EUROPEAN SYNCHROTRON RADIATION FACILITY

INSTALLATION EUROPEENNE DE RAYONNEMENT SYNCHROTRON

ESRF

Experiment Report Form

The double page inside this form is to be filled in by all users or groups of users who have had access to beam time for measurements at the ESRF.

Once completed, the report should be submitted electronically to the User Office via the User Portal: *https://wwws.esrf.fr/misapps/SMISWebClient/protected/welcome.do*

Deadlines for submission of Experimental Reports

Experimental reports must be submitted within the period of 3 months after the end of the experiment.

Experiment Report supporting a new proposal ("relevant report")

If you are submitting a proposal for a new project, or to continue a project for which you have previously been allocated beam time, you must submit a report on each of your previous measurement(s):

- even on those carried out close to the proposal submission deadline (it can be a *"preliminary report")*,
- even for experiments whose scientific area is different form the scientific area of the new proposal,
- carried out on CRG beamlines.

You must then register the report(s) as "relevant report(s)" in the new application form for beam time.

Deadlines for submitting a report supporting a new proposal

- 1st March Proposal Round - **5th March**
- 10th September Proposal Round - **13th September**

The Review Committees reserve the right to reject new proposals from groups who have not reported on the use of beam time allocated previously.

Reports on experiments relating to long term projects

Proposers awarded beam time for a long term project are required to submit an interim report at the end of each year, irrespective of the number of shifts of beam time they have used.

Published papers

All users must give proper credit to ESRF staff members and proper mention to ESRF facilities which were essential for the results described in any ensuing publication. Further, they are obliged to send to the Joint ESRF/ ILL library the complete reference and the abstract of all papers appearing in print, and resulting from the use of the ESRF.

Should you wish to make more general comments on the experiment, please note them on the User Evaluation Form, and send both the Report and the Evaluation Form to the User Office.

Instructions for preparing your Report

- fill in a separate form for each project or series of measurements.
- type your report in English.
- include the experiment number to which the report refers.
- make sure that the text, tables and figures fit into the space available.
- if your work is published or is in press, you may prefer to paste in the abstract, and add full reference details. If the abstract is in a language other than English, please include an English translation.

ESRF	**Experiment title:** The content and occurrence states of Fe0, Fe2+, and Fe3+ in the China Chang'E-5 lunar sample	**Experiment number**: ES-1336
Beamline: ID18	**Date of experiment**: from: 11.07.2023 to: 15.07.2023	**Date of report**: 06.09.2023
Shifts: 12	**Local contact(s)**: KUPENKO Ilya, LI Xiang	*Received at ESRF:*

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Report:

Micrometeorites (MM) are microscopic (~100 µm), mostly spherical remnants of cosmic dust that can be collected on the Earth's surface. The determination of the origin of individual MMs with regard to their formation in the solar system (e.g. asteroid collisions or comet sublimations) has so far remained an experimental challenge - the determination of iron minerals with Mössbauer spectroscopy at the ESRF can make an important contribution to this. The micrometeorites analyzed here were obtained from an up to 3.8 million years old time-resolved sediment profile from the Atacama Desert in Chile. Extraterrestial micro objects were measured by synchrotron Mössbauer-Spectroscopie to characterize their inner and outer layer composition, and assumptions about their origin can be made. Two different sample groups were analysed for their different iron phases. Both groups contain different subgroups of samples, which are explained below. One group consisted of micrometeorites excavated in the Atacama desert in Chile. Due to the different depths the meteorites were found in, their time of formation could be approximated and was then verified by ^{10}Be-dating. Depending on the depth of the deposit, the age of the micrometeorite varies between a few 10,000 years and several million years. The second group consisted of the Luna 24 sample, which was sourced on the moon in a sample return mission in 1976.

Analysis of Micrometeorites:

Overall, 16 micrometeorites (between 60 - 100 µm in diameter) were analysed. They were categorized into three different groups of micrometeorites, 9 stony, 6 iron and 1 stony-iron micrometeorite were chosen. At first, the absorption maximum was determined using absorption scans. Therefore it can be estimated, that the measurements were approximately taken in the middle of the micrometeorites. Additionally, some of the samples were measured at the edge, to detect composition changes between the center and the surface. Two of the iron micrometeorites could only be measured at the edge, due to the absorption being too high at the center.
Figure 1 shows three examples of meausured Mössbauer-spectra and the fitted data of the analysis, one for each group. Olivine, magnetite, maghemite, α-(Fe,Ni), austenitic Fe, pyroxene/glassy Fe(II) and smectite phases were found in the micrometeorites, providing much more informations about their iron phases than the previous XRF

measurements. For the stony micrometeorites olivine is a characteristic phase, for the iron micrometeorites with a higher nickel and chromium content austenitic iron respectively. The stony-iron micrometeorite had α-(Fe,Ni) in the center as the main phase. On the edge magnetite and possibly a smectite phase were predominantly found.

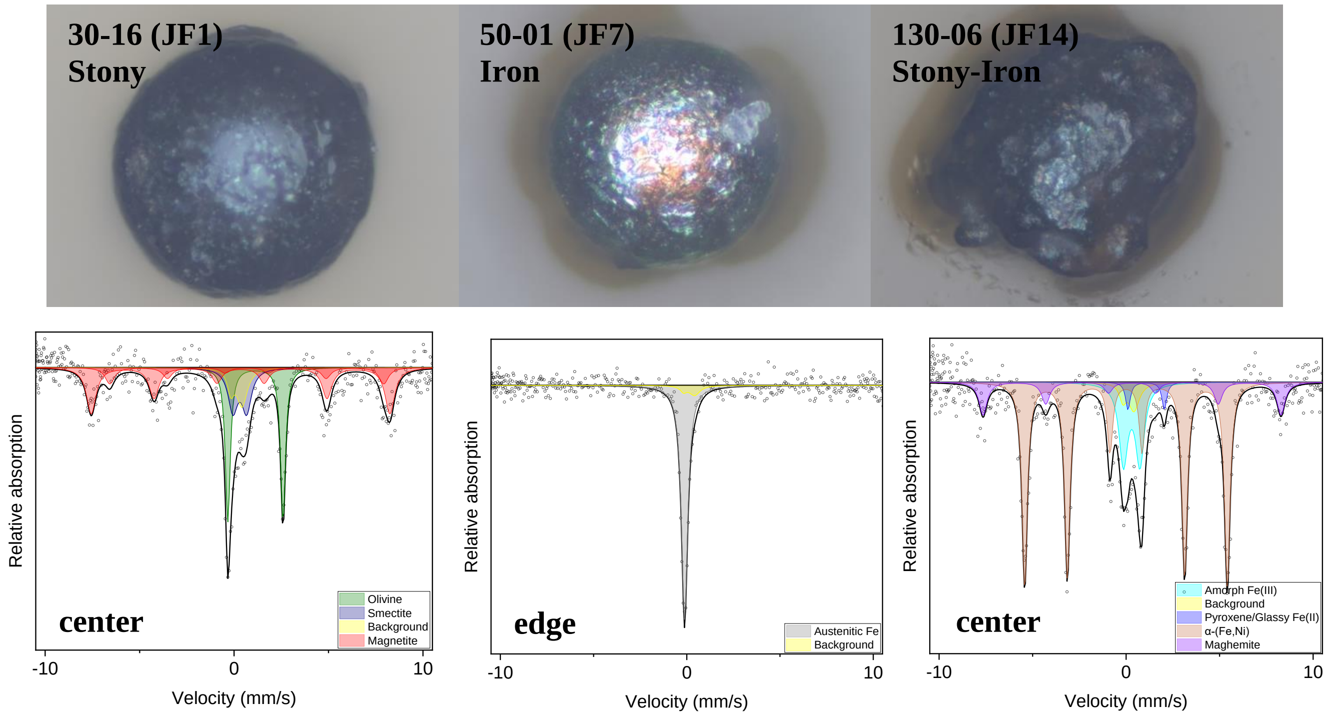

Figure 1: Three examples of the different types of micrometeorites with their corresponding spectra**.**

Lunar 24:

Since the sample consists of an inhomogeneous mixture of single particles, characteristic groups were defined and suitable particles from each group were measured. They are namely melt spherules (3), black grains (2), colourless minerals (1) and red minerals (1). At least one sample from each group was chosen for analysis. The size of the measured grains varied between 50 - 75 µm. All samples were measured at the point of highest absorbtion. Figure 2 shows exemplary particles. One melt spherule and one red mineral with their corresponding spectra are shown below. In general pyroxene/glassy Fe(II) was the main component of the grains except the red mineral grain, there it was ilmenite. Nanoparticular Fe(0) phases were also found in some samples**.**

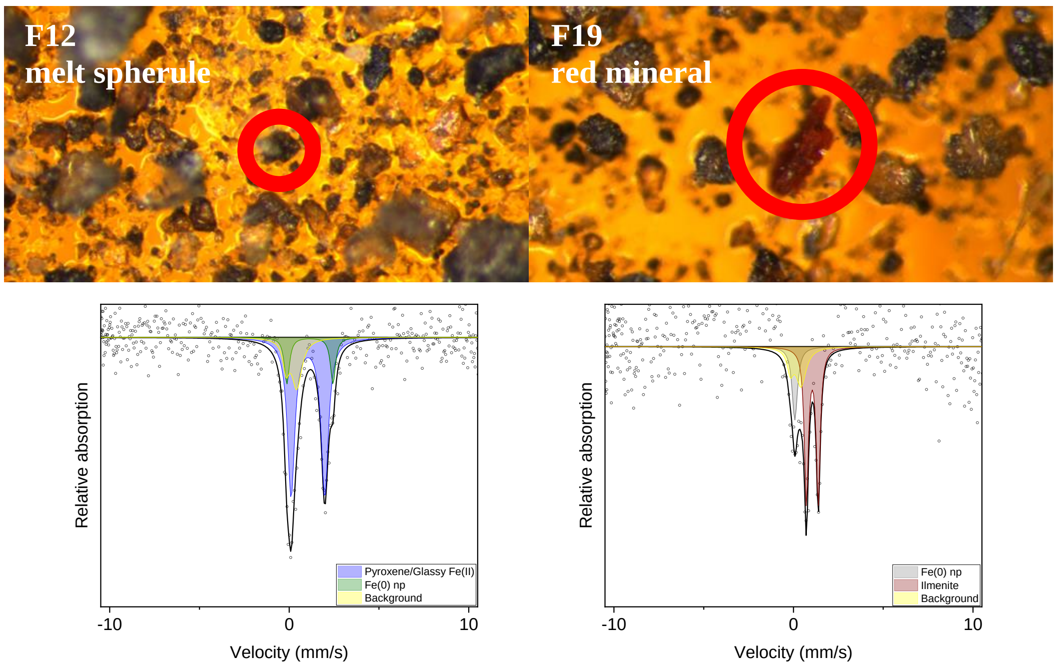

Figure 2: Two different types of Lunar 24 samples with their corresponding spectra.