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FROZEN RESERVOIRS OF WATER UNDER THE SURFACE OF MARS

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Abstract. *At the beginning of the 21st century, with the help of the equipment of the orbital stations, geological structures were discovered on the surface of Mars, which could have arisen only under the influence of powerful liquid flows. A little later, the photographs revealed new signs of traces of water, which spread over several geological layers. Open bodies of water cannot currently exist on the surface of Mars. Therefore, only possible underground and subglacial reservoirs remained from the planet's once powerful hydrosphere. Recently, it turned out that this permafrost can sometimes melt under the influence of sunlight in summer seasons. In the images from the Martian orbital stations, it was possible to discover fresh traces of streams that very recently flowed down the slopes of the Martian hills inclined to the Sun in the mid-latitudes of the planet. The detection of phyllosilicates and hydrated sulfates on the surface of Mars also indicates that water was present on the surface of Mars in the past. Subsequently, the water-altered rocks were covered by lava fields. Nowadays, erosion has only in some places exposed ancient rocks containing phyllosilicates.*

Key words: *Mars, streams of water, frozen water reservoirs, fresh traces of streams, phyllosilicates.*

At the beginning of the 21st century, with the help of orbital stations, geological structures were discovered on the surface of Mars, which could have arisen only under the influence of powerful water flows. A little later, a huge ice reservoir [17, 18] with possible liquid water under its ice was recorded in photographs of the planet's mountain ranges. And sometime later, it was reported about the presence of a possible huge sea (Figure 1, Left) with frozen water under the surface of the Utopia plain [16, 29]. Its upper layer consists of water ice, frozen CO_2, and a sand-dust mixture [6-9, 15]. A couple of years later, the equipment of the rover "Opportunity" discovered new signs of traces of water [2, 10, 21]. Moreover, these signs are spread over several geological layers. This significantly increases the duration of the period of presence of water on the surface of Mars [22, 33, 34]. Maybe even enough for life to start there [25, 26, 28]. At the same time, it was possible to discover carbonic acid salts for the first time. And carbonates are formed only in the presence of water and carbon dioxide. Their discovery supported the hypothesis that in the distant past on Mars [29, 31, 37] there were large reserves of water.

The freezing point of water decreases due to the pressure of the ice layer of 1.5 km, as well as due to mineral salts [1, 4, 13, 35] that are dissolved in it. After all, it is known that sodium, magnesium and calcium salts, which were discovered on Mars, can reduce the freezing point of water down to -74°C. By the way, one of the saltiest lakes on Earth – Lake Don Juan in Antarctica – does not freeze even at a temperature of -50°C. Therefore, nothing contradicts the possibility of the existence of such salty water bodies on Mars as well [11, 14, 32]. Perhaps there are other reservoirs of water under the polar caps of this planet. The "MARSIS" radar has a low resolution, so it

could not see bodies of water ranging in size from a few meters to several kilometers. Meanwhile, open bodies of water cannot currently exist on the surface of Mars.

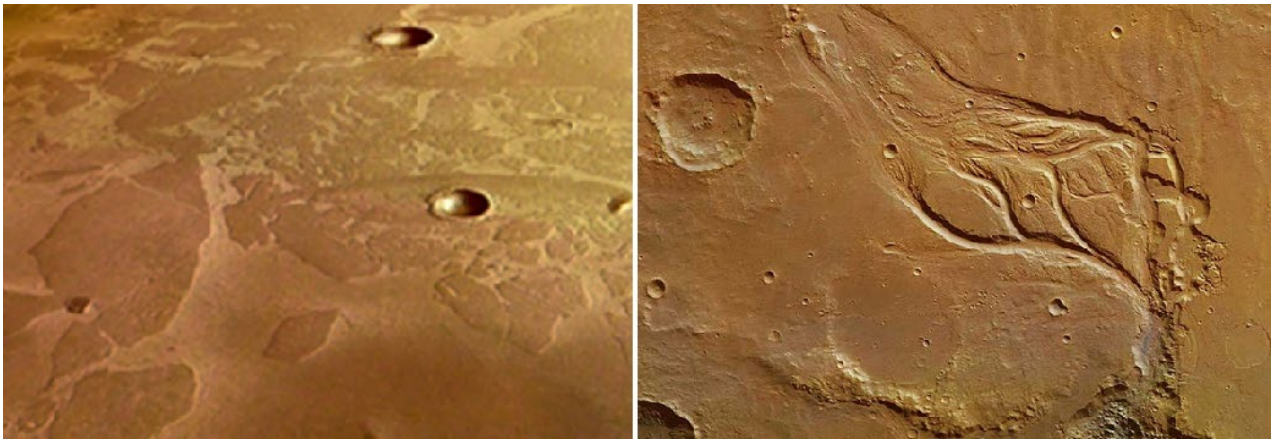

Figure 1 – Left – a possible frozen water reservoir on Mars near the equator *(http://photojournal.jpl.nasa.gov/).* **Right – ancient riverbeds on Mars** *(https://nauka.ua/news/)*

After all, in conditions of a hundred times less pressure than on Earth, as well as very low temperatures, water would either immediately freeze or evaporate very quickly. The accumulation of a certain amount of water vapor, which is formed in the atmosphere [12, 19, 20] of the planet, does not condense in the atmosphere, but immediately turns into ice crystals that settle in the form of frost. Therefore, underground and subglacial reservoirs are all that remains of the planet's once powerful hydrosphere. About 4.3 billion years ago, its Northern Hemisphere was covered by an ocean. And now, satellite images show ancient riverbeds (Figure 1, Right), traces of lakes and large-scale floods. Most likely, most of the Martian ocean evaporated into space together with its atmosphere [3, 5, 30]. The reason for this, due to the absence of a protective magnetic field on Mars, could be the solar wind or powerful volcanic activity [27, 36].

Therefore, the once possible blue planet has now turned into a red desert. The rest of the water is hidden in the polar caps and permafrost, which now covers almost the entire surface of the planet. Recently, it turned out that this permafrost can sometimes melt under the influence of sunlight in summer seasons. And in the images from the Martian orbital stations, it was possible to discover fresh traces of streams that very recently flowed down the slopes of the Martian hills inclined to the Sun in the mid-latitudes of the planet.

Thus, some landforms on Mars, such as riverbeds and lake beds, indicate that there was once water on the surface of the planet. A small amount of water exists in the thin Martian atmosphere even now, and the poles of Mars are covered by ice caps. In addition, it is assumed that the dark bands that appear on some slopes of the planet in the summer seasons for this hemisphere [23, 24] may turn out to be streams of very salty water or streams of sand. And the information received from the rovers allowed to find evidence of the presence of a wet environment in the rocky region at Meridiani Planum, called "El Capitan". Figure 1 (Left) shows its image from the Mars Exploration Rover "Opportunity" panoramic camera, obtained using red, green,

and blue filters. Sulfates and minerals were found in these rocks, which could only form in the presence of water.

Later, a similar discovery was made by the rover "Spirit", penetrating into the stone named "Humphrey" and recording the presence of voids there, which could only be formed under the influence of water. And in the voids themselves, deposits of minerals were found, which could only form in the presence of water. New results were also obtained as a result of processing observations of the "OMEGA" (Observatoire pour la Minéralogie, l'Eau, les Glaces et l'Activite) spectrometer installed on the "Mars Express" device of the European Space Agency. With the help of the received spectral observations, it was possible to detect areas on the surface of Mars containing water-bearing minerals phyllosilicates and hydrated sulfates (Figure 2, Right).

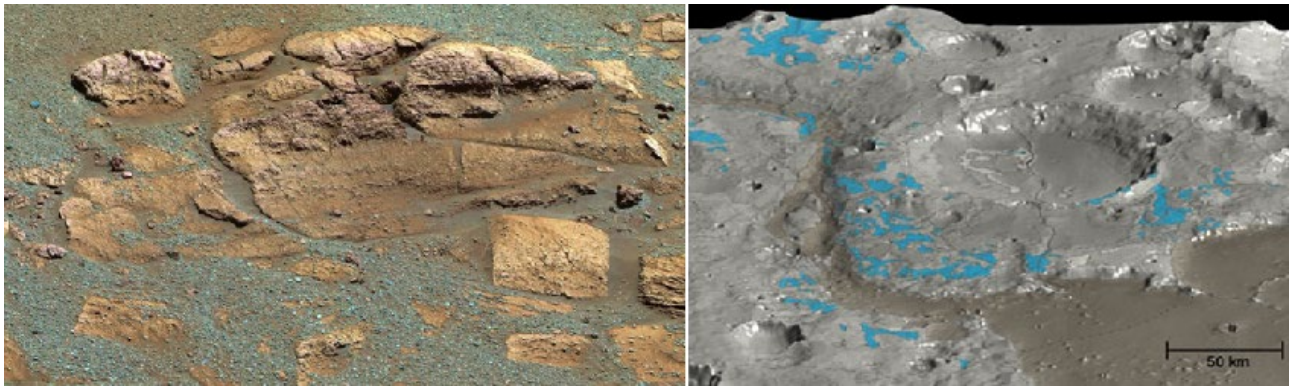

Figure 2 – Left – image from the Mars Exploration Rover "Opportunity's" panoramic camera shows the "El Capitan" region. Right – shows the location of hydrous minerals - phyllosilicates and hydrated sulfates according to the data obtained by the "OMEGA" spectrometers *(http://photojournal.jpl.nasa.gov/).*

These groups of minerals arise as a result of chemical changes in rocks. However, they differ in the mechanism of formation. For example, phyllosilicates are formed during long-term contact of igneous rocks with water. Whereas for the formation of hydrated sulfates, the action of water on them can be relatively short-lived.

However, it is necessary that the water has a sufficiently high acidity. The presence of these minerals on the surface of Mars indicates the presence of water there in the first few hundred million years.

Moreover, phyllosilicate-rich sediments were formed on Mars precisely in the ancient geological period. Such a conclusion was made on the basis of counting the number of meteorite craters and assessing the degree of their erosion. The obtained data well explain why the areas where phyllosilicates were found are not connected, for example, with dry riverbeds formed later on the surface of Mars.

That is, similar channels could be formed later. Therefore, water flowed in them for a relatively short time, and this did not lead to the formation of phyllosilicates there. However, hydrated sulfates were able to form in these places in later times. This happened when the atmosphere evaporated and the climate on Mars changed significantly. It is for this reason that the amount of water has significantly decreased, and it has become significantly more acidic.

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