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ТЕХНОЛОГИЈА НА ПОДЗЕМНА И ПОВРШИНСКА ЕКСПЛОАТАЦИЈА НА МИНЕРАЛНИ СУРОВИНИ

ЗБОРНИК НА ТРУДОВИ

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XIII СТРУЧНО СОВЕТУВАЊЕ НА ТЕМА:

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XIII СТРУЧНО СОВЕТУВАЊЕ НА ТЕМА:

"Технологија на подземна и површинска експлоатација на минерални суровини"

ПОДЕКС – ПОВЕКС '22

ЗРГИМ

Охрид
14 ÷ 16. 10. 2022 год.

ПРЕДГОВОР

Меѓународното стручно советување за подземната експлоатација на минералните суровини (ПОДЕКС), за првпат се одржа на 06.12.2007 год. во Пробиштип во организација на Сојузот на Рударските и Геолошките Инженери на Македонија (СРГИМ).

Од 2012 година советувањето е проширено со трудови од површинската експлоатација на минерални суровини и е именувано како ПОДЕКС-ПОВЕКС.

Стручното советување, на тема: технологија на подземна и површинска експлоатација на минерални суровини, традиционално се одржуваше секоја година во месец ноември. По пауза од три години, поради пандемијата од COVID-19, од оваа година започнува со оддржување во октомври. На ова советување земаат учество голем број на стручни лица од: рударската индустрија, универзитетите, научно - истражувачките и проектантските организации, производителите на опрема и др.

На досегашните дванаесет советувања (2007, 2008, 2009, 2010, 2011, 2012, 2014, 2015, 2016, 2017, 2018 и 2019 год.) учествуваа повеќе автори од 12 држави, кои презентираа 337 стручни трудови.

За ова тринаесетто советување (ПОДЕКС - ПОВЕКС '22) пријавени се 29 труда, на автори од 3 држави.

Големиот број на трудови од домашните автори произлезе како резултат на научно-истражувачката работа реализирана на високообразовните институции во Р. С. Македонија. Меѓутоа, посебно не радува учеството на автори од непосредното рударско производство, кои што презентираат постигнати резултати во рударската пракса.

Се надеваме дека традицијата за собирање на сите специјалисти од областа на подземната и површинската експлоатација на минералните суровини, ќе продолжи и дека во идниот период ова советување ќе прерасне во меѓународен симпозиум.

Уредници

AMGEM	**XIII EXPERT CONFERENCE THEMED:** **“Technology of underground and surface mining of mineral raw materials”** **PODEKS - POVEKS ’22** **Ohrid** **14 ÷ 16. 10. 2022.**

FOREWORD

The International expert conference on underground mining of mineral raw materials (PODEKS), organized by the Association of Mining and Geology Engineers of Macedonia (AMGEM), was first held on 06.12.2007 in Probishtip.

Since 2012, in this counseling, surface exploitation of mineral resources is included too, and it is called PODEKS-POVEKS.

This expert conference called: Technology of underground and surface mining of mineral raw materials, traditionally, was been organized annually during November. After a three-year hiatus, due to the COVID-19 pandemic, this year it starts taking place in October. A number of experts from the mining industry, universities, research institutions, planning companies, and equipment manufacturing companies participate in this conference.

Many authors from 12 countries participated in the previous twelve conferences (2007, 2008, 2009, 2010, 2011, 2012, 2014, 2015, 2016, 2017, 2018 and 2019) presenting 337 expert papers.

Twenty-nine authors from 3 countries have registered their expert papers for the XIIIth conference (PODEKS - POVEKS ’22).

The large number of expert papers from the domestic authors has emerged as a result of the research work carried out at the higher education institutions in the Republic of North Macedonia. We are particularly delighted by the participation of the authors involved in the immediate mining production who will be presenting the achieved results in the mining practice.

We hope that the tradition of gathering of all specialists from the field of underground and surface mining of mineral raw materials will continue and that this conference will grow up to an international conference in the future.

The Editors

СОДРЖИНА

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Здружение на рударски и геолошки инженери на Р. Македонија

XIII ТО СТРУЧНО СОВЕТУВАЊЕ НА ТЕМА:
Технологија на подземна и површинска експлоатација на минерални суровини

ПОДЕКС – ПОВЕКС '22

Охрид
14 – 16. 10. 2022 год.

GEOLOGY OF MARS

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Abstract: *In the last years of the last century, the search for possible life on Mars began, these studies focused on different areas depending on the expertise of the researchers.*
In particular, research was done on the presence of water, as well as research on the geology of March. To do the presentation of the geology of Mars, we will present results from different studies by different researchers.
Through this seminar paper, we will present various researches carried out related to the geology of Mars, the tectonics of Mars, the various geophysical and water studies on Mars, the presence of volcanoes, and other geological phenomena in Mars.

Keywords: *Plates, Tectonics, Geodynamic, Geology, Activity, Mars.*

ГЕОЛОГИЈАТА НА МАРС

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Апстракт: *Истражувањата на Марс се едни од најзначајните вселенски истражувања кои се спроведуваат во Сончевиот Систем, и тоа во континуитет повеќе од 60 години. Ма основа на овие истражувања нашите сознанија за планетата Марс, денес се многу големи од тоа како од аспект на неговата еволуција така и од аспект на познавањето на неговата геологија. Во геологијата на Марс влегуваат следните типови на карпи: базалти, пирокластични карпи, бречи и конгломерати, седиментни карпи, еолски седименти.*

Клучни зборови: *геологија, Марс, геодинамика, плочи, активност.*

1. INTRODUCTION

The geology of Mars is the scientific study of the planet's surface, crust, and interior. It stresses the planet's composition, structure, history, and physical processes. It is comparable to the study of terrestrial geology. (Greeley, 1993) Geology, in its widest definition, refers to the study of the solid components of planets and moons in planetary science. Geophysics, geochemistry, mineralogy, geodesy, and cartography are all included in one phrase. ("World Wide Words: Areologist," n.d.).

On Mars, the geological past has been recreated by delineating geological units using the worldwide Viking picture data collection (Geologic Map of the Eastern Equatorial Region of Mars, n.d.; Tanaka et al., 2014) and cross-cutting linkages to determine their relative ages, with impact crater abundance connected to an absolute chronology (Hartmann & Neukum, 2001). Mars has a surprisingly rich and complex preserved geological record that has been irreparably lost owing to the continual crustal recycling performed by terrestrial plate tectonics (Hamilton, 2007).

Mars has a diameter of 6790 kilometers, little more than half the diameter of Earth, giving it a total surface area almost equivalent to our planet's continental (land) area. Its total density of 3.9 g/cm^3 reveals a silicate-based composition with a tiny metal core. Although there are pockets of significant surface magnetization that show a global magnetic field existed billions of years ago, there is no global magnetic field now. The red planet's core no longer contains any liquid substance capable of conducting electricity. (M. G. Chapman, 2007). Mars Global Surveyor has mapped the whole planet, as seen in Fig 4. A laser altimeter on board took millions of individual measurements of the surface topography to a few meters of precision, revealing even the yearly deposition and evaporation of the polar caps. Mars, like Earth, the Moon, and Venus, includes continental or highland portions as well as vast volcanic plains. The height difference between the tallest peak (Olympus Mons) and the lowest basin (Hellas) is 31 kilometers.(Astronomy OpensTax, 2022) Most of what we know about Mars is derived from spacecraft: highly successful orbiters, landers, and rovers.

Geological processes associated with interactions with the atmosphere (e.g., eolian, polar), the hydrosphere (e.g., fluvial, lacustrine), the cryosphere (e.g., glacial and periglacial), or the crust, lithosphere, and interior of planets represent the major dynamic forces shaping the surfaces, crusts, and lithospheres of planets (e.g., tectonism and volcanism)(Head et al., 2001). (Fig.1).

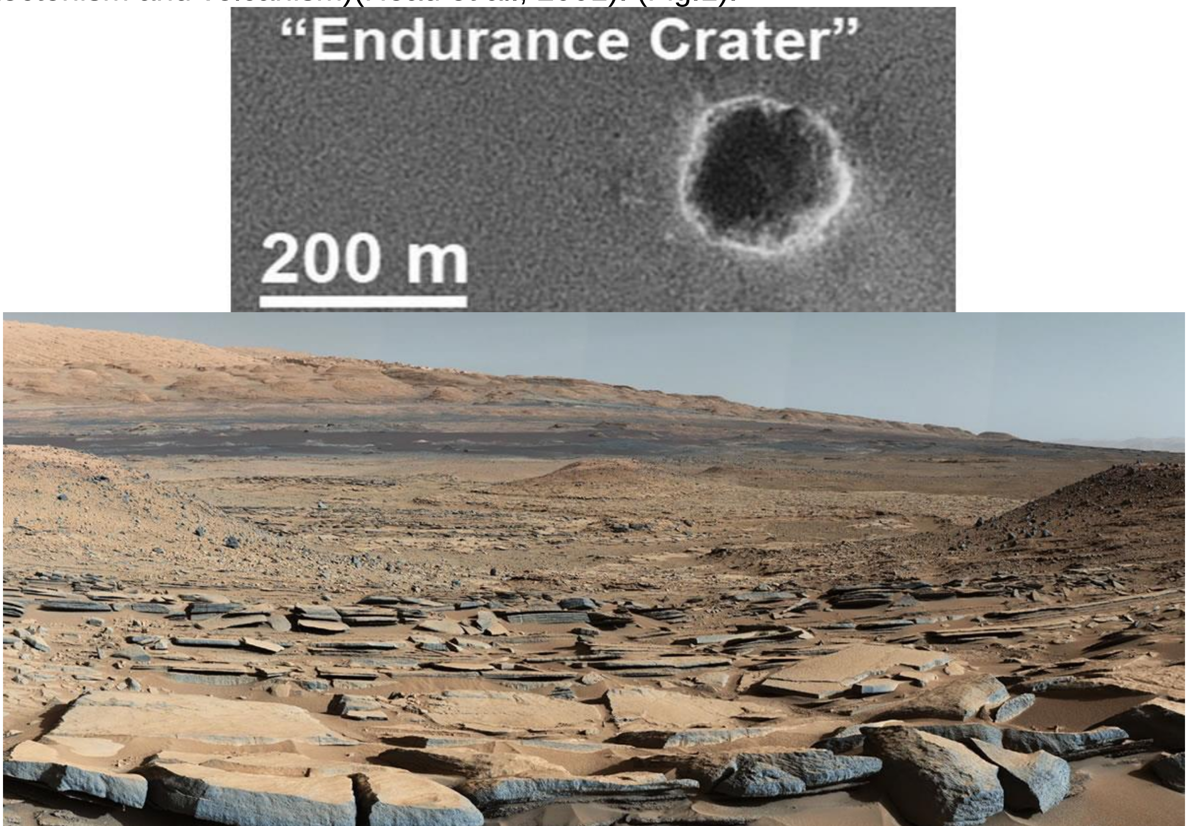

Figure 1. Crater in Mars and Geomorphology of Mars. (Head, 2007)

The hemispheric dichotomy is a key aspect of Martian geology: around one-third of the planet's surface (mainly in the northern hemisphere) is 3-6 km lower in elevation than the southern two-thirds. The dichotomy may also be evident in the number of impact craters and crustal thickness differences between the two hemispheres. (M. H. Michael H. . Carr, 2006a)
Interaction with the planetary external environment also occurs, as in the case of impact cratering processes. Geological processes vary in relative importance in space and time; for example, impact cratering was a key process in forming and shaping planetary crusts in the first one-quarter of Solar System history, but its global influence has waned considerably since that(Rossi & Van Gasselt, 2010)
Volcanism has played an essential role in geologic history. Mars possesses the solar system's greatest shield volcanoes, enormous plains of lava flows, many lava channels, domes, and cones, and indications of explosive volcanism and massive pyroclastic deposits. Most of what we know about Mars is derived from spacecraft: highly successful orbiters, landers, and rovers. Because Mars has been the primary focus of planetary exploration since the mid-1990s, and because it has been visited by several spacecraft including orbiters, landers, and rovers, there is a wealth of data on Martian surface geology available, including images at resolutions ranging from 30 cm/pixel to several km/pixel, as well as data on surface compositions and the role of volatiles, and atmospheric dynamics and composition.(Lopes & Solomonidou, 2014).

Figure 2. Mars Craters (Greeley & Spudis, 1981),(Neukum et al., 2004)

The panoramic camera on the Mars Exploration Rover Opportunity captured this image of the inside of the "Endurance" impact crater. The exposed walls reveal what lies under Mars' surface and hence what geologic processes transpired there in the past. While recent studies of the smaller "Eagle" crater discovered evidence of an old evaporating pool of salty water, that crater was not deep enough to suggest what came before the water. Endurance investigated this question in the rocks embedded in the cliff. (Golombek et al., 2020) Endurance spans 130 meters. Images like this bridge the gap between orbital views and sample examination, and they give a useful size perspective when employing terrestrial analogs. (NASA/JPL/Cornell)(M. G. Chapman, 2007; Head, 2007)

2. GEOLOGY OF MARS

Mars is a terrestrial planet that consists of minerals containing silicon and oxygen, metals, and other elements that typically makeup rock. The surface of Mars is primarily composed of tholeiitic basalt, although parts are more silica-rich than typical basalt and may be similar to andesitic rocks on Earth or silica glass. (Greeley & Spudis, 1981; Seelos et al., 2010), (Fig.2). Regions of low albedo show concentrations of plagioclase feldspar, with northern low albedo regions displaying higher than normal concentrations of sheet silicates and high-silicon glass. Parts of the southern highlands include detectable amounts of high-calcium pyroxenes. Localized concentrations of hematite and olivine have also been found. Much of the surface is deeply covered by finely grained iron(III) oxide dust(AstronomyOpensTax, 2022) (Hughes et al., 2019)

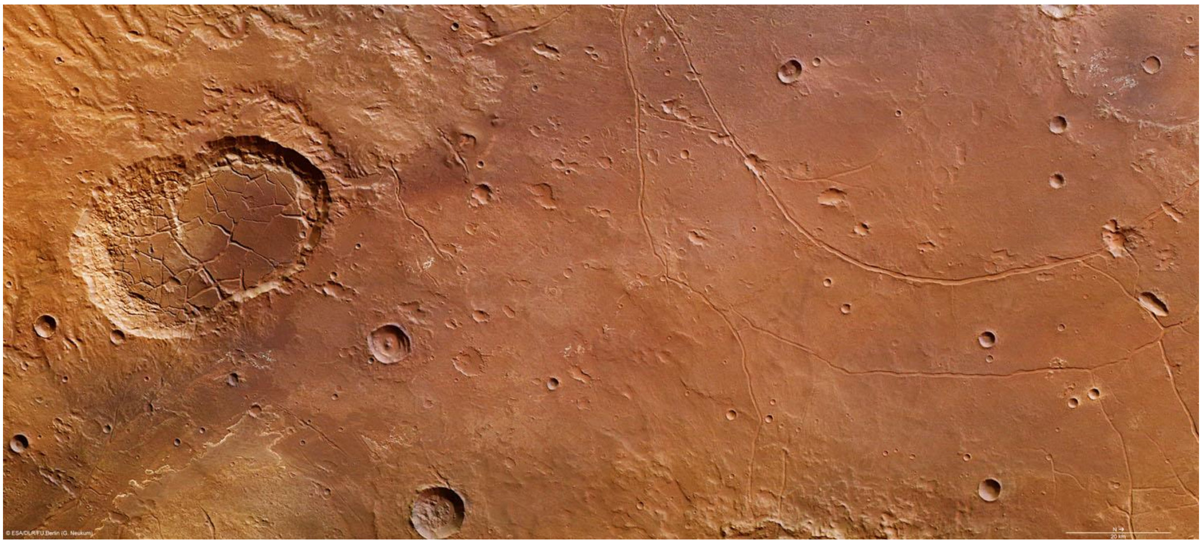

Figure 3. Geomorphology of Mars (Balme et al., 2011)

Although there is no evidence of a present organized global magnetic field on Mars, investigations suggest that sections of its crust have been magnetized and that alternating polarity reversals of the planet's dipole field have happened in the past. The features of this paleomagnetism of magnetically sensitive minerals are extremely similar to the alternating bands observed on Earth's ocean floors. According to one idea, which was published in 1999 and re-examined in October 2005 (with the aid of the Mars Global Surveyor), these bands show plate tectonics on Mars four billion years ago, before the planetary dynamo stopped working and the planet's magnetic field went away.(AstronomyOpensTax, 2022; Rossi & Van Gasselt, 2010) (Balme et al., 2011) (Fig.3).
Mars formed during the creation of the Solar System as a consequence of a stochastic process of run-away accretion from the protoplanetary disk that orbited the Sun. Mars has several specific chemical characteristics as a result of its location in the Solar System. Elements with low boiling points, such as chlorine, phosphorus, and sulfur, are far more abundant on Mars than on Earth; these elements were most likely

evacuated from places closer to the Sun by the strong solar wind of the newborn star. (Golombek et al., 2020)(Des Marais et al., 2002; Williams & Knacke, 2004)

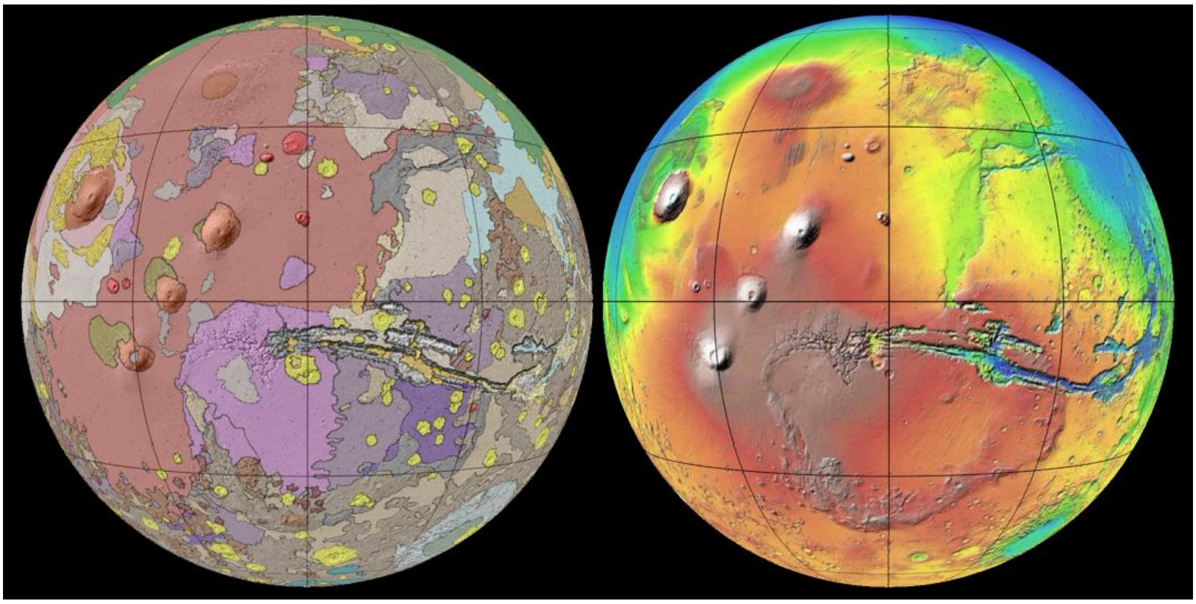

Figure 4. Surveying Mars (Barlow & Bradley, 1990; Christensen et al., 2004; Tanaka et al., 2014)

Mars Laser Ranging Map: These globes are very accurate topographic maps that were created by reconstructing millions of individual elevation measurements taken by the Mars Global Surveyor. The elevation is shown via color. The left hemisphere contains the Tharsis bulge and Olympus Mons, Mars' tallest peak; the right hemisphere has the Hellas basin, Mars' lowest height. (credit: NASA/JPL modification of work),(Christensen et al., 2004)(Barlow & Bradley, 1990; Christensen et al., 2004; Tanaka et al., 2014) (Fig.4).

Approximately half of the planet is made up of highly cratered highland terrain, which is mostly found in the southern hemisphere. The remaining half, largely in the north, comprises newer, gently cratered volcanic plains roughly 5 kilometers lower in height than the highlands. Remember that a similar pattern was observed on Earth, the Moon, and Venus. (Robbins & Hynek, 2012)

The most evolution of studying in Geology of Mars is creating a Geological Map of Mars as we have described below in Fig 5.

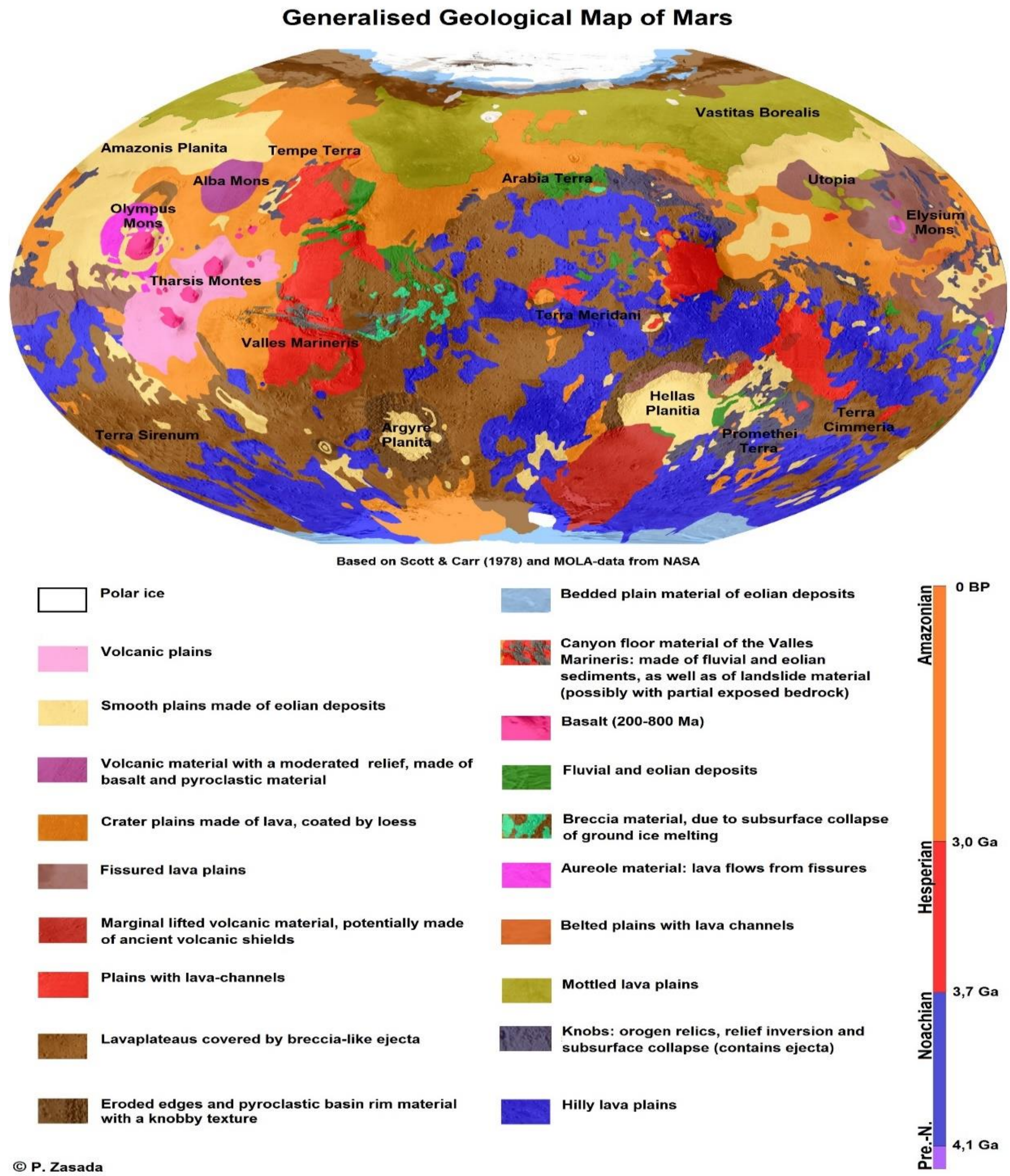

Figure 5. Geological Map of Mars (Tanaka & Scott, 1987)(Platz et al., 2013)

The most current regional- and global-scale maps of the northern plains' geology are mostly based on Viking Orbiter imaging data(Christensen et al., 2004; Greeley & Guest, 1987; Tanaka & Scott, 1987)(Witbeck & Underwood, 1984). Using local stratigraphic connections and crater counts, these maps identify highland, plains, volcanic, and polar units based on morphologic character, albedo, and relative ages. This geologic map of Mars' northern plains is the first to be released, and it uses topography and imaging data from both the Mars Global Surveyor and Mars Odyssey missions. The new data shed new light on the region's geology, revealing previously unknown units, features, and historical relationships. (Tanaka et al., 2003)

3. WHAT KIND OF GEOLOGY HAS MARS

Based on the Generalized Geological Map of Mars and their legend we can see various geological formations, but based on this scale of map we can identify some of these geological formations:

- ✓ Basalts,
- ✓ Pyroclastic materials
- ✓ Breccia
- ✓ Fluvial and eolian sediments

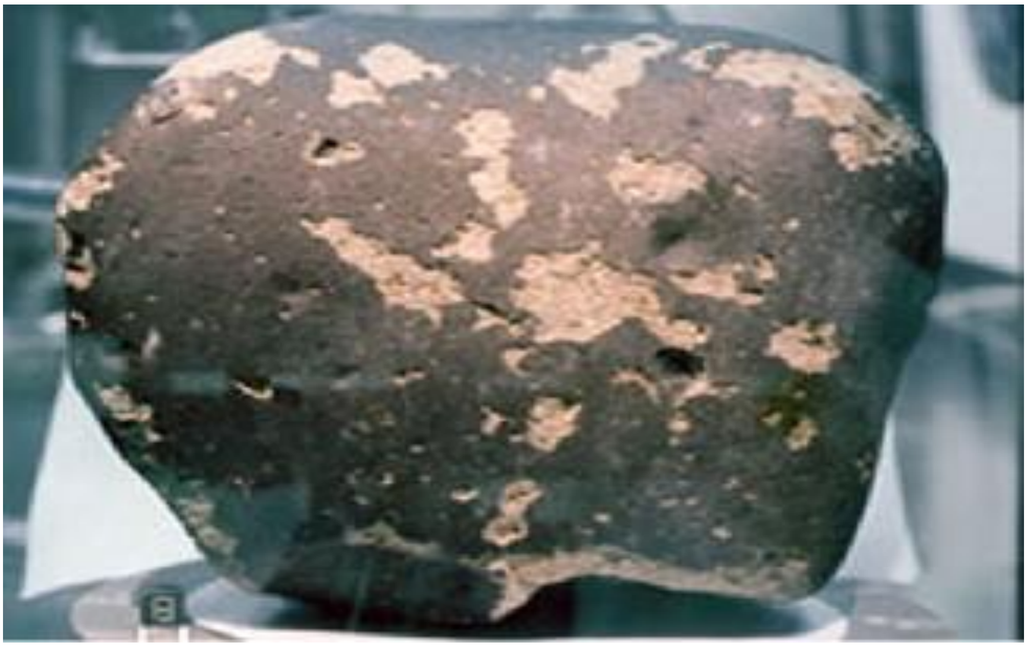

Figure 6. Basalts from Mars(M. H. (Michael H. . Carr, 2006a)

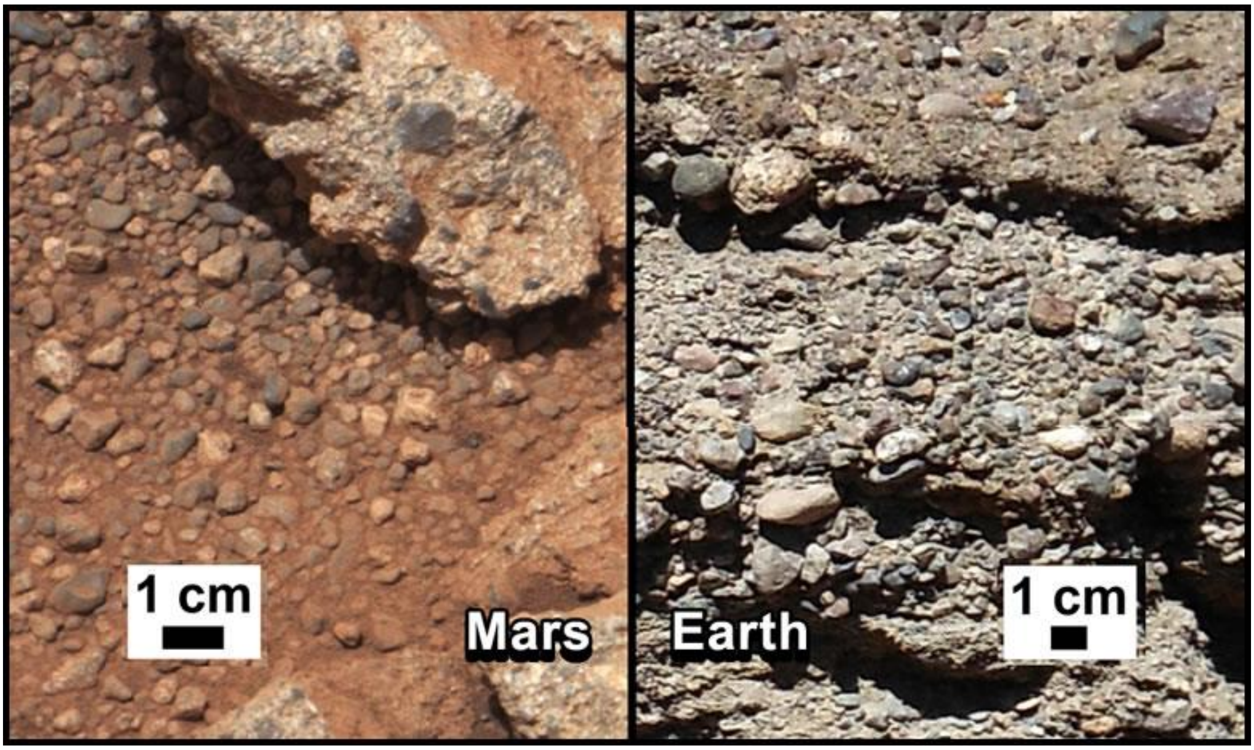

Figure 7a. Conglomerate from Mars and from Earth

This fragment of basalt, ejected from Mars in a crater-forming impact, eventually arrived on Earth's surface.(Korsgaard Jensen et al., 2020; Viles et al., 2010) (Fig.6).

Figure 7b. Sedimentary rocks (shale outcrops) of the Mars

Sedimentary rocks of the Mars is presented on figure 7.

But, based on the results and researchers made, on several volcanoes that are we can conclude that there can be a high presence of igneous rocks but for this, we must prove it, also based on tectonic of the mars we can conclude that there are a lot of geological formation that can be present, to see more about tectonic of mars we will present in next figure below (Fig.8).

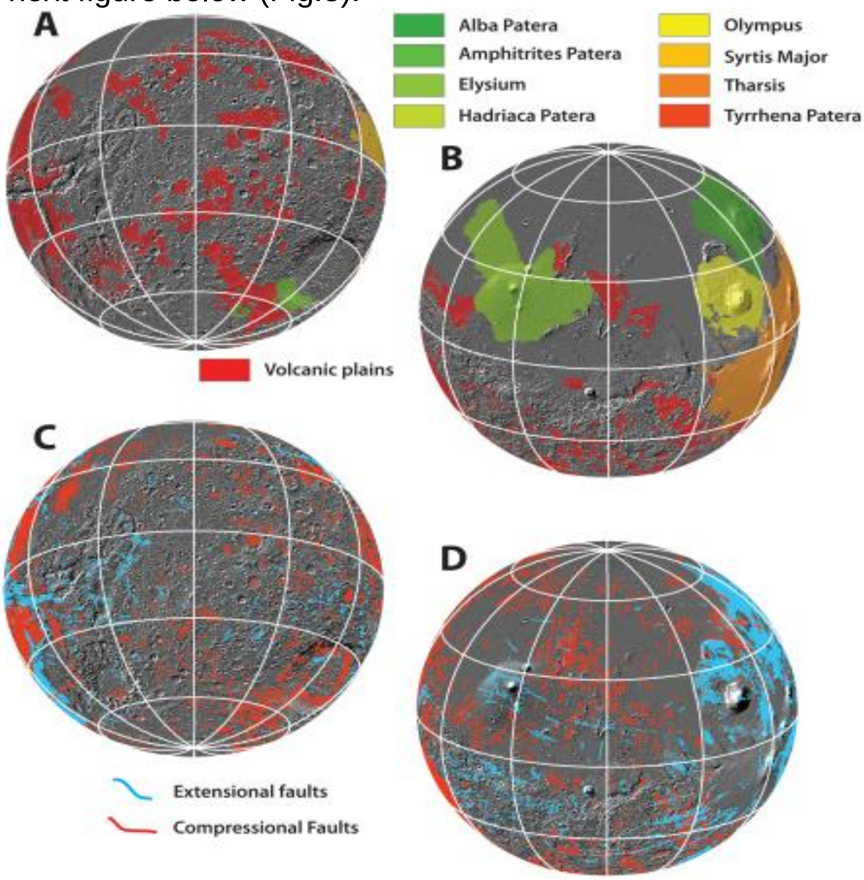

Figure 8. Tectonic and Volcanic map of Mars(Rossi & Van Gasselt, 2010)

The northern and southern hemispheres of Mars are strikingly different from each other in topography and physiography. This dichotomy is a fundamental global geologic feature of the planet. The northern part is an enormous topographic depression. About one-third of the surface (mostly in the northern hemisphere) lies 3–6 km lower in elevation than the southern two-thirds. This is a first-order relief feature on par with the elevation difference between Earth's continents and ocean basins. (Watters, Mcgovern, et al., 2007)
The dichotomy is also expressed in two other ways: as a difference in impact crater density and crustal thickness between the two hemispheres(M. H. (Michael H. . Carr, 2006a; M. Chapman, 2007; Watters, McGovern, et al., 2007). The hemisphere south of the dichotomy boundary (often called the southern highlands or uplands) is very heavily cratered and ancient, characterized by rugged surfaces that date back to the period of heavy bombardment. In contrast, the lowlands north of the dichotomy boundary have few large craters, are very smooth and flat, and have other features indicating that extensive resurfacing has occurred since the southern highlands formed. The third distinction between the two hemispheres is in crustal thickness. Topographic and geophysical gravity data indicate that the crust in the southern highlands has a maximum thickness of about 58 km (36 mi), whereas the crust in the northern lowlands "peaks" at around 32 km (20 mi) in thickness. The location of the dichotomy boundary varies in latitude across Mars and depends on which of the three physical expressions of the dichotomy is being considered (M. H. (Michael H. . Carr, 2006b)

Does Mars have volcanoes?

Questions about Mars' volcanism vary from timing and volume to emplacement patterns (Wilson & Head, 1994), compositional changes(Bibring et al., 2006), and temporal and spatial variability(Greeley & Spudis, 1981; Neukum et al., 2004). Many of these have been addressed by previous and ongoing operations.
Most volcanic activity has been in two provinces, Tharsis and Elysium, which are at the centers of large bulges on the planet's surface. The Tharsis bulge caused fracturing over about one-third of the planet's surface, and this fracturing may be largely responsible for the formation of enormous canyons down the east flank of the bulge. Massive floods of water have flowed periodically across the surface, and some of these may have been triggered somehow by volcanism. (The Reason for Mars' Tumultuous Past | University of Arizona News, n.d.)
Furthermore, the fragmentation of certain surfaces by networks of small branching valleys, especially in the old cratered highlands, suggests gradual erosion by flowing water and perhaps catastrophic global climatic shifts. The form of impact craters, together with the presence of multiple characteristics resembling ground ice, suggests that ground ice is prevalent at shallow depths at high latitudes and higher depths at low latitudes (M. H. (Michael H. . Carr, 2006a; Head et al., 2001)
The lowland plains of Mars resemble the lunar maria and feature almost the same density of impact craters. They, like the lunar maria, are thought to have developed between 3 and 4 billion years ago. Mars appears to have had a substantial volcanic activity about the same period as the Moon, resulting in comparable basaltic lavas.

Figure 8. Olympus Mons: The largest volcano on Mars

The greatest volcanic mountains on Mars may be found in the Tharsis region (shown in Fig 8), while lesser volcanoes can be found all across the planet. Olympus Mons (Mount Olympus) is Mars' most striking volcano, with a circumference of more than 500 kilometers and a summit that soars more than 20 kilometers above the surrounding plains—three times higher than the tallest mountain on Earth. The volume of this massive volcano is roughly 100 times that of Hawaii's Mauna Loa. Olympus would more than cover the whole state of Missouri if placed on Earth's surface.
Scientists can determine the age of these volcanoes by searching for impact craters on their slopes using images acquired from space.(Morris, 1982; P. J. Mouginis-Mark & Robinson, 1992) Many the canoes have a large number of such craters, indicating that they were active for a billion years or more. Olympus Mons, on the other hand, contains extremely few impact craters. Its current surface can't be more than 100 million years old; it might be considerably younger. Some of the new-looking lava flows may have originated a hundred, thousand, or million years ago, but geologically, they are extremely modern. This leads geologists to believe the Olympus Mons is still active, which is something future Mars land planners should bear in mind.(Harris, 1977; P. Mouginis-Mark, 2018).

Does Mars have water?

The atmosphere of Mars, which is largely composed of carbon dioxide, nitrogen, and argon, is the principal driver of present Martian geology. The air is absurdly thin by Earth standards; air pressure atop Mount Everest is around 50 times higher than on the Martian surface. Despite the thin atmosphere, Martian winds may reach speeds of up to 60 miles per hour, throwing up dust that generates gigantic dust storms and vast fields of alien dunes. (Williams & Knacke, 2004)(Vervelidou et al., 2017) Wind and water did, however, formerly flow over the crimson planet. Robotic rovers have discovered compelling evidence that lakes and rivers of liquid water flowed over the surface of Mars billions of years ago. This implies that at some point in the distant past, Mars' atmosphere was thick enough and held enough heat to keep water liquid on the red planet's surface. Today, there are no major pools of liquid water on Mars's surface, even though water ice abounds under its surface and in its polar ice caps. (Beaty et al., 2005)(Tanaka et al., 2003)(M. H. Carr, 1986)(Daerden et al., 2022) (Fig.9.). Mars is also devoid of an active plate tectonic system, the geologic engine that powers our dynamic Earth, as well as a planetary magnetic field. The lack of this protective barrier allows the sun's high-energy particles to more easily peel away the red planet's atmosphere, which may explain why Mars's atmosphere is currently so thin. However, until around 4.12 to 4.14 billion years ago, Mars appears to have possessed an inner dynamo that powered a planet-wide magnetic field. What caused the Martian dynamo to shut down? Scientists are still working on it. (Haberle et al., 2001)(Greshko. M, 2003)

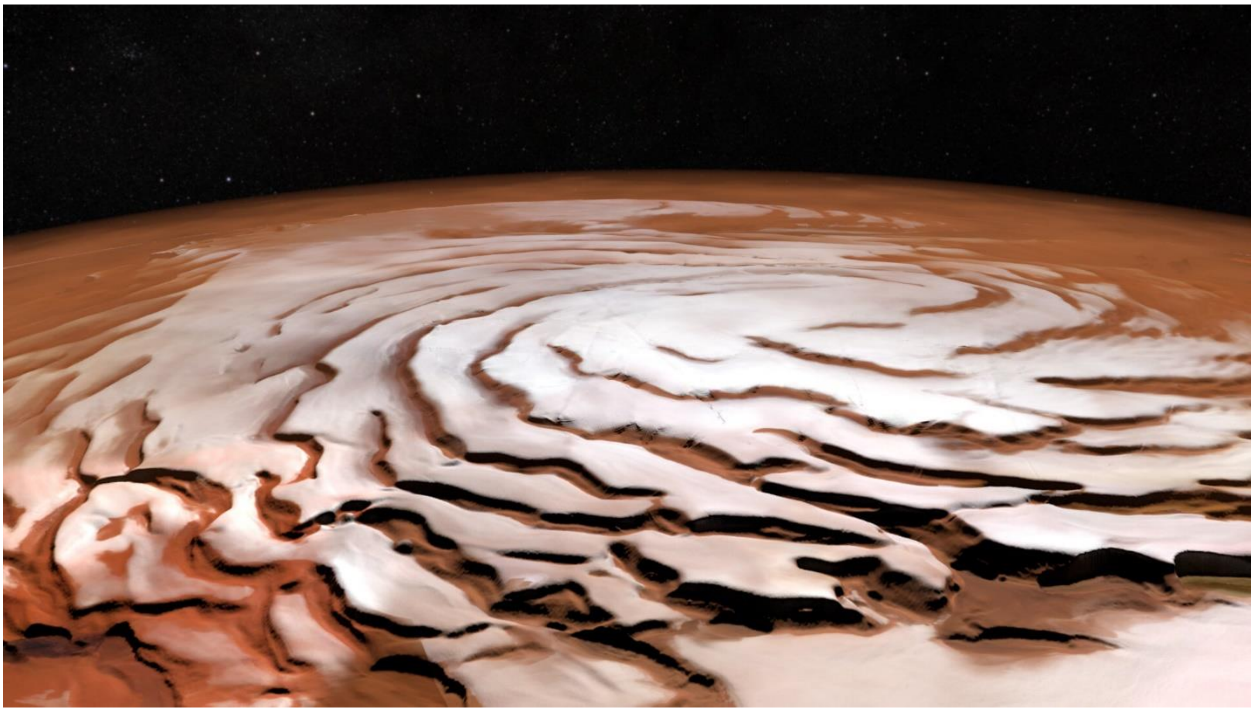

Figure 9. Ice caps on the Mars

4. CONCLUSIONS

Thus, Mars is a planet where most of the geologic processes that we are familiar with on Earth have occurred. However, the two worlds are quite different. The absence of plate tectonics on Mars has resulted in higher surface stability and the formation of massive volcanoes and canyons. Furthermore, the ineffectiveness of water erosion un removing topographic relief has resulted in the near-perfect preservation of features ranging in age. Despite the excellent photographic coverage and nearly perfect preservation, the origin of many of the features remains obscure. (M. Chapman, 2007; Greeley, 1993; Head et al., 2001)

Mars, like Earth, has a varied geologic past. An old, deeply cratered surface records events from the planet's early past. Volcanic activity has persisted throughout the planet's history, probably to the present, resulting in the construction of vast lava plains and enormous shield volcanoes. (Hartmann, 2022)(Hartmann & Daubar, 2017)
The desire to discover is profoundly ingrained in human nature. Exploration elevates us above the mundane worries of food and shelter to sentiments of astonishment, wonderment, and pride. If humans ever travel to Mars, such factors may be what propels us there. However, human exploration is still a long distance off. Meanwhile, there's an entire planet to find, as well as perhaps new biology.

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