Tom Lyons

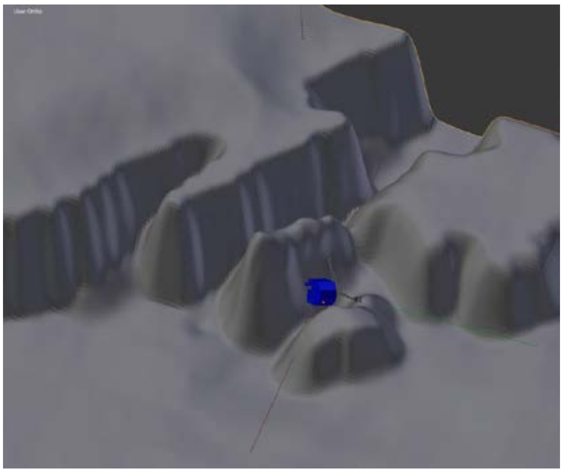
The landing
Philae touches down

In two recent issues of CATALYST, ***Tom Lyons*** *described how the Rosetta spacecraft travelled across the Solar System to rendez-vous with Comet 67P Churyumov-Gerasimenko, and how the landing craft Philae, carrying a payload of scientific instruments, was prepared to descend on to the comet's surface. Now the first results are in from this audacious mission.*

After a 10-year wait, on 12th November 2014, the Philae lander was dropped towards the surface of Comet 67P. Due to the very weak gravitational acceleration of the comet, release to landing took around 7 hours. Compared to a landing on Mars, which from orbit to surface takes nearer 7 minutes, the technology required is far more basic but just as fraught with uncertainties. Rather than being concerned about crashing into the surface, this landing was all about trying not to bounce off.

Anxious scientists await the first signals indicating that Philae has landed safely on the comet surface, 12th November 2014.

Philae had three mechanisms by which it should secure itself to the ground: boosters to prevent bouncing, harpoons to attach to the surface, and drills on its feet, as a final measure. Unfortunately, even before landing, the boosters had failed. Initially, scientists in the control room at Darmstadt announced a successful landing on the surface. After some time, however, it became clear that Philae had bounced. This was in fact a two hour bounce, which took it over 1 km from the landing site. A second, shorter bounce then took Philae to its final resting place, in a shadow at the edge of a crater, next to a cliff, lying on its side – or as some described it 'stuck between a rock and a hard place'.



(top) The Philae lander leaves the Rosetta spacecraft, heading for touchdown on Comet 67P; (left) Philae is awkwardly positioned in the shadow of an icy cliff.

There was then a race against time to collect as much data from Philae's instruments as possible before its batteries ran out of power. The team knew that they had around 60 hours before Philae would get so low on power that it would go into hibernation. The original plan was to try to increase this time by charging the battery from the solar cells, but in its final landing position this was not possible. It is hoped that Philae may awaken again as the comet gets closer to the Sun.

Comet surface

Despite the problems with attaching itself to the surface, the landing was a great success. Philae was able to record data and download this, via Rosetta, to Earth.

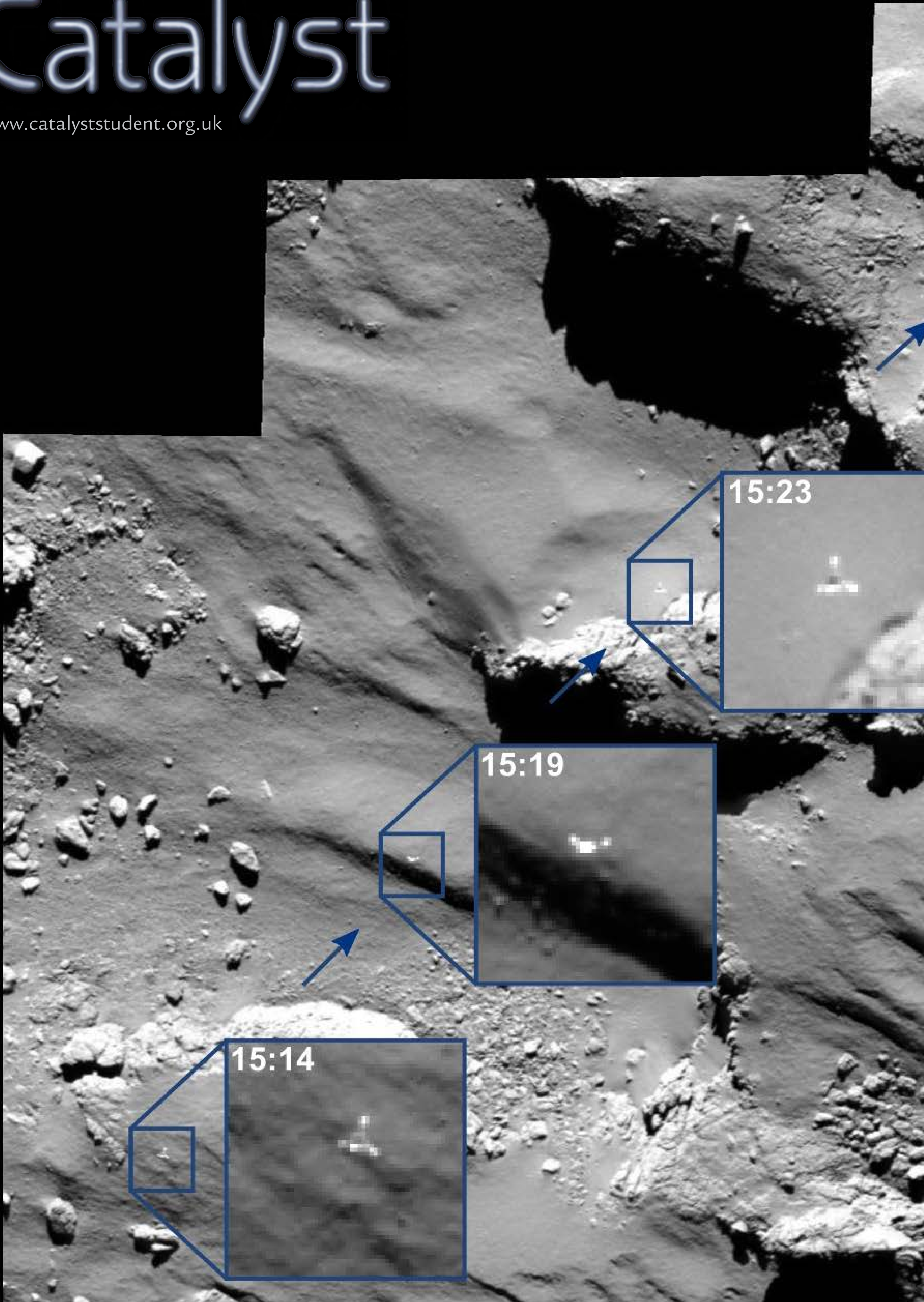
The ROLIS camera showed that the surface of the comet was made of pea-sized gravel with some larger pieces mixed in. The top layer appears to have very low strength – crumbling to dust when disturbed.

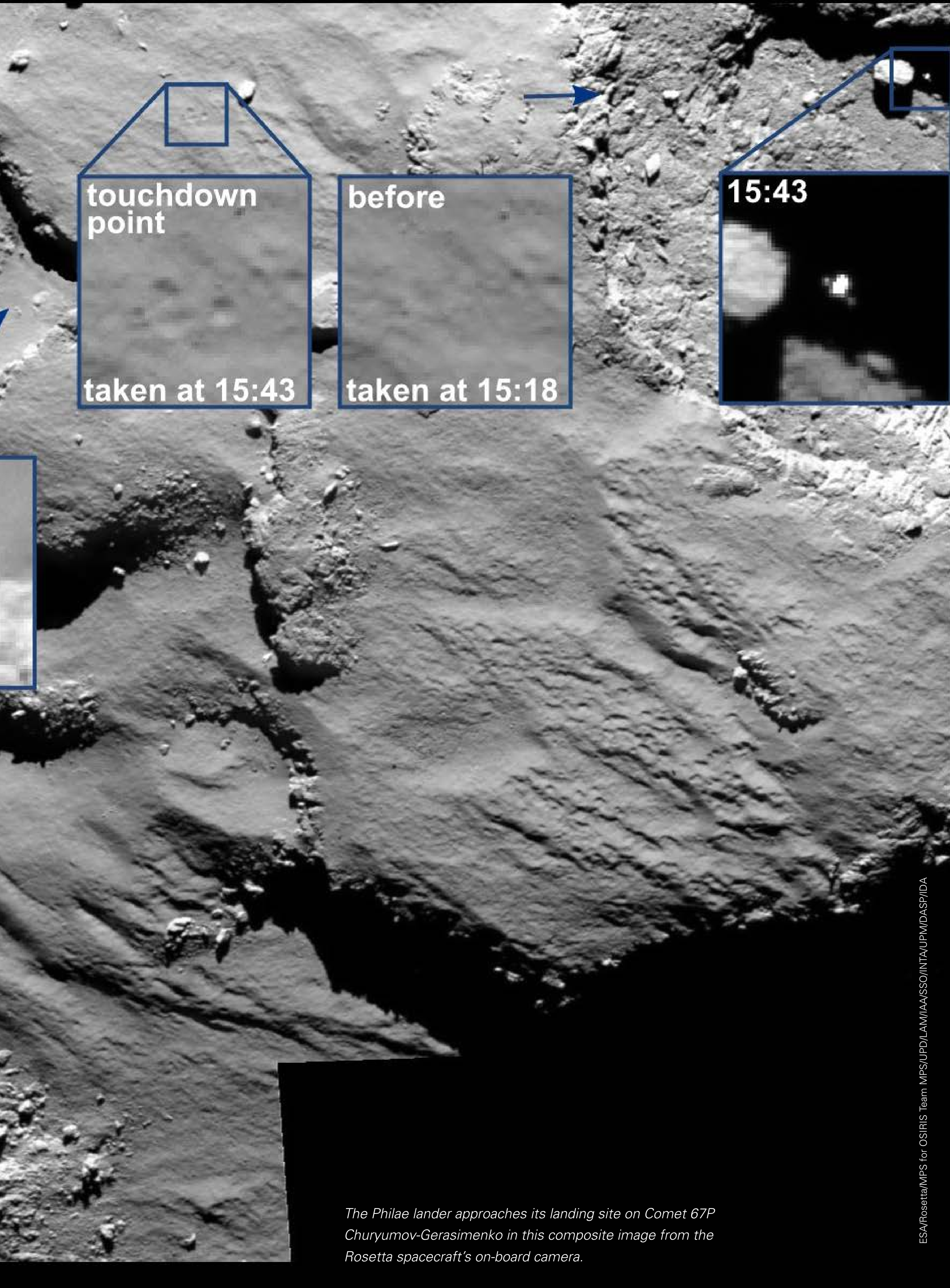
The surface of Comet 67P seen from just 40 m above the comet's surface. The large block at top right is 5 m across.

The composite photo on pages 10-11 shows the Philae lander as it approached its landing point at 0.5 m/s. You can see where it bounced at 15:43. Each square is 17 m across. Rosetta was 15 km above the comet surface when it took these photos.

Catalyst

www.catalyststudent.org.uk





The Philae lander approaches its landing site on Comet 67P Churyumov-Gerasimenko in this composite image from the Rosetta spacecraft's on-board camera.

Analysing water vapour

Much of the data from Philae's time on the surface still requires further analysis but important results have already been found using instruments on board the Rosetta spacecraft. The Rosina instrument has provided the most significant science to date. It has tested the idea that most of the water on the surface of the Earth came originally from comets, but the data from Rosetta is casting doubt on this hypothesis. It has analysed water vapour coming from the comet, and found it to be to be significantly different to that found on Earth.

The ratio of deuterium to hydrogen within the water vapour provides the signature as to whether the water is the same type as on the Earth. Deuterium is an isotope of hydrogen – a deuterium atom is a hydrogen atom with an extra neutron in its nucleus. It is found in very small proportions in water on the Earth but several times more was found in the water coming from Comet 67P. Despite asteroids containing much less water than comets, it appears that their D/H ratio is much closer to that of the Earth, and they are therefore much better candidates for bringing water to our planet.

ROSINA is the Rosetta Orbiter Sensor for Ion and Neutral Analysis instrument and comprises two mass spectrometers: the double focusing mass spectrometer (DFMS) and the reflectron time of flight mass spectrometer (RTOF) – and the cometary pressure sensor (COPS). The measurements reported here were conducted with DFMS.

The future

Rosetta continues to orbit Comet 67P, its closest approach (186 million km) to the Sun occurring in August 2015. As the spacecraft gets closer to the Sun, the volume of gas and dust leaving the surface of the comet, known as the coma, will increase. This will enable more detailed measurements of the composition of the comet. The increased light level may also enable the lander Philae to come out of hibernation and take more in-situ data from the surface of the comet, presuming it survives the increasingly harsh environment around the comet.

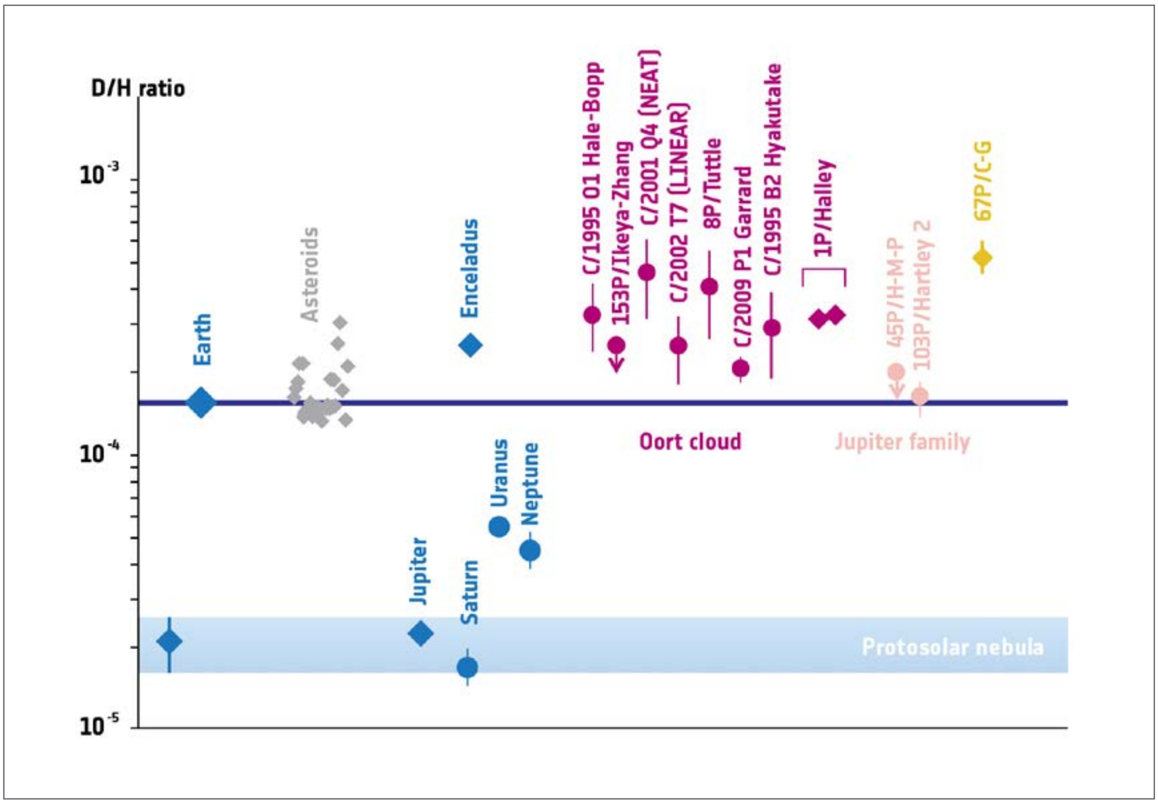
Rosetta's mission ends in December 2015, although data may still be coming from the satellite beyond this time. As ever, with complex space missions, the data from the satellite will be analysed for many years to come.

Tom Lyons has worked as an engineer on space satellite systems. He now works at the National STEM Centre in York.

Look here!

Find out how a mass spectrometer can distinguish between hydrogen and deuterium atoms: *http://stem.org.uk/rxbm6*

Rosetta-themed science resources for schools: *http://stem.org.uk/cx3yd*



The different values of the deuterium-to-hydrogen ratio (D/H) in water observed in various bodies in the Solar System. The data points are grouped by colour as planets and moons (blue), meteorites from the Asteroid Belt (grey), comets originating from the Oort cloud (purple) and Jupiter family comets (pink). Rosetta's Jupiter-family comet 97P is highlighted in yellow; its D/H ratio is more than 3 times that found in water from the Earth's oceans.