Rock Magnetic Research at IIG and its Application to Paleomagnetic, Archaeomagnetic and Environmental Magnetic Aspects – Nathani Basavaiah, Indian Institute of Geomagnetism (IIG), Navi Mumbai. *(E: nathani.basavaiah@gmail.com)*

Prof. C. Radhakrishnamurty Award Lecture - 2019

Geomagnetism, being the oldest Earth science, studies the Earth's magnetic field (EMF) and the way it changes with time. The fact that the geomagnetic field, as recorded in rocks and sediments, undergoes complete polarity reversals has been well-known for many decades. The use of this phenomenon in providing magnetostratigraphic chronologies is therefore firmly established. In the present context, two classic examples were the recognition of several geomagnetic polarity reversals in Deccan Traps effusion, and in the Pliocene-Pleistocene Karewa Group sediments of the Kashmir basin. The new paleomagnetic study on the dykes along the Arabian Sea coastal track in the vicinity of Mumbai found an additional magnetochron corresponding to 31R that preceded the known three polarity chrons (30N-29R-29N) in the Deccan lava flows. This finding could significantly extend the duration of Deccan Trap emplacement indicating that the Deccan volcanic activity was initiated close to 71 Ma (anomaly 31R). The age difference between the older, reversed and younger, normal polarity dykes was interpreted to result from the rapid northward movement of India that occurred between 71 Ma and 64 Ma. The magnetostratigraphic analysis of the Romushi River section in the intermontane Kashmir basin dated the lower Karewa lacustrine formation from ~4.4 Ma to 0.77 Ma, and found accelerated sedimentation accumulation rate (SAR) of 32 cm/kyr from 1.9 Ma to 1.7 Ma, which was related to strengthening of the southwest monsoon and Pir Panjal uplift in the last phase of the Himalayan orogeny.

Applying paleomagnetic and rock magnetic methods in archaeology, two archaeological sites in the Krishna-Godavari (KG) from the east coast of India basin were archaeomagnetically dated by comparison of their paleointenstiy field estimates to the secular variation curve of India. Apart from traditional geological topics of paleomagnetism and magnetostratigraphy, several research techniques were introduced to determine whether paleomagnetic directions and magnetic fabrics were influenced by a meteorite impact at Lonar crater. To test the meteorite impact hypothesis, the Anisotropy of Magnetic Susceptibility (AMS) was applied and suggested that the impactor hit the Lonar crater from the east and more stress was recorded in rocks on the west based on reorientation of K_3 (minimum) AMS axis due to meteorite impact. The Lonar crater provided important perspectives for studying impact effects in basaltic targets in Mars and Moon.

What is not so widely appreciated especially in India and South Asia, however, is the fact that rock magnetism also provides paleoclimatic information. In the present context, rock magnetic parameters of sediments were used to establish paleoenvironmental and paleoclimatic conditions during deposition in the marine and in the continental realm. Magnetic studies of varved sediments from Higher Central Himalayan lakes of Goting, Burfu and Garbyang (proglacial lakes) provided high resolution Late Quaternary climate instability in the Indian Summer Monsoon (ISM), c. 25-10 ka. A major achievement in these sediments was the recognition of two major cooling events of Last Glacial Maximum (LGM) and Younger Dryas (YD) that were dated to 18 and 11 ka respectively. This is the first evidence for LGM and YD from the Central Higher Himalaya. Correspondence to these high latitude events, the Himalayan loess dated between 20 to 9 ka was reported from Alakhnanda and Pindari basins.

Relatively higher values of magnetic susceptibility (χ) and magnetomineralogical S-ratio were interpreted to be caused by Low Temperature Oxidation (LTO) of pre-existing titanomagnetite to magnetite under oxygenous conditions in a shallow lake or weathering processes in the catchment and vice versa. To infer climatic events effecting the entire Indian subcontinent, composite S-ratio map depicting an accurate proxy of paleomonsoon rainfall was prepared from different depositional environments and climate regimes. Stacked S-ratio map revealed for the first time prevalence of globally recognized drought between 4600–3500 years BP resulting in the collapse of Harappan civilization. Quick and cost effective magnetic measurement was employed to arrive at possible extent of industrial contamination, heavy metal (HM), petroleum hydrocarbons and polycyclic hydrocarbons (PAH) in the Arabian Sea coast line and urban environments. A significant correlation was found between magnetic susceptibility and vertical distribution of HM and PAHs in Mumbai mudflat sediments and road dusts, implying the use of magnetism in anthropogenic pollution monitoring.

The study areas spread from the Himalayan proglacial lakes to peninsular lakes (Lonar lake) and coastal (Kolleru) lakes of India, Lonar impact crater and Deccan Trap basalts. The study materials consisted of the Deccan dyke swarm, shocked Lonar target basalts, archaeological deposits for paleointensity dating, Himalayan paleolake sediments in front of the snout of the glacier, the wind-blown sediments called loess, core sediments from marine/lacustrine environments, surface lake-bed sediments, earthquake-affected soft sediments, Mumbai mudflat sediments, topsoils near thermal power plant, road dust particulates, plant leaves and vegetable samples. In this Prof. CRK Murty's endowment lecture, it is showed that how several areas such as rock-, paleo-, archaeo- and environmental magnetism researches were tied together with the establishment of environmental magnetism laboratory at IIG from the equipment donation received from the Alexander von Humboldt (AvH) Foundation, Germany. The facility established by Prof. Nathani Basavaiah (2003) is capable of a full suite of rock and mineral magnetic measurements in the non-destructive analysis of soils and sediments, generating records of environmental change from marine, coastal, lacustrine, fluvial, wetland and aeolian sedimentary sequences (Basavaiah, 2004, 2011). I take this opportunity to thank all my collaborators with diverse skills and students who brought me to this level including British Council, Liverpool Univ. & AvH, Tuebingen Univ.

References

Basavaiah, N. Geomagnetism - Solid Earth and Upper Atmosphere Perspectives, Springer, (2011).

Basavaiah, N. and Khadkikar, A.S. (Guest Editors). Environmental magnetism and palaeomonsoons, Special Issue, Jour. Indian Geophys. Uni. 8 (2004).

DOI: 10.1007/s12594-019-1357-8