

CATALOGUING THE UK'S MOON ROCKS: LUNA SAMPLES FROM THE SOVIET UNION. S. K. Bell¹, K. H. Joy¹ and K. Moore², ¹Department of Earth and Environmental Sciences, University of Manchester, Oxford Road, Manchester, M19 3PL, UK (samantha.bell@manchester.ac.uk), ²The Royal Society, 6-9 Carlton House Terrace, London, SW1Y 5AG, UK.

Introduction: The 21st of February 2022 will mark the 50th anniversary of the Luna 20 mission landing on the Moon. Luna 20 was one of three Soviet Union robotic missions to return samples from the lunar surface. Collectively, the three missions returned to Earth approximately 300 grams of lunar samples from the eastern region of the Moon's near-side. The Luna 16 lander touched down in Mare Fecunditatis, (0° 41' S, 56° 18' E) and drilled 35 cm into the regolith collecting 101 g of soil dominated by mare basalt clasts and basaltic mineral fragments [1]. This was followed in 1972 by Luna 20 which landed in the Apollonius Highlands (3° 32' N, 56° 33' E), located in the region between Mare Fecunditatis and Mare Crisium. Regolith at the Luna 20 site was less consolidated than at the Luna 16 site and as a result only 55 g of predominantly anorthositic material was collected from the top 29 cm of the lunar regolith [2]. The final sample return mission, Luna 24, landed in Mare Crisium (12° 45' N, 62° 12' E) and was equipped with a modified drill with hollow drill tube and flexible collection liner, different to that used on Luna 16 and 20. The Luna 24 drill collected 160 cm of core weighing 170 g [3]. Upon examination, the core was found to be stratigraphically layered with four main distinct zones, each with varying abundances of rock and mineral fragment types and grain sizes [3,4].

Luna Goodwill Samples: The act of giving Moon rocks as diplomatic gifts was most famously implemented by the US after the Apollo missions to countries around the world. This practice was also adopted by the Soviet Union following the success of the Luna sample return missions, and a number of Luna 16, Luna 20 and Luna 24 samples were distributed scientific originations in the US, India, France, the Czechoslovakia, and the UK.

The UK Royal Society Collection: The Academy of Sciences of the Union of Soviet Socialist Republics (USSR) gifted samples of Luna 16, 20 and 24 to the Royal Society for the purposes of scientific study by UK lunar scientist. The Royal Society received approximately 0.5 g of both the Luna 16 and Luna 20 samples in 1972. The Luna 16 sample (L1627) was from the 27 cm level depth within the drill core in a section known as Zone C [5]. The Luna 20 sample (L2015) was from the 27-32 cm level within the drill core [5]. This was followed by the receipt in 1977 of a further four

samples from depths of 90, 125, 170 and 196 cm in the Luna 24 core, each weighing ~0.3 g (Fig. 1) [6].



Figure 1: The original containers of the Luna 24 samples (box and sample containers) gifted to the Royal Society by the Soviet Academy of Sciences.

Analysis of Luna samples conducted in the UK:

In response to the donation, the Royal Society established a committee of leading UK lunar science experts to determine the best way to subdivide and allocate the samples for analysis [5]. Professor Colin Pillinger FRS (1943-2014) was tasked with curating the Luna samples and distributing them to various institutions around the UK. Samples were initially processed and sorted by size, visual appearance, density and magnetic susceptibility [5]. Following this, the samples were sent out to at least 13 UK science institutions for further analysis.

In January 1977, analyses of Luna 16 and Luna 20 samples were published in a special issue of the Philosophical Transactions of the Royal Society Series A (Volume 284, issue 1319). The manuscripts presented included studies into the oxygen isotopes [7], carbon chemistries [8], magnetic properties [9], ⁴⁰Ar/³⁹Ar dating [10], charged-particle track analysis and thermoluminescence [11].

As with Luna 16 and 20, the majority of the findings of the Luna 24 samples analyses were published in a special issue of the Philosophical Transactions of the Royal Society Series A (Volume 297, issue 1428), in June 1980. The volume included work on the mineralogy and petrology of the Luna 24 core [12,13], solar-flare tracks [14], optical spectroscopy [15] and ⁴⁰Ar/³⁹Ar dating [16].

The Present Day Collection: The remaining collection is now being reviewed to create a digital

database and image archive of what samples remain in the collection. The aim of the new database is to: gather sample information and images; document the analysis chain of each sample; and identify any unaccounted for samples that may still be located at universities within the UK. The database has now been completed and each sample has been digitally documented.

The current sample collection includes remnants of material from analysis conducted in the 1970s including grains mounted on thin sections, and soil samples sealed in glass vials and Pyrex tubes. In addition, there are also previously unanalyzed sieved soil fractions and individual hand-picked rock and mineral fragments of varying grain sizes $< \sim 2$ mm in size (Fig. 2).

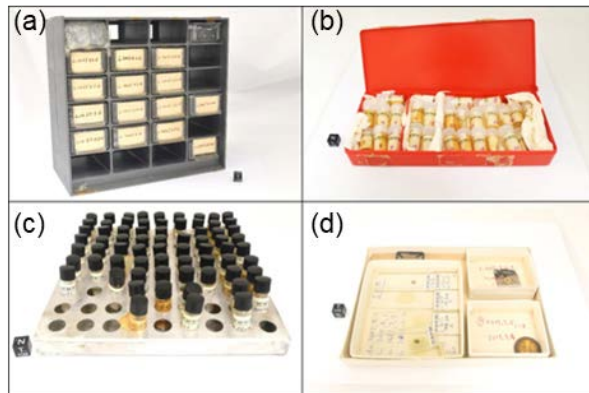


Figure 2: A selection of the original Luna sample storage containers, documented as part of the new Luna sample digital database. (a) Plastic storage drawers containing vials of Luna 16 and 20 samples, (b) a selection of plastic vials each housing a small sealed glass vial containing Luna 24 material (c) a tray of Luna 24 samples in glass vials with original labels, and (d) a selection of thin sections in original cardboard trays. These materials will no longer be used to store the collection as some of the materials have experienced degradation, but remain as part of the object archive.

Many of the samples remained in the original vials and storage containers that were allocated or prepared in the 1970s (Fig. 2). Therefore, as part of the curation project, efforts have also been made to stabilize the collection and ensure the safety and integrity of the samples in the future. This included processes such as replacing degraded sample vial labels with new acid free paper labels, transferring samples from their original plastic pots into inert organic free glass vials (where this process did not incur sample loss), and sourcing more robust and easy to access sample containers.

Future Plans: Establishing a digital record of each sample within the Royal Society Luna sample collection was the first step towards the long-term goal of making

the collection available once again to the lunar sample community. The new database will allow potential investigators to browse the available data and material prior to making a sample request. It will also be a valuable source of information pertaining to all of the previous analysis conducted on these samples by the original investigators. Work to store the database in an online repository and to establish an official process of sample request and allocation is currently ongoing.

Potential Additional Samples? Our archiving efforts suggest that some of the material which was originally allocated to UK Principal Investigators may never have been returned after their research in the 1970s and 1980s was completed. Therefore, we ask that you please get in contact with one of the authors if come across material or documentation which has any records relating to the UK Royal Society Luna sample collection, so that we can reunite the samples within the updated collection.

Summary: At 50 years old, the Luna sample collection is still extremely scientifically precious, as well as now being of historical cultural importance. Many advances in analytical capability and our understanding of lunar geology have been made since the Luna samples were initially gifted to the UK. We hope that with the creation of a new digital sample database and careful curation of the remaining material, many more scientific findings will come from renewed analysis of the Royal Society's Luna sample collection.

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