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PHYSICS

ARCHAEOMAGNETIC STUDY AND DATING OF TITTAKUDI ARCHAEOLOGICAL SITE IN TAMILNADU, INDIA

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Abstract
Archaeomagnetic dating study has been carried out for the fragmented archaeological pottery samples collected from Tittakudi archaeological site in Tamilnadu. Various Mineral magnetic studies have been performed. The results obtained from the study showed all are highly magnetically enhanced except few samples. The samples having stable remanent property undergone paleointensity measurement and the mean paleointensity value of the sample is found to be 42.44± 0.2 μT and its age predicted around 170 BCE.
Key Words: Mineral magnetism; Archaeomagnetic Dating; Pottery shreds.

Introduction

Clay having a mixture of minerals especially Iron oxide. Iron oxides are omnipresent in our environment and form minerals like Magnetite or Hematite (1). Clays are the main ingredient used for making pottery. Potteries having remanence property because of the clay minerals. The remanence is parallel and proportional to the geomagnetic field that existed at the time of manufacture. Also the place where the cooling process occurred. Archaeomagnetic dating is a technique used to date the prehistoric ruins like pottery, bricks, tiles, kilns, hearths, burnt houses, furnaces and floors. In the present study, an attempt has been made to date the Tittakudi archaeological pottery samples. Tittakudi (11° 23'.N 79° 06'. E) is located at about 74km to the west of caddalore district in Tamilnadu. This site was excavated by the Department of Epigraphy and Archaeology, Tamil University, Thanjavur. During excavation a number of broken pottery pieces, ruined Siva and Perumal temple have been found.

Methods

Mass specific magnetic susceptibility was measured at two frequency (χ_{LF} = 0.47 KHz and χ_{HF} = 4.7 KHz) with Bartington MS2B dual frequency susceptibility meter with accuracy of 1 X 10^{-5} SI unit by applying the field strength of 80A/m. Isothermal remanence was carried out using MOLSPIN pulse magnetizer, UK. Magnetizations were measured with MINISPIN spinner magnetometer (MOLSPIN Ltd., UK) with an accuracy of 2.4 x 10^{-6} A/m. Modified Thellier and Thellier method is established to obtain the paleointensity values measurements. Thermal demagnetization was carried out using Magnetic Measurement Thermal Demagnetizer (MMTD, UK).

Results and Discussion

The Archaeological pottery samples subjected to mineral magnetic studies are named as TTK1, TTK2, TTK3, TTK4 and TTK5. Mineral magnetic studies like Q-ratio, S-ratio and Soft and Hard IRM are discussed below.

1. Koenigsberger Ratio (Q-ratio)

Koenigsberger ratio is the magnetic parameter which is obtained from the two most important parameters NRM and X_{LF}. From these two parameters, Q-ratio is calculated by dividing the NRM by the induced magnetization (Susceptibility x ambient field). The magnetization value 0.5 Oe which corresponds to magnetizing force 39.79 A/m (2). The Q-ratio of the pottery samples provides the information about the type of minerals and its domain state that produce induce remanent magnetization. High Q-ratio values are the characteristics of stable origin of NRM while low values(Q<1) are mainly for non stable remanence. It provides the relative importance of remanence and induced magnetization, being remanence dominant for Q>1 (3). Variation in NRM and susceptibility mainly

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depends on the volume content of magnetite. The Q>1 indicates the presence of single domain/pseudo single domain (SD/PSD) magnetic grains present in the samples. Fig.1 shows the Q-ratio of the archaeological pottery samples. In the present study, all the archaeological pottery samples having high Q-ratio values (Q>1) except TTK4 and TTK5 indicates the presence of SD/PSD magnetite grains.

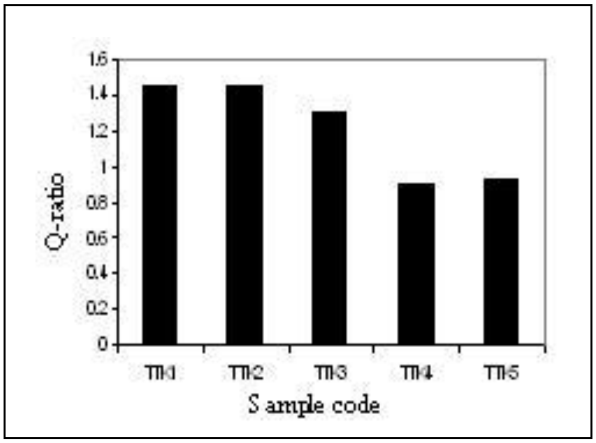

Fig.1 Q-ratio Vs Archaeological artifacts

2. S-Ratio (-300mT)

This parameter is very much helpful to determine the concentration of the magnetic minerals of Magnetite/Hematite in the sample. Blomendal et al., (4) reported that S-ratio value of pure magnetite is 1 and it decreases with increasing proportion of antiferromagnetic particles such as hematite.

From the above suggestion it is well known that all the samples shows the presence of both magnetite and hematite in varying concentration except TTK4 and TTK5 which shows low value of S-ratio indicating the presence low concentration of magnetite but dominated by antiferromagnetic minerals. Fig. 2 represents the S-ratio for the samples

3. Soft and Hard IRM

Soft IRM and Hard IRM are the two parameters which also indicate the type of magnetic minerals present in the samples. Basavaiah and Kadkikar (5) reported that the high values of Soft IRM shows the presence of more ferrimagnetic grains than anti ferromagnetic grains. Based on this, the samples subjected to Soft and Hard IRM clearly shows the presence of ferri and antiferromagnetic grains. The samples TTK1-TTK3 shows high values of soft IRM. But these two parameter values for TTK4-TTK5 show equal proportion of ferrimagnetic and antiferromagnetic minerals present in the sample.

The discussed details here are depicted in the Fig 3. From the above information, it is cleared that all the samples except TTK4 and TTK5 having good stable remanent property which are more suitable for estimating the paleointensity field value.

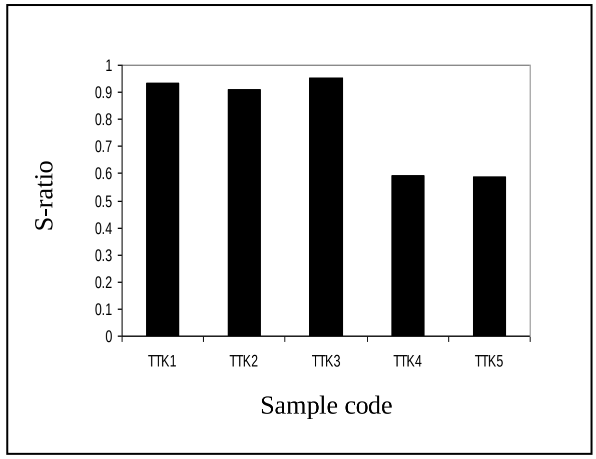

Fig.2 S-ratio Vs Archaeological artifacts

In the present study, the results obtained from the mineral magnetic parameters confirmed that TTK1-TTK3 having good stable remanent property except TTK4 and TTK5. Hence the two samples are rejected for paleointensity measurement. Zijderveld diagram also confirms that the TTK4 and TTK5 are not suitable for archaeomagnetic study. Fig 4 A and 4B shows the Zijderveld diagram (1) for the samples TTK1 (eg. for good sample) and TTK5 (eg. for rejected sample)

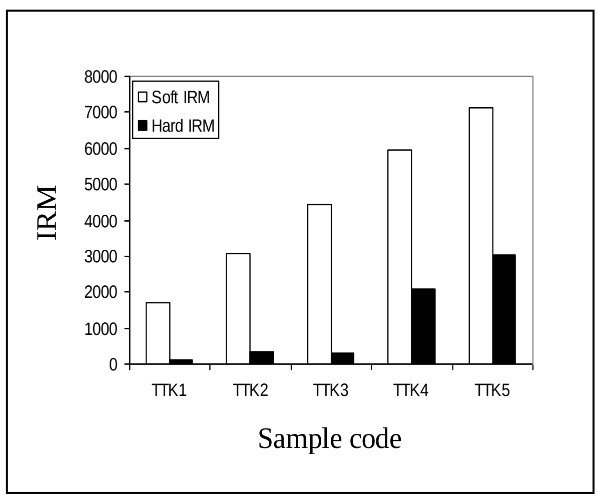

Fig.3 IRM Vs Archaeological artifacts

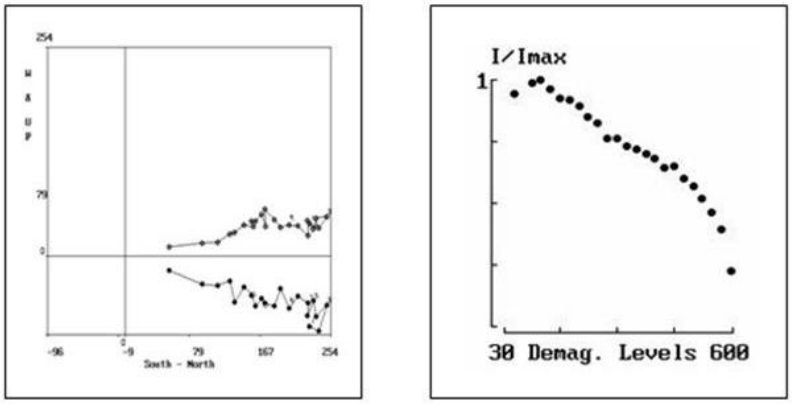

Fig.4 A. Zijderveld diagram and Demagnetisation of an representative sample TTK1

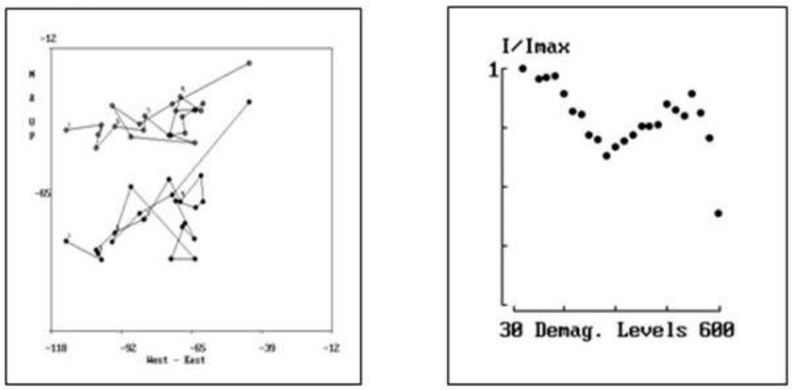

Fig.4 B. Zijderveld diagram and Demagnetisation curve of TTK5 (Rejected sample)

Paleointensity Measurements

Most Paleointensity determination using archaeological artifacts like pottery, bricks and tiles and lava flow are mainly based on the classical Thellier and Thellier (6) method or its modification (7,8).The paleointensity fossilized in the baked materials can be retrieved through archaeomagnetic investigation (9). Modified Thellier and Thellier method holds double heating process. This method involves heating the sample in the zero field system for different increasing temperature (75°C to 600°C in steps of 25°C) and measuring the NRM intensity of the samples. After removing all the magnetization from the sample, the heating process is repeated for the same different temperature but the sample is exposed to the known reference field and its TRM is measured. Arai plot has been drawn for the normalized NRM and TRM values. The Arai plot for TTK1 sample is shown in Fig.5. The slope of the best fitting line to the linear part of the arai diagram multiplied by the laboratory field value gives the Intensity of ancient geomagnetic field,

B_{anc}= (NRM/TRM) x B_{lab} (μT).

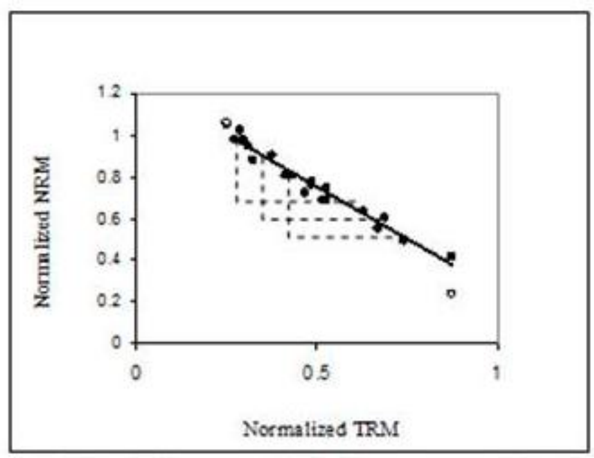

Fig.5 Arai diagram of Tittakudi pottery sample TTK1

The Paleointensity of all the samples is found to be 42.44± 0.2 μT. The B_{lab} was fixed in pre-drawn secular variation curve by Ramasamy and Duraisamy (10) and the archaeomagnetic date of the sample is found to 170 BCE and it is coincide with the date predicted by the archaeologist. Fig 6 represent the Secular Variation curve of south India and the age of Tittakudi site is marked in Secular Variation curve.

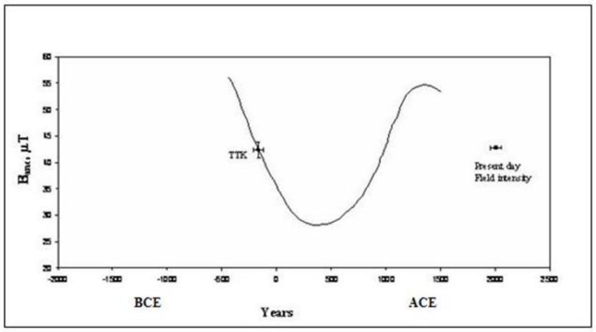

Fig.6 Secular variation curve indicating archeomagnetic age of Tittakudi archaeological site, India

Conclusion

The mineral magnetic studies of Tittakudi archaeological pottery samples reflect the magnetic mineralogy and their grain size. Q-ratio values reflect the presence of single of pseudo single domain magnetite grains in all samples. S-ratio reflects the concentration of both Magnetite and Hematite. The Soft and Hard IRM indicates the presence of high concentration of ferromagnetic minerals present in the samples. All mineral magnetic parameter indicates the samples are highly enhanced magnetic minerals except TTK4 and TTk5. The Zijdervelt diagram results also coincide with the mineral magnetic studies. It is confirmed that TTK1-TTK3 having stable remanence and the ancient geomagnetic field intensity is found to be 42.44± 0.2 μT. The age predicted from this study has good agreement with the archaeological reference data.

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References

1. De Marco, E., Spassov, S., Kondopoulou, D., Zananiri, I., and Gerofoka, E., 2008. Archaeomagnetic study and dating of Hellenistic site in Katerini (N.Greece), Physics and Chemistry of Earth, 33, 481-495
2. McElhinny, M.W. and Senanayake, W.E., 1982. Variations in the geomagnetic dipole 1: the past 50,000 years. J. Geomagnetism Geoelectricity, 34, 39-51
3. Alva- Valdivia L.M., Rivas, M.L., Goguitchaichivili, A., Urrutiafucugauchi, J., Gonzalez, J.A., Morales, J.and Gomez, S., 2003. Rock magnetic and oxide Microscopic studies of the El Laco Iron ore deposits, Chilean Andes and Implications for magnetic Anamoly Modeling. International Geology Review, 45, 533-547.
4. Bloemendal, J., King, J.W., Hall, F.R and Doh, S.H. 1992. Rock magnetism to late Neogene and Pleistocene deep sea sediments: Relationship to sediment source, diagenetic processes and sediment lithology. Journal of Geophysical Research, 97, 4361-4375
5. Basavaiah, N. and Khadkikar, A.S. 2004. Environmental magnetism and Paleomonsoon. Journal of Indian Geophysical Union, 8, 1-77.
6. Thellier, E., and Thellier, O., 1959, Sur l'intensite du champ magnetique terrestre dans le passé, historique et geologique. Annales de Geophysique, 15, 285-376.
7. Coe, R.S., 1976. The determination of paleointensity of the Earth's magnetic field with emphasis on mechanisms which could cause non-ideal behaviour in Thellier's method. Journal of Geomagnetism and Geoelectricity, 25, 415-435.
8. Kono, M., Ueno,N., 1977. Paleointensity determination by a modified Thellier method. Physics of the Earth and Planetary Interiors, 13(4), 305-314.
9. Manoharan, C., Veeramuthu, K., Venkatachalapathy, R., Radhakrishnan, T., and Ilango, R., 2008. Spectroscopic And ancient geomagnetic field Intensity on Archaeological pottery samples, India. Lithuanian Journal of Physics, 48(2), 95-202.
10. Ramaswamy, K., Duraiswamy, D., 1990. Archaeomagnetic studies on some archaeological sites in Tamilnadu, India, Physics of the Earth and Planetary Interiors, 60 (1-4), 278- 284.