UZAY İNŞAAT MÜHENDİSLİĞİ

En eski mühendislik dalının yeni dünyalarda uygulamaları

14.12.2023 19:00
İnşaat Mühendisleri Odası
İstanbul Şubesi
Karaköy Hizmet Binası
Harun Karadeniz Konferans salonu

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d

UZAY İNŞAAT MÜHENDİSLİĞİ VE YZ

SPACE CIVIL ENGINEERING AND AI

Uzay İnşaat Mühendisliği Nedir?

Uzay inşaat mühendisliği, uzay araçları ve uydu sistemleri tasarımı, üretimi, testi ve işletmesi gibi konularda teorik ve pratik eğitim veren bir alandır .

Uzay inşaat mühendisliği, uzay araçlarının yapım süreci, mühendislik ve inşaat aşamalarından oluşmaktadır. Uzay araçlarının yapımının temel aşamaları ise mühendislik ve inşaat aşamalarıdır Bu alanda eğitim alan kişiler, uzay araçları ve uydu sistemleriyle ilgili çalışmalar yapabilirler.

Uzay inşaat mühendisliği, genellikle uzay mühendisliği olarak da adlandırılır ve uzay araçları ve uydu sistemleri tasarımı, üretimi, testi ve işletmesi gibi konularda teorik ve pratik eğitim verir . Uzay inşaat mühendisliği, genellikle makine mühendisliği, malzeme mühendisliği ve inşaat mühendisliği gibi alanlarla ilişkilidir Uzay inşaat mühendisleri, uzay endüstrisinde ve otomotiv ve gemi inşa endüstrisinde görev alabilirler Uzay inşaat mühendisliği, uzay araçları ve uydu sistemleri tasarımı, üretimi, testi ve işletmesi gibi konularda teorik ve pratik eğitim veren bir alandır

Space Civil Engineering

Space civil engineering is an emerging discipline that focuses on extending and expanding civil engineering know-how to address the unique challenges of space exploration and habitation. Civil engineers play a crucial role in the space industry by designing and analyzing structures for space missions, lunar habitats, and planetary settlements.

Civil engineers are employed in the space industry because they are well-versed in the design and analysis of structures, which is essential for space exploration and habitation.

They are involved in various aspects such as the construction of consumables depots for crew and power, habitat construction, and addressing the engineering challenges posed by future expeditions to the moon, Mars, and deep space.

The role of civil engineers in the space program is significant, as they contribute to the development of structures for future space travel, lunar missions, and Mars settlement design.

This field offers exciting opportunities for civil engineers to make new discoveries and contribute to changing the world through their expertise in structural design and engineering.

SUNUCU

PRESENTER

1960. One of my rockets exploding during take-off. When I was a middle school student.

Cam piramit içinde, azot gazı ile çevrelenmiş "ay taşı"

■ Doğu Akdeniz Üniversitesi'nde düzenlenecek "Uluslararası İnşaat Mühendisliği'nde Gelişmeler Kongresi"nde tanıtılmak üzere 3.3 milyar yıllık ay taşı Houston Uzay Merkezi'nden KKTC'ye getirildi

■ Özel bir cam piramit içerisinde korunan taş, 1971 yılında uzaya giden "Apollo 15" ekibi tarafından dünyaya ulaştırılmıştı. Söz konusu taş National Aeronautics and Space Administration'da (NASA) muhafaza ediliyor

3.3 milyar yıllık ay taşı KKTC'de

■ Boğaziçi, İstanbul Teknik ve Orta Doğu Teknik üniversitelerinin desteğiyle yapılacak kongre, 1-3 Kasım tarihlerinde yer alacak. DAÜ öğretim üyesi Yrd. Prof. Dr. Cengiz Toklu tarafından adamıza getirilen 3.3 milyar yıllık ay taşı, 9 Ekim Pazartesi günü DAÜ'de sergilenecek

Sevilây SADIKOĞLU

Houston Uzay Merkezi'nden KKTC'ye getirilen 3.3 milyar yıllık ay taşı, Doğu Akdeniz Üniversitesi'nde (DAÜ) sergilenecek. "4. Uluslararası İnşaat Mühendisliği'nde Gelişmeler Kongresi"nde tanıtılacak ay taşı, önceki gün DAÜ öğretim üyesi Yrd. Prof. Dr.Cengiz Toklu tarafından National Aeronautics and Space Administration (NASA) Houston Uzay Merkezi'nden alınarak KKTC'ye getirildi.

Özel bir cam piramit içerisinde korunan taş, 1971 yılında uzaya giden "Apollo 15" ekibi tarafından dünyaya ulaştırılmıştı. 3.3 milyar yıllık ay taşı, 9 Ekim Pazartesi günü DAÜ'de sergilenecek.

"İnşaat Mühendisliği'nde Gelişmeler 4. Uluslararası Kongresi" 1-3 Kasım 2000 tarihlerinde DAÜ önderliğinde, Boğaziçi Üniversitesi, İstanbul Teknik Üniversitesi (İTÜ) ve Orta Doğu Teknik Üniversitesi (ODTÜ) gibi Türkiye'nin önde gelen üç üniversitesinin işbirliği ve desteğiyle yapılacak.

Bilim ve uygulama açılarından büyük önem taşıyan bu kongreye yerli ve yabancı 300 kadar bilim adamı, akademisyen, inşaat mühendisi ve çeşitli görevlerde bulunan konuklar katılacak. Kongrede 210 kadar bildiri sunulacak. Kongrede "İnşaat Mühendisliğinde Teknik Gelişmeler" konusunun yanı sıra iki özel ve de önemli konuda ayrı oturumlar yapılacak. Tanınmış uluslararası uzmanların katılacağı bu toplantılardan birincisinde "Uzay Mühendisliği" konusu ele alınacak.

3.3 milyar yıllık ay taşı "Uzay Mühendisliği" konulu toplantıda tanıtılacak. Dünyada bir başka örneği olmayan söz konusu taş, 26 Temmuz 1971 yılında Cape Kennedy Uzay Üssü'nden hareket eden David R.Scott (kumandan), James B.Irwin (kumandan modülü pilotu) ve Alfred M. Worden (ay modülü pilotu) isimli astronotlar tarafından alınmıştı.

30 Temmuz 1971'de aya iniş yapan üç astronotun, aydaki 26.1 kuzey enleminde, 3.6 doğu boylamında Apenin dağlarının eteklerinde Hadley lav çukuru kenarından aldıkları ve 7 Ağustos 1971 tarihinde dünyaya taşıdıkları ay taşı, kongrede katılımcılara tanıtılacak. Yetkililer, 3.3 milyar yıllık uzay taşıyla ilgili şu bilgileri verdi:

"Bu taş o zamana kadar dünyaya getirilen en büyük taştır. 9.6 kg. ağırlıkta olan taş, dünyada çeşitli büyüklükte parçalara ayrılarak deneylere tabi tutulmuş, ya da sergilenmeler için kullanılmıştır.

KKTC'ye getirilen parça, 92.5 gramlık kahverengi-gri renkli homojen görünümlü bir taştır. Bazalt orijinli olan taşın yaşı, 3.3 milyar yıl olarak belirlenmiştir.

Bilindiği gibi ayda atmosfer olmadığından, meteor çarpmalarına hedef olmayan taşlar değişime uğramadan kalabilmektedir.

15555 numaralı bu taş, astronotların 3. araç dışı çalışmaları sırasında alınmıştır. Bu araç dışı çıkış sırasında astronotlar, araçlarından 5.1 km kadar uzaklaşmışlardır.

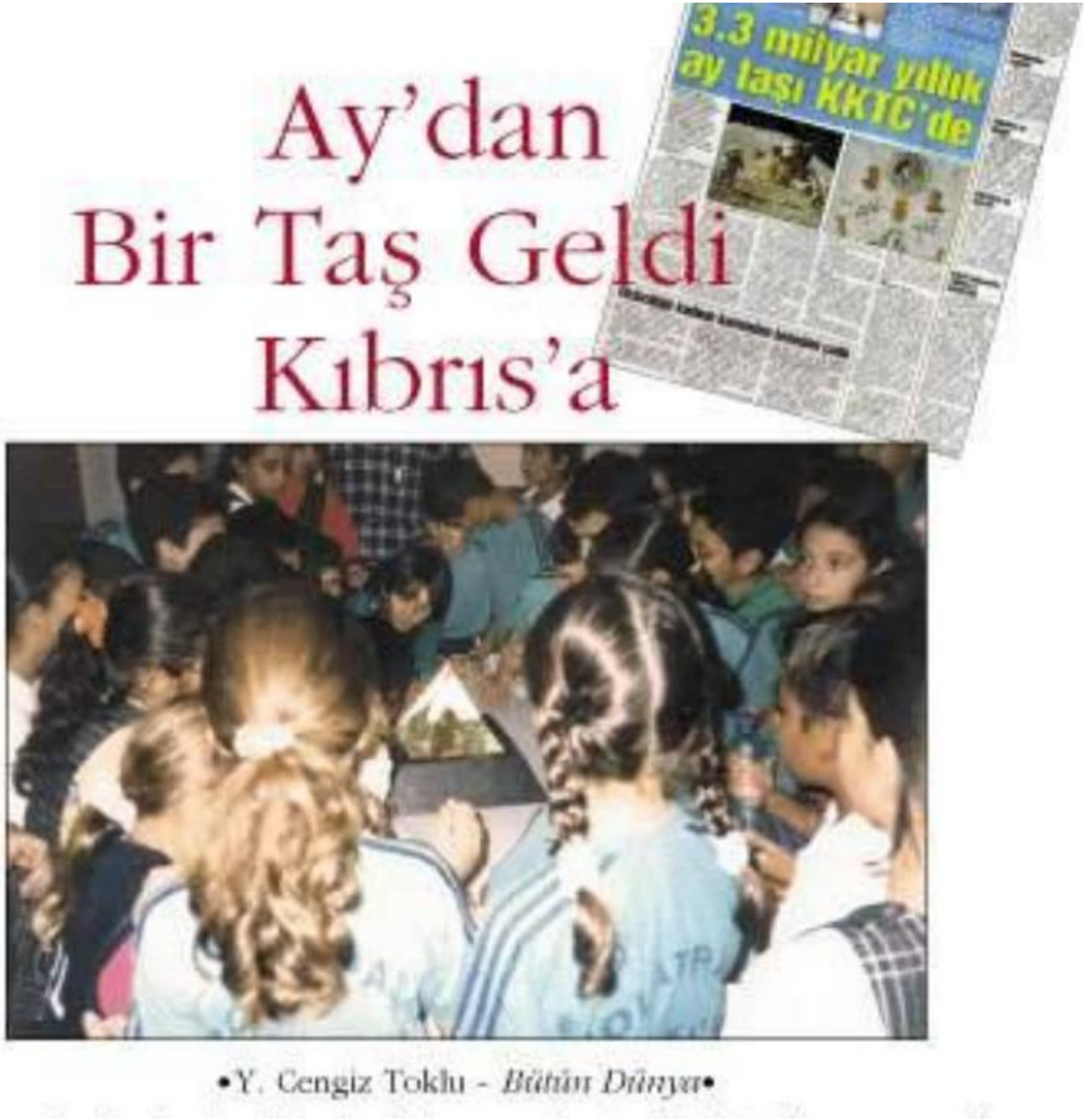
Ay taşı, yapılan yazışmalar sonunda (NASA) National Aeronautics and Space Administration - Houston Uzay Merkezi'nde DAÜ öğretim üyesi Y. Prof. Dr. Cengiz Toklu'ya teslim edilmiş ve güvenlik kuralları gereği hiç geceleme yapılmadan KKTC'ye getirilerek emniyet altına alınmıştır."

Ülkemizde ilk kez

Houston Uzay Merkezi'nden KKTC'ye getirilen taş, KKTC'de ilk kez 9 - 29 Ekim 2000 tarihleri arasında, üniversitenin çeşitli yerlerinde sergilenecek. 1 - 3 Kasım 2000 tarihlerinde Salamis Bay Conti Resort Hotel'de yapılacak "4. Uluslararası İnşaat Mühendisliği'nde Gelişmeler Kongresi" ve İnşaat Fuarı'nda da söz konusu taş tanıtılacak. Türkiye Deprem Konseyi Başkanı Tuğrul Tankut'un da katılacağı diğer oturumun konusu ise "Deprem Mühendisliği" ve 1999 yılında meydana gelen "Türkiye Depremleri" olacak.

Kongre sırasında yapılacak sergiyle de inşaat sanayiinin ve inşaat mühendisliğinin tanıtımına yardımcı olunması, kamuoyunun bu alandaki gelişmeleri gözlemlemesine olanak tanınması planlanıyor.

Serginin üç gün süresince kongrenin yapılacağı Salamis Bay Conti Resort Hotel'de ayrıca, bir hafta boyunca DAÜ'de yapılması düşünülüyor. Bu sergi sayesinde üst düzey bilimsel bir toplantı ile geniş kitlelere ulaşmak amaçlanıyor. Sergiye yerli firmalarımızın da DAÜ'de İnşaat Mühendisliği Bölümü'ne başvu-



•Y. Cengiz Toklu - *Bütün Dünya*•

----- Original Message -----
From: "PARKER, LOUIS A. (JSC-AP161) (NASA)" <louis.a.pa

To: "'Cengiz Toklu'" <cengiz.toklu@emu.edu.tr>
Sent: Thursday, February 06, 2003 5:47 PM
Subject: RE: Columbia

Dr. Toklu,
Thank you for your kind words. We're coping well, although it's still hard to imagine that we lost our 7 astronauts the way we did. We're working hard to find the problem, and rest assured, we'll find it, correct it, and will move forward. The Shuttle will fly again, and we'll be stronger for it.... Keep your eyes on the stars!

Louis Parker
JSC Exhibits Manager
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web www.jsc.nasa.gov/programs


HAVACILIK VE UZAY
TEKNOLOJİLERİ


LUNAR AVM
İNŞAAT SAHASINA GİRMEK
TEHLİKELİ VE YASAKTIR
BAYRAMOĞLU
ÖNCE EMNİYET
Çalışırken uzay kaskı,
oksijen tüpü ve emniyet
kemeri takmak zorunludur.


TÜRKİYE
MÜHENDİSLİK
HABERLERİ
YIL : 62 / 2017 - 2 SAYI : 494
LUNAR AVM
İNŞAAT SAHASINA GİRMEK
TEHLİKELİ VE YASAKTIR
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Uzayda İnşaat
Mühendisliği

19th Conference, since 1988

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ASCE AEROSPACE

April 15 - 18, 2024; Greater Miami, FL

FIU Engineering & Computing
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The 19th ASCE ASD Biennial International Conference on Engineering, Science, Construction and Operations in Challenging Environment (Earth & Space 2024)

of Moon and Mars. The talks will highlight the architectural and structural engineering challenges in the design of Lunar and Martian habitats. The papers will address design issues for zero-gravity and planetary surfaces, spatial planning, material and system selection, and structural design. Accompanying topics may include mechanical aspects related to deployment and construction methods such as 3D printing.

7. Inflatable and Deployable Structures: Applications for Space and Planetary Environments

Session Organizer: Y. C. Toklu, Ph.D., Beykent University, Istanbul, Turkiye (E-mail: cengiztoklu@gmail.com) and Pezhman Mardanpour, Ph.D., Florida International University, Miami, FL (E-mail: pmardanp@fiu.edu)

With manned space flight missions increasing in duration to return to the Moon, and Mars, habitable volume in spacecraft and planetary structures for performing work, living, and storage for supplies must increase as well. Inflatable and deployable structures have the potential to provide the needed habitable volumes with fewer rocket launches over traditional structures. This special session will focus on design and analysis these soft good habitat structures and both the benefits and technical challenges they provide for manned space flight and planetary environments. This topic would include: materials, construction, deployment, testing and verification, launch packing, radiation protection, simulations, damage protection and repair, terrestrial analogues, planetary resource utilization in relation to inflatable and deployable structures.

8. Engineering Concepts for Resilient Deep Space (Lunar and Martian) Habitats

Session Organizer(s): Ramesh B. Malla, Ph.D., F.ASCE, F.EMI, A.F.AIAA; University of Connecticut, Storrs, CT (E-mail:

Son Dakika | Finans | Video | Dünya | Spor | Tv Programları | Sağlık | Magazin

SON DAKİKA 15:03 Ali Babacan'ın annesi, son yolculuğuna ... • 14:41 ABD'nin Tennessee eyaletini hortum vu

Türkiye 'Ay toprağı' üreten ülkeler arasında yerini aldı

İlerde uzaya yerleşim amacıyla 'Ay toprağı' üreten ülkeler arasında Türkiye, 10 sırada yerini aldı. Türkiye'deki Ay toprağı üretimi çalışmalarının daha avantajlı olduğunu belirten Prof. Dr. Y. Cengiz Toklu bunu, tüm Ay toprağı çeşitlerini üretebilecek formüllerin geliştirilmesine bağladı.

Haberler > Güneş > Türkiye de 'Ay toprağı' üretti

14 Mart 2022 Pazartesi 18:55 | Son Güncelleme: 14 Mart 2022 Pazart

Türkiye de 'Ay topr

AA yazdır

Türkiye Ay toprağı üreten 10. ülke oldu. Apollo ve Luna seferleriyle dünyaya yaklaşık 400 kilo Ay toprağı getirildiğini belirten Prof. Toklu, "Tüm toprak çeşitleri için formül oluşturduk" dedi.

Türkiye 'Ay toprağı' üreten onuncu ülke oldu: Ay toprağı nedir?

Gelecekte uzaya yerleşim amacıyla 'Ay toprağı' üreten ülkeler arasında Türkiye de yer aldı. Almanya, ABD, Avustralya, Çin, Hindistan, İtalya, Kanada, Japonya ve Kore'nin ardından Türkiye de Ay toprağına benzer bir toprak üretmeyi başardı. Ay toprağı, gelecek yıllarda uzayda bir yerleşim sağlanabilmesi için gerekli olan malzemelerin temelini oluşturuyor.

14 Mart 2022 11:50 Güncelleme: 14 Mart 2022 11:50

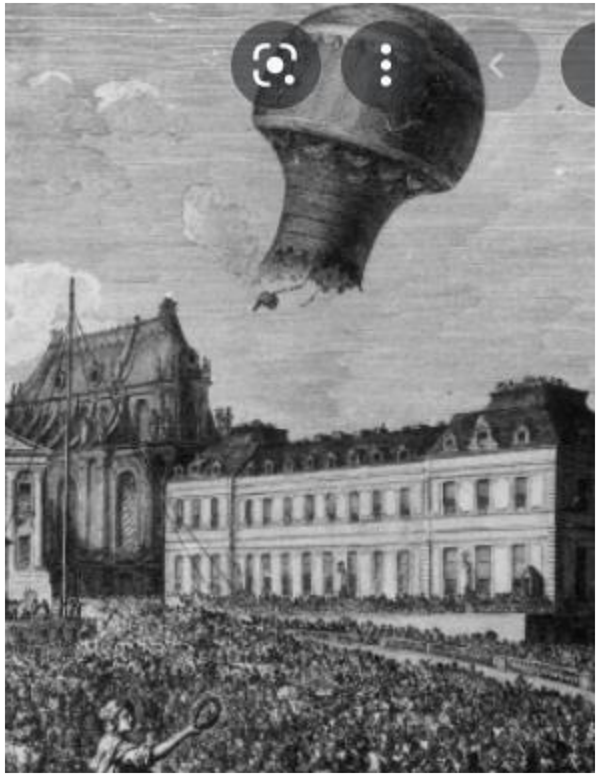
THE MOON SOCIETY

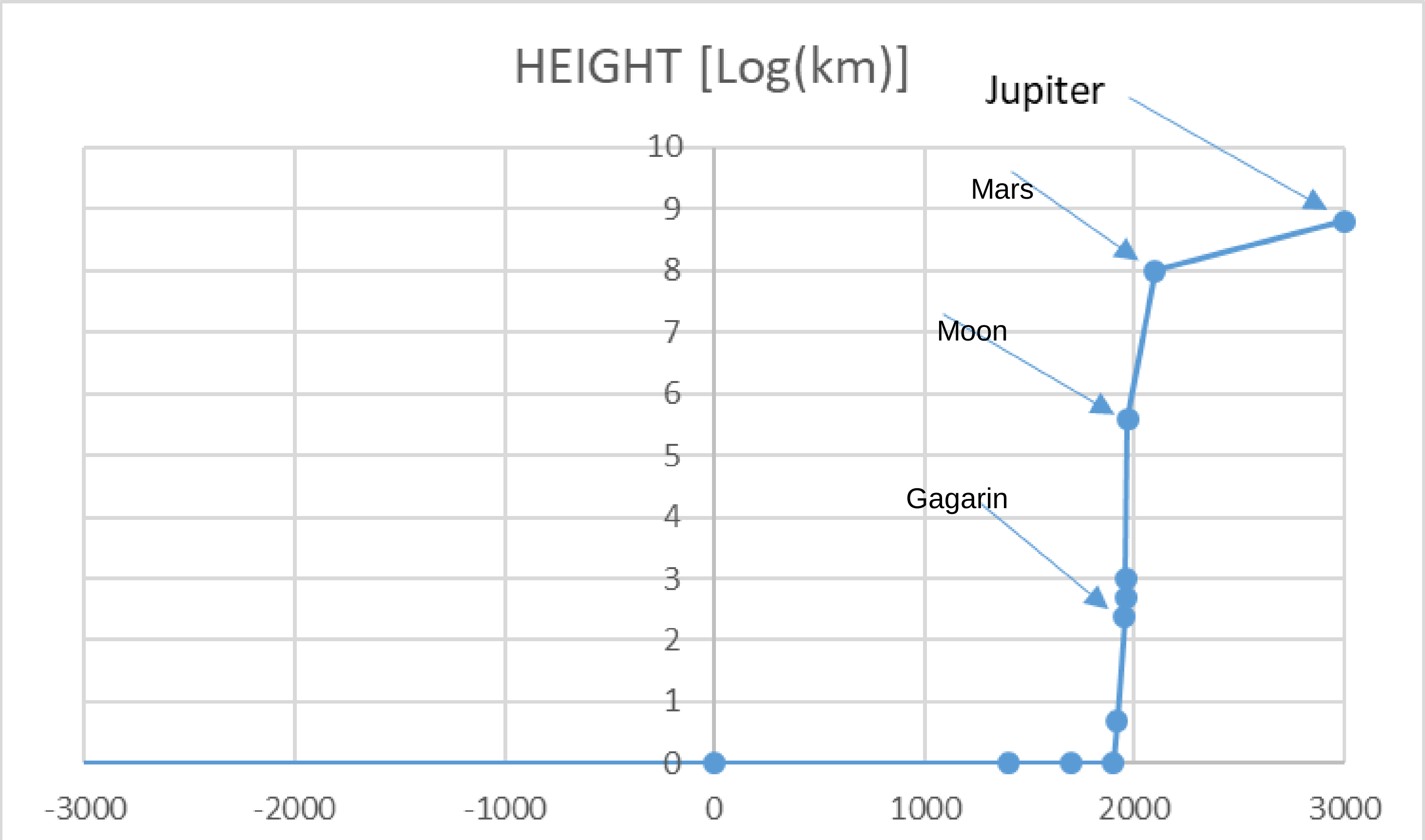
BOARD MEMBER

GİRİŞ

INTRODUCTION

Manned flights to space





A CAVE, FIRST HABITAT

A SMALL WORLD

First environment of humans was a few miles around their habitats. They were exploiting the resources in that environment. They new the characteristics of the “nature” which was prevailing in that area.

AREA GETTING BIGGER

As their environmental area got bigger, the resources became richer in variety and quantity and the humans met new natural conditions. Increased richness enabled humans to discover larger areas thus to enlarge their environmental area.

New natural conditions made them more flexible and more powerful to deal with new difficulties thus increasing their technological abilities.

GLOBALIZATION

This spiral of

Increased Environmental Area <> Increased use of resources

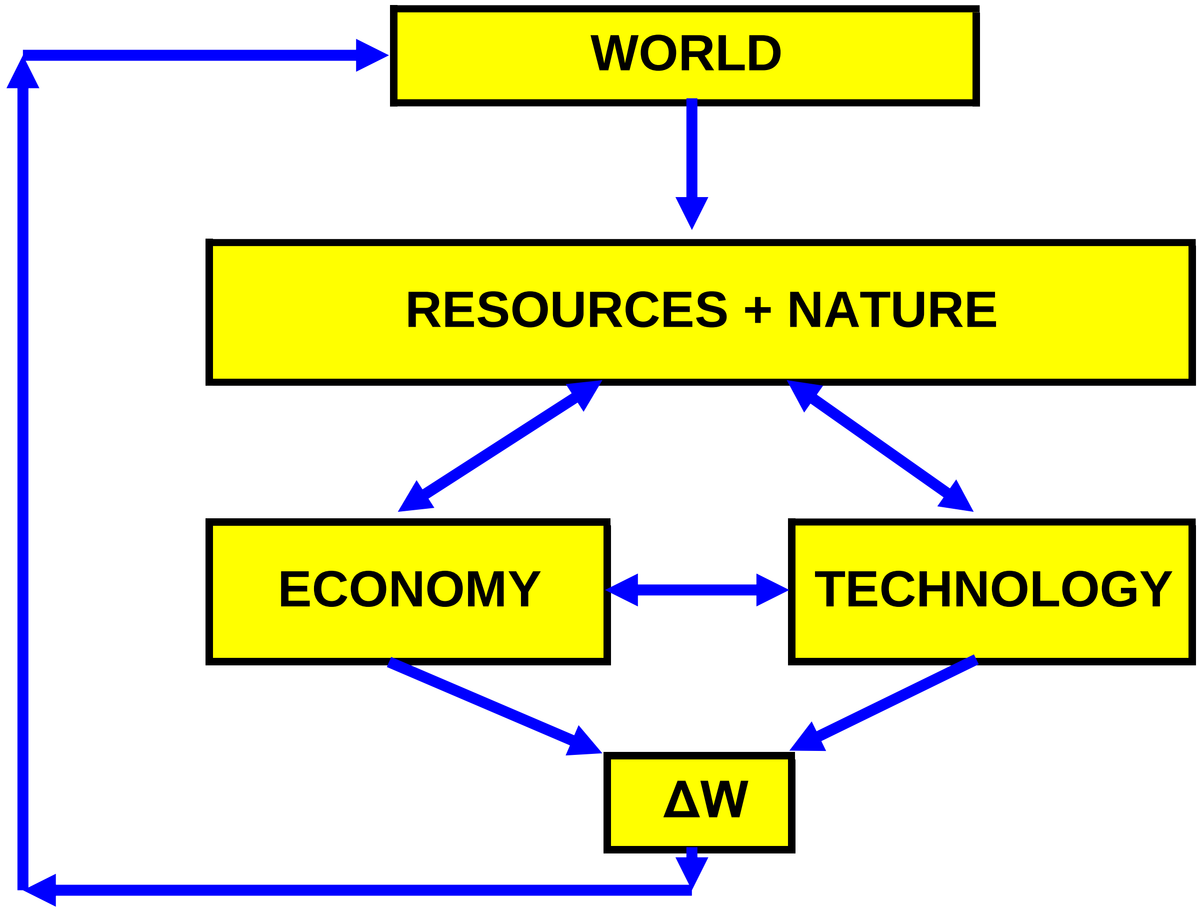
and

higher level of technology

has continued until now so that we have finally reached at the point of using the term

“globalization”

The spiral of
WORLD <> ECONOMY & TECHNOLOGY



OUR WORLD NOW IS THE WHOLE GLOBE.
WE ARE NOW CONCIOUS THAT WE ARE LIVING ON A GLOBE IN 3 DIMENSIONS

Are we now masters of this globe? Non, not yet. But we are close. The undiscovered areas of the Earth is getting smaller and smaller. We know the places of almost every natural resources. We have ample information about climate conditions in different parts of the World.

Unfortunately the last sentence, though it seems to be true momentarily, it is not valid for all times. We are now aware that climate is changing in the global scale and this change may have disastrous effects on humanity. It is also interesting to know that climate change is a natural phenomenon, but men is contributing to make it more devastating.

In our speech, we will concentrate on going away from Earth, space research, and space habitations.

The Earth – Cradle of Mankind

The Earth is the Cradle of Mankind, but one cannot expect to remain forever in the cradle.

Konstantin Tsiolkovsky

Russian scientist

1857 - 1935

Dünya insanlığın beşiğidir, ama kimse sonsuza kadar beşiğinde kalmaz.

UZAYLILAŞMA
SPATIALIZATION / EXTRATERRESTRIALIZATION
WORLD 2050

This picture of the Earth and Moon in a single frame, the first of its kind ever taken by a spacecraft, was recorded

September 18, 1977,

by NASA's Voyager 1 when it was 12 million km from Earth.

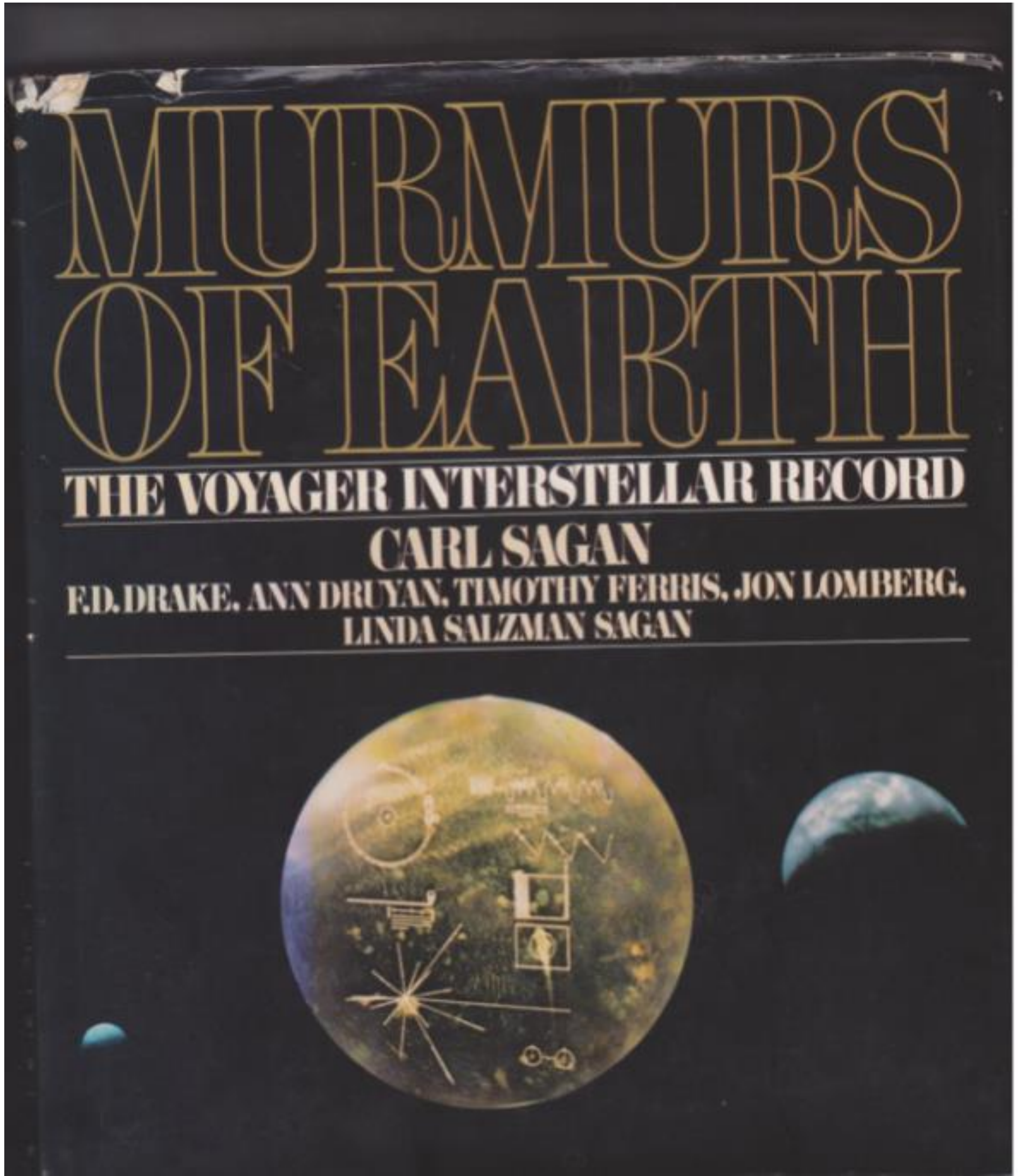
Mars is soon to be added to this "world" to yield World 2100.

Voyager 1
Mon, 05 Sept 1977
161.9 AU

Voyager 2
Sat, 20 Aug 1977
135.1 AU

Silima khemen

Peter Ian Kuniholm



UZAYLILAŞMA
SPATIALIZATION / EXTRATERRESTRIALIZATION
WORLD 2100

- Earth
- Moon
- Mars
- Satellites
  of Mars
- Space
between
Earth
and Mars

Man goes to everywhere he can go

- So, we can look to “space research” simply as a new attack to increase the dimensions of our world, a push outward of current frontiers.

- This means that it is a natural phenomenon. As history has shown all through the passed millenniums, mankind will stop at no boundaries. On the contrary, humans will always go beyond, following the moto

- “Man goes to everywhere he can go”.

YENİ BİR DÜNYA, YENİ BİR ÇEVRE

A NEW WORLD, A NEW ENVIRONEMENT

AY

MOON

The Moon is Earth’s largest natural satellite, formed when a Mars–sized planet collided with Earth 4.6 billion years ago.

Some of this planet, called Theia, was absorbed into Earth and the rest of the debris clumped together to form the Moon.

A NEW NATURE (1) GENERALITIES

- Lunar gravitation is 1/6 of that on Earth
- There is no atmosphere on the Moon
- There is no global magnetic field on the Moon.
- The same side is always facing the Earth
- 1 lunar day is equivalent to 27.3 terrestrial days, half with sunlight, half with darkness on lunar equator.

A NEW NATURE (2) TEMPERATURE

- The lunar surface temperature is predicted to show a fluctuation such that the range is (between $–170^0$C and $+120^0$C on the equator) 3 times greater than that on the Earth, with a minimum of approximately -250^0C at the poles.

- It has also been measured that temperatures 30cm below ground surfaces remained relatively constant at $–56\ ^0$C with a slight variation of only 2^0 to 4^0C. [Lin et al, 1991]

A NEW NATURE (3) RADIATION

- The surface of the moon is continuously exposed to a flux of cosmic radiation.

- This effect considerably increases during daytime, due to solar radiation.

A NEW NATURE (4) MICROMETEORITES

- The thin atmosphere of the Moon allows even the smallest micrometeorites to impact with their full cosmic velocities.

- This bombardment poses a hazard to all surfaces exposed on the lunar surface, especially to delicate materials like telescope mirrors and coatings.

A NEW NATURE (5.1) WATER

Until very recently, research has indicated water ice presence at both the north and south lunar poles. Data from Lunar Prospector was indicating the possible presence of discrete, confined, near-pure water ice deposits buried beneath as much as 400 mm of dry regolith, with the water signature being stronger at the north pole than at the south. The estimated total volume of ice was 6.6 billion tons. Uncertainities in the models was obliging the scientists to state that this estimate could be off considerably. Effectively, and on purpose impact (July 31, 1999) of Lunar Prospector “produced no observable signature of water”. But later, scientists have found evidence for the existence of water on moon.

A NEW NATURE (5.2) WATER

Permanantly Shadowed Regions (PSR)

Sürekli Gölge Bölgeler (SGB)

3.4 milyar yıl önce yoklar

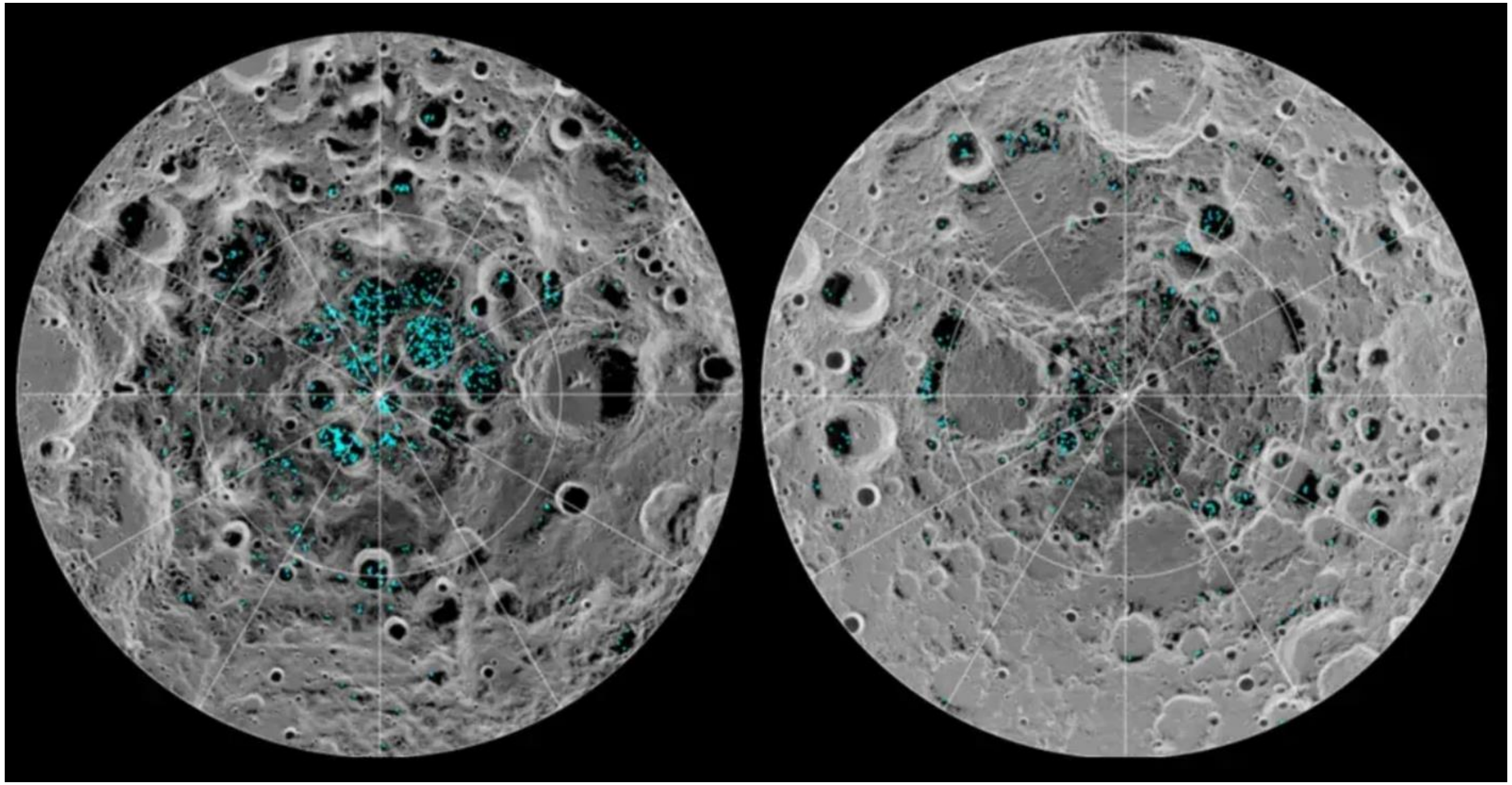
Su daha çok bu bölgelerde, buz halinde.

- Volcanic outgassing peaked 3.7 to 3.5 Ga ago but continued to at least 2 Ga ago.

- Water from comets and asteroids (About 1013 kg. Clark, R. N. (2009). Detection of adsorbed water and hydroxyl on the Moon. *Science*, *326*(5952), 562-564.)

- Solar wind–generated water

Güney Kutup Kuzey Kutup



Schörghofer, N., & Rufu, R. (2023). Past extent of lunar permanently shadowed areas. *Science Advances*, *9*(37), eadh4302.

A NEW NATURE (6.1) MOONQUAKES

In Apollo era
28 shallow moonquakes higher than magnitude 3.5
with 8 events over magnitude 5
maximum moonquake recorded at 5.5 on Richter scale
average of 1-2 on Richter scale.

4 seismometers was completed in April 1972 and worked continuously until September 30, 1977

Jablonski, A. M. (2010). Technical aspects of seismicity on the moon. Apollo The International Magazine Of Art And Antiques, (613), 1-25.

Watters, T. R., Weber, R. C., Collins, G. C., Howley, I. J., Schmerr, N. C., & Johnson, C. L. (2019). Shallow seismic activity and young thrust faults on the Moon. *Nature Geoscience*, *12*(6), 411-417.

Nunn, C., Garcia, R. F., Nakamura, Y., Marusiak, A. G., Kawamura, T., Sun, D., ... & Zhu, P. (2020). Lunar seismology: A data and instrumentation review. *Space Science Reviews*, *216*(5), 89.

A NEW NATURE (6.2) MOONQUAKES

1. Thermal moonquakes – caused by the diurnal temperature

2. Deep moonquakes – originated from the zone between 700 – 1,200 km inside of the Moon (more frequent events), with magnitude less than 3 on the Richter scale Their origin is unclear, but some researchers tried to relate them to tidal influences caused by the interaction between the Moon and Earth. More than 7,000 records of moonquakes were indentified based on Apollo data sets.

A NEW NATURE (6.2) MOONQUAKES

3. Seismic events due to meteoroid impacts – they exhibit characteristic amplitude variations with distance from the point of an impact. More than 1,700 events were recognized in the Apollo measured data sets (from meteoroid masses between 0.1 – 1,000 kg) between 1969 and 1977.

4. Shallow moonquakes – with focus (hypocenter) located between 50-200 km from the surface. They were strongest of all recorded moonquakes and with 7 of 28 recorded and recognized events greater than magnitude 5 on the Richter scale.

Very different frequency content than Earthquakes, of the order of tens of Hz, and may last about an hour because of the low damping of the Moon rocks

Earth-Moon Differences

- Terrestrial Nature

- Lunar Nature
- Difficulties of transport of manpower and resources
- Difficulty of maintenance
- Low efficiency of workmanship
- High degree of risk

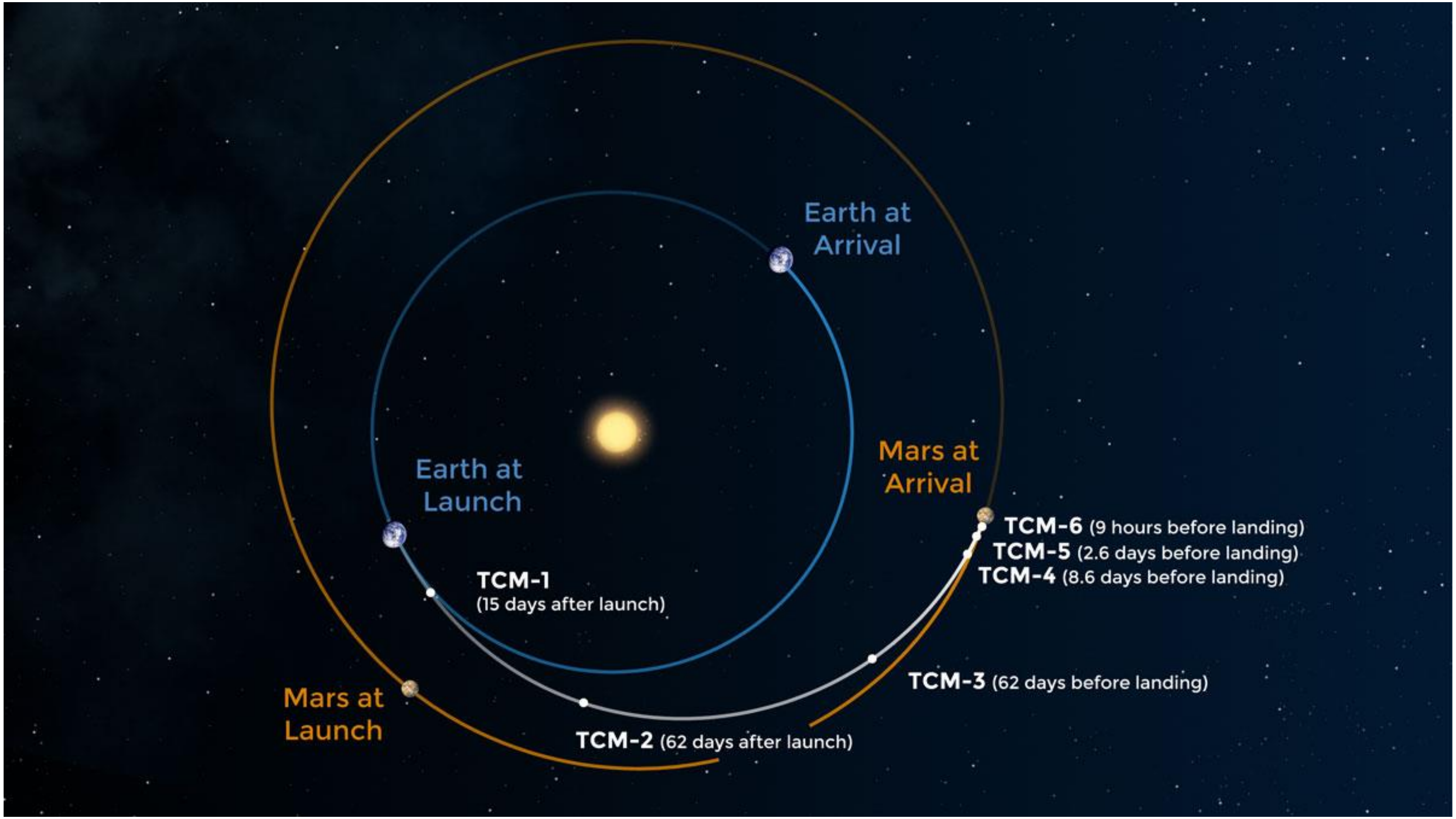
AY ve MERİH

MOON and MARS

Currently, the fastest crewed flight to the moon was Apollo 8. The spacecraft entered lunar orbit just 69 hours and 8 minutes after launch

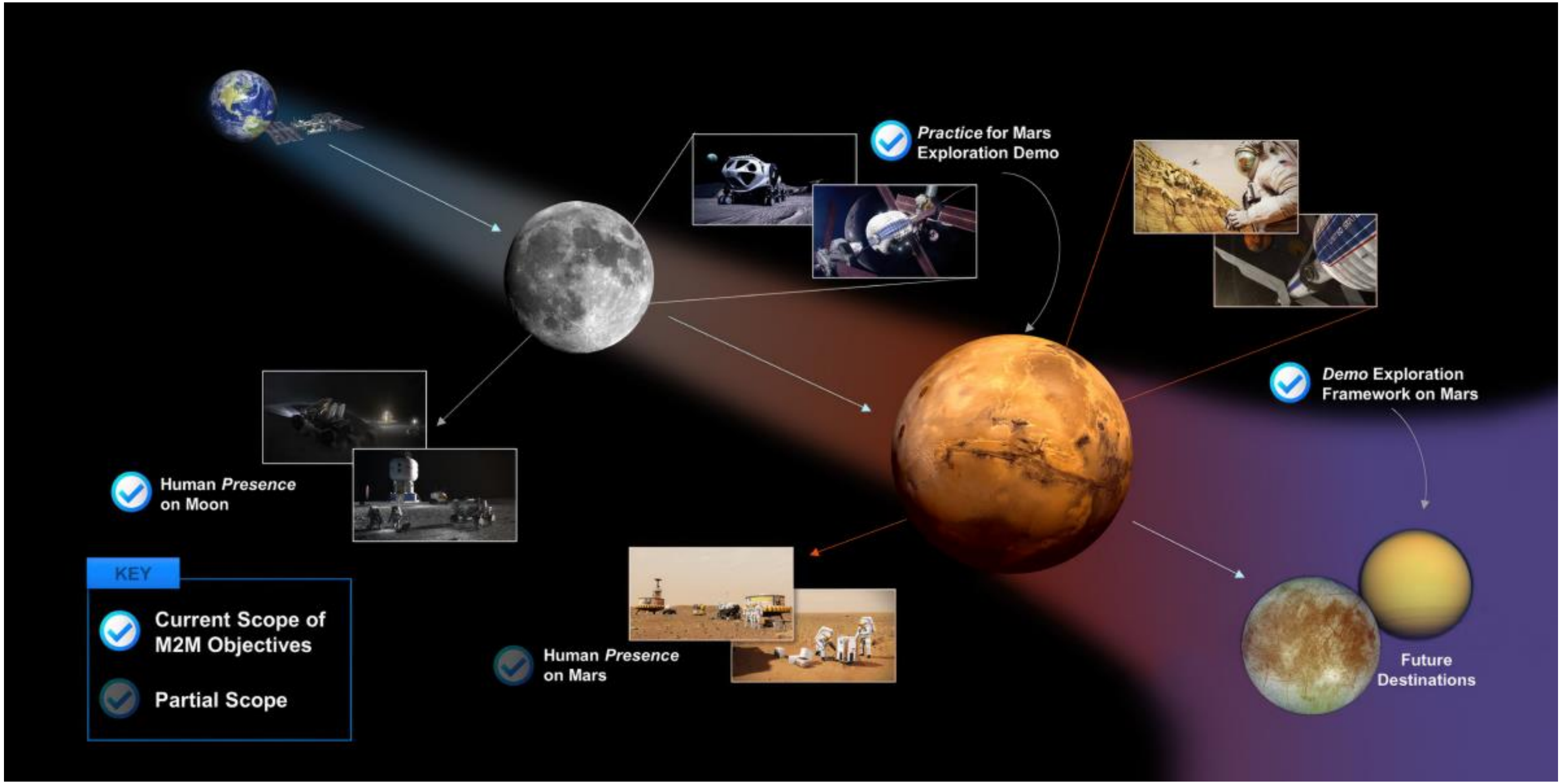
The fastest flight to the moon without stopping was achieved by NASA's New Horizons probe when it passed the moon in just 8 hours 35 minutes while en route to Pluto.

https://www.space.com/how-long-does-it-take-to-get-to-the-moon



Perseverance’s <sabır> Route to Mars, including several trajectory correction maneuvers (TCMs) to adjust its flight path. 7 months, 480 million kms. Window open every 26 months.

https://mars.nasa.gov/mars2020/timeline/cruise/



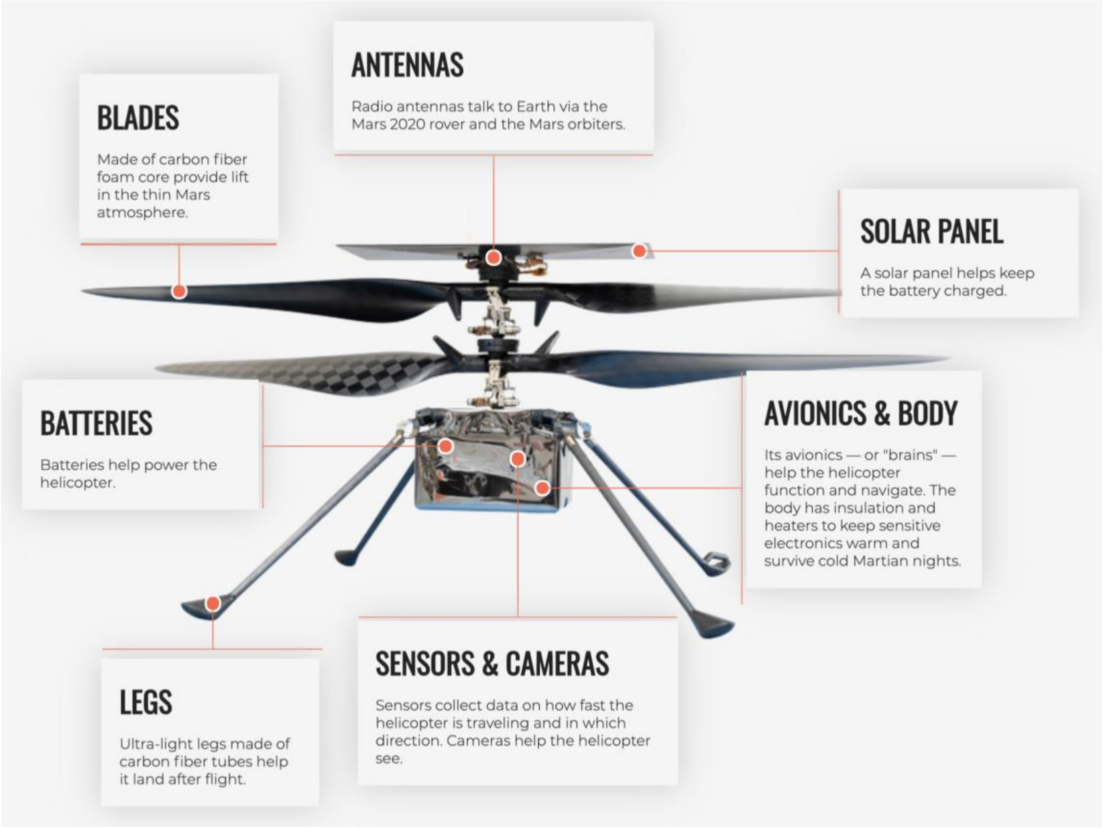
NASA MOON TO MARS SCOPE

https://www.nasa.gov/wp-content/uploads/2023/04/m2m_strategy_and_objectives_development.pdf

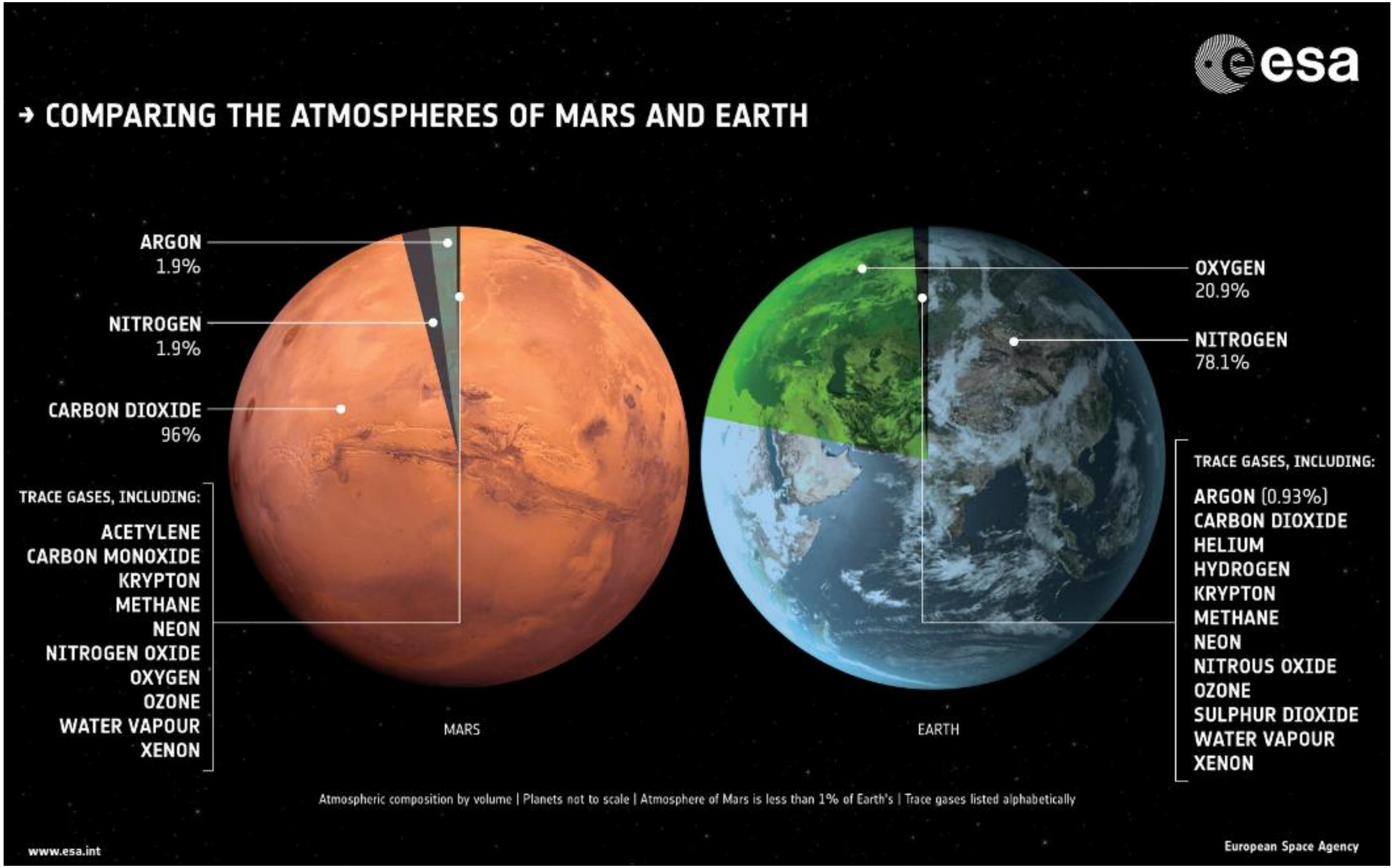
	Dünya	Ay	Mars
Uydu Sayısı	1	-	2
Ortalama çapı (oran)	1	0,27	0,53
Ortalama çapı (km)	12756	3476	6080
Ortalama Yoğunluk (kg/m^3	5520	3340	3950
Kütle (oran)	1	0,0123	0,107
Yörünge zamanı (gün)	365,24	27,322	687
Güneşe uzaklık (km)	149.6x10^6	-	227.9x10^6
Güneşe uzaklık (AU)	1	-	1,52
Kaçış hızı (km/san)	11,2	2,38	5,03
Sıcaklık (derece)	-90 +60	-190 +150	-120 +30
Yerçekimi (m^2/san)	9,81	1,62	3,71
Yerçekimi (oran)	1	0,166	0,378
Hava basıncı (kPa)	101,3	-	0,51
Hava Yoğunluğu (kg/m^3)	1,033	-	0,02

MARS UYDULARI	Phobos	Deimos

Dünya-Güneş (milyon km)	147,1 - 152,1
Dünya-Mars (milyon km)	54,6 - 250
Dünya-Ay (milyon km)	0,384



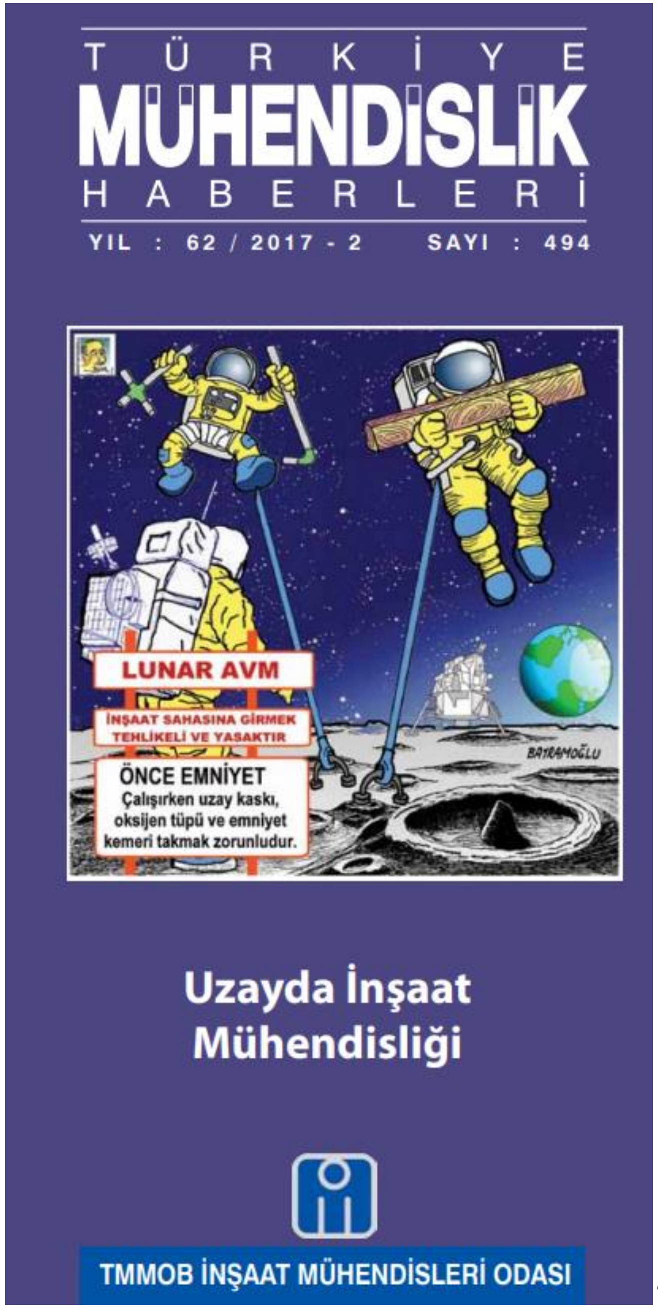
https://www.wikiwand.com/en/Ingenuity_(helicopter)



https://www.esa.int/ESA_Multimedia/Images/2018/04/Comparing_the_atmospheres_of_Mars_and_Earth

İNŞAAT MÜHENDİSLİĞİ

CIVIL ENGINEERING



HAMMURABI'S CODE

~1800 BC

- 282 items
- 9 about us

53. If anyone be too lazy to keep his dam in proper condition and does not so keep it; if then the dam break and all the fields be flooded, then shall he in whose dam the break occurred be sold for money, and the money shall replace the corn which he has caused to be ruined.

54. If he be not able to replace the corn, then he and his possessions shall be divided among the farmers whose corn he has flooded.

55. If any one open his ditches to water his crop, but is careless, and the water flood the field of his neighbor, then he shall pay his neighbor corn for his loss.

228. If a builder build a house for someone and complete it, he shall give him a fee of two shekels in money for each sar of surface.

229 If a builder build a house for someone, and does not construct it properly, and the house which he built fall in and kill its owner, then that builder shall be put to death

230. If it kill the son of the owner the son of that builder shall be put to death.

231. If it kill a slave of the owner, then he shall pay slave for slave to the owner of the house.

232. If it ruin goods, he shall make compensation for all that has been ruined, and inasmuch as he did not construct properly this house which he built and it fell, he shall re-erect the house from his own means.

233. If a builder build a house for someone, even though he has not yet completed it; if then the walls seem toppling, the builder must make the walls solid from his own means.

Thomas Tredgold, 1828

"That species of knowledge which constitutes the profession of Civil Engineering; being the art of directing great sources of power in Nature for the use and convenience of man, as the means of production and of traffic in States both for external and internal trade, as applied in the construction of roads, bridges, aqueducts, canals, river navigation and docks, for internal intercourse and exchange; and in the construction of ports, harbours, moles, breakwaters and lighthouses, and in the art of navigation by artificial power for the purpose of commerce; and in the construction and adaptation of machinery; and in the drainage of cities and towns.“

Doğanın sağladığı kaynakları

insanlığın kullanımı ve rahatı için kullanmak,

bunlardan yararlanarak

- insanlığı doğal tehlikelerden ve olumsuzluklardan korumak,

- insanlığın doğal güçlükleri aşmasını sağlamak.

Branches of CE

- Geotechnical Engineering
- Structural Engineering
- Materials of Construction
- Transport Engineering
- Construction Management
- (Hydraulics Engineering, Space Civil Engineering Education)

GEOTECHNICAL ENGINEERING

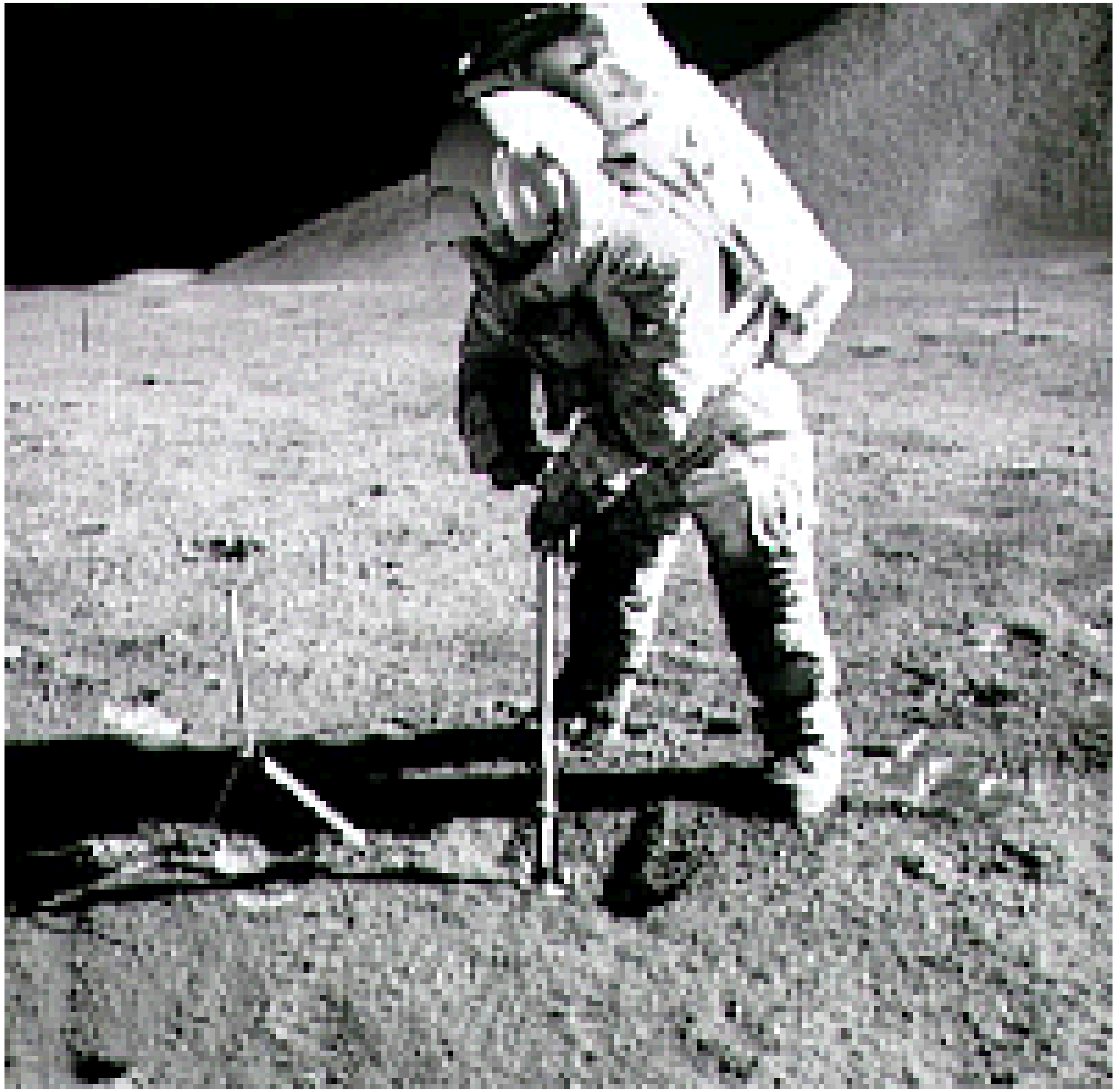
Regolith, the soil formed by the continual bombardment of the lunar rocks by micrometeorites.

Properties as to grain size, bulk density, porosity, surface area, shear strength, adhesion, …

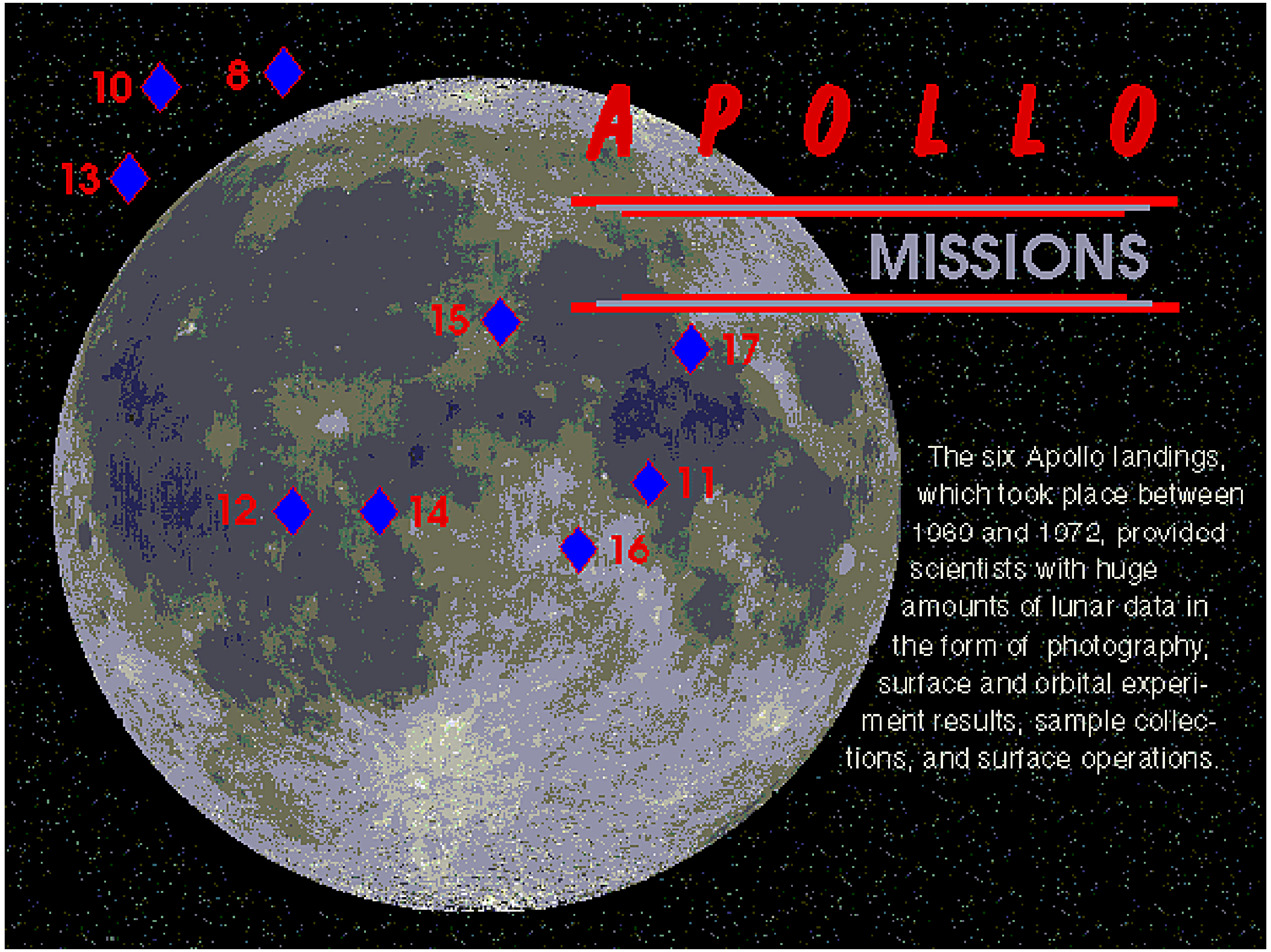
Modulus of subgrade reaction: Typically, 1000 $kN/m^2/m$ which means 10 mm settlement under a pressure of 10 kN/m^2

Thickness: Average 4-5m (ranging between a few cm’s to some tens of meters)

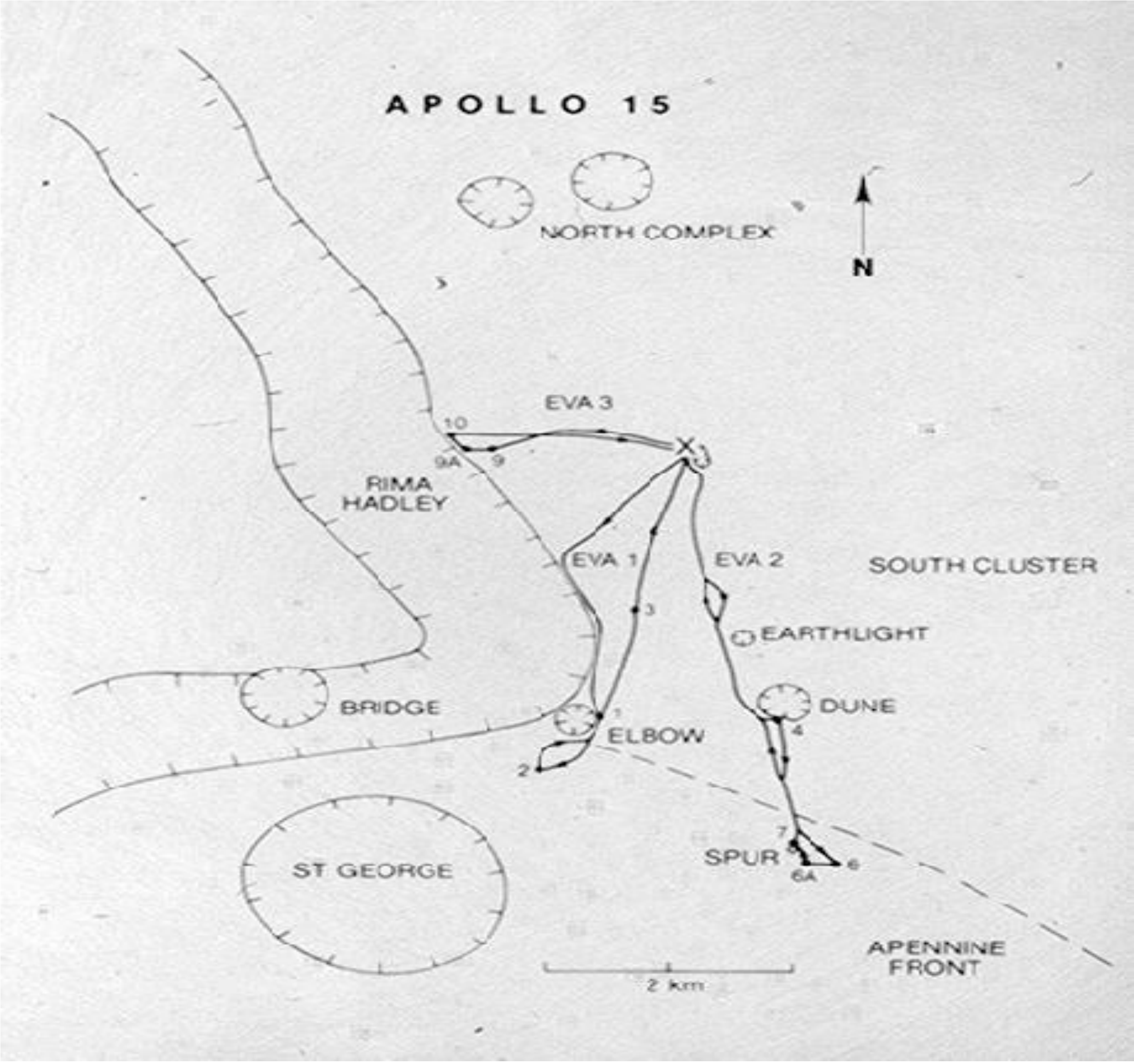
Apollo 15 Soil Mechanics Investigation
The Self-Recording Penetrometer being used in training



Apollo Missions

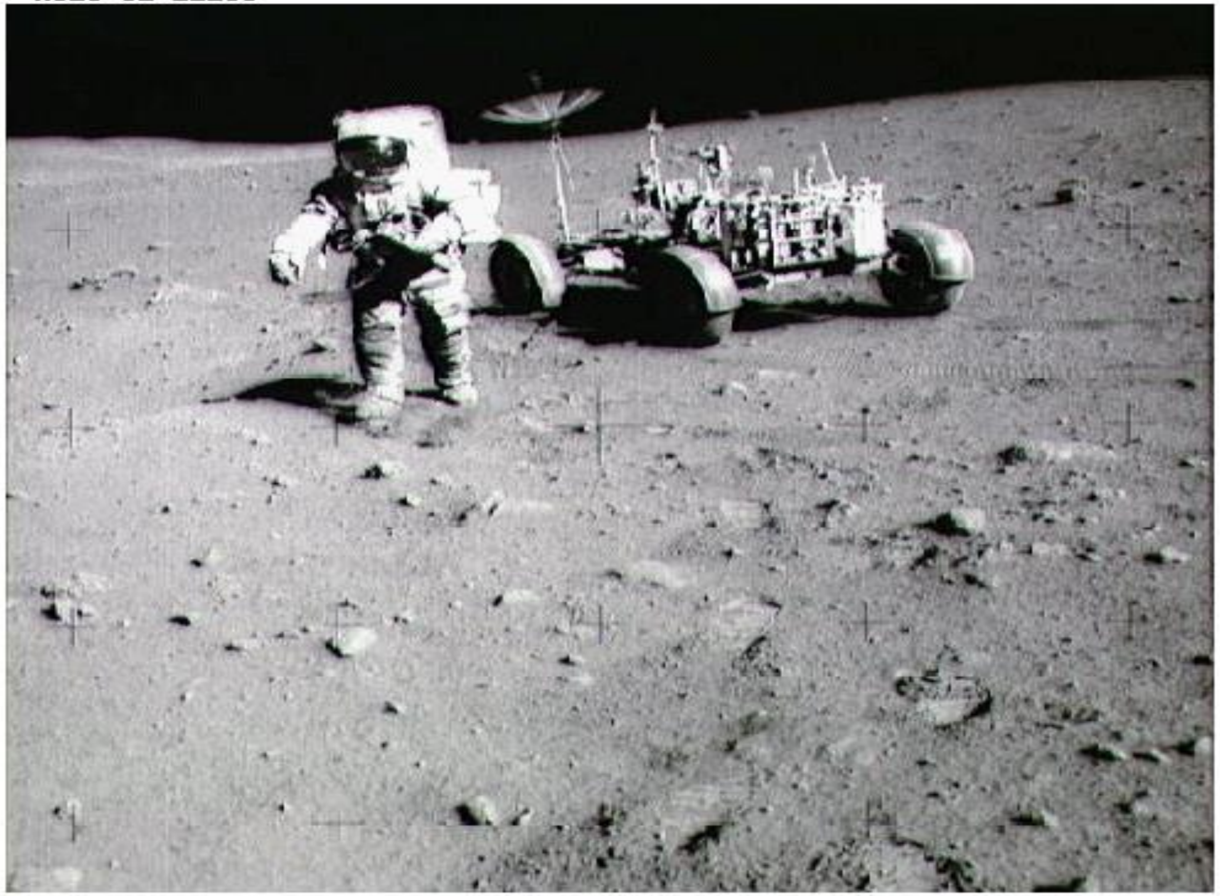


Apollo 15 Extra Vehicular Activities



APOLLO 15, 3rd EVA. The third EVA began at 4:52 a.m. EDT on August 2, about 1.5 hours late to allow the crew to get some additional rest. This EVA included a 5.1-kilometer traverse west to Scarp Crater and northwest along the edge of Hadley Rille, and east across the mare to the lunar module. The EVA was shortened to approximately 4 hours and 50 minutes to meet the lift off time line.

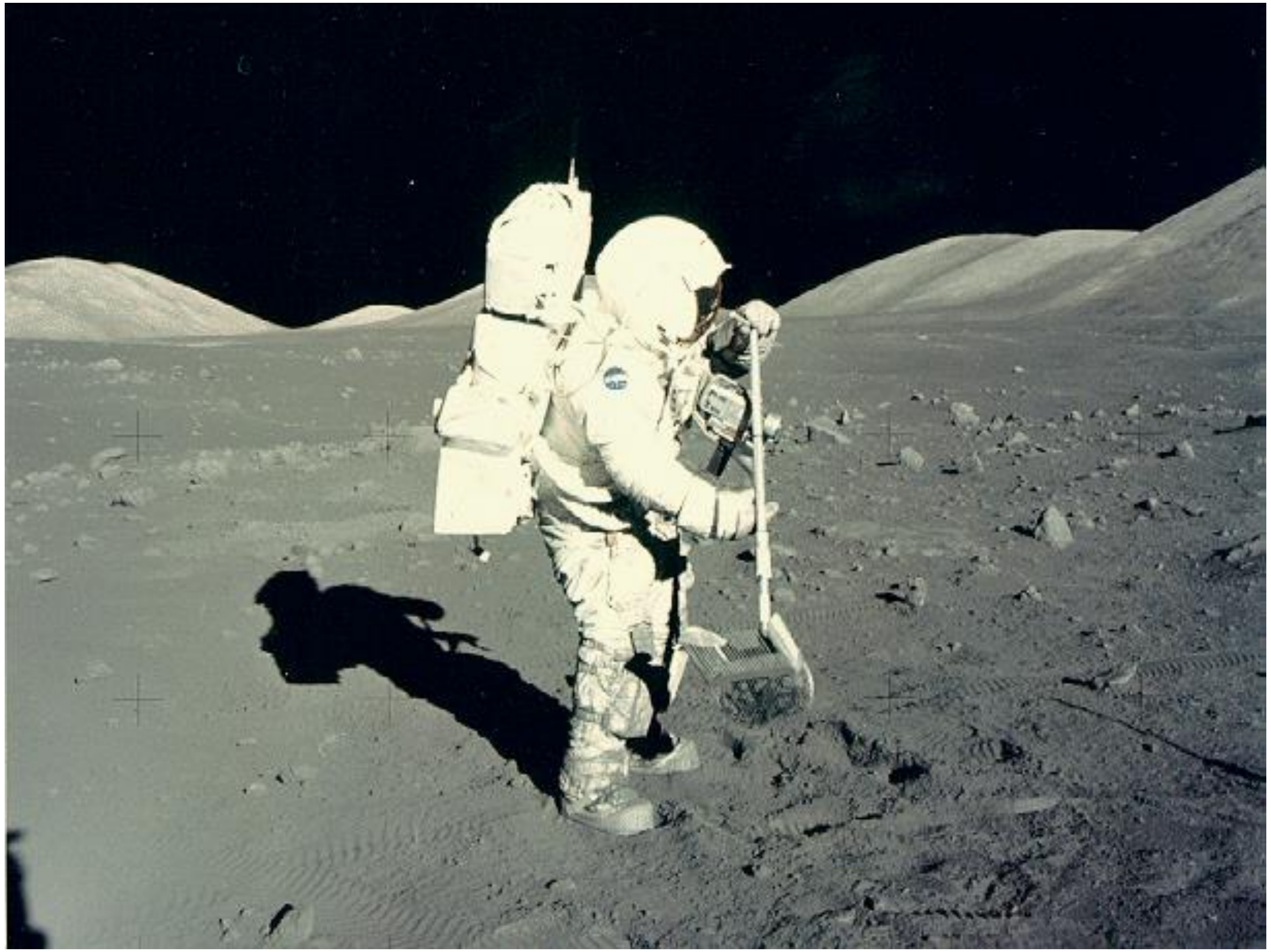
AS15-82-11168



Picking up Rock Samples. *Apollo 12*

Collecting Soil Samples *Apollo 17*

Apollo 17 Astronaut Jack Schmitt Using a Rake



Collection bag attached to astronaut's backpack. *Apollo 17*

LUNAR SAMPLES RETURNED ON APOLLO MISSIONS

LUNAR SAMPLE 12017

LUNAR SAMPLE 15495

LUNAR SAMPLE 61016

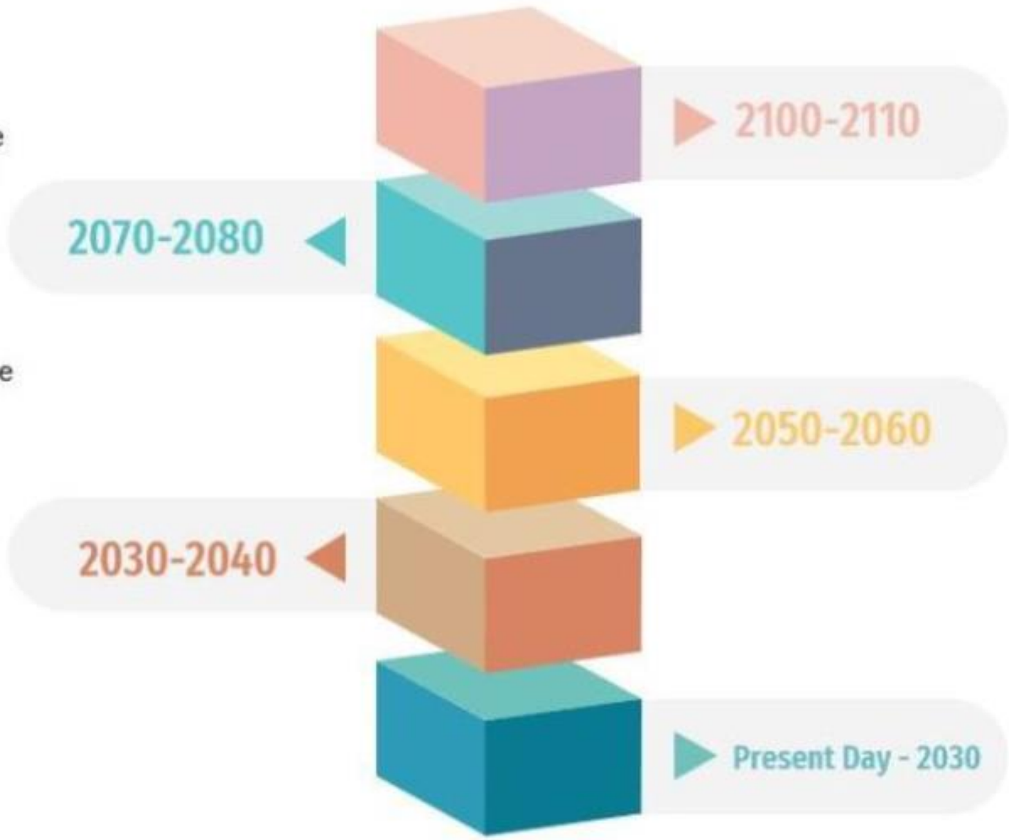
LUNAR SAMPLE 76535

Ay Taşı Örneği 15555,462

Comparing the Evolution of Geotechnical Engineering: Earth vs. Moon

- Lunar geotechnical engineering reaches a level where it can support large-scale infrastructure projects, such as extensive underground tunnels and storage facilities.
- Advanced materials and technologies developed on Earth are adapted for lunar use, improving construction efficiency and safety.
- Sustainable lunar habitats and life support systems are further developed.

- Lunar exploration efforts continue to expand, with more missions and infrastructure planned.
- Basic geotechnical engineering techniques are developed for lunar missions, including landing pad construction and habitat foundation design.
- Some resource extraction begins using rudimentary methods.



- Lunar geotechnical engineering achieves a level comparable to Earth, as lunar colonization efforts mature.
- Lunar colonies are largely self-sufficient and have well-developed infrastructure, including extensive underground networks.
- The moon serves as a stepping stone for further human exploration of the solar system.

- Geotechnical engineering on the Moon advances significantly with increased human presence.
- Construction of lunar bases and habitats becomes routine, incorporating more advanced geotechnical considerations.
- Resource extraction techniques are refined.

- On Earth, geotechnical engineering is highly advanced, with well-established practices for infrastructure, construction, and environmental management.
- On the Moon, geotechnical engineering is in its infancy, with limited practical experience and knowledge due to the unique lunar environment.

Author: R. de Moraes

MATERIALS OF CONSTRUCTION

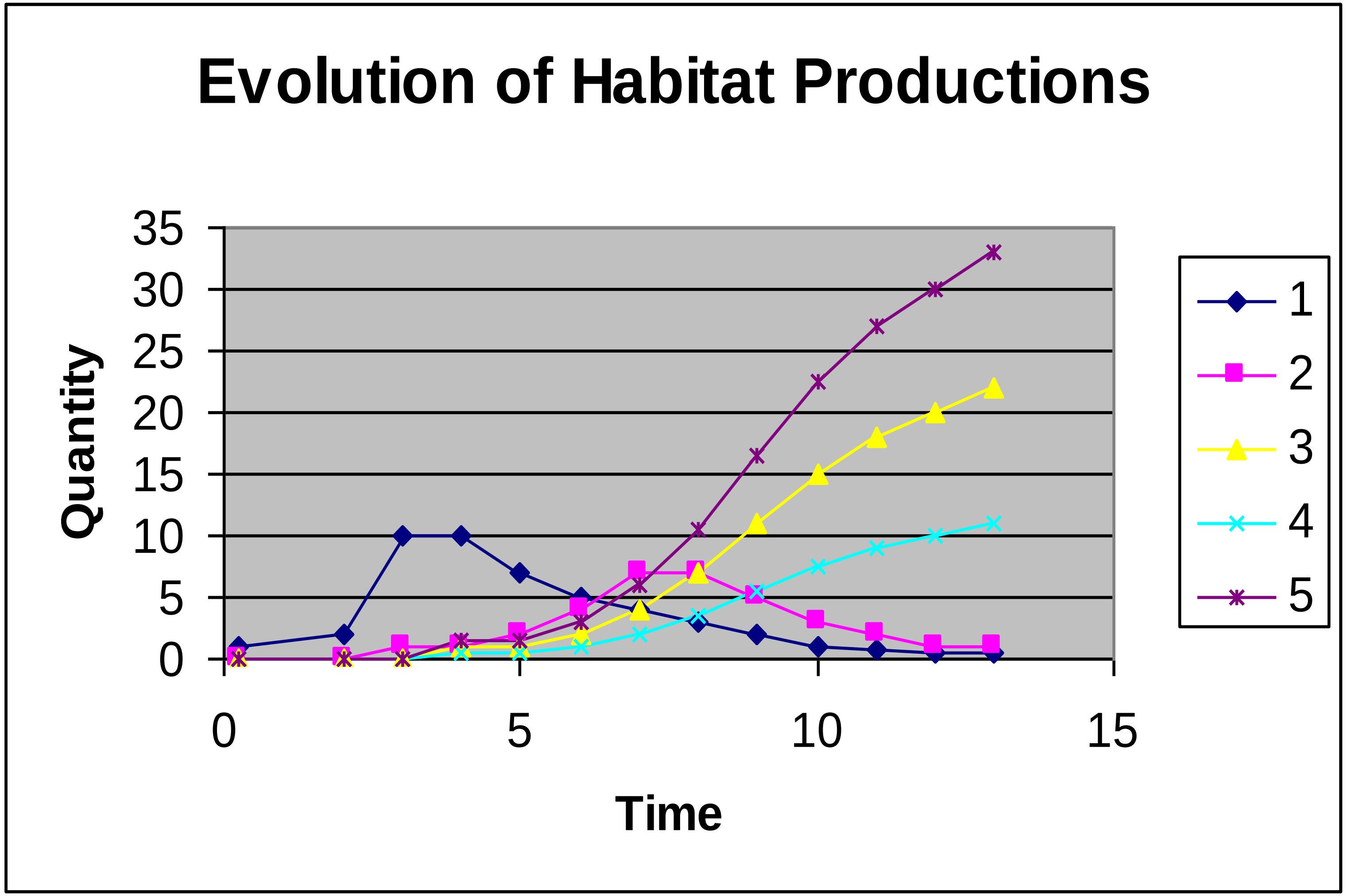
- A completely new era
- Three basic routes

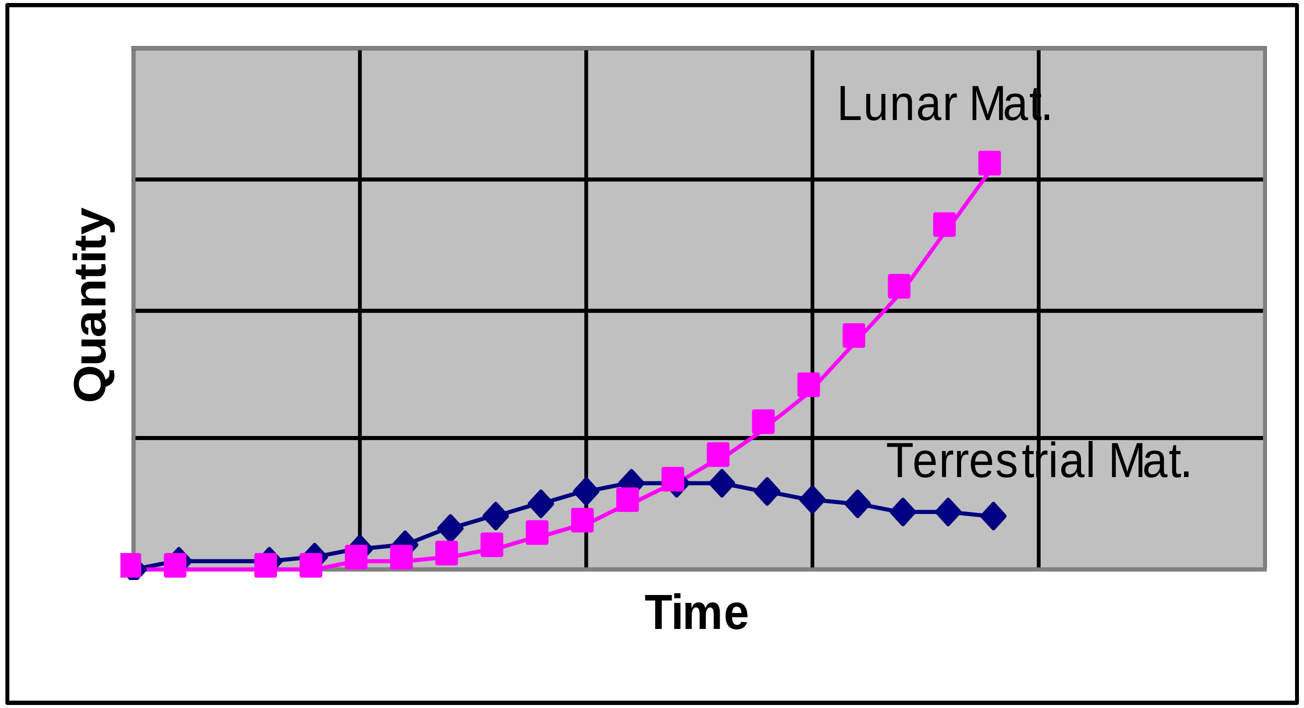
- Lightweight tensile resistant materials
- Exploitation of local materials
- Behavior under lunar conditions

Apollo Mission	Launch Date	Landing Site	Sample Return (kg)
11	16 Jul 1969	Mare Tranquilitatis	21.55
12	14 Nov 1969	Oceanus Procellarum	34.35
14	31 Jan 1971	Fra Mauro	42.28
15	26 Jul 1971	Hadley Rille	77.31
16	16 Apr 1972	Descartes	95.71
17	07 Dec 1972	Taurus-Littrow	110.52

These missions are so arranged that Apollo 11 and 12 landed on mare areas, Apollo 14 and 15 landed on highlands, and Apollo 16 and 17 landed on highland – mare contact areas

	RESOURCES		PLANT	
	EARTH	MOON	EARTH	MOON
(1)	X		X	
(2)	X			X
(3)	X	X		X
(4)		X		X
(5)	X	X	X	X




Lunar Mat.
Terrestrial Mat.
Quantity
Time

First lunar resource - Soil

- In regard of these, several research studies have been carried out on the feasibility of using lunar regolith as ”the” source for building materials that is aimed eventually to serve to construct habitats, surface paving, radiation protection shielding, spacecraft landing pads and so on.

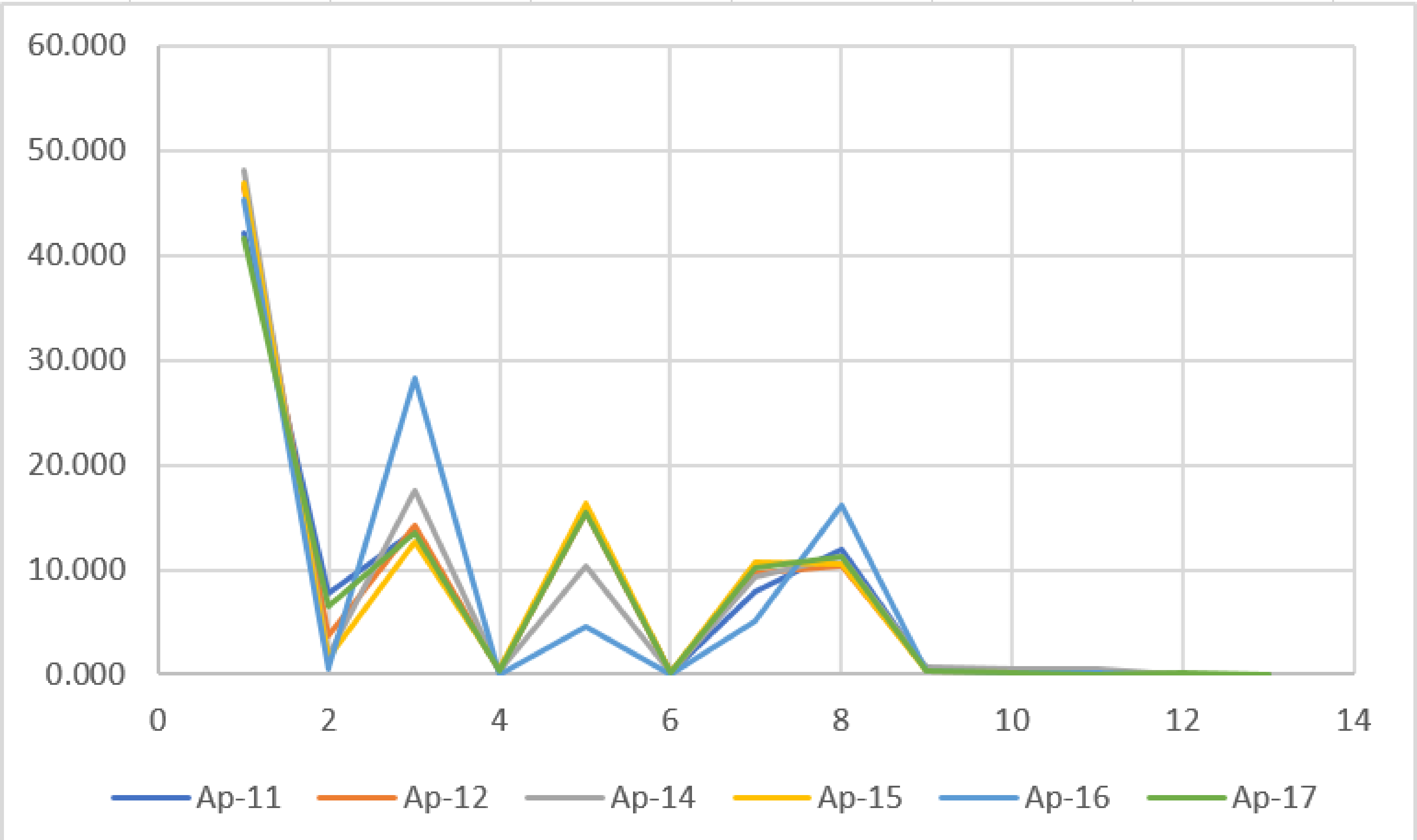
- As a first step of these studies, since the regolith brought by previous lunar missions are very limited, (~300kg) various lunar soil simulants have been developed.

Learning on Lunar and Martian Soil Conditions

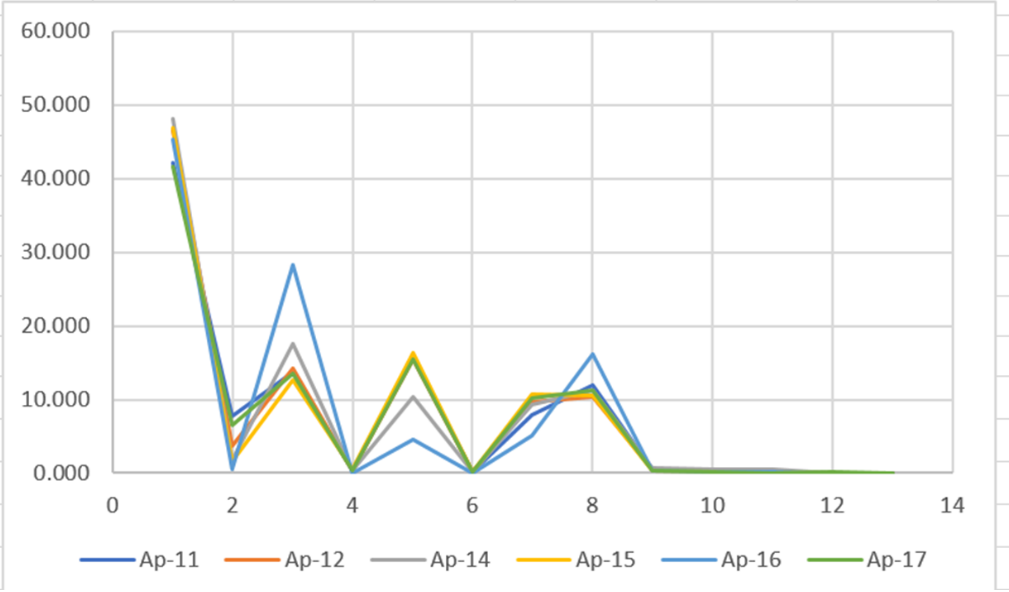
- Continuation of these studies for thorough verification of properties and behavior of lunar building materials are crucial for the success of lunar missions aiming to establish lunar outposts.

- These studies are being followed by Mars soil also, in other ways.

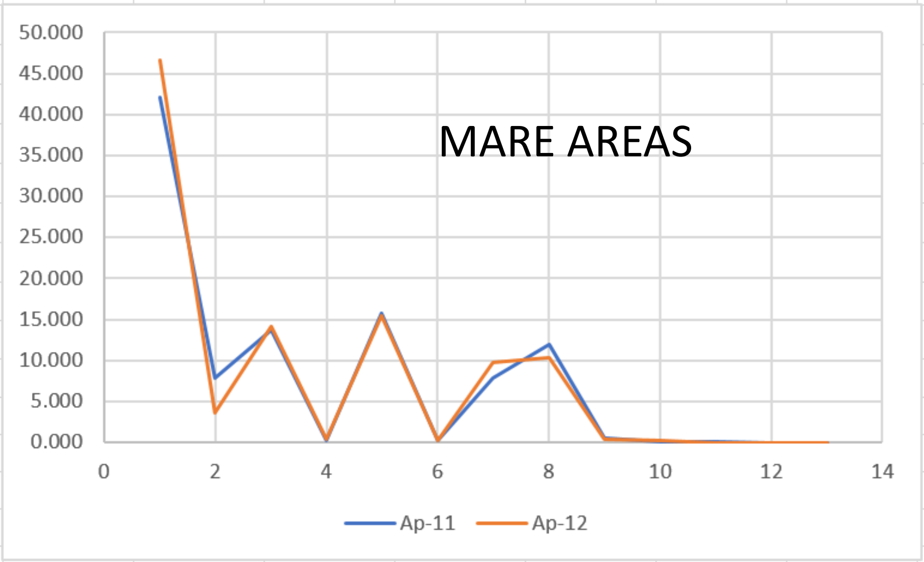
Görev	Numune	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5
Apollo 11	10,084	42.1	7.8	13.7	0.3	—	15.8	0.2	7.9	12	0.5	0.1	0.1
	—	42.2	7.8	13.6	—	—	15.3	0.2	7.8	11.9	0.47	0.16	0.05
Apollo 12	12,030	46.6	3.6	14.2	0.35	—	15.4	0.22	9.7	10.4	0.43	0.24	—
	12,001	46	2.8	12.5	0.41	—	17.2	0.22	9.7	10.9	0.48	0.24	—
Apollo 14	14,259	48.2	1.73	17.6	0.26	—	10.41	0.14	9.26	11.25	0.61	0.51	0.53
	14,163	47.3	1.6	17.8	0.2	—	10.5	0.1	9.6	11.4	0.7	0.6	—
	Average	48.1	1.7	17.4	—	—	10.4	0.14	9.4	10.7	0.7	0.55	0.51
Apollo 15	15,071	46.95	1.6	12.7	0.465	—	16.29	0.217	10.75	10.49	0.33	0.092	0.16
Apollo 16	61,221	45.35	0.49	28.25	—	—	4.55	0.06	5.02	16.21	0.42	0.09	0.1
	61,141	45.2	0.58	26.4	0.16	—	5.29	0.7	6.1	15.32	0.52	0.14	0.12
	62,241	44.65	0.56	27	—	—	5.49	0.7	5.84	15.95	0.44	0.13	0.1
	64,801	44.9	0.47	27.7	0.11	—	5.01	—	5.69	15.7	0.51	0.22	0.16
	67,461	44.77	0.37	28.99	—	—	4.35	0.07	4.2	16.85	0.44	0.06	0.05
	—	45	0.54	27.3	—	—	5.1	0.3	5.7	15.7	0.46	0.17	0.11
Apollo 17	79,221	41.67	6.52	13.57	0.42	—	15.37	0.21	10.22	11.18	0.34	0.09	0.06
	71,501	39.82	9.52	11.13	0.46	—	17.41	0.25	9.51	10.85	0.32	0.07	0.06
	71,061	40.09	9.32	10.7	0.49	—	17.85	0.24	9.92	10.59	0.36	0.08	0.07
	70,051	42.2	5.09	15.7	—	—	12.4	0.15	10.3	11.5	0.24	0.07	—



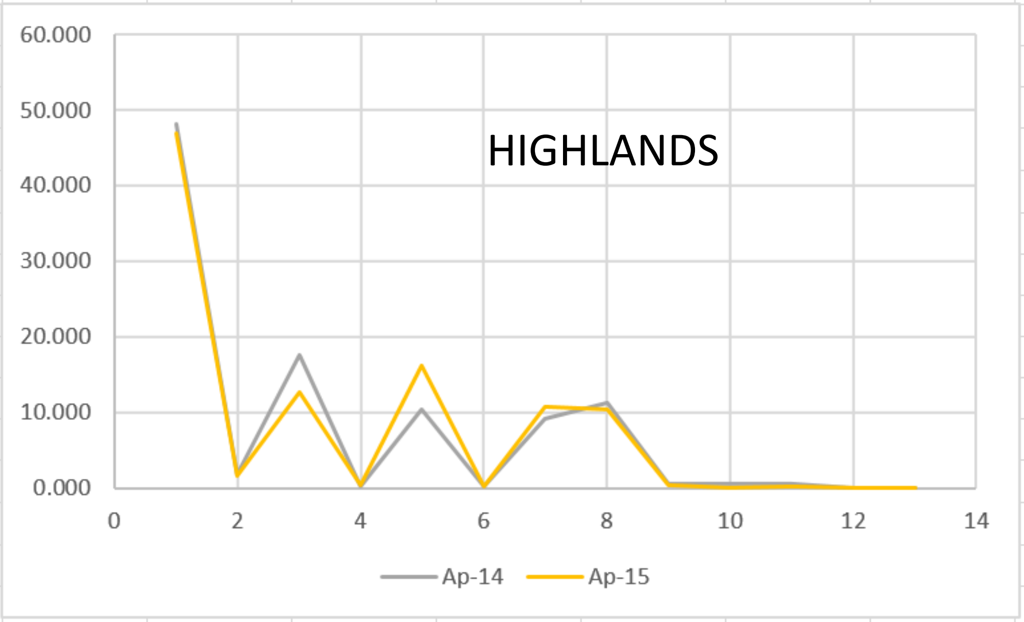
1:SiO2, 2:TiO2, 3:Al2O3, 4:Cr2O3, 5:FeO, 6:MnO, 7:MgO, 8:CaO, 9:Na2O, 10:K2O, 11:P2O5, 12:S, 13:LOI



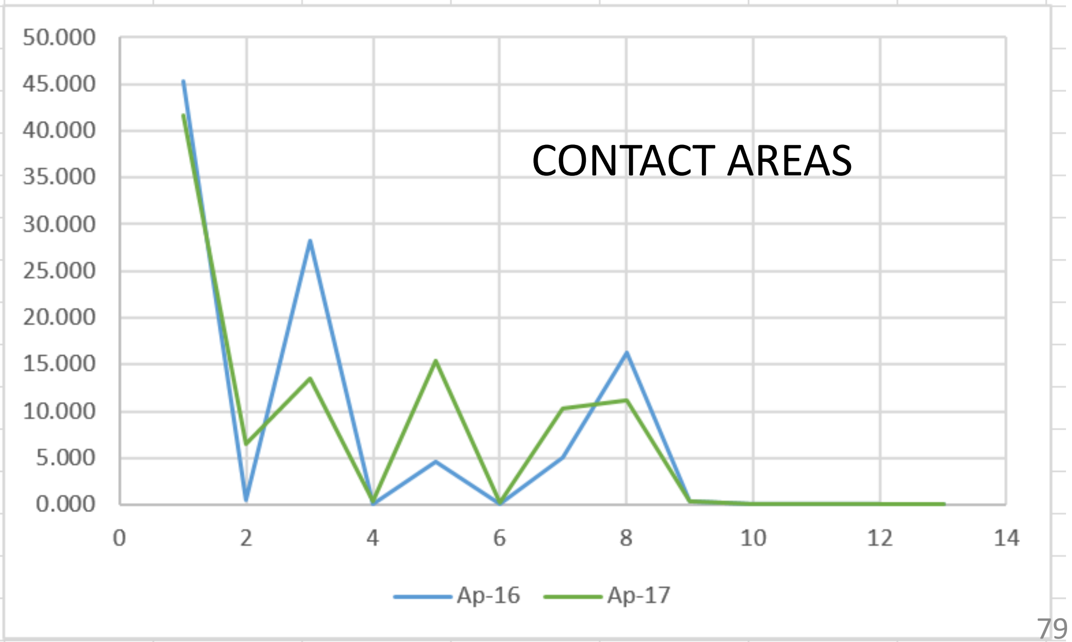
60.000
50.000
40.000
30.000
20.000
10.000
0.000
0
2
4
6
8
10
12
14
Ap-11
Ap-12
Ap-14
Ap-15
Ap-16
Ap-17



MARE AREAS
50.000
45.000
40.000
35.000
30.000
25.000
20.000
15.000
10.000
5.000
0.000
0
2
4
6
8
10
12
14
Ap-11
Ap-12



HIGHLANDS
60.000
50.000
40.000
30.000
20.000
10.000
0.000
0
2
4
6
8
10
12
14
Ap-14
Ap-15



CONTACT AREAS
50.000
45.000
40.000
35.000
30.000
25.000
20.000
15.000
10.000
5.000
0.000
0
2
4
6
8
10
12
14
Ap-16
Ap-17

An International Project

- Lunar soil simulants production might be more feasible with the use of source materials from different countries in the world.

- Manufacture of lunar building materials from such simulants and studies providing information on their properties and behavior have the potential to make significant contributions to the related scientific literature.

- Many countries can contribute to this project improving their own level of science and technology.

Simulant	Country	Year	Related Reference
MLS-1 MLS-1P	USA	1990	Weiblen et al., 1990*
MLS-2	USA	1992	Tucker et al., 1992*
ALS	USA	1993	Desai et al., 1993*
JSC-1 JSC-1A JSC-1AF	USA	1994	McKay et al., 1994*
FJS-1(type 1) FJS-1(type 2) FJS-1(type 3)	Japan	1998	Kanamori et al., 1998*
MKS-1	USA		Carpenter, 2005*
OB-1	Canada	2009	Battler & Spray, 2009*
CHENOBI	Canada		http://www.evcltd.com /index_005.htm*
CAS-1	China	2008	Zheng et al, 2008*
GCA-1	USA	2008	Taylor et al, 2008*
NU-LHT-1M NU-LHT-1D NU-LHT-2M NU-LHT-2C	USA	2009	Stoeser et al, 2009*
Oshima	Japan	2008	Sueyoshi et al, 2008*
Kohyama,	Japan	2008	Sueyoshi et al, 2008*
NAO-1	China	2009	Li et al, 2009*
CLRS-1	China	2009	Chinese Acad. of Sci., 2009*
CUG-1	China	2010	He et al, 2010*
GRC-1 GRC-3	USA		Oravec et al, 2010*
TJ-1 TJ-2	China	2010	Jiang et al, 2010*
KOHLS-1	China	2010	Jiang et al, 2010*
BP-1	USA	2010	Rahmatian&Metzger, 2010*
CSM-CL	USA	2010	Dreyer & Susante, 2010*
ASRL-1	Australia	2012	Bonnano& Bernold, 2015
TRI-1	India	2014	Sreenivasulu, 2014; Jayalekshm & Kumar 2019
QH-E	China	2015	Zou et al., 2015
EAC-1	Germany (by ESA)	2017	Nash et al., 2017
CLDS-i	China	2017	Tang et al., 2017
BHLD20	China	2017	Sun et al., 2017
NEU-1a NEU-1b	China	2017	Liyu et al., 2017; Li et al., (in press)
KLS-1	Korea	2018	Byung-Hyun Ryu et al., 2018
DNA-1 DNA-1A	Italy	2014 2019	Cesaretti et al., 2014 Marzulli & Cafaro, 2019

AUSTRALIA

CANADA

CHINA

EUROPE UNION - GERMANY

EUROPE UNION - ITALY

INDIA

JAPAN

SOUTH KOREA

USA

TURKIYE


Gürcistan
Sinop
Gerze
Bafra
Samsun
Ünye
Ordu
Fatsa
Giresun
Trabzon
Rize
Hopa
Batum
Artvin
Ardahan
Kars
Kırklareli
Edirne
Tekirdağ
İstanbul
Gebze
İzmit
Sakarya
Düzce
Bolu
Bartın
Zonguldak
Ereğli
Karabük
Kastamonu
Boyabat
Tosya
Merzifon
Amasya
Çankırı
Çorum
Tokat
Gümüşhane
Bayburt
Horasan
Ermen
Iğdır
Ağrı
Doğubayazıt
Çanakkale
Beypazarı
Ankara
Kırıkkale
Yozgat
Sivas
Erzincan
Eskişehir
Gölbaşı
Balıkesir
Kütahya
Kırşehir
Şereflikoçhisar
Türkiye
Tunceli
Bingöl
Muş
Patnos
Erciş
Tatvan
Van
Akhisar
Manisa
Uşak
Afyonkarahisar
Nevşehir
Elâzığ
Malatya
İzmir
Çeşme
Turgutlu
Akşehir
Aksaray
Afşin
Elbistan
Niğde
Kuşadası
Aydın
Denizli
Isparta
Burdur
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Çumra
Seydişehir
Kahramanmaraş
Adıyaman
Kahta
Siverek
Diyarbakır
Batman
Siirt
Şırnak
Hakkâri
Yüksekova
Muğla
Bodrum
Marmaris
Rodos
Fethiye
Antalya
Manavgat
Kemer
Alanya
Kaş
Karaman
Mersin
Adana
Osmaniye
Gaziantep
Nizip
Şanlıurfa
Mardin
Midyat
Cizre
Kızıltepe
Duhok
İskenderun
Antakya
Halep
Silifke
Anamur
Hasiçi
Ash Shaddadi
Telafer
Musul
Erbil

Tablo 1. İncelenen numunelerin kod adları, bölgeleri ve koordinatları

Numune kodu	Toplanan Bölge	Koordinatlar	
		Kuzey	Doğu
A1	Avanos	38°40'20"	34°50'22"
P1	Palandöken	39°50'53.7"	41°16'59.7"
E1	Erciyes Dağı	38°32'33"	35°29'44"
G1	Göreme	38°38'44.4"	34°50'41.9"
K1	Kula	38°34'35"	28°32'55"
S1	Sivrihisar	39°27'11"	31°32'12"
T1	Toros Dağları	37°45'14"	35°11'16.27"
U1	Uludağ	40°05'21.6"	29°08'46.4"
Ü1	Ürgüp	38°38'07"	34°53'26"
OL	Olivin	Temin Edilmiştir.	
UK	Uçucu Kül	Temin Edilmiştir.	
AB	Ankara Bazaltı	Temin Edilmiştir.	
KB	Kayseri Bazaltı	Temin Edilmiştir.	
İL	İlmenit	Temin Edilmiştir.	

Distribution of oxide contents in local soil samples.

SAMPLES	OXIDES % IN WEIGHT												
	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	S	LOI
A1	47.68	0.91	15.39	0.00	6.57	0.04	2.96	7.28	1.08	4.63	0.14	0.09	12.03
P1	66.22	0.57	16.09	0.01	4.05	0.12	0.62	2.42	5.12	3.94	0.15	0.01	0.70
E1	51.93	0.66	14.86	0.07	7.23	0.24	8.36	10.14	3.85	0.15	0.07	0.00	2.43
G1	7.98	0.03	2.29	0.00	1.01	0.09	17.75	27.88	0.25	0.80	0.05	0.02	41.83
K1	47.34	1.78	18.14	0.00	7.16	0.15	4.61	8.35	5.23	3.49	0.81	0.04	2.89
S1	59.73	0.54	17.97	0.00	4.63	0.12	1.91	6.15	4.64	3.08	0.35	0.01	0.88
T1	1.98	0.00	1.00	0.00	0.33	0.00	0.43	54.21	0.12	0.05	0.03	0.01	41.84
U1	2.26	0.00	1.02	0.00	0.28	0.02	0.39	53.35	0.06	0.14	0.03	0.02	42.41
UR	68.23	0.24	15.45	0.01	2.43	0.09	0.63	3.26	3.13	3.46	0.09	0.02	2.97
AB	59.81	0.98	16.65	0.00	5.00	0.12	2.99	5.94	4.57	1.88	0.34	0.00	1.74
KB	51.77	1.27	18.00	0.05	8.46	0.18	5.25	9.79	3.72	0.73	0.20	0.00	0.57
OL	42.12	0.00	0.85	0.43	8.15	0.15	46.35	0.58	0.00	0.03	0.01	0.00	1.33
UK	59.72	0.86	19.98	0.00	7.68	0.07	2.24	2.39	1.50	2.29	0.16	0.05	3.06
IL	1.83	57.40	0.82	0.07	38.39	0.65	0.58	0.13	0.00	0.00	0.12	0.02	0.00

Toklu, Y. C., Açıkbaş, N. Ç., Açıkbaş, G., Çerçevik, A. E., & Akpinar, P. (2023). Production of a set of lunar regolith simulants based on Apollo and Chinese samples. *Advances in Space Research*. 72 (2), pp. 565-576.

Tablo 18: Aydan getirilen örneklerle (üst satır), her biri için elde edilen benzerlerin (alt satır) karşılaştırılmaları.

Mission	NO	SiO2	TiO2	Al2O3	Cr2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2 O5	S	LOI
Apollo 11	A1	42.100	7.800	13.700	0.300	15.800	0.200	7.900	12.000	0.500	0.100	0.100	0.000	0.000
		42.367	8.987	13.704	0.080	12.353	0.237	7.602	9.217	2.792	0.551	0.168	0.003	1.932
	A2	42.200	7.800	13.600	0.000	15.300	0.200	7.800	11.900	0.470	0.160	0.050	0.000	0.120
		42.383	8.898	13.719	0.080	12.296	0.236	7.573	9.300	2.795	0.552	0.168	0.003	1.990
Apollo 12	A3	46.600	3.600	14.200	0.350	15.400	0.220	9.700	10.400	0.430	0.240	0.000	0.000	0.000
		46.048	5.439	14.394	0.096	10.619	0.210	9.692	8.594	2.940	0.581	0.169	0.002	1.212
	A4	46.000	2.800	12.500	0.410	17.200	0.220	9.700	10.900	0.480	0.240	0.000	0.000	0.000
		45.422	5.464	14.009	0.100	10.568	0.209	10.149	8.881	2.857	0.565	0.165	0.002	1.602
Apollo 14	A5	48.200	1.730	17.600	0.260	10.410	0.140	9.260	11.250	0.610	0.510	0.530	0.000	0.000
		49.585	2.022	16.067	0.082	8.806	0.183	8.636	9.370	3.302	0.651	0.181	0.000	1.107
	A6	47.300	1.600	17.800	0.200	10.500	0.100	9.600	11.400	0.700	0.600	0.000	0.000	0.000
		49.630	1.889	16.012	0.084	8.734	0.181	8.853	9.361	3.290	0.649	0.180	0.000	1.127
	A7	48.100	1.700	17.400	0.000	10.400	0.140	9.400	10.700	0.700	0.550	0.510	0.000	0.000
		49.732	2.042	16.043	0.084	8.850	0.183	8.874	9.124	3.296	0.650	0.180	0.000	0.932
Apollo 15	A8	46.950	1.600	12.700	0.465	16.290	0.217	10.750	10.490	0.330	0.092	0.160	0.070	0.000
		46.546	4.187	14.078	0.109	9.930	0.198	11.219	8.680	2.871	0.569	0.163	0.001	1.442
Apollo 16	A9	45.350	0.490	28.250	0.000	4.550	0.060	5.020	16.210	0.420	0.090	0.100	0.060	0.000
		49.598	1.215	17.258	0.048	8.105	0.172	5.040	11.728	3.563	0.700	0.193	0.000	2.370
	A10	45.200	0.580	26.400	0.160	5.290	0.700	6.100	15.320	0.520	0.140	0.120	0.000	0.000
		50.017	1.225	17.401	0.048	8.174	0.174	5.080	11.354	3.593	0.706	0.194	0.000	2.023
	A11	44.650	0.560	27.000	0.000	5.490	0.700	5.840	15.950	0.440	0.130	0.100	0.000	0.000
		49.801	1.220	17.328	0.048	8.138	0.173	5.059	11.547	3.578	0.703	0.193	0.000	2.202
	A12	44.900	0.470	27.700	0.110	5.010	0.000	5.690	15.700	0.510	0.220	0.160	0.000	0.000
		49.866	1.221	17.350	0.048	8.149	0.173	5.066	11.489	3.582	0.704	0.193	0.000	2.148
	A13	44.770	0.370	28.990	0.000	4.350	0.070	4.200	16.850	0.440	0.060	0.050	0.000	0.000
		49.289	1.207	17.153	0.048	8.055	0.171	5.010	12.004	3.541	0.696	0.192	0.000	2.627
	A14	45.000	0.540	27.300	0.000	5.100	0.300	5.700	15.700	0.460	0.170	0.110	0.000	0.070
		49.814	1.220	17.332	0.048	8.141	0.173	5.061	11.535	3.579	0.703	0.193	0.000	2.191
Apollo 17	A15	41.670	6.520	13.570	0.420	15.370	0.210	10.220	11.180	0.340	0.090	0.060	0.120	0.000
		43.278	7.734	13.304	0.100	11.755	0.227	9.853	8.641	2.704	0.535	0.162	0.003	1.698
	A16	39.820	9.520	11.130	0.460	17.410	0.250	9.510	10.850	0.320	0.070	0.060	0.120	0.000
		39.786	11.163	12.080	0.101	13.522	0.254	9.596	8.403	2.440	0.484	0.155	0.004	2.008
	A17	40.090	9.320	10.700	0.490	17.850	0.240	9.920	10.590	0.360	0.080	0.070	0.130	0.000
		39.677	11.172	11.869	0.106	13.537	0.254	10.111	8.253	2.394	0.475	0.153	0.004	1.989
	A18	42.200	5.090	15.700	0.000	12.400	0.150	10.300	11.500	0.240	0.070	0.000	0.000	0.000
		45.625	5.432	14.275	0.095	10.549	0.209	9.572	9.002	2.915	0.576	0.168	0.002	1.574

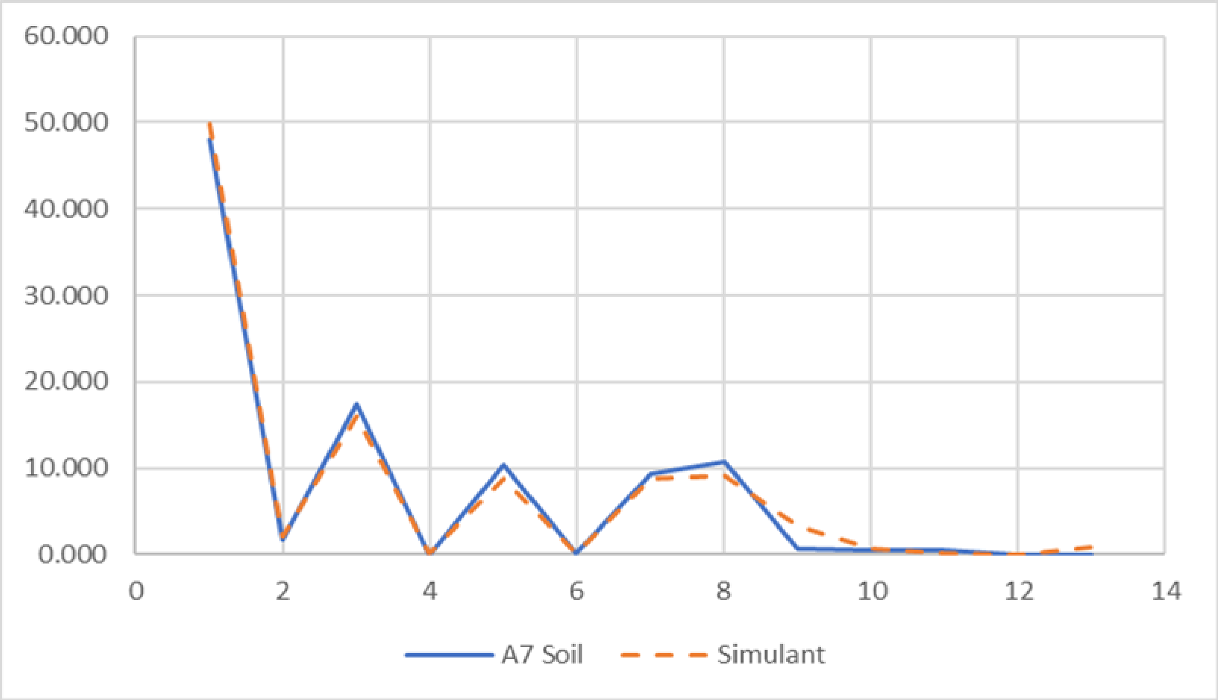
Apollo 14	A5	48.200	1.730	17.600	0.260	10.410	0.140	9.260	11.250	0.610	0.510	0.530	0.000	0.000
		49.585	2.022	16.067	0.082	8.806	0.183	8.636	9.370	3.302	0.651	0.181	0.000	1.107
	A6	47.300	1.600	17.800	0.200	10.500	0.100	9.600	11.400	0.700	0.600	0.000	0.000	0.000
		49.630	1.889	16.012	0.084	8.734	0.181	8.853	9.361	3.290	0.649	0.180	0.000	1.127
	A7	48.100	1.700	17.400	0.000	10.400	0.140	9.400	10.700	0.700	0.550	0.510	0.000	0.000
		49.732	2.042	16.043	0.084	8.850	0.183	8.874	9.124	3.296	0.650	0.180	0.000	0.932
Apollo 15	A8	46.950	1.600	12.700	0.465	16.290	0.217	10.750	10.490	0.330	0.092	0.160	0.070	0.000
		46.546	4.187	14.078	0.109	9.930	0.198	11.219	8.680	2.871	0.569	0.163	0.001	1.442

TARGET	R01	R02	R03	R04	R05	R06	**R07**	R08	R09
DISTANCE δ	13.43	12.62	14.93	19.16	10.82	11.14	**10.00**	18.81	25.90
TARGET	R10	R11	R12	**R13**	R14	R15	R16	R17	R18
DISTANCE δ	22.79	23.64	24.40	**27.14**	23.97	13.36	13.72	14.28	12.02

JAYA ALGORITHM

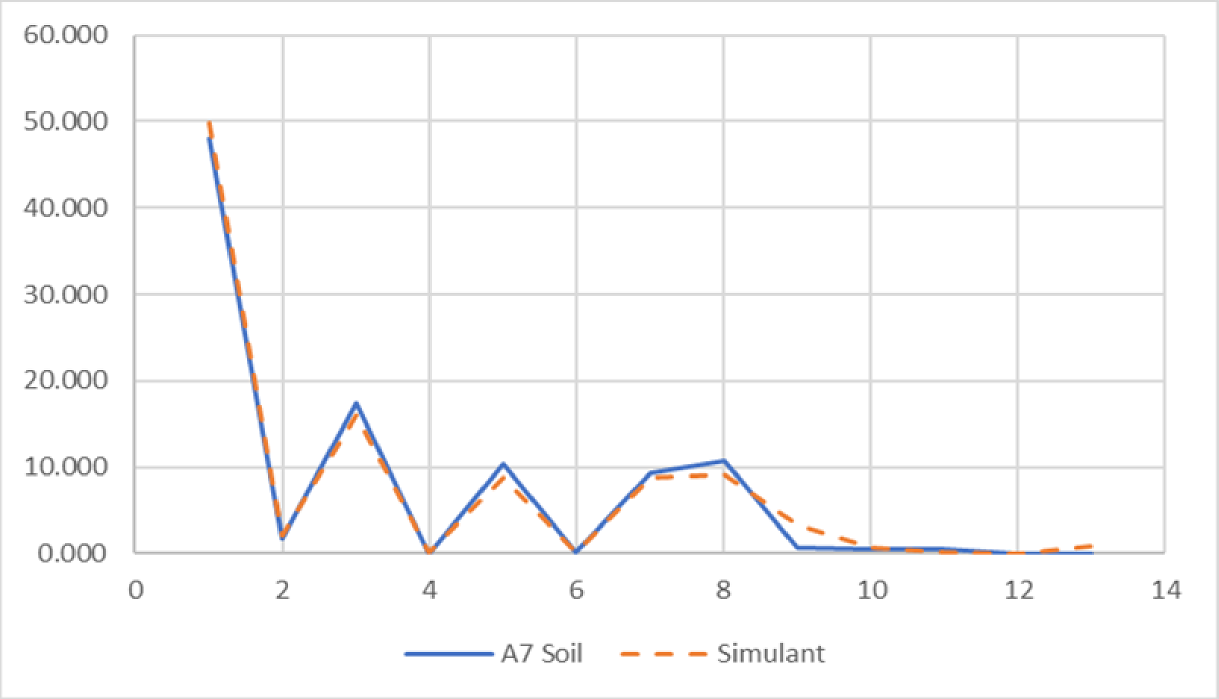
$$\delta = \sqrt{\frac{\sum_{i=1}^{n} w_i (p_i - q_i)^2}{n}}$$

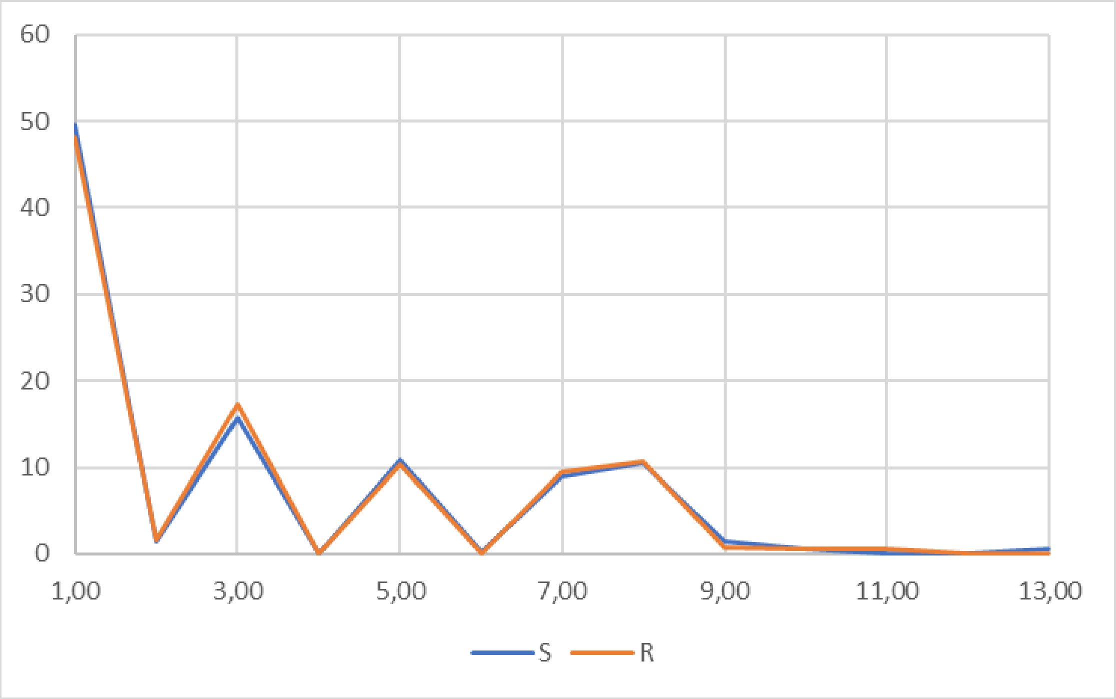
$$x_i^{t+1} = x_i^t + r_1\left(g_i^b - x_i^t\right) - r_2\left(g_i^w - x_i^t\right)$$



1:SiO2, 2:TiO2, 3:Al2O3, 4:Cr2O3, 5:FeO, 6:MnO, 7:MgO, 8:CaO, 9:Na2O, 10:K2O, 11:P2O5, 12:S, 13:LOI

2021. The output of a scientific research project run under the leadership of Dr. Toklu at Beykent University in collaboration with Bilecik University. A simulant, named TBG-01, close to lunar soil brought to Earth with Apollo 14 mission. This project makes Turkey the 10th country in the World producing a lunar soil simulant.





1:SiO2, 2:TiO2, 3:Al2O3, 4:Cr2O3, 5:FeO, 6:MnO, 7:MgO, 8:CaO, 9:Na2O, 10:K2O, 11:P2O5, 12:S, 13:LOI

On the left, TBG01 simulant (2021), On the right new simulant produced in November 2023.

10. UNCU ÜLKE OLDUK
Türkiye'de Ay toprağı benzeri üretildi

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Dünyada bulunan ay toprakları: İnsanoğlunun dünya dışında yapım işlemlerini yürüteceği ilk yer tabii ki en yakın komşumuz olan Ay'dır. Bu işlemlerde iki türlü malzeme kullanılacaktır, dünyadan götürülenler ve Ay'daki yerel malzemeler. Tahmin edilebileceği gibi önceleri dünyadan götürülenler büyük çoğunluğu oluştururken, zaman içinde yerel malzemelerin oranı hızla artacaktır. Ay'daki yerel malzemeler ise sadece ve sadece Ay toprağıdır.

AY üzerinde yapı inşaatının nasıl gerçekleşeceği konusunda dünyada çalışmalar yapılıyor. Cengiz Toklu ve arkadaşları da, Apollo'nun getirdiği örneklerin her birine yakın karışım formülleri geliştirdi ve yüksek değerde ay toprağı üretti.

Ay'daki yapım işlemlerinde ay toprağının nasıl kullanılacağı bugün için araştırmacıların üzerinde çalıştığı en önemli konulardan biridir. Pek çok araştırma kuruluşunda ay toprağı üzerinde deneyler yapılarak bu malzemeden Ay ortamında nasıl çimento, beton, briket yapılabileceği ya da az işlenmiş veya hiç işlenmemiş Ay toprağının çeşitli inşaat işlerinde, mesela toprak-armede, yol ve şev yapımlarında nasıl kullanılabileceği üzerinde çalışmalar planlanmakta.

Fakat eldeki ay toprağı örnekleri 400 kg kadardır. Bu örneklerin 382 kg kadarı Apollo 11, 12, 14, 15, 16, 17 seferleri sırasında Ay'ın 6 değişik bölgesinden alınmış 2200 örnek olup, bir kısmı da Sovyetler zamanında Luna seferleri ile getirilen 3 ayrı yerden alınmış olan 300 gr kadardır. Bunlara yakında Çinlilerin getirmiş olduğu 1.7 kg'lık toprak eklendi. Ayrıca ay yüzeyine düşen göktaşlarının fırlattığı ay **taşları da dünyaya düşebilmekte**. Bunların bilinenlerinin miktarının 50kg kadar olduğu sanılıyor.

Ay toprağı benzeri üretilir mi?

Eldeki ay toprağı azlığı araştırmacıları benzerlerini dünyada üretmeye yöneltti. 9 ülkede bu tip örnekler üretildi: ABD, Almanya (AB ile), Avustralya, Çin, Hindistan, İtalya (AB ile), Japonya, Kanada, ve Kore [1]. Bu gruba katılan 10. ülke ise Türkiye oldu.

1970'lerde başlanan dünyada üretme çalışmaları sonucu tonlarca üretim yapıldı. Çalışmalarda, genelde, birkaç yerel örnek alınarak bunlardan belli bir ay toprağına benzeyen karışımlar yapılıyor. Bu çalışmalara verilebilecek birkaç örnek[1]:

- ABD Marshall Uzay Merkezinde yapılan NU-LHT adlı seride Montana, ABD'de bir madenden alınan örneklere olivin ve ilmenit mineralleri eklenerek Ay'da yüksek bölgelerde bulunan topraklara benzer ürünler elde edilmiştir.
- Avustralya'da üretilen ALRS-1 benzerinde New South Wales eyaletindeki bir madenden elde edilen bazalt temelli malzemeler kullanılmıştır.
- KLS tip1 adlı Kore ürününde de bu ülkenin Cheorwon bölgesindeki bazalt örnekleri kullanılmıştır
- İtalya'da üretilen DNA-1 ve 1A benzerlerinde bu ülkedeki Bolsena kraterinden elde edilen malzemeler kullanılmıştır.

Ay toprağı üretimi için yerel toprak örneklerinin alındığı yerler: Avanos, Palandöken Dağı, Erciyes Dağı, Göreme, Kula, Sivrihisar, Toros Dağları, Uludağ, ve Ürgüp (1)

Türkiye'de ay toprağı üretme

Türkiye'de çalışmalarda ise konuya daha geniş bir açıdan bakıldı, ülkenin volkanik özellikleriyle bilinen yerlerinden 9 tanesinden bozulmamış toprak örnekleri alındı, bunlara ayrıca çeşitli madenlerden de örnekler eklendi. Toprak örneği alınan yerler Görsel 1'de. Bunlara çeşitli kaynaklardan alınan ilmenit, olivin, uçucu küller ve 2 çeşit bazaltın da eklenmesiyle toplam 14 örneğe ulaşıldı.

Daha sonra tüm bu örnekler üzerinde çalışılarak Dalga Boyu Saçınımlı X Işını Floresans Cihazı (WD-XRF) ile elementsel ve/veya oksit içerikleri ve X-ışını Difraksiyon (XRD) cihazı ile faz bileşimleri belirlendi. Bu bilgiler daha sonra Ay'dan getirilmiş Apollo örneklerinin özellikleriyle [1] karşılaştırıldı ve ay örneklerine en yakın karışımlar belirlendi. Bu amaçla Jaya algoritması [2] kullanılarak özel bir eniyileme yazılımı hazırlandı.

Elde edilen en iyi Ay toprağı benzeri örneği

Türkiye'de yapılan bu çalışmaların önemli özelliği, Apollo örneklerinin her birine yakın karışım formüllerinin bulunmasıdır. Bu özelliğiyle bu araştırma diğer çalışmalar arasında özgün bir konumda olacaktır. Çalışmalarda bu benzerliğin Apollo 14 seferiyle getirilen örneklere göre en yüksek düzeyde olduğu, en düşük benzerliğin ise Apollo 16 örneğine göre olduğu belirlenmiştir. Bu arada Apollo 14 seferinin yüksek bölgelere, Apollo 16 seferinin ise yüksek ve alçak bölgelerin birleşme yerlerine yakın olduğunu da belirtelim [3].

İstanbul Beykent Üniversitesi tarafından desteklenen bu çalışma bu üniversiteden Prof. Dr. Y. Cengiz Toklu'nun yürütücülüğünde, Prof. Dr. **Nurcan Çalış Açıkbaş** (Mersin Universitesi), Doç. Dr. **Gökhan Açıkbaş** (Mersin Universitesi), Dr. **Ali Erdem Çerçevik** (Bilecik Şeyh Edebali Üniversitesi), ve Dr. **Pınar Akpınar** (Bahçeşehir Kıbrıs Üniversitesi) tarafından gerçekleştirildi.

İlk Ay toprağı benzerinin üretilmesinden sonra bu çalışmaların Ay yapı malzemelerinin bu benzerden yararlanılarak üretilmesi konusunda devam etmesi, Türkiye'nin bu alanda en önde olan ülkeler arasına girmesini sağlayacaktır [4].

KAYNAKÇA

[1] Toklu, Y. C., Akpınar, P., (2019) "Lunar soil simulants- An assessment", in: Proc. 9th Int. Conf. Recent Adv.Sp.Technol. RAST 2019. https://doi.org/10.1109/RAST.2019.8767790.

[2] Toklu, Y. C., Bekdaş, G., & Nigdeli, S. M. (2021). Metaheuristics for Structural Design and Analysis. John Wiley & Sons.

[3] Toklu, Y. C., Akpınar, P. "Lunar Soils, Simulants and Lunar Construction Materials: An Overview". Baskıda

[4] Toklu, Y. C. "Uzay Yapılarında Yerel Malzeme Kullanımı" TIAD2001 - 1. ULUSLARARASI UZAY SEMPOZYUMU (1st International Space Symposium) 30-31 May 2001, Ankara, pp: I-107 - I-111, ISBN 975-409-186-2

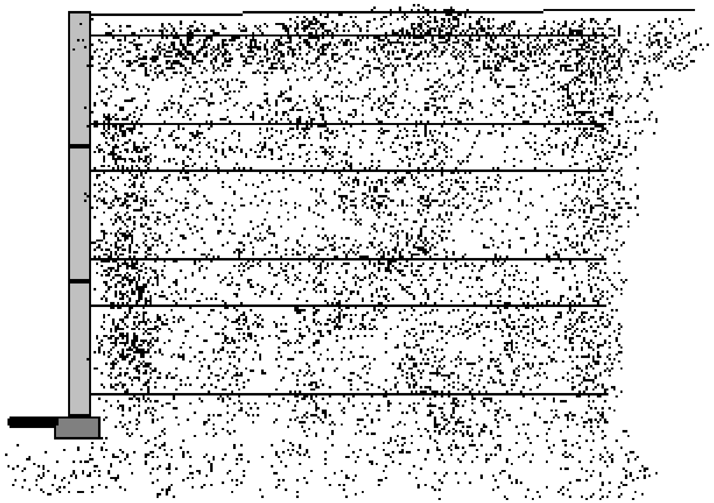
Regolith provides a good protection medium against radiation and micrometeorites.

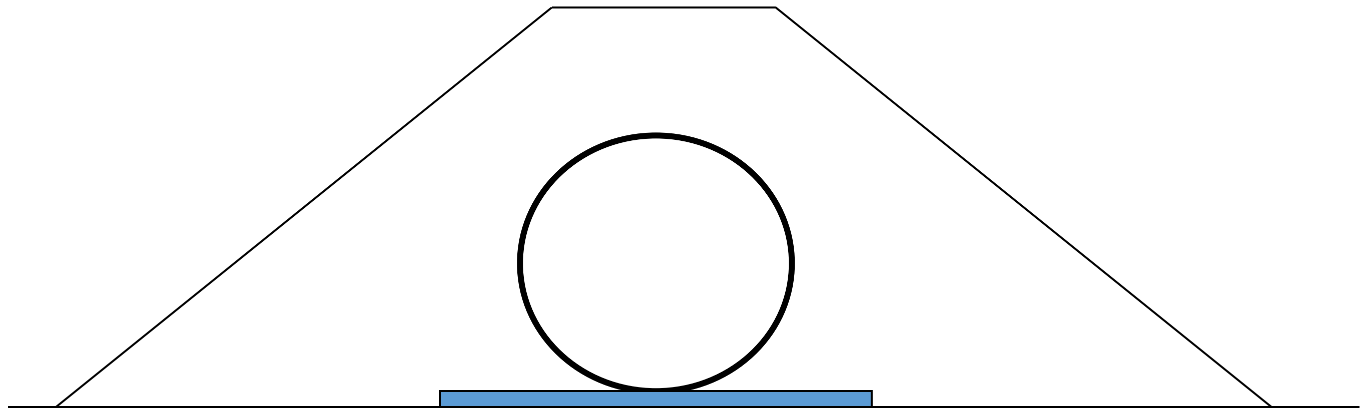
Estimate: ~2 m.> sufficient protection

Pressed, prefabricated blocks of regolith for smaller thicknesses.

It can be used as a raw material also for many other applications, the most important being concrete production.

Reinforced Regolith - ReRe





AY BETONU ÇALIŞMALARI

Studies on Lunar Concrete

- Further studies involving the use of such simulants for producing conventional building materials such as cement and concrete has been carried out.

- Waterless concrete, sulphur-based concrete, polymer concrete, and phosphoric acid-based concrete have been considered and investigated.

- Brick like materials

BETON VE DİĞER YAPI MALZEMELERİ

CONCRETE AND OTHER CONSTRUCTION MATERIALS

Regolith-based ordinary cements and concretes

Sulfur-based lunar concretes

Polymer-based lunar concretes

Geopolymerized regolith concretes sintered or cast regolith blocks

Regolith bricks with microbial induced calcite precipitation

Regolith-based magnesium oxychloride composites with graphene

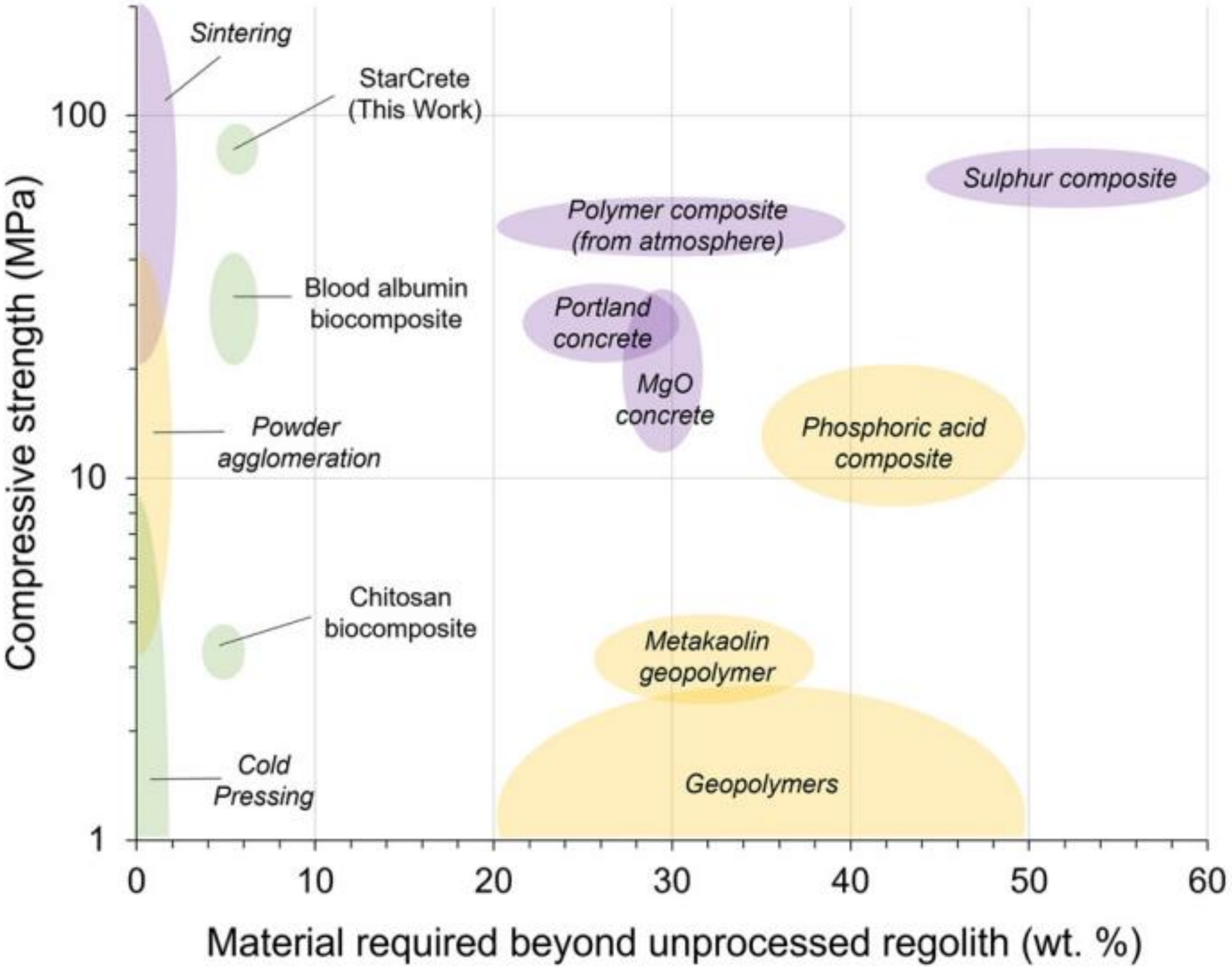
Biopolymer-bound regolith composites

Starch added lunar concrete

Lunar construction materials with 3D printing

Toklu, Y. C., & Akpinar, P. (2022). Lunar soils, simulants and lunar construction materials: An overview. *Advances in Space Research*, *70*(3), 762-779.

Type of Lunar Construction Material	Examples Studies	Reported Max Compressive Strength	Reported Max Flexural Strength
Ordinary Concrete	Lin et al., 1985		
Sulfur-based Concrete	Omar, 1993	33.8MPa & 43MPa (with fibers)	3.7MPa
	Toutanji et al., 2010	22MPa	
	Toutanji et al., 2012	31MPa	
	Grugel, 2012	~47 MPa	
Polymer-based Concrete	Lee et al., 2015	12.9MPa	
	Chen et al., 2018		~60MPa
	Su et al., 2019		47.8MPa
	Oh et al., 2020		16MPa
Geopolymer Concrete	Wang et al., 2016	35MPa	
	Wang et al., 2017	~50MPa	
	Davis et al., 2017	~19MPa with ambient curing & ~3MPa curing under simulated lunar exposure conditions	
3D Printed Construction Elements/materials	Cesaretti et al., 2012		
	Cesaretti et al., 2014	20.35MPa	7.1MPa
	Balla et al., 2012		
	Sitta & Lavagna, 2018	22.7MPa	
	Meurisse et al., 2018	~5MPa	
	Taylor et al., 2018	19MPa	
Other sintered & cast lunar regolith blocks	Happel, 1993	538MPa	34.5MPa
	Indyk & Benaroya, 2017	218.8MPa	
	Mueller, 2017 (Based on NASA studies)	>200MPa	
	Kim et al., 2021	37MPa	



Tensile strength 8MPa

Roberts, A. D., & Scrutton, N. S. (2023). StarCrete: A starch-based biocomposite for off-world construction. *Open Engineering*, *13*(1), 20220390.

STRUCTURAL ENGINEERING

- Choice of Structure

Type of Structure

Resistant to Radiation and micrometeorites.

Shielding (using regolith) or underground (lavatubes e.g.)

Easy to construct/mount

At the beginning using terrestrial resources, but as the time goes on, using lunar resources

- Design of Structures
- Loads

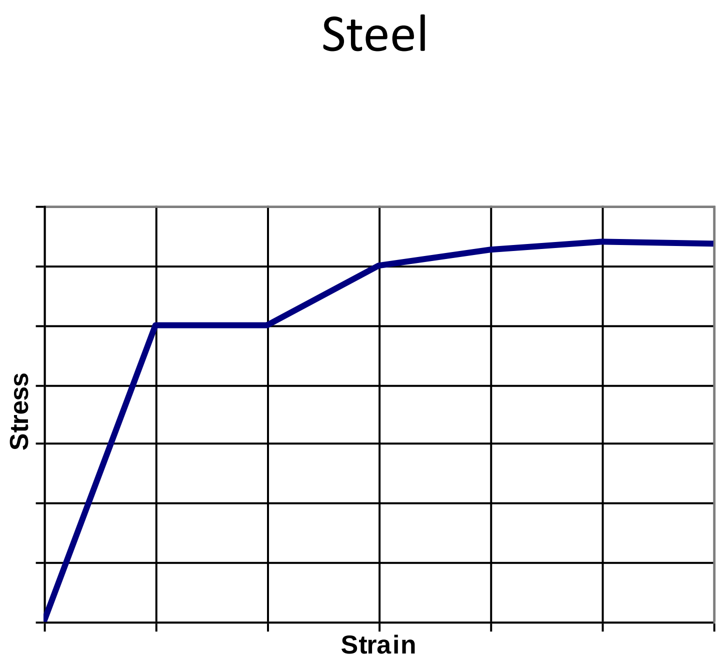
Gravity Loads 1/6

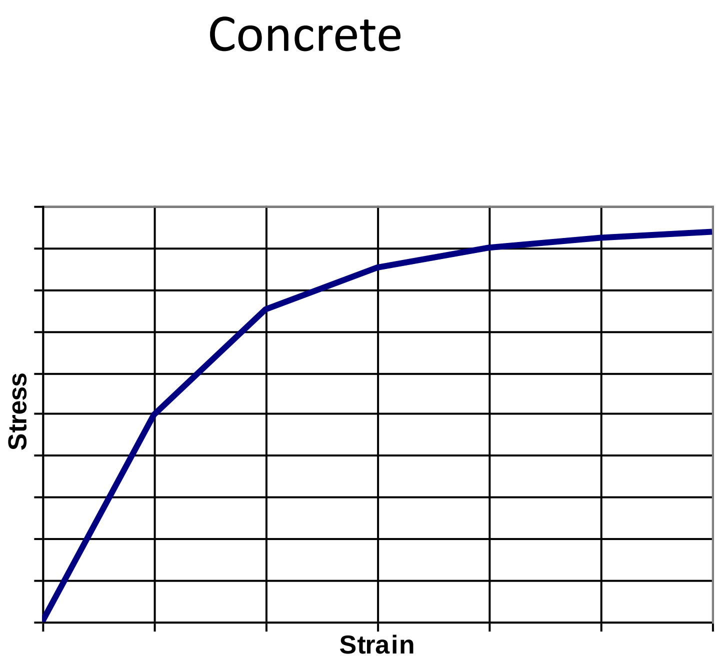
Inside pressure 1 ~ .85atm
85~100 kPa

Structures will resist compressive forces and/or tensile forces, thus the name tension-compression-column

Optimisation to highest degree.

Linear design - Nonlinear design





- Phase One (2010-2020): Designs for equipment shelters during initial unmanned robotic or manned missions (short term manned missions);

- Phase Two (2020-2030): Development of structures for medium length of stay (up to several months, approximately one year);

- Phase Three (2030 on): Long-term construction of lunar structures for different purposes (primarily for long term habitats, resource use, laboratories, and finally permanent lunar bases).

Jablonski, A. M. (2010). Technical aspects of seismicity on the moon. *Apollo The International Magazine Of Art And Antiques*, (613), 1-25.

$30 m^2$ surface area

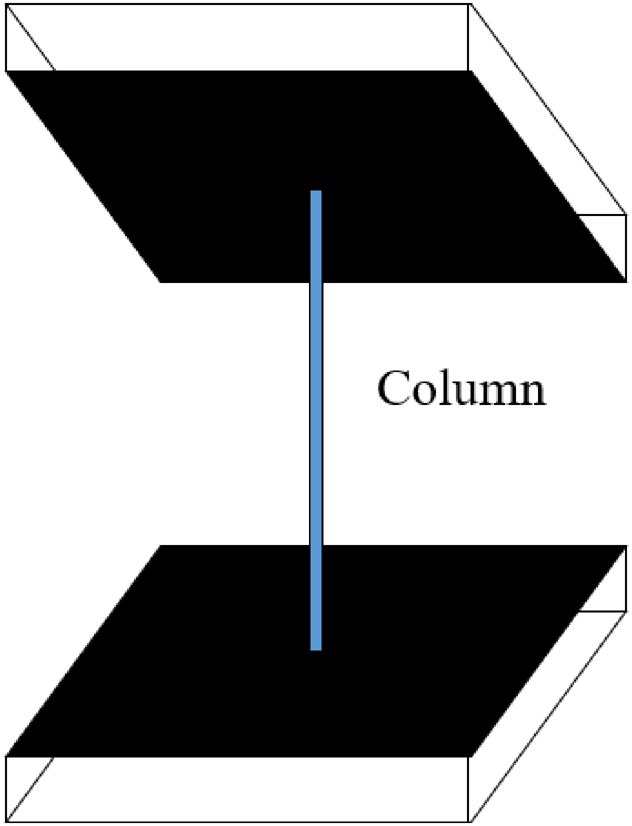
U.D.L. 5 kN/m^2

Total downward load: 150 kN

σ_{all}=200MPa

A_{min}=$750mm^2$

27mmx27mm



$30m^2$ surface area
Total structural downward load:
150/6=25 kN

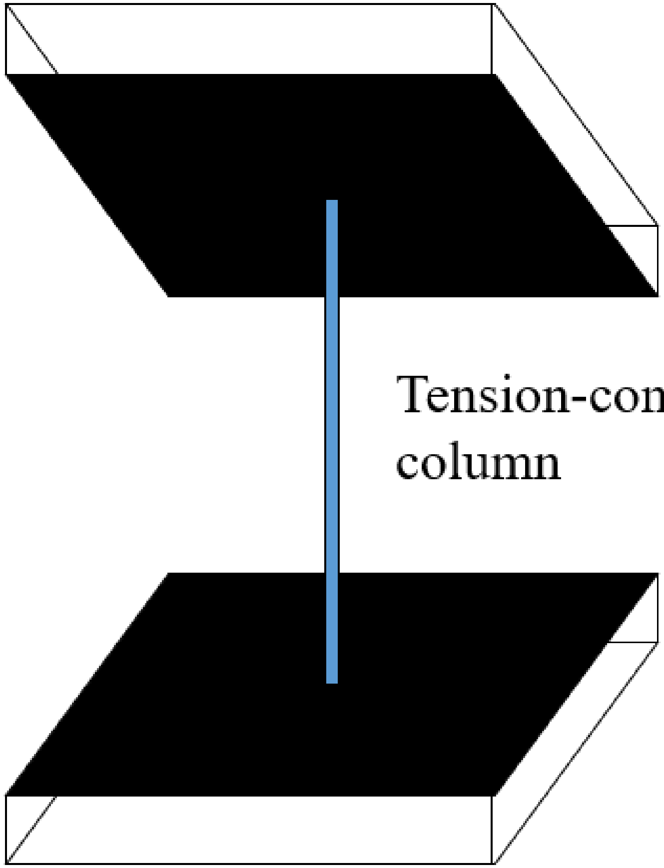
2m thick regolith
1500 kg/m^3 x 10/6N/kg x 2 m = 5000 N/m^2,
>>>>150 kN
Total compressive load 175 kN.

Inside pressure
1atm=$1x10^5$Pa
Total tensile force 3000 kN

-175kN < F < 2825kN
σ_{all}=200MPa

A_{min}=~$14000mm^2$

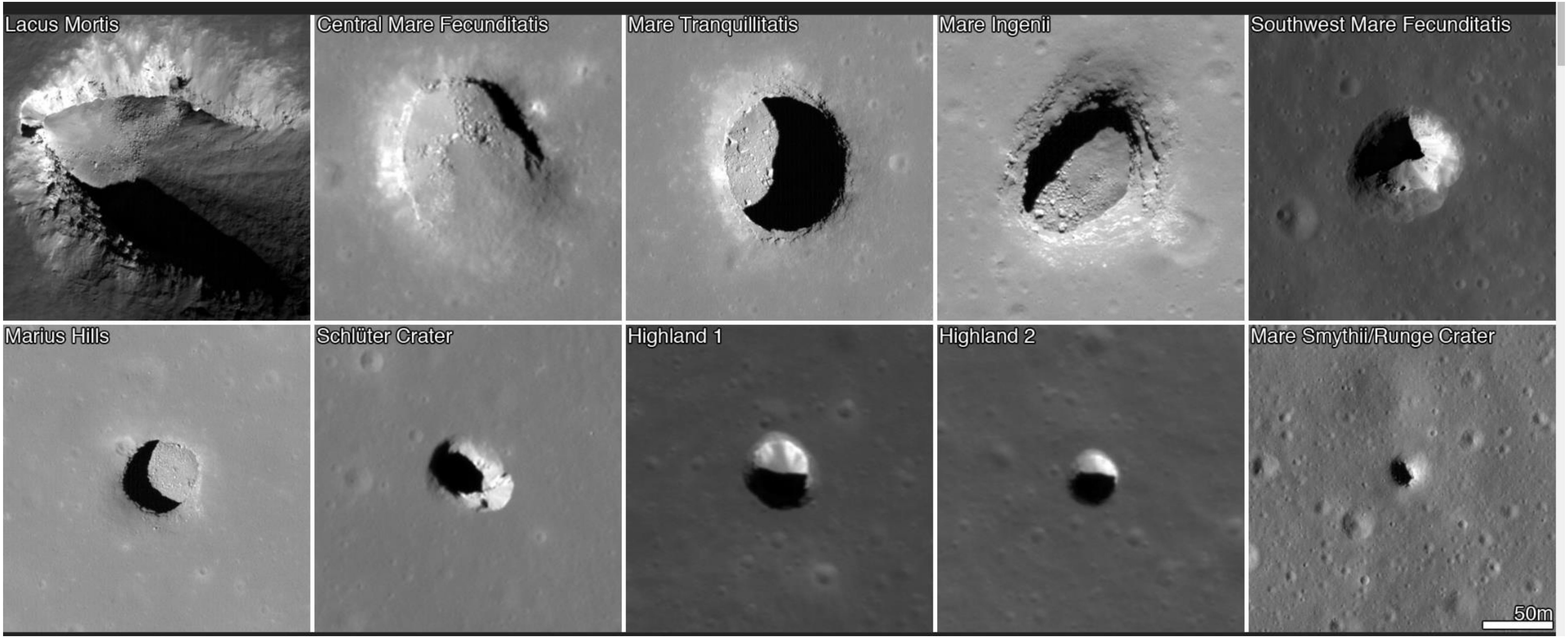
118mm x 118 mm



Choice of structures

- Tension resistant

  Spherical or like (ellipsoidal, toroidal),
- Spherical structures connected to each other by cylinderical tubes
- Inflatable structures, Deployable structures
- Cable-strut structures, Tensegrity (tensile-integrity) structures
- Prestressed or post-tensioned concrete
- Important shielding (or underground, in lava tubes)



PROBABLE LAVA TUBES DETECTED

https://www.universetoday.com/156932/lava-tubes-on-the-moon-maintain-comfortable-room-temperatures-inside/

CABLE-STRUT STRUCTURES

KABLO-ÇUBUK YAPILAR

TENSEGRIC STRUCTURES, TENSILE INTEGRITY STRUCTURES

ÇEKME-TÜMLEŞİK YAPILAR

FEMEM EESEY

These structures are highly nonlinear, because of the characteristics of cables: they do not carry compressive forces.

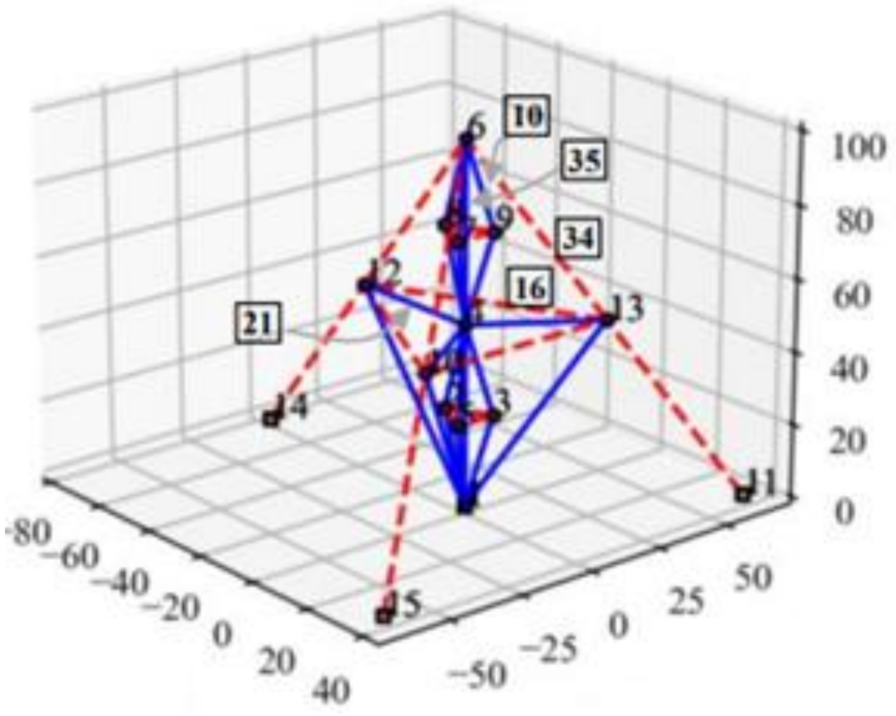
Therefore, these structures cannot be analyzed directly with classical methods, for instance using the well-known Finite Element Method (FEM). There are methods specially designed for this purpose.

On the other hand, the method developed by Dr. Toklu, named Finite Element Method with Energy Minimization (FEMEM) <Enerji Enküçüklemeli Sonlu Elemanlar Yöntemi (EESEY)> can solve these problems without necessitating any special measure.

See for instance:

Toklu, Y. C., Bekdas, G., & Nigdeli, S. M. (2021). Metaheuristics for Structural Design and Analysis. John Wiley & Sons

Tensegric structure - Tensile integrity structure - Çekme tümleşik yapı

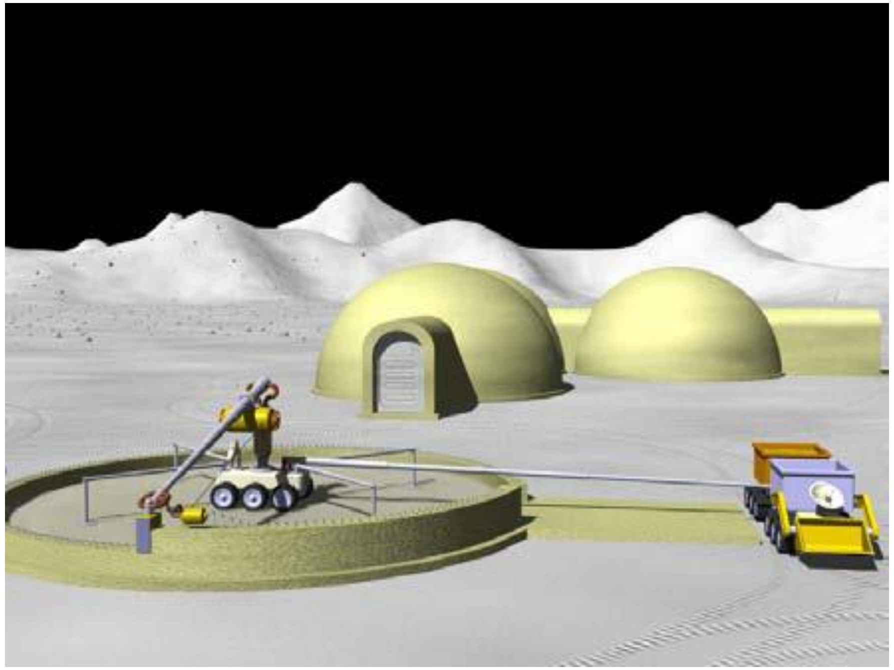


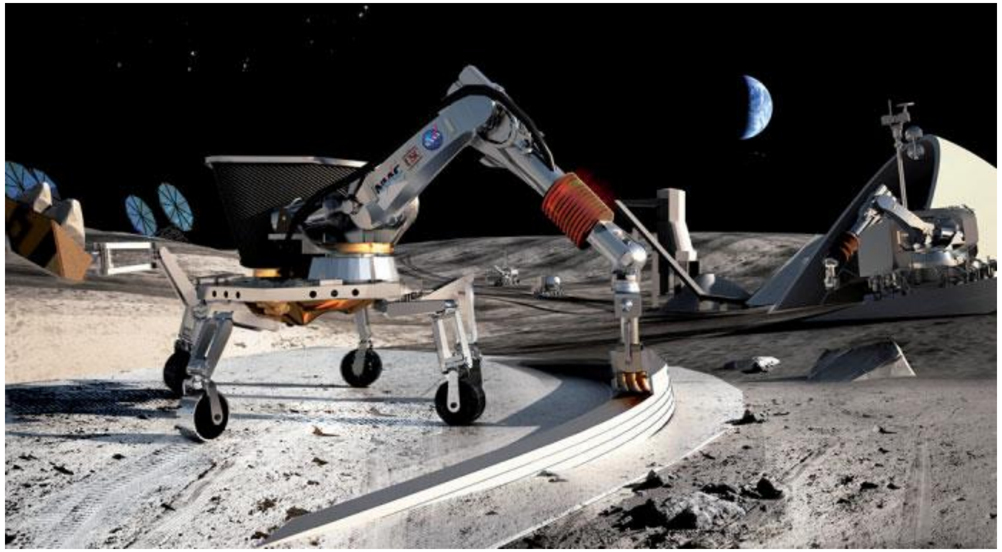
A 100m high lunar tower. Bottom nodes fixed. Red lines are strings and blue lines are bars

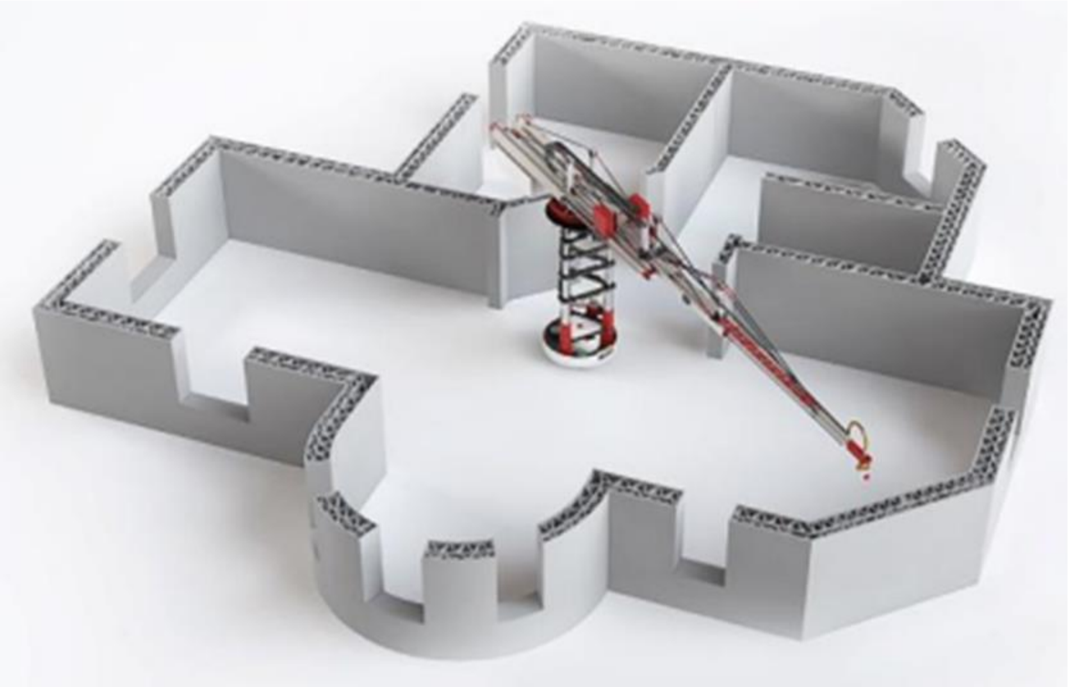
Toklu, Y. C., Muderrisoglu, Z., Ozbasaran, H. (2024) "An Iterative Approach, TPO/MA, for Non-linear Analysis of Tensegrity Structures Under Terrestrial and Lunar Conditions", ASCE Earth & Space Conference 2024, April 15-18, 2024, Miami, Florida, USA

3D PRINTED STRUCTURES

3B KATMANLI İNŞAAT

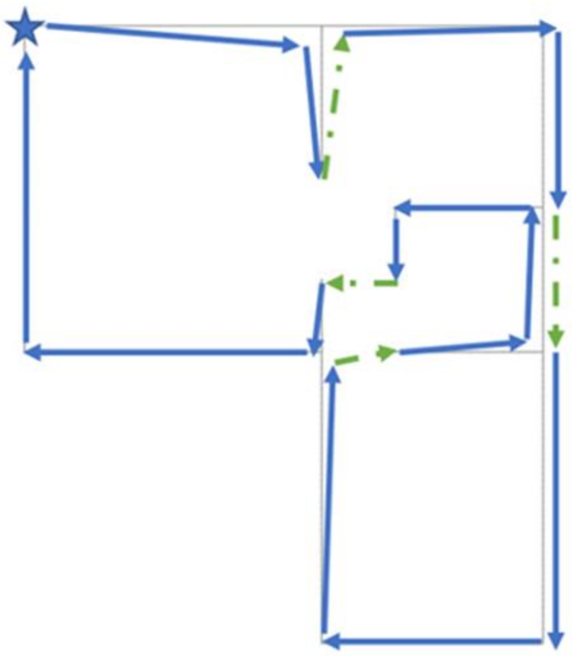






Nadarajah, N. (2018). Development of concrete 3D printing. MS thesis. Aalto University, Finland

Zhang, J., Wang, J., Dong, S., Yu, X., & Han, B. (2019). A review of the current progress and application of 3D printed concrete. *Composites Part A: Applied Science and Manufacturing*, *125*, 105533.



An 14-wall flat

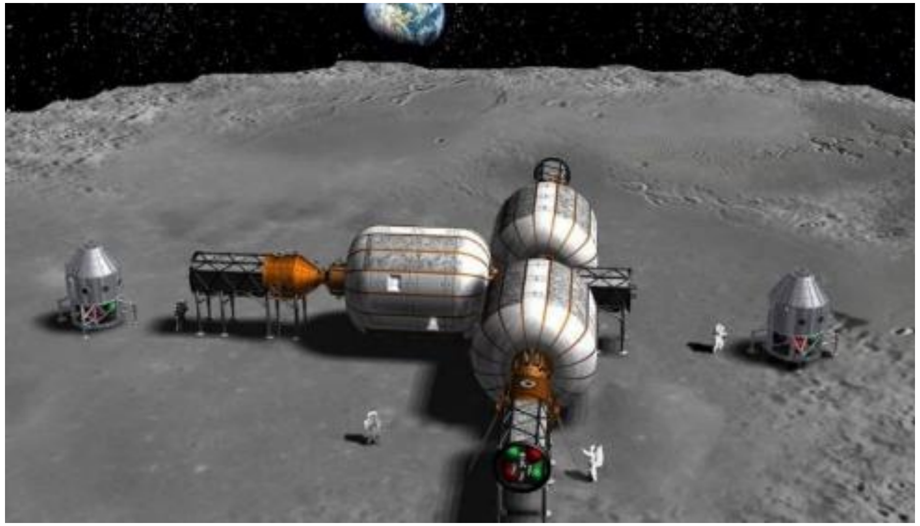
$P_1 = 2^{w-1}(w-1)!$ $\qquad$ $P_2 = 2^{w}\, w!$

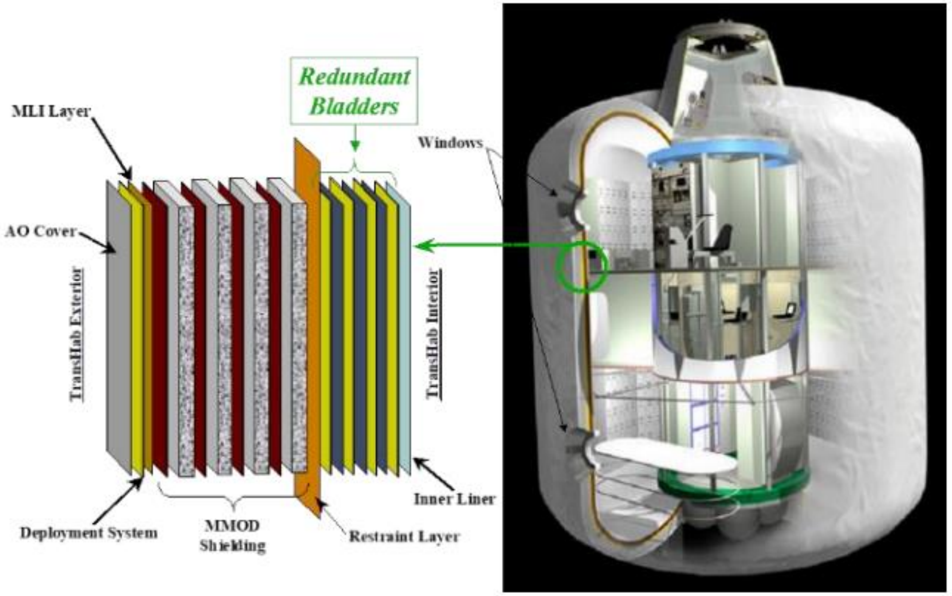
Number of walls	Start from a given joint in prescribed direction	Start from any joint in any direction
7	46080	645120
8	645120	10321920
14	5,10118E+13	1,42833E+15
31	2,84813E+41	1,76584E+43
17	1,3712E+18	4,66207E+19

Toklu, Y.C, Bekdaş, G., Geem, Z.W. (2020) Harmony Search Optimization of Nozzle Movement for Additive Manufacturing of Concrete Structures and Concrete Elements. Applied Sciences. 10(12), 4413

Toklu, Y. C., Çerçevik, A.E. (2023) "Additive Manufacturing of Concrete Structures and Concrete Elements, Optimization of the Time Consumed" 7th International Congress on 3D Printing (Additive Manufacturing) Technologies and Digital Industry 2023, Otober 25 to 27, 2023 - ISTANBUL, TURKIYE

INFLATABLE AND DEPLOYABLE STRUCTURES

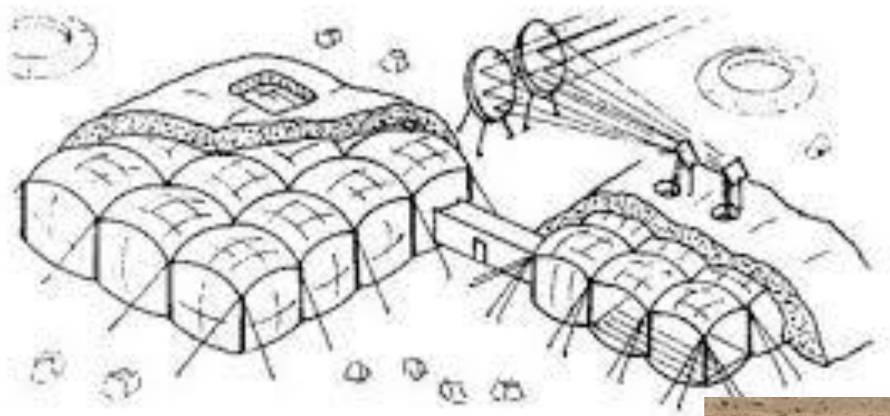


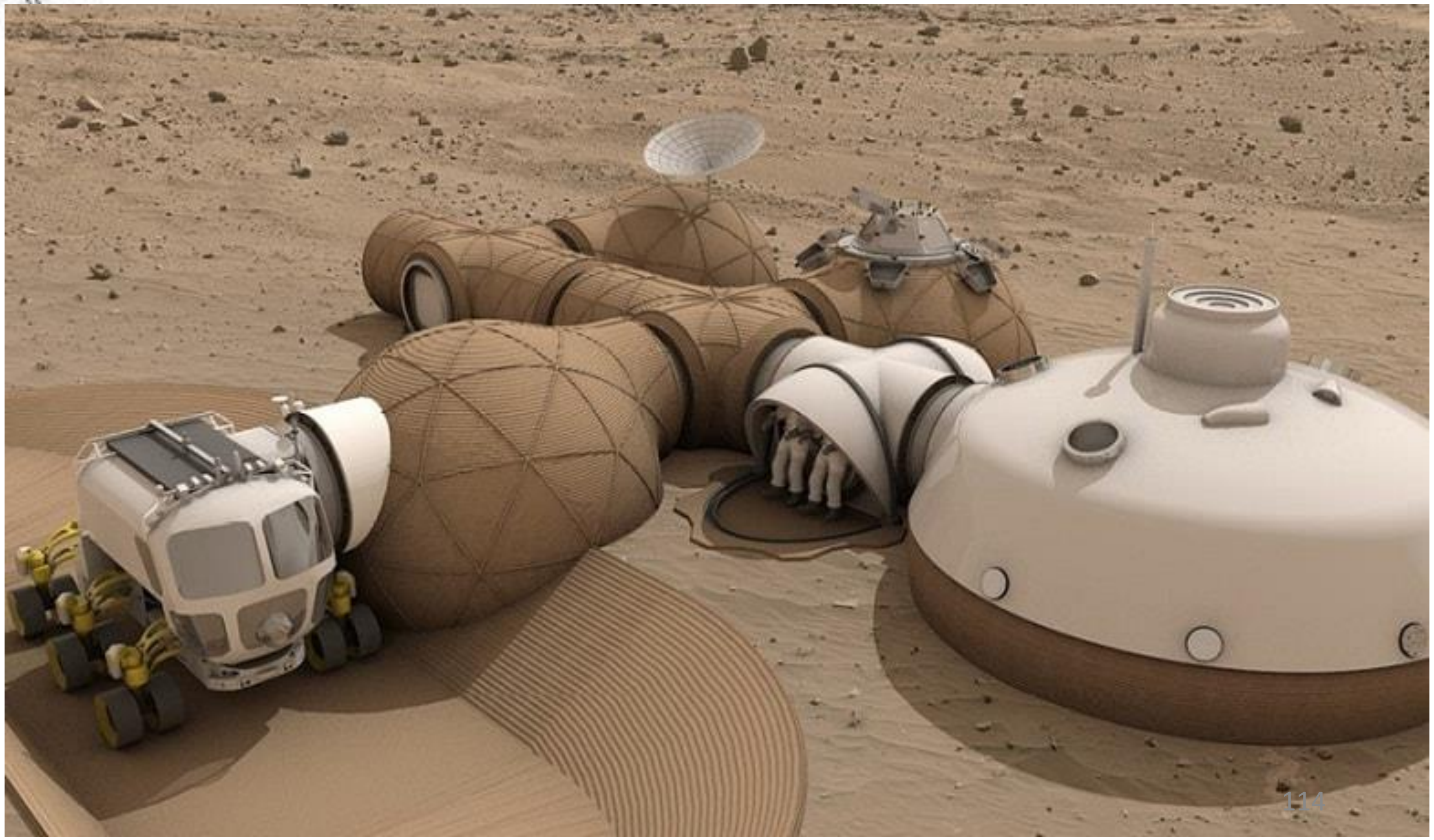


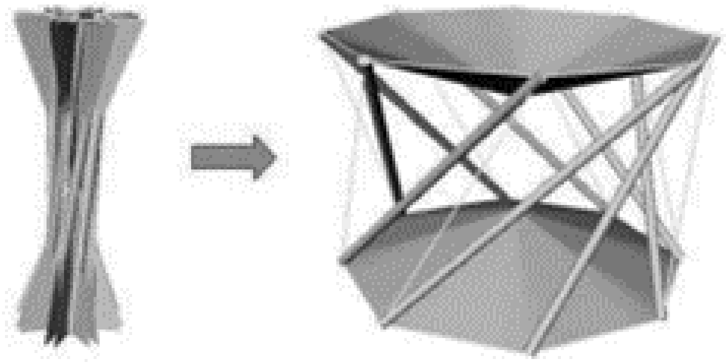
BEAM
Bigelow Expandable Activity Module

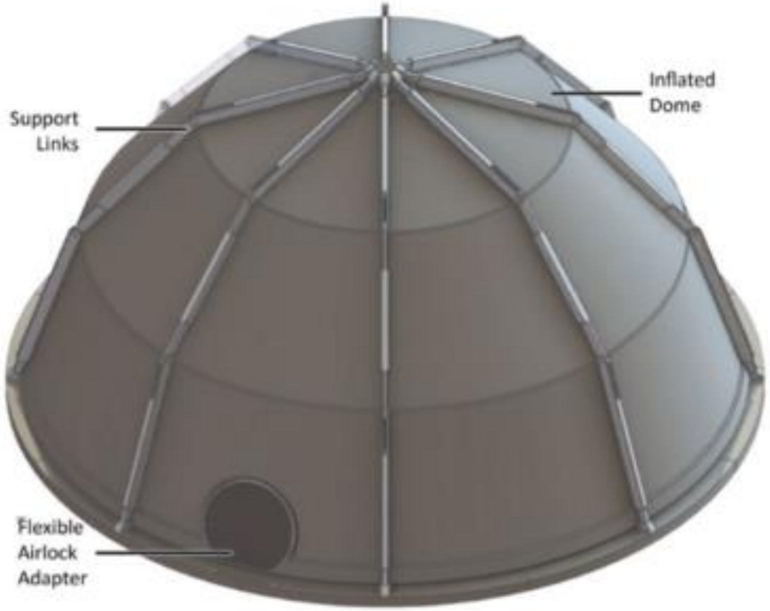
BEAM	Packed	Inflated	Inflated/Packed Ratio
Mass (w/ PCBM & FSE)	~1400 kg (~3K lb)		1.0
Volume	**3.6 m³**	**16 m³**	**4.4**
Length (w/ FRGF)	2.16 m	4.01 m	1.9
Diameter	2.36 m	3.23 m	1.4
Pressure	0	14.7 psi	-

Wells, N., & Valle, G. (2018, July). Bigelow Expandable Activity Module (BEAM) ISS Year-Two. In *International Space Station Research & Development Conference (ISSR&D 2018)* (No. JSC-E-DAA-TN59119).









De Boeck, J. (2013). Tensegrity bridges: Concept design of pedestrian bridges using tensegrity as load carrying system

Dronadula, R., Benaroya, H.: Hybrid lunar inflatable structure. Acta Astronaut. 179, 42–55 (2021)

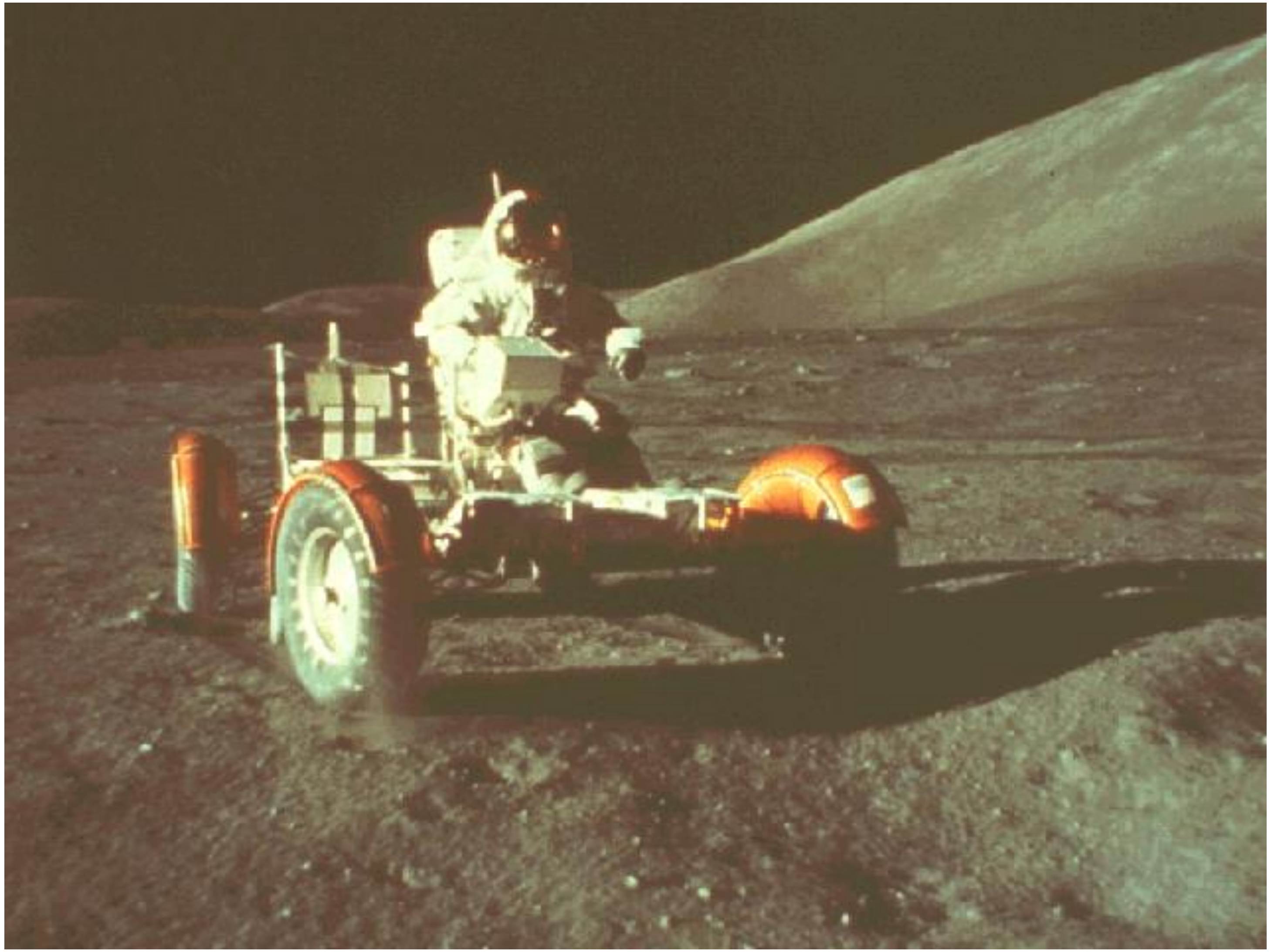
- Passive structure
- Active structure, Smart structure, intelligent structure

- Passive design, active design

TRANSPORTATION ENGINEERING

- Lunar vehicles
- Lunar Railroads
- Cable Transportation

APOLLO 17



APOLLO 17, December 1972

ROADS, LANDING AND LAUNCHING PADS

CONSTRUCTION MANAGEMENT

- SITE PLANNING AND SITE CHOICE
- SCHEDULING OF OPERATIONS
- CONSTRUCTION EQUIPMENT
- COST ANALYSIS, COST CONTROL

SITE PLANNING AND SITE CHOICE

Location of site

The polar sides are believed to have the advantage of containing water ice. Especially southern pole [i)ice(?), ii)largest impact crater, iii)permanently shadowed crater bottoms, iv)places with almost continuous sunlight, v)constant temperature ~-30C, vi)close to farside]

Planning of site

In addition to similar problems on Earth, landing areas and their preparations have to be considered

PSR: Permanantly shadowed regions

SGB: Sürekli gölge bölgeler

SCHEDULING OF OPERATIONS

Risk factor. Follow up very closely.

CONSTRUCTION EQUIPMENT

Soil resistance is similar.

Weight of equipment is low. Thus an anchoring system or downward push is necessary.

COST ANALYSIS, COST CONTROL

A new data base will be formed.

SON SÖZLER

FINAL WORDS

FUTURE AND CIVIL ENGINEERS

It is to be noted that, up to now, the pioneering countries have been extremely successful in their manned an unmanned operations on the moon and elsewhere in the space. It is this success that gives all mankind the hope and the security that the coming operations also will be successful and thus the thought that this pioneering work has to be followed. In this context, civil engineers will continue to do their work adopted for the new Nature.

Space architect – Space civil engineer

Current Status

- Several space agencies from all around the world, including NASA (USA), ESA (Europe), CSA (Canada), CNSA (China), JAXA (Japan), Roscosmos (Russia), ISA (Israel) and ISRO (India), have declared their interests in launching space missions within the next two decades.

- Some of these missions, which are intended to be destined to Moon, involve establishing outposts in order to facilitate further deep-space explorations

- **DÖRT ÜLKE BAŞARILI İNİŞ YAPTI**
- Bugüne kadar Ay'a sadece dört ülke başarıyla iniş yaptı;
  bunlar **ABD**, **Rusya**, **Çin** ve son olarak da **Hindistan**'dır.

CONCIOUSNESS AND DIFFICULTY

Perhaps the most important differences between the current enlargement of the living area and the previous ones are

1. The level of conciousness
2. The level of difficulty

Consciousness

In the past, most of the activities to push forward the frontiers were made unconsciously or at least in a half-conscious manner.

Full consciousness was rare.

The activities of today are all made in a completely conscious way, every step being well calculated and measured.

Current difficulties

Effectively, this new attack is much more difficult than the previous ones. It necessitates

- a powerful economy,
- an advanced level of technology,
- scientific research organizations,
- political will and decisiveness.

Difference between nations

- Very few nations and unions can bring all these together in order to follow space research and push the boundaries.
- But the fact is that, remembering the spiral which defines our current position, if a nation does not take place in this process, it will probably lack the relevant benefits, coming from new resources and new technologies.

Internationality, Multi-nationality

- Thus, mankind must find a solution to attract the highest number of nations, groups, and unions into this process.
- The remedies for achieving this goal may be

- To encourage internationality and multi-nationality in space research projects, and

- To encourage breakdown of the projects into smaller activities which can be afforded by a larger community.

Summary

Point 1: Space Research is a natural continuation of the historical activities starting from primitive habitats to globalization, i.e. the advent or evolution of civilization.

Point 2: Space research is not a single dimensional activity. There are direct activities which are very expensive to run. But there are also some side activities that necessitate less amount of resources but are equally productive.

Point 3: Research on these side subjects can be run by nations or unions who have limited capabilities. If this is realized, it will help to form a more uniformly developed world.

Advances in Space Technology (Direct and Indirect)

Space research is expensive. Developing a rocket to launch a spacecraft to comet Halley or establishing an outpost on the south pole of the Moon necessitates billions in any currency.

But there are activities which can be run by nations who cannot be categorized among the richest ones.

Examples of Indirect Research Areas

- In the following are given some indirect research subjects which could well be attacked by smaller sized research and development organizations that can be found in many places over the globe.

Examples of Byproducts

- - Wind Turbine
- - Water ballasted raft
- - Viscoelastic foam
- - Agents for safer railroads
- - Structural foam protecting external tank of boats and ships
- - “Cognitive fitness” software to monitor alertness
- - A tiny sensor, that monitors voltage changes near sensitive instruments

Byproducts

- It seems that, until now, there have been more than 30000 innovations like the ones given above. Most of them are indirectly related to space research, and many of them have helped to give birth to unexpected byproducts which can be used in areas not related to space affairs.

- This means that space research is not a single dimensional activity. On the contrary, it is a multi-dimensional task if not infinite dimensional. This is true for the aims and for outputs at the same time.

Feedback to Earth

"We went to explore the Moon, and in fact discovered the Earth,"

Eugene Cernan

Apollo 17 astronaut

"Last man on Moon"

1934 -2017

TÜRKİYE’YE VE DÜNYAYA UYGULAMA DÜŞÜNCELERİ

- Yeni tip betonlar
    - Çimento yerine başka bağlayıcı kullanan betonlar

- Afet bölgelerinde kullanılabilecek yapılar
    - Şişme Yapılar
    - Açılır kapanır yapılar
    - Kablo-çubuk yapılar

Benefits of Multinationality

- In this way, a higher percentage of the world population will be contributing to the space research, directly or indirectly.

- This will also mean that more people will benefit from the economical and technological benefits of space research.

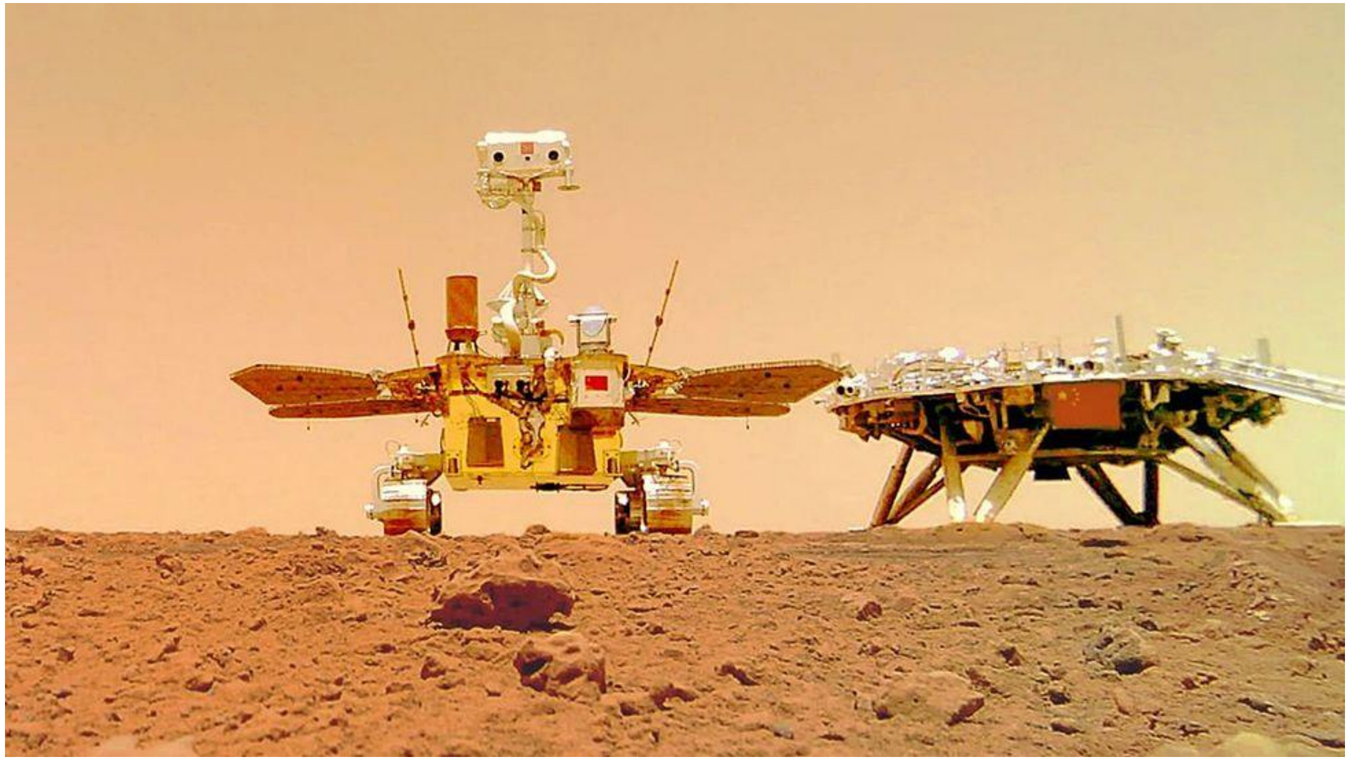
- Such an approach will be helping to a more evenly developed world.

Benefits of International Cooperation

- Increasing scientific payoff
- Sharing costs and increasing cost effectiveness
- Providing access to needed facilities
- Providing access to technology or experience possessed by others
- Increasing domestic support for space pograms
- Strengthening relationships among allies or creating friendlier relationships with non-allies
- Influencing the content or direction of a partner’s space efforts.
- Demonstrating leadership and enhancing prestige.

Peter Eckart 2006

Mars. 2020. Perseverance



China Zhurong rover

Le Petit Prince - Man will certainly go to other space bodies for good

Mühendislik, insanın çevresiyle beraber uyum içinde yaşatılması sanatıdır. İnsanoğlu ilk önce yakın çevresiyle uyum içinde olmaya çalışmış, dolayısıyla yakın çevresiyle uğraşmıştır. Sıcak ülkelerde ormanlarda yaşayanlar ağaç liflerinden asma köprüler, ağaç tepelerinde evler yaparken, uzun liflerin olmadığı ama bol miktarda taş bulunan yerlerde insanlar kemer yapmayı öğrenerek bunlarla tapınaklar ve köprüler yapmayı becermişlerdir. Ağaçların ve taşların olmadığı yerlerde ise en önemli yapı hammaddesi toprak olmuş, kerpiç ve benzeri unsurlarla barınaklar, surlar inşa edilmiştir.

Uygarlığın ve ulaşım olanaklarının gelişmesiyle “yerel” sözcüğünün anlamı değişmiştir. İnsanlar daha uzaklara gittikçe, çok yakınlarında olan koşullardan bambaşka durumlarla karşılaşmış, bunlarla başedebilmek için yeni deneyimler edinmişler, teknolojilerini geliştirmişlerdir.

Bugün artık insanlık için “yerel” kavramı “küresel” anlamını yüklenmiş bulunmaktadır. Yani insanlar artık adı Dünya olan, küre biçiminde bir cismin üzerinde yaşadıklarının ayırdına varmışlardır.

Yerel kavramının mağaranın önündeki birkaç bin metreden, tüm dünyayı içine alacak şekilde değişmesi, bu büyümeye koşut bilimsel ve teknolojik gelişmeleri de beraberinde getirmiştir.

Alanın her büyümesi, yeni veriler, değişik koşullar, yenilecek başka güçlükler getirmiştir. Teknoloji ve bilimin gelişmesi bu etmenler sayesinde hız kazanmıştır. Gelişmeler sonra da alanın büyümesini sağlamış, yeni yerlere gidilebilmesini mümkün kılmıştır. Bu sarmal bizi bu günlere getirmiştir.

Son zamanlarda şu sözleri sıkça duyuyoruz: “Ay’a bu kez kalmak üzere gidiyoruz!”

Bu demektir ki yerel kavramı yeni bir aşama kaydetmek üzeredir. Bugünkü mühendislik, insanlığı Ay üzerinde yaşatacak düzeydedir. “İnsan gidebileceği her yere gider” kuralı gereği, artık Ay’a gidilecek, orada yaşanacaktır.

Ay üzerine yerleşme, daha sonra da orada sürdürülebilir yaşam ortamı sağlanması sırasında inanılmayacak bilimsel ve teknolojik gelişmeler zorunlu olarak gerçekleştirilecektir. Bu arada Ay kaynaklarının kullanılması yönünde de adımlar atılacak, sonuçta Ay, üzerinde üs sahibi olanlara ekonomik ve askeri fırsatlar da sunacaktır.

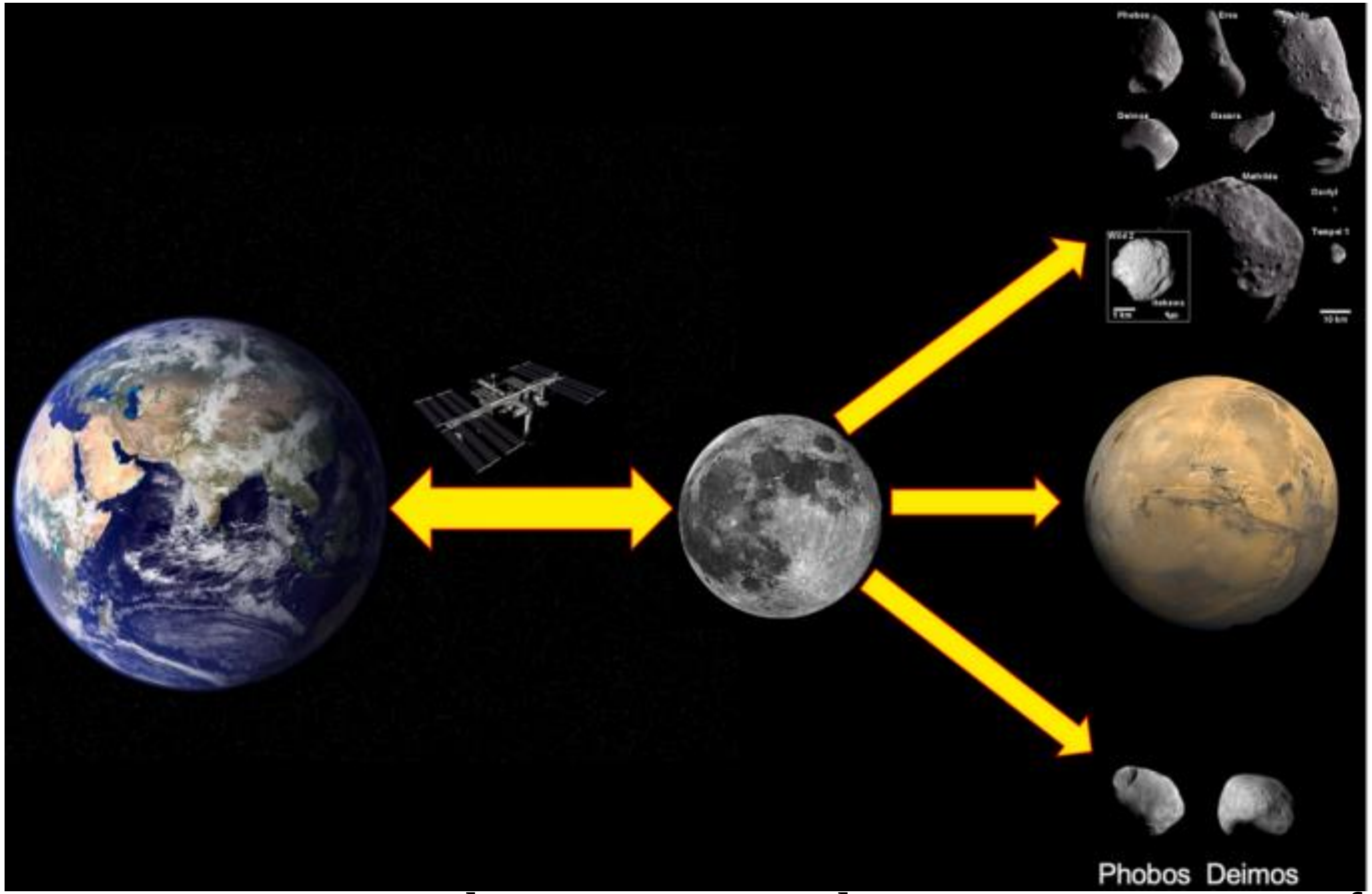
Bu noktada Ay üzerinde üs kuracak ülkelerin ne büyük avantajlara sahip olacakları belirginleşmektedir. Bu ülkeler hem büyük bir bilimsel ve teknolojik gelişmenin içinde yer alacaklar, hem de Ay'ın sağlayacağı ekonomik ve askeri üstünlüklerle donanmış olacaklardır. Bu çalışmalardan uzakta kalan ülkelerin ise bundan sonraki gelişmeleri geriden, gıptayla izlemekten başka seçenekleri olmayacaktır.

İşte bu nedenle Türkiye mutlaka bu faaliyetlerin içinde olmalıdır. Türkiye'nin Ay'da kendi üssünü kurma olanağı olmadığı açıktır. Bunun için ne yeterli teknoloji altyapısı vardır, ne de gerekli finansman sağlanabilir. Ancak, gerçekleştirilecek bazı ortaklıklarla söz konusu çalışmaların içinde olmak mümkündür.

Bilinmelidir ki Ay'da kalıcı bir üs kurulması demek, Dünyada var olan hemen her konunun Ay'a taşınması demektir. Bu da neredeyse sonsuz sayıda araştırma konusu anlamına gelir. Ay ile ilgili mümkün olan çok sayıda araştırmanın Türk bilim insanlarının katkılarıyla yürütülmesi, Ay üsleri kurulması ve yaşatılması aşamasında ülkemizin belli bir yer almasının önünü açabilecektir.

Unutulmamalıdır ki uzay araştırmaları demek, sadece uydu çalışmaları yapmak demek değildir. Ve de Türkiye, Ay, Mars ve diğer gök cisimleri üzerinde yerleşme çabalarını uzaktan seyretmek lüksüne sahip değildir.

On-yirmi yıl sonrasında Ay'ı, yirmi-otuz yıl sonrasında da Mars'ı içine alacak insanoğlu yerel bölgesinde Türklerin ve Türkiye'nin büyük ölçüde var olması, bu çalışmaların içinde olunmasına bağlıdır.



German-American rocket engineer and space visionary, Kraftt Ehricke (1917-1984) said “If God wanted man to become a space-faring species, He would have given man a Moon”.

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CE 475 SPACE CIVIL ENGINEERING

PROJECT SUBJECTS

Design of a Structure in Free Space
Meteorite Impact Loads on Structures
Wind Loads on the Earth and on Mars
Transportation on the Moon
Foundation Engineering on Moon and Mars
Lunar Excavators
Comparison of Lunar Soil Samples and Terrestrial Soils
Space Towers and Elevators
Space Civil engineering Education in the World
Safety Factors for Vehicles, Aeroplanes, and Lunar Structures
The Lagrange Points
Quakes on Moon and Mars
Minimum Level for Atmospheric Pressure for Living
Design of a Cylinder, a Sphere and a Torus
In Situ Soil Mechanics Tests on Moon
Lunar Concrete
Design Loads on the Moon
Lunar Soil Mechanics
High-Rise Buildings
Space Suits
Optimum structures on the Moon
Optimum structures on Mars
Comparison of optimum structures in different environments

HUTEN’DE YÖNETİLEN YL ÇALIŞMALARI

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