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MAJOR VOLCANIC FORMATIONS ON THE SURFACE OF MARS IN THE THARSIS REGIO PROVINCE.

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The Tharsis Regio Province is the most impressive display of volcanism not only on Mars but in the entire Solar System. This region is a vast volcanic plateau located near the planet's equator. It is located at an altitude of more than 10 km above the mean surface of Mars. That is, Tharsis Regio is one of the most geologically significant regions on this planet. It has unique features, which include the highest volcanoes in the Solar System [3, 9, 10, 17, 19, 20, 25, 33] and many signs of rich and long-term geological activity.

Let us consider the geographical location of the Tharsis Province, its geological composition, geomorphological features, as well as space missions [1, 15, 26, 30] that have explored this region. This vast plateau, covering an area of about 4 million square kilometers, is located around the Martian equator between latitudes 30°N and 30°S, and extends in longitude from 70° to 135°W.

Due to its large scale and location near the equator, Tharsis Regio serves as one of the key places for a deeper understanding of ancient hydrological cycles, features of the planet's tectonic history [5, 7, 8, 14] and Martian geology. The surface of the Tharsis Province is formed mainly by basaltic lava flows. This emphasizes that this region is of predominantly volcanic origin [23, 24, 28, 31, 32]. Spectroscopic methods have been used by many space missions to study it. They have allowed the detection of various minerals on its surface; among them, iron oxides, olivines and pyroxenes have been found. The range of mineral formations indicated indicates a variety of magmatic sources, which indicate the presence of different styles and multiple phases of volcanic activity.

In some areas of the Tharsis Province, sulfates [13] and clays have also been found. Recall that these minerals indicate their interaction in the distant past with liquid water. This fact significantly enriches the geological history of this province. This area is further complicated by the presence of huge shield volcanoes. After all, they demonstrate a great variety of geological formations, which include vents in cracks, extensive calderas and quite complex networks of lava tubes. Among the rather important findings in the Tharsis Regio area are the huge and quite long-term scales in its volcanic activity. For example, Mount Olympus (Fig. 1, a) is powerful evidence of the action of colossal volcanic processes, which, with repeated eruptions over time, led to the fact that this volcano became the highest and most extensive shield volcano in the entire Solar System. The Tharsis Province is also a center of powerful tectonic activity. It is here that a complex network of large cracks, deep faults and rift zones is located. These relief features are convincing evidence that in this area the crust on Mars underwent enormous deformations. Such tectonic features lead to the formulation of a number of questions regarding the features of the internal structure of this planet and the mechanical properties of its crust.

In some parts of the Tharsis Regio, such geomorphological features are also manifested, which indicate the former activity of water resources in this area [16, 18, 20-22, 34]. Among them, we can point out the remains of structures that resemble ancient river valleys and the bottom of several lake basins.

The “Viking 1” and “Viking 2” missions managed to obtain detailed images of Tharsis Regio. Another mission, “Mars Global Surveyor”, used the latest topographic instruments, which allowed us to propose complex models to explain the features of this area. The “Mars Reconnaissance Orbiter” mission was equipped with modern systems for detailed visualization with a fairly high spatial resolution and several instruments that allowed for spectroscopic observations [2, 11, 29].

The work of these instruments made it possible to decipher the geological features and mineralogical composition of the surface in Tharsis Regio, being able to identify many different minerals [4, 6, 12, 27]. At this location on the Martian surface, the landscape features are dominated by shield volcanoes with fairly gentle slopes, which could have been formed by slow lava flows with fairly high fluidity.

The large number of rift valleys, cracks and calderas may indicate a high level of complexity of this region. After all, these relief elements indicate a combination of tectonic forces and volcanic formations. They led to the formation of the largest volcanoes in the entire Solar System in this region. For example, Olympus Mons is the highest mountain in the Solar System and the most famous volcano on Mars.

Its height is almost 21.9 km above the mean surface of Mars, or 27 km from its base to its summit. The diameter of its base is over 600 km. At the summit of the Olympus volcano is a rather complex caldera, which is a complex of six nested calderas that form an irregular depression with dimensions of 85×60 km and a depth of up to 3.2 km, formed after the eruption; that is, it consists of several craters that overlap in places (Fig. 1, b). Along the edges of this volcano are steep ledges (or escarpments), the height of which in some places reaches 8 km.

Other volcanoes in Tharsis Regio – Tharsis Montes – are located in a chain to the southeast of the Olympus volcano; they are a group of three also very large shield volcanoes. These include Ascraeus Mons, Pavonis Mons and Arsia Mons. The diameter of the base of each of them is several hundred kilometers, and the height is from 14 to 18 km above the average level. The southernmost of the three Tharsis Montes volcanoes, Arsia Mons is located near the equator and has the widest caldera, with a diameter of about 130 km and a depth of 1.3 km. It is about 11.7 km high and

435 km in diameter. Arsia Mons is considered the second largest volcano on Mars after Olympus Mons in terms of volume.

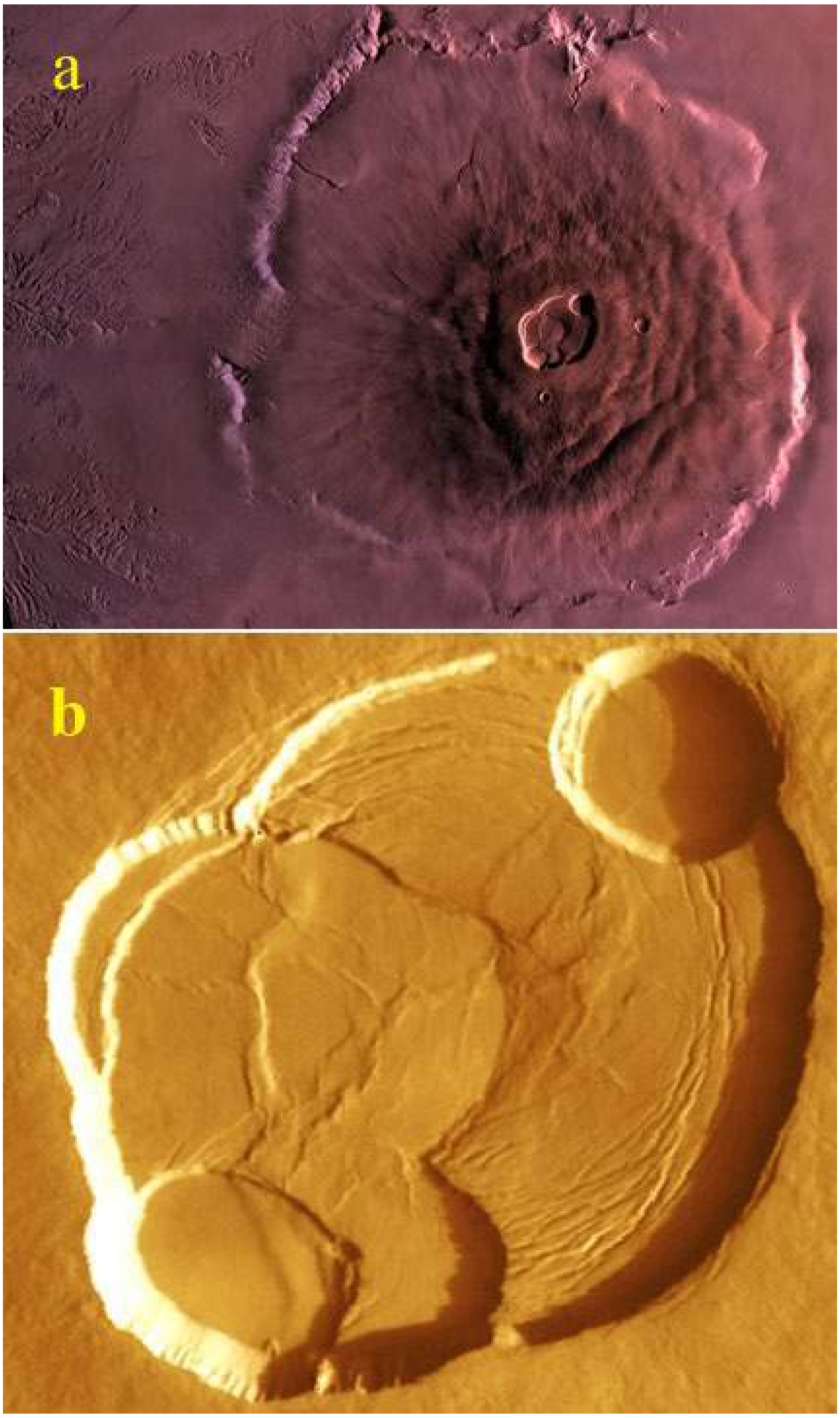

Figure 1. a – volcano Olympus (https://www.whiteclouds.com/wp-content/uploads/2023/09/Olympus-Mons.jpg). b – view of the caldera of the Olympus volcano with several craters in its middle (http://upload.wikimedia.org/wikipedia/commons/e/eb/Olympus_Mons_caldeira.png)

Ascraeus Mons, located in the central part of the Tharsis Uplift, is the northernmost and highest of the three shield volcanoes known as the Tharsis Mountains. Its elevation is about 18.1 km above the Martian mean sea level. This makes it the second-highest mountain on Mars. Ascraeus Mons is approximately 480 km in diameter.

The volcano is topped by a caldera complex consisting of a central caldera about 24 km in diameter and 3.4 km deep, surrounded by four smaller, merged calderas.

From the northeast and southwest edges of the volcano, extensive lava sheets extend more than 100 km into the surrounding plains, giving the volcano an overall size of about 375 by 870 km, if included in its structure.

Pavonis Mons is a medium-sized volcano in the Tharsis Montes chain, also located near the equator. It rises 8.7 km above mean sea level and has a diameter of about 375 km. At the summit of Pavonis Mons is a deep, circular caldera with a diameter of 47 km and a depth of almost 5 km. To the northeast of it is a slightly larger, about 90 km in diameter, but less deep, but more complex, depression.

Alba Mons is located in the northern Tharsis region. It is the largest volcano on Mars by area, with gentle lava flows that extend at least 1,350 km from its summit.

Despite its enormous size, its maximum height is only 6.8 km. This volcano has an oval central part measuring approximately 1,500 by 1,000 km, surrounded by a wide, almost flat belt of lava flows extending outward for over 1,000 km.

References

1. Acuna M.H., Connerney J.E.P., Ness N.F., et al. (1999) Global distribution of Crustal Magnetization Discovered by the Mars Global Surveyor MAG/ER Experiment. Science. 284(5415), p. 790-793.
2. Adams J.B., Filice A.L. (1967) Spectral reflectance 0.4 to 2.0 microns of silicate rock powders. J. Geophys. Res. 72(22), p. 5705-5715.
3. Batson R.M. (1973) Cartographic products from the Mariner-9 mission. J. Geophys. Res. 78(20), p. 4424-4435.
4. Bertka C.M., Fei Y. (1998) A profile of Martian mineralogy and density up to core-mantle boundary. LPSC. V. 27. P. 107-108.
5. Bi H., Sun D., Sun N., et al. (2025) Seismic detection of a 600-km solid inner core in Mars. Nature. 645, p. 67–72.
6. Bibring J.-P., Langevin Y., MustardJohn Y. F., et al (2006) Global mineralogical and aqueous mars history derived from OMEGA/Mars express data. Science. 312, p. 400-404.
7. Clinton J.F. (2017) Preparing for InSight: An Invitation to Participate in a Blind Test for Martian Seismicity. Seismological Research Letters. 88(5), p. 1290-1302.
8. Goins N.R., Lazarewicz A.R. (1979) Martian seismicity. Geophys. Res. Let. 6(5), p. 368-370.
9. Goldstein R.M., Melbourne W.G., Morris G.A., et al. (1970) Preliminary radar results of Mars. Radio. Sci. 5(2), p. 475-478.
10. Morozhenko A.V., Vid'machenko A.P. (2004) Polarimetry and Physics of Solar System Bodies. Photopolarimetry in Remote Sensing, NATO Science Series II: Mathematics, Physics and Chemistry. 161, p 369-384.
11. Morozhenko A.V., Vidmachenko A.P., Kostogryz N.M. (2015) Spectrophotometric properties of Moon's and Mars's surfaces exploration by shadow mechanism. Highlights of Astronomy, 6, p. 182-182.

12. Murchie S.L., Mustard J.F., Ehlmann B.L., et al. (2009) A synthesis of Martian aqueous mineralogy after 1 Mars year of observations from the Mars Reconnaissance Orbiter. Journal of Geophysical Research: Planets. 114(IssueE2). E00D06. P. 1-30.
13. Schmidt F., Chassefière E., Tian F., et al. (2016) Early Mars volcanic sulfur storage in the upper cryosphere and formation of transient SO2-rich atmospheres during the Hesperian. Meteoritics & Planetary Science. 51(11), p. 2226-2233.
14. Sleep N.H. (1994) Martian Plate Tectonics. J. Geophys. Res. 99(E3), p. 5639-5655.
15. Vidmachenko A.P. (2009) Research of the Mars by space vehicles. 11 International scientific conference Astronomical School of Young Scientists, May 26-29, 2009, Kherson, Ukraine. P. 11-12.
16. Vidmachenko A.P. (2009) Water on Mars. Astron. almanac. 56, p. 225-249. 83
17. Vidmachenko A.P. (2014) Study of Earth-like planets. 16 International scientific conference Astronomical School of Young Scientists. Kirovohrad, Ukraine. May 29–31, 2014. P. 12-13.
18. Vidmachenko A.P. (2016) Traces of life on Mars must be sought around the valley Hellas in areas where the water coming out from under the planet's surface. 18 International scientific conference Astronomical School of Young Scientists. Kyiv, Ukraine, May 26-27, p. 14-16.
19. Vidmachenko A.P. (2018) Features of volcanic activity on various bodies of the Solar system. Materials of the ISPCo The Objectives of the Sustainable Development of the Third Millennium: Challenges for Universities of Life Sciences, 5, May 23-25, Kyiv, p. 41-42.
20. Vidmachenko A.P. (2018) Modern volcanic activity on the Moon. 20 International scientific conference Astronomical School of Young Scientists. May 23-24. Uman, Ukraine. P. 5-7.
21. Vidmachenko A.P. (2018) Water in Solar system. 20 International scientific conference Astronomical School of Young Scientists, May 23–24 2018, Uman, Ukraine, p. 91-93.
22. Vidmachenko A.P. (2019) Traces of Martian Life Should be Sought in Places Around Hellas Crater, Where Water has Recently Spilled Out onto the Surface. Ninth International Conference on Mars, Pasadena, California, Jul 22-25, 2019, LPI Contrib. No. 2089, 6005.
23. Vidmachenko A.P. (2023) About volcanoes on Mars. Proceedings of 11 All-Ukrainian Scientific Conference "Astronomy and present day", April 12, 2023. Vinnytsia, Ukraine. LLC "TVORY". ISBN 978-617-552-363-6. P. 76-81.
24. Vidmachenko A.P. (2023) Comparison of features of impact and volcanic craters on the surface of Mars. Proceedings of VIII International Scientific and Practical Conference. Progressive research in the modern world (April 27-29). P. 237-246.
25. Vidmachenko A.P. (2023) Features of volcanic structures on Venus. Proceedings of the 9th International scientific and practical conference. Modern directions of scientific research development. Chicago, 23-25.02.2022. P. 195-204.
26. Vidmachenko A. P. (2026) Exploration of the planet Mars by spacecraft. Current Research and Innovative Approaches in Science: Proceedings of the International Scientific Conference (Nottingham, United Kingdom, 23 January 2026). Lulu Press, Inc. P. 211-215.

27. Vidmachenko A. P. (2026) Mineralogy of the planet Mars. The III International scientific and practical conference «Technology development: shaping modern thinking and scientific approaches», January 19-21, 2026, Krakow, Poland, 265 p. P. 187-193.
28. Vidmachenko A.P. (2023) Macrorelief of the surface of Mars. Proceedings of XIV ISPCo. Prospects for the development of science and the environment. (April 10-12, 2023). Chapter 7. P. 34-39.
29. Vidmachenko A.P., Klimenko V.M., Morozhenko A.V. (1981) Apparent spectral albedos of the disk of Mars in September-October 1977. Solar System Research. 14(4), p. 157-159.
30. Vidmachenko A.P., Morozhenko A.V. (2014) The study Earth-like planets using spacecraft. Astronomical School's Report 10 (1), 6-19.
31. Vidmachenko A.P., Mozghovyi O.V., Steklov O.F. (2023) About volcanoes on Mars. Proceedings of 11 All-Ukrainian Scientific Conference "Astronomy and present day", April 12, 2023. Vinnytsia, Ukraine. LLC "TVORY", p. 76-81.
32. Vidmachenko A.P., Mozghovyi O.V., Steklov O.F. (2023) Features of the relief on the surface of Mars. Proceedings of 11 All-Ukrainian Scientific Conference "Astronomy and present day", April 12, 2023. Vinnytsia, Ukraine. LLC "TVORY". P. 66-71.
33. Vidmachenko A.P., Steklov A.F. (2022) Features of volcanic structures on Venus. Proceedings of the 9th ISPCo Modern directions of scientific research development. Chicago, 23-25.02.2022. P195-204.
34. Vidmachenko A.P., Steklov A.F. (2022) How long ago has water flowed on Mars surface? Results of modern scientific research and development. Proceedings of XI International Scientific and Practical Conference. Barca Academy Publishing, Madrid, Spain. 16-18.01.2022. P. 226-232.

IMPACT OF STRUCTURAL VARIABILITY ON THE HEAT CONDUCTION MECHANISMS IN REINFORCED COMPOSITE MATERIALS

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Abstract. This study utilizes the finite element method and the equivalent inclusion method to evaluate the effective thermal conductivity of reinforced composite materials. The analytical framework incorporates several critical factors, including inclusion anisotropy, orientation distribution, thermal interface conductance, and inclusion dimensions. The findings reveal that when the thermal conductance at the interface is high, the effective conductivity of the composite is primarily determined by the anisotropy of the inclusions. In contrast, at lower conductance levels, the influence of anisotropy is substantially reduced as the restricted heat flow across