

# Crater dimension analysis

Key  
stage  
4/5

## The scenario

In 2018, scientists will be landing a seismometer on Mars and expect to start detecting signals from meteorite impacts early in 2019. Satellite images from Mars can be used to identify new impact craters; if we can locate these new craters and work out how much energy it took to create them, scientists will be able to use the seismic signals to discover more about the internal structure of Mars.

For this exercise, you are working in one of the project teams for this mission. Each team has been tasked to analyse techniques used to measure crater width and depth remotely.

Your group have decided to simulate impact craters using low-velocity experiments and then model satellite imagery with a phone, or tablet, camera. Your group has been told that the surface of Mars is very powdery like flour.

A homework could be to research the Mars Reconnaissance Orbiter including HiRISE and the other instruments it carries.

## Activity: remote measuring of your own craters

You will need to create a crater and an image that can be used to understand the science behind the technique.

### Preparing the crater

The landing area could be a deep baking tray or a cardboard box — something with high sides works well to prevent ejecta escaping. The landing area should be at least 30 cm by 30 cm. The landing material is a key factor to consider; flour has been found to be the best material although fine sand is a possibility.

The landing is prepared by slowly pouring the flour (or sand) into the container; the flour does not want to be too compressed, so a sieve should be used if possible. Shift the container from side to side to evenly distribute the flour. The flour should be to a depth of at least 5 cm.

You can investigate the patterns of impact craters in greater detail by tracking the ejecta by using a fine powder, which is a different colour to the flour; for example, cocoa powder, custard powder or powdered paint. Some of the

## Learning objectives

- scaling
- data validation
- using tangent, sine and cosine functions

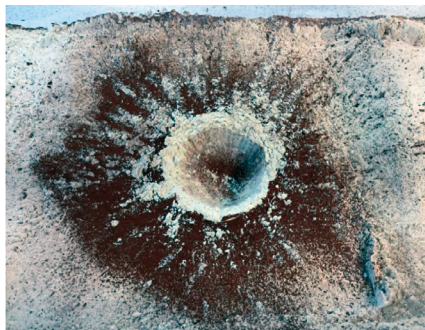
## Equipment needed

- deep baking tray or cardboard box (at least 30 x 30 cm)
- flour (enough to fill the above container to a depth of 5 cm)
- cocoa powder (for a thin ejecta 'blanket' layer)
- wooden ball (impactor c.1.75 radius; 30g)
- lamp (to produce a 'Sun shadow')
- iPad (with camera)
- 1 m ruler or measuring tape
- HiView software installation (free; [www.uahirise.org/hiview](http://www.uahirise.org/hiview))
- Paint or Photoshop image manipulation software



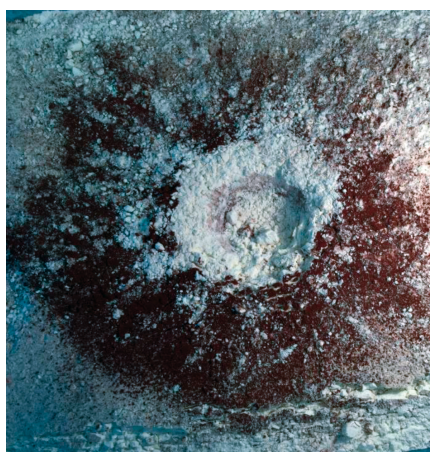
coloured powder is sieved onto the surface of the flour when preparing the impact area; this will allow the ejecta and rays thrown up from the impact event to be seen and measured.

The best impactor has been found to be a wooden ball (the density is a key factor) of radius around 1.75 cm and mass of 30g, dropped from a height of roughly 60 cm produces a crater as shown below.



### **Making a shadow**

A table lamp angled at 45° will model the Sun and produce a shadow in the crater as shown below.



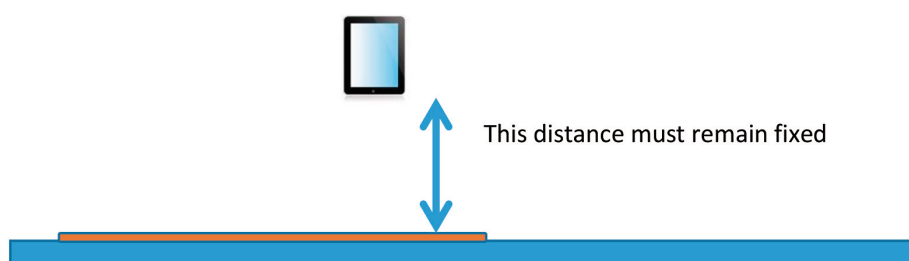
### **Producing a scaling image**

Fundamental to the technique is an understanding of:

- resolution — what distance each pixel on the image represents
- image size — how many pixels make up the image

It is vital to use the same camera and from the same height each time. We used an iPad.

A scaling image is first taken as seen on the following page.

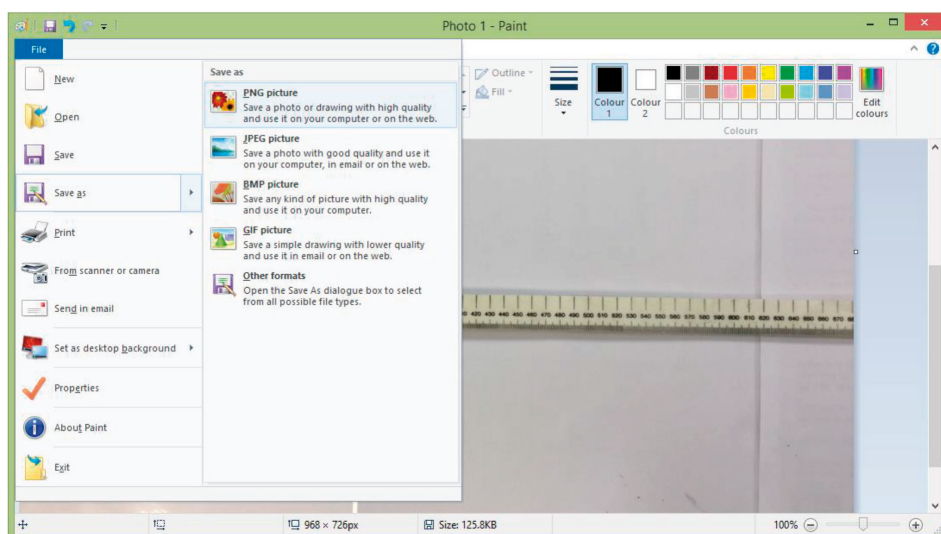


This results in an image as shown below.



### Converting the image for analysis

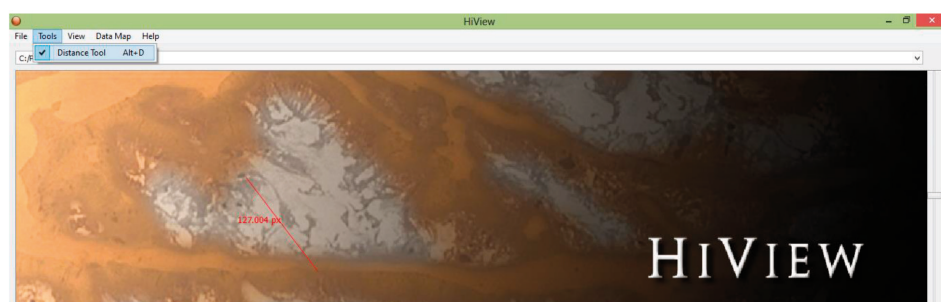
The image needs to be downloaded from the iPad (for which there are various methods) and it will probably be stored as a JPG file. It will need to be converted to a PNG file for use in HiView. Do this by opening it in Paint and using the Save as... function.



### Installing HiView

#### *Using the measuring tool in HiView*

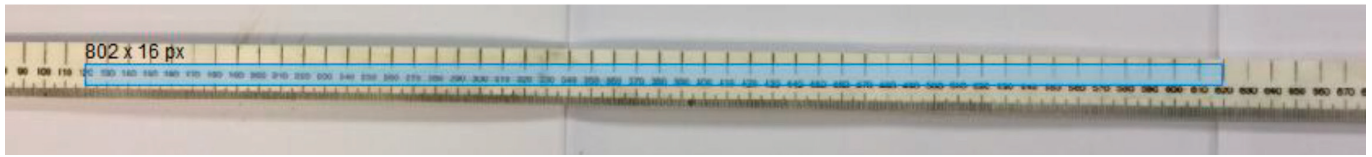
The PNG image is then uploaded into HiView and the measuring tool is used to count the number of pixels along a distance of the ruler. Click on tools and select the Distance Tool as shown below.



Download HiView at:  
[www.uahirise.org/hiview](http://www.uahirise.org/hiview)



Click on the starting position in the image and drag the tape measure across the image: HiView will count the pixels in the image. This produces a result like this:



### Calculating the resolution

So we have 802 pixels representing a distance of 500 mm, so our resolution (with this camera and at this height) is:

$$\text{Resolution} = 500/802 = 0.61 \text{ mm per pixel}$$

### Measuring the crater

The crater image can be analysed in the same way using HiView: convert to PNG and upload the image into HiView and use the measuring tool to count the pixels.



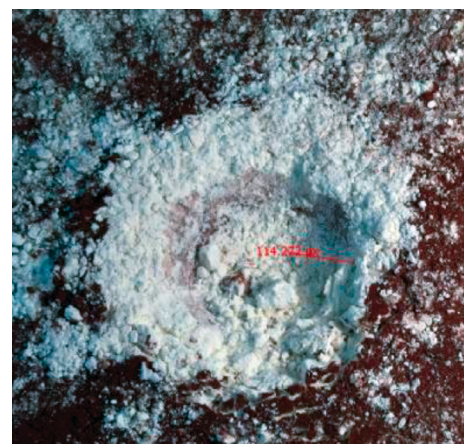
The image is 324 (rounded from 323.79) pixels in diameter and, since we used the iPad at the same height, each pixel is 0.61 mm in actual length.

So the crater has an actual diameter of:

$$\text{Crater diameter} = 324 \times 0.61 \text{ mm} = 197 \text{ mm}$$

Which can then be directly measured to validate the technique

The crater depth formula can now also be used; firstly measure the shadow length.



A shadow length of 114 pixels represents a distance of  $(114 \times 0.61)$  69.5 mm. Using the shadow formula

$$d = \tan (90-\theta) \times L$$

Where the incident angle is 450 gives crater depth as

$$d = \tan (45) \times 69.5$$

$$= 69 \text{ mm}$$

Which again can be checked by direct measurement.

## Activity: analysis of real craters using HiView

The High Resolution Imaging Science Experiment (HiRISE) is a camera on board the Mars Reconnaissance Orbiter. It consists of a 0.5 m aperture, reflecting telescope; the largest so far of any deep space mission, which allows it to take pictures of Mars with resolutions of 0.3 m per pixel, which can resolve objects below a metre across.

Images taken by the HiRISE camera have been stored in an online database with free access.

### The HiRISE database

You can get online to the HiRISE database via <https://hirise.lpl.arizona.edu>



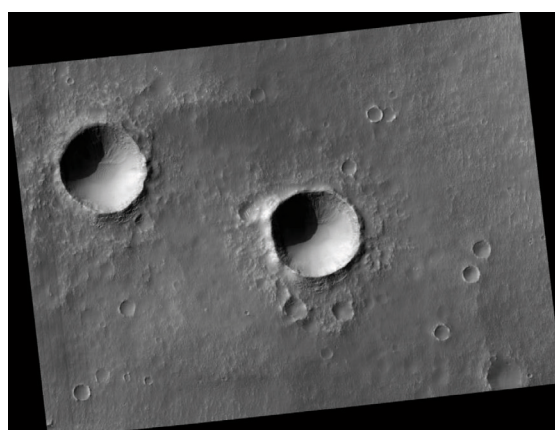
There are lots of different functions in the database and just clicking on some of the images produces some fascinating images.

### Downloading a crater image

If you want to download an image of a crater, the easiest way to do this is to use the search function. The search box requires a PSP or ESP reference number to identify the image. A list of potential crater images is given in the Excel file 'New crater Excel 2007–2013'.

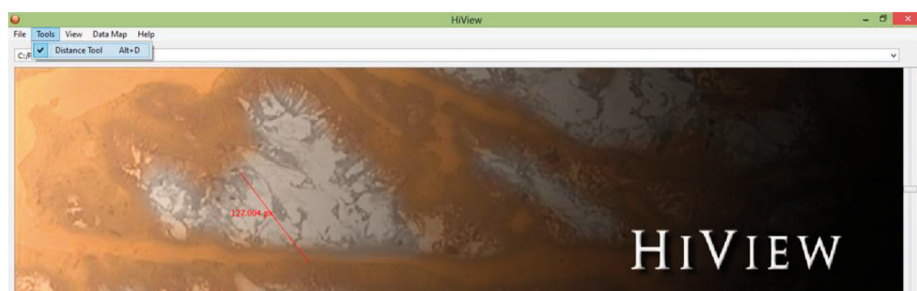
The example used here is PSP\_001750\_1425

Note: to complete the HiView activity you must use the full resolution image, any compressed image will ruin your analysis. The grayscale JP2 red channel is the least compressed. These are very large files and will take a few minutes to download.



Once the images have been selected and the impact craters identified it is time to take measurements. The technique is exactly the same as for your own craters. You will need to install HiView from [www.uahirise.org/hiview](http://www.uahirise.org/hiview).

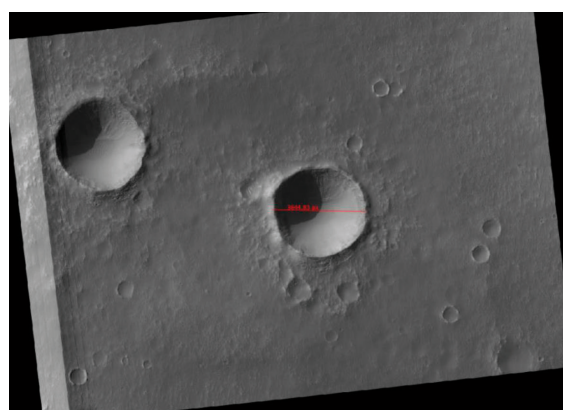
Upload the image into HiView and use the distance tool to count the pixels



Use the resolution (in this case 25 cm per pixel) to calculate the diameter of the crater

$$\text{Diameter} = 3645 \times 25 \text{ cm} = 911.25 \text{ m}$$

The published value for the craters is in the region of 900 m.



The data for this image was given as

Resolution (e.g. 25 cm per pixel)

Incident angle (e.g. 720°)

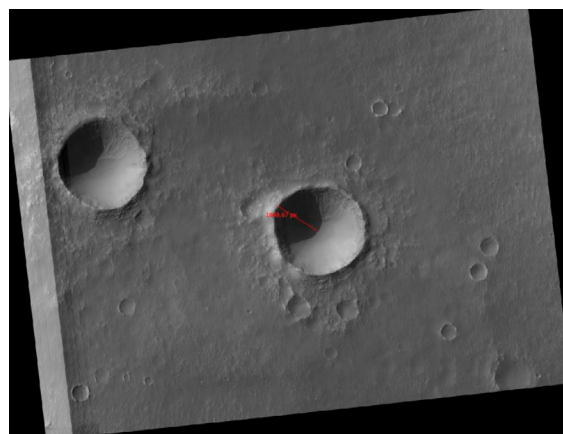
Emission angle (e.g. 6.20°)

So we use the measuring tool to count the pixels for the shadow length and then use the shadow length formula to give:

$$d = \tan(90 - \theta) \times L$$

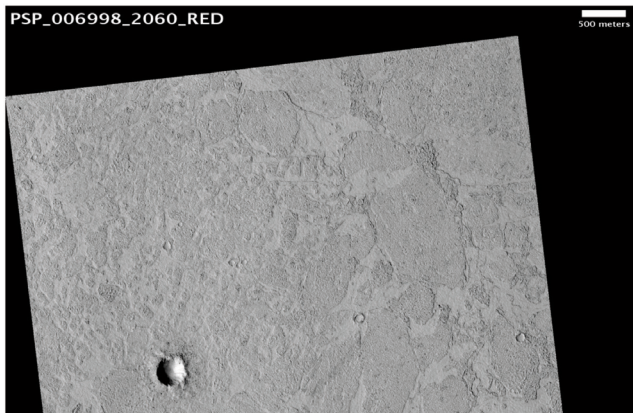
$$d = \tan(90 - 72) \times 4339.5 \text{ cm}$$

$$d = 1409.9 \text{ cm} = 141 \text{ m}$$



## Activity: analysis of real craters using map projected images

Using HiView can be a bit of a blocker for some students. However, images can be downloaded from the HiRise database, in this example PSP\_006998\_2060 as map projected images.



These images have a scale printed on the image, so any resizing due to printing will be always be in proportion so this can be used to measure the diameter and shadow length of the crater.