Qualitative Interpretation of Magnetic Anomalies for Archeological Structure (Kiln) at Kg Padang Chichak, Lembah Bujang, Kedah

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ABSTRACT

The magnetic method which measures the physical parameter such as susceptibility is very applicable in archeological structure discovery. Fire for heating, cooking, production and industry; produce high magnetic susceptibility, creating special patterns of anomalies in the Earth's magnetic field, detectable with sensitive instruments - magnetometers. Reported by locals, two kilns were found at Kg. Padang Chicak, Lembah Bujang (Kedah). The qualitative interpretation conducted by plotting the graph profile of magnetic intensity obtained from magnetic survey. Result shows that high magnetic anomaly, 30-50 nT was located the kiln. Meanwhile, the value was dramatically dropped as the kiln has a void inside. With the value, it is predicted that the clay which made up the kiln was experience burning.

KEYWORDS: Archeological, kiln, magnetic, burning.

INTRODUCTION

Remanent magnetization (RM) is a magnetic field which may exist within rock even in absence of external field due to permanently magnetic particles. RM of archeological objects is particularly significant not only because of its large relative intensity, but it is intimately associated with baked clay which comprises bricks, tiles, pottery, kilns, hearths and similar features. The RM called as thermoremant magnetization as created when the magnetite-bearing clay is heated to a relatively high temperature and cooled in the presence of the earth's magnetic field (Breiner, 1999).

The location of fired structures is possible because of themoremanent magnetization acquired as a result of the firing. In unfired clay, the magnetic domains which represent the dispersed iron oxide grains point in random directions, so that the resultant permanent magnetic moment is zero (Figure 1a). However, when the clay is heated with high temperatures, reversal of the direction of magnetization can occur as a result of the thermal agitation. Since the direction parallel to the Earth's magnetic field, therefore a fractional excess of grains whose magnetization is parallel, rather than anti-parallel to the Earth's magnetic field. During subsequent cooling, this fractional excess remains frozen in position, thus leaving the clay with a nett permanent magnetic moment in the direction of the Earth's magnetic field (Figure 1b).

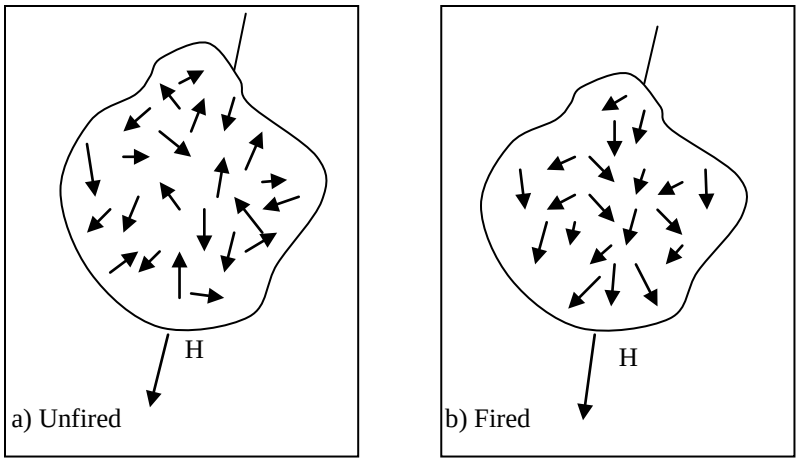

Figure 1: Thermoremanent magnetism in the Earth's magnetic field, H. a) magnetic domains are randomly orientated in unfired clay. b) fired clay, there is a nett magnetic moment parallel to H (after Tite, 1972).

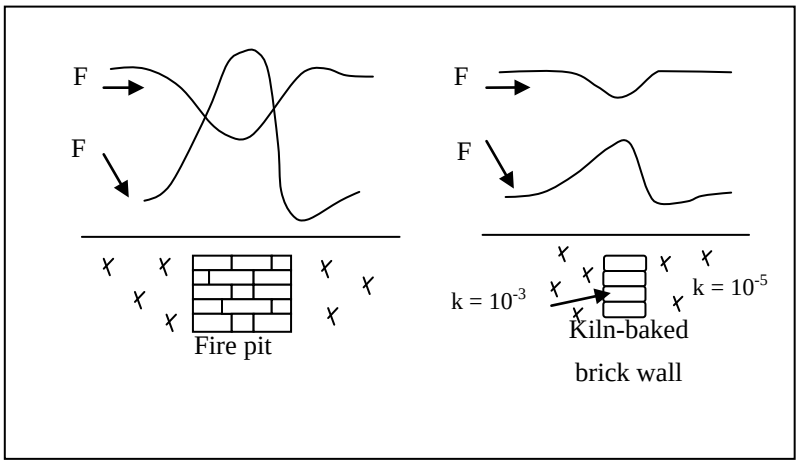

Figure 2: Typical magnetic anomalies of common archeological features (modified from Breiner, 1999)

STUDY AREA

The magnetic survey was carried out at planar area, Kg. Padang Chicak, Sik (Kedah) with 0.5 m rover stations spacing. The magnetic intensity were measured at the kiln and the surrounding as shown in Figure 3 (red cross-line indicates the rover stations).

METHODOLOGY

The ground magnetic survey was conducted using Geometrics G-856 Proton Precision Magnetometer and GEM. A base station is continuously taking data for every 1 minute for diurnal variations of earth magnetic field and other sources of interferences. Due to the archaeological study, magnetic survey was designed with close line spacing in a grid manner to achieve good accuracy in the determination anomaly features of the subsurface. A survey designed with 0.5 m interval gridding of rover station to cover the survey area. A profile created using Microsoft Excel with magnetic intensity versus stations position.

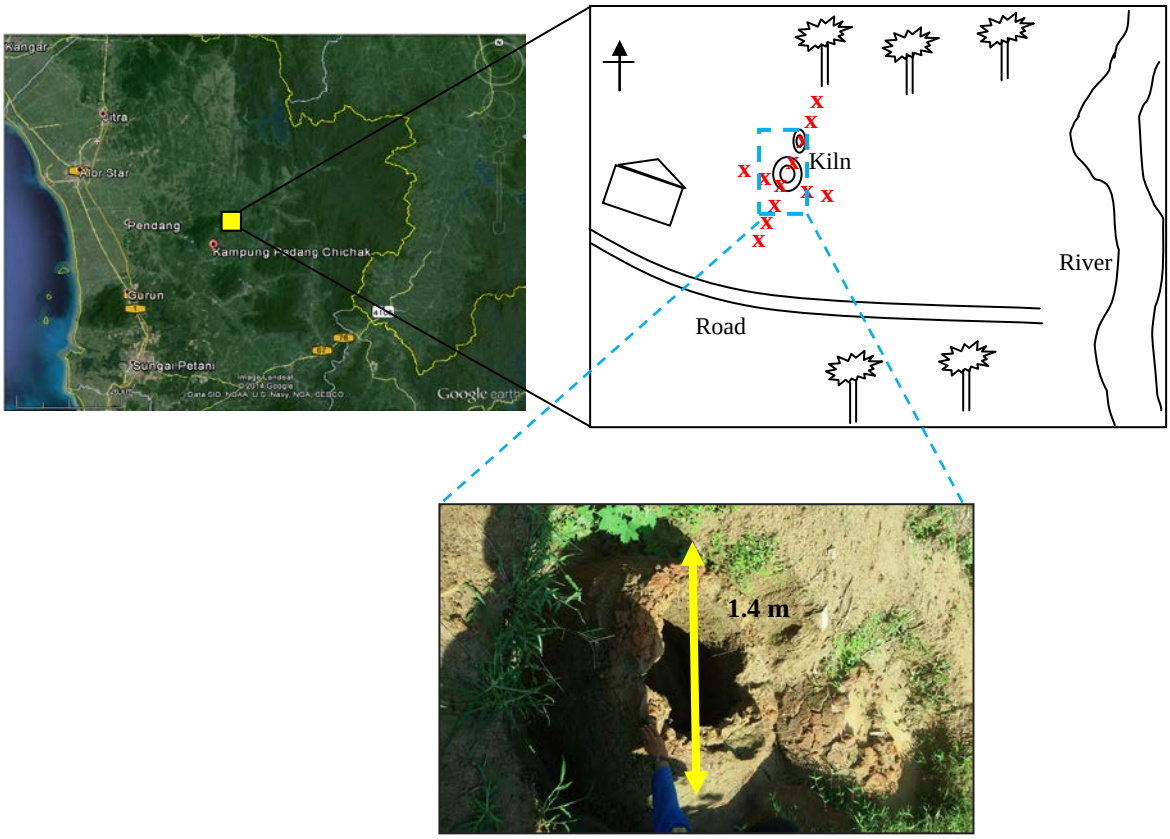

Figure 3: The magnetic survey employed at the kiln area found at Kg. Padang Chicak

RESULTS AND DISCUSSION

Figure 4 shows the magnetic anomaly contour map of the study area. Note that the kiln presented by closed contour lines. Box 1 is the existence kiln meanwhile Box 2 and 3 are the suspected kiln. The value of magnetic intensity were digitized and presented in graph profile.

The graph profiles were created by plotting the value crossing the kiln in N-S and W-E direction. General inferences can be made from magnetic anomaly shapes. Figure 5 shows an anomaly A which suspected due to presence of another kiln. Meanwhile, anomaly B has greater wavelength compare to anomaly A and C which interpreted as deeper kiln. Not only that, anomaly B also has greater magnetization due to greater amplitude compare to others. For anomaly D, the high value (60-90 nT) perhaps effectuate from human activities whose accompanying fires. According to Clark (2013), the susceptibility is increased or enhanced by vegetation fires and fermentation effects, the oxidation-reduction cycles associated with alternate wetting and drying of the soil. All of these tend to convert the iron compounds to the quite

strongly magnetic oxide maghaemite. In addition, human occupation with accompanying rubbish and fires, further increases the effects, leaving permanent magnetic imprint on the soil.

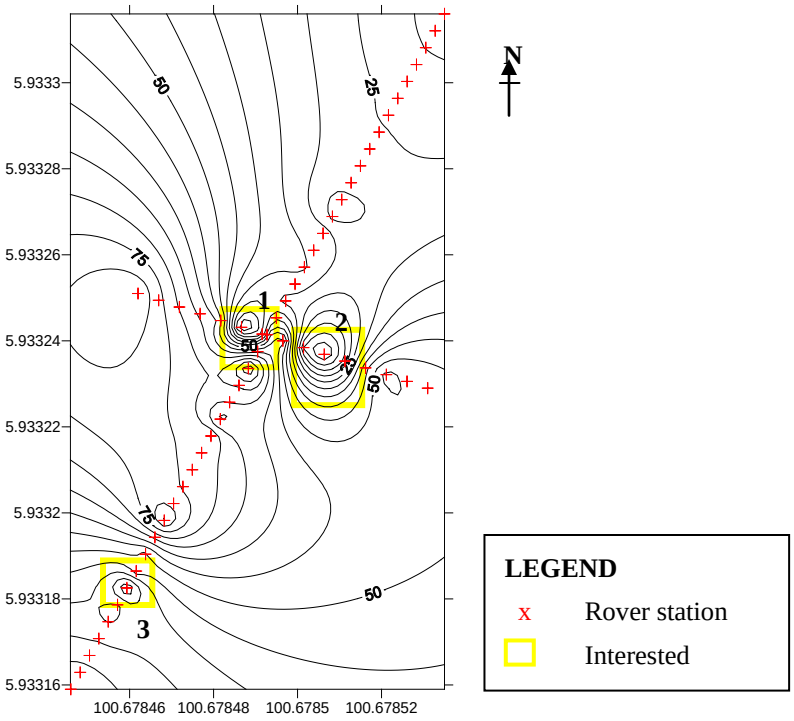

Figure 4: Magnetic anomaly contour map of study area with rover stations.

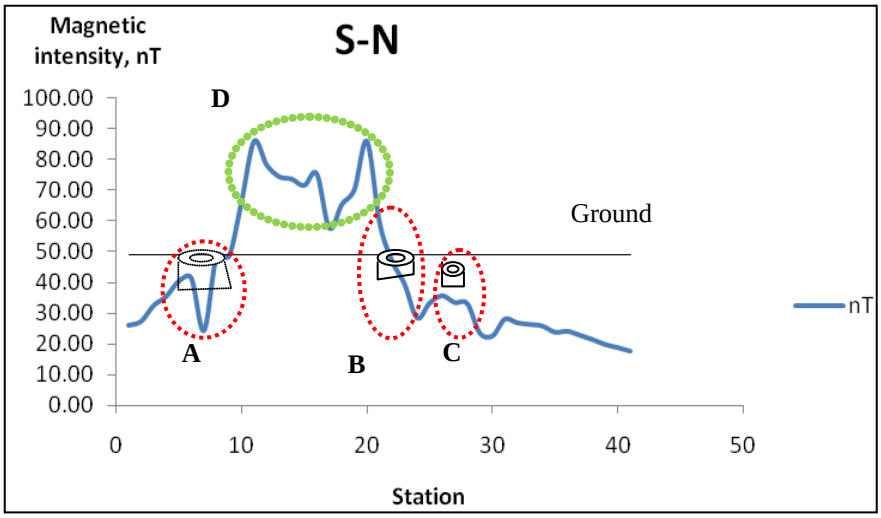

Figure 5: Magnetic intensity over the kiln in S-N direction.

In Figure 6 two interesting trough displayed where anomaly A shows the center of kiln found meanwhile anomaly B become suspected to another presence. The spikes in magnetic susceptibility in vertical sections can point to burned or habitation layers (Clark, 2013).

Regarding the wavelength and amplitude, the anomaly B perhaps much deeper and has stronger magnetization.

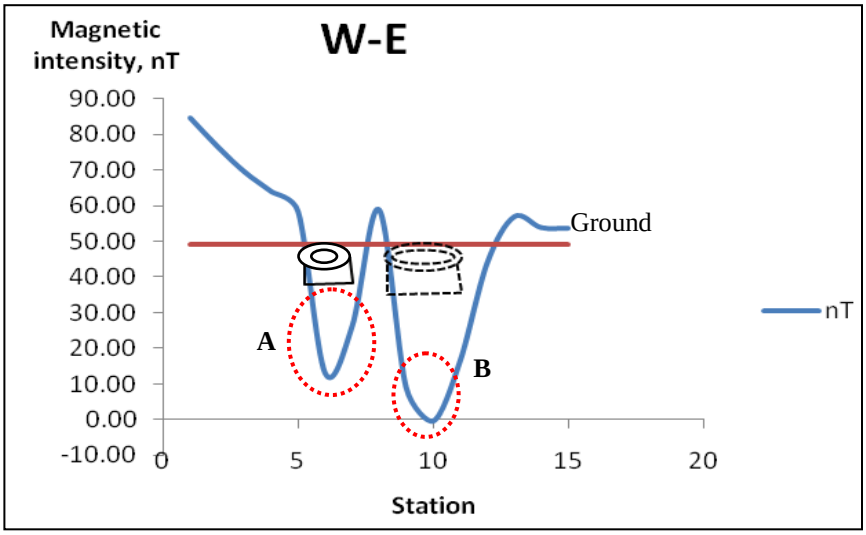

Figure 6: Magnetic intensity over the kiln in W-E direction.

The remanent magnetization is related to the effect of heating whether naturally or artificially heated. Archeological objects such as kilns, furnaces, slag block, and fire places posses strong remanent magnetization and will produce a positive magnetic signal. Smekalova (2008) stated that archeological earthen structures typically show local magnetic anomalies in the range of 1-20 nT, most rare fired structures show 10-1000 nT, quite rare ferrous archeological objects including iron-smelting slag blocks show 20-2000 nT.

CONCLUSION

As the conclusion, the kiln which is made of baked brick stand with high magnetic intensity due to strong remanent magnetization.

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REFERENCES

1. Breiner S. (1999); Application Manual for Portable Magnetometers, San Jose, USA: Geometrics.
2. Clark A. J. (2013); Magnetic Susceptibility in Archeological Prospecting, AN0009 13/05
3. Smekalova T.N (2008); Magnetic Surveying in Archeology; 2nd revised edition, Wormianum 2008.
4. Tite M.S. (1972); Methods of Physical Examination in Archeology, Seminar Press Ltd, London. Page 7-11.