Archaeointensity Variations for the Past 7,500 Years Evaluated from Ancient Chinese Ceramics

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Archaeointensity data have been obtained for the past 7,500 years by analyzing ancient Chinese ceramics using a new version of the Shaw techniques (Shaw, 1974) and the Coe (1967) version of the Thellier techniques (Thellier and Thellier, 1959). Several rock magnetic parameters and measurements, such as Curie temperature, low temperature susceptibility, hysteresis and magnetic anisotropy, have been made on sub-samples. These measurements have enabled us to preselect the most suitable samples for archaeomagnetic analysis. There is acceptable agreement between the results obtained from separated areas of China. Major features of the geomagnetic field in China determined from this study are generally consistent with those of the global average field model of McElhinny and Senanayake (1982) but with detailed differences which we may be due either to local non-dipole field effects or lack of resolution in the global model. Comparison of the present results with contemporaneous results from Greece (Aitken *et al.*, 1989) shows significant differences that may be due to the movement of a large non-dipole anomaly. Samples younger than 4,000 years ago were usually dated by archaeological context and/or artefact type; radiocarbon dating was used to date the older samples.

1. Introduction

China, with a long and well-documented history, provides a wealth of archaeomagnetic materials with board geographical and temporal distributions. Since the early 1980s many archaeomagnetic investigations have been carried out (Wei *et al.*, 1982, 1986, 1987; Tang *et al.*, 1991; Yang *et al.*, 1993a, b) and results have been obtained from various artifacts (bricks, tiles, ceramics, baked earth, etc). The ceramic samples used for the present investigation were collected from 10 archaeological areas in north central China and 11 archaeological areas in northeast (NE) China covering 7500 to 900 years ago (Fig. 1 and Table 1). Cylindrical samples with diameter 9 mm and approximate length 7–10 mm were used in rock magnetic investigations and in both the Thellier and Shaw techniques. The shape anisotropy caused by different lengths is generally considered to be insignificant in comparison to the intrinsic anisotropy of the samples (Yang *et al.*, 1993a, b).

2. Magnetic Mineralogy

A series of experiments has been undertaken to investigate various aspects of the magnetic mineralogy of the ceramics. The magnetic mineralogy of these samples is dominated, in terms of the intensity of magnetisation, by magnetite-type minerals. Since Curie temperature depends only on the type of magnetic mineral the thermomagnetic behaviour of each sample was investigated by measuring the magnetisation of a crushed sub-specimen in a strong field (about 0.6 Tesla) during thermal cycling from room temperature to 700°C and back to room temperature in air. The Curie temperatures for these samples are typical of magnetite (570–590°C, Fig. 2a). The presence

Fig. 1. Distribution of Sampling areas in north central and northeast China. G, H, J, and L are the abbreviations of Gansu, Helongjiang, Jilin and Liaolin provinces respectively.

of cation deficient (CD) magnetite was identified for some samples with Curie temperatures distributed in the range of 610–630°C (Fig. 2b). The apparent absence of haematite (Curie temperature 680°C) may simply reflect its relatively weak saturation magnetisation, which is about two orders at magnitude less than magnetite. Thus when a significant portion of magnetite is present, the signal from haematite is swamped.

The precise nature and size distribution of domain states cannot be elucidated. However, using the ratio M_{rs}/M_s (Fig. 3) from magnetic hysteresis results together with susceptibility changes from liquid nitrogen temperature (–196°C) to room temperature, some information about the domain states can be estimated. If the magnetic mineral in a sample is only magnetite,

Table 1. Site mean archaeointensity data from Chinese Ceramics.

Site	Lat	Long	Dynasty	Age (B.P.)	Method	N	Ba $\pm$ Sd
ShenYang	41.75°	123.4°	Neolithic	7000 $\pm$ 500	C14	2	36.2 $\pm$ 5.9
LongAn	44.5°	125.2°	Neolithic	6500 $\pm$ 500	C14	1	36.9 $\pm$ 5.6
ChangLing	44.6°	124.0°	Neolithic	6000 $\pm$ 500	C14	1	31.9 $\pm$ 4.6
ZhengGun	44.8°	123.2°	Neolithic	4750 $\pm$ 450	C14	2	37.0 $\pm$ 4.5
ShenYang	41.75°	123.4°	Neolithic	4500 $\pm$ 400	C14	4	41.8 $\pm$ 1.2
ChangLing	44.6°	124.0°	Neolithic	4200 $\pm$ 300	C14	1	45.1 $\pm$ 3.7
ChaoYang	41.6°	120.5°	Xia	3750 $\pm$ 250	A*	2	67.2 $\pm$ 4.1
ChaoYang	41.6°	120.5°	Early Shany	3500 $\pm$ 200	A*	1	59.2 $\pm$ 2.6
FuShun	41.8°	123.9°	Late Shang	3150 $\pm$ 200	A*	2	64.6 $\pm$ 2.5
GeZho	41.0°	119.7°	Shang-Zhou	3000 $\pm$ 250	A*	2	53.7 $\pm$ 2.2
ChaoYang	41.6°	120.5°	Western Zhou	2763 $\pm$ 200	A*	3	55.8 $\pm$ 5.0
ZhaoYuan	45.4°	125.1°	Western Zhou	2750 $\pm$ 150	A*	2	52.8 $\pm$ 6.2
FuShun	41.8°	123.9°	Western Zhou	2550 $\pm$ 300	A*	2	48.2 $\pm$ 3.8
YongJi	43.65°	126.5°	Western Zhou	2500 $\pm$ 300	A*	2	54.1 $\pm$ 0.2
YuShu	44.85°	126.5°	Western Han	1990 $\pm$ 150	A*	1	56.4 $\pm$ 4.0
FuShun	41.8°	123.9°	Eastern Han	1870 $\pm$ 98	A*	2	56.6 $\pm$ 0.2
ChaoYang	41.6°	120.5°	Eastern Han	1770 $\pm$ 198	A*	2	55.2 $\pm$ 1.7
ChaoYang	41.6°	120.5°	Liao	976 $\pm$ 109	A*	5	64.1 $\pm$ 4.5
A'Cheng	45.6°	126.9°	Liao	900 $\pm$ 100	A*	1	64.1 $\pm$ 6.3
DongXiang	35.9°	103.5°	Neolithic	4750 $\pm$ 300	C14	3	29.1 $\pm$ 3.0
LanZhou	36.0°	103.8°	Neolithic	4000 $\pm$ 400	C14	2	46.5 $\pm$ 1.0
LeDou	36.3°	102.4°	Neolithic	7000 $\pm$ 700	C14	3	34.6 $\pm$ 2.8
LingTai	35.1°	107.6°	Xia-Shany	3700 $\pm$ 350	A*	2	46.9 $\pm$ 3.5
MinLe	38.5°	101.1°	Xia-Shany	3500 $\pm$ 350	A*	2	44.0 $\pm$ 2.5
Qin'an	34.8°	105.7°	Neolithic	7500 $\pm$ 600	C14	3	30.8 $\pm$ 0.4
Qin'an	34.8°	105.7°	Neolithic	6200 $\pm$ 500	C14	3	27.9 $\pm$ 1.5
Qin'an	34.8°	105.7°	Neolithic	5000 $\pm$ 350	C14	2	36.6 $\pm$ 2.7
Qin'an	34.8°	105.7°	Neolithic	5700 $\pm$ 350	C14	3	28.7 $\pm$ 1.0
Qin'an	34.8°	105.7°	Neolithic	5200 $\pm$ 400	C14	2	35.6 $\pm$ 0.5
YongDeng	36.8°	103.3°	Western Zhou	2700 $\pm$ 150	A*	2	42.1 $\pm$ 6.0
YongCheng	38.2°	101.9°	Neolithic	4500 $\pm$ 350	C14	3	40.0 $\pm$ 2.1
YongQing	35.7°	103.3°	Xiao-Shang	3600 $\pm$ 350	C14	3	49.5 $\pm$ 6.8

A*: Dating was made by archaeological context and/or artefact type.

the value of Mrs/Ms can give an insight into the distribution of domain states (Day *et al.*, 1977), e.g. 0.5 for single-domain (SD), from 0.5 to 0.1 for pseudo-single-domain (PSD), less than 0.1 for multidomain (MD) and even lower for superparamagnetic (SP) grains. It was found that superparamagnetic (SP) and single domain (SD) particles dominate the magnetic mineralogy of most samples, although the presence of MD particles is evident for a few samples which showed susceptibility peaks at about -150°C (Senanayake and McElhinny, 1981).

The mineralogy and domain states of the magnetic particles present in a ceramic shard affect the acquisition of the NRM, the alteration of the NRM over time and the retrieval of the ancient field magnitude from the ceramic sample. Samples containing CD magnetite are problematic since CD magnetite is a low temperature alteration product of magnetite and part of the remanence held by CD magnetite is probably formed chemically after the initial firing.

The anisotropy of magnetic susceptibility (AMS) caused by a preferred orientation of magnetic particles and the effect of AMS upon TRM and ARM acquisition is a well known phe-

Fig. 2. (a) Histogram of Curie temperatures for a collection of pottery samples from north central and northeast China. (b) An example of a thermomagnetic curves showing Curie temperatures higher than 600°C.

Fig. 3. Histogram of Mrs/Ms of a collection of pottery samples from north central and northeast China.

nomenon that has been investigated previously (Rogers *et al.*, 1979; Stephenson *et al.*, 1986; Yang *et al.*, 1993a). The direction and normalised magnitudes of the susceptibility axes ($K1$, $K2$, $K3$, where $K1 > K2 > K3$) were measured for all the samples using a Molspin anisotropy delineator. These AMS measurements showed that the orientation of the minimum axis ($K3$) is nearly perpendicular to the plane of the ceramics and $K1$ and $K2$ (which define an 'easy plane' of magnetisation) are almost coincident with the plane of the ceramics. Samples showed quite a high degree of anisotropy, with an average $K1/K3$ of about 1.1. The anisotropy ratio of remanence (TRM or ARM) is even greater. In archaeointensity studies, the direction of the TRM produced in the laboratory (in our experiments usually along the axes of the cylindrical samples) often differs from the direction of the NRM. In such circumstances an anisotropy correction should be applied otherwise the archaeointensity will be overestimated (Yang *et al.*, 1993a).

3. Archaeointensity Determinations

For the samples from north central China, 20 of them were analyzed using the Shaw method and 34 using the Thellier method. Acceptable agreement between the results from two method was found (Yang *et al.*, 1993a). A previous investigation of ceramic samples from Peru (Yang *et al.*, 1993c) found that the lower part of the NRM blocking temperature spectrum (up to 300°C) was often affected by magnetic viscosity or partial reheating. Chemical alteration usually occurred during laboratory heating to higher temperatures so it was sometimes quite difficult to choose a suitable NRM temperature range for archaeointensity determination by the Thellier technique. Although the modified Shaw technique (Rolph and Shaw, 1985) can provide a correc-

Fig. 4. Examples of thermal and a.f. demagnetisation of NRM.

tion for thermal alteration by using ARM1 and ARM2 (ARM1 given before, and ARM2 given after a laboratory heating and in identical conditions) to correct the TRM for thermal alteration, alternating field (AF) demagnetisation was not always able to isolate the low temperature PTRM components that had been identified in samples by thermal demagnetisation (Yang *et al.*, 1993a). In an attempt to incorporate the best aspects of the Thellier and Shaw techniques the samples from northeast China were initially thermally demagnetized to 300°C and then the remaining remanences (NRM, ARM1, TRM, ARM2) were analyzed by AF demagnetisation, as in the modified Shaw palaeointensity technique (Rolph and Shaw, 1985). The palaeointensity experimental procedures consisted of the following steps.

- (1) Measure the total NRM for each sample.
- (2) Heat the sample to 100°C in zero magnetic field and measure the NRM remaining.
- (3) Heat the sample to 100°C and cool in a magnetic field of 50 μT to create PTRM1; measure PTRM1.
- (4) Thermally demagnetise by heating to 300°C in a zero field and then measure the NRM remaining.
- (5) Heat the sample to 100°C and cool in a magnetic field of 50 μT to create PTRM2; measure PTRM2.
- (6) Thermally demagnetise by heating to 100°C and cool in a zero magnetic field.
- (7) Stepwise AF demagnetise and measure up to 170 mT.
- (8) Create an ARM (ARM1) in the same direction as the NRM.
- (9) Thermally demagnetise to 300°C and then stepwise AF demagnetise and measure PARM1 as in (7).
- (10) Heat to 650°C and cool in a field of 50 μT to create a TRM.
- (11) Thermally and AF demagnetise as in (9).
- (12) Create ARM2 in the same direction as the TRM.
- (13) Thermally and AF demagnetise as in (9).

Fig. 5. An example of archaeointensity determination by the modified Shaw Method. NRM, TRM, ARM1 and ARM2 are partial remanences from the blocking temperature interval above 300°C rather than total remanences. The units for archaeointensity are μT , the units for NRM and TRM are $10^{-5} \text{ Am}^2\text{kg}^{-1}$.

By comparing PTRM1 and PTRM2 for each sample, thermal alteration can be checked in the intervening heating steps. For the samples showing a significant difference between the PTRMs, the magnetic susceptibility or thermomagnetic behaviour is used to confirm the chemical alteration. Four samples were rejected because the magnetic susceptibility also showed significant alteration (more than 5%) after heating to 300°C.

A previous investigation (Yang *et al.*, 1993a) demonstrated that ARM anisotropy is very similar to the corresponding TRM anisotropy and therefore ARM can be used to replace TRM for anisotropy correction when using the Thellier technique. When using the Shaw technique in the present investigation, ARM1 and ARM2 were given in the direction of the NRM and TRM respectively. The ARM correction (Rolph and Shaw, 1985) was applied to the TRM; this also corrects for any magnetic anisotropy. It was found that the ARM-corrected TRM (TRMc), as shown in an example in Figs. 4 and 5, often shows a linear NRM-TRMc relationship although the NRM-TRM relationship deviates from a straight line.

To impart the TRM's used in experiments, samples were cooled down from elevated temperature to room temperature in about half an hour, almost two orders of magnitude faster than the cooling which took place in antiquity. Experimental results indicate that such disparity in cooling rates can cause archaeointensities to be overestimated up to 10% (Fox and Aitken, 1980). To observe this cooling rate effect, fifteen samples were given consecutive TRMs, the first with a cooling time of 35 minutes and the second with a cooling time of 7 hours. The slower cooled TRMs compared to the faster cooled TRM's showed an average increase of 4% (1% to 6% for individual sample), as shown in Fig. 6. However no cooling rate correction has been applied to the results presented here. The archaeointensity results from the present investigation are given in Table 1 and the specimen data are summarized in the Appendix. There is good agreement between the results from north central China and northeast China, as shown in Fig. 7.

Fig. 6. TRM's of 15 Chinese ceramics obtained by cooling from 650°C in a constant laboratory field (50 μ T) with cooling time of about 35 minutes (fast) or 7 hours (slow). The line was fitted by least squares regression and has a slope of 0.94. The units for TRM are $10^{-5} \text{ Am}^2\text{kg}^{-1}$.

Fig. 7. Archaeointensity results from north central and northeast China.

4. Discussion and Conclusion

The equivalent virtual axial dipole moments (VDAM) of the archaeointensity results from northeast China and a smoothed secular variation curve, fitted by using a cubic spline approximation in which the error of each data point (the standard error of the mean) was used as a weighting factor, are shown in Fig. 8. After an initial small decrease ($6.5 \times 10^{22} \text{ Am}^2$ to $6.0 \times 10^{22} \text{ Am}^2$, 7500–5500 years ago) the dipole moment shows a large increase almost doubling ($6.0 \times 10^{22} \text{ Am}^2$ to $11.0 \times 10^{22} \text{ Am}^2$) between 5500 and 3500 years ago. Thus it forms a peak at about 3500 years ago. The magnitude of the VADM decreased for about 1000 years, from 3500 years ago to 2500 years ago, (from 11.0 to $8.5 \times 10^{22} \text{ Am}^2$ or even lower). This decrease can also be seen in previous archaeointensity results from different areas of China (Wei *et al.*, 1982, 1986, 1987), as shown in Fig. 9, but cannot be clearly identified in the global model of McElhinny and Senanayake (1982). Comparing our Chinese data with Japanese data (Tanaka, 1990), it is found that generally the changes in the magnitude of the geomagnetic field are very similar for the past 2,000 years. Some anomalously high values are found in the Japanese data around 3,000–4,000 years ago, but they do not form a clear peak in paleointensity. Using the Thellier method on Hawaiian volcanics, palaeointensity results for the last 15,000 years were recently reported (Mankinen and Champion, 1993) with some high palaeointensity values around 3,000–4,000 years ago. High values in the Chinese, Japanese and Hawaii results suggest a global high palaeointensity value around 3,500 years ago.

Alternatively the Chinese 3,500 year maximum may be a local feature of the non-dipole field. Geomagnetic intensity variations from Greece for the last 4000 years (Aitken *et al.*, 1989) show a maximum close to 2,650 years ago and a minimum at about 1800 years ago. This decrease lags significantly behind the equivalent trend in the Chinese results which may indicate that it is not dipolar in origin. In order to look at the non-dipole field in Greece and China each archaeomagnetic data set was first normalised to its average and then subtracted from the similarly normalised global field model of McElhinny and Senanayake (1982). If the observed decrease in field strength is attributed to a non-dipole source then it is possible to determine the sense and rate of the drift of this feature by comparing the two data sets. This analysis indicates a westward drift (Fig. 10) of a non-dipole feature. The magnitude of the supposed non-dipole fields are as

Fig. 8. The results from northeast China averaged according to age. Vertical error bars are the standard error of the mean. The curve is a cubic spline approximation.

Fig. 9. Comparison of present results from northeast China (curve) with previous archaeointensity data from central east China (square) and south east China (solid square) (after Wei *et al.*, 1982, 1986, 1987).

high as 26% of the dipole field in China but only 17% or less in Greece. Using cross correlation analysis, the Greek curve lags the Chinese curve by 800 years (cross correlation coefficient 0.87). If we consider the average longitude of the two sites (Greece, 23°E; NE China 124°E), the rate of westward drift of this large non-dipole anomaly is estimated to be about 0.126°/yr. This westward drift rate is within the limits (0.1–0.4°/yr) derived by Aitken *et al.* (1989) and also consistent with the value of 0.2°/yr derived by Bullard *et al.* (1950). The two archaeomagnetic curves (Fig. 10) corrected for westward drift are not identical but that is to be expected because non-dipole anomalies are themselves changing shape and magnitude with time and the global model of McElhinny and Senanayake (1982) contains more weighing for European results. Also

Fig. 10. Comparison of normalised NDF (non-dipole Field) intensities expressed as the difference between normalised archaeointensity data and the normalised dipole field data of McElhinny and Senanayake (1982). Present result from northeast China and Greece (solid curves as indicated separately) and Greece with time shifted 800 years (dashed curve).

the peak VDM for north central China is lower in magnitude than the peak for northeast China (Fig. 7). The average latitude difference between the two data sets is 10° so this difference may be because the north central China sites are on the southern flanks of a non-dipole anomaly while the northeast sites are nearer the centre of the anomaly.

Is the 3,500 year maximum a global or local feature? Better regional and global coverage of archaeointensity results is necessary if we are to answer this important question.

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Appendix: Specimen Data

Site	Sample	Method	BI (μT)	Low-High	n	-r	-b	Ba $\pm$ Sd	Age (B.P)
ShenYang	A	Shaw	50	20-110	7	0.996	0.853	42.6 ± 1.4	7000 ± 500
	B	Shaw	50	20-110	7	0.998	0.612	30.2 ± 1.2	
LongAn	A	Shaw	50	30-140	7	0.984	0.737	36.9 ± 5.6	6500 ± 500
ChangLing	A	Shaw	50	20-110	7	0.989	0.638	31.9 ± 4.6	6000 ± 500
ZhengGun	A	Shaw	50	20-110	7	0.967	0.762	38.1 ± 9.7	4750 ± 450
	B	Shaw	50	20-110	7	0.992	0.728	36.4 ± 4.5	
ShenYang	A	Shaw	50	30-110	6	0.999	0.856	42.8 ± 1.7	4500 ± 400
	B	Shaw	50	30-110	6	0.999	0.892	44.6 ± 2.7	
	C	Shaw	50	30-110	6	0.997	0.828	41.4 ± 4.9	
	D	Thellier	50	250-550	7	0.994	0.836	41.8 ± 3.3	
ChangLing	A	Shaw	50	20-140	8	0.997	0.902	45.1 ± 3.7	4200 ± 300
ChaoYang	A	Shaw	50	10-160	8	0.998	1.424	71.2 ± 3.4	3750 ± 250
	B	Shaw	50	10-160	8	0.993	1.274	63.7 ± 4.1	
ChaoYang	A	Shaw	50	20-110	7	0.995	1.184	59.2 ± 2.6	3500 ± 200
FuShun	A	Shaw	50	10-90	7	0.991	1.344	67.2 ± 2.1	3150 ± 200
	B	Shaw	50	10-90	7	0.993	1.242	62.1 ± 2.3	

GeZho	A	Thellier	50	200-500	7	0.982	1.012	50.6 ± 5.8	3000 ± 250
	B	Shaw	50	0-70	9	0.999	1.114	55.9 ± 1.7	
ChaoYang	A	Shaw	50	20-110	7	0.996	1.192	59.6 ± 3.9	2763 ± 200
	B	Shaw	50	20-110	7	0.991	0.966	48.3 ± 3.2	
	C	Thellier	50	200-500	7	0.986	1.192	59.6 ± 5.6	
ZhaoYuan	A	Shaw	50	20-110	7	0.989	1.072	53.6 ± 5.9	2750 ± 150
	B	Shaw	50	20-110	7	0.990	1.040	52.0 ± 6.2	
FuShun	A	Shaw	50	35-140	6	0.992	0.966	48.3 ± 3.3	2550 ± 300
	B	Shaw	50	35-140	6	0.990	0.962	48.1 ± 3.8	
YongJi	A	Shaw	50	30-140	6	0.992	1.072	53.8 ± 4.6	2500 ± 300
	B	Shaw	50	30-140	6	0.973	1.086	54.3 ± 9.2	
YuShu	A	Shaw	50	20-130	7	0.991	1.128	56.4 ± 4.0	1990 ± 150
FuShun	A	Shaw	50	30-140	6	0.994	1.128	56.4 ± 3.0	1870 ± 98
	B	Shaw	50	30-140	6	0.999	1.136	56.8 ± 1.8	
ChaoYang	A	Shaw	50	10-80	6	0.986	1.136	56.8 ± 5.1	1770 ± 198
	B	Shaw	50	10-80	6	0.997	1.014	50.7 ± 2.0	
ChaoYang	A	Shaw	50	20-90	6	0.999	1.301	65.0 ± 1.7	976 ± 109
	B	Shaw	50	20-90	6	0.992	1.366	68.3 ± 3.3	
	C	Thellier	50	200-500	7	0.994	1.314	65.7 ± 2.2	
	D	Shaw	50	20-110	7	0.990	1.172	58.6 ± 4.4	
	E	Shaw	50	20-110	7	0.997	1.390	69.5 ± 3.3	
A'Cheng	A	Thellier	50	200-500	7	0.983	1.282	64.1 ± 6.3	900 ± 100
DongXiang	A	Thellier	50	250-550	7	0.987	0.588	29.4 ± 3.1	4750 ± 300
	B	Thellier	50	250-550	7	0.983	0.570	28.5 ± 3.3	
	C	Thellier	50	250-550	7	0.984	0.586	29.3 ± 2.9	
LanZhou	A	Thellier	50	300-550	6	0.989	0.922	46.1 ± 3.3	4000 ± 400
	A	Shaw	50	20-100	7	0.997	0.892	44.6 ± 1.6	
	B	Shaw	50	20-100	7	0.994	0.951	47.5 ± 2.6	
LeDou	A	Thellier	50	300-550	6	0.987	0.602	30.1 ± 3.0	7000 ± 700
	A	Shaw	50	20-140	8	0.984	0.694	34.7 ± 3.2	
	B	Thellier	50	250-550	7	0.995	0.636	31.8 ± 1.8	
	C	Shaw	50	20-140	8	0.997	0.722	36.4 ± 1.1	
LingTai	A	Thellier	50	250-550	7	0.984	0.882	44.1 ± 4.4	3700 ± 350
	A	Shaw	50	15-100	9	0.991	0.868	43.4 ± 3.5	
	B	Thellier	50	250-550	7	0.979	1.061	53.0 ± 5.7	
	B	Shaw	50	15-100	9	0.986	1.006	50.3 ± 5.9	
MinLe	A	Thellier	50	350-600	6	0.990	0.844	42.2 ± 2.2	3500 ± 300
	A	Shaw	50	15-130	7	0.998	0.931	46.5 ± 0.8	
	B	Thellier	50	300-550	6	0.987	0.872	43.6 ± 4.5	
Qin'an	A	Thellier	50	300-550	6	0.998	0.608	30.8 ± 0.4	7500 ± 600
Qin'an	A	Thellier	50	250-500	6	0.983	0.514	25.7 ± 2.3	6200 ± 500
	A	Shaw	50	20-100	7	0.985	0.668	33.4 ± 3.7	
	B	Thellier	50	250-500	6	0.997	0.528	26.4 ± 1.0	
Qin'an	A	Thellier	50	250-500	6	0.984	0.772	38.7 ± 4.3	5000 ± 350
	B	Thellier	50	250-500	6	0.986	0.666	33.3 ± 3.5	
Qin'an	A	Thellier	50	250-500	6	0.989	0.576	28.9 ± 3.1	5700 ± 350
	B	Thellier	50	250-500	6	0.978	0.560	28.0 ± 4.8	
	B	Shaw	50	20-100	7	0.991	0.656	32.8 ± 2.9	
Qin'an	A	Thellier	50	300-550	6	0.990	0.694	34.7 ± 3.0	5200 ± 400
	B	Thellier	50	300-550	6	0.998	0.644	32.2 ± 1.2	
	B	Shaw	50	30-100	5	0.984	0.816	40.8 ± 2.7	
YongDeng	A	Thellier	50	300-550	6	0.988	0.952	47.6 ± 5.5	2700 ± 150
	B	Thellier	50	300-550	6	0.986	0.819	41.0 ± 4.2	
	B	Shaw	50	20-80	7	0.992	0.644	32.2 ± 1.9	

YongCheng	A	Thellier	50	250-550	7	0.997	0.689	34.5 ± 1.9	4500 ± 350
	B	Thellier	50	250-550	7	0.975	0.756	37.8 ± 4.1	
	B	Shaw	50	30-110	6	0.999	0.928	46.5 ± 1.2	
YongQing	A	Thellier	50	250-550	6	0.972	0.852	42.6 ± 6.0	3600 ± 350
	A	Shaw	50	20-100	7	0.987	1.126	56.3 ± 4.2	
	B	Thellier	50	250-550	6	0.993	0.914	45.6 ± 2.0	
	C	Thellier	50	250-550	6	0.998	1.166	58.3 ± 1.1	
	C	Shaw	50	20-100	7	0.999	1.322	66.1 ± 1.3	

Note: Bl is the laboratory field used to create a TRM. The low and high.

Value are temperature ($^{\circ}\text{C}$) and alternating field (mT) for the Thellier and the Shaw methods respectively.

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