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History of China's Robotic Lunar Program[1]

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A look at a key figure in China's robotic lunar exploration program—Ouyang Ziyuan—helps locate his crucial role in the development of China's long-term space plans. His position currently is that of senior consultant to China's Lunar Exploration Program. Despite the fact that Ouyang is beyond the "official" retirement age, he seems to have remained influential or knowledgeable of China's future plans. For example, in January 2021 when he proposed creating a space station to orbit the Moon. In August 2021, he lectured at the Gezhi Institute on the planned creation of a Moon-based International Lunar Research Station together with the Russians.

Why The Moon?

In December of 1978, Deng Xiaoping gave his ground-breaking speech on China's new policy of "reform and opening up" to the world at the 11th Party Congress. Six months previously, he had addressed an association of Chinese scientists, most of whom had been sent to the countryside for "rehabilitation" during the Cultural Revolution. They would now be considered a major part of the "productive forces" of the country, he said, and would play an important role in developing the economy.

In March 1986, four members of the Chinese Academy of Science wrote to Deng Xiaoping calling for a program of high-tech development to prepare China for the 21st century. That program, they stated, should concentrate on the areas of space, energy, lasers, biotechnology, automation, and information technology. Deng accepted the proposal and the members formed the *863* project. In Brian Harvey's first edition of his book China's Space Program, he describes Project 863 as "a scientific research and applications programme designed to stimulate Chinese technology across a broad range of fronts." For example, in the 1990s, it was recognized that China had to develop a more powerful rocket able to launch at least 20 tons of payload to Earth orbit. Through the *863* program, funding was provided to develop some of the most critical technology for the Long March-5 rocket that met that requirement. Harvey stated that between 1986 and 2001, millions were invested in 5,200 individual projects like this one.

Ouyang Ziyuan at the Institute of Geochemistry in the city of Guiyang was chosen to oversee lunar research. Ouyang was to take two years to have his team examine the possibility of China developing a lunar program and to submit a report on their findings. If it seemed unusual for a geochemist to write a program for space exploration, the fact was that Ouyang had a greater sense

[1] This is an update and expansion of Marsha Freeman's 2020 CASI report on Ouyang Ziyuan: https://www.airuniversity.af.edu/CASI/Display/Article/2261271/china-and-the-moon/

of the geological nature of the planets, and in particular of the Moon, than anyone else in the country. He had done detailed studies on many of the meteorites that had landed in China and as a student his passion had been astronomy and space exploration. Ouyang was also the author of what was then considered the definitive work on Celestial Chemistry.

When Zbigniew Brzezinski came to China during the Carter Administration, he brought with him a Moon rock as a gift to China. The U.S. gave no indication of when or where on the Moon it had come from. Ouyang was assigned the challenge of determining if it really was a lunar rock. Not only did he confirm its authenticity but determined that it had come back with Apollo 17, and he calculated precisely where on the Moon it had been found.

His focus on the Moon was to prove critical to China’s space program. At a small Institute of Geochemistry in Guizhou Province, Ouyang had already conducted a comprehensive study of the Moon and its resources. By 1986, he was considered one of the leading international experts on the subject. And it was the Moon’s resources that were at the center of his attention, since he was fully aware that at some point mankind must seek its resources in space. Also, it was already suspected that the Moon contained quite extensive amounts of helium-3, and as a geochemist, Ouyang knew the value this would have as a fuel for fusion energy, a project in which China had already begun to show interest.

In his report to the *863* committee in 1992, Ouyang insisted that “the lunar exploration project is the third milestone in our country's space activities after man-made satellites and manned spaceflight, and it is also an important symbol of our country's high-tech development…. In addition, the mineral resources, energy and special environment on the Moon are important areas for human society to further open up territories in the future. If China stays on the sidelines, it will be difficult to safeguard the interests of our nation and it will lose its say in the exploration of deep space,” according to a Chinese book on Ziyuan’s role in the Chang’e program.

In his report, Ouyang described the advances already made in China that would contribute to a successful robotic lunar mission. He noted how his own institute’s study of the Moon had accumulated perhaps the most significant knowledge base on all aspects of the Moon’s nature: its topography, its mineral resources, rock categories, geological stratum, volcanic and lava movements, surface structure, and distribution and age of impact craters. The origin and evolution of the history of the Earth-Moon system had also been systematically categorized and analyzed.

He pointed out that China possessed a complete study of lunar exploration sub-systems, including architecture, control systems, automated systems, trajectory control, electric power sources, measurement and control capabilities, and data management. Most of the systems needed for the lunar program would thus inherit existing research results and experience in the study of the space environment, remote sensing, and orbital operations management. There had also already been positive developments in China’s Long March series of rockets, a critical component in the country’s space program.

Further, Ouyang was familiar with the beneficial effects of the Apollo program on the U.S. economy, and understood that a Chinese lunar mission would similarly serve as a “science driver” to help develop the scientific capabilities of the younger generation and create a substantial cadre of scientists and engineers for China’s further development.

In 1990, Ouyang was appointed the head of the China Academy of Sciences' Natural Resources Studies Office, responsible for researching natural resources in the Earth, in the seas, in space, in the atmosphere, and in the ecology. Under him would be 40 d-ifferent institutions. In 1991, he was elected to the China Academy of Sciences. He accepted the new posting on condition that the work remain centered in his institute in Guizhou, now re-named the Center for Lunar and Space Sciences. In 1992, he was elected vice president of the Guizhou Provincial People's Congress, which assured his attendance at the National People's Congress, the best place to make the case for space to the Chinese people's representatives.

In 1996, Ouyang delivered his second report on a possible lunar program. In the report, he explained that the program was initially seen as a three-pronged plan to orbit the Moon, to land a rover on the Moon, and to bring lunar soil back to Earth for study. The concept of a manned probe was not yet on the table.

Two years later, Ouyang put together a team of researchers to begin working out the details of the proposed lunar program. By 2000, he was ready with a four-point program for orbiting the Moon. The objectives would be obtaining a detailed picture of the topology and geology of the Moon, mapping the rocks and craters, examining the soil layers, and identifying the most important mineral resources. The U.S. Apollo missions had identified five such elements on the Moon; China would go on to identify nine more. In August of that year, Ouyang's proposal was approved by the body of scientists leading the project.

In 2001, Ouyang delivered a report regarding the long-term pathway for China's space program to China National Space Administration (CNSA) director Luan Enjie. This detailed three steps: a phase of unmanned lunar exploration, secondly, a manned Moon landing, and thirdly, building a base on the Moon. Luan Enjie, in agreement with the decades-long proposal, gave his approval for implementing phase one, leading to the Chang'e program.

The years 2005 and 2006 were critical for China's robotic lunar program. All of the elements had to be examined for suitability. In March 2006, the Lunar Exploration Group held a working meeting to determine the mobilization of China's engineering forces for lunar exploration. Luan Enjie declared 2006 as the year of "the decisive battle." In the course of that year, China's satellites, rockets, launch pad, measurement and control apparatus, integration of ground facilities and integrated testing capabilities all had to be prepared and readied for implementation of the mission.

On June 18, 2006 at the third evaluation meeting of the China Lunar Exploration Project (CLEP), Long March chief designer Long Lehao said that the lunar orbital mission was proceeding smoothly and that the plan was to launch by the end of May 2007. On July 8, 2006, a spokesman for China's civilian Commission for Science, Technology and Industry for National Defense (COSTIND), Huang Qiang, announced that China's first lunar orbiting satellite Chang'e-1 would be launched the following year, which would constitute the first stage of China's Lunar Exploration Project.

One month later, at the Committee on Space Research (COSPAR) assembly held for the first time in Beijing, Ouyang Ziyuan announced that "The satellite payloads for the four major scientific missions undertaken by Chang'e-1 have been delivered. There are seven types of them, namely CCD (Charge-Coupled Device) cameras and laser altimeters for the detection of three-dimensional images on the lunar surface, and imaging spectrometers for the detection of lunar variability elements and matter detection. Spectrometers and coded X-ray spectrometers, microwave radiometers for the detection of lunar soil characteristics, and solar high-energy particle detectors and solar wind particle detectors for Earth-Moon space environment detection."[1]

On October 12, the Chinese government issued a White Paper entitled "China's Space Activities in 2006" which summarized the previous five years' work of the Chinese space agency and discussed development targets and major tasks for the next five years. It recognized that the "space industry is an important part of the national overall development strategy," and that China will "maintain long-term, stable development in this field." The paper emphasized, "China will follow the principles guiding the development of the country's scientific and technological programs, mainly, making innovations independently, making leapfrogging development in key areas, (and) shoring up the economy."

The paper stated that over the next five years, the overall goal was "to remarkably improve the country's capabilities in space technology." Specifically, "to enable astronauts to engage in extra-vehicular operations and conduct experiments on spacecraft rendezvous and docking; and to carry out research on short-term manned and long-term autonomously orbiting space laboratories." Another stated goal was "to realize a lunar-orbiting probe, make breakthroughs in developing basic technologies for lunar exploration, and develop and launch China's first lunar probe satellite, `Chang'e-1,' for lunar science and lunar resources exploration."

Ouyang had been insistent from the beginning that it was the responsibility of the government "to make overall plans" for space exploration. In that regard, he stressed, it is most important for the government to "guarantee the input of funds for space activities."

China's Robotic Lunar Exploration Missions

People throughout history have dreamed of going to the Moon. In China, that dream is centered around the centuries-old myth of the Princess Chang'e who was banished to the Moon with her pet Jade Rabbit Yutu. Her name lent itself to China's first series of lunar missions. The Chinese robotic lunar program entailed orbiting the Moon, landing on the Moon, and returning from the Moon. Chang'e missions 1-5 concluded in February 2021 and successfully completed the first steps toward China's human exploration of the Moon.

Chang'e-1 (October 2007, Long March 3A, Xichang Satellite Launch Center): Chang'e-1 was China's first deep space probe and its launch was unexpectedly covered live and to a worldwide feed. It tested the hardware and infrastructure needed for exploration outside Earth orbit and laid the foundation for upcoming missions. Among other things, it sent back China's first 3-D stereo images of the lunar surface, including of the polar region, as well as the first lunar hologram with a resolution of 7 meters. Chang'e-1 made a controlled crash landing on the lunar surface after orbiting the Moon for about 16 months.

Among the scientific equipment included on Chang'e-1 were:

- A stereo camera to take 3-D images with resolution of 120 meters

- An ultraviolet imager
- A laser altimeter
- An imaging spectromer in 32 bands
- A gamma ray spectrometer which detected as many as 14 chemical elements
- A microwave radiometer
- A high-energy particle detector for photons
- An X-ray spectrometer
- A low-energy solar wind plasma detector

Among objectives achieved during the mission were analysis of the distribution and abundance of potentially useful chemical elements, surveying the thickness of lunar soil and surface temperatures, and exploring the environment between the Moon and the Earth. This involved analyzing heavy ions and protons from the Earth to the Moon and around the Moon.

On Sept. 29, 2009, Xinhua news agency reported that China's space scientists had completed the world's first high-resolution three-dimensional map of the Moon, using imagery obtained from the stereo camera carried on Chang'e-1. Chinese Academy of Surveying and Mapping Academician Liu Xianlin is quoted by Xinhua saying the map could greatly help in the study of the Moon's surface and deepen understanding of lunar geology and its evolution. "It would also pave the way for setting scientific objectives in future lunar probe projects," Liu said.

China Daily on July 26, 2010 reported that a committee of 123 leading Chinese scientists had been deployed to study the 1.37 terrabytes of data captured by the Chang'e-1 probe, and Ouyang Ziyuan was described as discussing the implications of the data collected. First of all, he said, the imagery captured by the CCD cameras on the probe yielded digital elevation models and a three-dimensional topographical map with the highest possible accuracy and resolution.The probe had also provided researchers with data on the microwave radiation temperatures of the lunar regolith, the powdery soil layer on the moon's surface, which was significant to identify the thickness of the regolith and the rare gases within it. Further, said Ouyang, "unique" data about the high-energy particles in near-lunar space and solar-wind particles had also been obtained, which would enrich knowledge about solar radiation, the magnetic field between the Sun and the Earth, and the Moon.

Chang'e-2 (October 2010, Long March 3C, Xichang Satellite Launch Center): Chang'e-2's orbital mission was to do a more in-depth study of the Moon's chemical composition with more detailed photographs and improved communications with Earth. It had been built as a possible back-up for Chang'e 1, but could now be used for more challenging engineering tests. In particular, it carried a new gamma spectrometer which was three times more effective than its predecessor. It detected additional elements, including potassium, thorium, magnesium, silicon, aluminum, oxygen, titanium and calcium. One of its more exciting finds was between 1.03 million and 1.29 million metric tons of helium-3. Ouyang had hoped to find this element because it represented a a long-term source of fuel for producing fusion energy, for Earth as well as for the Moon. In comments to Xinhua news agency following the Chang'e-3 mission in 2013, Ouyang said "Everyone knows fossil fuels such as gas and coal will be used up one day, but there are at least one million metric tons of helium-3 on the Moon."

Additionally, to support the future Chang'e-3 mission which would attempt to land a rover on the Moon, Chang'e 2 in May 2011, diverted from its 100-km circular lunar orbit to a lower elliptical orbit that took it as close as 9 miles from the lunar surface, enabling the spacecraft to survey the north and south poles of the Moon. Images from Chang'e 2 allowed Chinese scientists to pick five possible landing sites for Chang'e 3.

After six months of orbiting the Moon and completing its primary mission objectives, Chang'e-2 had sufficient fuel to be deployed on yet another mission. On June 8, 2011, Chang'e-2 left lunar orbit and travelled to the Earth-Sun Lagrange Point 2 at some 1.5 million kilometers from Earth in order to study Earth's magnetic field and to test China's tracking and control capability.

From there, Chang'e-2 continued deeper into space, and by December 2012, was recorded at 7 million kilometers from Earth, where it was able to conduct a survey of the Toutatis asteroid. By February 2014, Chang'e-2 had reached 70 million kilometers from Earth at which point communication with the spacecraft was lost due to distance. It is expected to come back to near earth around 2029.

Chang'e-3 (December 2013, Long March 4C, Xichang Satellite Launch Center)): Chang'e-3 was a major breakthrough for the Chinese space program, as it marked the first time that China sent a craft to soft land on the surface of an extraterrestrial body. The Chang'e-3 carried a lander and a rover called Yutu, which took pictures of each other upon landing. Chang'e-3 caused great excitement throughout the world

Because the spacecraft carried a rover and a lander, it was heavier than the Chang'e-1 and Chang'e-2 orbiters, so the Long March rocket that launched Chang'e-3 had to be more powerful than its predecessors Eighty percent of the spacecraft contained new technologies and represented significant scientific and engineering achievements in the design of spacecraft guidance, navigation and control systems, the propulsion system, and the thermal control system. New soft landing cushion technology was adopted, based in part on the development of new superplastic materials. A notable accomplishment was the pinpoint accuracy of the Chang'e-3 landing, achieved by drawing on an integration of photographic imaging, radar, lasers and gamma ray sensors.

A highlight of Chang'e 3's scientific payloads was the Lunar-based Ultraviolet Telescope (LUT), which according to Andrew Jones, is "the first long-term, automated, and remote-operated telescope ever placed on an extraterrestial body." It has been used to monitor galaxies, binary stars, active galactic nuclei and bright stars. It has also performed low-galactic-latitude sky surveys during the daytime. One significant achievement of the LUT was that it conducted *in situ* measurements of the water content in the lunar exosphere which according to the author's research corrected measurements from earlier lunar missions. Another critical scientific payload was the Moon-based Extreme Ultraviolet Camera, designed to study the low-energy plasma located above Earth's ionosphere.

Exciting breakthrough data was achieved through use of the Yutu rover's ground-penetrating radar, as well as an Active Particle-Induced Spectrometer and Visible and Near-Infrared Imaging Spectrometer to study fresh lunar soil (regolith) at the landing site. Based on chemicals found within the solidified lava (basaltic rock), scientists are starting to piece together a history of the

Moon’s evolution. “Results indicated that this region’s composition differs from other sample-return sites and is a new type of mare basalt not previously sampled,” said a 2015 report of a Chinese-led team studying the Chang’e-3 soil samples collected and examined by Yutu. The report’s conclusions were reported in the a late 2015 article in Nature Communications.

On the eve of the Chang’e-3 launch, China Network TV did an interview with Ouyang Ziyuan, where he described the probe’s mission as achieving three firsts: “Number one: space observation from the Moon. This is the dream of many astronomers because atmosphere, wind, snow, and pollution don’t obstruct visibility as they do on Earth. The result is also better because of the longer periods of uninterrupted observation from the Moon due to it orbiting the Earth. One day of observation on the Moon is equivalent to 14 days on Earth. Number two: we have an ultraviolet camera on the lander to monitor the Earth. This camera is different from the one used by America’s Apollo 16. Ours can see the formation of the Earth’s plasmasphere and its density change. It’s better than a satellite, which can only record data section by section as it orbits around the Earth. From the Moon, it can observe half of the Earth at a time without moving. This is something people have always wanted to do. Number three: we will be the first to learn the structure and layers of the Moon 100 meters below its surface with radars installed underneath the rover. As the rover drives on the lunar surface, it will be as if it can cut and see what lies 100 meters below. These three highlights are what no other countries have done so far.”

Yutu lost its mobility in January 2014 following a malfunction of the power circuitry. Still, the data it did collect was invaluable.

Chang’e 5-T1 (October 2014,Long March 3C, Xichang Satellite Launch Center) : Due to the success of Chang’e-1 ,-2 and -3, the back-up craft for any failed missions was repurposed as an experimental spacecraft. It was given a “T” because it was test craft, designated as Number 1 in case it did not succeed, and subsequent test vehicles were necessary. It was comprised of a re-entry capsule and a service module, to serve as a “rehearsal” of technologies for the Chang’e-5 mission which was to return lunar samples to Earth. It was launched on October 24. On October 27, it passed 11,300 km around the Moon to attain a higher speed – and higher temperature - at its return to the Earth’s atmosphere. This was done to test the ability of the material to protect payloads and to test a highly complex Earth-return aerobraking technology. This test consisted of “dipping” the spacecraft into the upper atmosphere which slows it down. The 5-T1 return capsule did this twice. Using aerobraking for Earth return from deep space reduces the amount of fuel that the spacecraft has to carry. Since the Chang’e 5-T1 is a smaller version of the Shenzhou capsule, which carries Chinese astronauts to the space station, this will be important for future crewed lunar missions. On Nov. 1, 2014, the return capsule of 5-T1 touched down at the designated landing area in north China's Inner Mongolia Autonomous Region. After dropping off the re-entry capsule, the service module performed a divert maneuver to avoid re-entry and to put it on the path to the Earth-Moon L2 point. It remained there until 4 January 2015, when it headed back to lunar orbit. The probe lowered its orbit to perform two virtual target rendezvous exercises as well as imaging operations of the target landing zone for Chang'e-5.

Liu Jizhong, deputy chief commander of the lunar probe project commented to Xinua March 2015 that the success of the mission: “In the tests of the service module, we have simulated three key procedures needed for Chang’e-5: re-entry (to the moon’s orbit) at high speed, adjustment of lunar orbit and docking in lunar orbit, laying a solid foundation for China’s three step lunar program—orbiting, landing, and returning.”

Chang’e-4 (December 2018, Long March 3B, Xichang Space Launch Center): Chang’e-4 was also a backup spacecraft for Chang’e 3, which was not needed. It was repurposed and executed China’s first record-setting space mission. With the Chang'e-4 mission, China did what no other country has done, namely soft-landed on the far side of the Moon. Chang’e-4 included a lander and a Moon rover named Yutu-2. The region of the Moon that was targeted as the landing site was the South Polar Aiken Basin. This impact structure, believed to be the largest crater in the Solar System, spans both the near and far side of the Moon.

Why did Chang’e-4 target the far side of the Moon? According to Liu Jizhong, who had then been promoted to chief of the lunar exploration center of the State Administration of Science, Technology and Industry for National Defense, speaking Jan. 14, 2016 to the Yangguang network and reported by Xinhua state news agency: “Chang’e-4 will utilize the distinctive features of the far side which are screened from the Earth’s radio waves, to develop a space science region in a forward position for a low-frequency radio astronomy survey that hopefully will fill in some of the blanks in our knowledge.”

Liu went on to explain that the mission will go into great depth on the geology and dust features of the Moon: “Utilizing the very old rock of the lunar crust preserved on the far side of the Moon, we can investigate its geological characteristics, and hopefully by doing that, pull together for the first time a topographical configuration of the far side, its shallow structure, the composition of the lunar material of a particular cross-section, and attain a picture of its evolution, creating new knowledge about the history of the planet.”

The only way mission control was able to talk to the lander was through a second spacecraft that was deployed eight months prior to the Chang’e-4 launch. A small relay satellite, named Queqiao or “magpie bridge,” was sent into a stable “halo” orbit at the Earth-Moon L2, essentially parked in a hover position some 60,000 kilometers from the lunar far side, with a line of sight both to Earth and the lunar far side. From there it could send data that was collected by the Chang’e-4 lander and rover back to Earth, and relay commands from Earth to the spacecraft on the Moon.

In addition to its own nine scientific payloads, Chang’e-4 carried experiments from the Netherlands, Germany, Sweden, and Saudi Arabia. Germany’s contribution was a neutron radiation detector built into the lander to gauge radiation levels which could be important for future astronauts; Sweden’s was a neutral atom detector built into the rover which studied how charged particles from the Sun interacted with the lunar surface. Saudi Arabia’s optical camera was included on the relay satellite, as was the Netherlands-China Low-Frequency Explorer (NCLE), a space-based astronomy pathfinder experiment that would attempt to detect radio signals from the “cosmic dark ages,” before emission of light by the first stars in the universe.

Shortly after Chang’e-4’s January 2019 landing, Wu Yanhua, a deputy head of the CNSA, told a televised press conference called by the State Council Information Office that Chang’e-4’s success had inaugurated the “fourth phase” of China's lunar exploration program, according to Leonard David’s reporting. "Experts are still discussing and verifying the feasibility of subsequent projects, but it's confirmed that there will be another three missions after Chang'e-5," said Wu.

According to Wu, the Chang'e-6 mission will be designed to bring samples back from the South Pole of the Moon. "Whether the probe will land on the near side or the far side of the Moon, we will make the decision according to the performance of Chang'e-5," he said, referring to the results of the samples brought back. The Chang'e-7 mission will carry out comprehensive surveys around the South Pole, including studying terrain and landform, physical composition as well as the space environment in the region.

The Chang'e-8 mission, in addition to scientific surveys and experiments, will test key technologies to lay the groundwork for the construction of a science and research base on the Moon. Wu advised that China, the United States, Russia and some European countries will all want to try out technologies needed for such a scientific lunar base. "For example, can we build houses on the Moon with lunar soil using 3D printing technology?" Wu said. "We hope that Chang'e-8 will help test some technologies, and do some exploring for the building of a joint lunar base shared by multiple countries."

Chang’e-5 (November 2020, Long March 5, Wenchang Spacecraft Launch Site)): The Chang’e-5 spacecraft arrived at the Ocean of Storms on the near side of the Moon on November 24, and consisted of four distinct vehicles. An orbiter, the largest of the four, transported all the rest: a lander, designed to carry out the drilling and scooping of the lunar soil; an ascender, or ascent stage, which would blast off from the surface of the Moon with the samples; and a returner, which would carry the soil samples through the Earth’s atmosphere and back to its landing site.

Chang'e-5 included four scientific payloads, a Landing Camera, a Panoramic Camera, a Lunar Mineralogical Spectrometer, and Lunar Regolith Penetrating Radar. Using the latter instrumentation, the rover both scooped surface samples and also drilled two meters deep into the lunar surface to access soil samples. Within a week of landing, the rover had completed its task, collecting 2 kilograms of sample materials. The ascender holding the lunar materials then took off from the Moon’s surface and entered the preset lunar orbit, waiting for the precise moment for it to intersect with the orbiter’s path. On Dec. 6, it successfully rendezvoused and docked with the orbiter-returner combination, and transferred the samples to a special capsule on the returner. On Dec. 17, once a pathway to the Earth opened up, the returner separated from the orbiter and successfully touched down at its landing site in Inner Mongolia Autonomous Region.

Chang’e-5’s extended mission began when the orbiter, now freed from the returner, headed toward the Sun-Earth L1 location, about 1.5 million kilometers from Earth, where it entered a gravitationally stable orbit ideal for observing solar weather patterns, testing the design and control of the orbit, and taking readings of the radiation environment.

Short-sighted people have complained that more lunar samples were not needed because they had already been collected as far back as the 1970s. But over the course of fifty years, the science has dramatically changed with the use of new technologies like 3-D imaging, ultrahigh-resolution microtomy, mass spectrometry and ion probe technology.

In anticipation of the delivery of the samples, China built a new laboratory in Beijing under the auspices of the National Astronomical Observatories (NAO), staffed with an international team of scientists, to study the materials brought back by Chang’e-5. The consortium includes members from China, Australia, the U.S., the U.K. and Sweden. One of these, Professor of Planetary Sciences

Brad Joliff of Washington University in Saint Louis described the effort: "This is science done in the ideal way: an international collaboration, with free sharing of data and knowledge…. This is diplomacy by science," according to reporting by Talia Ogliore in late 2021. Already, important discoveries regarding the age of these lunar samples have enabled fine-tuned re-calibrations of scientific chronology tools with regard to the Moon and its evolution, as well as the history of other planetary bodies.

On January 18, 2021, China sponsored an event entitled “Access to China’s Lunar Exploration” at the National Astronomical Observatories. According to Chinese Foreign Ministry spokesperson Hua Chunying, “32 countries and regional organizations participated.” Delegates received awards at the event in commemoration of international partnership in Chang’e-5. Further, a document was released by the National Space Administration (CNSA), entitled “Regulations on the Management of Lunar Space Samples” which promised international cooperation in storage, management and use of the samples and called for findings to be shared among participating researchers from home and abroad.

According to the Chinese, Chang’e-5 accomplished records in China’s aerospace history: a highly-complex take-off from the lunar surface without use of a launch tower; a first-ever rendezvous and docking with the orbiter module at 400,000 kilometers above the lunar surface; and the first-ever lunar sample return to Earth at a speed of 11 km per second, reaching second cosmic velocity.

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[1] Hu, Ping, op.cit. p.287