Background information 2:

Do the given location factors allow for human settlement on the Moon?

In contrast to the earth, the Moon only has a pseudo-atmosphere, the so-called exosphere. The gravitational acceleration on the surface of the Moon is just one sixth (approx. 17%) of that on the surface of the earth. This gravitational pull is far too low to bind volatile gases to the Moon and thus create an atmosphere similar to that of the Earth. Only a few atoms and ions of volatile elements surround the Moon in a wafer-thin exosphere. It is almost like a perfect vacuum and is created by the influence of the solar wind, which causes local magnetic fields to create statically charged particles that can rise upwards despite the absence of an atmosphere. These particles contain helium from the solar wind as well as sodium and potassium atoms. These are released from the layer of debris and dust surrounding the entire moon, the regolith, when particles from the solar wind hit the lunar surface. Argon, radon and polonium can also be detected in the exosphere.

The Moon is an extremely dry celestial body, but satellite data from several space probes indicate that there are large quantities of water ice in the permanently shadowed craters at the north and south poles in the lunar soil. In addition, very small amounts of water ice can be detected distributed over the entire lunar surface. These have been brought to the Moon by comets and ice asteroids. The water is only present in small quantities, as it usually evaporates directly on the Moon due to the strong and unprotected solar radiation, even if it has formed during the extremely cold lunar night. In addition, the physical state of water on the Moon is significantly different from that on Earth. This is due to the more fluctuating temperatures on the Moon and the difference in pressure. On the Moon, the pressure is almost 0 bar due to the absence of an atmosphere (compared to approx. 1 bar on Earth). As a result, water on the Moon is only present in a solid or gaseous state. Liquid water cannot form at almost 0 bar pressure, as the boiling point of water is too low under these conditions. In order to obtain liquid water on the Moon, the temperature and pressure would have to be adjusted accordingly (see Fig. 1).

Author: Roman Hiby (roman.hiby@rub.de); Contact: Jun. Prof. Dr. Andreas Rienow (andreas.rienow@rub.de)
AG Geomatics – Interdisciplinary Geoinformation Sciences, Institute of Geography, Ruhr-Universität Bochum

Funding: By the German Space Agency at the German Aerospace Center with funds from the Federal Ministry for Economic Affairs and Climate Action on the basis of a decision by the German Bundestag under the funding code 50TD2201.

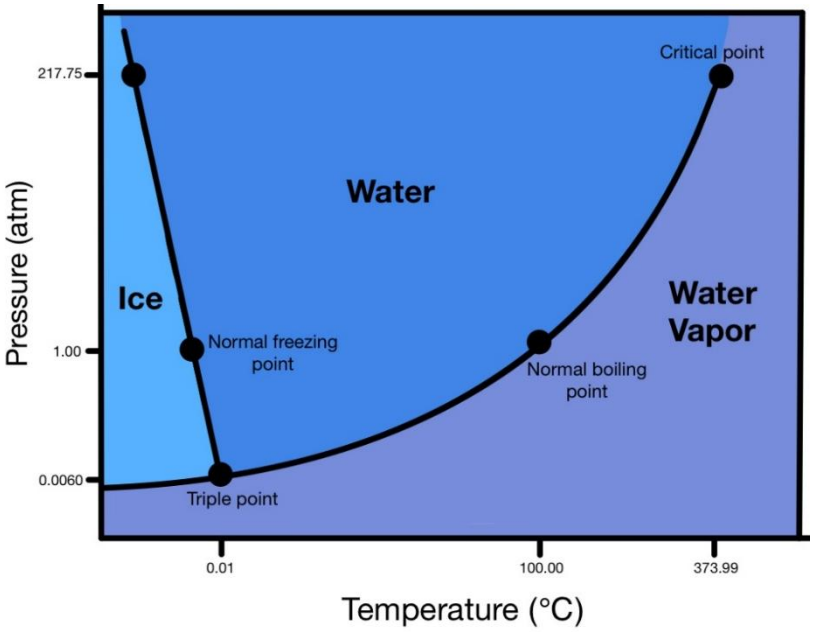

Figure 1: Aggregate states of water under different pressures and temperatures

Due to the extremely thin exosphere, temperatures on the Moon fluctuate much more than on Earth. The surface temperature fluctuates between a minimum of -160 °C and a maximum of 130 °C. As a result, life is unthinkable without appropriate protection from the extreme solar radiation and the given temperatures. Due to the absence of an atmosphere, the Moon also has no air temperature, only a surface temperature.

However, the Moon offers greater potential for the use of solar energy than the Earth. Especially for future research missions and for stationary stays on the Moon, energy supply with the help of solar energy could be a milestone for energy self-sufficiency on the Moon.

Regarding the topography of the Moon, which is also one of the hard location factors, plateaus, so-called terra regions, have developed on the side facing away from the earth and mare/maria regions on the side facing the earth. Terra areas are very densely covered with craters of various sizes, while mare plains are poorer in craters. In addition, the mare plains are usually much lower than the adjacent terra areas. All mare areas are of volcanic origin and are mainly found on the side facing the earth. They are younger than the highlands and consist of lava that has filled the basins formed by asteroid and comet impacts. Figure 2 shows the topography of the Moon with the different elevation data of the near and the far side of the Moon.

Author: Roman Hiby (roman.hiby@rub.de); Contact: Jun. Prof. Dr. Andreas Rienow (andreas.rienow@rub.de)
AG Geomatics – Interdisciplinary Geoinformation Sciences, Institute of Geography, Ruhr-Universität Bochum

Funding: By the German Space Agency at the German Aerospace Center with funds from the Federal Ministry for Economic Affairs and Climate Action on the basis of a decision by the German Bundestag under the funding code 50TD2201.

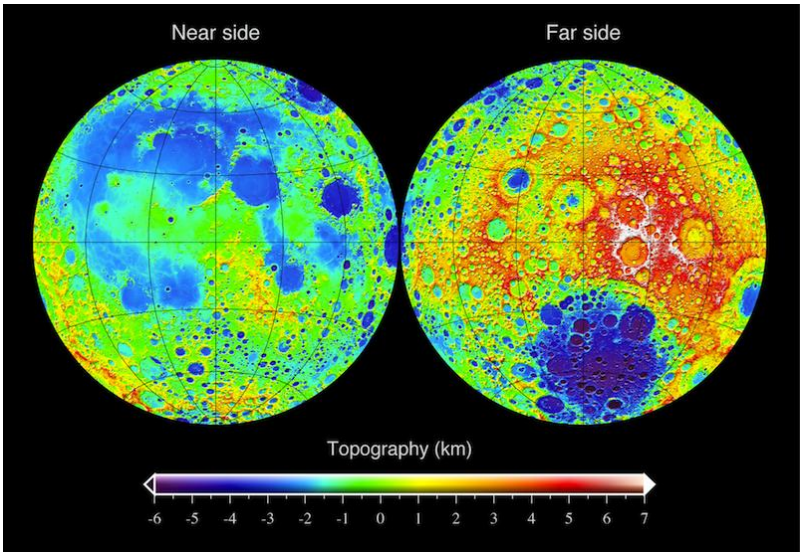

Abbildung 2: Höhenkarte des Mondes

The gravitational acceleration on the Moon is 1.62 m/s² and is therefore six times lower than on Earth (9.81 m/s²). This is due to the lower mass and the associated weaker gravitational force of the Moon.

Compared to the Earth, a day on the Moon does not last 24 hours, but 29.53 days, i.e. one exact orbit around the Earth. This is due to the synchronized orbit, as the Moon's own rotation was slowed down by the Earth's gravitational force early on after the Moon was formed. Since then, the Moon has been in a tidal locking with the Earth, which means that the same side of the Moon can always be seen from Earth.

However, there are other aspects to consider when colonizing the Moon, such as cosmic radiation, the lack of oxygen or breathable air and the effects of weightlessness. As the Moon is located outside the Earth's protective magnetic field, the radiation exposure for humans is very high, so that it poses a health risk. Appropriate protective measures must therefore be taken. According to Jaumann, protection against radiation could be achieved by insulating the lunar base with regolith. Existing water on the Moon could also solve the problem of the lack of oxygen, as transporting oxygen would not only be very time-consuming but also expensive. Electrolysis could easily produce hydrogen and oxygen, which could be used as rocket fuel. However, electrolysis works less well on the Moon than on earth. The reason for this is the very low gravity. The British company Metalysis is also currently working on a working on a solution to extract oxygen from moon rock. Finally, the physical consequences of weightlessness must be taken into account. For example, after a longer stay on the Moon, muscle and bone atrophy or effects on eyesight are to be expected.

Author: Roman Hiby (roman.hiby@rub.de); Contact: Jun. Prof. Dr. Andreas Rienow (andreas.rienow@rub.de)
AG Geomatics – Interdisciplinary Geoinformation Sciences, Institute of Geography, Ruhr-Universität Bochum

Funding: By the German Space Agency at the German Aerospace Center with funds from the Federal Ministry for Economic Affairs and Climate Action on the basis of a decision by the German Bundestag under the funding code 50TD2201.

Sources:

Jaumann, R.; Köhler, U.; Sohl, F.; Tirsch, D.; Pieth, S. (2018): Expedition zu fremden Welten. 20 Milliarden Kilometer durch das Sonnensystem. Deutsches Zentrum für Luft- und Raumfahrt. Springer-Verlag GmbH Deutschland. Berlin.

https://www.die-debatte.org/weltraumnutzung-zurueckkehren-um-zu-bleiben/

Wanner, C. (2021): Diese Idee soll Leben auf dem Mond ermöglichen. In: WELT, 11.01.2021, URL: https://www.welt.de/wirtschaft/article224112990/Wunderstoff-Mondstaub-Ermoeglicht-er-bald-schon-menschliches-Leben.html [20.12.2022].

https://www.spektrum.de/news/warum-elektrolyse-auf-dem-mond-schlechter-funktioniert/1984495#:~:text=Auf%20Mond%20oder%20Mars%20funktioniert,nur%20schwer%20zu%20vermeidender%20Effekt.&text=Um%20eine%20permanente%20Kolonie%20auf,zu%20errichten%2C%20braucht%20man%20Sauerstoff [20.12.2022].

https://www.nationalgeographic.de/wissenschaft/2018/10/weltraumreisen-veraendern-das-menschliche-gehirn#:~:text=Die%20Schwerkraft%20der%20Erde%20sorgt,werden%20und%20einfacher%20brechen%20k%C3%B6nnen [20.12.2022].

Author: Roman Hiby (roman.hiby@rub.de); Contact: Jun. Prof. Dr. Andreas Rienow (andreas.rienow@rub.de)
AG Geomatics – Interdisciplinary Geoinformation Sciences, Institute of Geography, Ruhr-Universität Bochum

Funding: By the German Space Agency at the German Aerospace Center with funds from the Federal Ministry for Economic Affairs and Climate Action on the basis of a decision by the German Bundestag under the funding code 50TD2201.