

ARCHEOMAGNETIC STUDY OF KILNS IN SAN-IN AND KYUSHU, JAPAN

by

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Abstract

About 100 samples of baked clays were collected from five kilns found in Tottori and Shimane Prefecture in San-in district and Saga Prefecture in Kyushu district, and the natural remanent magnetizations were measured. The ages of the kilns have been estimated to be between 500 A. D. and 1800 A. D. The stable natural remanent magnetization was plotted on the reference curve, which had been established by Hirooka, in order to check the secular variation of the earth's magnetic field during 500 A. D. to 1800 A. D.

(1) Introduction

It is well known that ferromagnetic minerals such as magnetite and hematite contained in clays are magnetized in the direction of the ambient magnetic field in cooling process through their Curie temperature. Such a remanent magnetization is called the thermo-remanent magnetization (TRM). The TRM of baked clays is weak and of the order of 10^{-5} to 10^{-6} emu/gr in its intensity, but is stable against physico-chemical changes after the formation. Therefore, it is possible to know a direction of an ancient geomagnetic field by measuring a direction of the stable natural remanent magnetization which has been firmly remained in a baked earth of a kiln since its acquisition. Investigations of the geomagnetic archeo-secular variation in direction have been recently developed by many workers; Thellier⁽¹⁾ in France, Aitken *et al.*⁽²⁾ in England, Brynjolfsson⁽³⁾ in Iceland, Burlatskaya⁽⁴⁾ in U. S. S. R., Watanabe⁽⁵⁾, Yukutake⁽⁶⁾, Kawai and Hirooka⁽⁷⁾⁽⁸⁾, in Japan and others. Hirooka has been made a intensive research on the archeomagnetism of the kilns which are located mainly in Kinki district, and he has established the general tendency of the geomagnetic secular variation in historic time in Japan, especially in detail during the period from 400 A. D. to 800 A. D. (Hirooka, 1971). A number of archeomagnetic data have been accumulated, and they cover a wide time span from pre-Christian to the present age. However, a few data are only available for the period from 1000 A. D. to 1800 A. D. at present. Fortunately, many kilns of requisite ages for archeomagnetism are distributed in San-in and Kyushu district, and

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most of them are found to have a well baked floor which has been remained *in situ* since last date of its firing. The ages of the kilns in this region are estimated from archeological cultural analysis. Since 1970, we have engaged in a continuous programme of archeomagnetic investigations for supplement of new data. This paper is a preliminary report on the results obtained up to the present.

(2) Sampling and measurements

About twenty oriented samples mould in a piece of plaster of Paris were collected from each site of five kilns in Tottori, Shimane and Saga Prefecture. The sampling sites are shown in Fig. 1. All samples were taken from the floor of the kilns, because

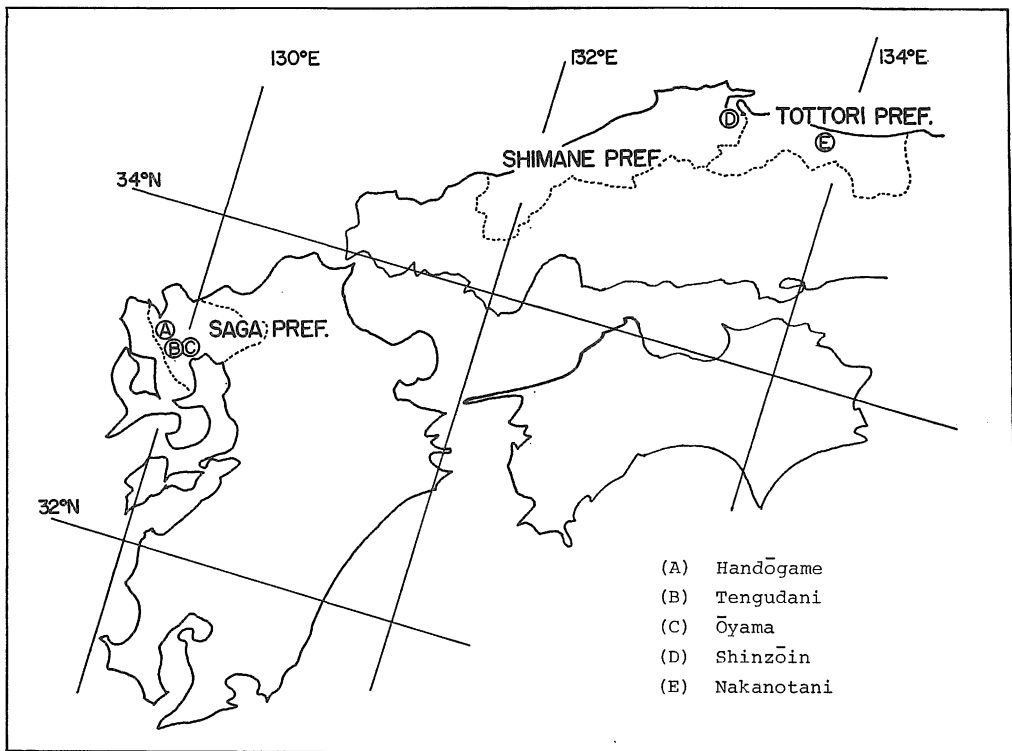


Fig. 1. Map of sampling site

the wall was sometimes found to incline to the inner part under the pressure applied by the outer ground (Hirooka, 1971). Sampling techniques used here are as follows: (1) a rod of baked earth surrounded by a square ditch is made at a good place on the floor of the kiln, (2) then thin plaster is poured in covering the material to be sampled, (3) thick plaster is put on and a small duralmin plate is applied on the upper portion to make a plane surface, (4) the orientation is made by measuring the strike and dip angle of the plane with a clinometer, (5) after removal of the samples away from the floor, thin plaster is applied to the bottom of the sample. Sampling procedure mentioned above are illustrated in Fig. 2. Each sample was cut into a cubic specimen in the laboratory and the NRM of the specimens was measured in all using

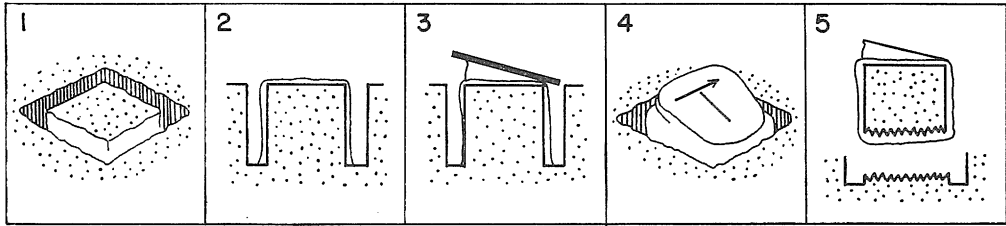


Fig. 2.

an astatic magnetometer.

(3) Results and discussion

The declination and inclination of the NRM of each kiln obtained from San-in and Kyushu districts have been reduced to values at Kyoto under the assumption of an axial dipole, because it is convenient to compare the values obtained here with the archeomagnetic data accumulated from different places in Japan. Results of measurements are summarized in Table 1 and shown in Fig. 3 together with reference curves, showing the observed geomagnetic secular variation, which have been established by Hirooka (1971). The reference curve is drawn through the representative points averaged over in the successive short period. Both declination and inclination deviate slightly from the value which is predicted by the reference curve. For example, the declination is 7° more to the east and the inclination is 10° steeper than the predicted value at Handōgame. But this deviation is not so serious value, because it is within the zone, shown

Table (1)

Site name	Locality	Age	D	I	θ_{95}	K
Handōgame	Kitahara-mura, Matsuura-gun, Saga	1570-1600 A. D.	$10^\circ 33'$ ($12^\circ 57'$)	$44^\circ 39'$ ($47^\circ 03'$)	$3^\circ 26'$	60
Tengudani	Arita-cho, Saga	1616-1656	$-47'$ ($34'$)	$37^\circ 32'$ ($40^\circ 02'$)	$1^\circ 10'$	212
Ōyama	Ōyama, Nishitaku-gun, Saga	1800-1870	$36'$ ($1^\circ 8'$)	$47^\circ 29'$ ($49^\circ 52'$)	$1^\circ 10'$	400
Shinzōin	Kamiyoshida-cho, Yasugi-shi, Shimane	700-750	$48'$ ($56'$)	$51^\circ 50'$ ($51^\circ 19'$)	$1^\circ 49'$	61
Nakanotani	Tōgō-cho Tottori	530-570	$-11^\circ 48'$ ($-11^\circ 23'$)	$44^\circ 54'$ ($43^\circ 52'$)	$3^\circ 25'$	94

D, I: Declination and Inclination. The value shown in a bracket has been reduced from each sampling site to Kyoto under the assumption of an axial dipole.

θ_{95} : Fisher's circle of confidence ($P=0.05$).

K: Precision parameter.

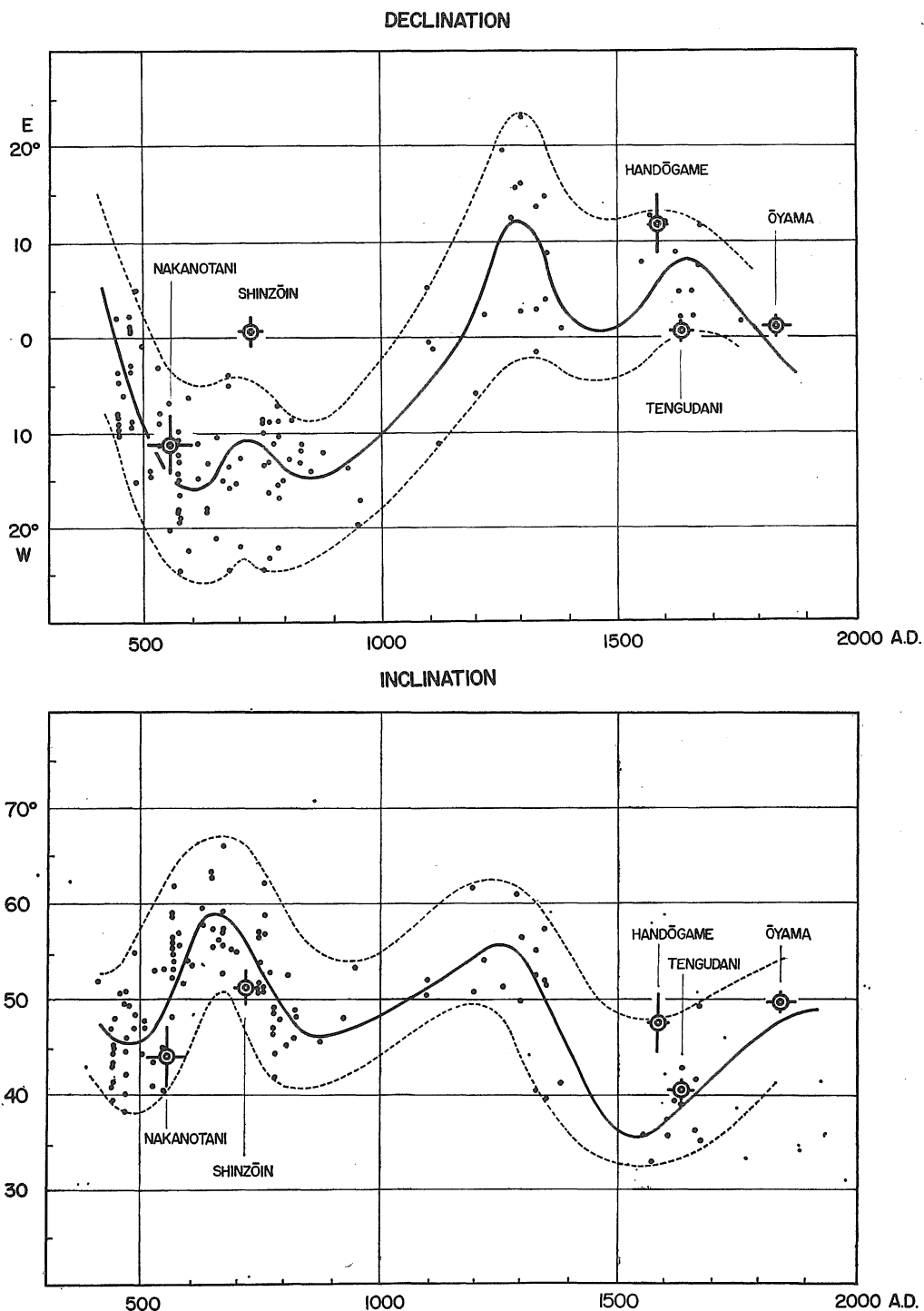


Fig. 3. Archeo-secular variation in southwestern Japan

⊙ : New data

• : Data obtained by Hirooka

Solid lines are the reference curve which has been established by Hirooka (1971)

by two dotted lines in Fig. 3, over which the original data for drawing the reference curve are spread. Such a wide spreading is mainly due to an uncertainty of the ages estimated from archeological dating method. However, the NRM of all samples of five kilns was stable and reliable. This shows that the direction of the earth's magnetic field at the time of last firing has been fixed in the NRM. Therefore, the fact that the direction obtained from five kilns is plotted within the narrow zone represents to be reasonable to adopt this reference curve.

On the other hand, although some archeologists have given two ages to the Hand-ōgame kiln, the age given in Fig. 3 is archeomagnetically more reasonable than being older one, because both declination and inclination deviate more greatly from the reference curve, if we take older age as the date of last firing of this kiln. The fission-track dating method which has been developed recently should be useful for detailed analysis of the geomagnetic secular variations as this time.

Acknowledgement

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