WHICH CAVES ON MARS ARE SAFER TO LIVE IN? A. P. Vidmachenko[1], [1]National University of Life and Environmental Sciences of Ukraine, Str. Heroyiv Oborony, 12, Kyiv, 03041, Ukraine, avidmachenko@gmail.com.

Humanity faced the question of exploring Mars. For this, it is necessary to send the first settlers there, and provide for the possibility of ensuring their residence in a hostile environment. This is quite a difficult task for scientists and engineers. After all, it leaves no room for error. Planning missions to Mars is a step towards the beginning of the era of interplanetary resettlement [1]. Mankind took its first steps in the 1970s, visiting the moon. However, a trip to Mars requires much more time and effort. When planning flights to Mars, it is necessary to simulate a wide range of possible situations that the first colonists may encounter.

Mars is a relatively calm planet with a rather cold climate. There is a rarefied atmosphere, consisting mainly of carbon dioxide, and a very weak magnetic field [6]. Therefore, the surface of the planet is constantly bombarded by cosmic rays and a stream of high-energy charged particles of the solar wind. Another feature of Mars is frequent local and global dust storms [3, 4]. Recently, significant reserves of water in the form of ice were discovered there [9, 15]. It was found both in the polar caps and under the entire surface, starting from depths of 15-20 cm [18, 19].

For reliable protection against cosmic radiation [7], living and working spaces for colonists are best built below the surface. These colonies also need to be provided with energy. And solar panels are not the best option because the solar radiation flux is much lower on Mars and the panels will be constantly dusted with dust due to frequent dust storms. A nuclear reactor may be the best option.

Humans also need constant access to water resources [5]. From the point of view of the reliability of the future housing, a lava tube with strong walls best meets these requirements. It is a hollow formation in the crust, formed as a result of the release of volcanic lava [12-14, 16, 17]. And based on the need to provide settlements with water, a more suitable case should be considered underground caves in glacial cracks with a gentle horizontal entrance. After all, there are already significant deposits of water ice under the surface [2]. But the walls of such settlements will be less strong, and they will require more careful preparatory work.

The best case would be a lava tube with strong walls found next to powerful glacial structures. The colony itself, most likely, will have the appearance of separate premises, with residential, engineering, elevator and greenhouse compartments. They will have to be connected to each other by small transition tunnels to control the pressure and composition of the artificially created atmosphere in them. The nuclear unit of the power plant should be located nearby. It is clear that there must be several small domes and solar power plants on the surface of Mars. It is necessary that, over time, the colonists switch to self-sufficiency in provisions. And therefore, settlements on Mars should become the next technological breakthrough for humanity.

Bright representatives of volcanic craters are large craters on the tops of the highest mountains on Mars: Olympus, Askraeus, Arsya and Pavonis. It was on the slopes of the Arsya volcano at the beginning of the 2000s that seven dark spots were found, named after the female names of Wendy, Dana, Jinn, Annie, Abby, Nikki and Chloe. These dark spots on the surface of Mars turned out to be deep rocky wells, entrances to deep cave formations beneath the planet's surface.

That is, they are gaps in the ceiling of very large underground caves with diameters in the range of 100-250 m, formed at moments when streams of molten lava "burned" the void under the surface of the planet, sliding further down the slope of the volcano. The relative youth of these formations is evidenced by the sharp edges of the dips. After all, they were not covered with sand and dust, given the frequent dust storms.

Such reliable caves can be used to create the first permanent settlements. They will allow you to reliably protect yourself from powerful radiation exposure. And a certain drawback will be the need to organize the delivery of water ice to provide the settlers with water resources and raw materials for extracting the much-needed oxygen and hydrogen fuel for rocket engines.

Near the Elysium volcanic region on the plain of the Hebrus Valles, channels with a width of several hundred meters to several kilometers have been found. At the end of one of them, a pit measuring 1800□1125 m and a depth of up to 500 m was discovered. It is believed that water ice can be kept under the surface in such pits, or next to them. Therefore, such formations can be used for the placement of future human settlements.

In some areas on the slopes of the Pavonis volcano, lava tubes with several rounded dark spots were also found. Such lava tubes appeared as chains of collapses with a flat bottom and gentle or almost vertical sides. Gaps in the roof of caves or of lava tubes open access to them from the surface. And near Askraeus Mons it was possible to find a pair of dark pits too (Fig. 1, left). In the pits, boulders and rock sediments were found along the walls, and brighter dune deposits – on their bottoms. Both pits have steeper eastern walls (right in Fig. 1) with

ledges containing boulders, and gentler western walls that gradually transition into the bottom of the pit.

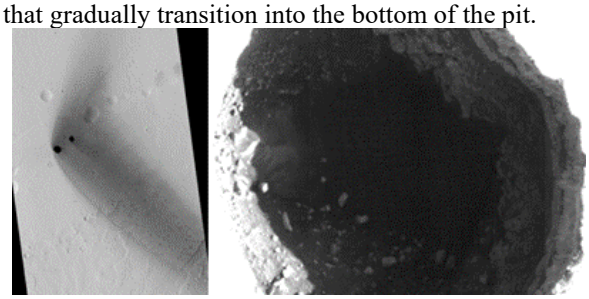

Fig. 1. On the left – are two dark holes on the northwest slope of Askraeus Mons with a diameter of 180 m and 310 m (http://hirise.lpl.arizona.edu/ESP_019997_1975). On the right – is a close-up of the larger opening (https://hirise-pds.lpl_RED.browse.jpg).

Long erosion channels were found on the slopes of some volcanoes. It is believed that they were formed when soft surface material sank into underground cavities. This easily eroded soil layer may have had a significant proportion of soft volcanic ash. The presence of subsurface water ice in such channels also makes them suitable candidates for future human settlement.

Numerous pits have also been found in the southern part of Acidalia Planitia and to the west and northwest of Cydonia Mensae. That is, objects of round, elongated, or irregular shape with raised edges that reach several hundred meters in diameter (Fig. 2). They are mainly located on slopes facing the equator, for example, on the inner walls of impact craters, or on any other form of relief with gentle slopes up to 2°. These pits are concentrated between 24°N latitude. and 36° N latitude.

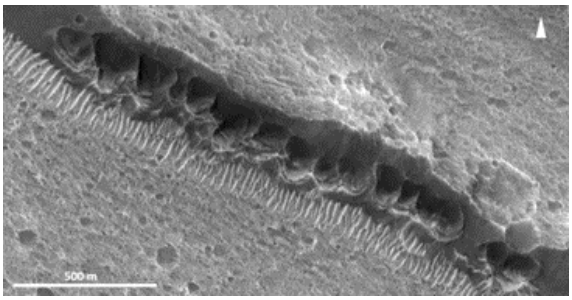

Fig. 2. A chain of pits located on the equator-facing slope of a local ridge (HiRISE ID: PSP_PSP_008641_2105_RED). The pits appear young, based on the well-preserved rims. Some pits show limited eolian deposition and ripple forms (https://www.uahirise.org/PSP_008641_2105).

The orientation of pits to the equator indicates their control by seasonal insolation [8, 10, 11]. In addition, the raised edges may indicate their high-energy excavation by some unknown agent. One possibility is gas jets created by sublimation of CO2 under a slab of dry ice. Another possibility is that they represent residual landforms from a time when the dust/ice-rich shell spread further south, or insolation-controlled water ejection [20]. That is, either by melting the subsurface layer of ice, or by cooling the lava below it. As cooling causes the volume to decrease, the region above the lava collapses.

Chain pits can be of volcanic origin. Lava flowing from a volcano solidifies at the surface, leaving a molten tube of lava flowing below. When volcanic activity stops, the pipe empties, leaving behind an underground cavity. Over time, parts of the roof above the cavity may collapse, leaving circular depressions on the surface. On Earth, recent examples can be seen on the slopes of Kilauea volcano in Hawaii, while on the Moon - it was Hadley Rille, who visited "Apollo 15" in 1971; is believed to have formed the same way many years ago.

References:

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