**Preparation and analysis process for future returned lunar samples and verification results for simulation experiment.** G. L. Zhang[1,2], C. L. Li[1,2], W. Zuo[1,2], B. Liu[1,2], Q. Zhou[1,2], F. Gao[1,2], D. W. Liu[1,2], Z. B. Zhang[1,2], X. G. Zeng[1,2], L. Y. Deng[1,2], [1]National Astronomical Observatory, Chinese Academy of Sciences, 20A Datun Road, Chaoyang District, Beijing , China, 100012, zhanggl@nao.cas.cn. [2]Key Laboratory of Lunar and Deep Space Exploration, National Astronomical Observatories, Chinese Academy of Sciences, Beijing 100012, China.

**Introduction:** The United States and the former Soviet Union conducted a space race focusing on landing on the surface of the Moon between early 1960s and mid 1970s[1]. Many satellites had been launched and humans were sent to the Moon with the aim of taking samples. From 1969 to 1972, six Apollo missions had returned about 382 kg samples including lunar rocks, rock cores, gravels, lunar soils and dust, which were collected from the different landing sites on the surface of the Moon [2]. Because of the limited amount of returned lunar samples, the consumption should be reduced in each stage. In addition to store the returned samples safely, sample preparation is also needed in the lab before scientific research[3]. Furthermore, during sample processing and preparation, contamination from the Earth should be avoided[4]. Achievement acquired through analyzing lunar samples collected by Apollo missions have far exceeded the other exploration missions, indicating that studies on lunar samples are important for reaching scientific goal of China's lunar exploration[5,6].

Lunar samples planned to be collected are precious and vital research objects in future space exploration. To ensure the accuracy of analysis results, more refined and reliable techniques and process are required for lunar sample preparation. In this study, through the testing process and result analysis on the simulated lunar samples, we can satisfy the need for the future investigations on the physical properties, chemical composition, isotope and chronology of lunar samples[7]. This study is also fundamental for the investigation of returned lunar samples in future.

**Mission description:** The simulated samples are first weighed and divided, and then transferred to the preparation area. (1) For the samples with variable particle size, handmade agate mortar or automatic grinding equipment can be used. (2) For large size debris (>1mm), they are first cut by wire saw, and then polished to make polished sections. (3) For the uniformly distributed powder sample after grinding, epoxy injection is directly conducted. Diamond or tungsten filament wire saw should be used to cut and polish powdered samples when they are solidified and to make polished sections.

There are two types of sample analysis process including physical, chemical and structural analysis.(1) Sample physical property analysis: surface area, density, particle size, consolidation index, magnetic susceptibility, dielectric constant, etc.(2) Sample chemical and structural analysis: conducting SEM, mass spectrometry and spectral analysis on the polished sections and chemical analytical samples. Fig.1 shows the flowchart of sample preparation and probably analysis.

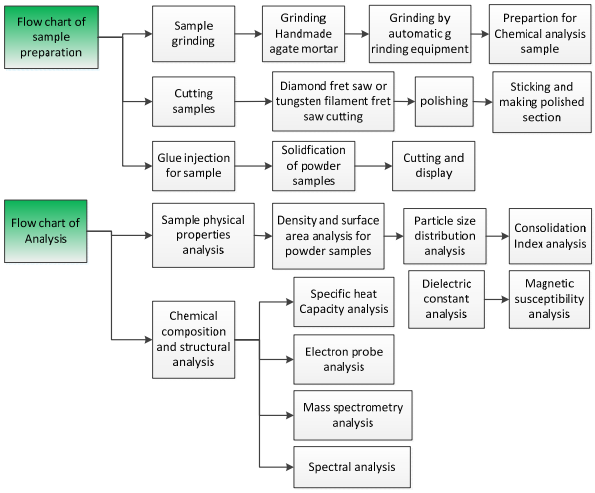


Fig 1 Fig. 1 Flow chart of sample preparation and analysis. All the process of grinding and cutting should be conducted in the nitrogen environment, water and oxygen content and numbers of dust particles in the nitrogen gas are required to be strictly controlled.

Because of the lack of experience in lunar sample preparation and analysis, we need to test aforementioned procedures to ensure reasonable application for the future returned lunar samples in China. In this study, we prepared loess and basalt samples from the Earth, and some other testing equipment related to experiments such as electronic balance and microscope. Using the nitrogen environment established by glovebox[8,9], whole process verification was conducted for the experiment procedure, and the results were recorded, analyzed and evaluated.

**Description of testing process:** Lunar surface is covered by fine-sized regolith and most of the collected samples are lunar soils. According to the design of experiment, two types of samples are needed to be prepared in the process verification test: powdered and debris samples were simulated by loess and Zhangbei

basalt collected from NE China. All samples are earth samples.

For separation, rock debris (particle size > 1mm), single particle mineral, glassy particles should be selected from loess by using stereo microscope. In this study, we put a small amount of samples on the glass dish and then selected single particle mineral using stereo microscope.Because of non-uniform particle size of lunar samples, they should be grinded to uniform particle size before conducting chemical analysis for whole rock, spectral and X-ray diffractometer analysis. Thus, the preparation of grinding samples need to be ground into a powder sample with a median particle size about 75 μm in the nitrogen environment.

The selection of powder samples and grinding process were conducted in the glovebox filled with nitrogen gas, which was to simulate the actual operating environment for future return samples. Fig. 2 shows the equipment.

Fig. 2 Glovebox equipment. this figure shows the first step in establishing the nitrogen environment in glovebox. Sample selection, grinding and cutting were performed in this environment. Polished sections preparation was conducted in the atmosphere environment, the use of selected debris and original powder samples were made into the required polished section.

**Results and discussion:**Since there are no rock debris in the loess samples used in the experiment with grain sizes greater than 1mm, so only minerals and glass samples were selected. Through grinding loess samples, the average particle size is 6.7μm. Besides, polished section samples were made by grinding and polishing the Zhangbei basaltic rock debris, the thickness of which is only 0.23μm.

Although the samples used for test and analyses were obtained by this experiment, there are still some problems need to be solved for the future lunar samples' processing, storage and preparation in the glovebox. For example, considering the fine-size of the returned lunar samples, directly dumping samples should not be adopted in the preparation experiment to avoid small dust particles flying in the box. Due to limited space of glovebox and inconvenient operation in the glovebox, the training and experiments for people using glove boxes should be added, which can reduce the loss and waste of lunar samples induced by human.

During the preparation of polished section, cutting, coarse grinding, fine grinding and polishing can result in samples waste. Thus, polished section should be the first choice rather than thin section. In addition, bubbles existed in the epoxy resin samples during the process of polished section preparation. This can be influenced by the following factors: 1) the vacuum is not high enough because the vacuum tank was not tightly sealed in our lab. 2) the ordinary double-sided adhesive is easy to make bubbles. 3) Un-skilled and non-professional operation.

The technology for returned samples' preparation and analysis is a crucial step for realizing scientific goals of the lunar exploration. In addition, sample analysis programs require different sample preparation techniques. The key questions and techniques encountered during the process of sample preparation should be investigated in details. How to storage, process and prepare lunar returned samples and how to avoid Earth environment contamination and oxidation are future directions for studying lunar, Mars and asteroids returned samples.

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