CHINESE TOMBS ORIENTED BY A COMPASS: EVIDENCE FROM PALEOMAGNETIC CHANGES VERSUS THE AGE OF TOMBS

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ABSTRACT

Extant written records indicate that knowledge of an ancient type of compass in China is very old - dating back to before the Han dynasty (206 BC– 220 AD) to at least the 4th century BC. Geomancy (feng shui) was practised for a long time (for millenia) and had a profound influence on the face of China's landscape and city plans. The tombs (pyramids) near the former Chinese capital cities of Xi'an and Luoyang (together with their suburban fields and roads) show strong spatial orientations, sometimes along a basic South-North axis (relative to the geographic pole), but usually with deviations of several degrees to the East or West. The use of the compass means that the needle was directed towards the actual magnetic pole at the time of construction, or last reconstruction, of the respective tomb. However the magnetic pole, relative to the nearly 'fixed' geographic pole, shifts significantly over time. By matching paleomagnetic observations with modeled paleomagnetic history we have identified the date of pyramid construction in central China with the orientation relative to the magnetic pole positions at the respective time of construction. As in Mesoamerica, where according to the Fuson hypothesis the Olmécs and Maya oriented their ceremonial buildings and pyramids using a compass even before the Chinese, here in central China the same technique may have been used. We found a good agreement of trends between the paleodeclinations observed from tomb aligments and the available global geomagnetic field model CALS7K.2.

Keywords: Chinese tombs ("pyramids"), magnetic compass, paleomagnetic declination, Fuson hypothesis

1. INTRODUCTION AND MOTIVATION

Everywhere in this paper we use the official *pinyin* system of transcription of Chinese names.

According to ancient chronicles, *a magnetic compass* in China has been known since at least the 4th century BC, since the Zhou dynasty (1046–250 BC) (*Gui Gu Zi, 4th century BC*). A spoon-shaped lodestone placed on a square brass plate with the circle at its centre represents one of the ancient forms of Chinese South-pointers. It was used for divination. In the Song period (420–479 AD), one of its early forms was a small piece of lodestone embedded in the body of a wooden fish with a small needle projecting from it; floating in water, it indicates the South (see e.g., *Needham, 1964*). We are accustomed to thinking of the magnetic needle as pointing to the North, but in China the Polar Star represented the emperor who faced South on his throne, and so the basic direction was to the South.

More than 1500 years ago Chinese sailors discovered that an elongated piece of lodestone suspended from a thread "magically" pivots until it points South and thus that this stone could act as an aid to navigation on their voyages; the lodestone exhibits this behaviour because it contains magnetite, an iron-rich mineral that acts like a permanent magnet (e.g., *Lund, 2007*).

Geomancy or *feng shui* is a mean of divination intended to find the most suitable sites and orientation for establishing cities, streets, palaces, houses, tombs, canals, etc. Practised for millenia it has exerted a profound influence on the face of China's landscape and city plans. Significant differences can be discerned between European and Chinese (see e.g. *http://www.maps-china.com/Xian*) landscapes. While the European landscape is typically very multiform, the Chinese landscape is checkered. This would seem to indicate that the use of geomancy (and therefore probably a compass) was widespread for millennia. Chinese history it is known to date back to nearly 5000 BP. Throughout its history, geomancy has made use of different versions of magnetic compasses (the geomantic compass, a divination device called *shi* in Han times, etc., see e.g., *Needham, 1964* or *Carlson, 1975*).

It is curious that in the archaeology of *Mesoamerica* there is an hypothesis about the use of a compass by the Olmécs for the orientation of Olméc and Mayan pyramids and ceremonial centers (*Fuson, 1969*). Further, *Carlson (1975)* described the excavation and analyses of an artifact (made from pure hematite Fe_2O_3) which was recognized at the time as a possible geomagnetic lodestone compass in San Lorenzo, Mexico (dated to 1400–1000 BC, about 1000 years before the Han Dynasty in China). As in the case of China such a lodestone compass might have been used for the siting and orientation of important buildings. However *Fuson (1969)* and *Carlson (1975)* were not able at that time to prove that hypothesis because reliable paleomagnetic data were not available.

A geomagnetic pole is that pole defined by the best-fit dipole to the Earth's magnetic field. The magnetic declination read with a magnetic compass is the angle between the meridian and the compass needle and may be affected by non-dipole contributions that vary over the Earth surface. The position of the geomagnetic North pole with respect to the geographic North pole is changing continuously and notably (Fig. 1). The pole of rotation of the Earth is also changing in time but nearly negligibly. The directions from

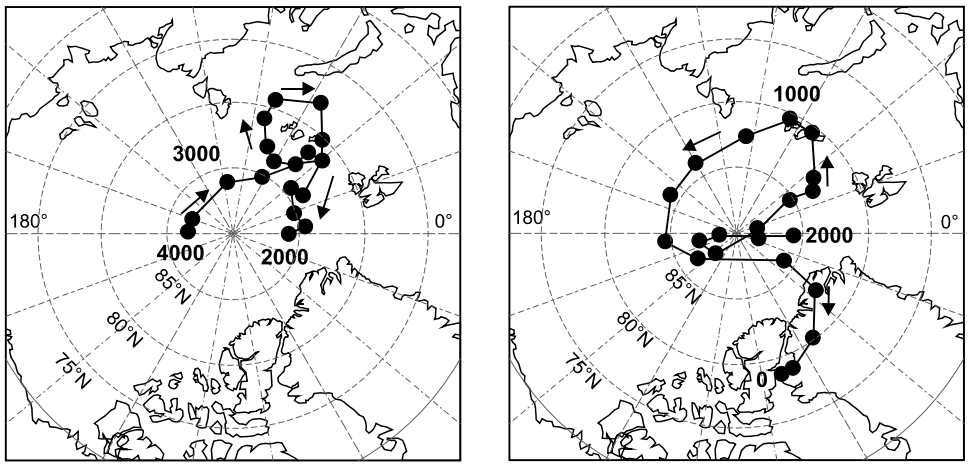

Fig. 1. Paleomagnetic pole positions (defined by averaging global data) during the last 4000 years; the data taken from *McElhinny and McFadden (2000).*

individual points on the Earth to the geomagnetic North pole are therefore also continuously changing.

Paleomagnetism is a research field which studies the behaviour of the ancient magnetic field of the Earth by means of processing records contained in various materials such as sediments and volcanic rocks. Archeological materials such as baked clay, mud, brick, walls, baked rock, burnt walls, porcelain, ceramics, tiles, pottery, coins, etc. can also be used to retrieve a record from the ancient geomagnetic field. The paleomagnetic pole wandering, computed by geophysicists for the interval of the last 6000 years for the whole Earth, e.g., in *McElhinny and McFadden (2000)*, is shown in Fig. 1. For the localities investigated (Luoyang, Beijing, see *http://www.maps-china.com/Xian*), one can compute models of the paleomagnetic declination (e.g. *Korte et al., 2005*) and compare it with the declinations observed from the pyramid orientations. Figs. 2a,b show the changes through time of the magnetic declination as observed from localities within central China (*Korte et al., 2005*; *Donadini et al., 2007*; *Korhonen et al., 2008*). The CALS7K.2 model curves (*Korte et al., 2005*) are drawn for the area of central China, covering the city surroundings of Xi'an and Luoyang.

The core of the Fuson hypothesis (*Fuson, 1969*) is the following: each building is oriented using a compass at the time of its construction or at its last reconstruction and revails information about the direction towards the magnetic pole at that time. Because the geomagnetic field orientation changes in time, we can compare geomagnetic field records with available geomagnetic field models for the same region, and find an associated date.

Thus, we can, at least theoretically, correlate the date of the building construction with its orientation, assuming this was carried out using a magnetic compass. Knowing the orientation of a building and the history of paleomagnetism we can estimate its date, and vice versa. The practical problem is that the paleomagnetic data (and thus also the paleomagnetic declination) is not known to a greater accuracy than a few degrees.

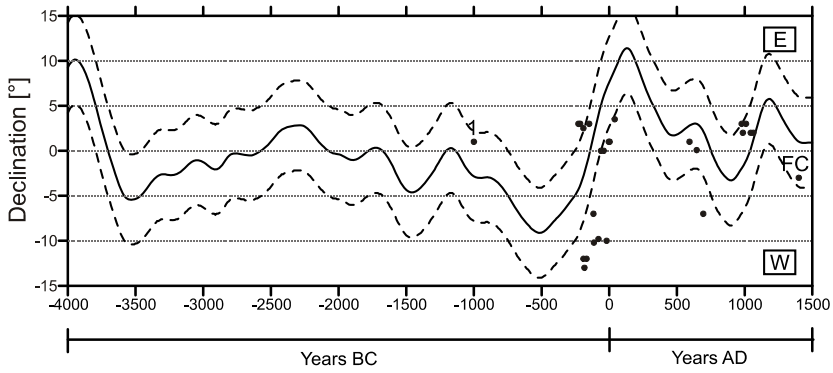

Fig. 2a. Paleomagnetic declinations for the region of central China area, according to the CALS7K.2 model (*Korte et al., 2005*) for the time interval 4000 BC till 1500 AD. The deviation of the declination from the North geographic pole is plotted in degrees, positive values are to the East. The precision of CALS7K.2 has been estimated by the authors of the model to be about 5°, indicated by the dashed lines around the paleodeclination curve. Numbers (where indicated) correspond to the numbers in Table 1, FC stands for the Forbidden City, Beijing. For more details for the area of Xi'an (Nos.1–22, 24–26 in Table 1) and Luoyang (Nos.23, 27–31 in Table 1) see Fig. 2b.

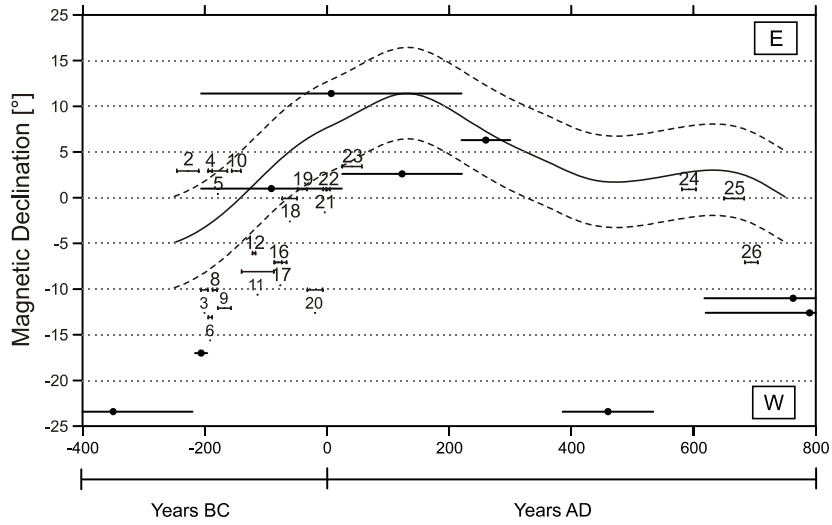

Fig. 2b. A blow-up of the paleomagnetic declination curve for Xi'an and Luoyang for the period of 400 BC–800 AD. Positive values are orientations to the East (E). Numbers are taken from Table 1 for the individual tombs with (i) the orientation derived from satellite images on Google Earth and with (ii) the date for the individual emperors as deciphered mainly from *Moule (1957)*. The dots with horizontal bars (for standard errors) are values of paleomagnetic declinations computed using GEOMAGIAv2 according to *Donadini et al. (2006)* and *Korhonen et al. (2008)*, while the smoothed curve is CALS7K.2 (as in Fig. 2a) from *Korte et al. (2005)*. The dashed lines demarcate the error envelope of ±5°, as in Fig. 2a.

Table 1. A list of tombs at the Xi'an area (1–22, 24–26, 33, 34) and Luoyang area (23, 27–31) in central China with their geographic coordinates, information about the dynasties and the reign period of the relevant emperor (# empress) and the orientation of tombs with respect to the North geographic pole (E - east of North pole, W - west of North pole, in degrees) as measured by AutoCAD 2004LT software from the Google Earth pictures (printings). The Big Wild Goose Pagoda (No.25) is a Buddhistic temple built in the year 652 AD. The Forbidden City, Beijing, built in the years 1406–1420 AD, is also included. The periods of constructions are denoted by *. According to the strong Chinese imperial principle, the respective tombs had to be built in the second year of the emperor's reign (the year of enthronement +1 year). [*Di* in Chinese means *the emperor, ling* in Chinese means *the tomb of emperor*.]

#	Lat. N	Long. E	Object	Dynasty Emperor	Period of Reign	Orientation
1	34°24′	108°44′	Kangwang Maus.	Western Zhou, Kangwang	1020–966 BC	0–2 E
2	34 23	109 15	Shihuangling	Qin, Shihuangdi	246–210 BC	3 E
3	34 26	108 53	Changling	Western Han, Gaozu+ (Lu#)	206–195 BC	10 W
4	34 27	108 57	Anling	Western Han, Huidi	194–188 BC	2–3 E
5	34 27	108 57	Anling	Western Han, Zhang#	194–163 BC	2–4 E
6	34 25	108 50	Anling, Jinhe	Western Han, related?	194–188 BC?	12–15 W
7	34 25	108 51	Anling, Jinhe	Western Han, related?	?	10–12 W
8	34 26	108 52	Lüzhi Maus.	Western Han, Lüzhi#	187–180 BC	10 W
9	34 24	108 44	Baling	Western Han, Wendi	179–157 BC	12 W
10	34 26	108 56	Yanling	Western Han, Jingdi	156–141 BC	2–3 E
11	34 20	108 34	Maoling	Western Han, Wudi	140–87 BC	8 W
12	34 20	108 35	Xianyang	Western Han, Yuanshou	122–117 BC	4–8 W
13	34 20	108 35	Xianyang	Western Han,	?	4–10 W
14	34 20	108 36	Xianyang	Western Han,	?	8 W
15	34 20	108 36	Xianyang	Western Han	?	14 W
16	34 21	108 38	Pingling	Western Han, Zhaodi	86–74 BC	7 W
17	34 21	108 38		Western Han, Xiaozhao#	86– BC	7 W
18	34 11	109 01	Duling	Western Han, Xuandi	73–49 BC	0
19	34 24	108 43	Weiling	Western Han, Yuandi	48–33 BC	1 E
20	34 22	108 42	Yangling	Western Han, Chengdi	32–7 BC	10 W
21	34 24	108 44	Yiling	Western Han, Aidi	6–1 BC	0–2 E
22	34 23	108 42	Kan(g)ling	Western Han, Pingdi	1 BC–5 AD	1 E
23	34 84	112 60	Guangwudiling	Eastern Han, Guangwudi	25–57 AD	3–4 E
24	34 24	108 46	Tailing	Sui, Wendi	581–604 AD	0–2 E
25	34 13	108 58	Big Wild Goose Pagoda*	Tang, Gaozong	650–683(652*) AD	0
26	34 28	108 48	Shunling	Tang, Wuzetian#	684–705 AD	6–8 W
27	34 40	112 57	Yongchangling	Song, Taizu	960–976 AD	3 E
28	34 40	112 57	Yongxiling	Song, Taizong	976–997AD	2 E
29	34 42	112 58	Gongyi	Song, Zhenzong	998–1022 AD	2–3 E
30	34 45	112 59	Gongyi	Song, Renzong	1023–1063 AD	1–2 E
31	34 45	112 59	Gongyi	Song, Yingzong	1064–1067 AD	2 E
32	39 53	116 23	Beijing, Forbidden City	Ming, Yongle*	(1406–1420 AD*)	3–4W
33	34 13	109 06	Bashui river	?	?	24 E
34	34 14	109 07	Bashui river	?	?	22 E

A specific problem for Mesoamerica is that the absolute age of many structures is not known at all. For Mesoamerica, there is an additional complication, namely that the relationship of the Maya calendar to our Christian (Julian) calendar is not well established and may be in error by as much as 100 years or more (see *Klokočník et al., 2008*, for further references). Nevertheless *Klokočník et al. (2007)* tried to support the Fuson hypothesis by taking new field measurements within the territory of Mexico, Guatemala and Honduras making use of recent paleomagnetic information from scientists of that region. The proof that the hypothesis is valid, however, is still missing. Since China has much more suitable objects (pyramids, etc.) for this purpose than Mesoamerica a verification of the Fuson hypothesis is more hopeful there (China had 308 emperors and many empresses) and has had a total of seven former capital cities. The Chinese case also is clearer, because we know that they used a rudimentary magnetic compass for divination purposes from time immemorias - as Chinese legends tell. The first written record dates from the 4th century BC (*Gui Gu Zi, 4th century BC*). The relationship between Chinese calendar and our own calendar is also clear. However it remains to be shown that this ancient compass was used also for the orientation of buildings.

Starting from the Qin dynasty (246–207 BC) up to the Qing dynasty (1644–1911 AD) all data concerning Chinese emperors can be counted reliably and accurately, as far as their personal and posthumous names and/or titles are concerned. This includes the dates of their birth (year, month, day), accession to the throne (including abdication and/or deposition) and death.

In the Chinese sources this is derived from a means of Chinese calendar calculation based on the traditional Chinese sexagenary cycle, called *jiazi* (the 1st year = *jiazi* to 60th year = g*uihai*). For conversion of chronological data given according to the Chinese *yinli* calendar, i.e. the year of the birth /reign/death, etc. of the respective emperor plus the month plus the day designated by the combination of the "heavenly stems" (*tiangan*) and the twelve "earthly branches" (*dizhi*), into the Christian calendar (BC, AD) the reader is referred to the following authoritative Chronological Tables (*Dong Zuobin, 1960*; *Jiang Lianfu, 1959*; *Moule, 1957*; *Wan Guoding, 1956*; *Zheng Haosheng, 1936*). In short: conversions between the Chinese calendar and our own do not add any additional error to our results. The Chinese calendar is accurate to within a day.

In this paper, we compare and observe paleomagnetic declinations with the available geomagnetic field model calculated at the tombs in the location of central China (Xi'an and Luoyang) aiming to correlate them with the known date (the starting year of pyramid construction) and orientation of "pyramids" in those regions. The strict principle in China was that the "pyramid" had to be built from the second year of the respective emperor reign. This means from the year of accession to the throne +1 year.

The geographic orientation of these "pyramids" (Columns 1 and 2 in Table 1) was read (observed) from satellite images shown by Google Earth or from *http://www.maps-china.com/Xian* (Luoyang). Problems with age of the structures and with the calendar, which are so important for Mesoamerica, do not exist in the case of China. So it may seem that there were no obstacles to our analysis. However, the paleomagnetic declinations are still not known with sufficient accuracy (see below). The contribution of paleosecular variation records from China to the global paleomagnetic results is small (*Korte and Constable, 2008*, *Fig. 1*).

Here in this paper, we use the term "pyramids" for the "burial mounds", i.e. for the external shape of uncovered Chinese tombs, because satellite images now available showing the Earth's surface in great detail (by Google Earth) are reminiscent of the pyramid shape. The "pyramid" is the upper part of a tomb building. It is made from packing soil (clay) which covers the base, i.e. the actual tomb, which is made from another, more resistant material, usually large bricks and stones (since the Eastern Han dynasty).

If the application of the *Fuson (1969)* hypothesis formulated originally for Mesoamerica is to be successful also for China, we must show that (1) "pyramids" of different date have different spatial orientations with respect to the geographic North pole and (2) that this orientation agrees reasonably well with the paleomagnetic data for those areas and time intervals. Unfortunately, the available amount of paleomagnetic data from China (see Fig. 1 in *Korte and Constable, 2008*) is so far small.

Fig. 3. Maoling, Western Han, Wudi 140–87 BC, No.11 in Table 1, eye altitude 1.1 km, size 235 × 240 m; Source of all figures: *Google Earth (2008, 2009)* and http//www.maps-china.com/Xian (Luoyang). Source for ages of all pyramids: *Moule (1957)*. North is to the top of the picture (also in the next pictures).

The first step ("pyramids" orientation) can now be accomplished easily with the aid of Google Earth, with a sufficient precision without any on-site measurements. All pyramids found via Google Earth and with further information from various historical sources for the vicinities of Xi'an and Luoayng were gathered into Table 1. Figs. 3–8 show examples of pyramids of different shapes and sizes (about 230–240 m or 160–170 m). Four pyramids have a Westerly orientation and four pyramids have an Easterly orientation there.

The pyramids in China have a normal shape, either an inverted bucket shape or they have flat bases at their tops. As for the second step, the trends between the orientation and the date of the "pyramids" can be estimated using the history of paleomagnetic declinations for central China. The results are presented in Figs. 2a,b. Details follow in the next sections.

Fig. 4. Changling, Western Han, left: Gaozu (size 160 × 130 m) and right: **L**u# (size 160 × 130 m) 206–195 BC, No.3 in Table , eye altitude 1.1 km.

2. DATA AND METHOD

We have employed Google Earth satellite images: no geodetic measurements were carried out on the ground. First we scanned the area around the town of Xi'an, the capital of the Western Han dynasty (206 BC–9 AD). We also found that the layout of the areas around the pyramids, including fields, roads, etc., exhibited the same orientation as the local "central pyramid(s)". Pyramids stand inside larger ceremonial areas where long spirit paths (between two lines of noted men, lions, horses, elephants, etc.) running from the South to the pyramid in the same direction as the pyramid sides. We show examples of various types, dimensions and orientations of pyramids in Figs. 3–8. The area of Luoyang, the capital of Eastern Han dynasty (25–220 AD) and Song dynasty (960–1279 AD), was also scanned. We chose and processed 28 individual "pyramid" objects. The Forbidden City, Beijing was also incorporated into our research (No.32 in Table 1)

Fig. 5. Yangling, Western Han, Chengdi 32–7 BC, No.20 in Table 1, eye altitude 1.1 km, size 165 × 170 m.

We can see that some pyramids are declined to the West from the basic North-South axis and others have an East declination (Figs. 3–8). We can "read" the directions from Google Earth images with a small error. Measuring the angles on the images with precise AutoCAD 2004LT software results in a much higher degree of precision (a few minutes), well above our requirements. Nonetheless we used this software for obtaining our directions. Typically five readings were taken.

Additional complications are that the walls of pyramids are often slightly curvilinear, uneven (see e.g. Fig. 6), or that the pyramid ground plans were sometimes trapezoidal, not square or rectangular. The more uneven the shape, the more measurements were made (from four to ten). Averages were calculated or a minimum-maximum range of values for the orientations of the "pyramids" were computed (cf. Table 1). It is clear that this factor increases the uncertainties of the declinations in Table 1.

Fig. 6. Western Han, Kan(g)ling 1 BC–5 AD, No.22 in Table 1, eye altitude 1.1 km, size 225 × 235 m.

The next important step was to find correctly when the relevant dynasty and the respective emperor reigned or lived. These data were verified from several sources: *Moule (1957)*, *Kolmaš and Malina (2005)*, *Wan Guoding (1956)*, Wikipedia 2009 (*http://en.wikipedia.org/wiki/List_of_Chinese_monarchs*), from historical descriptions in: *http://www.maps-china.com/Xian* (Luoyang) and from *http://www.eorc.jaxa.jp/en /imgdata/*. This information was added to Table 1. We were successful with such an identification in 28 of 34 cases listed in Table 1.

Paleomagnetic declinations for the region of central China are based on the global (low degree spherical harmonic) model developed by *Korte et al. (2005)* and they are shown from 4000 BC till 1500 AD in Fig. 2a. Most objects gathered in Table 1 fall into the period 246 BC–705 AD. Therefore Fig. 2b is an expansion of Fig. 2a for this interval and the Xi'an and Luoyang areas. The declination curve is again from CALS7K.2 (*Korte et al., 2005*). Models like CALS7K.2 are inherently smoothed so we sought actually measured paleodeclinations. Based on information from *Donadini et al. (2006)* and *Korhonen et al. (2008)*, these declinations are added to Fig. 2b as black dots with bars showing formal standard errors in time. What is not known are possible local anomalies of

Fig. 7. Yiling, Western Han, Aidi 6 1 BC, No.21 in Table 1, eye altitude 1.1 km, size 165 × 165 m.

the magnetic field which can be as high as a few degrees. Since these cannot be modelled, they might have to be measured in situ. It is impossible to compare today's local anomalies in China with those 3000 years ago.

With Table 1 and Figs. 2a,b we can compare the paleomagnetic declinations with the dates of the pyramids and their orientations and discuss the results.

3. RESULTS AND DISCUSSION

Maoling and pyramids nearby show evident Westerly deviations, between 4 and 14°W. The objects belong usually to the Western Han dynasty (206 BC–9 AD). Paleomagnetic declination from the *Korte et al. (2005)* model is here either negative or around zero (we recall its error ±5°). The "pyramid" orientations at 200 BC show North-South deviations below 15°W (also with an error margin of ±5°) in fair agreement with the paleomagnetic data, although the scatter between the paleomagnetic model and the "observed" data around 0 (AD) permits positive and negative orientation. In general,

Fig. 8. Song, Zhenzong 998–1022 AD, No.29 in Table 1, eye altitude 0.9 km, size of the pyramid 65 × 65 m, length of the spirit path 310 m.

Figs. 2a,b show the trends in "pyramid" orientations which correspond to the modelled paleodeclination curve. No.23 is the pyramid from the Luoyang area, the Eastern Han dynasty (25–220 AD), Guangwudi (26 AD), while the objects 27–31 are from the Luoyang area, the Song dynasty (960–1067 AD); the last building is not a "pyramid", but a flat quadrate structure with a central rectangular mound.

No.1 is the oldest tomb investigated here (1019 BC) and is oriented North-South (0–2°E). It also agrees with the paleomagnetic model (Fig. 2a, –2 ± 5°W). But as we have only one such case, this agreement may be accidental. If it is genuine it would indicate that the practice of using the compass in China might be much older than generally accepted. No written record about astronomical orientations of Chinese structures is extant. The orientations of tombs Nos.33 and 34 in Table 1 are considerably to the East. Unfortunately we were not able to identify the relevant dynasty/emperor and hence the date of construction of these buildings.

No.23 is the tomb of the great emperor Guangwudi (25–57 AD) from the Eastern Han dynasty. As expected (according to the declination curve in Figs. 2a,b) the tomb shows an East deviation (Figs. 2a,b). This emperor ordered that his successors also be buried in his pyramid. His pyramid is one of the largest Chinese pyramids measuring 240 × 235 m. (This dimension and the dimensions of the pyramids in Fig. 3 (No.11) and Fig. 6 (No.22) correspond to the dimension of the Cheops pyramid in Egypt.) Pyramid No.24 belongs to the Sui dynasty, pyramids Nos.25–26 belong to the Tang dynasty and pyramids Nos.27–31 to the period of the Song dynasty (960–1127 AD, *Franke, 1976*). They all support the tested hypothesis and exhibit good agreement between the observed

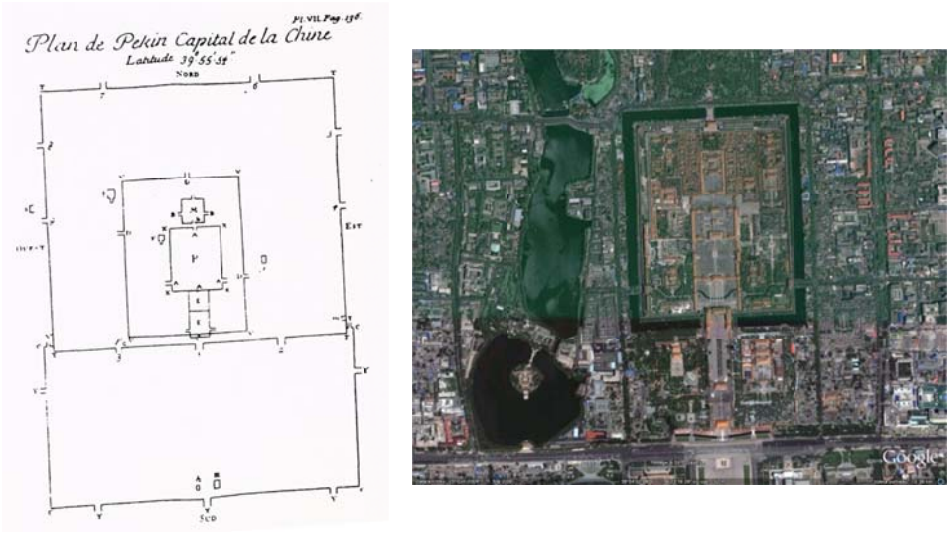

Fig. 9. Orientation of the Forbidden City. **Left:** according to "Plan de Pekin Capital de la Chine" (*Kolmaš, 1995, p. 154*); **Right:** with *Google Earth 2009*, No.32 in Table 1, eye altitude 2.4 km.

orientations, dates and the CALS7K.2 model (*Korte et al., 2005*) declinations for central China (Fig. 2a).

The layout of the Forbidden City in Beijing dates from 1406–1420 AD. It is known that the city was oriented using a compass as described (confirmed by some details), e.g. in the correspondence of Karel Slavíček, a Czech astronomer at Chinese imperial court in Beijing (see *Kolmaš, 1995*). The Forbidden City has about a 3–4°W deviation (Figs. 9a,b). The paleomagnetic curve (*Korte et al., 2005*; *Korte and Constable, 2008*) for Beijing is similar to that in Fig. 2a (point FC), with a slightly higher positive value for the declination around 1350 AD.

There are several possible sources of uncertainties in our research: we do not know the local anomalies on the sites themselves. The data of *Donadini et al. (2009)* and *Korhonen et al. (2008)* are not derived from the localities studied here. The accuracy of the ancient types of compass could have been lower. The paleodeclination model curves are, so far, not quite complete due to a scarcity of data from large areas of the Earth (e.g. Asia - China). In spite of this, there appears to be a good agreement between the trends in the modeled curve and the observed (in Google Earth) values (Figs. 2a,b).

An additional caution in interpreting these results: we do not account for poorly known local anomalies in magnetic declinations. These local anomalies can amount to several degrees. The CALS7K.2 model is based on a low degree spherical harmonic expansion and thus is inevitably smoothed; real paleomagnetic declinations might be much more scattered (our experience with Mesoamerica and Böhnel's data (*H. Böhnel, personal communication, 2008*). The resulting declination curve depends also on data processing techniques (*Lanos et al., 2005*). Our results are summarized in Table 1 and Figs. 2a,b and support the validity of the *Fuson (1969)* hypothesis also for the central China.

4. CONCLUSIONS

The Chinese have been aware of magnetism since the second millenium BC. But the first written record dates from the 4th century BC: "*When the people of Cheng (1042–1021 BC) go out to collect jade, they carry a South-pointer with them so as not to lose their way."* (*Gui Gu Zi, 4th century BC*). The use of the compass in China since 1000 BC was described also by *Needham (1964)*.

The Chinese used the compass not only for landscape design (layout) but also for the alignment of buildings, city walls, streets, palaces, mausoleums, canals, etc. The buildings of tombs ("pyramids") and also the layout of their wide surroundings bear the stamps of the directions towards the moving geomagnetic North pole in the era of their respective constructions. Figs. 3–8 clearly show different orientations of the "pyramids" built in various epochs at the Xi'an and Luoyang areas. The Forbidden City, Beijing (No.32 in Table 1) was also incorporated into our research. There are no indications (extant written records) indicating East and West points at the equinoxes or solstices. The wandering magnetic pole easily explains the „wandering" found in the orientations of buildings.

Summarizing our method, we can reconstruct paleomagnetic declinations for the region of central China area and the time interval needed from the data of *Korte et al. (2005)* and compare (correlate) the observed (from Google Earth) orientations of tombs ("pyramids") with the values of reconstructed paleodeclinations for given (known) ages of

the buildings. A correspondence between the model declinations and these orientations was discovered. Although we do not have complete paleomagnetic data to support it, we think the similar small deviations from true North for buildings prior to the Han dynasty could indicate that the magnetic compass was used in China as early as about 3000 BP.

The wandering of the North geomagnetic pole over the past few thousand years has been studied extensively in the past few decades. We expect even better resolution of this wandering history through future research. Together with a better knowledge of actual local (regional) magnetic anomalies and on-site surveys we should have a much firmer answer to this interesting orientation-hypothesis. *Donadini et al. (2009, Fig. 10)* show a paleodeclination curve for East Asia. Their declination values are slightly different from the CALS7K.2 model (*Korte et al., 2005*) but the curve trends are similar.

Principles of feng shui have been used in China may be since immemorial. Paleomagnetic secular variation data are not (yet) widely available for China (*Korte and Constable, 2008, Fig. 1*). Conversely: it may be possible that the orientations of large and long Chinese constructions (such as city walls, streets, palaces, spirit paths, canals, etc.) oriented along a North-South axis which has been changing through time could be employed as a supplement to customary paleomagnetic research. The results could be better than obtained those from the pyramids: the largest sides of imperial tombs are about 240 m and the sides are sometimes uneven. The above mentioned constructions are up to several kilometres long and they are straight.

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