Pyramids and Ceremonial Centers in Mesoamerica and China: Were They Oriented Using a Magnetic Compass?

Jaroslav Klokočník

Astronomical Institute, p.r.i., Academy of Sciences of the Czech Republic,
CZ - 251 65 Ondřejov Observatory, Czech Republic
(jklokon@asu.cas.cz, www.asu.cas.cz/~jklokon)

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Correspondence:
Prof Ing Jaroslav Klokočník DrSc
research worker
Astronomical Institute of the Academy of Sciences,
CZ 251 65 Ondřejov Observatory
Fričova str. 298
Czech Republic, EU
jklokon@asu.cas.cz,
[+ 420] 323 620 158

Abstract
Fuson (1969) and Carlson (1975) claim that Olmecs and Maya knew and used a (lodestone) compass for the orientation of pyramids, ceremonial and other important buildings. 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. Fuson’s
hypothesis has been tested with the aid of the paleomagnetic declinations for time and areas of Olmécs/Maya and central China with orientation data of buildings based on our measurements at various archaeological localities of México, Guatemala, and in Copán in Honduras by GPS and with a precise compass during 2003-2010. In China (Xi’an and Luoyang provinces) we had to rely upon satellite images from Google Earth (now with excellent resolution of few meters in many areas). After eliminating known astronomical and calendar orientation of some buildings, we have found that there is majority of structures with an orientation that clearly deviates from geographic north (pole of rotation of the Earth). When trying to explain this, we can rule out pure chance, local topography, aesthetic, meteorological or defense reasons. The structures might be oriented by means of a magnetic compass. The use of the compass means that the „needle“ was directed towards the actual „magnetic pole“ (roughly speaking) at the time of construction of the respective pyramid. However, the magnetic pole, relative to the nearly 'fixed' geographic pole, shifts significantly over time; changes in its direction ~10 degrees per century as observed from the given locality are not exceptional. By matching measurements of buildings’ orientation with modeled paleomagnetic history we found a fair correlation between the date of pyramid construction and their space orientation relative to the magnetic pole positions at the respective time of construction. Thus, the Fuson’s hypothesis can explain the observed sites layout and building orientations in Mesoamerica (Klokočník et al, 2007) as well as in China (Charvátová et al, 2010), in majority (but not all) cases.

Pyramids, Olmécs/Maya, ancient Chinese, magnetic compass, paleomagnetic declination, Fuson hypothesis
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Orientation and Motivation for Orientation

Everybody can see and can easily check (from detailed maps or now very quickly and easily using Google Earth, providing on many places already sufficient resolution) that pyramids and other buildings in many archaeological sites of Mesoamerica are oriented along the cardinal “north-south” direction (or east-west direction rotated by 90°) to geographic („astronomical“) pole, but not perfectly. Majority of the structures in Mesoamerica is directed to the north geographic pole with an east “deflection” or “deviation” that ranges from 0° to about 35° (typically 10°-20°) which is too large to be considered an error (inaccuracy) of the planning and/or of construction of the objects. We show examples for Teotihuacán (Fig. 1), Tikal (Fig. 2), Monte Albán (Fig. 3), Chichén Itzá (Fig. 4), and Palenque (Fig. 5). Similarly for the pyramids in China (sometimes with east sometimes with west “inclination“, see example in Fig. 6, and for more information see below).

Insert Figures 1-5 Here

It is hard to believe that such alignments are only accidental, especially in the case of Maya or Chinese who are famous for their care and precision and high knowledge of mathematics and astronomy. That “deflection” in the orientation occurs too often to be just accidental, is spread over whole Mesoamerica, from Olmēcs to Mexicans, and covers the period from about 1500 BC to 1200 AD. In “central“ China, it covers interval ~ 200 BC - 1100 AD. The objection that the building orientation was dictated by the terrain irregularities, local topography or by defense necessities or due to meteorology reasons can not be accepted: places like Chichén Itzá are nearly flat and there is the “east deflection” everywhere, and even hilly Palenque site would offer to the ancient “engineers” many choices of the orientation without
additional (and from our viewpoint abundant) terrain works. Sometimes the orientation defy the local topography: “At some sites there may have been a conscious effort to preserve a particular alignment in spite of the intervening terrain …” (e.g., in Teotihuacán, Calixtlahuaca, Xochicalco), wrote Aveni (1980, p. 237). To explain the observed facts we can rule out: pure chance, local topography, aesthetic reasons, climate, water supply, military defense and similar. It is obvious that there must have been for these societies very strong (religious?) and perduring motivation to use such diverging orientations.

Insert Figure 6 Here

In central part of China, Xi’an (Sian) and Luoyang provinces, one can see by satellite images (e.g. from Google Earth) tens of pyramids (see Table 1 for their geographic latitudes and longitudes to make your own search, Fig. 6 here and 12-14 below). They are not small, size of some of them is comparable to the Egyptian Giza pyramids, their height is lower. We use the term „pyramids“ for the „burial mounds“, i.e. for the external shape of uncovered Chinese tombs, because satellite images are reminiscent of a pyramidal shape. The Chinese “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.

Also the Chinese pyramids in our set (including fields and roads in their vicinity), as those in Mesoamerica, are „inclined“ to east or west (here mostly to west) from the direction to the geographic north pole (Table 1).

Haven and earth for the ancient people were interconnected, thus something like „cosmic geomancy“ (or feng-shui, living till today) can not suprise us. Geomancy or feng shui is a mean of divination intended to find the most suitable sites and orientation for establishing cities, streets, palaces, houses, canals, tombs, etc. Practised for millenia has exerted a profound influence on the face of China’s landscape and city plans. In México, one can expect something similar, another form of „cosmic geomancy“.
Fuson Hypothesis

The core of Fuson’s hypothesis (1969) is the following: Olmécs and Maya used a lodestone compass for the orientation of their important buildings. The compass aligns along the magnetic field and defines magnetic declination at the time of the building construction (or its last reconstruction). Due to the fact that the magnetic pole is wandering (Fig. 7), the direction as observed from the given locality, is changing with time. In other words because of the magnetic secular variation the declination changes slowly with time at a given locality. Buildings of various ages then should have different space orientation (it means different ‘deviations’ from the cardinal direction).

Insert Figure 7 Here

Fuson (1969) and Carlson (1975) wrote about a discovery of the artifact excavated in San Lorenzo (Veracruz state, México), see figures 4 and 5 in Carlson, 1975. The sample is considered to be a lodestone compass, made carefully and precisely from mineral which is essentially pure hematite (Fe$_2$O$_3$), an iron-rich mineral that acts like a permanent magnet. The age of the sample was estimated by radiocarbon dating of surrounding organic layers to $1400 \pm 1000$ BC. A piece of lodestone could float on liquid mercury and a mechanism for a compass is given. The materials needed to build it (mercury, magnetite rocks, cinnabar, and limestone) were available at this region. Methods to prepare liquid mercury from cinnabar (HgS, mercuric sulfide) by roasting in air or with limestone were also known and used by Olmécs and Maya, for painting ceramics, walls, and other purposes.

Malmström (1976) proved knowledge of magnetism in pre-Columbian Mesoamerica by discoveries of the statue of a “magnetic turtle” in Izapa (near the Pacific Ocean on border with Guatemala) and the statues of 12 “Fat Boys” in La Democracia (southern Guatemala) unearthed in the late 1940s at Monte Alto. It seems that the ancient local people knew about magnetism and reserved basaltic boulders rich in iron for their carvings. The magnetic turtlehead is a large stone $256 \times 144 \times 122$ cm large with carvings executed so carefully that the magnetic lines of force came to a focus in the snout of the animal, wrote Malmström.
(1976). We verified that fact by our own measurements with our precise compass (Klokočník and Vítek, 2005). The carving so precisely located must be intentional and can be achieved only by a compass.

In China, according to ancient chronicles, a magnetic compass has been known before the Han dynasty (206 BC – 220 AD), since at least the 4th century BC, may be during the Zhou dynasty (1046 - 250 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. Later, 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.]

If the Fuson’s hypothesis is valid, then the alignment of the structures and their age should be correlated; knowing former we could derive the latter and vice versa. The problem in practice is, however, that the accuracy of paleomagnetic and other data needed for the analysis is low (e.g. the absolute age of the structures in Mesoamerica is often not known at all).

Our findings based on our own measurements (2003-2010 in Mesoamerica) or on inspection of the satellite images (2008-2010 for central China) support the Fuson’s hypothesis (originally formulated only for Mesoamerica) and suggest that magnetic compasses (of various constructions) were actually used in planning site layouts. Chinese results (Charvátová et al, 2010, Table 1, also reproduced here as Table 1) supported our previous conclusions for Mesoamerica (Klokočník et al, 2007, see the long table in this paper).

**Paleomagnetic declinations**

Paleomagnetism 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 (e.g., Jacobs 1987).
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 directional precision of the paleomagnetic data can hardly be better than a few degrees.

The pole of magnetic field of the Earth and the pole of Earth’s rotation are not identical and they change with time. It means that the direction we measured by compass is not direction to true pole of rotation and is not constant in time. Since the lithospheric motions and the secular motion of the geographic pole (i.e. the pole of rotation of the Earth’s body) are much slower and smaller on the interval of few thousand years than the “erratic wobbling” of the magnetic pole, we can neglect the former. The magnetic pole wandering has a huge amplitude, is of irregular nature, fast, but has a tendency to be periodic (see, e.g., McElhinny and McFadden, 2000, p. 23), here Fig. 7.

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. In the 70ties of the 20th century, the knowledge of the magnetic declinations and inclinations was too poor to prove the Fuson hypothesis. Recently Korte et al. (2005) published the global model based on a compilation of all available paleomagnetic data of the past 7000 years.

For our application, we take the best now available, the Böhnel’s curve (Böhnel, personal communication, 2006), based mostly on (Böhnel and Molina-Garza, 2002), Fig. 8 as the reference for Mesoamerica (central Yucatán), and the results from Korte et al (2005), Donadini et al (2007), and Korhonen et al (2008) for central China, Fig. 9. We have to accept that the accuracy of these paleomagnetic declinations is only ± 5° (estimated by the authors of the quoted models). More about the paleomagnetic data for this purpose see in (Klokočník et al, 2007 and Charvátová et al, 2010).

Insert Figures 8 and 9 Here
Preparation for analysis

Evidently astronomically oriented buildings have to be rejected from the test of the Fuson hypothesis, so we first of all had to identify them among the structures (for details see Klokočník et al, 2007). There is a significant minority of all structures which is oriented astronomically. Few examples: Caracol and Castillo (the Kukulcán pyramid) in Chichén Itzá, the Structure 1 (or temple of Seven Dolls) in Dzibilchaltún, the temples I-V in Tikal, the structure E in Uaxactún, the Palace of Governor in Uxmal, the building J in Monte Albán, the window T-22 in Copán, etc. Some structures were equipped by vertical shafts to determine instants of the Sun zenith passes (e.g., pyramid of Niches in El Tajín, Aveni, 1980). The passes occur in these latitudes twice per year. We computed that times of the zenith passes might be predicted with an error of 1–2 days (Klokočník and Vítek, 2005).

A further investigation may discover more „connections“ between space orientation of various archeological structures and calendar (directions of the Sun rises/sets at specific agricultural seasons, at datums important for the local society, etc.), which are now still “hidden” to us or we do not understand them. For China we have no information about possible astronomical orientations of the pyramids.

Having excluded astronomically orientaed buildings we correlated age and orientation of the remaining buildings (majority). The prevailing eastern deviations for Mesoamerica were evident. It is important that the Fuson’s hypothesis permits positive, zero as well as negative deviations, depending on age. Roughly speaking, Maya sites are oriented with an east deviation from the north (see example on Figs. 2 or 5) and Olmécs sites (older, like La Venta) are oriented mostly between 7 and 12° W (see already Carlson, 1975). For the central China, prevailing is the west deviation (see below, Figs. 6 or 13).

The following obstacle for our research (concerning Mesoamerica only) may seems surprising: mayanists
do not know correct relationship of the Maya calendar (LC) to our “christian” calendar (JD). This problem is known as “correlation problem”. According to the traditional and often used Goodman-Martínez-Thompson (GMT) correlation (e.g., Thompson, 1935), we need to add \( C = 584\,285 \) days to LC to get JD. However, here are serious objections against GMT by various authors. The most probable correlation value, based on analyses of astronomical phenomena decoded in the famous Mayan „Dresden Codex“ is \( C = 622\,261 \) days (Klokočník et al, 2008). The difference between this and GMT is huge, about 104 years and the results of some other investigators indicate still large differences (ibid). The uncertain “timing” between Maya and our culture poses an additional obstacle for our testing because the alignments may change significantly during 100 years. The radiocarbon dating by C14 suffers from a great uncertainty, about \( \pm 100 \) years for the time of our interest, so it can not help us to decide.

**Measurements, Analysis, and the Results**

In November–December 2003, in March–April 2005, and in March 2010 we measured using a portable GPS (precision few meters in geocentric coordinates) and a special, large and precise compass (with precision \( \sim 1 \) degree). We have about 25 baselines measured with the GPS at 22 different archaeological localities. We measured approximately 400 points by the compass. The visited localities were: Atzompa (Oaxaca), Chichén Itzá, Cobá, Copán, Dzibilchaltún, El Tajín, Izamal, Izapa, Kabáh, Kaminaluyú, Labná, Mitla, Monte Albán, Palenque, Quiriguá, Sayil, Teotihuacán, Tikal, Tres Zapotés, Tulúm, Uaxactún, and Uxmal.

Measurements obtained by a compass, related to the present-day magnetic north pole (roughly speaking), must be transformed to the direction related to the geographic pole. The correction can be derived from directions of baselines measured both by the compass and GPS on the spot and can be checked by the model of NGDC (Nat. Geophys. Data Center) NOAA „calculator“ on [http://www.ngdc.noaa.gov/geomag](http://www.ngdc.noaa.gov/geomag).

For China, the geographic orientation of the pyramids was read from satellite images shown by Google
Earth or from http://www.maps-china.com/Xian. It is the orientation to the pole of the Earth’s rotation, not to the north magnetic pole. The angles on the prints of the images, showing directions of the sides of the pyramids, were measured by precise AutoCAD 2004LT software. Problems with age of the structures and with the calendar, which are so important for Mesoamerica, do not exist in the case of China. 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. Figures 6&13 and 12&14 show examples of pyramids with (a large) western and with eastern deviation, respectively.

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 1966, Tung Tso-pin) 1960, (http://en.wikipedia.org/wiki/-List_of_Chinese_monarchs), from historical descriptions in: http://www.maps-china.com/Luoyang and from http://www.eorc.jaxa.jp/en/imgdata/. This information is also in Table 1. We were successful with such identification in 28 of 34 cases listed in Table 1. 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 (see Zheng Haosheng 1936 and Refs. above).

Maoling “mausoleum” (Fig. 6) and the pyramids nearby show evident west deviations, between 4 and 14°W. The objects belong usually to the Western Han dynasty (206 BC – 9 AD). Paleomagnetic declination from the Korte model is here either negative or around zero (we recall its error ±5°). The pyramid orientation at 200 BC show deviations from north-south below 15°W in fair agreement with the paleomagnetic data. In general, Fig. shows the trends in pyramid orientation which correspond to the modelled paleodeclination curve. The same is true for the pyramids from the Luoyang area. The pyramid
No. 1 in Table 1 is the oldest tomb investigated here (1019 BC) and is oriented north-south (0-2°E). It also agrees with the paleomagnetic model (-2±5°W). But as we have only one such old 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.

The layout of the Forbidden City (FC) 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 Slaviček, a Czech astronomer at Chinese imperial court in Beijing (see Kolman, 1995). The Forbidden City has about a 3-4° W deviation (compare to Fig. 9).

Conclusions

The Fuson hypothesis about possible orientation of Olmecs, Maya and other ceremonial centers by (paleo)magnetic pole, using a magnetic compass cannot be simply rejected in the light of existing facts; it still provides an explanation for the “strange” alignments, where the other interpretation (as astronomical-calendaric) are not helpful. Our measurements and computations from 2003–2010 support this hypothesis both for Mesoamerica and central China. The Chinese case is clearer, because we know that Chinese used a rudimentary magnetic compass for divination purposes from “time immemorias”.

More precise and more extensive information from geodesy (more reliable and detailed maps of the archaeological localities and satellite images with a higher resolution), from astronomy (the correlation between Mayan and our calendar), from archaeology (age of the structures, namely the absolute age for the buildings in Mesoamerica), and namely better paleomagnetic declinations (everywhere in the world) are needed to finally reject or accept that Olmecs/Maya and Chinese actually used compass for planning site layouts. The preliminary answer is: yes, both civilizations used a magnetic compass for (among others) orientation of their buildings and ceremonial centers. Also the question of primacy, Chinese or Olmecs, and possible relationships between these cultures, is legitimate, very interesting and should be answered.
Acknowledgements

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References


http://www.maps-china.com/Xian (Luoyang)


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 (latitude, longitude east of Greenwich (degrees and minutes of arcs), 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* printings.
Fig. 1 a,b,c. Teotihuacán, México; photo from the ground (1a, upper left) from the Pyramid of the Moon in the southern direction (© J. Klokočník, 2010), a plan of the central part of Teotihuacán (1b, left, http://archaeology.asu.edu/teo/intro/citymp2.htm) and Teotihuacán in satellite image (1c, right; © Google Earth, 2010). The basic orientation axis of the locality which gave the space orientation to the whole City is the Calzada de los Muertos (Avenue of the Dead), a “road” 2.2 km long and about 40 meters wide, with a clockwise deviation of about 15.5 deg (direction to the east of astronomical north). The traditional explanation for this orientation is astronomical (e.g. www.dartmouth.edu), although an alternative possibility is discussed in (Klokočník and Kostelecký, 2010).

Fig. 2. Tikal, Guatemala, Temple II and map of central part of Tikal [map based on the Guide Map in W. Coe's Tikal: A Handbook of the Ancient Maya Ruins, http://mayaruins.com/tikal/Tikal_map.html]. Google Earth in this area has not yet sufficient resolution.

Fig. 3. Monte Albán, photo from airplane (upper left), a map (north to left) and image from Google Earth (north up). Building “L” (called in literature building J) has astronomical orientation (e.g., Aveni 1980), but the others might be oriented by a compass (for more details see Klokočník et al, 2007).

Fig. 4. Plan of Chichén Itzá according to the US mapping project (© J. Skidmore 2000). Kukulcán (Quetzalcoatl) pyramid also called Castillo (upper left - photo at spring equinox, © J. Klokočník, 2010) and Caracol (the observatory, ibid) have astronomical orientation. But some other structures may be oriented by means of a compass (see Klokočník et al, 2007).

Fig 5. A map from the US Palenque Mapping Project, © Ed Barnhart 2000, reproduced from (French and Christopher, 2009; French and Duffy, 2010). Detail of the central part at the Palace and Temple of the Inscriptions (top) - J. Skidmore (personal communication, 2000), www.mesoweb.com/palenque/resources/maps (© 2000 E. Barnhart); see the arrow “N” showing direction to the astronomical North, and a map of the whole archaeological locality. Google Earth in this area has not yet sufficient resolution (on right).
Fig. 6. The pyramid known as Maoling “mausoleum”, in Xi’an (Sian) area in central China, dynasty Western Han, emperor Wudi 140-87 BC, see No. 11 in Tab.1, eye altitude ~2 km, size 235 x 240 m. Source: Google Earth 2010 and http://www.maps-china.com/Xian. Source for ages of all the pyramids in central China (Figures 6, 12-14 and Table 1): Moule, 1957.

Fig. 7. Paleomagnetic pole positions (defined by averaging global data) during the last 4 000 years; the data taken from McElhinny and McFadden (2000).

Fig. 8. Paleomagnetic declinations for Yucatan, México, according to Böhnel (priv. commun.) for the time interval 2000 BC - 2000 AD. Symbol BP means “before present”. The deviation of the declination from the north geographic pole is plotted in degrees, positive values are to the East. The precision is indicated by error bars.

Fig. 9. 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 precision of CALS7K.2 has been estimated by the authors of the model to be about 5 degrees, indicated by the dashed lines around the paleodeclination curve. Number 1 corresponds to Table 1, FC stands for the Forbidden City, Beijing.

Fig. 10. A “fan” of declinations around the cardinal north-south (west-east) directions of the structures at various ceremonial centers in Mesoamerica (according to Aveni, 1980).

Fig. 11. The plan of part of Uxmal archaeological site, north Yucatán. The Palace of Governor (bottom left) is oriented astronomically (according to the direction of rise of Venus in its extreme declination about 800 AD, see Aveni 1980, p. 275, verified by Klokočník and Vítek, 2005), the other objects might be oriented by a magnetic compass.
Fig. 12. Pyramid Weiling, Xi’an area, dynasty Western Han, emperor Yuandi, 48-33 BC, No. 19 in Tab. 1, eye alt. ~2 km, size 165x165 m. Google Earth 2010.

Reader can use geographic latitudes and longitudes in Table 1 to find all the pyramids mentioned in Table 1 using Google Earth or images from other satellite sources.

Fig. 13. Yangling and a row of pyramids, Xi’an area, dynasty Western Han, emperor Chengdi, 32-7 BC, No. 20 in Tab. 1, altitude about 1.6 km, size 170 m, orientation 10° west. Google Earth 2010.

Fig. 14. Pyramid (size 65x65 m) and ceremonial space (spirit path long 310 m), Gongy near Luoyang, east of town Xi’an, Song, Zhenzong, 998-1022 AD, No. 29 in Tab. 1, eye alt. 0.8 km. Google Earth 2009.
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<td>86-74 BC</td>
</tr>
<tr>
<td>16</td>
<td>34 21</td>
<td>108 38</td>
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<td>Western Han, Xiaozhao</td>
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<tr>
<td>17</td>
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<td>Western Han, Xuandi</td>
<td>73-49 BC</td>
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<tr>
<td>18</td>
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<td>108 43</td>
<td>Weiling</td>
<td>Western Han, Yuandi</td>
<td>48-33 BC</td>
</tr>
<tr>
<td>19</td>
<td>34 22</td>
<td>108 42</td>
<td>Yangling</td>
<td>Western Han, Chengdi</td>
<td>32-7 BC</td>
</tr>
<tr>
<td>20</td>
<td>34 24</td>
<td>108 44</td>
<td>Yiling</td>
<td>Western Han, Aidi</td>
<td>6-1 BC</td>
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<td>21</td>
<td>34 23</td>
<td>108 42</td>
<td>Kan(g)ling</td>
<td>Western Han, Pingdi</td>
<td>1 BC-5 AD</td>
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<td>34 84</td>
<td>112 60</td>
<td>Guangwudiling</td>
<td>Eastern Han, Guangwudi</td>
<td>25-57 AD</td>
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<tr>
<td>23</td>
<td>34 24</td>
<td>108 46</td>
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<td>Sui, Wendi</td>
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<td>24</td>
<td>34 13</td>
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<td>Tang, Gaozong</td>
<td>650-683 AD</td>
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<td>Shunling</td>
<td>Tang, Wuzetian</td>
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<td>26</td>
<td>34 40</td>
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<td>Song, Taizui</td>
<td>960-976 AD</td>
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</tr>
<tr>
<td>28</td>
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<td>Gongy</td>
<td>Song, Zhenzong</td>
<td>998-1022 AD</td>
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<td>29</td>
<td>34 45</td>
<td>112 59</td>
<td>Gongy</td>
<td>Song, Renzong</td>
<td>1023-1063 AD</td>
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<td>30</td>
<td>34 45</td>
<td>112 59</td>
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<td>Song, Yingzong</td>
<td>1064-1067 AD</td>
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<td>31</td>
<td>39 53</td>
<td>116 23</td>
<td>Beijing, Forbidden City</td>
<td>Ming, Yongjie</td>
<td>(1406-1420 AD)</td>
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<tr>
<td>32</td>
<td>34 13</td>
<td>109 06</td>
<td>Bashui river</td>
<td>?</td>
<td>?</td>
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<td>33</td>
<td>34 14</td>
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<td>Bashui river</td>
<td>?</td>
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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 (latitude, longitude east of Greenwich (degrees and minutes of arcs), 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 printings.
Figures – Figs. 1-14.
Fig. 1 a,b,c. Teotihuacán, México; photo from the ground (1a, upper left) from the Pyramid of the Moon in the southern direction (© J. Klokočník, 2010), a plan of the central part of Teotihuacán (1b, left, http://archaeology.asu.edu/teo/intro/citymp2.htm) and Teotihuacán in satellite image (1c, right; © Google Earth, 2010. The basic orientation axis of the locality which gave the space orientation to the whole City is the *Calzada de los Muertos* (Avenue of the Dead), a “road” 2.2 km long and about 40 meters wide, with a clockwise deviation of about 15.5 deg (direction to the east of astronomical north). The traditional explanation for this orientation is astronomical (e.g. www.dartmouth.edu), although an alternative possibility is discussed in (Klokočník and Kostelecký, 2010).
Fig. 2. Tikal, Guatemala, Temple II and map of central part of Tikal
[map based on the Guide Map in W. Coe's Tikal: A Handbook of the Ancient Maya Ruins,
http://mayaruins.com/tikal/Tikal_map.html]. Google Earth in this area has not yet sufficient resolution.
Fig. 3. Monte Albán, photo from airplane (upper left), a map (north to left) and image from Google Earth (north up). Building “L” (called in literature building J) has astronomical orientation (e.g., Aveni 1980), but the others might be oriented by a compass (for more details see Klokočník et al, 2007).
Fig. 4. Plan of Chichén Itzá according to the US mapping project (© Joel Skidmore, © Ed Barnhart 2000). Kukulcán (Quetzalcoatl) pyramid also called Castillo (upper left - photo at spring equinox, © J. Klokočník, 2010) and Caracol (the observatory, *ibid*) have astronomical orientation. But some other structures may be oriented by means of a compass (see Klokočník et al, 2007). Google Earth in this area has not yet sufficient resolution (on right).
Fig 5. A map from the US Palenque Mapping Project, © Ed Barnhart 2000, reproduced from (French and Christopher, 2009; French and Duffy, 2010).

Detail of the central part at the Palace and Temple of the Inscriptions (top) –
- J. Skidmore (personal communication, 2000),
  [www.mesoweb.com/palenque/resources/maps](http://www.mesoweb.com/palenque/resources/maps) (© 2000 E. Barnhart);
see the arrows “N” showing direction to the astronomical North, and a map of the whole archaeological locality. Google Earth in this area has not yet sufficient resolution.

Note:
arrows to **N**
have different directions at these figures
Fig. 6. The pyramid known as Maoling “mausoleum”, in Xi’an (Sian) area in central China, dynasty Western Han, emperor Wudi 140-87 BC, see No. 11 in Tab.1, eye altitude ~2 km, size 235 x 240 m. Source: Google Earth 2010 and http://www.maps-china.com/Xian. Source for ages of all the pyramids in central China (Figures 6, 12-14 and Table 1): Moule, 1957.
Fig. 7. Paleomagnetic pole positions (defined by averaging global data) during the last 4,000 years; the data taken from McElhinny and McFadden (2000).
Fig. 8. Paleomagnetic declinations for Yucatan, México, according to Böhnel (priv. commun.) for the time interval 2000 BC - 2000 AD. Symbol BP means “before present”. The deviation of the declination from the north geographic pole is plotted in degrees, positive values are to the East. The precision is indicated by error bars.

Fig. 9. 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 precision of CALS7K.2 has been estimated by the authors of the model to be about 5 degrees, indicated by the dashed lines around the paleodeclination curve. Number 1 corresponds to Table 1, FC stands for the Forbidden City, Beijing.
Fig. 10. A “fan” of declinations around the cardinal north-south (west-east) directions of the structures at various ceremonial centers in Mesoamerica (according to Aveni, 1980).

Fig. 11. The plan of part of Uxmal archaeological site, north Yucatán. The Palace of Governor (arrow) is oriented astronomically (according to the direction of rise of Venus in its extreme declination at about 800 AD, see Aveni 1980, p. 275, verified by Klokočník and Vítek, 2005), the other objects might be oriented by a magnetic compass. Photo on the right side: The Palace of Governor, © J. Klokočník, 2010.
Fig. 12. Pyramid Weiling, Xi’an area, dynasty Western Han, emperor Yuandi, 48-33 BC, No. 19 in Tab. 1, eye alt. ~2 km, size 165x165 m. Google Earth 2010.
Reader can use geographic latitudes and longitudes in Table 1 to find all the pyramids mentioned in Table 1 using Google Earth or images from other satellite sources.
Fig. 13. Yangling and a row of pyramids, Xi’an area, dynasty Western Han, emperor Chengdi, 32-7 BC, No. 20 in Tab. 1, altitude about 1.6 km, size 170 m, orientation 10° west.
Google Earth 2010.
Fig. 14. Pyramid (size 65x65 m) and ceremonial space (spirit path long 310 m), Gongy near Luoyang, east of town Xi’an, Song, Zhenzong, 998-1022 AD, No. 29 in Tab.1, eye alt. 0.8 km. Google Earth 2009.