimens were recovered with 6 abundant species The ostracod assemblage recorded herein is indicative of a tropical, shallow, and inner shelf environment

Radhakrihnan et al. retrieved 15 surface samples along five vertical transects in the Gulf of Mannar, south coast of India. These ostracoda came from the shallow marine environment. Forty-one ostracod species belonging to thirty-seven genera have been identified. Sand and silty sand are the congenial sediment substrate for the ostracod's growth. Calcium carbonate has a sheer control over the ostracod population. These authors observed that ostracod population decreases as the depth increases. External morphology of carapaces indicate that they lie in a moderately agitated and turbulent environment. Ostracode assemblages indicate that the deposition of sediments is under normal oxygenated, tropical, shallow marine, and inner shelf environment. The ratio between the carapaces and open valves of ostracoda suggested a relatively faster rate of sedimentation.

İhsan Ekin has reported the discovery of a fossil fish *Gadiformes* and *Bregmacerotidae* from the Early Miocene Fırat Formation of Diyarbakır region in southeast Turkey. The host rock is a layer of limestone layer in Sağlam village of Eğil district of Diyarbakır. This fish fossil is comparable to *B. albyi* or *B. filamentosus* known from the Miocene sediments of the Mediterranean region. Poor preservation did not allow identification at the species level. The specimen described here has an elongated body, 60 mm in length with anal, dorsal and partially visible pectoral rays. Forty four vertebrae can be counted. Although similar fossil fishes have been studied from many parts of the world, the present discovery is documented from the Anatolia region for the first time.

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