International Journal of Advance Research in Science and Engineering
Volume No.06, Special Issue No.(01), Nov 2017
www.ijarse.com
IJARSE
ISSN: 2319-8354

Computational Application of Environmental Magnetism in Study of Environmental Changes at Navlakhi, Gulf of Kuch

T.R.Mudgal[1], Puneet Chawla[2], Sanjay Dahiya[3], Ved Parkash[4]

[1]*Department of Physics, CDLSIET, Panniwala Mota, Sirsa (Haryana) (India)*

[2]*Department of EE, CDLSIET, Panniwala Mota, Sirsa (Haryana) (India)*

[3,4]*Department of CSE, CDLSIET, Panniwala Mota, Sirsa (Haryana) (India)*

ABSTRACT

Magnetism is one among the fundamental properties of the Earth. Sediments and sedimentary rocks are considered to be important sources for study of palaeoclimate and environmental changes. These studies are greatly dependent on the reliable extraction of the detrital magnetic signal. Environmental magnetic methods are non-destructive and provide bulk sample information. Ratios of various magnetic properties are specific for grain size, mineralogy and/or concentration, whereas coercive force distributions can be used to discriminate between magnetic minerals (Thompson and Oldfield, 1986; Robertson and France, 1994; Kruiver *et al.*, 2001; Basavaiah et al., 2011). In environmental magnetism, properties of magnetic minerals are used as proxies for palaeoclimatic and palaeoenvironmental changes. Water-laid lake sediments have long been used for obtaining climatic and environmental information (Thompson et al., 1975). However, the time period that could be investigated was generally relatively short, ~10,000 years. In contrast, marine sediments provide short high-resolution records as well as long records (i.e. obtained by the Ocean Drilling Program), and have become an important archive of mineral magnetism related to environmental variability.

The magnetic susceptibility is such a proxy which can be used to predict the climate, rainfall and depositional environment. A core of sediments up to depth of 3.5 m is collected from Gulf of Kuch (22°44′N, 70°E) by driving a PVC pipe into the mudflat zone at a location of about 200 m west of Navlakhi port, where about 10 m thick clay horizon directly rests over the basaltic basement. The clay samples at two levels were dated at Birbal Sahni Institute of Palaeobotany, Lucknow. The environmental magnetic measurements were carried out at Indian Institute of Geomagnetism, Navi Mumbai. In this article environmental magnetic analysis has been used to reconstruct the depositional environment of the clays from a 3.5 m shallow core of the mudflats of Gulf of Kuch.

Key words: *Sediments, palaeoclimate, mineralogy, environmental magnetism, loess, magnetic susceptibility.*

I. INTRODUCTION

Natural earth processes and thus climate and human environment are influenced by the Sun–Earth-Moon system which encompasses the atmosphere, hydrosphere and the lithosphere (T.R.Mudgal,2015, Puneet Chawla *et.al*. 2016) The climate system can be considered as the prototype of a complex system. Magnetic mineralogy is a net effect of the movement of solid particles during bio-geo activities in system. Comminution involving reduced size with or without change in shape of magnetic minerals present results from physical weathering, erosion, transport by water or ice. This might also involve conversion from multidomain to stable single domain. Transport and deposition sorts the sediments which affects the fractions of magnetic and non-magnetic fractions in the material which crucially deters the magnetic behaviour the sediments from that of the source material. Concentration and dilution of magnetic minerals is a function of the competence of the weathered source (T.R.Mudgal, *et. al* .2015).

In presented framework, an environmental magnetic approach to the reconstruction of the palaeoclimate is attempted. Coastal zones that form the interface between the land and marine processes are the repositories of palaeoenvironmental phenomena and hence studies of coastal sediments assume greater significance. Several studies are carried out the world over to understand the coastal environment and its management (Pirazzoli, 1991). The studies on coastal environment are also important in the light of sea level changes. In India, the Holocene coastal sediments that occur as extensive clay-rich mudflats are the dominant coastal features, especially in the intertidal regions of the Gulf of Kuch in the northern part of west coast. The aim of this study is to present the sediment proxies toward understanding the coastal evolution and related events. The mineral magnetic results combined with micropalaeontological study (Rajshekhar et al., 2004) on Holocene mudflats of the Gulf of Kuch are presented in order to understand the palaeoclimatic conditions.

Reconstructions of changes in the Earth systems help us to understand the past, the present and to make reasonable predictions about the future. Due to the observed global temperature rise that characterized the majority of the twentieth century AD, an important scientific and political priority has become to establish the significance of human activity on the climate system, which requires that the full range of natural variability is also known. Lake sediments and marine sediments contain a variety of proxy environmental and climate indictors that precede the time range of instrumental observations and those studies of these sediments form an integrated insight into ecosystem variations on all time-scales.

Direct measurements of climate parameters provide only a limited temporal and spatial perspective on climate change. Determination of long-term changes and trends requires the extraction and interpretation of proxy climate data. Dating of geological materials, such as marine sediments, is fundamental in order to understand the natural and cultural changes that took place in the past. It is a crucial and often a delicate task in all studies of past environmental changes, particularly those that aim to reconstruct rates of change, to construct an accurate chronology. A range of dating methods and techniques with various degrees of resolution and precision are available. On account of the high potential of sediments for palaeoclimatic reconstructions, numerous studies of the marine deposits have recently been carried out in India during the last two to three decades (Chauhan, 1994).

Many methods can be used to decipher environmental change records in lake sediments. One method, commonly referred to as environmental magnetism, involves magnetic analysis to determine the types, distributions, and origins of magnetic minerals. Environmental magnetic studies have been especially effective, when applied to problems in climate change, in landscape disturbance related to land-use changes and in the dispersal of pollutants (e.g. Thompson and Oldfield, 1986; Verosub and Roberts 1995).

II. STUDY AREA AND GEOLOGY

Navlakhi forms a major mudflat of the Gulf of Kuch (22°44′N, 70°E) and is located along the fringes of major Hansthal creek in Gujarat. The Gulf stretches over 170 Km across from Okha in the west of Little Rann on the landward end in the East (Figure 1). Jamnagar and Rajkot districts of Saurashtra form the Southern boundary while Kuch district constitutes the northern limit of the Gulf. The average rainfall in this region ranges from 400 to 600 mm resulting mostly from South West monsoon. The air temperature varies from 7.8°C (January) to 44.8°C (May) and the water temperature ranges from 15°C to 35°C. At present, there is no perennial river in Saurashtra and Kuch and discharge of rain water through seasonal monsoon is reduced due to the construction of dams. Tide amplitude as recorded in the Gulf varies from 3.0 m to 7.0 m (Chauhan, 1994). Water salinity, especially in the creek, normally varies from 37 per mill to 44 per mill and still higher salinity is recorded in summer in water bodies of the hyper saline zone. According to Gupta (1977), the average rate of sedimentation during the Holocene in the Little Rann was about 2 mm per year ranging from 1.5 mm to 3 mm per year at different locations. The distribution of organic carbon in the Gulf of Kuch is also not uniform (Setty et al., 1982).

Figure 1: Study area of Navlakhi (www. maps of india.com)

The Gulf of Kuch region exhibits a variety of geological formations such as the late Tertiary sandstone, conglomerates and grits, and the Quaternary formations of miliolitic limestone, alluvium, beach sands and mudflats including the sediments of Little Rann (Shrivastava, 1968; Biswas, 1971; Merh, 1993; Chamyal & Merh, 1995). Lithological variations have been observed from Okha in the West to Navlakhi. The sediments in and around Navlakhi are fine grained clay to silty-clay as evident from the vast mudflats whereas coarse sediments represented by moderately hard shelly limestone and conglomerates dominate in the western part toward Okha. The Holocene marine sequence rests unconformably over older rocks and is distinguished by well defined lithological and environmental diversities. At Navlakhi the clays are directly resting over the basalt. The marine Holocene rocks can be practically traced all along the coastal areas right from the great Rann of Kachchh in the north to as far as South Gujarat and beyond, along the West coast. Not much work has been carried out on the Quaternaries of Kuch and Northern Saurashtra coast and practically no systematic documentation is available on the lithological, stratigraphic as well as palaeontological aspects. However, Merh (1993) indicated that the fluviomarine sediments show evidences of sea-level fluctuations influenced by glacio-eustasy and neotectonism while Sharma (1990) observed that the raised beach sands mudflats in the area represent the high Holocene strandline.

III. METHODOLOGY

A combination of foraminiferal and mineral magnetic analyses has been used to reconstruct the depositional environment of the clays from a 3.5 m shallow core of mudflats of Gulf of Kuch. The overall foraminiferal assemblage is related to the early Holocene high sea level (Rajshekhar et al., 2004). Core sampling up to depth of 3.5 m was done by driving a PVC pipe into the mudflat zone at a location of about 200 m west of Navlakhi port, where about 10 m thick clay horizon directly rests over the basaltic basement. The retrieved core was subsampled at 10 cm intervals in the laboratory. The mineral magnetic analyses were carried on 44 samples at 8 cm interval and the curves for various magnetic parameters such as ARM/SIRM, S-ration and magnetic susceptibility are plotted on a graph (Figure 2). The mineral magnetic results are compared with the foraminiferal analysis (Rajshekhar et al., 2004).

The clay samples at two levels were dated at Birbal Sahni Institute of Palaeobotany, Lucknow. An attempt is made here to analyse the results obtained from all these laboratory studies synergistically in order to interpret past climate (monsoon) and environment in the Gulf region.

IV. ENVIRONMENTAL MAGNETIC ANALYSIS OF SAMPLES

The core samples from Navlakhi were subjected for measurements of magnetic susceptibility χ, ARM (peak field-100 mT, bias field-0.05 mT) and SIRM (1.5 T). Their interparametric ratios of S-ratio (IRM-0.3T/SIRM) and ARM/SIRM are computed. Thermomagnetic and XRD analysis of magnetic extracts indicate the presence of titanomagnetite. χ, ARM and SIRM are concentration dependent, to eliminate this dependence, ratios between individual magnetic parameters of S-ratio and ARM/SIRM are used to assess the magnetic assemblage grain size in sediments. The S-ratio is an indicator of proportion of high coercivity (particularly anti-ferromagnetic minerals such as hematite), to the lower coercivity ferrimagnetic (such as magnetite), but it is really discriminant only when the proportion of antiferromagnetic mineral is greater than 80% of the magnetic assemblage (Bloemendel et al., 1992). ARM/SIRM decreases with increasing grain size (King, 1991).

The relation of magnetic parameters (Figure 2) to climate change is through discharge variations across time. For example low variations in the reverse field S-ratio, which relates directly to presence of hematite, (also confirmed by thermomagnetic experiments), indicates fresh water influx in this environmental setup. As this magnetic mineral is derived from erosion of oxidized soils of catchment during drier periods, low values in S-ratio can directly be related to low discharge conditions (weaker monsoons). On the other hand, high S-ratio values reflecting more titanomagnetite in the sediments reveal increased fresh water influx during wet periods of monsoon reinforcement. It is further argued that during wet periods, the formation of single domain (titano-) magnetite grains is promoted probably due to break-down of multi domain grains in the sediment provenance in mudflat. This hypothesis is further confirmed by high ARM/SIRM (Figure 2) during increased discharge periods.

Magneto-mineralogical S-ratio ranges between 0.9 and 0.95 at two depth intervals of 200 cm – 140 cm and again at 80 cm – 0 cm, indicated the presence of low coercivity titanomagnetite component (Figure 2). The magnetic susceptibility and ARM/SIRM display higher values in same depth levels, though χ shows an alternating high and low phases. On the other hand, ARM/SIRM follows higher trends of S-ratio. At interval of middle depths between 140 cm and 80 cm, lower values are observed in all three magnetic parameters. The low S-ratio values represent the presence of high coercivity hematite supported by lower susceptibility values and low ARM/SIRM reflect larger magnetic grains through its increasing trend Is observed from 140 cm to 80 cm depth (Figure 2).

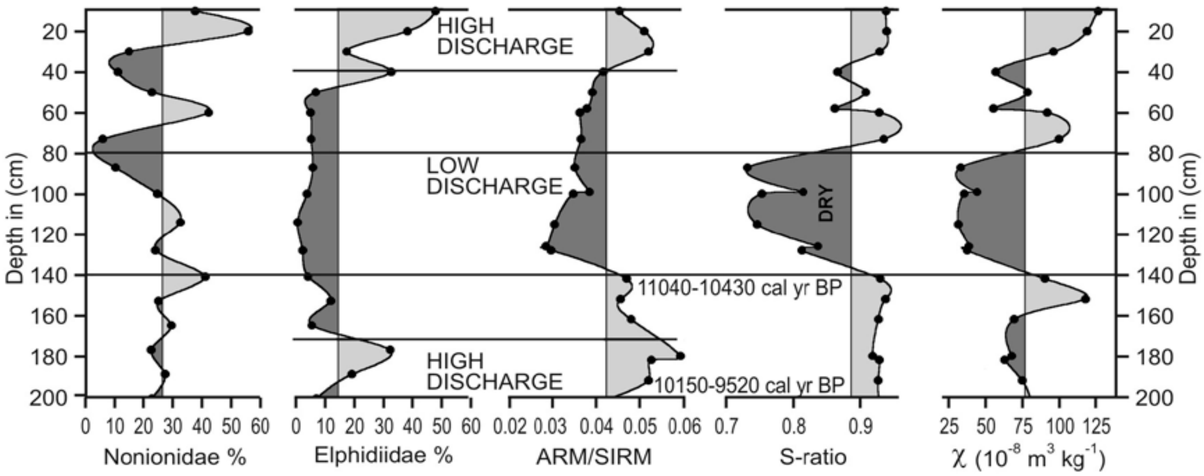

Figure 2: Foraminiferal and mineral magnetic records from Navlakhi mudflat core. Interpreted low and high discharges are marked across the plots.

V. RESULTS AND DISCUSSION

Rajshekhar et al. in 2004 have shown that foraminiferal assemblage is characterized by low diversity. The pattern obtained is compared with the magnetic curves (Figure 2). There is a general fluctuation in the value of *Nonionidae* from 20% in the bottom sample to almost 60% in the samples analyzed from the top portion of the core. Higher percentage of *Elphidiidae* both at upper and lower portions of the core are interrupted by one peak of lower percentage of *Elphidiidae* with other magnetic parameters highlights the the history of high and low discharges in and around Navlakhi in the Gulf. Samples of two levels at 1.3 m to 2.0 m were estimated 9390 ± 140 yr BP and 8720 ± 200 yr BP respectively. The average dates indicate early Holocene age to the clay sediments of Navlakhi. The S-ratio ranges between 0.90 and 0.95 at two depth intervals of 200 cm–140 cm and again at 80 cm–0 cm, indicated the presence of low coercivity titanomagnetite component. The χ and ARM/SIRM display higher values at same depth levels, though χ reveals alternating high and low phases. On the other hand, ARM/SIRM follows higher trends of S-ratio. At intervals of middle depths between 140 cm and 80 cm, lower values are observed in all three magnetic records. The low S-ratio values represent the presence of high coercivity hematite supported by lower χ values and low ARM/SIRM reflect larger magnetic grains though its increasing trend is observed from 140 cm to 80 cm depth. This indicates fresh water influx in this environmental setup. As this magnetic mineral is derived from erosion of oxidized soils of catchment during drier periods, low values in S-ratio can directly be related to low discharge conditions (weaker monsoons). On the other hand, high S-ratio values reflecting more titanomagnetite in the sediments reveal increased fresh water influx during wet periods of monsoon reinforcement. It is further argued that during wet periods, the formation of single domain titanomagnetite grains is promoted probably due to break down of multi-domain grains in the sediment provenance of the mudflat. This hypothesis is further confirmed by high ARM/SIRM during increased discharged periods. Such conditions presumably gave rise to fluctuations in salinity. Kumaran et al in 2004 have shown that the climate of India is dominated by two monsoon seasons and the rate of rainfall varies from north to south along both the coasts, Holocene monsoonal changes are expected to be stored in unique and sensitive environment located near ocen-continent interface where high rate of sediment accumulation take place.

From the above analyses it is concluded that the marine sediments provide the initial impetus for the development of environmental magnetism in palaeoclimate studies. Magnetic measurements are suited to differentiating the various climatic and monsoonal events, rainfall, drought, dry and wet conditions. The magnetic properties of marine sediments have been used as proxies for climatic and environmental change. Also it is found that the technique has the potential to identify different depositional environments and evaluating the effects of fluvial influence on mudflat sediments at Navlakhi, Gulf of Kuch.

REFERENCES

[1.] Basavaiah, N., (2011), Geomagnetism, Solid Earth and Upper Atmospheric Perspectives. *Springer*, Netherlands and *Capital publishing Company*, New Delhi, ISBN: 978-94-007-0402-2.

[2.] Biswas, SK., (1971), The milestone rocks of Kutch and Kathiawar, *Sedimentological Geology*, 5, 147-164.

[3.] Bolemendal, J., King, JW., Hall, FR and Doh, SJ., (1992), Rock magnetism of late Neogene and Pliestocene deep sea sediments: relationship to sediment sources, diagenic process and sediment lithology, *Journal of Geophysical Research*, 97, 4361-4375.

[4.] Chamyal, LS., Merh, SS., (1975), The Quaternary formation of Gujarat. *Memoirs of Geological Society of India*, 32, 246–269.

[5.] Chauhan, OS., (1994), Influence of macrotidal environment on shelf sedimentation, Gulf of Kachchh, India. *Continental Shelf Research*, 14 (13/14), 1477–1493.

[6.] Gupta, SK., (1977), Quaternary sea level changes on the Saurashtra coast. Ecology And Archaeology of Western India, Delhi, 181–193.

[7.] King, JW., (1991), Sedimentary magnetism, environmental magnetism and magnetostratigraphy. *Review of Geophysics*, 358–370.

[8.] Kruiver, P.P., Dekkers, M.J. and Heslop D., (2001), Quantification of magnetic coercivity components by the analysis of acquisition curves of isothermal remanent magnetisation. *Earth Planet. Sci. Lett.*, 189, 269-276.

[9.] Kumaran KPN., Shindikar, MR., Mudgal, TR., (2004), Florostic Composition, palynology and sedimentary facies of Hadi mangrove swamp (Maharashtra), *JIGU*,8, 55-63.

[10.] Merh, SS., (1993). Neogene-Quaternary sequence in Gujarat: a review, *Journal of Geological Society of India*, 41, 259–276.

[11.] Pirazzoli, PA., (1991), World Atlas of Holocene sea-level changes, *Elsevier Oceanography Series*, 58, 1–300.

[12.] Puneet Chawla, T.R.Mudgal, Sanjan Dahiya and Ved Parkash., (2016). Electric and Magnetc field management, *IJATES, 08, 669-676.*

[13.] Rajshekhar, c., Gawali, PB., Mudgal, TR., Reddy, PP., and Basavaiah, N., (2004), Micropaleontology and mineral magnetic evidences of the Holocene mudflats of Navlakhi, Gulf of Kachchh,*JIGU*,8, 71-77.

[14.] Robertson, D.J. and France, D.E., (1994). Discrimination of remanence-carrying minerals in mixtures, using isothermal remanent magnetization acquisition curves. *Phys. Earth Planet. Inter.*, 82, 223-234.

[15.] Setty, MG., Padmanabha, A., Ambre, NV., (1982), Organic carbon pattern and Foraminiferal assemblage in the sediments of Gulf of Kutch.

[16.] Sharma, V., (1990), Geomorphic evolution of Kutch coastline with special reference of erosional and depositional processes, *Ph. D. Dissertation, Univ. Of Delhi*.

[17.] Shrivastava, PK., (1968), A note on the Quaternary geology of Saurashtra peninsula, *Quaternary Journal of the Geological*, *Min. Metal. Soc. India*, 40 (2), 52–64.

[18.] Thompson, R., Batterbee, R.W., O'Sullivan, P.E. and Oldfield, F., (1975), Magnetic susceptibility of lake sediments, *Limnol. Oceanogr.*, 20, 687-698.

[19.] Thompson, R., Oldfield, F., (1986), Environmental magnetism, *Allen and Unwin Publishers Ltd, UK.*

[20.] T.R. Mudgal, (2015), "Study of Environmental Changes at Navlakhi, Gulf of Kachchh (Gujarat) Using Magnetism*", National Conference on Emerging Trends in Physics and Material Science (ETPMS-2015), March 9-10, 2015*, Ch. Devi Lal University, Sirsa.

[21.] T.R.Mudgal, Susheel Kumar, Sanjay Dahiya and Ved Parkash., (2015), Tool Kit of Environmental Magnetism, *IJSR, 4,142-144*.

[22.] Verosub, KL., Roberts, AP., (1995), Environmental magnetism: Past, present and future, *Journal of geophysical research*, 100 (B2), 2175–2192.