NOACHIAN-HESPERIAN BOUNDARY : A POTENTIAL PIVOTAL MOMENT FOR MARS' MAGNETOSPHERE

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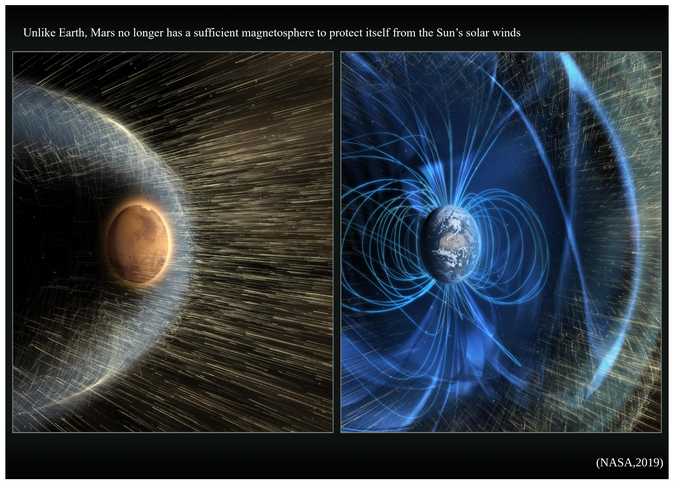
Abstract

A magnetosphere is essential for an atmosphere and the potential of life, so what happened to Mars' ? This poster will examine a section of Mars' geologic history that may house the answer. The Noachian and Hesperian periods.

Context



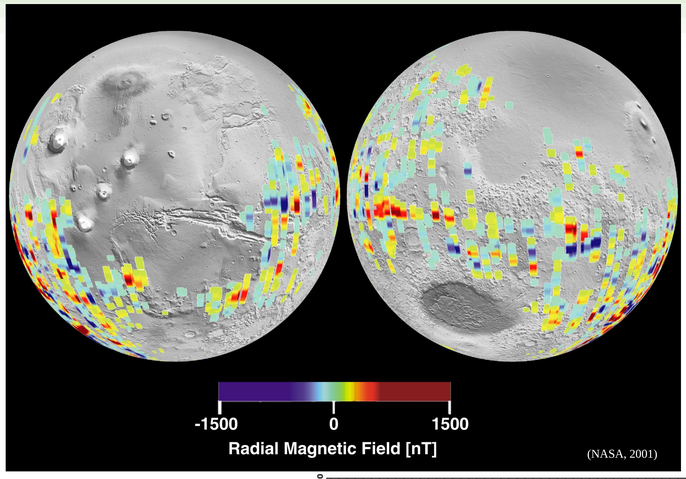
Introduction

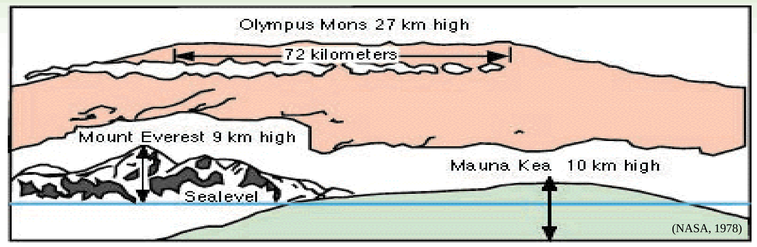
Mars used to possess a magnetosphere like what we have here on Earth. However, it disappeared due to unclear circumstances. As a result of the loss of its magnetosphere, Mars was no longer being defended from the suns solar winds. These solar winds over time, would strip away Mars' atmosphere eventually to what we observe today. As a result of this, most flowing water was removed and as of right now is contained as ice caps on the planet's poles. There may also potentially be underground water.

As of today, the accepted theory for the generation of Earth's magnetosphere is the dynamo theory. This was first introduced by a publication from Walter M. Elsasser in 1956. In summary of that theory, Earth's magnetosphere exists because of the relationship and interaction of our solid inner core and molten outer core. Currently, there are seismic tests being done on Mars with the NASA InSight lander, it has been in operation since 2018. While there has been seismic simulations done to estimate Mars' composition to the mantle-core boundary (Yoshizaki, T., et. Al., 2020), and even actual seismic measurements taken of the core and mantle boundary (Böse, M., et. Al., 2021). Neither of these have answered if Mars has a molten / solid core like Earth or not. Despite Mars boasting the largest volcano in the solar system (Olympus Mons), as well as other volcanoes in the Tharsis region that are 10 to 100 times larger than those anywhere on Earth. It is only about half the size of Earth.

My guiding question is, did an event of extensive volcanic activity on Mars cause it to lose its magnetosphere?

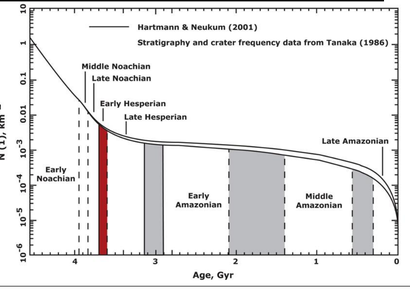
Data

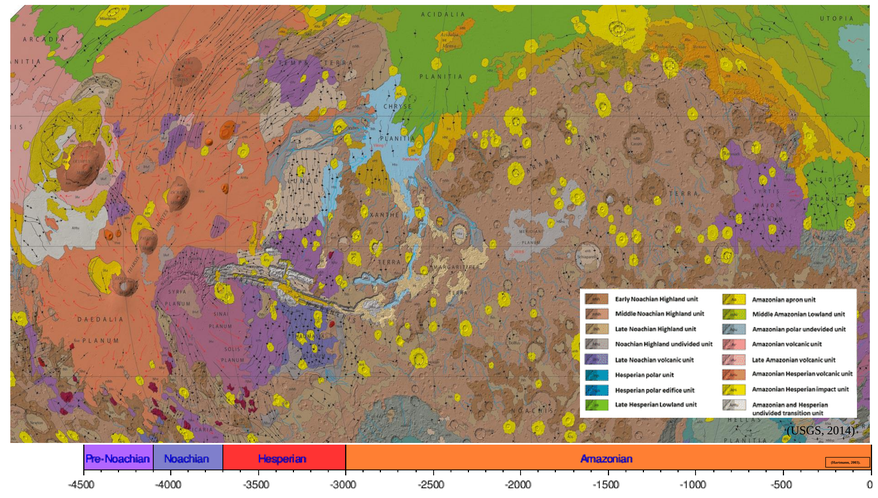




Narration of data

The data shown gives the geologic timeline of Mars, the major volcanoes and the remnants of its magnetic field in the crust





Discussion

Above, the data shows what is left of Mars' magnetic field today in units of Teslas. The left image has the Tharsis region, the right image shows Arabia Terra. Both areas were locations of super-eruptions for around 500 million years (Whelley, P., et. Al., 2021). This event is observed to have happened around the Noachian – Hesperian boundary about 3.7 Gya (Whelley, P., et. Al., 2021) To help understand the size of Olympus Mons, the image in the top right shows it in comparison to Mt. Everest and Mauna Kea. My guiding question is that volcanoes such as Olympus Mons and the ones lying within the Tharsis region and Arabia Terra, ejected a satisfactory amount of Mars' iron liquid inner core. My hypothesis then follows that this would have disrupted its dynamo effect. Ultimately leading to the eventual diminishing of the atmosphere, allowing the surface to be bombarded by foreign objects. It is my belief that this is supported by the amount of ferrous oxides present on the surface of Mars.

The two glaring issues however are that NASA's InSight lander has not done sufficient enough analysis of Mars' core to determine its composition. The other is that looking at the Hartmann & Neukum diagram, it shows that the largest impact craters appear to have happened before this event of extensive volcanic activity.

When NASA's InSight lander has completed its stated mission to determine what the composition of Mars' core is, this hypothesis could then be supported or disproven to a greater extent.

Summary

Mars did at one point have a magnetosphere; this is shown by fluvial features on the surface of Mars. However, something happened on the red planet that caused it to lose its magnetosphere causing it to turn into what we see today. My guiding question / hypothesis was that due to extensive super-eruptions for an estimated 500 million years at the Noachian- Hesperian boundary, caused this disruption of the magnetosphere by displacing enough iron from the core to the surface. More research is needed however from NASA.

References Cited

Böse, Maren, Stähler, Simon C., Deichmann, Nicholas, Giardini, Domenico, Clinton, John, Lognonné, Philppe Ceylan, Savas, Driel, Martin v., Charalambous, Constantinos, Dahmen, Nikolaj, Horleston, Anna, Kawamura, Taichi, Khan, Amir, Knapmeyer, Martin, Orhand-Mainsant, Guénolé, Scholz, John-Robert, Euchner, Fabian, Banerdt, Bruce W.,2021, Magnitude Scales for Marsquakes Calibrated from InSight Data: Bulletin of the Seismological Society of America 2021;; 111 (6): 3003–3015. doi: https://doi-org.ezproxy.lib.ndsu.nodak.edu/10.1785/0120210045

Elsasser, Walter M., 1956, Hydromagnetic Dynamo Theory. Reviews of Modern Physics, 28 (2). 135-163 doi:10.1103/revmodphys.28.135

Hartmann, William K., Neukum, Gerhard, 2001, Cratering chronology and the evolution of mars: Space Science Reviews v. 96, p. 165-194, http://www2.ess.ucla.edu/~nimmo/ess250/hartmann.pdf

Whelley, Patrick, Novak, Alexandra M., Richardson, Jacob, Bleacher, Jacob, Mach, Smith, Kelsey R.N., 2021, Stratigraphic Evidence for Early Martian Explosive Volcanism in Arabia Terra: GRL v. 48, issue 15, e2021GL094109, https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2021GL094109

Yoshizaki, Takahashi, McDonough, William F., 2020, The composition of Mars: Geochimica et Cosmochimica Acta v. 273, p. 137-162, https://www-sciencedirect com.ezproxy.lib.ndsu.nodak.edu/science/article/pii/S0016703720300235?via%3Dihub#!