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# The Role of Astronomy and Feng Shui in the Planning of Ming Beijing

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## Abstract

Present day Beijing developed on the urban layout of the Ming capital, founded in 1420 over the former city of Dadu, the Yuan dynasty capital. The planning of Ming Beijing aimed at conveying a key political message, namely that the ruling dynasty was in charge of the Mandate of Heaven, so that Beijing was the true cosmic centre of the world. We explore here, using satellite imagery and palaeomagnetic data analysys, symbolic aspects of the planning of the city related to astronomical alignments and to the feng shui doctrine, both in its "form" and "compass" schools. In particular, we show that orientations of the axes of the "cosmic" temples and of the Forbidden City were most likely magnetic, while astronomy was used in topographical connections between the temples and in the plan of the Forbidden City in itself.

**Keywords** Archaeoastronomy of Ming Beijing · Forbidden City · Form feng shui · Compass feng shui · Ancient Chinese urban planning · Temple design

## Introduction

In the second half of the fourteenth century, China sat in rebellion against the foreign rule of the Mongols, the Yuan dynasty. Among the rebels, an outstanding personage emerged: Zhu Yuanzhang, who succeeded in expelling the foreigners, proclaiming in 1368 the beginning of a new era: the Ming dynasty (Paludan 1998). Zhu took the reign title of Hongwu and made his capital Nanjing. His succession was problematic: he chose one of his grandsons, who ascended to

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the throne as the Jianwen Emperor. However, Jianwen's uncle—the Prince of Beiping, the future Beijing—championed a revolt that led him to overthrow the nephew and to proclaim himself emperor with the throne name of Yongle (1402).

The historical figure of Yongle is controversial. On one hand, his ferocious persecution of adversaries is legendary; on the other, in his hands the economy of the empire flourished. The wealth of the state finances allowed Yongle to carry out an impressive building program, which reached its apex when he decided to move the capital from Nanjing to the town of his former principate, Beiping, which was then renamed Beijing—the Northern Capital. The reasons for the move are unclear, but Beiping was the former Yuan capital and the place from which Yongle contrived his ascent to power, and this must have played a significant part (see detailed discussion in Liu 1998). Whatever the motive, for his triumphal return as emperor, Yongle set in action a massive building program which, started in 1407, was virtually complete 13 years later and led to an almost complete reconstruction of the former town. Beijing was to remain the capital of China for the whole imperial period up to the advent of the Republic in 1906, and of course, up to the present day.

The focus of our study here is on the symbolic aspects of Ming Beijing, viewed as a "cosmic" capital. Indeed, the planning of the city pursued the aim of conveying a political message: the idea that the ruling dynasty was in charge of the *Tianming*, the Mandate of Heaven. This idea had formed the basis of the Chinese doctrine of power since the times of the first emperor, Shihuang: Chinese rulers justified themselves as having been chosen by *Tian*—the deified sky, identified with the celestial order and the regularity of the celestial cycles—to be the keeper of the very same order on earth. As a consequence, the Chinese capitals were identified as the "pivot of the four quarters", being the place of residence of the emperor and, therefore, the true cosmic centre of the world.

It is, of course, worth noticing that symbolic aspects of Beijing as a "cosmic capital" have been already thoroughly studied from many viewpoints. In particular, after the seminal work of Paul Wheatley (1971) on Chinese towns, Krupp (1982,1983,1989) was the first to frame the symbolic aspects of the town's plan and temples into a "cosmic" setting, putting also in evidence the relationships between directions and seasonal rites (see also Meyer 1978, 1991). Here, we investigate on these issues, following the lines of scientific archaeoastronomy (Magli 2018a) and using digital tools such as satellite imagery and computerized paleomagnetic field reconstruction. In this approach, the classical area of interest of archaeoastronomy (that is, the study of astronomical alignments) is much broadened to include the sky as just one of the elements of the built, sacred landscape. In this way, orientations which are due to the traditional Chinese doctrine of the landscape (the so-called feng shui) can be individuated and studied as well. As a consequence, topographical as well as astronomical references can be analysed within a global, scientific framework aimed at a better understanding of the ideas and the religion of their planners. As we shall see, in the case of Ming Beijing this approach leads to a series of new results which, in particular, highlight the role of feng shui in both its "form" and "compass" schools.

## The Yuan Capitals: Shangdu and Dadu

In the area of modern Beijing the existence of a town (called Ji) is documented starting in the Zhou period (around 1000 BC). The town became one of the capitals during the Liao dynasty (916–1125 AD; from now on all dates in the present paper are AD) and later the capital of the Jin dynasty (1126–1234). The same area was then chosen by the Mongol emperors of the Yuan dynasty (1267–1368) to build their capital. The Mongols destroyed almost completely the Jin city so that their town, called Dadu, could be constructed anew. Dadu was completed in 1293; not many years before its planning, however, another new capital had already been built by the same dynasty: Shangdu (this city, today in the Inner Mongolian Autonomous Region 280 km almost due north of Beijing, became the summer capital when Dadu was established). At the fall of the Mongols, Shangdu was conquered by the Ming army (1369) and lay abandoned for a few years. In order to have a better understanding of the choices made for Ming Beijing, it is important to discuss briefly here both of the Yuan capitals.

The urban layout of Shangdu was designed by Kublai Khan's Chinese advisor, Liu Bingzhong, the same architect later in charge of the planning of Dadu. The entire plan of Shangdu is masterfully oriented to the cardinal points. Orientations of the towns discussed in this paper are given in Table 1; data collection and accuracy are discussed below.

The layout consists of an Outer City, which is roughly a square with sides of about 2200 m, and an Inner City in the south–east area. The Inner City also forms a square (the south and the east sides coincide with the enclosure of the Outer City wall), with sides about 1380 m in length. Two gates are located in both the east and the west walls of the Inner City while a single gate is found in both the north and south walls, along the main axes. The Outer City has two gates along the north wall, only one in the west and east walls, and two (with one in common with the Inner City) along the south wall; while we find an axial correlation between the gates of the Inner City, those of the largest enclosure do not match. At the core of the town is the Palace City, where the emperor Kublai Khan resided in summer; this was the portion of Shangdu where the influence of Chinese planning was most strongly felt. The Palace has sides of roughly 550 m, the whole enclosing an area of about 484 ha. It was enclosed by a defensive wall and a moat and contains the remains of royal pavilions and palaces. The Palace

Site	Emperor	Date	Az	Mag. Dec	Notes
Shangdu	Kublai	1256	179°40′	1°00′	Urban plan
Dadu city walls	Kublai	1264	179°30′	1°20′	Northern section preserved in Dadu relics park
Ming Nanjing	Hongwu	1365	185°40′	1°40′	Urban plan
Zhongdu	Hongwu	1369	184°00'	1°00′	Urban plan
Ming Beijing	Yongle	1405	177°40′	- 0°25′	Southern Section of walls preserved near Beijing rail station, Qianmen Gate

Table 1 Orientation of the towns discussed in the paper

City is not in the centre of the Imperial city area: while the distance from the east and west walls corresponds to the axis, that between the external limit and the southern wall is almost four times the corresponding distance in the north. The Outer City extended 815 m to the west and 820 m to the north and was enclosed later than the Imperial city. The wall is not defensive: its construction differs from that of the Imperial City being of rammed earth, and the moat is only for drainage purposes and runs along only outside the west and southern walls.

The choice of the area of the former Jin city for founding Dadu was dictated by the fact that it was the place of a former Chinese-dynasty capital, and at the same time it was not too far from Shangdu, about 270 km. It's interesting to notice that Shangdu and Beijing lie on almost the same meridian, the difference in longitude being only 15', but this is probably due to chance. The Yuan city was planned by Liu Bingzhong locating the Imperial area in a zone which was formerly a suburban royal palace of the Jin emperors, endowed with an artificial lake (that area was later used as a gardened residence by both the Ming and the Qing emperors, and it is today called Bihai West Park). The general plan consisted again of a triple-walled city, but with "concentric" rectangular boundaries. From the exterior these were the Outer City, the Administrative City, and the Palace City. The huge perimeter of the Outer City had sides of 6635 m from east to west, 7400 m from south to north. The wall had eleven gates, three per side except for the northern one, which had only two. The gates were located at equal distances along the sides, so that the axes originating at the southern gates did not match the gates at the opposite ends, while the east-west ones did. However, the central, north-south axis identifies an axis of symmetry for the whole town, crossing the Imperial City and the east-west avenue in the area of the Central Pavilion, the Bell Tower and the Drum Tower. In the same area was located the centre marker (equidistant from the midpoint of each outer wall face) (Steinhardt 1983).

All in all, the plan of Dadu is close to the so-called "magic square" plan: a square divided into nine equal parts. Together with the location of markets to the north, the construction of the Ancestral Temple to the east of the administrative city and of the Altar of the God of Land and Grain to the west of it, these features make Dadu conform to the instructions of the Kaogong Ji section of the Confucian classic Zhou Li. This text, written during the Han period, reports the traditional Chinese canons for town construction, which allegedly already existed during the Zhou (Schinz 1996; Xu 2019). Ironically, the Mongols-thus foreign rulers—were the first to adhere rather strictly to the Chinese canons, more than 1200 years after their writing. Indeed, most if not all previous Chinese imperial capitals followed instead a scheme in which either the Palace City is in the north, or the city is "double", consisting of two walled enclosures, which may or may not have been in use at the same time (Steinhardt 1986, 1999, 2002). Apparently, Liu Bingzhong opted to adhere to the most traditional Chinese canons with the aim of facilitating acceptance of the foreign rule, within a general politics of legitimization pursued at the Mongol court after the conquest of the Jin empire, and in preparation of the conquest of the southern part of the country (at the time of the foundation of Dadu the south was still independent and ruled by the dynasty of the Southern Song) (Fig. 1).



**Fig. 1** Plan of Ming Beijing. The original borders the Yuan capital Dadu are shaded. 1) Forbidden City, 2) Temple of Heaven, 3) Temple of Agriculture, 4) Temple of the Moon, 5) Temple of the Earth, 6) Temple of the Sun, 7) Imperial Ancestral Temple, 8) Altar of Land and Grain (Drawing by the authors)

## **The Yongle Project**

In principle, the Ming urban program was based on the existing Yuan city grid but involved a shortening and a displacement of the whole town. Today, the Ming city walls of Beijing are visible only in a preserved section located to the south of the main railway station, as they were almost completely removed in the last century to make room for the third ring road. Nevertheless, we do have a clear idea of their original plan. The area of the city was diminished by translating the northern side to the south (the scant remains of the northern sector of the Yuan walls are today enclosed in the public park called Yuan Dadu Relics Park). In order to maintain a certain balance between the location of the Forbidden City and the ideal centre of the town, the southern boundary was also displaced further south, although not as much as the northern one. The plan finally assumed is characteristic, double-rectangle form later on (about 1550) when a global enlargement was planned, but only its southern part was completed, the upper part being since then identified as Inner City.

The Inner City is a rectangle 6650 m wide and 5350 m long, endowed with nine gates: three along the south wall, two on each other sides. The Imperial City, almost square in plan (2500 m from east to west and 2750 m north to south) is slightly displaced to the south of the centre of it. Endowed with four gates, one per side, the imperial city contained an artificial hill to the north and, along the meridian axis but slightly displaced east of the centre, the Forbidden City.

## The Forbidden City and the Temples to the South

The walled enclosure usually called Forbidden City was actually called *Zijincheng*. This means *Purple* Forbidden City, the adjective being an explicit reference to the *celestial* Purple Enclosure, the region of the sky near the north celestial pole whose stars were identified with the emperor and his court in the Chinese tradition. From the very beginning, therefore, the core of the "cosmic" Beijing was identified with the earthly counterpart of the most important region of the heavens (Fig. 2).

The Forbidden City is a walled rectangle (about 1000 m north-south by 750 m east-west) surrounded by a wide moat. There are four towers at the four corners, and four gates, one per side. The most important gates are the Meridian Gate—endowed with protruding wings—to the south, and the northern gate (Gate of Divine Might), which connects the imperial apartments area with Jingshan Park (see below). The plan is characterized by an extremely rigorous geometrical layout. Generally speaking, it is divided north-south into a public part and a private part, and it is divided east-west in three sections, the central one being reserved for the emperor and crossed by an ideal path exclusive to him. Entering through the Meridian Gate, the visitor meets a vast square. A meandering,



**Fig. 2** From left to right: Imperial Palace of Nanjing, Zhongdu and Beijing. 1) Golden Water river 2) Hall of Supreme Harmony 3) Jangshan Hill. The skew of the axes with respect to north is coherent with the magnetic declination values at the time of planning (Drawing by the authors)



Fig. 3 Beijing, Forbidden City. The gate of Supreme Harmony and the Golden Water river (Image by the authors)

canalized river (the "Golden Water" River) flows across the square and is spanned by five bridges. To the north of it stands the imposing mass of the Gate of Supreme Harmony (Fig. 3).

Behind that, a second esplanade prepares the visitor for the focus of the complex, a succession of three halls, or pavilions, built on a raised terrace: the Hall of Supreme Harmony, the Hall of Central Harmony, and the Hall of Preserving Harmony. The central ascending ramps to the halls are part of the imperial route and were reserved for the emperor's baldachin; they are made of huge blocks of stone carved with fine reliefs of dragons and phoenixes, symbols of the royal couple (the wooden superstructures were rebuilt several times due to fire). The halls were devoted to imperial duties and each one hosts a throne. In particular, the Hall of Supreme Harmony is the largest and most symbolic building of Ming Beijing; it was used for court and ceremonial occasions, and it is the largest wooden structure existing in China (Fig. 4).

The second hall or Hall of Central Harmony is a square building used as a transitional place for the emperor to rest during ceremonies. The third hall or Hall of Preserving Harmony is famous mostly because it was the place where the final stage of the laborious process of the Imperial State Examination took place.

The private part of the Forbidden City is where the court lived. This section was also planned following a rigorous, geometrical order and its core is a sort of mirror image of the public section, based as it is on the succession of three halls, called the Palace of Heavenly Purity (the emperor's residence), the Hall of Union, and the Palace of Earthly Tranquillity (the empress's residence).

Interestingly, many of the architectural solutions adopted for the Forbidden City were replicated in the Ming royal necropolis, located in Shisanling, some 40 km north-west of Beijing (Paludan 1981, 1991). The necropolis is in a beautiful, verdant valley which satisfies the most rigorous canons of form feng shui. Each tomb develops along a linear axis, endowed with ritual buildings and ending with a circular mound. The architecture of the most important building in each complex, devoted to the cult of the deceased emperor, clearly resembles the Hall of Supreme Harmony. Furthermore, the tripartite structure of the Forbidden city—therefore, of the residence of the living emperor—was replicated in the funerary apartments located under the mound, at least from what we can infer from the only tomb which has been completely excavated, Dingling, the tomb of Wanli (1572–1620). The funerary chambers lie on the axis of the exterior complex and are accessed from



**Fig. 4** Beijing, Forbidden City. The Hall of Supreme Harmony. The pavilion on the summit of Jangshan hill is visible in background (Image by the authors)

a descending corridor which crosses an "A"-like opening ("diamond wall"). From the antechamber, a huge marble door opens into a vast series of rooms, which were built inside a pit 26 m deep. The apartments occupy more than 1000 square meters and have a strict, formal structure: behind the marble door and on axis with it is a large corridor, 6 m wide and 32 m deep; parallel to this run two rectangular chambers connected by galleries to the central one. Therefore, the underground palace is tripartite in the longitudinal direction, with the main section reserved for the emperor. Like the three Halls of the Forbidden City, the central room houses three marble thrones, or imperial spirit seats, each equipped with ritual vessels (Wu 2010). The burial chamber lies at the end of the central hall, in analogy to the private section located at the upper end of the Forbidden City.

The Ming planning of the Forbidden City also influenced the overall urban layout of Beijing, as the southern prolongation of the main axis through Tianamen gate (and today Tianamen square) became the central axis of the town. In particular, Yongle constructed along this axis a series of sacred complexes devoted to the explicit celebration of the role of the emperor as intermediary with the Celestial Gods and to the renewal of the Mandate of Heaven. First of all, near the south corners of the Forbidden City, the emperor built (or perhaps rebuilt) the Altar of Land and Grain (south-west corner) and the Ancestral Temple (south-east corner). The Altar is an open-air, three-level square terrace of white marble, used for making sacrifices to the Earth's gods (in the Chinese tradition, square is associated to Earth and round to Heavens). On the top, a basin contains soil of five colours: green (east), red (south), white (west), black (north) and finally yellow in the middle. The Imperial Ancestral Temple is a huge complex, culminating in the Hall where Ming's ancestors were venerated. Proceeding farther south after Tianamen, and parallel to the main axis, we meet two more huge complexes originally built by Yongle: to the west the Temple of Agriculture, and to the east the Temple of Heaven.

What remains today of the Temple of Agriculture is found within a vast area of sport fields. The complex was based on a series of buildings devoted to ritual activities related to farming. Of these, Yongle built the *Xiannongtan*, devoted to the God of Agriculture ("the first farmer"), while several additions were made later by Jiajing. The Temple of Heaven originally included two main buildings. First (from north to south) is the Hall of Prayer for Good Harvests, a high, circular wooden hall, built on a three-level marble terrace. The second, linked to the first by a processional walkway, is the Imperial Vault of Heaven, similar to the Hall of Prayer for Good Harvests and like it built on a white marble platform, but smaller. It is enclosed by a curved wall, traditionally called the Echo Wall because of its (true or presumed) acoustic characteristics. The third main building of the Temple of Heaven was added one century later by Emperor Jiajing, who was the responsible for the definitive "cosmization" of the Ming capital (Fig. 5).

#### The Jiajing Additions

The Ming Emperor Jiajing (1521–1567) started a building program aimed at what he apparently considered a necessary completion of the



Fig. 5 Beijing, Temple of Heaven. The axis of the complex seen from the Altar of Earth (Image by the authors)

symbolic—cosmic—structure of Beijing. The origin certainly has to be found in his devotion to Daoism, but the ultimate aim of the program is clearly related to the enhancement of the image of the emperor as unique mediator in charge of the connection with the Heaven, since he added a series of buildings devoted to seasonal rituals carried out by the ruler in person.

First of all, the temple area to the south of the Forbidden City described above received a series of relevant additions. To the south of the Temple of Heaven and on axis with it, a spectacular new building was added. Called the Circular Mound Altar and built around 1530, it is an open-air, three-tier, circular platform of white marble decorated with stone dragons. To the complex of the Temple of Agriculture, Jiajing added a square, open-air altar devoted to the Spirits of Earth and the huge Taisui temple, devoted to the God associated to Jupiter.

Jiajing also built ex-novo three other temples, placed at the other three cardinal points with respect to the Forbidden city. These temples all follow similar architectural canons, and their designs clearly show a unity of intents. Their focus is always an open-air central altar whose precinct is accessed on all the four sides by a stone gate. Among the four entrances, however, a main portal—therefore, a main direction—can be individuated as it has three stone-pillared entrances (and thus six pillars) while the other three gates only have one entrance. These temples are in the east, the Temple of the Sun (today enclosed in Ritan Park), whose focus is a square marble platform endowed with four access ramps, encircled by a circular compound, with main entrance facing west. In the north, the Temple of the Earth (also called Fangze Temple) square in shape, encircled by a square compound and with main entrance facing south. In the west, the Temple of the Moon, whose altar is unfortunately today occupied by a huge communication antenna. However, annexed buildings and the main entrance way, facing to the east, remain.

## Ming Beijing as a Cosmological Capital

### The Pivot of the Four Quarters

The Zhou Li is permeated by the idea of a symbolic connection between the emperor-viewed as the pivot of the entire state-and the capital as the centre of the empire. Since the emperor is endowed with the Mandate of Heaven, he is also an earthly manifestation of the pivot of the sky, the north celestial pole (Pankenier 2004, 2013). To bring to completion the connection between Heaven and Earth, the capital thus has to be "cosmicized" following a mechanism which has been common to many civilizations of the past: in the famous words of the historian of religion Mircea Eliade, "the sacred reveals absolute reality and at the same time makes orientation possible; hence it founds the world in the sense that it fixes the limits and establishes the order of the world" (1959: 30). Order here means cosmic order, and indeed the Zhou Li describes the choice of the site of the capital and the determination of the cardinal points to which the town's grid should be oriented and specifies that the emperor "sits in the north", which is at the origin of the north-south axis of the layout of the Forbidden City, as well as many other Chinese capitals in the course of the centuries. The Chinese capital is thus the "pivot of the four quarters" as Paul Wheatley (1971, 1975) puts it.

As far as the methods of orientation of the town grid are concerned, a procedure for the determination of the cardinal points based on the measures of the shadows produced by a gnomon is explicitly described in the Zhou Li. Of course, the Chinese were accurate starwatchers as well, and we have clear proof that they also possessed methods of orientation based on the stars (Pankenier 2009). However, it must be remembered that, due to the phenomenon called precession, in the Han period, when the text was written, the north celestial pole was very far from Polaris, and actually was still some 4° away from it in the fourteenth century. This is a fact which is easily overlooked in the existing modern literature, which mentions, for instance, "orientation to the pole star" as a synonym for "orientation to true north" valid in any epoch. The two things must instead be kept strictly separated, and care must be taken when interpreting ancient passages, such as a famous one by Confucius, in which the emperor is identified with the "pole star" (in Confucius's times, the pole was actually closer to the star Kochab than to Polaris). We have evidence that the Han emperors oriented many of their tombs to the elongation (maximal distance in degrees) of Polaris from the pole, showing a perfect knowledge of the celestial situation, if not of the underlying physical phenomenon (Magli 2018b, 2019a).

Besides the enormous importance of the heavens in the Chinese doctrine of power, there is another traditional doctrine related to orientation and symbolic topography which must be taken into account when studying Chinese town planning: feng shui. Feng shui is the Chinese "geomancy", that is, divination in accordance with the geographical and morphological features of the terrain (Bruun 2008). In a nutshell, the idea at the basis of feng shui is that special locations exhibiting particular natural features are favourable from the point

of view of encapsulating and enhancing the so-called *Qi*, a "positive energy" allegedly flowing on the Earth and are thus to be preferred for city planning and for the location of houses and tombs. Of course, this idea is a superstition which has no physical basis whatsoever, and it is worth pointing out that our approach here is fully scientific and our interest in feng shui is due to the relevant role it plays in Chinese ancient architecture. From the historical point of view, the development of this doctrine is more understandable if we consider that the tradition of a "vital energy" flowing north-south was already in existence when, during the Han period, the Chinese discovered the magnetic compass, which showed the existence of "something" that seemed to flow on the Earth along such a direction (Needham 1965). Actually, in spite of the fact that the origins of some feng shui ideas-such as the identification of the four cardinal points with four symbolic animals and the idea that the north-south direction is favourablecan be traced back to the Chinese Bronze Age or even earlier (Pankenier 2013), written records directly referring to the geomancy of the terrain appear only at the end of the Han dynasty, and feng shui in architectural planning appears even later, during the Song dynasty (960-1279). Since then, however, to study Chinese architecture we are obliged to take feng shui into account, and this is particularly true in the case of the Ming dynasty.

Feng shui developed in two schools, traditionally called "form feng shui" and "compass feng shui". The first relied mostly on the natural topography, while the second was mainly based on the *luopan*, the magnetic compass. Form feng shui implied the observation of the morphology of mountains and rivers and of their relationship to winds in order to establish favourable places according to the presumed benign flow of Qi. A "correct place" in form feng shui must first of all have the tallest visible mountain to the north and a meandering river flowing to the south. Starting from these two main characteristics, a series of further refinements were applied to establish the supposed level of suitability of a site. Among these refinements, the principal ones include the shape of the main mountain, which must have an undulating form, the presence of protective hills to the east (Green Dragon hills) and to the west (White Tiger hills) and of a low, facing hill to the south. In contrast, compass feng shui is based on the measure of the magnetic north (identified as the most favourable direction) and on a complicated series of values of auspiciousness assigned to the topographic elements in consequence of their magnetic azimuths. This school probably arose with the discovery of the magnetic properties of lodestone but developed only with the introduction of a compass based on a freely floating needle, which occurred in the last centuries of the first millennium.

In what follows we are going to discuss the role of the above-mentioned doctrines in the planning of Ming Beijing. We will use here the scientific approach which is typical of modern archaeoastronomy and has been recently applied in the study of the imperial Chinese necropolises (Magli 2019b). To this aim we performed a series of measures of topographical and astronomical alignments whose azimuths are reported in Table 2. Although one of us has taken many of these measures on site, for the sake of internal consistency and homogeneity, all data reported here have been obtained through Google Earth satellite imagery. The program has a

Table 2     Orientations of main       buildings of Ming Beijing in	Site	Date	Az	Mag. Dec			
chronological order	Forbidden city	1405	177°40′	- 0°25′			
	Temple of Heaven	1406	177°40′	- 0°25′			
	Imperial Ancestral Temple	1420	177°40′	- 0°40′			
	Altar of Land and Grain	1421	177°40′	- 0°40′			
	Temple of Agriculture	1420	177°40′	- 0°40′			
	Altar of Earth spirits	1420	177°40′	- 0°40′			
	Zhenjue Temple	1473	176°00'	- 1°25′			
	Tian Temple	1530	176°30′	- 1°25′			
	Temple of Earth	1530	174°40′	- 1°25′			
	Temple of the Moon	1530	176°40′	- 1°25′			
	Temple of the Sun	1530	176°40′	- 1°25′			
	White Pagoda	1651	176°00′	- 1°30′			

very good resolution, and the intrinsic error is quite low (Potere 2008; Luo et al 2018); the results of on-site tests further confirm the validity of the satellite imagery approach. In addition, use of satellite imagery allows us to study the cases where landscape and visibility were different in ancient times, by tracing visibility lines that are today lost or broken up by intervening obstacles. In Table 2 we also report the estimated magnetic declinations at the time of construction. This is necessary in order to test whether compass feng shui was used, since the Earth's magnetic poles do not coincide with the Earth's rotation poles and continuously move over the Earth's surface. Therefore, the direction of the magnetic compass bearing varies continuously. The reconstruction of magnetic field declinations is made possible by the recent development of reliable models of palaeomagnetism, and in the present paper we have used the model CALS10k.2 developed at the German Research Centre for Geosciences in Potsdam (Korte et al. 2011; Constable et al. 2016).

#### The Orientation of the Urban's Grid and of the Forbidden City

As we have seen, the original plan of Yuan Dadu followed in a rather strict manner the dictates of the *Kaogong Ji*, but at the moment of planning Beijing the Ming architects took into account only a part of the Yuan structures, geometries, and orientations. To address this issue, it is convenient to consider first the orientation of the Forbidden City. Although it is usually stated that it is "perfectly oriented north–south" (see for instance Meyer 1991) this is *not* true. The axis exhibits a deviation of  $2.5^{\circ}$  towards the west. It is impossible to ascribe this to an error, as the methods in use to find the cardinal directions were giving an accuracy well below  $1/2^{\circ}$  already in Han times, 1500 years earlier. Therefore, the skew towards the west was intended. To understand why, it is crucial to understand whether it reflects an original skew of the whole Mongol plan of Dadu with respect to the cardinal points, or if it is a decision taken a century later by the Ming architects. To solve this riddle, we measured the surviving section of the Ming walls, which is located to the south of modern Beijing railway station. This section exhibits exactly the same skew of the Forbidden City. Then, we tried to measure the scant remains of the Yuan walls to the north, but this is very difficult. Nevertheless, the canal which runs parallel to them along the corresponding public park is almost perfectly oriented east-west. This finally led us to measure the orthogonal grid of Beijing as a whole, which the Ming basically inherited from Dadu. To our surprise, on the average and after taking several measures, the grid turns out to be oriented to the cardinal points with an error not exceeding 40', therefore perfectly in accordance with the orientation of Shangdu, planned by the same architects as Dadu. This is confirmed also by the Beijing palaces which appear to be of secure Yuan foundation, such as the Hall of Receiving Light (*Chengguang dian*) in the Bihai park and the Drum Tower, which also exhibit an almost cardinal orientation  $(179^{\circ} 30')$ . In turn, this orientation is not consistent with the later Ming additions so that, for instance, the angle formed with the meridians of the grid with the preserved section of the Ming walls, although almost imperceptible on site, is clearly greater than 90° when measured in satellite images (Fig. 6).

All in all, this analysis shows that the urban plan of Yuan Dadu was oriented to the cardinal points in perfect accord with the *Kaogong Ji*, while the Ming architects working at Yongle times skewed this orientation in the planning of the Forbidden City and remained faithful to the latter orientation any time they planned new relevant constructions (see again Table 2). At a first sight, this may seem a detail. It is, however, a fact which has profound symbolic significance,



**Fig. 6** A satellite image of the Forbidden City highlighted with a yellow solid line together with the Ming walls. The reconstruction of the Yuan grid (red) shows the existing, although small, angle between the two (Image courtesy Google Earth, drawings by the authors) (color figure online)

since the orientation method which was used was different, and the reason for the choice of the method was symbolic. Indeed, while the planning of Dadu (as that of Shangdu) was of course astronomical, we claim that the Ming used compass feng shui, and therefore magnetic orientation (apparently, a magnetic orientation for the Forbidden City was already proposed by the eighteenth-century Czech astronomer Karel Slavíček; see Charvatova et al. 2011; Sparavigna 2017).

This assertion is corroborated by the following facts.

- (1) The first Ming emperor Hongwu was actually the first to conceive the idea of moving the capital from Nanjing. His plan was to build a new capital in his native town, Fengyang, where he had a huge tomb (Huangling) built for his parents. The project of the new capital, named Zhongdu, was abandoned, probably due to the excessive costs. However, the walls and the moat of the planned Inner City (very similar in dimensions to the future Forbidden City) are measurable, and exhibit a macroscopic skew to the east, whose likely explanation is that magnetic orientation was used (Table 1). The very same situation also occurs in Nanjing, where Hongwu built a completely new imperial town in the eastern part of the city perimeter. This "Forbidden City of Nanjing" is today almost destroyed but its axis is easily measurable and, again, the skew with respect to the meridian direction is compatible with the magnetic declination at the time of construction.
- (2) The temples added ex-novo by Jiajing exhibit a macroscopic skew which can only be due to a varied magnetic declination. Indeed, while the axis of his additions to the Temple of Heaven and to the Temple of Agriculture are consistent with the pre-existing one and therefore coherent with those of the Forbidden City, the orientations of the other three temples, constructed ex-novo, are macroscopically skewed and qualitatively in accordance with the variation in magnetic declination occurred in the meanwhile (Table 2). This also excludes the possibility of an orientation to the maximal elongation of Polaris (observed in some monuments of previous dynasties) as that was decreasing in the slow precessional approach of the celestial pole to the star.
- (3) More generally, all the data we collected for orientation of Ming imperial towns (Nanjing, Zhongdu and Beijing, Table 1) and buildings (Table 2) are coherent with the local behaviour of the magnetic declination, with an impressive value of the correlation coefficient R = 0.96. A correlation so close to 1.00 is a very strong hint that the variables in question (orientation vs. magnetic declination at the date of construction) are linearly correlated. We notice, however, that while the general coherence of the orientations with the variation of the magnetic field appears evident, the actual values of the predicted declinations are typically smaller than the observed deviations from geographical north. This may depend on a smoothing in the model insofar the actual value (not the direction) of the declination is predicted, as a comparison of Beijing data with the corresponding available data of the NOAA model shows to be a likely possibility (unfortunately this model is limited to the years after 1590, so we cannot use it for the specific dates of interest).

#### Astronomical and Topographical Issues Related to the Hall of Supreme Harmony

Inside the general, geometric structure of the plan of Ming Beijing discussed above, there is a curious, apparently mysterious fact: the side gates of the Forbidden City are notably displaced to the south with respect to the mid-line of the enclosure, and there appears to be no functional reason for this choice. There is, however, a term of comparison: in Shangdu, the southern gates of the sides of the central town are displaced as well, and their azimuths measured from the centre of the imperial palace correspond with impressive precision with those of the sun rising/setting at the winter solstice (with a flat horizon), a thing which can hardly be attributed to a chance (Romain 2017). In Beijing, a similar effect occurs. However, Shangdu is very precisely oriented to true north, and therefore the two lines are symmetric and form equal angles with the east-west direction. In Beijing, satisfying both requirements was not possible, since the axis of the Forbidden City is skewed to the west. The gates of the Forbidden City were positioned in such a way that the azimuth of the eastern gate taken from the centre of the Hall of Supreme Harmony is aligned to the sun rising at the winter solstice: this azimuth is indeed  $122^{\circ}$ , to be compared with winter solstice sunrise azimuth with a flat horizon which is 121° 20' (the azimuth of the western gate, being symmetrical to the eastern one with respect to the axis of the Forbidden City, is not that of the sun setting at winter solstice). This alignment embedded in the core geometry of the layout of the Forbidden City confirms the special relevance of the winter solstice for the symbolic apparatus connected with the Mandate of Heaven and finds its natural counterpart in the prominence and complexity of the rites which were held at the circular mound altar on the very same day (see below).

Further alignments referring to the Hall of Supreme Harmony were introduced when Emperor Jiajing set about implementing the cosmization of Beijing according to his religious views. In fact, the location of his newly built temples was chosen in accordance with a very rigorous symbolic structure. As a result, these temples are strongly interconnected with each other and with the Hall of Supreme Harmony. Indeed:

- the centre of the altar of the Temple of the Earth lies almost on the same meridian of the centre of the circular mound altar (distance 8.4 km, error less than 1.5°);
- the parallel of the centre of the altar of the Temple of the Sun crosses the heart of the Forbidden City and was probably meant to connect with the centre of the Hall of Supreme Harmony, which it misses by less than 150 m (distance 4 km, error in degrees less than 0.5°);
- the parallel of the centre of the altar of the Temple of the Moon passes through the Hall of Supreme Harmony with no discernible error (distance 3.8 km).

These alignments were probably obtained with the help of high poles, starting from a measurement of the cardinal directions that was certainly astronomical and probably based on the sun (not magnetic). The temples are indeed associated with the yearly cycle and the emperor made sacrifices in all these places on a yearly basis. The sacrifices were made in coincidence with the autumnal equinox (Temple of the Moon), the summer solstice (Temple of the Earth), the spring equinox (Temple of the Sun), and the winter solstice (Circular Mound Altar) respectively. Many details of the complex rituals associated with these sacrifices are known, and their cosmic significance to assure the regularity of the celestial cycles and of the calendar is thoroughly discussed in Krupp (1989). Of special relevance was the winter solstice sacrifice at the Circular Mound Altar, this being the unique occasion in which the emperor—who was usually identified with the Northern Sky—was himself looking towards the north along the axis of the Temple of Heaven complex (Fig. 5). Timing of the ceremony was, of course, fundamental and, as a matter of fact, to the southwest of the Circular Mound Altar stands a very high pole which was used—together with two others nearby of which only the foundations remain—for hanging a lantern. Measuring the position of this complex in relation to the centre of the altar mound allows us to understand that it could be useful as a signpost to check, at sunset, the correct date of the solstice.

#### The Role of Form Feng Shui in Ming Beijing

We believe that our analysis convincingly shows that a magnetic compass, and therefore some version of compass feng shui, was used in the planning of the Forbidden City and of the Ming additions to the walls, as well as in many other buildings of Ming Beijing. Nevertheless, the compass and form schools of feng shui were not mutually exclusive, and we do know from previous research that form feng shui was abundantly applied in the planning of the Ming tombs (Paludan 1981; Magli 2020). Thus, it remains to analyse the role—if any—played by form feng shui in the planning of Ming Beijing.

First of all, there exist many Chinese sources which exalt the geographic location of the city based on traditional Chinese theories of sacred geography, in particular that of the "three Dragons", three mountain ranges ideally dividing the whole country, with Beijing belonging to the northern one. Whether this is "pure" feng shui or rather refers to more eradicated cultural traditions is difficult to say, but in any case, even the most ancient of these sources were written after the choice of the area for the establishment of the Jin capital: these are by Zhu Xi, writing in the second half of the twelfth century, and Liu Ji, writing in early Ming times. Thus, there is no evidence that such ideas-which, in any case, pertain to a Chinese tradition that should not be identified exclusively with feng shui-influenced the choice of the site (Liu 1998). Furthermore, the place itself is defective in all the supposed characteristics which would have made the Beijing location a perfect feng shui place, since the necessary characteristics are all too far away to be considered effective: the city actually lies in flat land, the mountain range to the north being many tens of kilometres away, with the mountains barely visible. As a consequence, the "geomantic maps" published during the centuries which allegedly showed the auspiciousness of the Beijing site usually featured exaggerated geographical characters, or misleading scales, or both (Yoon 2008).

A very different situation occurs instead for the Forbidden City. Indeed, there can hardly be any doubt of the fact that the two main dictates of form feng shui—hill to the north, meandering river to the south—were respected in its design. Of course, ab initio both were absent, so that the Forbidden City was conceived as "a feng shui landscape where there is no feng shui landscape" (Magli 2020: 111): the Ming architects decided to add the main features of any auspicious landscape artificially. In this way, Jangshan Hill and the Golden Water River were brought to being.

Constructing auspicious hills certainly was not a novelty for Chinese emperors: a famous case is the Genyue, an artificial mountain constructed by Huizong (the last emperor of the Northern Song, ruling 1100-1126) in his capital Kaifeng (Hargett 1988). The hill was built because geomancers determined that Kaifeng needed a screen of mountains to the north east in order for the emperor to have sons, and the emperor took this advice seriously, building the hill's screen (which according to some sources was more than 100 m high) directly inside the capital (the insane project was completely razed by the Jin army when Kaifeng was lost). Perhaps inspired by this antecedent, the Ming planners used hundreds of thousands of tons of the material excavated from the Forbidden City moat to build a hill to the immediate north of the Forbidden City. The result, called Jangshan Hill, is more than 50 m high and appears as a five-peak scenery directly abutting on the private imperial gardens, which are placed at the northern end of the Forbidden City. The central summit of the hill houses a pavilion from which, on clear days, a marvellous view of the Forbidden City can be enjoyed. The Golden Water river was instead an already existing canal, connected with the lakes area of the West Park. The waters were however accurately canalized to flow across the southern esplanade of the Forbidden City with a meandering design crossed by five bridges. Curiously enough, later attempts were also made to improve further the feng shui of the Forbidden City. For instance, in 1455 the Court chief astronomer proposed moving the observatory, re-building it to the immediate east of the Forbidden City, in order to act-together with an existing pagoda to the west—as Green Dragon and White Tiger surrogates (the project was not realized).

## Conclusions

Since the times of the first emperor, an explicit connection was established in China between the plan of the capital and the sky. This tradition can be traced from the Han up to the Yuan dynasty, but in Ming Beijing we observe a clear change of focal point, from the sky in itself (and therefore, from cardinal and astronomical orientations) to the geomantic properties of the architectural projects. If indeed it is certain that Chinese geomancy (feng shui) did *not* play a role in the choice of the site of the town—decided long before the Ming—we have shown that both schools of feng shui played a fundamental role in the Ming urban plan and in the huge projects developed therein, such as the Forbidden City and the Jiajing Emperor's temples. Being in flat land, for the planning of the city the use of the compass school was preferred, as shown by the orientation of the Forbidden City and of the temples constructed later, whose orientations are coherent with the variation of magnetic declination. However, for the very heart of the empire, the Forbidden City, also

the main dictates of the form school were followed, with the additions of artificial elements to the urban landscape.

It could be objected that the official role of diviners and feng shui masters at the Ming and later Qing court does *not* appear to be prominent with respect, for instance to that of the chief court astronomer and his numerous collaborators (Bruun 2008). Actually, the elite of the country, selected through the rigorous process of imperial examination and trained in the Confucian classics, almost certainly did not/ could not easily endorse the rather esoteric feng shui viewpoints, and the very same holds for the emperor himself. Nevertheless, this was true on official occasions only. Indeed, there can be no possible doubts that feng shui was widely diffused in all social classes, and the facts show that all the Ming (and later Qing) emperors strictly followed the dictates of form feng shui when planning their magnificent tombs. These tombs were in turn "official" under all respects: their beautiful siting in the landscape was celebrated and almost legendary, and the living emperor visited the burials of his ancestors on a regular basis. Feng shui is also apparent in "regional"but no less important-imperial projects, such as Yongle's temples celebrating the Daoist warrior divinity Zhenwu on Wudang mountain peaks (Campbell 2020). Therefore, it should come as no true surprise that the huge imperial projects devised in Beijing also followed the feng shui dictates.

The use of this doctrine, intimately related to the forces of nature, in a place where nature in itself was artificially re-created was of help in reinforcing the power associated with the Mandate of Heaven, as well as bringing to bear some among the most astonishing architectural masterpieces humans ever dared to conceive.

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