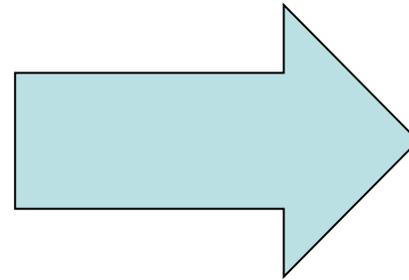
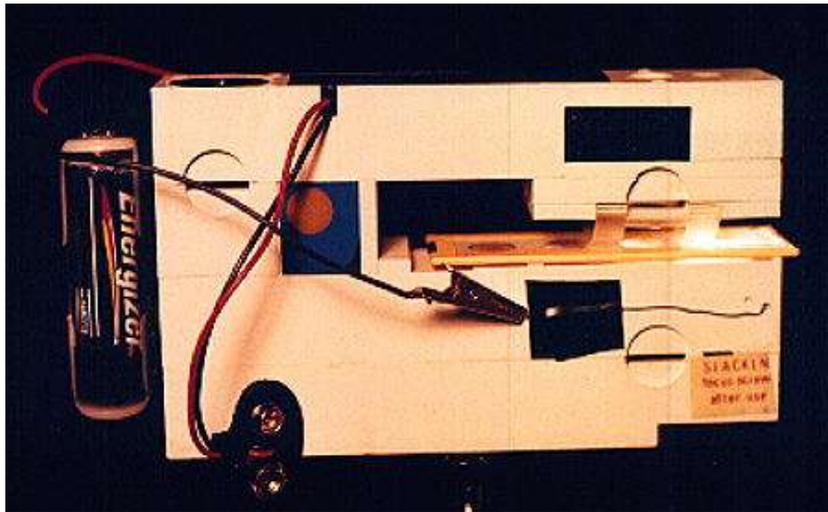




# From Darwin to the Moon, the experience of using a virtual microscope for teaching and outreach

- Simon Kelley, Andy Tindle (Earth and Environmental Sciences Dept),
- and Peter Whalley (Knowledge Media Institute).
- The Open University

# Open University petrological microscopes through the years





S276 Virtual Microscope - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www.open.ac.uk/StudentWeb/s276demosite/virtualmicroscope/LTSversion/current/index.ht

Most Visited Course forum

S276 Virtual Microscope

The Open University Virtual Microscope Peridotite

Field of view = 21 x 17 mm

select a rock specimen... Random

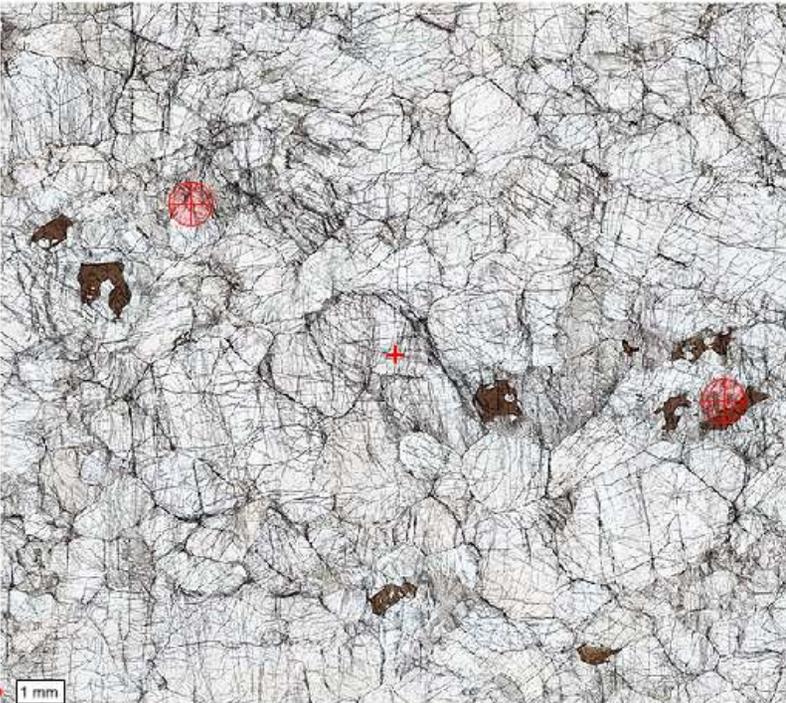
Peridotite

or view an example of a mineral or feature... ---Minerals---

Description

This coarse-grained igneous rock contains [olivine](#), [pyroxene](#), and [spinel](#).

This sample comes from Ivrea in Italy.



1 mm

Cross hairs at: X= 5002, Y= 4401

X  Y  Go

low high

Magnification

- Full specimen
- Low
- Medium
- High

Light

- plane-polarised
- crossed polars

Measurement

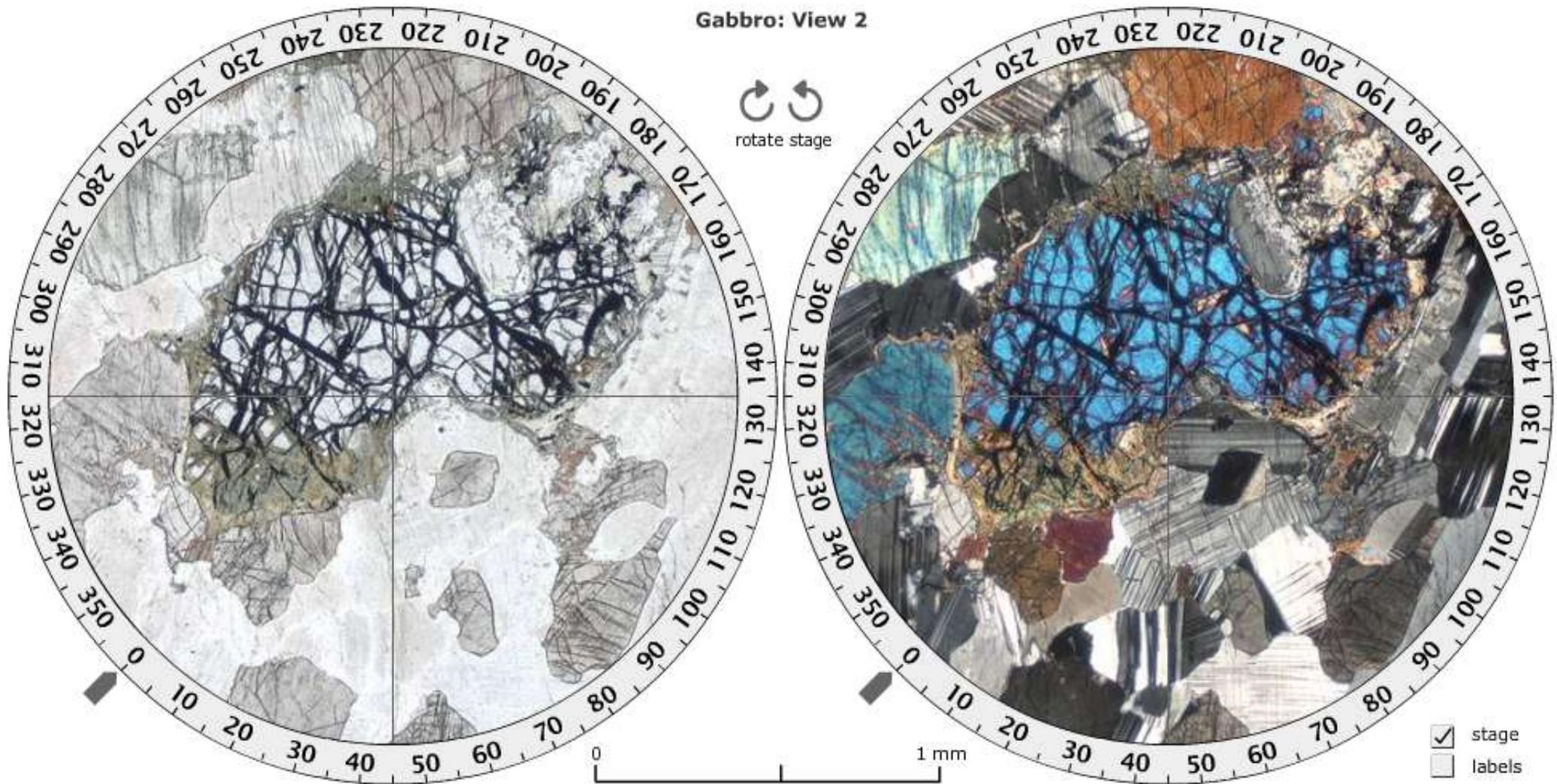
- grid
- 10 mm graticule

rotate grid/ graticule 0°

overlay colour

Read www.open.ac.uk

# The Virtual Microscope



[return to top](#)

[preload files](#)



# Teaching

- Why we developed a virtual microscope
- From passive to active learning
- Gaining practical skills

# Teaching petrology – books and images

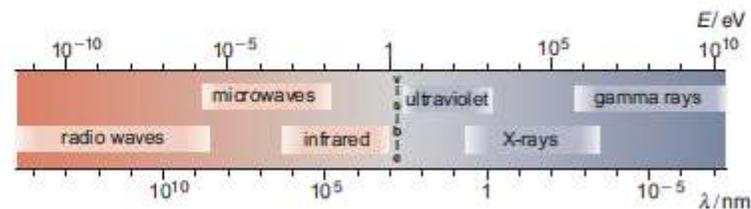


## Chapter 3 Minerals and the microscope

Although modern Earth Sciences departments use expensive and sophisticated electronic equipment to study minerals and rocks, the polarising microscope (which was the height of instrumental sophistication in the later 19th and early 20th centuries) remains an important tool in **petrology** (the study of rocks). This chapter gives an overview of crystal optics, a basic understanding of which is essential for use of the polarising microscope in **petrography** (the description of rocks). By identifying minerals and examining their interrelationships, petrographic evidence can be used to identify rocks and deduce how they formed.

### 3.1 The nature of light

Light is a form of **electromagnetic radiation**, but it is only a small part (the visible part) of the whole electromagnetic spectrum, which also includes X-rays, ultraviolet and infrared radiation, and microwaves (Figure 3.1). The wavelengths of visible light span the region of the electromagnetic spectrum from about 400 nm (violet) to about 700 nm (red). Some of the properties of waves, with which you may already be familiar, are summarised in Box 3.1.



**Figure 3.1** The electromagnetic spectrum. Note that wavelength,  $\lambda$ , decreases from left to right, but wave energy,  $E$ , increases in the same direction.

# But what about practical skills...



Virtual Microscope

Schist

Field of view = 5.3 x 4.1 mm

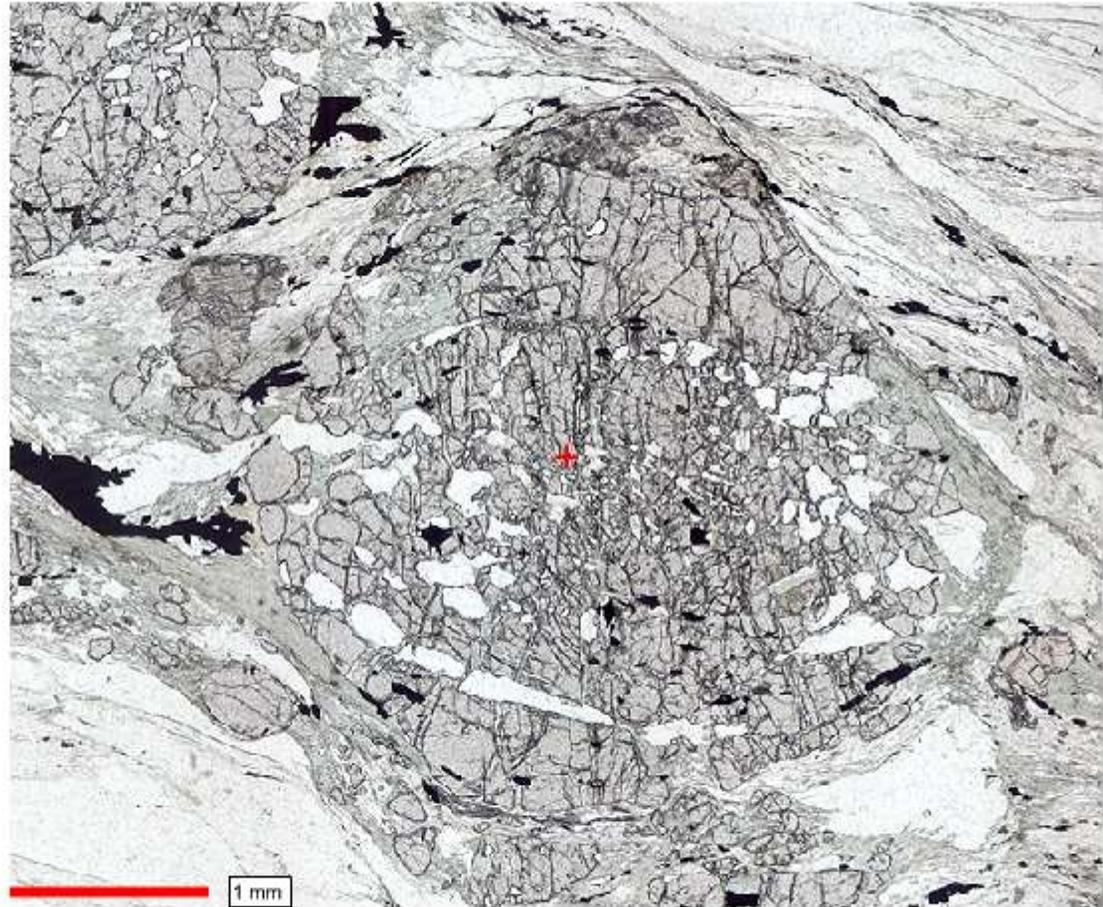
select a rock specimen...

Random

Schist

or view an example of a mineral or feature...

---Minerals---



Magnification

- Full specimen
- Low
- Medium
- High

Light

- plane-polarised
- crossed polars

Measurement

- grid
- 10 mm graticule

rotate grid/ graticule

0°

overlay colour

## Description

This coarse-grained metamorphic rock contains [garnet](#), [muscovite](#), [chlorite](#), [kyanite](#), [quartz](#) and [opaque minerals](#).

This sample comes from the Bergen area of Norway.

Cross hairs at: X= 10801, Y= 4532

X  Y

low  high



# We had one hour to introduce new students to practical petrology microscopy



S276 Workbook 1

## Activity 3.4 Introduction to the Virtual Microscope

You should allow about 1 hour for this activity, which introduces the Virtual Microscope.

During this course, you will be using the Virtual Microscope (VM), a system for viewing and exploring microscope slides (thin sections) of rocks using a computer and an internet browser window. The VM reproduces, and in some cases extends, the capabilities of the real microscope.

Open the VM on DVD 1 or on the course website and you should see a screen similar to the one shown in Figures 3.4.1 and 3.4.2. We will use the gabbro thin section to illustrate the Virtual Microscope, but this may not be the image that appears the first time you access the VM.

Virtual Microscope

Gabbro

Field of view = 20 x 15 mm

select a rock specimen... Random

Gabbro

or view an example of a mineral or feature... ---Minerals---

Description

This coarse-grained igneous rock contains crystals of olivine (and altered olivine), pyroxene and plagioclase.

This sample comes from Huntly in Aberdeenshire, Scotland.

1 mm

Cross hairs at: X= 5278, Y= 4167

low high

x y Go

Magnification

- Full specimen
- Low
- Medium
- High

Light

- plane-polarised
- crossed polars

Measurement

- grid
- 10 mm graticule

rotate grid/ graticule

0°

overlay colour

Figure 3.4.1 A view of the main screen of the Gabbro page in the Virtual Microscope.

# And then they were studying rock thin sections



---

## Activity 3.5 Exploring mineral properties in thin section

You should allow about 20 minutes for this activity.

For this activity you will require the Virtual Microscope. Use the drop-down menu of rock names to navigate to the thin sections specified.

### Question 3.5.1

Look at the thin section of quartzite in plane-polarised light. It contains many different grains of the same mineral (quartz). Can you see any boundaries between grains? Why are they not very clear? Now select crossed polars. Can you distinguish between different grains more easily? If so, what is the explanation for this?

### Question 3.5.2

Examine the thin section of peridotite, first in plane-polarised light, then between crossed polars. It contains abundant grains of the mineral olivine. How do (a) relief and (b) interference colours of olivine compare with those seen in the quartzite?

### Question 3.5.3

Look at the granite thin section in plane-polarised light. Note the brown mineral. Select one of the rotating view hot spots containing the mineral. What happens to the colour of this mineral when it is rotated in plane-polarised light? What is this phenomenon called? What is its origin?

### Question 3.5.4

Look at the thin section of schist. Note the large, equidimensional (garnet) crystals in plane-polarised light. These crystals seem to stand out from the slide and have more surface texture than the surrounding minerals. They are said to have high relief. How does the relief of these crystals compare with the relief of the other crystals in the slide? Now look at the thin section between crossed polars. What happens to the garnet crystals when the stage is rotated? What term describes crystals that exhibit this property? From this optical behaviour, what is the crystal system of garnet?

---

# Assessing students practical skills



**Seeing – Identifying - Classifying**



# Continuous assessment questions

This rock specimen contains holes and when a thin section is made of such a rock the holes are visible as areas with no large crystals, but they are not completely blank. The holes appear colourless in plane-polarised light but black between crossed polars, often with fine dust which is the polishing material. Some holes contain bubbles in the glue (such as the one at location (3265, 3280), others show glue and darker areas of polishing material (such as the one at location 7566, 5580). You will see at least 10 holes in the thin section; these are important in your answers to this question.

- a. Describe rock specimen *Unknown 7* in the Digital Kit using the 'zoom' and 'pan' features to examine the sample at a range of magnifications. You should note, in particular, colour, grain size, texture and any other features. Do not attempt to name any individual mineral at this stage.



## More questions – using locations

1. Identify the mineral at the centre of hotspot location 'View 1', giving your reasons
2. Identify the mineral at location (9352, 2983), giving your reasons.
3. The mineral at location (9210, 2728) is normally colourless but all the examples in this rock are altered and thus appear deep brown in colour. Nevertheless, the mineral preserves its original characteristics other than colour. Identify the original mineral, giving your reasons.



# The virtual microscope online

<http://microscope.open.ac.uk>

# Student experience



- Students and tutors engaged with the new virtual microscope with enthusiasm
- Staff reported that students at residential school were at least as well prepared having studied petrology using the virtual microscope
- Some staff and students miss the physical interaction and 'real rocks' of the kits

# Outreach



- Joint project with the Sedgwick Museum, Cambridge
- The STFC and OU-NASA virtual microscopes

# Darwin Year



Launch event photographs  
courtesy of Chris Valentine

# Darwin the geologist

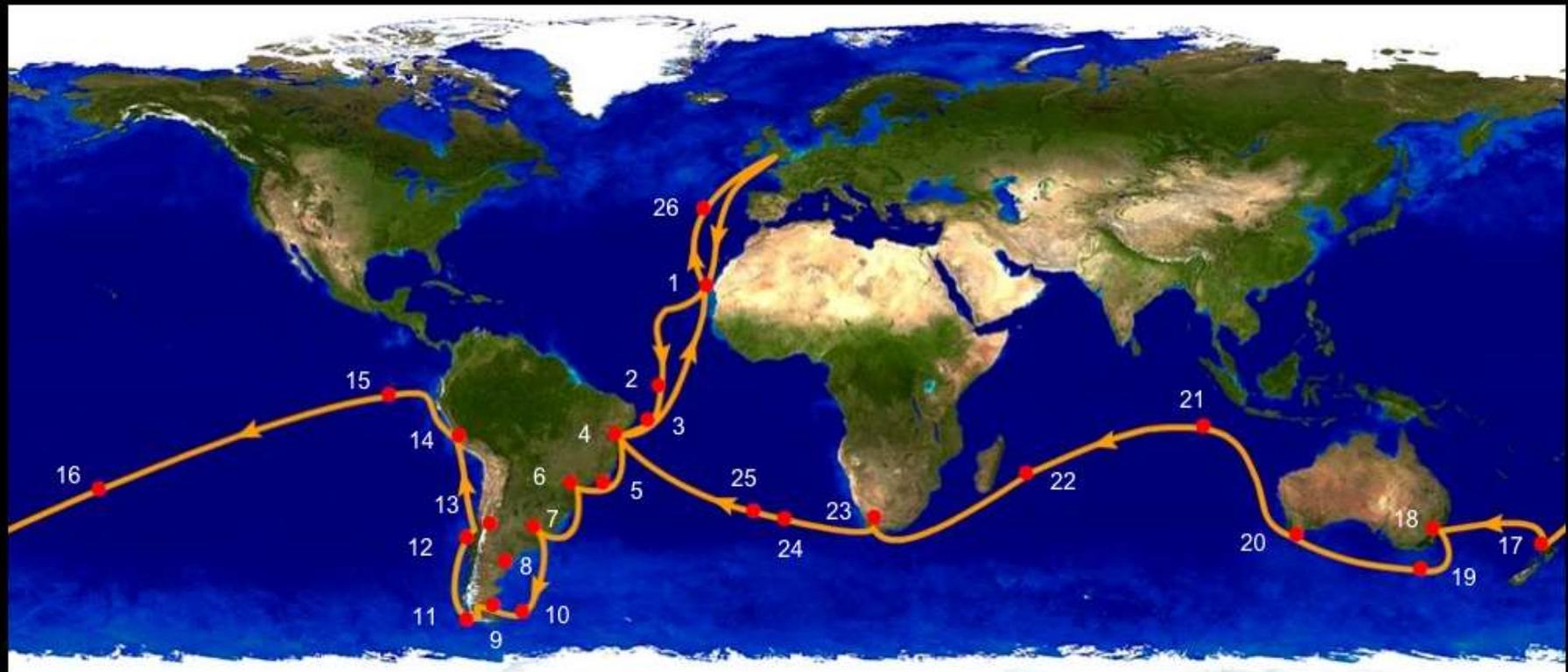


[Home](#) [Pegmatites](#) [Microprobe](#) [Virtual Microscope](#) [Mars](#) [NASA/Apollo](#) **Darwin** [BGS](#) [Ref Cards](#) [Meteorites](#)



## The Darwin Virtual Microscope

**A selection of samples collected  
by Charles Darwin on the Voyage of the Beagle**



# The Darwin VM



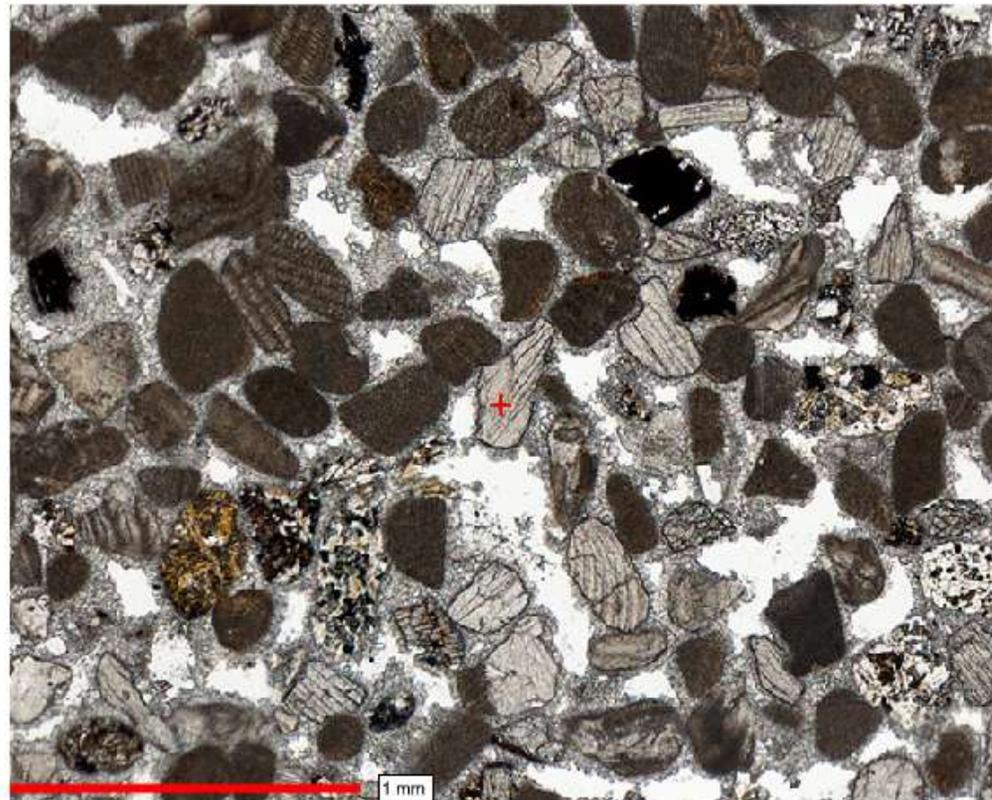
- The Darwin virtual microscope can be viewed at:  
[microscope.open.ac.uk](http://microscope.open.ac.uk)

# Saint Helena



CD3717 Consolidated beach sand

CD3717 Consolidated beach sand



Cross hairs at: X= 5538, Y= 4506

X  Y  Go

low high



## Description

A complex consolidated beach sand consisting of both igneous and sedimentary material. Individual mineral grains such as [pyroxene](#) occur with igneous [rock fragments](#), ovoid [micritic pellets](#) and [shell fragments](#) are all cemented together with a spary calcite cement.

Location: Saint Helena

Field c



# Access to rare samples such as moon rocks



The Lunar virtual microscope can be viewed at:  
[microscope.open.ac.uk](http://microscope.open.ac.uk)

[Home](#) [Pegmatites](#) [Microprobe](#) [Virtual Microscope](#) [Mars](#) **[NASA/Apollo](#)** [Darwin](#) [BGS](#) [Ref Cards](#) [Meteorites](#)



## OU-NASA Virtual Microscope



### Welcome

The Open University's Department of Earth and Environmental Sciences and Knowledge Media Institute have been working on virtual microscopes for many years. This collaboration has resulted in the creation of virtual microscopes for teaching purposes (current microscopes form part of two courses - S276 *Geology* and S339 *Understanding the Continents*). More recently we have established partnerships with other organizations (such as the Sedgwick Museum in Cambridge) to create microscopes for a more general audience.

The application you see here is the outcome of a partnership with NASA Johnson Space Center (the home of Moon rock collected by the Apollo astronauts between 1969 and 1972), and in particular with NASA scientists Everett Gibson, Gary Lofgren and Charles Meyer. Colin Pillinger of the Open University's Planetary and Space Sciences Research Institute also contributed to the



# Lunar virtual microscope



Low-Ti basalt  
12002

Mg-rich basalt  
12005

Olivine basalt (rapidly cooled)  
12009, 11

Ilmenite basalt  
12022, 110

**APOLLO 14**  
Aluminium-rich basalt  
14053, 261

Polymict breccia  
14305

Impact melt breccia  
(clast poor)  
14310, 167

**APOLLO 15**  
Pigeonite basalt  
(coarse-grained)  
15065, 83

Regolith breccia  
15299

61016, 217

Feldspathic regolith breccia  
61295, 32

Impact melt breccia  
65015

Melt rock with  
metal/sulphite phases  
66095, 11

Immature feldspathic  
regolith breccia  
67016, 399

Highlands regolith  
68501

**APOLLO 17**  
High-Ti basalt  
70017

Mature mare regolith  
70181

High-Ti basalt  
71035, 29

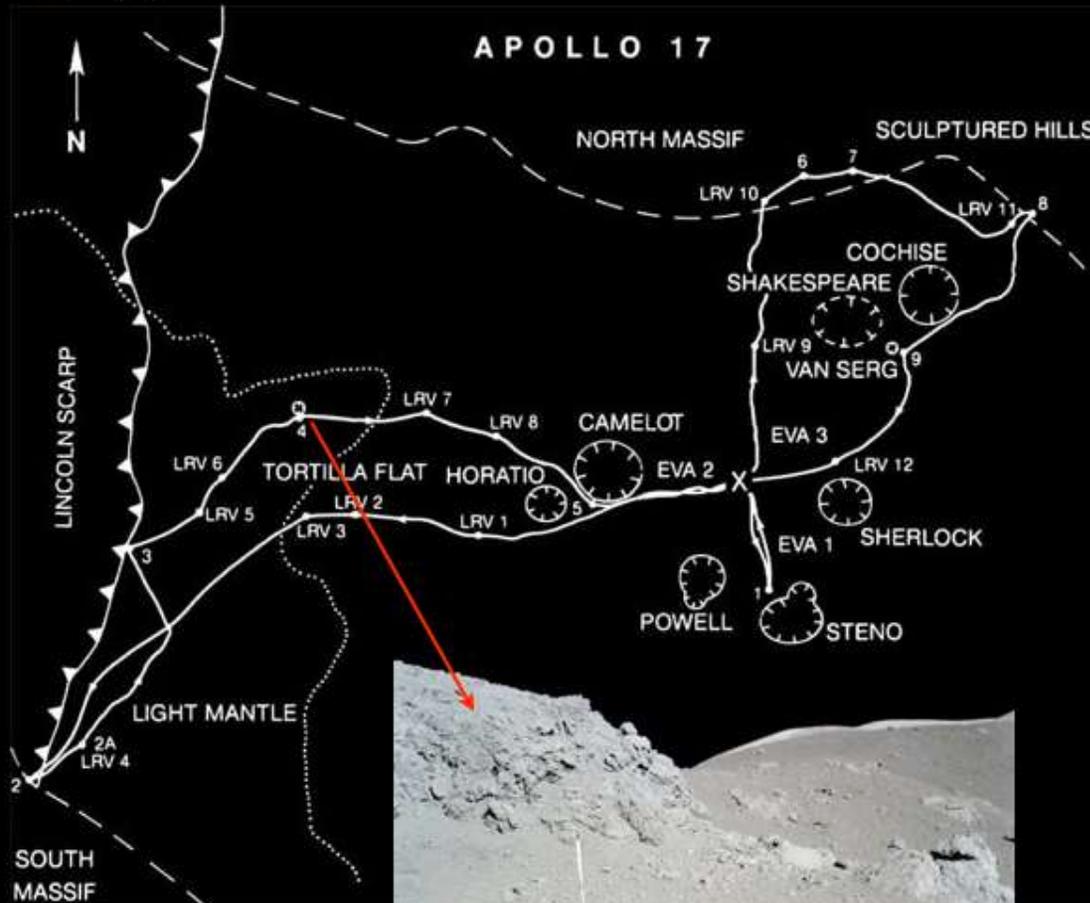
Feldspathic regolith breccia  
72275, 148



# 74220 Lunar soil



## OU-NASA Virtual Microscope



### Apollo 17: Orange spherule regolith (sample # 74220)

Soil sample 74220 was discovered at Shorty Crater. Most of the sample consists of orange glass although a proportion of the glass has devitrified and is now black where fine olivine needles and ilmenite feathers have grown. Compositionally the black "glass" is identical to the orange glass.

The sample is part of a pyroclastic deposit and has the same age as the mare basalts (3.6 billion years old).



[Click here for a QTVR panoramic movie of this location](#)

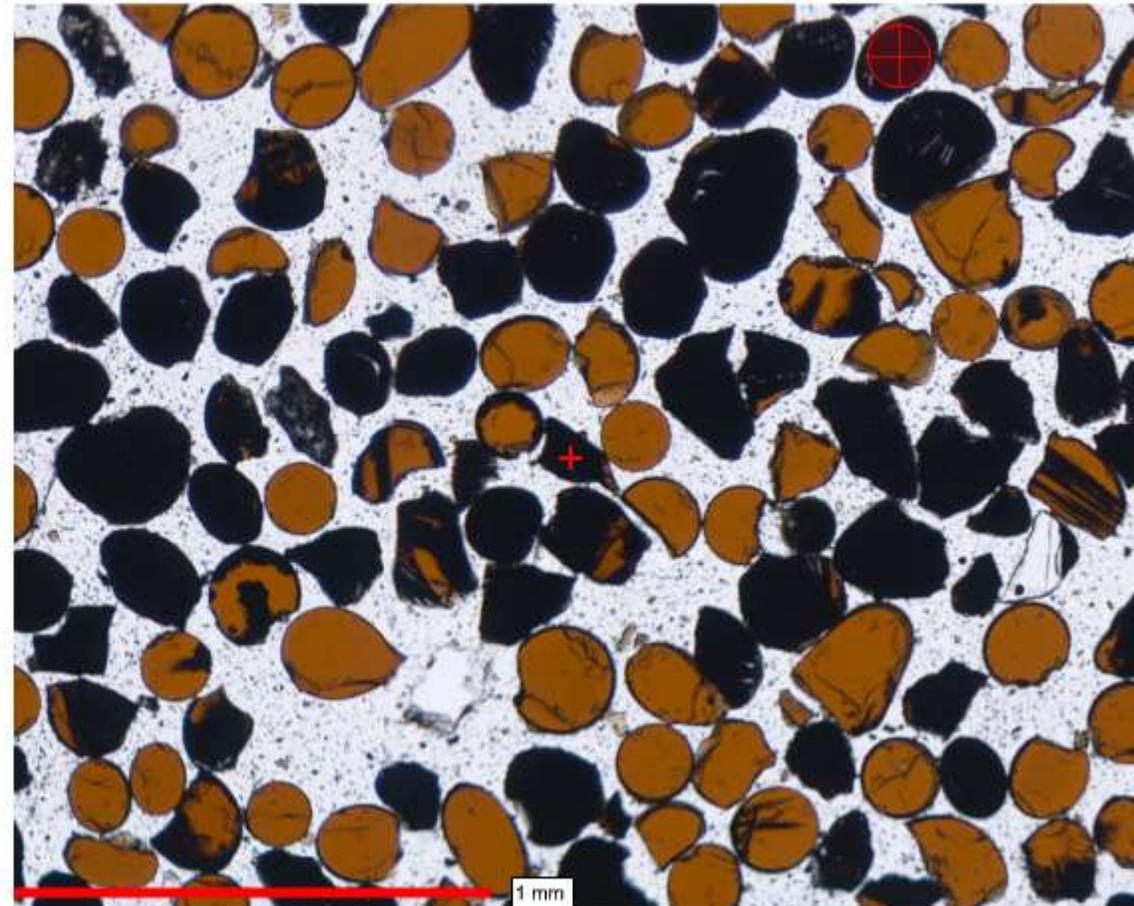


## 74220 Orange spherule regolith

Field of view = 2.2 x 1.7 mm

select a rock specimen...

74220 Orange spherule regolith



### Description

A Lunar soil samples containing predominantly orange and black spherules, with some mineral and rock fragments. Location: Taurus-Littrow Region. Mission: Apollo 17. Age: 3480 million years. Petrogenesis: The orange and black spherules in this soil have the same composition (the black spherules are partially crystallized), and are thought to be volcanic in origin.

### Magnification

- Full specimen
- Low
- Medium
- High

### Light

- plane-polarised
- crossed polars

### Measurement

- grid
- 10 mm graticule

rotate grid/ graticule



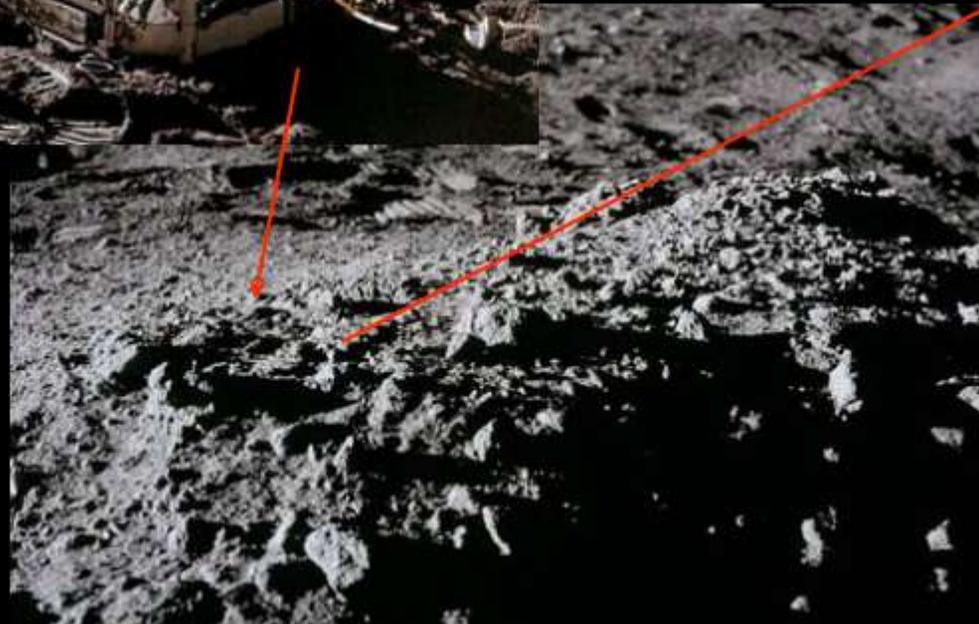
overlay colour

Cross hairs at: X= 2324, Y= 2101  
X  Y

low  high



# 12022 lunar basalt



A large piece of 12022 is on public display in the National Museum of Wales, Cardiff.

national  
museum  
wales  
amgueddfa  
cymru

# 12022



select a rock specimen...

12022 Ilmenite Basalt

## Description

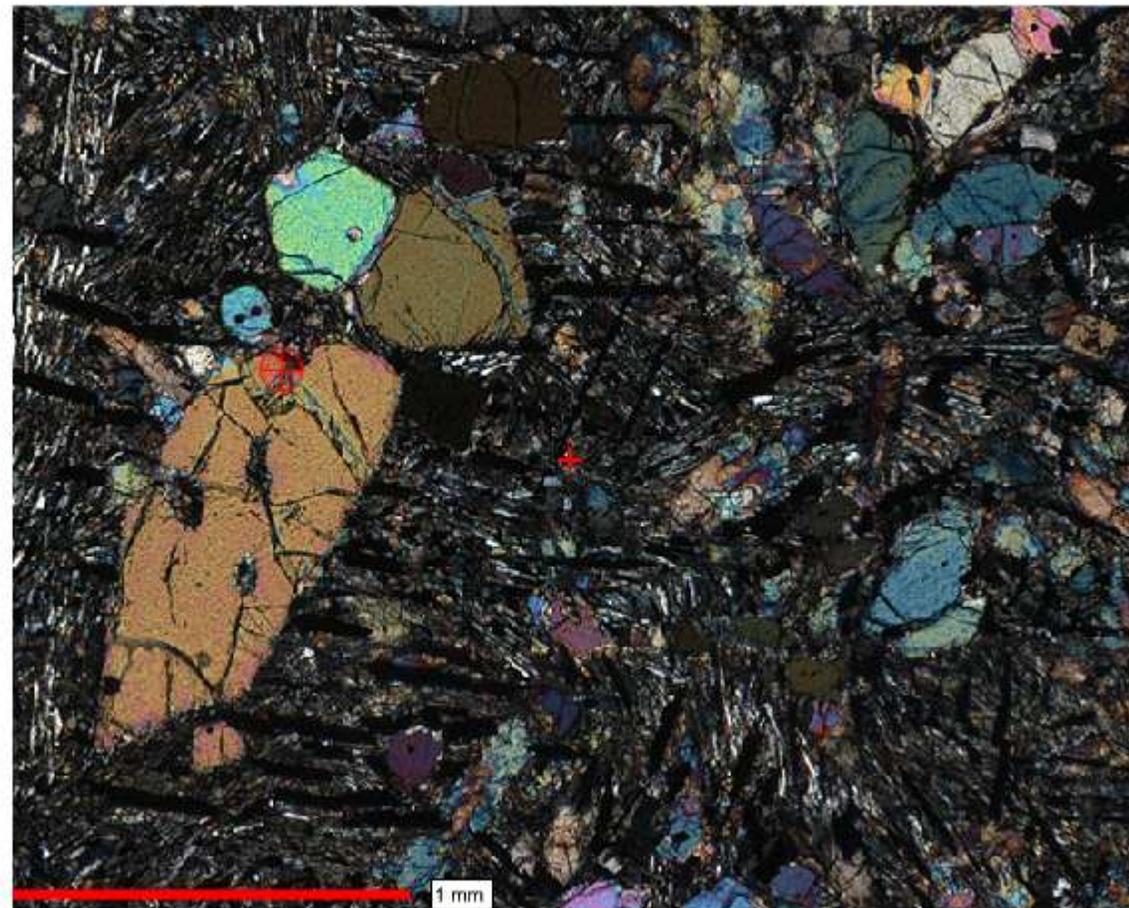
A medium-grained porphyritic mare basalt containing phenocrysts of **olivine** and **pyroxene** (augite and pigeonite). The groundmass consists of **feathery intergrowths of plagioclase feldspar**, ilmenite, pyroxene and a small amount of glass. Ilmenite has an interesting cross-cutting, parallel, skeletal habit. Accessory minerals include chromite, ulvo-spinel and iron-nickel metal.

Location: Oceanus Procellarum

Mission: Apollo 12

## 12022 Ilmenite Basalt

Field of view = 2.6 x 2 mm



### Magnification

- Full specimen
- Low
- Medium
- High

### Light

- plane-polarised
- crossed polars

### Measurement

- grid
- 10 mm graticule

rotate grid/ graticule

0°

overlay colour

Cross hairs at: X= 6984, Y= 3084

X  Y

low  high



# Mobile and other virtual microscopes



# Future



- Teaching collections
- Rocks of the British Isles – with BGS, just need the funding...