Acta Geochim (2017) 36(2):213–223
DOI 10.1007/s11631-017-0159-1

ORIGINAL ARTICLE

Nomenclature for lunar features at the Chang'e-3 landing site

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Received: 22 December 2016 / Revised: 15 February 2017 / Accepted: 9 April 2017 / Published online: 27 April 2017

Abstract Nomenclatures for lunar features always accompany the progresses of human lunar exploration, which has an important dual meaning in culture and science. The naming of lunar features not only can commemorate the outstanding contributions of academics, masters in various fields, and popularize the traditional cultures of ethnic groups all over the world, but also have a critical function of providing accurate indicative information on features with special morphology, origin, nature and scientific value. However, nomenclature for features at the Chang'e-3 landing site, which has a more arbitrary form without many constrains posed by a uniformed system, is unlike the features for other morphological units. This paper originated from the actual needs for the description of scientific exploration activities, interpretation of scientific research and dissemination of scientific results. Some prominent morphological units with great scientific importance and identification purpose were chosen from the images taken by the terrain camera, panorama cameras and landing camera onboard the Chang'e lander and Yutu rover. A nomenclature system was established under the three enclosures, four quadrants and twenty-eight lunar lodges' system of the Chinese ancient sky division method. Finally, a standard feature names set was published after some necessary approval procedures by the International Astronomical Union.

Keywords Moon · Chang'e-3 · Landing site · Lunar feature nomenclature

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1 Introduction

Planetary nomenclature, like terrestrial nomenclature, is used to uniquely identify a feature on the surface of a planet or satellite so that the feature can be easily located, described, and discussed. Nomenclature for lunar features originated in the seventeenth century, as early scientists in that era used telescopes to observe the lunar surface, named the remarkable features on the lunar surface according to their own naming systems and then marked them onto a map. As telescope performance continued to increase, more and more lunar features were designated with names by different observers, eventually leading to a chaotic situation where the same features were repeatedly named. In the early twentieth century, a committee was appointed to regularize the chaotic lunar nomenclatures. The publication of the IAU-approved "Named Lunar Formations" by Blagg and Müller in 1935 indicated a significant change for lunar nomenclature: from direct designation by observers to mandatory approval by an international committee (Blagg et al. 1935). As a result of the lunar exploration upsurge, the requirements for lunar nomenclature dramatically increased in the middle twentieth-century when more detailed images revealing newly discriminated lunar surface features became available. In 1973, IAU handed over the responsibility for the approval of new names over to the newly founded Working Group for Planetary System Nomenclature (Shevchenko et al. 2009). After decades of' continual improvement, a normalized nomenclature system was finally well established.

IAU classified all named lunar features into 18 types, including albedo feature, catena (catenae), crater (craters), dorsum (dorsa), fossa (fossae), lacus (lacūs), landing site name, mare (maria), mons (montes), oceanus (oceani), palus (paludes), planitia (planitiae), promontorium (promontoria), rima (rimae), rupes (rupēs), satellite feature, sinus (sinūs) and vallis (valles). As of October 1st 2016, a total of 9014 lunar feature names (including 7060 satellite features) (IAU 2016a) were approved by the IAU. China submitted nomenclature proposals twice to the IAU related to scientific research conducted under the China's lunar exploration project, and a total of seven features got official names, including six craters and one landing site name. After the success of China's lunar exploration project in 2007, the scientist team identified three craters near the north-pole using the Chang'e-1 (CE-1) high-resolution global images and submitted a its name request to IAU in 2010 for the first time. The IAU-approved the names of these three craters, Cai Lun (蔡伦), Bi Sheng (毕昇) and Zhang Yuzhe (张钰哲), indicated a milestone for China's efforts on lunar feature nomenclature. The second application China submitted was motivated by the successful implementation of the CE-3 mission, which signified China's first soft landing and roving on an extraterrestrial object. Finally, the memorial landing site name of Guang Han Gong (广寒宫) and three crater names of Zi Wei, Tian Shi and Tai Wei were approved by the IAU on October 5, 2015. Naming lunar features always accompanies the constant marching of human lunar exploration, not only providing accurate indicative information on features with special morphology, origin, nature and scientific value, facilitating the communication, propagation and application of science problems in lunar science community, but also indirectly reflectings the power of different countries in planetary exploration. Thus, lunar nomenclature plays an important role in the scientific activities in planetary exploration.

In this paper, we describe the investigation of the CE-3 lander and rover, the acquisition and processing of the data from the terrain camera, panoramic cameras and landing camera, and the identification of lunar surface features with significant scientific interest on the captured images. Finally, we introduced our nomenclature system for the features at the CE-3 landing site on the basis of the Chinese ancient sky division method.

2 Image data processing

2.1 Survey summary at the CE-3 landing site

CE-3 is China's first unmanned in situ mission of extraterrestrial objects. It consists of a lunar lander and rover (also known as Yutu). The CE-3 lander and rover each carry four science instruments. Instruments on the lander are: Landing Camera (LCAM), Terrain Camera (TCAM), Extreme Ultraviolet Camera (EUVC), and Moon-based Ultraviolet Telescope (MUVT). The four instruments on the rover are: Panoramic Camera (PCAM), VIS–NIR Imaging Spectrometer (VNIS), Active Particle induced X-ray Spectrometer (APXS), and Lunar Penetrating Radar (LPR). The CE-3 probe was successfully launched by the Long March 3B rocket on December 2, 2013 local time at Xichang Satellite Launch Center. The successful landing of CE-3 at (19.51°W, 44.12°N) in Mare Imbrium on December 14, 2013 marked the first return of a manmade spacecraft on the lunar surface since the former Soviet Union probe Luna 24 landed in Mare Crisium 37 years ago (Kaydash et al. 2013).

On December 15, 2013, Yutu was successfully released by the lander and they began their scheduled survey which is "measuring the Moon, surveying the sky and observing the Earth". In the first lunar day, Yutu was unlocked and separated from the lander, then moved slowly along the brackets to the lunar surface, before heading to the first navigation point Y01 (see Fig. 1). After a test imaging of TCAM at Y01, Yutu traversed to Y02, turned round and jointly took pictures on each other with the lander, then moved to Y03, Y04, and Y05. The lander and rover jointly took pictures at each point of Y02–Y05, all of which formed the left part of a lander-centered hexagon. After jointly taking pictures on each other with the lander for the last time at Y06, a navigation point 18 m south to the lander, Yutu moved to Y07 then stayed at Y08 its last stop of the first lunar day.

After a whole lunar night of rest, Yutu awoke to traverse along Y09–Y13, targeting a rock southwest for geological investigation. The detailed images returned to the ground revealed that the topographical condition near the rock would be potentially hazardous to the rover, so the scientist team adjusted the rover's cruise route to move northward and investigate the rim of a crater with a diameter of 500 m at the west of the rock. On January 25, 2014, Yutu encountered mechanical control issues, halting the rover's movement at Y16 with a total traverse distance of 114 m (Li et al. 2015).

In the 2 months of the exploration, the eight scientific instruments on the lander and rover acquired a large amount of scientific data. Some valuable scientific results were yielded through the analysis of this data: a detailed morphological analysis was conducted using the images acquired by LCAM, TCAM and PCAM; minerals in the lunar regolith at four exploration points were analyzed using the spectra data obtained by VNIS; energy spectra acquired by APXS at two points provided important information for the identification of elements and the

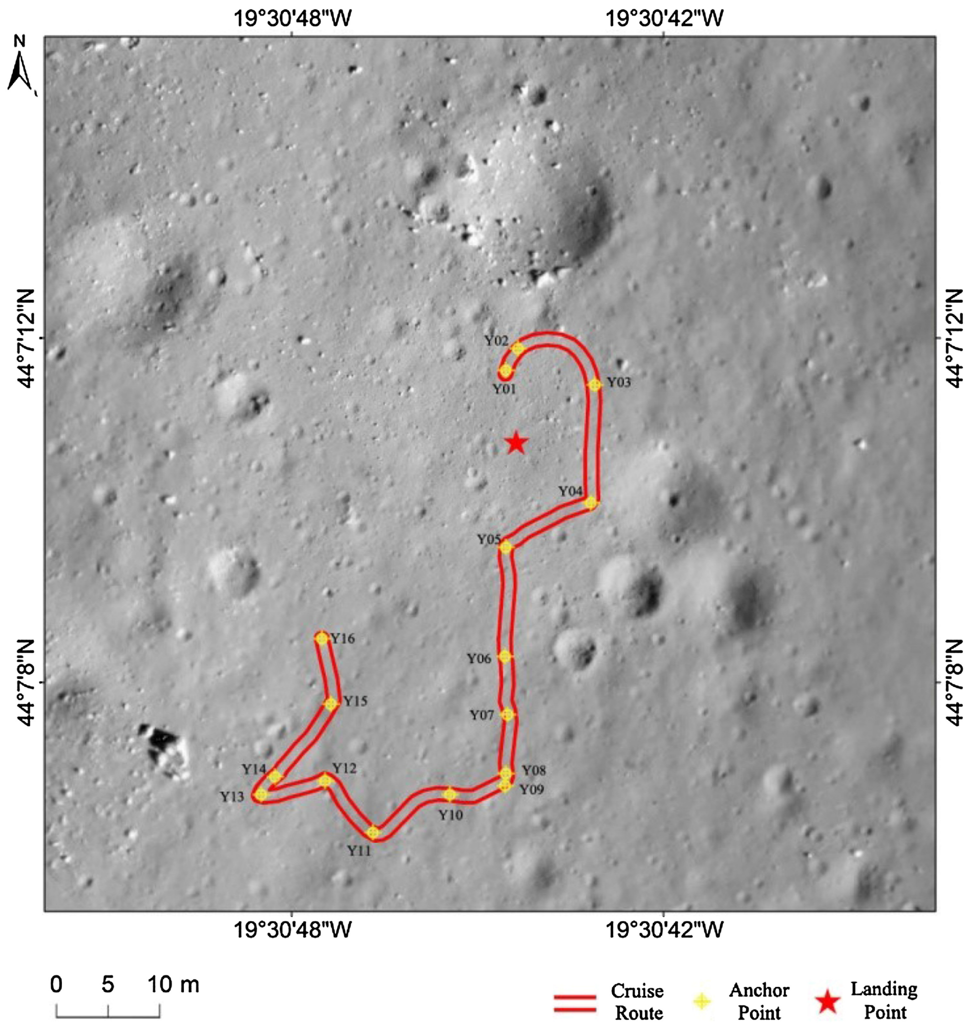

Fig. 1 Cruise route of the rover

resolution of their relative content; the depth of the lunar regolith and subsurface structure along the traverse path were analyzed with a total of 18,513 and 32,381 tracks of radar echo signals obtained for the first and second channel of LPR; a lunar-based, wide-angle, continuous view of Earth's plasma sphere was obtained for the first time by EUVC; night sky images of several sky areas were obtained by MUVT and utilized to determine the celestial coordinates of the target bodies (Li et al. 2015). Some outstanding findings were also derived from the CE-3 scientific data by researchers: Xiao et al. (2015) reported in the journal *Science* that more than nine subsurface layers were identified at the CE-3 landing site, suggesting that this region has experienced complex geological processes since the Imbrian and is compositionally distinct from the Apollo and Luna landing sites; Ling et al. (2015) revealed in the journal *Nature Communications* that the CE-3 landing site's composition differed from other mare sample-return sites and was a new type of mare basalt not previously sampled.

2.2 Image data acquisition and processing

In the previous CE-2 mission, the stereo cameras onboard acquired 32 orbits of high-resolution images of Sinus Iridum, all of which were processed through geometry calibration and photometric correction to produce the standard products of a digital orthophoto map (DOM) and digital elevation model (DEM) with a resolution of 1.5 m (Liu et al. 2013). Each orbit of an image has a width of about 6 km, and a height of about 80 km. The CE-3 landing point is located in the image with the orbital number of 236.

In the CE-3 mission, the LCAM and TCAM on the lander and PCAM on the lander were used to map the region near the CE-3 landing site. The data acquisition and processing are as follows:

1. Image data of LCAM. LCAM is capable of obtaining images with spatial resolutions between 3.2 and 1.62 m and with image widths between 1656.9 and 3.3 m at an elevation range of 2 km to 4 m during lander descent.

After geometric correction, these images were registered on the CE-2 1.5 m images using a method of cognominal points matching, resulting in a mosaic of the landing site as shown in Fig. 2 (Liu et al. 2014; Wang et al. 2014).

2. Image data of TCAM. In static imaging mode, TCAM can take 360° panoramic images of the landing area with a ±175° yaw angle. As it rotates on the horizontal plane, TCAM takes one image every 19°, or 19 images in one full circle; in two circles it captures 38 images for panoramic imaging. The imaging distance of TCAM is between 5 m and ∞. At a distance of 10–100 m, image resolution is 0.17–16.99 mm; at a distance of 600 m, the average image resolution is 10 cm. Thus, TCAM can image the landing area within a 600 m radius range for the purpose of morphologic and topographic analysis (Li et al. 2015), as shown in Fig. 3.
3. Image data of PCAM. PCAM is able to obtain decimeter resolution continuous 3D image profiles approximately 2000–2200 m long and 1400 m wide along the traverse path of the rover. At Y06, Y08, Y11, and Y13, PCAM took two circles of 360° panoramic images at different angles respectively, with 28 image pairs in one full circle. All of these images were also registered on the CE-2 1.5 m images using the method of cognominal points matching, resulting in a panoramic image at the current location as shown in Fig. 4 (Ren et al. 2014).

After the image processing described above, we carried out the searching and naming of typical features at the CE-3 landing site, using the CE-2 1.5 m DOM as a basemap, images of LCAM as a basemap of the landing site, and images of TCAM and PCAM as basemap of the region near the navigation points (Li et al. 2015; Tan et al. 2014).

3 Nomenclature system for features at the CE-3 landing site

As more and more scientific data was acquired and the academic research on this data flourished, the need to name some prominent and easily identifiable features became evident. A normalized set of feature names at the CE-3 landing site can facilitate the description of the scientific research, and a uniform usage of a name set in academic exchanges, the publication of maps and the popularization of science can avoid the confusion of reduplicative naming.

Nomenclature for features at a landing site is pretty different from that for other feature types listed in the gazetteer of planetary names, which is mainly concentrated on craters (IAU 2016c). Firstly, all the features to be named are concentrated on a narrow landing site area and are tiny in size. Secondly, the name designation is somewhat freer, as it does not have a consistent naming convention, unlike other feature types. So, a consistent nomenclature system should be established according to the IAU rules on

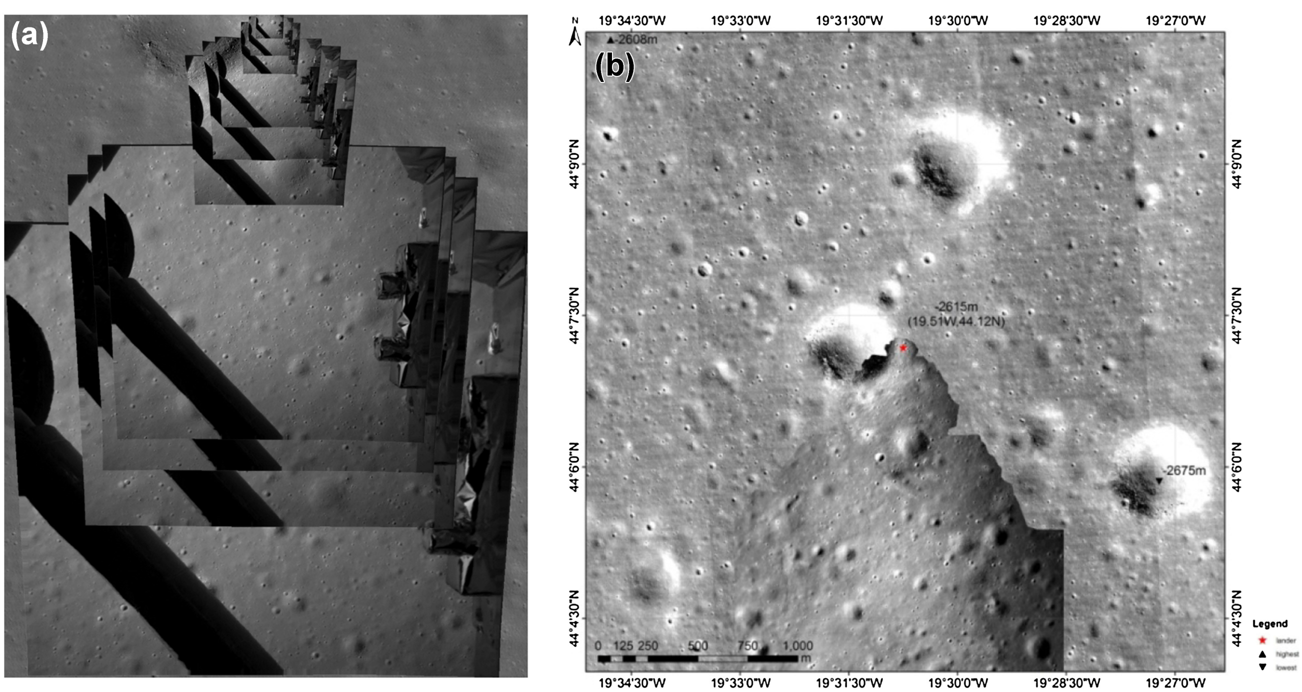

Fig. 2 Mosaic of LCAM images. **a** Image mosaic product. **b** Final map

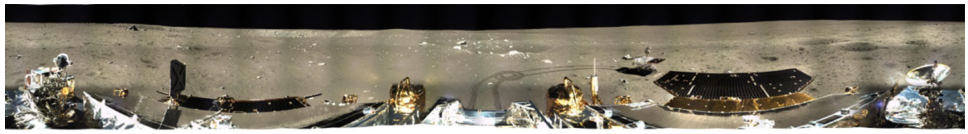

Fig. 3 Panoramic images of landing site (TCAM)

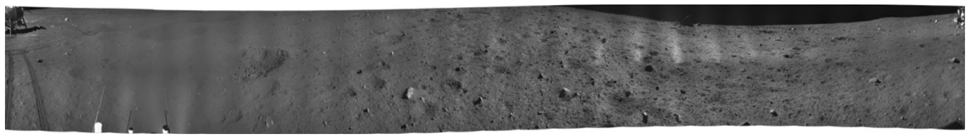

Fig. 4 Panoramic image at a navigation point (PCAM)

landing site names to normalize the name designation of features at the CE-3 landing site.

3.1 Status quo of landing site names

The IAU-approved feature names associated with landing missions are mainly related to the US Apollo missions and the Luna missions of the Soviet Union. In the IAU gazetteer, all feature names associated with the Apollo missions are collectively referred to as the 'landing site name'. The feature names at a landing site can be divided into two categories according to their meanings: one is to commemorate the landing location of the probe, the other is to indicate the easily identifiable features around the landing site, which can be intentionally used to discriminate the tiny surface features during the training or implementation of Apollo landing missions (see Table 1).

There are a total number of 79 landing site names related to the Apollo missions; in fact, these IAU-approved names are only a fraction of all the unofficial names the astronauts have developed during their trainings. All the features these names referred to are scattered around the cruise route of the Apollo missions and have prominent morphological characteristics, most of which are craters, with a few canyons, hills, cracks, steep slopes and other terrain also included. In terms of size, the vast majority of them are tiny features below 1 km, and the larger ones are mainly canyons, hills, cracks and other complex terrain (Davies and Colvin 2000). As for the selection of names, it is not consistent with a systemic pattern like a crater is, but one should use some interesting and easily remembered names for astronauts to quickly identify landmarks. The name s set not only traditionally includes personal names to commemorate the outstanding scientists, but also involves object names and straightforward words just to contribute to for vivid description and easy memorization.

3.2 Selection of features to be named at the CE-3 landing site

According to IAU rules, features should be named only when they have special scientific interest, and when the naming of such features is useful to the scientific and cartographic communities at large (IAU 2016b). Therefore, the naming of such features at the CE-3 landing site should serve the description of scientific exploration activities, the interpretation of scientific research and the dissemination of scientific results. We selected the following three types of features for a total number of 16 closely associated with the reconnaissance events implemented by the CE-3 lander and rover using detailed images captured by the landing camera, terrain camera and panoramic cameras and the 1.5 m image products of CE-2.

1. Landing site. The CE-3 landing site is a region where the lander and rover work together to carry out a detailed survey and is covered by high-resolution images taken by the three cameras. The exact range is

Table 1 Feature names associated with landing missions

Mission	Quantity	Note
Apollo 11	2	Include 1 commemorative name: Statio Tranquillitatis
Apollo 12	9	Landing site name
Apollo 14	6	Landing site name
Apollo 15	14	Landing site name
Apollo 16	19	Landing site name
Apollo 17	29	Landing site name
Luna 2	1	Commemorative name: Sinus Lunicus
Luna 9	1	Commemorative name: Planitia Descensus

defined as the 77 m^2 area of the longitude of 19°30′50″ W 19°30′40″ W, and the latitude of 44°7′16″ N 44°7′5″ N (See the blue box in Fig. 5a). The landing point is at the center of the region, and all exploration points of the detailed surveys are included. According to IAU rules, the naming of such a landing site is possible because it is China's first landing of a robotic spacecraft on the Moon.

2. Navigation points. The geographical extent of the landing site is too narrow to recognize at a certain high orbital altitude or on images with low resolution of that region, so craters with significant morphological characteristics around that region can serve as landmarks to help identify it. There are three craters with diameters from 400 to 500 m around the CE-3 landing site (see 13, 14, 15 in Fig. 5b), and the CE-3 spacecraft was landed at the western edge of crater 13 (the CE-3 landing site is marked by blue box in Fig. 5b). The three craters with a geographical distribution of a right triangle are suitable as navigation points to identify the CE-3 landing site at a large scale.
3. Key morphological features. In order to facilitate the description of the scientific exploration activities at the landing site and the interpretation of the scientific results, the typically tiny morphological features scattered around the cruise route of the CE-3 rover, such as craters, rocks, hills etc., can be treated as landmarks for identification. Finally, nine craters (1, 2, 5, 6, 7, 8, 9, 10, 12 in Fig. 5a) and three rocks (3, 4, 11 in Fig. 5a) with significant morphological characteristics along the cruise route of Yutu were selected as indicative points of location to describe the scientific exploration and other critical events.

3.3 Designation of names to the features at the CE-3 landing site

In the gazetteer of lunar feature names, the nomenclature of landing site names is relatively freestyle and arbitrary on the whole. Besides the scientific significance, the naming of lunar surface features also has the significance of promoting the traditional cultures of various ethnicities around the world (Hargitai and Shingareva 2011). Therefore, we developed a nomenclature system for the CE-3 landing site features in combination with Chinese ancient sky division system, which was summarized as "three enclosures, four quadrants and twenty-eight lodges" and is widely used in Chinese ancient stars maps.

This ancient Chinese sky division, used by ancient Chinese astronomers to discriminate stars and observe the sky, is very alike with similar to the constellations in

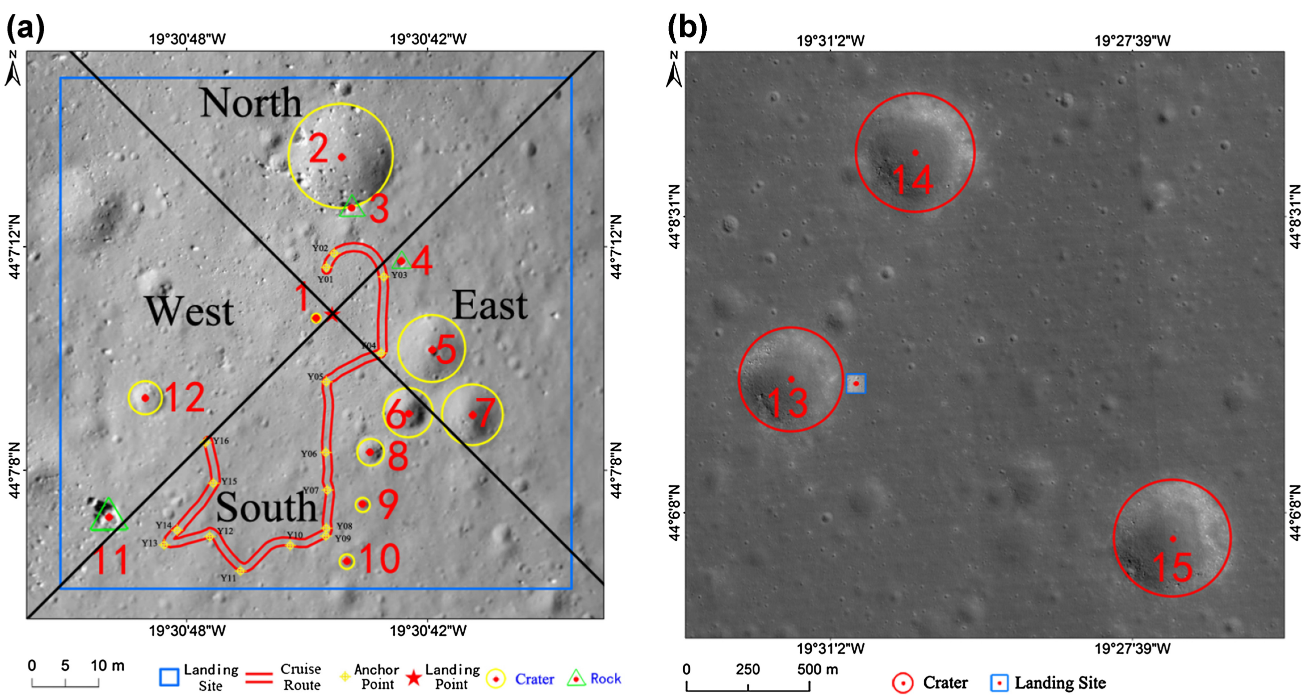

Fig. 5 Selected features to be named. **a** The distribution of key morphological features at the CE-3 landing site (LCAM image). **b** Three navigation craters (CE-2 image)

modern astronomy. It was originated from the Tang Dynasty and continued until the Qing Dynasty. The “three enclosures, four quadrants and twenty-eight lodges” method divides the whole sky into five palaces, which are east palace, west palace, south palace, north palace and middle palace. The middle palace is further divided into three enclosures, and the other four palaces are respectively corresponded to the four quadrants, and each quadrant consists of seven lodges, so there comes are 28 lodges in total. According to this method, the whole sky is finally divided into 31 zones, with each zone containing a certain few asterisms, and each asterism consisting of a certain few stars (Zhao and Li 2009; Zhao 2012), as shown in Fig. 6.

On the basis of this method, we established the specific rules for the name selection of the CE-3 landing site features:

Landing site. In consideration of the special commemorative significance of the CE-3 landing site, Guang Han Gong, the palace where goddess Chang’e and her rabbit lived in a well-known Chinese ancient mythology, is used as the formal name of the CE-3 landing site.

Navigation points. The navigation points provide the ability to identify the CE-3 landing site at a large scale. The craters 13, 14 and 15 are respectively named after the three enclosures Zi Wei, Tai Wei and Tian Shi.

Key morphological points. The names of constellations contained in each of the 28 lodges are designed to name such features. Specifically, two orthometric diagonals crossed at the landing point divide the CE-3 landing site into four azimuth zones (east, south, west and north) on the map of that area, and each azimuth zone respectively corresponds to the four quadrants which are eastern black dragon, southern linnet, western white tiger and northern black tortoise (see Fig. 5a). Each feature of the 12 craters is first determined by the quadrant of the azimuth zone it is located in, and then a candidate name is arbitrarily selected in some degree from the name pool consisting of all the constellation names from the seven lodges of that quadrant.

4 Results

4.1 The IAU-approved four feature names

After some preliminary work of feature selection and information extraction, China submitted the name request

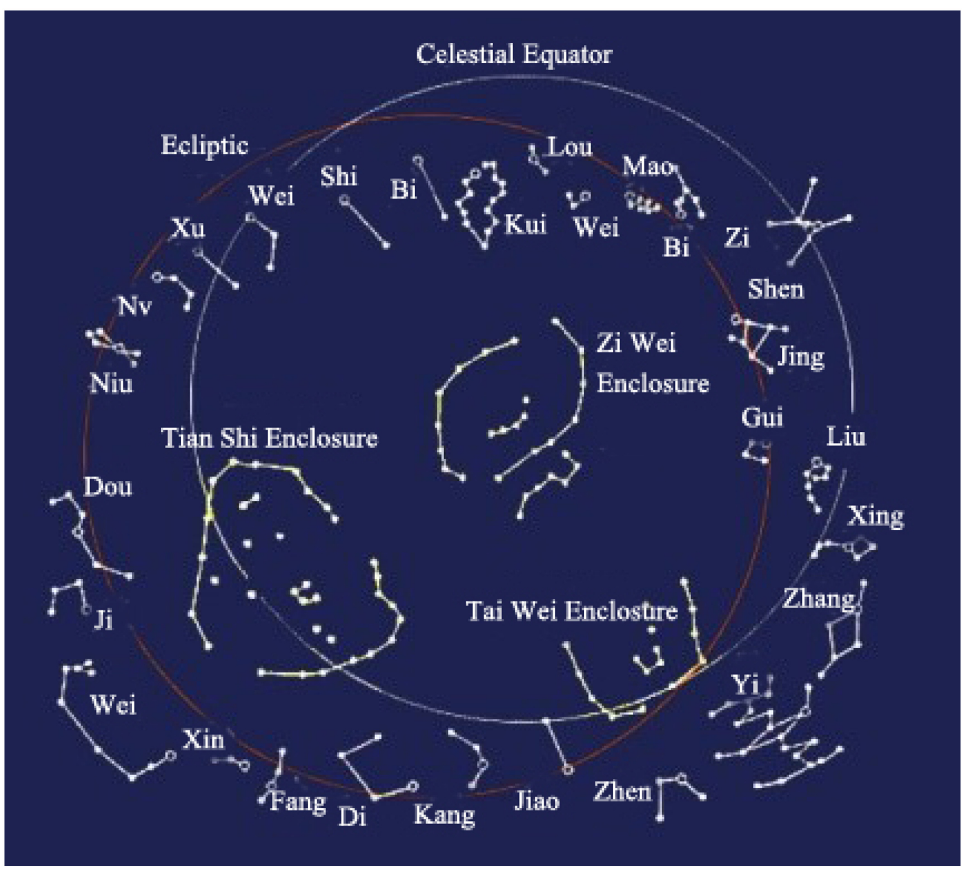

Fig. 6 The “three enclosures, four quadrants and twenty-eight lodges” system (Shi 2011)

Table 2 Feature names associated with the Chang'e-3 missions

Name	Type	Diameter (km)	Center latitude (°)	Center longitude (°)
Guang Han Gong	Landing site name	0.08	44.12	340.49
Zi Wei	Crater	0.42	44.12	340.48
Tian Shi	Crater	0.47	44.10	340.55
Tai Wei	Crater	0.48	44.15	340.51

Table 3 Feature names encouraged to widely use in Guang Han Gong

No.	Type	Center latitude	Center longitude	Diameter (m)	Chinese name	Name	Meaning
1	Crater	44.11964°N	19.51243°W	1.31	天潢	Tian Huang	The bridge or ferry of Galaxy
2	Crater	44.12044°N	19.51227°W	15.46	天渊	Tian Yuan	Deep pool in the heaven
3	Rock	44.12019°N	19.51219°W	2.48	离宫	Li Gong	Temporary imperial palace of emperor
4	Rock	44.11992°N	19.51185°W	1.59	阳门	Yang Men	The gate of frontier fortress
5	Crater	44.11950°N	19.51165°W	9.95	神宫	Shen Gong	Inner changing room
6	Crater	44.11918°N	19.51181°W	7.32	天庙	Tian Miao	The ancestor temple of emperor
7	Crater	44.11917°N	19.51137°W	9.02	亢池	Kang Chi	The water pool of Kang lodge
8	Crater	44.11899°N	19.51206°W	3.97	天稷	Tian Ji	The grain in the heaven, or the official responsible for agriculture
9	Crater	44.11873°N	19.51212°W	2.11	军市	Jun Shi	Market served for the military
10	Crater	44.11845°N	19.51222°W	2.16	器府	Qi Fu	The place where musical instruments stored, or official/organization in charge of music
11	Rock	44.11866°N	19.51388°W	5.20	外屏	Wai Ping	The screen of toilet
12	Crater	44.11925°N	19.51360°W	4.92	天关	Tian Guan	The gate which the Sun, Moon and five stars passed through

of 16 features to IAU in June 2015. After a half year's review, IAU announced four newly approved feature names on its official website on October 5, 2015: The specific region of the CE-3 landing site where the lander and rover worked together to carry out a detailed survey was officially named "Guang Han Gong" (广寒宫) (the blue box in Fig. 5b), and the three craters (13, 14 and 15 in Fig. 5b) near that region were officially named Zi Wei, Tian Shi and Tai Wei, respectively. Detailed information on all the four feature names is listed in Table 2.

The three craters, Zi Wei, Tian Shi and Tai Wei, with diameters of 420, 480 and 470 m, respectively, locate in a flat lunar mare in the northern part of the Mare Imbrium. About 41 km north of this area is Laplace F, which is the closest named feature, and approximately 120 km north is Montes Recti. The whole area has a smooth topography with a declining trend from west to east. The average elevation is below −2640 m and the lowest point is located in the floor of Tian Shi with an elevation of −2674 m. From a geological perspective, this dark area with low albedo is a high titanium basalt stratum, and its eruption age is early Eratoshenian (Li et al. 2014).

4.2 Feature names unapproved but encouraged to widely use

Guang Han Gong, the 77 m^2 area of the CE-3 landing site including the cruise route of the rover and some important landforms, is intent to commemorate China's first landing of a robotic spacecraft on the Moon. The 12 requested features within Guang Han Gong, i.e. the very small craters and the boulders, did not receive official IAU approved names according to the IAU rules because their sizes were below the agreed threshold of 100 m. But IAU encouraged Chang'e team to widely use these unapproved names as nicknames in scientific discussion. The 12 nicknames mark the features with remarkable morphological characteristics and with significant scientific value, including nine small craters and three small rocks in the surrounding area of the CE-3 landing site (see Table 3; Figs. 7, 8).

4.3 Global lunar feature names associated with China

After the successful approval of name requests submitted by the CE-3 team, the lunar feature names related to China

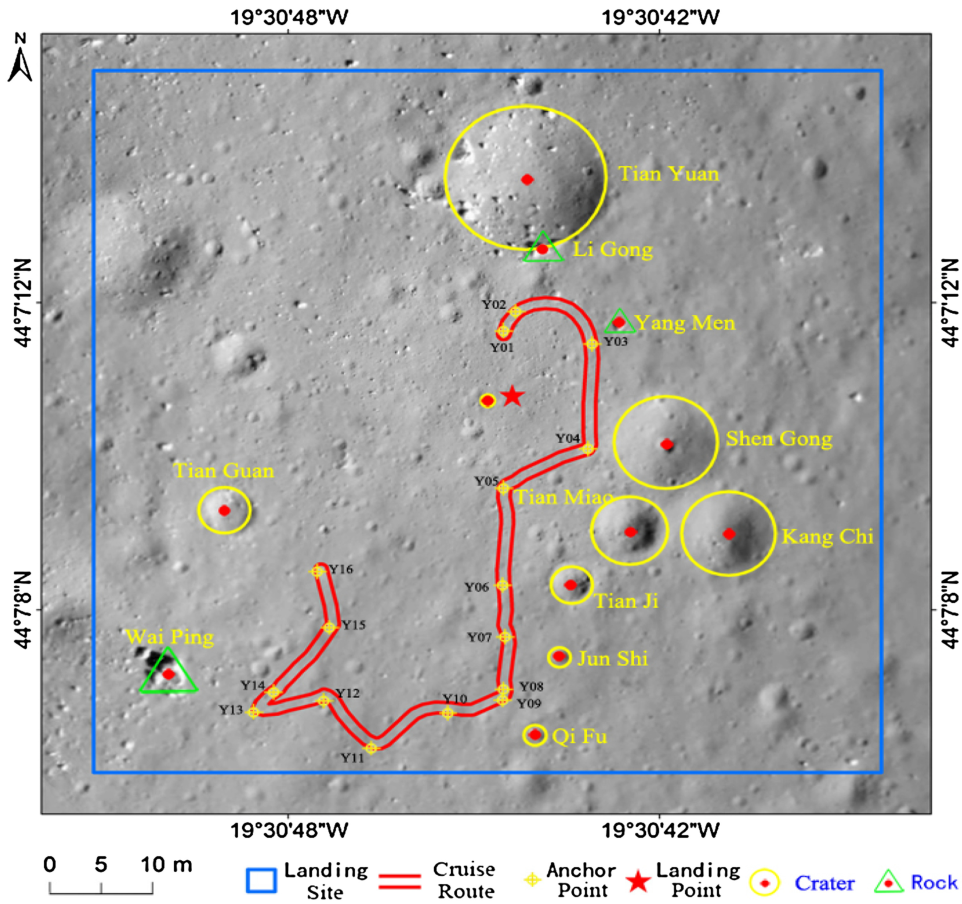

Fig. 7 Feature names encouraged to widely use in Guang Han Gong (LCAM image)

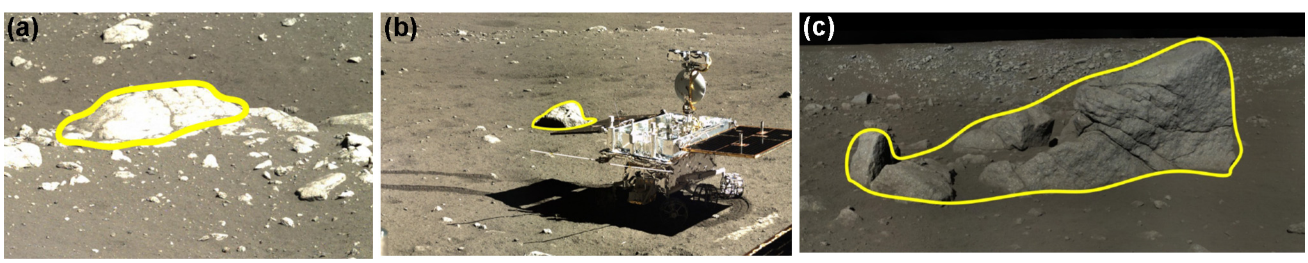

Fig. 8 Rocks in Guang Han Gong. **a** Li Gong (PCAM image). **b** Yang Men (TCAM image). **c** Wai Ping (PCAM image)

Table 4 Global lunar feature names associated with China

Feature name	Chinese name	IAU ID	Diameter (km)	Center latitude (°)	Center longitude (°)	Feature type	Approval date	Origin
Guang Han Gong	广寒宫	15415	0.08	44.12	340.49	Landing site name	2015.10.5	The palace where goddess Chang'e and her rabbit lived
Tai Wei	太微	15414	0.48	44.15	340.51	Crater	2015.10.5	Tai Wei enclosure—one of three enclosures in Chinese ancient star map
Tian Shi	天市	15413	0.47	44.10	340.55	Crater	2015.10.5	Tian Shi enclosure—one of three enclosures in Chinese ancient star map

Table 4 continued

Feature name	Chinese name	IAU ID	Diameter (km)	Center latitude (°)	Center longitude (°)	Feature type	Approval date	Origin
Zi Wei	紫微	15412	0.42	44.12	340.48	Crater	2015.10.5	Zi Wei enclosure—one of three enclosures in Chinese ancient star map
Bi Sheng	毕昇	14748	55.27	78.35	148.46	Crater	2010.08.02	Inventor of Chinese movable type printing (about 990–1051)
Cai Lun	蔡伦	14749	44.89	80.12	113.66	Crater	2010.08.02	Inventor of Chinese Papermaking (about 57–121)
Zhang Yuzhe	张钰哲	14750	38	−69.07	222.18	Crater	2010.08.02	Chinese astronomer (1902–1986)
Chang Heng C	张衡 C	8249	19.9	20.38	113.93	Satellite feature	2006	Satellite feature of Chang Heng
Shi Shen P	石申 P	13076	21.26	71.64	96.82	Satellite feature	2006	Satellite feature of Shi Shen
Shi Shen Q	石申 Q	13077	33.85	73.99	96.18	Satellite feature	2006	Satellite feature of Shi Shen
Tsu Chung-Chi W	祖冲之 W	13540	24.46	18.55	143.8	Satellite feature	2006	Satellite feature of Tsu Chung-Chi
Wan-Hoo (Van-Gu) T	万户T	13794	21.22	−10.18	218.87	Satellite feature	2006	Satellite feature of Wan-Hoo
Rima Sung-Mei	宋梅月溪	5084	3.88	24.59	11.28	Rima	1985	Chinese female name
Kao	高平子	2922	34	−6.7	87.6	Crater	1982	Chinese astronomer (Taiwan) (1888–1970)
Chang-Ngo	嫦娥	1135	2.34	−12.69	357.84	Crater	1976	Ancient Chinese mythological figures
Ching-Te	景德	1184	3.7	20.02	29.97	Crater	1976	Chinese male name
Rima Wan-Yu	万玉月溪	5087	13.72	19.98	328.57	Rima	1976	Chinese female name
Chang Heng	张衡	1133	42.65	18.9	112.21	Crater	1970	Astronomer in the Eastern Han Dynasty (78–139)
Kuo Shou Ching	郭守敬	3163	33.48	8.1	225.34	Crater	1970	Astronomer in the Eastern Han Dynasty (1231–1316)
Shi Shen	石申	5487	46.52	75.78	104.13	Crater	1970	Astronomer of Wei during the Warring States period (unknown—4 century BC)
Wan-Hoo (Van-Gu)	万户	6484	53.28	−9.96	221.09	Crater	1970	Official in the Ming Dynasty, who believed is the first man attempting to fly using a rocket he made
Tsu Chung-Chi	祖冲之	6110	28.53	17.16	145.16	Crater	1961	Mathematician in the Northern and Southern Dynasties (430–501)

add up to 22 (see Table 4), 14 of which are craters, five satellite features, two rimas and one landing site name.

5 Conclusion

Through the work of nomenclature of the CE-3 landing site, a normalized name set at the landing site is provided for the scientific community to regulate the usage of feature names in scientific activities under the established lunar nomenclature system with Chinese characteristics, meeting the demand of description for scientific exploration activities, the interpretation of scientific research and the dissemination of scientific results. The four newly approved feature names have been propagated by the media and widely used in the scientific activities by researchers, and the 12 unapproved tiny feature names have also been adopted as a standard name set for describing the scientific findings at the CE-3 landing site in many papers, such as Li et al. (2014). The naming of modern lunar exploration results after ancient Chinese ancient astronomical achievements shows great respect to ancient Chinese ancient astronomers, signifying the perfect fusion of the scientific achievement and the time-honoured cultural heritage on the beautiful Moon.

After this great success that China has achieved and the continued missions that are planned, the IAU-Working Group for Planetary System Nomenclature (WGPSN) believe that it is important for them to receive advice on the naming of features on the Moon also from an expert from China. Therefore, a Chinese representative was invited to become a member of the IAU Task Group for Lunar Nomenclature (TG-LN) to participate in discussing and approving future name proposals from scientists around the world, which indicated the acknowledgement of achievements that China has made in lunar and planetary science by the astronomical community. As China's lunar and deep space exploration project progressively carries forward, more and more symbols of China will appear on the Moon and other planetary body surfaces in the near future.

Acknowledgements Funding was provided by National Major Projects-GRAS Construction of China Lunar Exploration Project.

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