

Archaeomagnetic prospecting in Indian archaeology: comprehending its application in excavations at Lothal, Sisupalgarh and Keeladi

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In recent times, a profound number of scientific tools are being employed by social scientists to study topography and get an insight of the material remains during archaeological explorations, before commencing field excavations. One such tool which is progressively being used during geophysical surveys is the magnetometer. This article aims at understanding the working mechanism and use of magnetometry in detecting archaeological sites. Further, the gravity and urgency of this machinery are supported by presenting the successful use of magnetometer surveys in three prominent excavation projects in India over the last two decades.

Keywords: Archaeology, archaeomagnetic survey, excavation projects, magnetic susceptibility, magnetometry.

MAGNETOMETRY is a branch of geophysics which studies the constituency, direction and strength of magnetic fields at a particular location. The principal device used in this discipline is known as a magnetometer, which provides high-resolution images of the Earth's magnetic field from the present to thousands of years ago¹. However, this branch is not limited to the inquiries of geology, but is also a tool of assistance in detecting the corroboration of past human activities like tombs and foundations, sites of cremation, fire materials like kilns, bricks, and burned organic materials, and (probably) area of intensive habitation.

The amalgamation of this phenomenon of natural science and geology, physics and chemistry with humanities (archaeology, anthropology and art history) is what is referred to in academia as archaeomagnetism. In 1956, magnetometers were used for the first time in an Archaeological excavation in England by John C. Belshe². Since then, its application has progressed, incorporating various new advanced technologies like ground penetrating radar (GPR) and surface resistivity meters that are together revolutionizing archaeology³.

Understanding magnetometry in archaeological surveys

Electromagnetic force is one of the four fundamentals (along with gravity, strong interactions and weak interactions) which governs not only the Earth, but the entire

universe. Now Earth contains a large number of ferromagnetic materials, each having its own magnetic field and strength. Had the Earth been composed of uniform substances, the magnetic lines would have been evenly distributed between the poles. Since a variation exists between these substances, the magnetic lines of force are distorted. Therefore, these distortions can be used to analyse the activities of our ancestors using the magnetometer.

Among all activities, burning is the most crucial aspect of human activity that is studied using magnetometry. This is because the act of burning makes permanent changes in the magnetic properties, by altering the proportion of iron particles, of not only the intended material (animal, pottery or any other substance which was set on fire) but also of the soil where the activity was performed. For instance, kilns have very high magnetic susceptibility because of the constant burning of matter.

An important property that a magnetometer uses to study the Earth's crust is magnetic susceptibility. This is a measure of the degree to which some substances get magnetized under the force of an external magnetic field. So when the remains of activities like fire for heating, cooking, cremation, etc. and objects like walls, kilns and burnt bricks are brought under an extrinsic force of magnetic fields, notable patterns of magnetic anomalies are recorded due to the variance in the magnetic property of these materials from their relatively uninfluenced surroundings². Since these structures and materials have different magnetic susceptibilities, primarily based on their density and composition, the magnetic lines recorded by the magnetometer in pre-excavation surveys are distorted accordingly. The resultant graph comprising all these magnetic lines is referred to precisely locate any underlying structures⁴.

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The curves show magnetic declination (positive) and inclination (negative). This coalescence of ups and downs in a graph over various archaeological structures gives archaeologists an understanding regarding the material buried under the surface. This process is then followed by digital image processing, where these curves and graphs are transmuted to a digitized form for a more accurate processing of data (Figure 1). The diversification of magnetic susceptibility is so sensitive and small in scale that it is practically invisible even to a magnetic compass and is only detectable by magnetometers⁵.

Archaeomagnetism in modern Indian archaeology

In the past few years, many archaeologists and institutions in India have employed archaeomagnetism in pre-excavation surveys in almost every conceivable way. Here we discuss three excavation projects where magnetometer surveys proved to be rewarding in the planning and execution of these projects

The Lothal Revisitation Project (2008–09)

First discovered in 1954, Lothal, Gujarat, is a prime archaeological site of the Indus Valley Civilization, and home to what is considered to be one of the oldest dockyards in the world. The Lothal Revisitation Project was carried on by Denny Frenez (University of Bologna, Italy)⁶. Along with many tools of geospatial archaeology like GPR, satellite imagery, GPS, etc., magnetometric survey was also used for collecting the required data for the excavation project. Helmet Becker (Bavarian State Office for Monument Protection, Germany) used a cesium magne-

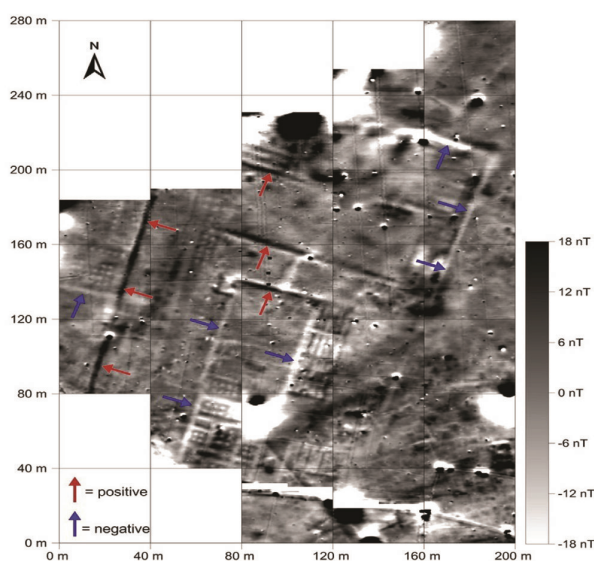


Figure 1. Magnetometer map of a palace of Ramses II in Qantir, Egypt (courtesy: Jorg W. E. Fassbinder).

tometer in the unexcavated part of the site, to find the following structures:

- A baked brick embankment canal running east to west and perpendicular to the dockyard, probably connecting the dockyard to the palaeo-channel of Sabarmati.
- A compound with rooms along a narrow street and separated lanes.
- A possible monumental gateway or a large drainage outlet on the southwest corner of the fortification⁷.

Post survey, Frenez carried out ‘test trenches’ in the above mentioned areas, which further verified the virtual data with actual buried structures (Figure 2). Within these three trenches objects like pottery, bronze knives, structures like mud bricks and a possible artificial baked brick-embanked canal superimposed by a kiln were also found. These findings in archaeomagnetism proved to be significant for deciphering the layout of the Lothal site.

Sisupalgarh excavation (2007–08)

Sisupalgarh is an archaeological site in Odisha, which is considered to be one of the largest and best-preserved fortified cities of historic times in India⁸. Archaeomagnetic survey conducted at this site by Mohanty and Smith (Costen Institute of Archaeology, UCLA, USA) in 2008 helped in prospecting an area of 13 acres, which distinctly demonstrated a 300 m long section of an ancient road, and various structures and streets connected to it. Further geophysical investigations at the site revealed the presence of long ‘roads’ entering the main site from all the formally existing gateways, and adjoining large ‘empty’ spaces which were probably used as courtyards or plazas (Figure 3)⁹.

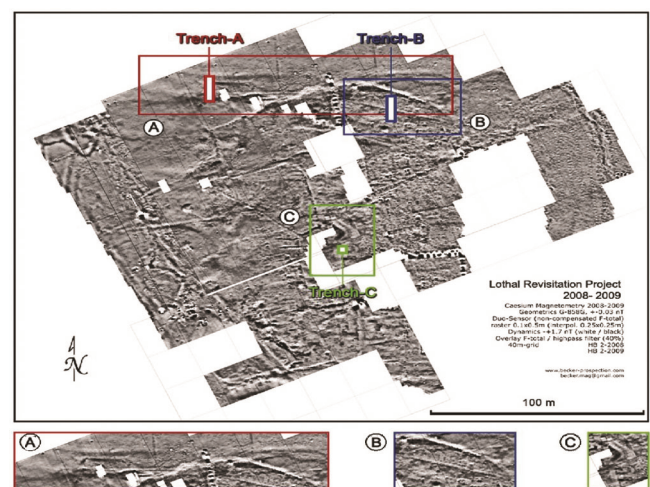


Figure 2. Photomosaic of the magnetograms obtained during the Lothal Revisitation Project showing the major anomalies and location of three trenches (courtesy: Denny Frenez).

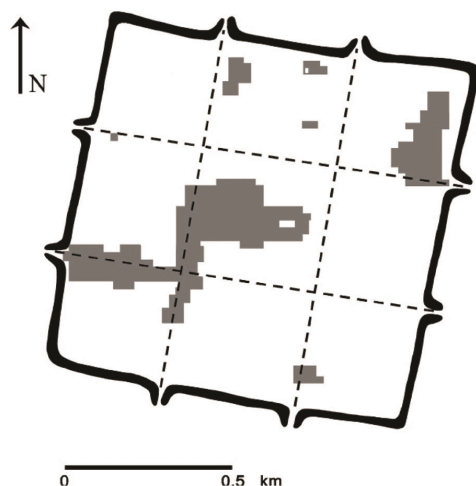


Figure 3. Areas of magnetic gradiometry survey at Sisupalgarh (shaded) indicating the presence of long linear features between gateways, projected here as dotted lines (courtesy: Monica L. Smith).

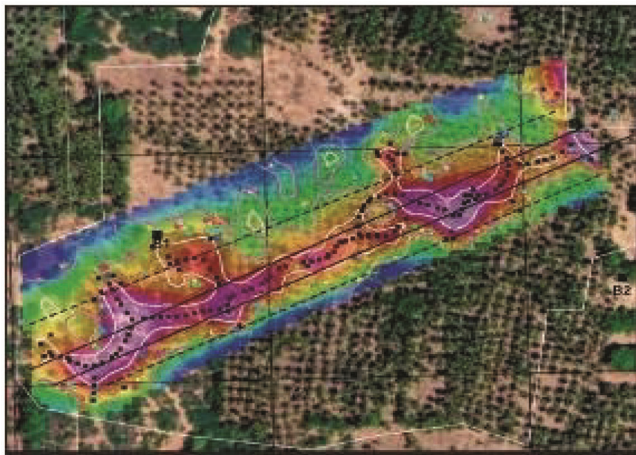


Figure 4. Magnetometer map showing a wall-like structure (courtesy: Department of Archaeology, Government of Tamil Nadu).

Keeladi Excavation Project (2015–present)

A recent testimony of archaeomagnetism in India comes from the Keeladi Excavation Project undertaken by the Archaeological Survey of India (ASI) and the Department of Archaeology, Government of Tamil Nadu. Excavations during the past few years in the tiny hamlet of Keeladi in Tamil Nadu have established evidence of an urban civilization of the Sangam era, i.e. the Vaigai Valley Civilization. The site has succeeded in attracting visitors and archaeologists from around the globe because of the fascinating material remains recovered from the site and its supposed connections with the Indus Valley Civilization.

The fifth round of excavations (2018–19) was a ‘guided excavation’ as a GPR and magnetometer survey was conducted by the Indian Institute of Geomagnetism, Mumbai.

The survey led to the discovery of an important wall-like structure, 350 m long and 20 m wide along a straight line¹⁰. Figure 4 suggests a multitude of moderately magnetized sources. A GPR was then used to further narrow down the primary spots in the area with salient features. Using similar technology, ten priority zones spread over an area of approximately 450 ha were deciphered.

Conclusion

Although archaeomagnetism has been used as an archaeological tool for more than seven decades now, it is still a relatively new concept in Indian archaeology, being used only for the past two and a half decades. However, in recent years it has become clear that archaeomagnetism and other geospatial innovations could help Indian archaeologists in surveying archaeological sites remotely and non-destructively. Magnetometer surveys provide the required information to refine crucial sites in large, multi-acre areas. This has helped ASI and institutions involved in various archaeological projects, to save time and money, which are already severely limited. Although magnetometers do not map out accurate depth information like GPR, they surely give a direction for the same. When combined with other modern technologies like long- and short-range laser scanners, mass spectrometer and photogrammetry, it can aid in the advancement of Indian archaeology.

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