THE CHANG'E 3 MISSION: ONE YEAR OVERVIEW. H. Li[1], C.L. Li[1], J.J. Liu[1], H.B. Zhang[1], Y. Su[1], W.B. Wen[1], W. Zuo[1], G.L. Zhang[1], Q. Zhou[1], Z.H. Ge[1], and S. Dai[1], [1]National Astronomical Observatories, Chinese Academy of Sciences (20A Datun Rd, Chaoyang District, Beijing 100012, China. Email: lih@nao.cas.cn)

Introduction: By December 14, 2014, the Chang'e 3 (CE-3) lander has accomplished data acquisition for 12 months on the lunar surface, marking the completion of its yearlong nominal mission. An extended mission has been carried out, with the lander and EUVC and MUVT onboard both performing well. We summarize the preliminary results obtained by each science instrument on CE-3 lander and rover as well as data accessibility.

Background: The Chang'e 3 (CE-3) mission was implemented as the first lander/rover mission of the Chinese Lunar Exploration Program (CLEP). Launched on December 2, 2013 via a Long March 3B rocket, CE-3 landed in northwestern Mare Imbrium (19.51ºW, 44.12ºN) on December 14, 2013 [1]. The successful landing of CE-3 marked the first return of manmade spacecraft on the lunar surface since the former Soviet Union probe Luna 24 landed in Mare Crisium 37 years before [2]. The science objectives of the CE-3 mission include: 1) investigation of the morphological features and geological structures of and near the landing area; 2) integrated in-situ analysis of mineral and chemical composition of and near the landing area; and 3) exploration of the terrestrial-lunar space environment and lunar-based astronomical observations [1].

The CE-3 lander and rover have a planned lifetime of one year and three months, respectively, and each carry four science instruments (Fig. 1). 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 Yutu rover traversed for a total of 0.114 km during two lunar days before mechanical control issues halted its movement (Fig. 2).

Results by Instrument: During the lander descent, LCAM captured a total of 4,673 images of the surface from an altitude range of 2 km to 4 m at a rate of 10 frame/s. These images, with millimeter to decimeter resolutions, are employed to locate the landing site, reconstruct the lander descent trajectory, construct control points on the lunar surface, and assist in morphological analysis [3,4].

TCAM on the lander obtained panoramic images of the landing area by imaging the surrounding terrain as the camera rotated at three pitch angles (horizontal and +/- 30°). Apart from imaging the lunar terrain, from an engineering point of view, TCAM also monitored the state of the rover as well as its traverse paths, and assisted in traverse planning and science target selection.

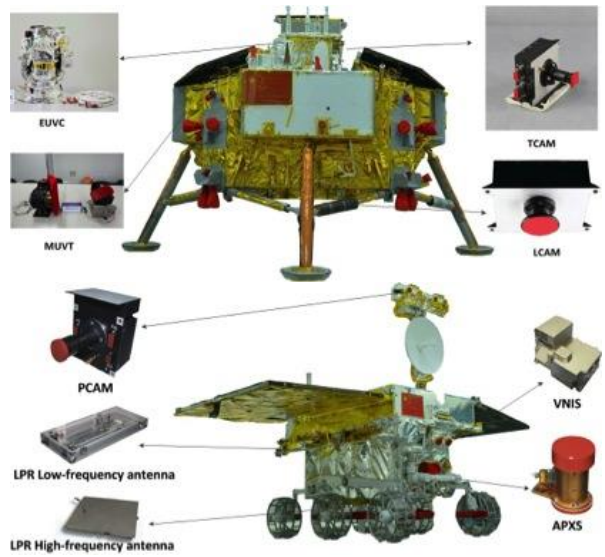

Figure 1 Placement of science instruments on CE-3 lander (upper) and rover (lower).

PCAM obtained 360° stereo panoramas at the first three exploration points. Color panoramas were

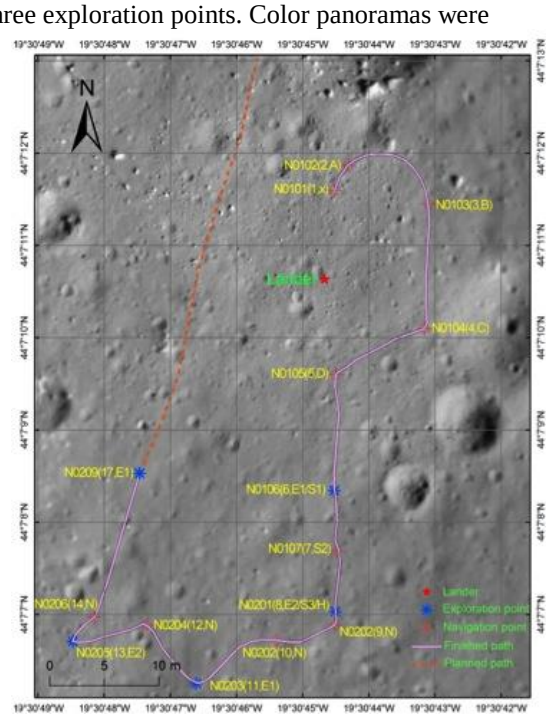

Figure 2 Traverse path of the Yutu rover.

acquired at points N203 and N205 (Fig. 1) [5]. Three stereo image pairs were obtained at exploration point N209. These mm- to decimeter-resolution images are used to construct Digital elevation models (DEMs) of the surrounding terrain and to assist in the analysis of local morphological and structural characteristics.

VNIS was powered on at four exploration points and obtained visible images and NIR spectral data of the regolith at points E, N203, and N205 (after calibration), with a total data volume of 350 MB. These spectra will assist in the analytical study of minerals in the lunar regolith [6]. Energy spectra acquired by APXS at points N202 and N205 are employed in the identification of elements and resolving their relative content.

LPR conducted continuous measurements along the rover's 113-m traverse path during ~6.8 hours [7]. A total of 18,513 and 32,381 tracks of radar echo signals have been obtained for the first and second channel of LPR, respectively, providing ground penetrating radar data for the first time to analyze the depth of lunar regolith and subsurface structure.

EUVC has been imaging the terrestrial plasmasphere in 30.4 nm wavelengths during each lunar day, obtaining for the first time a lunar-based, wide-angle, continuous view of Earth's plasmasphere. Until June 12, 2014, EUVC obtained more than 1,000 frames EUV images of Earth plasmasphere in 230 hours [8].

MUVT obtained night sky images in 245-340 nm wavelengths, employing both survey mode and target mode [9]. The telescope has surveyed over 1,000 square degrees of the sky, while monitoring light curve changes of 10's of short-period variable stars by mid 2014. After calibration and background subtraction, NUV images of three sky areas near Draco were obtained and utilized to determine the celestial coordinates of target bodies.

Data Accessibility: Calibrated CE-3 data have been deposited into the Data Release System hosted by the Ground Research and Application System (GRAS) at National Astronomical Observatories, Chinese Academy of Sciences (http://moon.bao.ac.cn/ceweb/datasrv/dmsce2.jsp). Raw data are organized by science payload into Level 0 data blocks after necessary processing. Level 1 data generally consist of count rates converted into physical units. Level 2 data are processed by radiometric calibration, approximate geometric correction, and photometric calibration. Level 3 data products, such as image products with geometric correction, are ready to be used by scientists without further processing.

Conclusion: CE-3 has successfully accomplished its engineering and science objectives within its one-year nominal mission phase. As of January 5, 2015, a total of 1.171 TB raw science data and 9.020 GB raw engineering data acquired by the eight instruments onboard have been archived. The engineering capabilities demonstrated by CE-3 to successfully soft land on the Moon and deploy the rover promise great potential to return lunar samples by the future Chang'e 5 mission.

References: [1] Li et al. (2015) *Space Sci. Rev*., in print. [2] Kaydash et al. (2013) *Planet. Space Sci., 89*, 172–182. [3] Liu et al., (2014) *Res. Astron. Astrophys.*, *14*, 1530-1542. [4] Wang et al. (2014) *Res. Astron. Astrophys*., *14*, 1543-1556. [5] Ren et al. (2014) *Res. Astron. Astrophys.*, *14*, 1557-1566. [6] Liu et al. (2014) *Res. Astron. Astrophys*., *14*, 1514-1529. [7] Su et al. (2014) *Res. Astron. Astrophys*., *14*, 1623-1632. [8] Feng et al. (2014) *Res. Astron. Astrophys.*, *14*, 1664-1673. [9] Wen et al. (2014) *Res. Astron. Astrophys*., *14*, 1674-1681.