China Takes Next Step Toward Lunar Industrial Development

by Marsha Freeman

Jan. 11—The successful Dec. 14 landing of China's Chang'e-3 spacecraft on the Moon, and deployment a few hours later of the Yutu ("Jade Rabbot" lunar rover, have laid the basis for its long-term goal of the industrial development of the Moon. Following on the success of the first two Chang'e-3 missions, which orbited the Moon, the current mission provides the on-the-ground intensive exploration that will lead to manned missions, in the future.

China's lunar exploration program, which has been under development for more than a decade, is aimed first at the scientific investigation of Earth's nearest neighbor, and an inventory of resources on the Moon. Eventually, missions will exploit the riches there, which are not gold or silver, but minerals which include a rare isotope of helium, that can power the thermonuclear fusion-energy-based economy of the future.

China is not "competing" with any other nation in its lunar exploration program, contrary to press commentary, but is following a multi-decade succession of increasingly complex missions. Each mission tests new capabilities aimed at meeting its long-term goals. The challenging Chang'e-3 mission was the first time that China landed a spacecraft on another celestial body. It was the first time that *any* nation carried out its first extraterrestrial landing which included the deployment of a rover.

The success of the Chang'e-3 mission has given China's space leadership the confidence to accelerate its next phase in lunar exploration, with the announcement that returning a sample of rock and soil from the Moon to Earth will take place only three years from now.

What We Will learn

In designing the Chang'e-3 mission, China had no intention of simply repeating the lunar missions that were carried out by the U.S. and Soviet Union nearly 40 years ago. The Yutu rover will, for the first time, use an on-board radar instrument to probe the subsurface of the Moon. Exploring the inner structure of the lifeless Moon with precision, down to a depth of 90 feet, will shed light on the development not only of this body, but of the Solar System as a whole.

The Chang'e-3 lander houses an ultraviolet telescope, a Moon-based "cosmic observatory," which will, for the first time, do astronomical observations from the surface of the Moon. A second ultraviolet instrument will study the Earth's ionosphere.

The rover, with a robotic arm similar to that on NASA's Mars Curiosity rover, will deploy instruments to describe the chemical and mineralogical composition of rocks on the Moon. On Jan. 3, the Chinese Academy's Institute of High Energy Physics released to the world scientific community the first data obtained by the rover.

The Institute posted on its website an initial analysis of data from the rover's Active Particle-induced

X-ray Spectrometer (APXS), which can identify the chemical elements in the lunar soil. The data indicate the presence of eight of the expected major rock-forming elements, and at least three minor elements. While these first results were not unexpected, they demonstrated that the instrument is working as designed. The release of the data and analysis to the public is an important policy decision by China, because it engages the global scientific community with the mission.

APXS was first powered up on Dec. 23, and two days later, was deployed to a position slightly above the lunar surface by the robotic arm, to go into its detection mode. Chinese scientists are pleased with the instrument's performance, and the Institute says this is one of the best X-ray spectrometers deployed on a planetary mission.

Both the Chang'e-3 lander and the Yutu rover depend upon solar energy for their power, and so, hibernate during the two-week lunar night. Yutu will awaken around Jan. 14, to carry out its three-month scientific mission on the lunar surface.

Looking Ahead

Although there has been no formal government decision on developing manned lunar missions, Chinese scientists and engineers are working on designs for a lunar base, which will include "new energy development," according to Zhang Yuhua, a manager of Chang'e-3, speaking at the Shanghai Science Communication Forum, as reported Jan. 8 in *Peoples' Daily*.

Zhang described the activity of a lunar base as setting up agricultural and industrial production, producing medicines in the vacuum environment, and carrying out "energy reconnaissance." The most oft-cited lunar energy resource by Chinese scientists is the isotope helium-3, which is rare on the Earth, but has remained largely undisturbed on the inert lunar surface, having been deposited there by the Sun. This allows a more advanced form of fusion energy, enabling many applications in energy, industry, and chemistry, and will power man on the Moon, and the people of the Earth.

Fusion on the Moon has been part of China's program since its inception. Ten years ago, speaking before the 12th conference of the Chinese Academy of Sciences, the scientist known as the "father" of China's lunar missions, Ouyang Ziyuan, described his nation's three-step lunar robotic program, stating that it should scout and map mineralogical elements, including helium-3.

More recently, Ouyang explained that "there are altogether 15 tons of helium-3 on Earth, while on the Moon, the total amount . . . can reach 1 to 5 million tons. Helium-3 is considered as a long-term, stable, safe, clean, and cheap material for human beings to get nuclear energy through controllable nuclear fusion experiments. . . . This means that the helium-3 reserves on the Moon can serve human society for at least 10,000 years." The goal, he has said, is to "bring enough fuel for all human beings across the world" from the Moon.

Chinese scientists are also conducting a series of experiments, growing a variety of basic crops under a simulated lunar environment. The Yuegong-1 laboratory, staffed by scientists from Beijing University of Aeronautics and Astronautics, hosts experiments in growing food that replicate lunar conditions.

The team, which is headed by Prof. Liu Hong, has done tests on more than ten plant varieties, controlling the food, water, oxygen, and soil chemistry of the environment. They are also investigating plants with a strong resistance to space radiation. The technologies developed through this and similar programs will also be important for China's next step in manned space flight—its space station.

Then, JFK—Now, China

If it is difficult for some to understand why China, a still-developing nation, is deploying precious resources to explore the Moon, the comments made by Chinese President Xi Jinping on Jan. 7, to the space scientists and engineers who participated in the research and development of the Chang'e-3 mission, should shed light. As reported by *Xinhua*, Xi said: "Dare to walk the unwalked paths. Constantly seek excellence through solving difficulties, and accelerate the shift to innovation-fueled development." Xi said that innovations in science and technology must be put in a "core position" in the country's overall development.

Innovation is "the soul of a people and the source for a country's prosperity," Xi said, going on to emphasize that the Chang'e-3 mission was " 'China-made' in every sense of the phrase."

That was the outlook of the United States under President John F. Kennedy, an outlook now exemplified by the Chinese. This is the outlook that the U.S., and all the trans-Atlantic region, must return to today, if they are going to survive.