Archaeomagnetic dating of the Liebrüti tile kilns, Kaiseraugst

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Archaeomagnetic dating of the Liebrüti tile kilns, Kaiseraugst

Ian G. Hedley[1]

Abstract

Two tile kilns at Liebrüti, Kaiseraugst, have been sampled for an archaeomagnetic study. Only the larger kiln gives an acceptable result and the samples from the smaller kiln have possibly been disturbed during restoration. Comparison with the archaeomagnetic reference curve for Paris gives two possible age solutions for the larger kiln: mid 2nd century and mid 3rd century. Both ages are somewhat older than that based on archaeological evidence: 4th century AD. The close proximity of the two kilns to each other could have distorted the ambient geomagnetic field in antiquity and so influenced the archaeomagnetic record in the larger kiln.

Key words

Archaeological research, archaeomagnetism, dating, Kaiseraugst/AG, tile kilns.

Zusammenfassung

Die beiden römischen Ziegelbrennöfen in Kaiseraugst-Liebrüti sind für eine archäomagnetische Untersuchung beprobt worden. Nur der grössere der beiden Öfen erbrachte ein brauchbares Resultat, während die Proben des kleineren Brennofens möglicherweise bei den Restaurierungsarbeiten verändert worden sind. Vergleiche mit der archäomagnetischen Referenzkurve aus Paris ergeben zwei mögliche Datierungen für den grösseren Ofen: Mitte 2. und Mitte 3. Jahrhundert n. Chr. Beide Datierungen sind etwas älter als die archäologische Datierung ins 4. Jahrhundert. Die enge Nachbarschaft der beiden Öfen hätte das umgebende Magnetfeld in der Antike verzerren und so die archäomagnetischen Werte des grösseren Ziegelbrennofens beeinflussen können.

Schlüsselwörter

Archäologische Forschung, Archäomagnetik, Datierung, Kasieraugst/AG, Ziegelbrennöfen.

The two tile kilns at Liebrüti[2], preserved inside a large building (fig. 1), were sampled in 1981 for an archaeomagnetic study (fig. 2). In the case of the *larger kiln*[3] 10 pieces of tile were taken from inside the central heating canal and also 5 fragments of baked clay removed from the floor using the glued-disk technique. Only 6 pieces of tile were sampled from the *smaller kiln*[4]. All the samples were oriented using a geologist's compass using a 13 cm plastic distance piece to reduce any influence of the kiln on the compass needle (fig. 3). The location of the kilns within a building meant that it was not possible to check the orientation even of the floor samples with a sun compass.

Fig. 1: Kaiseraugst, Liebrüti: "Tile works". The steel structure (dark window frames) of the protective building over the two tile kilns of the fortress garrison (with an exhibition on tile making).

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2 T. Tomasevic-Buck, Die Ziegelbrennöfen der Legio I Martia in Kaiseraugst, AG und die Ausgrabungen in der Liebrüti 1970–1975. Arch. Führer Augst/Kaiseraugst 1 (Liestal 1982); L. Berger (mit einem Beitr. v. Th. Hufschmid), Führer durch Augusta Raurica (Basel 19986) 194–196; A. R. Furger (English translation C. Aitken and Ch. Maier), Augusta Raurica. English Guide. Arch. Führer durch Augst/Kaiseraugst 2 – Archaeological guide to Augst and Kaiseraugst 2 (Augst 1995) 57. – For the chemical analysis of the clay for the tiles produced here see M. Maggetti/G. Galetti, Die Baukeramik von Augusta Raurica – eine mineralogisch-chemisch-technische Untersuchung. Zur Herstellung und Verbreitung der in Kaiseraugst produzierten Ziegel der Legio Prima Martia. Jahresber. Augst u. Kaiseraugst 14, 1993, 199–225.

3 Tomasevic-Buck (footnote 2) fig. 6, above; Berger (footnote 2) fig. 192.

4 Tomasevic-Buck (footnote 2) fig. 6, below; Berger (footnote 2) fig. 190; 191.

Fig. 2: Kaiseraugst, Liebrüti. Plan of the two tile kilns within the protective building (bright area), showing location of archaeomagnetic samples. Scale 1:100.

Kiln	Number of samples (accepted)	Mean Declination (°)	Mean Inclination (°)	Alpha[5] 95 (°)#	k-precision parameter[6]
Large	15 (11)	355,5	59,8	2,1	480
Small	6	341,2	64,1	8,8	58

The tile samples were then sub-sampled in the workshop using non-magnetic tools to give between 2 and 8 cylindrical specimens per tile. From the large and small kilns altogether 47, respectively 10 specimens were analysed[7].

The tile specimens were heated to 200° C and cooled in the absence of the earth's magnetic field to remove any secondary unstable magnetisation that could have been induced in the baked clay since the last cooling-down of the kiln.

Only the large kiln gives an acceptable archaeomagnetic result, as the directions obtained for the samples from the small kiln are too dispersed (large alpha 95) to provide a reliable archaeomagnetic date. The possibility that the tiles that were sampled from the outside of the small kiln had been moved during restoration[8] cannot be excluded. If this were the case then their original orientation in the kiln would be lost and consequently produce a large dispersion of the directions of remanent magnetisation.

Four of the 15 samples analysed from the larger kiln were rejected mainly because of their weak magnetisation, probably due to insufficient heating. The mean direction of the remaining 11 samples accepted from the large kiln was then transposed to the geographical site of Paris in order to be compared with the French archaeomagnetic reference curve[9]. This transposition was done on the hypothesis of a dipolar axial geomagnetic field and gives the following direction:

$$D_{Paris} = 354{,}5°,\ I_{Paris} = 61{,}2°.$$

Adopting an approach based on Bayesian statistics the programme REN-DATE[10] was used together with the smoothed French archaeomagnetic reference curve (REN-CMT) to date the large kiln[11]. Because of the narrow loop shape of the reference curve during Roman times *two dates* are possible: mid 2nd century and mid 3rd century. The curve showing the relative likelihood of the dates at 95% probability is shown in figure 4. The two solutions are not

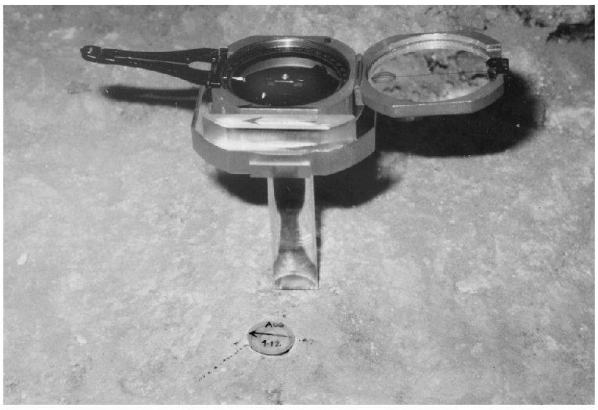

Fig. 3: Kaiseraugst, Liebrüti, tile kilns. Sampling of the floor of the large tile kiln using the glued-disc technique. Orientation of the specimen using a geologist's compass and a plastic distance piece.

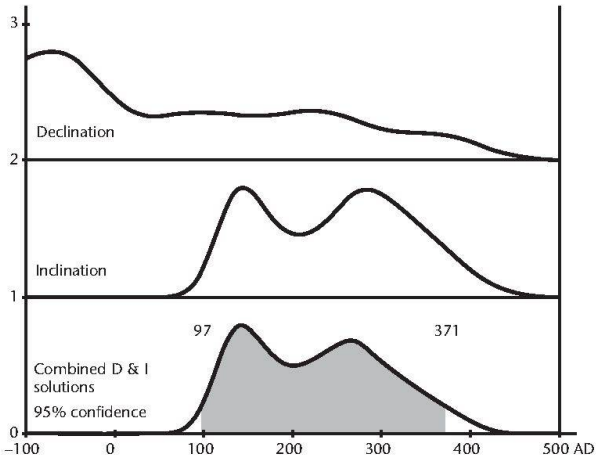

Fig. 4: Kaiseraugst, Liebrüti, large kiln. Archaeomagnetic dating based on 11 samples (fig. 2, "accepted"), using the programme (REN-DATE) together with the reference curve for Paris (REN-CURVE).

5 *Alpha 95* is the semi-angle of a cone around the calculated mean direction within which there is a 95% chance of finding the true mean direction (Fisher statistics). A value of only several degrees corresponds to good data.

6 *k* is the best estimate of the Fisher precision parameter that is a measure of the dispersion of the directions of the individual specimens. The greater the value the tighter is the dispersion around the calculated mean direction.

7 Thanks are due to Patrizia D'Ascoli for all the magnetic analyses.

8 For the restoration work carried out in 1979–1980 see W. Hürbin/J. Ewald, Denkmalpflege in Augst und Kaiseraugst 1975–1987. Bericht der Abteilung Konservierungen und Ruinendienst Augst/Kaiseraugst. Jahresber. Augst u. Kaiseraugst 9, 1988, 245–257 especially 254 fig. 12; Tomasevic-Buck (footnote 2) 15 fig. 14.

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10 Ph. Lanos, L'approche bayésienne en chronométrie: Application à l'archéomagnétisme. In: J.-N. Barrandon (ed.), Datation: actes des rencontres 19, 20, 21 octobre 2000. Rencontres Internationales Arch. et Hist. Antibes 21 (Antibes 2001) 113–139.

11 M. Kovacheva/I. Hedley/N. Jordanova/M. Kostadinova/V. Gigov, Archaeomagnetic dating of Archaeological sites from Switzerland and Bulgaria. Journal Arch. Science 31, 2004, 1463–1479.

distinct and overlap, giving an age band from 97 to 371 AD[12].

It should be mentioned that the magnetic influence on the orientation of the samples of the large mass of baked clay of the kiln as well as that of the steel structure of the protective building (fig. 1) when they were taken from the kiln is unknown. However, this would only affect the orientation azimuth of the samples and not their inclination. Furthermore, during the Roman period there was little change in magnetic declination as it was largely a variation in the inclination of the geomagnetic field that dominated. Judging from low dispersion of directions of the samples (alpha 95 = 2,1°) it would suggest that this disturbing effect was not important.

Another possible perturbing factor is the inherent magnetic anisotropy of the tiles, which arises from the mutual alignment of the magnetic grains in the tile produced during their manufacture. This magnetic anisotropy would cause the direction of magnetization of the tile to deviate from the direction of the ambient field when the kiln was last cooled down.

The magnitude of this effect depends on the degree of anisotropy as well as the orientation of the tile with respect to the geomagnetic field. A correction can be applied[13] and this was carried out during an archaeomagnetic directional study of a Roman lime kiln constructed with tiles at Vindonissa (Windisch, AG)[14].

However, a study of the anisotropy of the initial magnetic susceptibility of the tiles from Liebrüti shows that they are significantly less anisotropic than the tiles from Vindonissa. Although a detailed study of the anisotropy of the remanence of the Liebrüti tiles has not been undertaken it would seem that their anisotropy does not play an important role.

Due to the fact that the kilns have been protected for posterity, sampling was restricted and may not have been representative of the whole kiln. Consequently inadequate sampling coupled with a magnetic refraction effect due to the massive kiln cooling in its own field could possibly produce a bias in the mean direction obtained[15]. The mean magnetisation of the tiles sampled from the larger kiln was appreciable (2,5 A/m).

The presence of the smaller, but nevertheless substantial kiln so close to the larger one would have distorted the local geomagnetic field in antiquity, and if the effect was large enough, the direction recorded by this kiln when cooling down would deviate from that of the regional field at Kaiseraugst.

Acknowledgements of illustrations

Fig. 1:
Photo Ursi Schild.

Fig. 2:
Drawing Michael Vock (after a plan of Constant Clareboets); localisation of samples Ian G. Hedley.

Fig. 3:
Photo Ian G. Hedley.

Fig. 4:
Interpretation Ian G. Hedley; drawing Jacques Metzger.

12 Alex R. Furger gives the following comment on this dating result from the archaeological point of view: *Die sich aus der archäomagnetischen Datierung des grossen Ziegelbrennofens von Kaiseraugst-Liebrüti ergebenen beiden grössten Wahrscheinlichkeiten im 2. und im 3. Jahrhundert (Gesamtspanne innerhalb der 95%-Bandbreite 2.–4. Jh.; fig. 4) ist im Vergleich zum archäologischen Befund tendenziell rund ein Jahrhundert zu früh. Die der Legio Prima Martia zugeschriebene Ziegelei (siehe Lit. in Anm. 2) muss diesen Ziegelbrennofen im 4. Jahrhundert in Betrieb gehabt haben. Verschiedene archäologische und historische Indizien weisen in die 1. Hälfte des 4. Jahrhunderts (zuletzt R. Fellmann, Spätrömische Festungen und Posten im Bereich der Legio I Martia. In: C. Bridger/K.-J. Gilles [Hrsg.], Spätrömische Befestigungsanlagen in den Rhein- und Donauprovinzen. Beiträge der Arbeitsgemeinschaft «Römische Archäologie» bei der Tagung des West- und Süddeutschen Verbandes der Altertumsforschung in Kempten 08.06.–09.06.1995. BAR, Internat. Ser. 704 [Oxford 1998] 95–103 bes. 98 f.)* (publishers note, 07.04.2004).

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