# Wet moon, lucky moon

On Monday 26 October 2020, NASA revealed a sensational discovery about our Moon: there is definitely water, also on its sunlit surface. The announcement was made with a press conference streamed at 5 p.m. Italian time. The notion that there is water on the Moon was more than just a suspicion, but the SOFIA airborne observatory has now spotted it at the bottom of a crater, where the temperature is -200°C because it is never exposed to sunlight. But don't imagine lakes and rivers: the water is formed of tiny crystals mixed with regolith, lunar sand.

SOFIA (Stratospheric Observatory for Infrared Astronomy) is equipped with a 2.5-metre diameter telescope installed on a Boeing 747, a large airliner with no passenger seats and a big opening in the fuselage: the window through which the telescope overlooks the sky. The plane flies at an altitude of 12,000 metres: here, the rarefied, transparent air makes it possible to record extraordinarily high-quality observations.

The presence of water on the Moon is encouraging for the scientists of the Artemis project, which will take a pair of astronauts, a woman and a man, to walk on the satellite by 2024 and, perhaps, the first crew on Mars in 2030. Indeed, the Moon could become an intermediate stage on the great journey from Earth to the Red Planet: the lunar water could quench the astronauts' thirst and irrigate the space gardens. The NASA website contains wonderful detailed descriptions of all the equipment and technologies that will bring humanity back to the Moon 50 years after the last walk.

What is the origin of lunar water? It most likely came from asteroids bombarding its surface, in a similar manner, according to one hypothesis, to what happened on Earth. But while the water here is liquid, up there it is a kind of dust. Liquid water is a rarity. Drinking a glass of water is the easiest thing in the world. In this world. Very special and very rare conditions are required for water to be in a liquid state: our planet is a marvellous exception.

Water is an extraordinary molecule. It is tiny, consisting of only three atoms, two of which – the hydrogen atoms – are the smallest in existence. The third is an oxygen atom, which is large enough to attract the electrons of the two hydrogen atoms. The well-known chemical formula $H_2O$ signifies one atom of oxygen (O) plus two of hydrogen (H). Due to the unbalanced distribution of the electrons, i.e. negative charges, the water molecule behaves like a tiny magnet: oxygen is the negative pole, while the two hydrogen atoms are the positive pole. Water has a polarity – it is a polar compound. Much like magnets, water molecules attract and bond to each other in a fluid and dynamic lattice in which the bonds form and dissolve at a rate dependent on temperature: faster if the water is hot and slower if it is cold. At zero degrees, the bonds become stable and the water solidifies into ice; at a hundred degrees, the bonds are too fragile and the water turns into a gas: steam.

Like small magnets, water molecules attach to substances, infiltrate crystals, break bonds and dissolve matter. Water is an extraordinary solvent, exclusively dissolving everything, which, like it, has a polar nature: salt, sugar, lime and bicarbonate. Neutral molecules, i.e. without surface electric charges, are referred to as apolar and do not dissolve in water. Water rejects them and those immersed in the liquid aggregate in large drops, like oil on the surface of a glass of water. The interactions between the water solvent, solutes and apolar molecules are the chemical basis of life.

Water covers 71% of the Earth's surface, but only comprises one thousandth of the planet's total volume. If all the water on Earth was collected in a single sphere, it would be a ball sixteen times smaller than the Moon. A vital and daily presence, water is so familiar that we lose sight of its mysterious origin. Where does the water in our glass come from, the water in the seas, the water that constitutes up to 70% of our body? The debate on the origin of water on our planet

remains open. Some theories argue that water is of extraterrestrial origin, while others claim that it formed together with the Earth.

Comets are solid blocks of rock fragments held together by abundant frozen water and solid-state gas, such as carbon dioxide in the form of dry ice. Theories that claim that water originates from “space” argue that water-rich celestial bodies, such as comets and particular asteroids (carbonaceous chondrites), bombarded the newborn planet and released this precious substance on the surface. More recent theories consider it more likely that water was already present in the cloud of gas and debris that surrounded the sun and produced the planets. So, according to this view, the Earth is the child of that ancient wet dust. It is fascinating to think that we are drinking a sip of space in our glass.

Recently, a group of Italian researchers discovered liquid water on Mars by analysing the radar data collected by the Mars Express probe in orbit around our red cousin. Below the surface, at a depth of around 1500 metres, there is a lake that extends for twenty square kilometres and is therefore as large as Lake Orta in Piedmont. It is likely to be salty because the water is liquid even though the recorded temperature is below zero: we know that salt, also on Earth, lowers the freezing point of water. Together with the caps that whiten the poles of Mars, this salt lake is what remains of the abundant water that once flowed on the planet’s surface. We can be certain of this because Mars still contains traces of ancient seas, rivers and lakes dried up by solar wind, the flow of charged particles emitted by the star, which swept the planet’s surface, eliminating its water and, perhaps, simple forms of life. The underground lake, however, may still contain the descendants of what was left of life on Mars, although this would not be anything more complicated than a bacterial cell. The Earth is also constantly swept by solar wind, but fortunately the powerful magnetic field that moves our compasses repels the flow of radiation into space. At the poles of our planet, the auroras turn this continuous struggle between solar particles, the magnetic field and the atmosphere into a magnificent sight.

There is also water on the Moon: ice accumulated at the bottom of the craters that are always in shadow in the polar regions of the Earth’s satellite. Similarly, water can be found on the moons of other planets in the solar system. For example, beneath the frozen surface of Enceladus, a small moon of Saturn, there is an immense salty ocean. This was revealed by the Cassini spacecraft that orbited Saturn and its satellites for thirteen years before crashing into the ringed planet’s surface in September 2017. Cassini took Huygens with it, a small probe which detached in 2004 to travel around Titan for a while and then land on it. Titan is something else. On Saturn’s largest moon, the seas, lakes and rivers and even the rain are made of methane. It is an inhospitable environment for life as we know it. On this world.

*By Andrea Bellati*