The Apollo Virtual Microscope Collection: Lunar Mineralogy and Petrology of Apollo 11, 12, 14, 15 and 16 Rocks

Conference or Workshop Item

THE APOLLO VIRTUAL MICROSCOPE COLLECTION: LUNAR MINERALOGY AND PETROLOGY OF APOLLO 11, 12, 14, 15 AND 16 ROCKS. E. K. Gibson[1,2] , A. G. Tindle[1], S. P. Schwenzer[1], S. P. Kelley[1,3], G. H. Morgan[1], M. Anand[1] and J.M. Pillinger[1]. [1]Science, Technology, Engineering & Maths Faculty, The Open University, Walton Hall, Milton Keynes, MK7 6AA, UK., and [2]XI111, ARES, NASA Johnson Space Center, Houston, TX 77058. U.S.A. [everett.k.gibson@nasa.gov], [3]School of Geosciences, College of Science & Engineering, University of Edinburg, Edinburgh EH9 3FE, UK.

Abstract: The Apollo Virtual Microscope Collection is an Open Educational Resource which allows users to investigate the mineralogy and petrology of polished thin sections of every rock in the Apollo lunar sample collections. It uses software that duplicates many of the functions of a petrological microscope. Currently, images from the Apollo 11, 12, 14, 15 and 16 missions may be viewed at: **www.virtualmicroscope.org/content/apollo.**

A few Apollo 17 samples are also available, but the majority are currently being digitized and will be available in the near future.

Introduction: During the six NASA missions to the Moon from 1969-72 a total of 382 kg of rocks and soils, often referred to as "the legacy of Apollo", were collected and returned to Earth. A unique collection of polished thin sections (PTSs) was made from over 500 rocks by the Lunar Sample Curatorial Facility at the Johnson Spacecraft Center (JSC), Houston. These materials have been available for loan to approved Principal Investigators (PIs) but of course they cannot be simultaneously investigated by several researchers unless they are co-located or the sample is passed back and forward between them by mail/hand carrying - which is inefficient and very risky for irreplaceable material.

When The Open University (OU), the world's largest Distance Learning Higher Education Establishment, found itself facing a comparable problem (how to supply thousands of undergraduate students with an interactive petrological microscope and a personal set of thin sections), they decided to develop a software tool called the Virtual Microscope (VM). The Virtual Microscope allows users to view an entire thin section in plane polarized light, between crossed polars and also in reflected light. Measurements of length and angles are also possible. Through a collaboration between NASA and the OU it is now possible to make the unique and precious collection of Apollo specimens universally available as a resource for concurrent study by anybody in the world's Earth and Planetary Sciences community. Herein, we describe this collaborative project between the OU and the JSC Curatorial Facility to record a PTS for every lunar rock, beginning with those collected by the Apollo 11, 12, 14, 15 and 16 missions. Preparation of Apollo 17 are currently underway and should be available by the 50th anniversary of the A-11 landing.

Method: Production of a virtual microscope dedicated to a particular theme divides into four main parts - photography, image processing, building and assembly of virtual microscope components, and publication on a website. The method used to produce the VM images has been described earlier [1].

Earlier investigations: We have undertaken a number of pilot studies to demonstrate the efficacy of the petrological microscope with lunar samples. The first was to make available on-line images collected from the Educational Package of Apollo samples provided by NASA to the UK STFC (Science and Technical Facilities Council) for loan as educational material e.g. for schools. The real PTSs of the samples are no longer sent out to schools removing the risks associated with transport, accidental breakage and eliminating the possibility of loss.

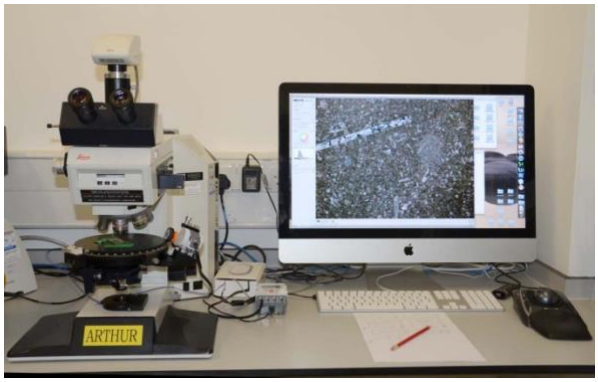

Figure 1: Rotating stage microscope with Lego Mindstorm® motor and controller – one of two microscopes used by the virtual microscope team.

Research possibilities: Although the Virtual Microscope was originally conceived as a teaching aid and was later recognised as a means of public outreach and engagement, we now realize that it also has enormous potential as a high level research tool.

Following discussions with the JSC Curators we have received CAPTAM permission to embark on the

programme of digitizing the entire lunar sample PTS collection. By the time of the 2018 LPSC meeting we will have completed 383 'virtual microscopes' of rocks collected during the Apollo 11, 12, 14, 15 and 16 missions. These cross-link to the Lunar Sample Compendium [2]. These go live on the Web in January 2018. 383 'virtual microscopes' of the A-11 (41 VM images), A-12 (47 VM images), A-14 (56 VM images), Apollo 15 (124 VM images) and Apollo 16 (115 VM images) along with 19 additional samples from A-17 missions can be studied at:
www.virtualmicroscope.org/content/apollo

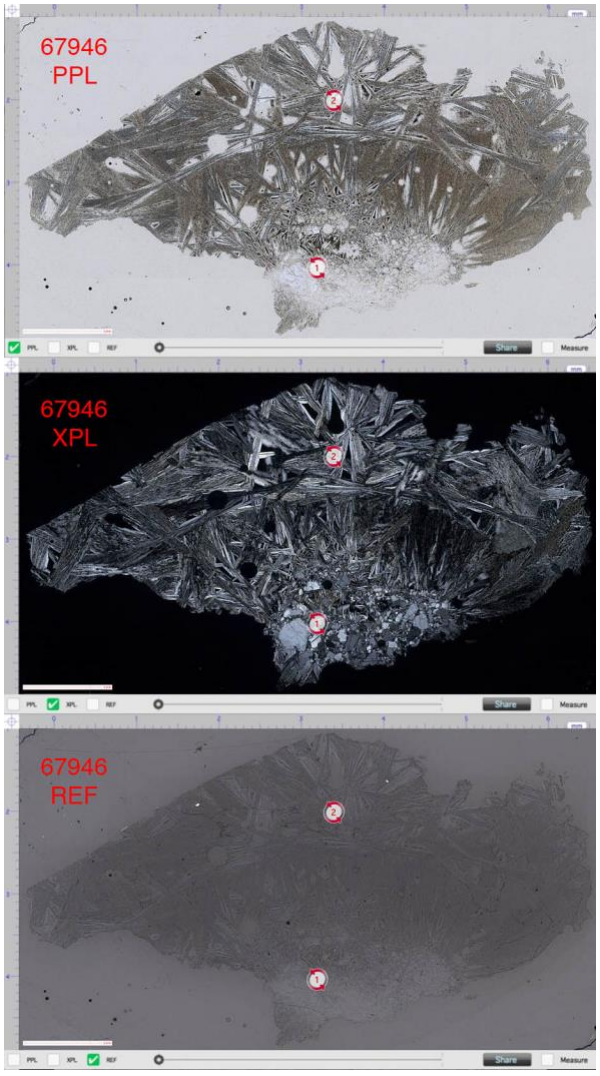

Figure 2: Screen shots from one of the Apollo 16 virtual microscopes showing impact melt sample 67946.

The Apollo VM will enable large numbers of skilled microscopists, but also novices and newcomers, who range from professional and amateur researchers, to educators and students, and to enthusiasts and the simply curious non-scientists, to share the information from a single sample in the comfort of their own laboratory. It means that all the PTSs already cut, even historical ones, could be available for new joint investigations or private study. This resource is widely used with several thousand users per week to the OU's VM site, many of who visit the Apollo collection. The mid-week peak of visitors thereby speaks for professional use. Most notably, the time visitors spend on the Apollo sites are significantly longer than for other pages, with a maximum at ~10 mins, and and average of ~5 mins (Data from Dec. 2017). The scientific return from the collection will increase exponentially as further VMs are completed and then discussed and shared between co-workers.

Simultaneously the VM will remove the need to make unnecessary multiple samplings or to consign delicate/breakable specimens (all of which are priceless) to insecure mail/courier services. A knock on effect will be to reduce direct labour and indirect costs, travel budgets and unproductive travelling time necessary for co-location of collaborating researchers.

For the future we have already recognized further potential for virtual technology. The next phase of our work is to prepare VM images for all the remaining ~180 Apollo 16 and 17 samples. But, there is nothing that a petrologist likes more than to see the original rock as a hand specimen. It would be entirely possible to recreate virtual hand specimens of Apollo rocks within the Curatorial Facility with 3-D hardware and software, already developed by the VM team for viewing Earth rocks and fossils.

The Team has also piloted a small Mars Virtual Microscope Collection that includes a range of Martian meteorite types. It can be viewed at:
http://www.virtualmicroscope.org/content/martian-meteorites

References:
[1] GIBSON, E.K., TINDLE, A.G, KELLEY S.P. AND PILLINGER J.M. (2016), , In LPSC XLVII, Abstract #1199.
[2] http://curator.jsc.nasa.gov/lunar/lsc/index.cfm

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