Investigating the Moon

Suggested Activities
Key Stages 3 and 4

Foreword

These teaching notes have been prepared by Monica Grady, Professor of Planetary and Space Sciences at the Open University, on behalf of the EURO-CARES consortium. Monica was advised by a small team of teachers who work with a range of age groups from KS1 to KS4; the team also included a SEND specialist. The notes were 'road tested' on children of different age groups from schools in different Local Education Authorities in England.

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EURO-CARES:

European Curation of Astromaterials Returned from the Exploration of Space

http://www.euro-cares.eu/

European Commission

Introduction

The purpose behind this set of notes is to provide two sets of practical activities that students can undertake on their own, in their own time, or as enrichment exercises in groups at school. The concepts encountered in the activities complement the requirements of the National Curriculum in England GCSE in Combined Science.

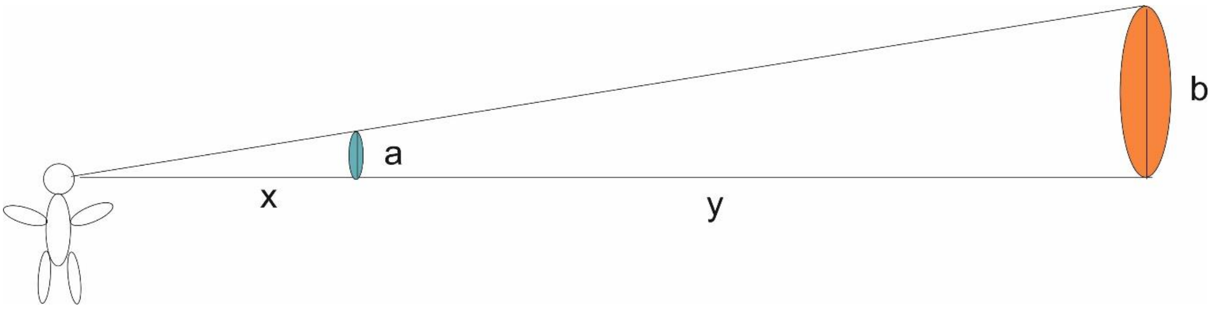
Measuring the size and distance of the Moon

On a day of hazy cloud, we can see the Sun. And on a clear night, we can often see the Moon. Have you ever noticed that the full Moon appears to be about the same size as the Sun? This correspondence is fortuitous, and a reflection of the fact that the Sun is about 400 times greater in diameter than the Moon and is also about 400 times as far away. The coincidence in apparent size is what enables a total eclipse to occur. The Sun and Moon have the same angular size. In the diagram below, the blue and orange disks have the same angular size – they subtend the same angle at the observer's eye.

If the distance from the observer to the blue circle is x and the diameter of the circle is a, and the distance from the orange circle is (x +y) and the diameter of the orange circle is b, then the angular size of the objects is given by:

$$\text{angular size} = \frac{a}{x} = \frac{b}{x+y}$$

For this relationship to work, the angular size is in radians, where 1 radian = 57°



So angular size depends on an object's actual size and its distance from the observer's eye. We can use this relationship to determine the size of the Moon and its distance from us. The following activity needs to be carried out when the Moon is clearly visible – either day or night.

DO NOT ATTEMPT THIS ACTIVITY ON THE SUN

Materials:

- selection of round coins (e.g., 1p, 5p, 10p or 1€, etc)
- a straight rod at least 2 m long (e.g. garden cane)
- tape measure at least 2 m long
- ruler marked in mm and cm
- blu-tack or plasticine
- calculator

The aim is to set up an arrangement with a coin fixed to the rod so that the coin just blocks out (eclipses) the Moon see the diagram below.

Observing from one end of the rod, try different coins until you find one that is the right size to eclipse the Moon when fixed somewhere on the rod. Then adjust the position of the coin until it just blocks your view of the Moon.

Image Credit: Open Univ.

Measure the distance from the coin to the end of the rod where you have placed your eye and measure the coin's diameter.

You now have the measurements that will enable you to calculate the angular size of a coin that has the same angular size as the Moon.

Use your two measurements on the coin to calculate its angular size in degrees, using the formula introduced earlier, adapted to the current case:

i.e. in the equation above, a = diameter of coin; b= diameter of Moon (=3476 km), x = distance from the end of the rod to your eye and y is the unknown to find.

Remember to be consistent with units – either convert a to km or b to cm

You might like to compare your result with the accurately measured value of the Moon's distance: 384 500 km. It is unlikely that you obtained exactly this value, but you probably got something in the range 300 000 to 500 000 km, which is pretty good for a quick and fairly rough measurement.

This activity has been adapted from one of the learning resources of the Open University. If you are interested in investigation any of the OU's free learning resources, they are available **here**.

What is the Moon made from?

The history of the Moon is hotly debated by scientists, but most are agreed that the Moon formed in a giant impact on the newly-forming Earth by a body about the size of Mars. The surface of the Moon remained molten for many millions of years, and parts of it were re-melted during continued bombardment by asteroids and comets. Moon rocks are igneous rocks, i.e., they have been produced from a melt.

There are two different types of Moon rock, and you can see them when you look at the Moon: there are dark patches and lighter patches.

The dark patches are called 'Mare', plural Maria (pronounced Mah-Ray and Mah-reeya) from the Latin word for sea. This is because people who first described the Moon thought the dark patches were lunar oceans. We now know that the regions are dark because of the type of rocks they are made from.

The light parts are the highlands and are made of a different rock type from the maria. Here, the rocks contain a lot of a very bright crystal, which reflects a lot of light.

The Moon rocks that we study today are almost all brecciated – that means that they have been broken up, then re-assembled, possibly several times.

We call the surface layer of the Moon its regolith – it differs from a soil on Earth because it does not contain organic matter (leaves, bits of animal, etc). It is produced by impact bombardment of the surface of the Moon. Occasionally by asteroids, but daily by micrometeorites and cosmic radiation. Constant cycling of temperature (a range of almost 400 °C between night and day) also contribute to breakdown of the rocks. Regolith samples are mainly fragments of minerals, some of which have become glued together by material melted by more recent impacts by micrometeorites.

We can look at pieces of the Moon using a microscope: a slice is cut from a rock, and then polished until it is very thin, so that light can be shone through it. Thin sections of lunar samples can be accessed through the internet: https://www.virtualmicroscope.org/.

Activity: Access the virtual microscope, and select the Apollo rock collection:

https://www.virtualmicroscope.org/collections/apollo

You can look at any sample, but these three are the ones illustrated in the Resources section:

Regolith: https://www.virtualmicroscope.org/content/70181-85-mature-mare-regolith

Mare: https://www.virtualmicroscope.org/content/15476-36-porphyritic-pigeonite-basalt

Highlands: https://www.virtualmicroscope.org/content/67559-9-highland-basalt

In each case, follow the link, and then click on the "View Microscope" icon:

There are three options to view the sections:

PPL – this is Plane Polarised Light – light has been shone through a polariser (like a pair of sunglasses), which produces a parallel beam of light;

XPL – crossed polarised light – after the light goes through the sample, it passes through another polariser before being detected. The colours are an indication of how much the beam of light has been bent as it travels through the mineral crystals (as light is bent in a water droplet in a rainbow), and is an indication of the composition of the grains.

REF - reflected light, where light is bounced off the surface of the section. It shows where metal grains are – but there is not much metal in lunar samples.

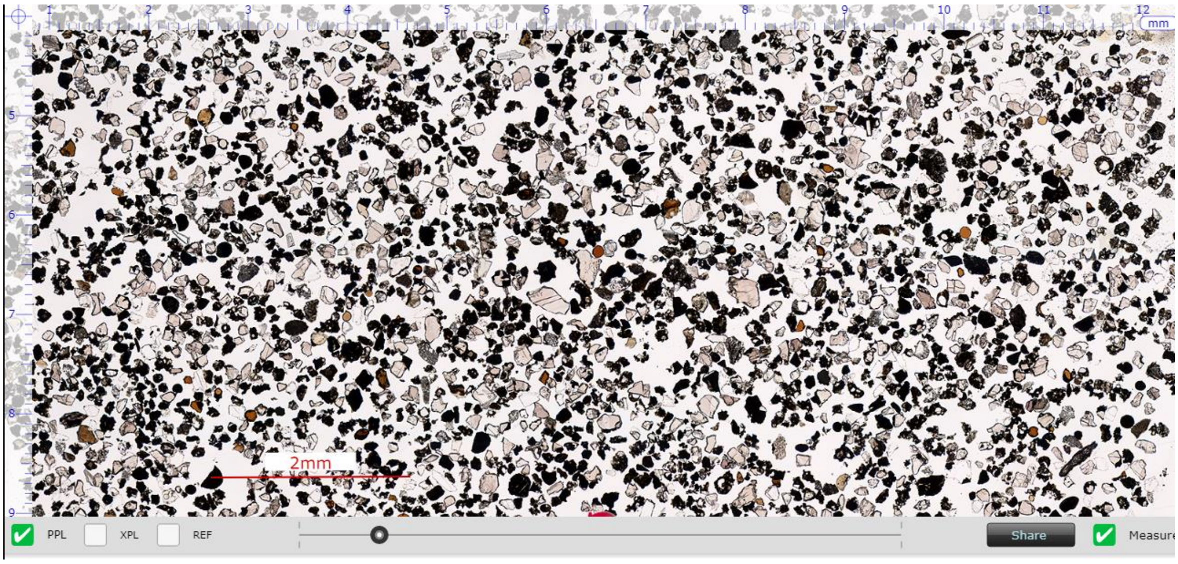
The images have one or two numbered red circles: If you click on one of them, it takes you to a page where you can see how the appearance of the rock changes as it is rotated {It can take about 30 s for the page to load).

Each of the Apollo sections are accompanied by an abbreviated description, and a link to a much more detailed and technical report. There are two minerals that are very common in lunar rocks. The first is plagioclase, which is pale in colour in plane polarised light, and usually black, white, grey and blue under crossed polars. Plagioclase is a calcium and aluminium silicate, and is a major constituent of the highland basalts.

The second mineral is pyroxene. This tends to be pale pinky-brownish in colour in plane polarised light, and a darker yellowy-brown under crossed polars. It is less abundant in the highland basalts than in mare basalts, and is an iron and magnesium silicate.

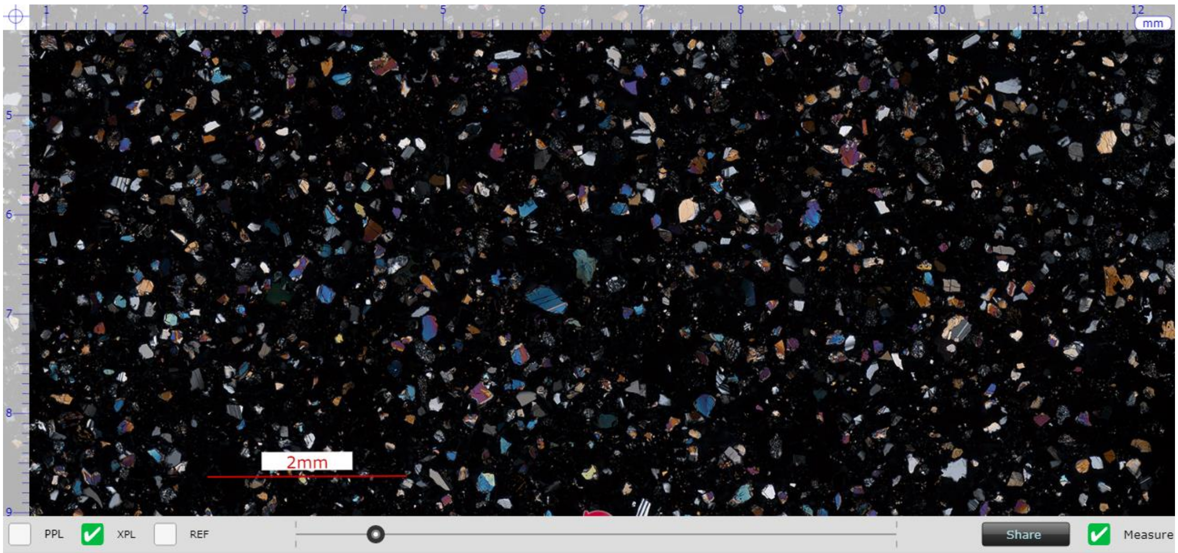
Apollo 17 regolith sample 70181

Plane Polarized light



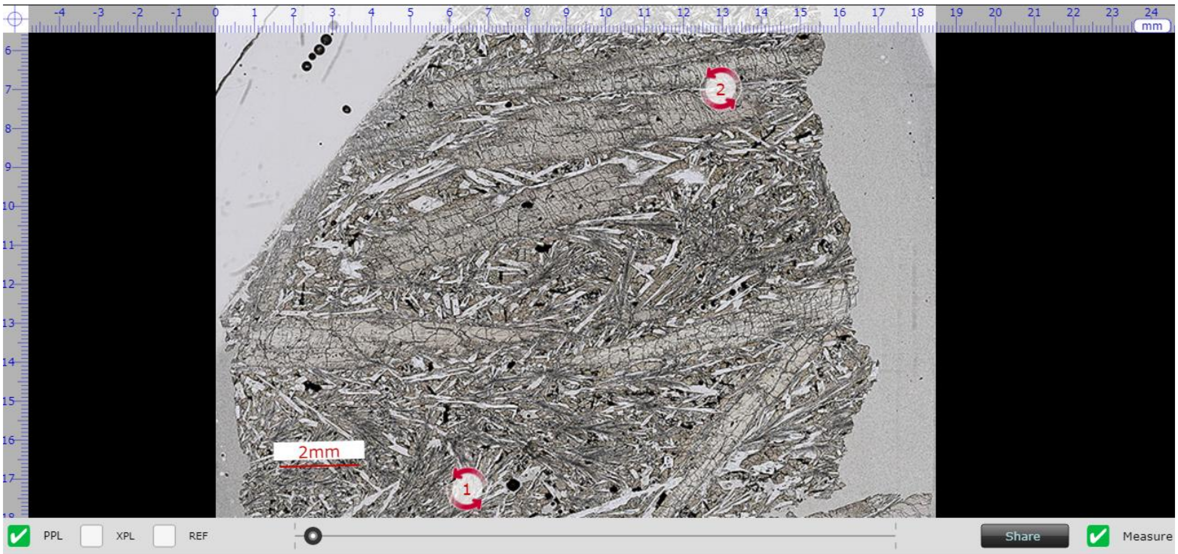
The image shows fine-grained shards of broken mineral grains, fragments of rock clasts and small orange spherules. The spherules are from splashes of molten volcanic rock. There are agglutinates: clusters of grains welded together by micrometeorite and cosmic ray bombardment at the lunar surface.

Crossed Polarized light

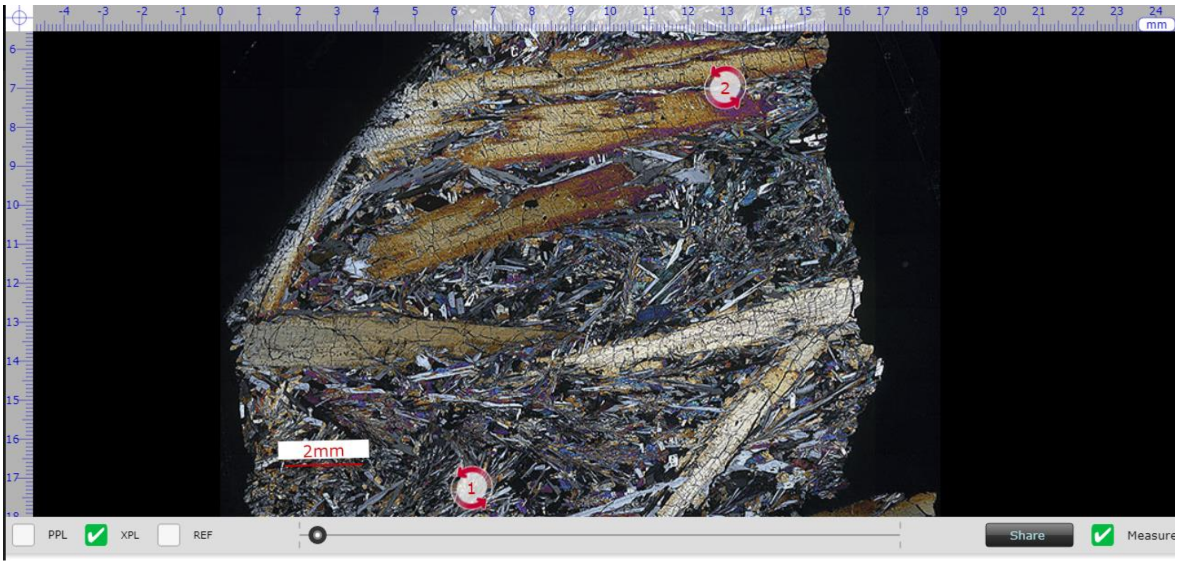


Apollo 15 mare basalt 15476.

Plane Polarized light

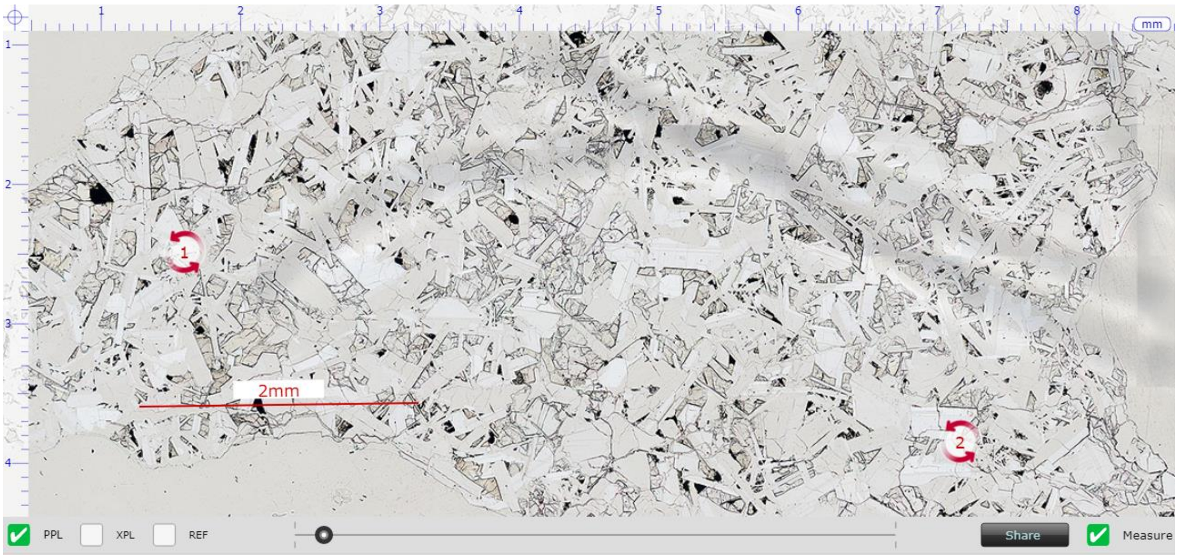


Crossed Polarized light



Apollo 16 highland basalt 67559

Plane Polarized light



Crossed Polarized light