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ROSINA restarts debate on origin of Earth's oceans

The question about the origin of the terrestrial oceans is one of the most important questions with respect to the formation of the Earth and the origin of life. The most popular theory is that water was brought by impacts of comets and asteroids. Data from the instrument ROSINA from the University of Bern now show, that water didn't come from comets like Chury.

Researchers agree that water must have been delivered by small bodies at a later stage of the planet's evolution. It is, however, not clear which family of small bodies is responsible. There are three different possibilities with increasing distance from the Sun: asteroid like small bodies from the region of Jupiter, Oort cloud comets which were formed inside of Neptune and finally Kuiper belt comets which were formed outside of Neptune.

The key to determining where the water originated is in its isotopic «flavour». That is, by measuring the level of deuterium (D) – a heavier form of hydrogen (H). By comparing the ratio of deuterium to hydrogen (D/H value) in different objects, scientists can identify where in the Solar System that object originated. Moreover, by comparing the D/H value for Earth's oceans – 1.5×10^{-4} – with that in other bodies, scientists can aim to identify the origin of our water.

New in situ measurements of ROSINA

The ROSINA instrument, developed, built and tested at the University of Bern and part of the suite of instruments on-board the Rosetta orbiter of the European Space Agency ESA, has determined the composition of Comet 67P/Churyumov-Gerasimenko's water vapour, finding it to be significantly different to that found on Earth. The ratio for D/H on the comet is more than three times the terrestrial value (5.3×10^{-4}). This is among the highest ever measured values in the solar system. That means it is very unlikely that comets like 67P/Churyumov-Gerasimenko are responsible for the terrestrial water. «We knew that Rosetta's in situ analysis of this comet was

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always going to throw up surprises for the bigger picture of Solar System science, and this outstanding observation certainly fuels the debate as to where Earth got its water from», says Matt Taylor, ESA's Rosetta project scientist.

Measurements since the 1980s didn't support the comet's origin of our water

Almost 30 years ago (1986) the mass spectrometers on board the European Giotto space craft to comet Halley could, for the first time, determine the deuterium to hydrogen (D/H) ratio in a comet. Already this in situ measured result came from the department of Space Research and Planetary Sciences of the Physics Institute of the University of Bern. It turned out to be twice the terrestrial ratio. The conclusion at that time was that Oort cloud comets, of which Halley is a member, cannot be the responsible reservoir for our water. Several other Oort cloud comets could be measured in the next 20 years, all displaying very similar D/H values compared to Halley. Subsequently, the models which had comets as the origin of the terrestrial water became less popular.

Findings of the 1980's revisited in 2011

This changed when the ESA Herschel space telescope determined the D/H value in comet Hartley 2, which is believed to be a Kuiper belt comet. The D/H ratio found was very close to our terrestrial value - which was not really expected. Most models on the early Solar System claim that Kuiper belt comets should have an even higher D/H ratio than Oort cloud comets because Kuiper belts objects were formed in a colder region than Oort cloud comets.

Asteroids are likely to have delivered the water

Due to the new findings of the Rosetta mission it becomes more likely that Earth got its water from asteroid like bodies closer to its orbit and/or that the Earth could actually preserve at least some of its original water in minerals and at the poles. «Our finding also disqualifies the idea that all Jupiter family comets contain Earth ocean-like water. This surprising finding could indicate a diverse origin for the Jupiter-family comets – perhaps they formed over a wider range of distances in the young Solar System than we previously thought. Our results rather support models that include asteroids as the main delivery mechanism for Earth's oceans», says Kathrin Altwegg, principal investigator for the ROSINA instrument and lead author of the paper reporting the results in the journal *Science* this week.

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The ROSINA (Rosetta Orbiter Spectrometer for Ion and Neutral Analysis) instrument package was designed and built by an international consortium led by the Space Research and Planetary Sciences Division, Physics Institute, University of Bern, Switzerland, that is additionally the host of ROSINA's principal investigator Kathrin Altwegg. Hardware subsystems were delivered by the Belgian Institute for Space Aeronomy (BIRA-IASP), Brussels, Belgium, the Research Institute in Astrophysics and Planetology (IRAP), Toulouse, France, the Institut Pierre Simon Laplace (IPSL), Paris, France, the Lockheed Martin Advanced Technology Center (LMATC), Palo Alto, USA, the Max Planck Institute for Solar System Research (MPS), Göttingen, Germany, the Institute of Computer and Network Engineering at the TU Braunschweig (IDA-TUB), Braunschweig, Germany, and the University of Michigan - Atmospheric, Oceanic and Space Sciences (UMich-AOSS), Ann Arbor, USA.