

Curso de Introducción a la Exploración Espacial y su Utilización



Espacio Cercano a la Tierra

Luna, Marte y asteroides

Jesús Martínez Frías



Somos la generación que está viviendo los primeros pasos científicos, tecnológicos y socio-culturales que está dando el ser humano **de la Tierra al Espacio**, con todo lo que ello conlleva como desafío presente y futuro en la vida en la Tierra y más allá → especie interplanetaria



Ahora podemos observar nuestro planeta y otros planetas y lunas con una **perspectiva distinta**. La Tierra es un **Sistema**, pero también un **Modelo**. Esto implica también criterios, procedimientos y conexiones multi e interdisciplinarias, para la realización de ciencia avanzada y para la exploración y búsqueda de vida extraterrestre

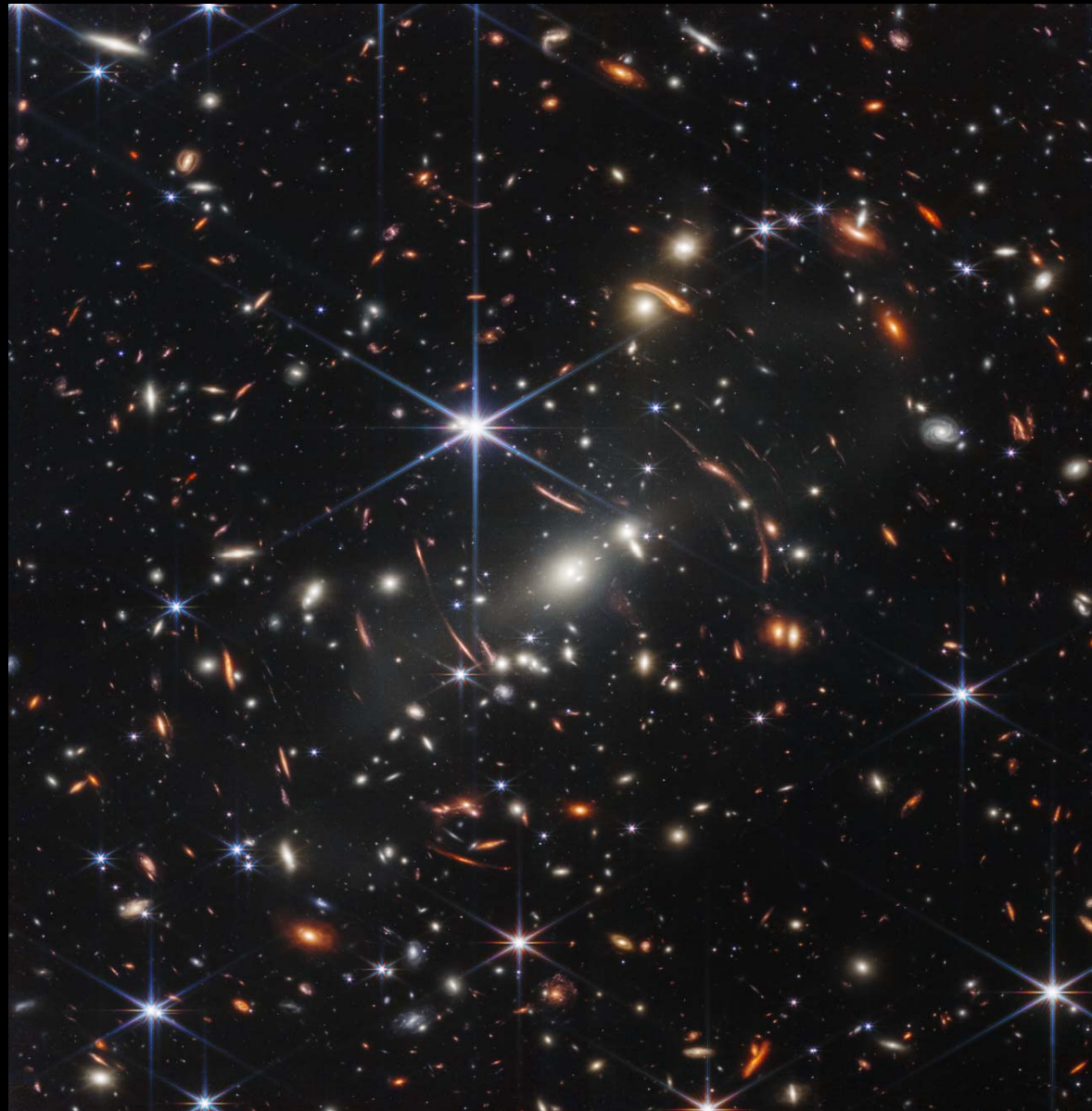


Astronauta Karen Nyberg, ISS, 10 Junio 2008, © NASA

Sobre nuestras limitaciones de investigación y la inmensidad del cosmos

Esta imagen del espacio profundo tomada por el James Webb Telescope muestra **miles de galaxias**, una mirada hacia el pasado de nuestro Universo que, en algunos momentos, llega hasta unos pocos cientos de millones de años tras el Big Bang.

Créditos: NASA, ESA, CSA, and STScI

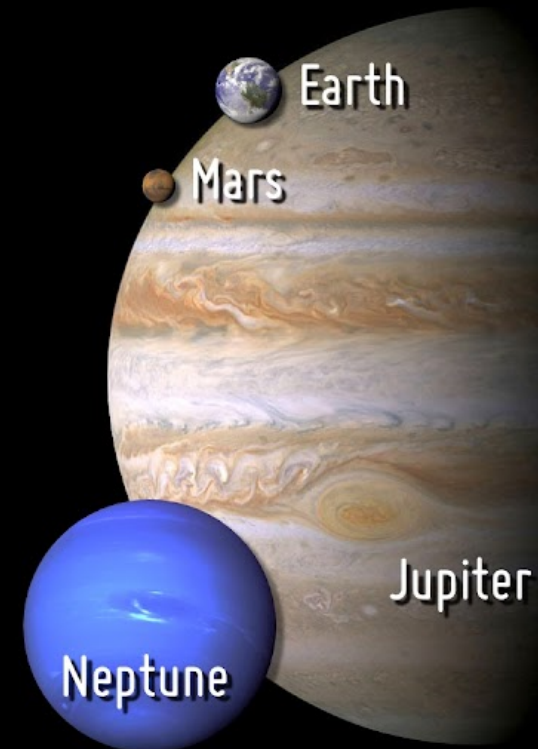
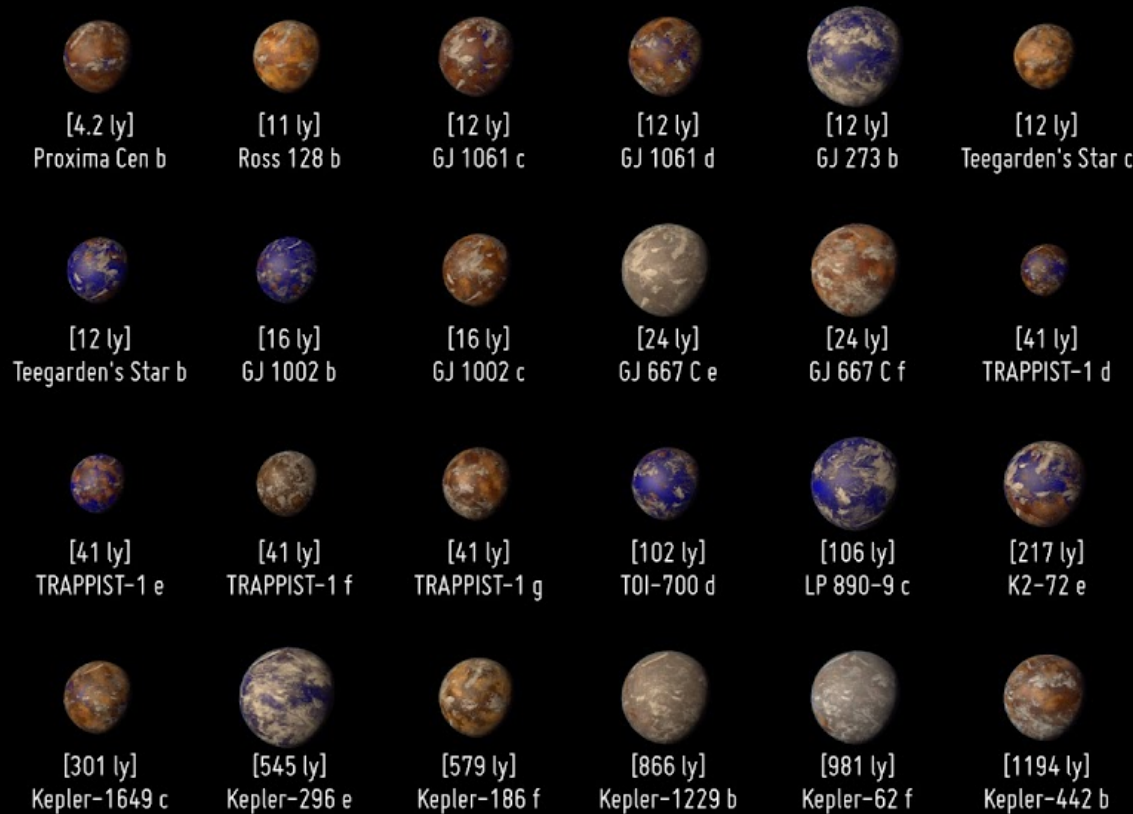


Aunque vamos progresando en nuestro conocimiento del universo, este progreso debe ir asociado a una auténtica revolución tecnológica, considerando las distancias que hay que recorrer hasta alcanzar a otros objetivos planetarios más allá de nuestro sistema solar.



Potentially Habitable Exoplanets

Sorted by Distance from Earth

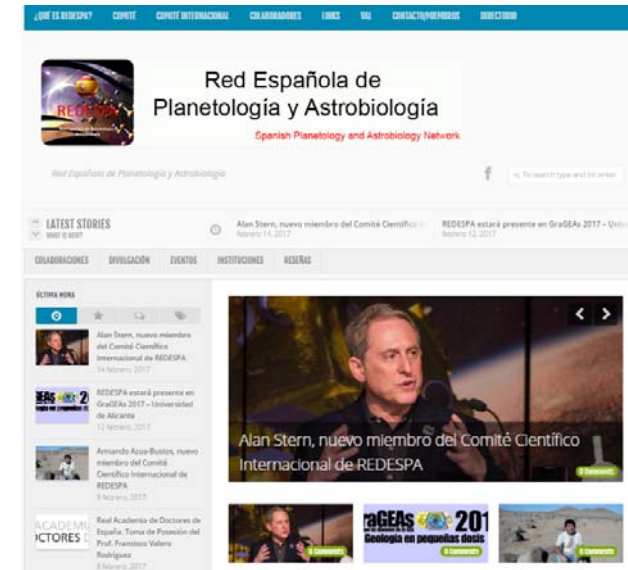


Artistic representations. Earth, Mars, Jupiter, and Neptune for scale. Distance from Earth in light years (ly) is between brackets.

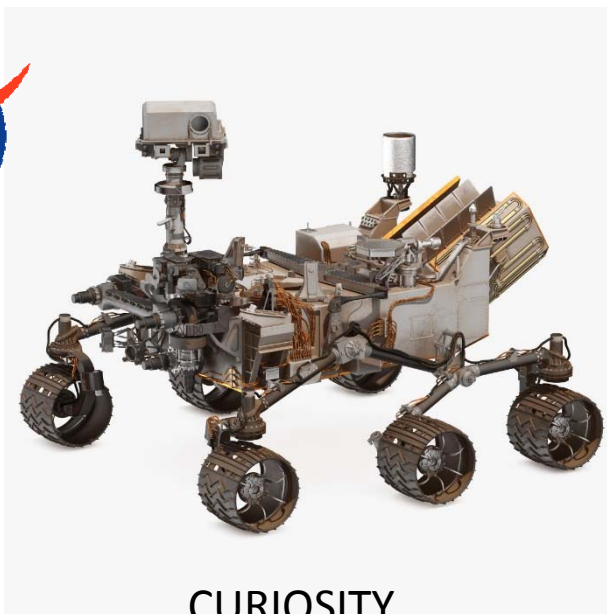
CREDIT: PHL @ UPR Arcibo (phl.upr.edu) Jan 5, 2023



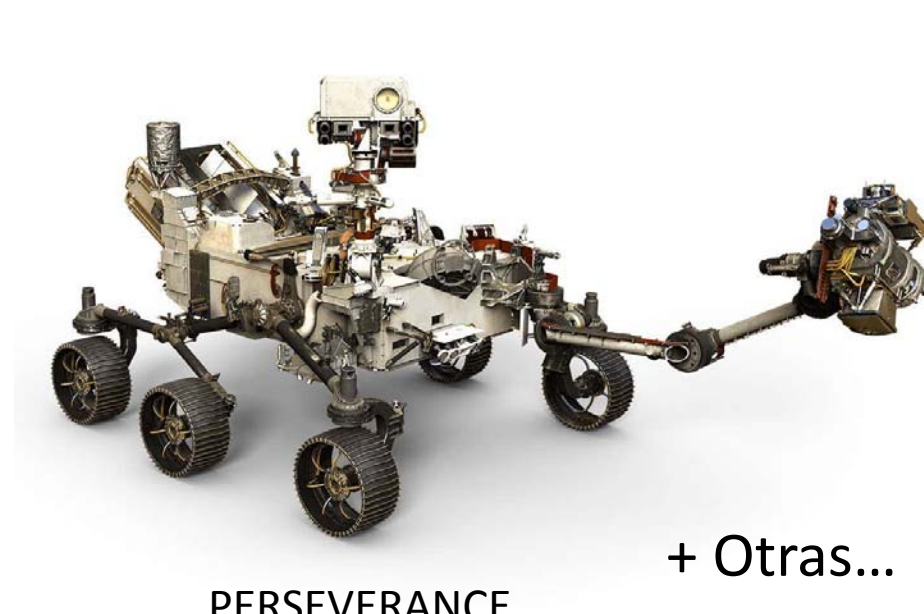
<http://www.icog.es/redespa/>



GEOCIENCIAS PLANETARIAS Y ASTROBIOLOGÍA → Luna, Marte y Asteroides



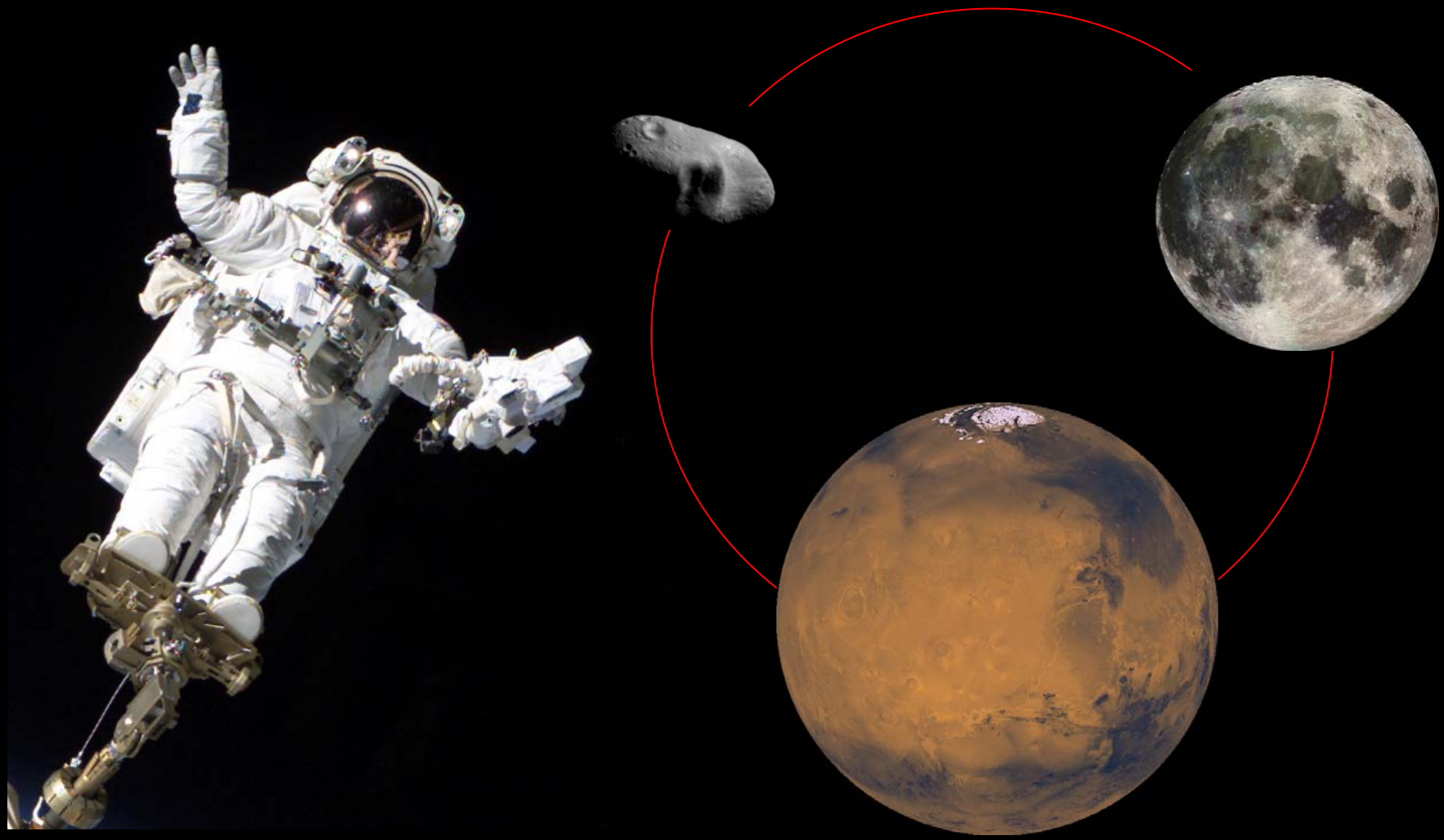
CURIOSITY



PERSEVERANCE

+ Otras...

IMPORTANCIA DEL ESPACIO CERCANO A LA TIERRA



La Luna



50

aniversario



Neil Armstrong, Michael Collins y Edwin (Buzz) Aldrin Jr.

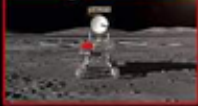
© NASA

Chang'e 3 Dec 2013

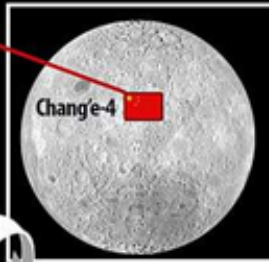


Primer módulo de aterrizaje lunar chino

Chang'e 4 Jan 2019

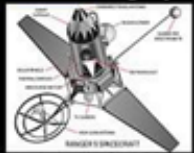


Sonda china. Primer aterrizaje exitoso en la cara oculta de la Luna



Chang'e-4

Ranger program



Sondas estadounidenses de impacto lunar no tripuladas de los años 1960

- Ranger 7 July 1964
- Ranger 8 Feb 1965
- Ranger 9 Mar 1965

Surveyor program

No todo se muestra en mapa
Sondas lunares de 'alunizaje suave' no tripulado

- Surveyor 1 June 1966
- Surveyor 2 Sept 1966
- Surveyor 3 April 1967
- Surveyor 4 July 1967
- Surveyor 5 Sept 1967
- Surveyor 6 Nov 1967
- Surveyor 7 Jan 1968

Apollo program

Alunizajes tripulados

- Apollo 11 July 1969
- Apollo 12 Nov 1969
- Apollo 14 Feb 1971
- Apollo 15 Aug 1971
- Apollo 16 April 1972
- Apollo 17 Dec 1972

Apollo 11 July 1969



Neil Armstrong es el primer hombre en caminar sobre la superficie de la luna



Beresheet April 2019



El módulo de aterrizaje lunar Beresheet de Israel, financiado con fondos privados, intentó un aterrizaje suave pero fracasó y se estrella contra la luna después de perder contacto con el cuartel general.

Luna program

Alunizajes soviéticos no tripulados

- Luna 2 Sept 1959
- Luna 7 Oct 1965
- Luna 8 Dec 1965
- Luna 9 Jan 1966
- Luna 13 Dec 1966
- Luna 15 July 1969
- Luna 16 Sept 1970
- Luna 17 Nov 1970
- Luna 18 Sept 1971
- Luna 20 Feb 1972
- Luna 21 Jan 1973
- Luna 23 Oct 1974
- Luna 24 Aug 1976

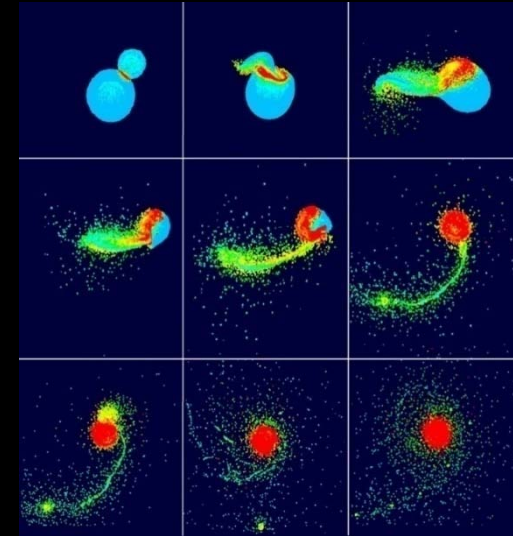


Modelos de impacto

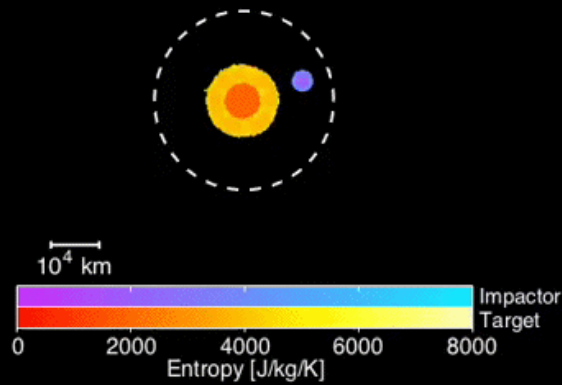


<http://www.astrosurf.com/luxorion/illustrations/terre-lune-evolution.jpg>

Canup (2012)



0 hr



Rufu et al (2017)

nature
geoscience

ARTICLES

<https://doi.org/10.1038/441561-019-0354-2>

Terrestrial magma ocean origin of the Moon

Natsuki Hosono^{1,2*}, Shun-ichiro Karato³, Junichiro Makino^{4,2} and Takayuki R. Saitoh^{4,5}

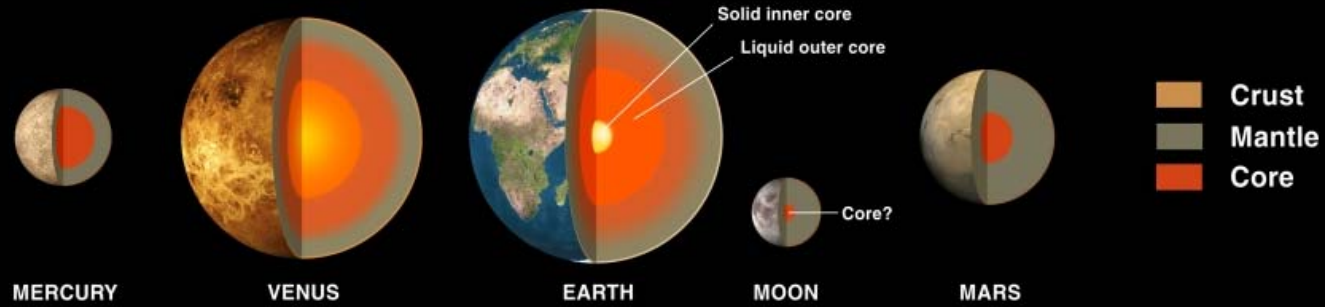
A conceptual framework for the origin of the Moon must explain both the chemical and the mechanical characteristics of the Earth-Moon system to be viable. The classic concept of an oblique giant impact explains the large angular momentum and the lack of a large iron-rich core to the Moon, but in this scenario it is difficult to explain the similarity in the isotopic compositions of the Earth and Moon without violating the angular momentum constraint. Here we propose that a giant, solid impactor hit the proto-Earth while it was covered with a magma ocean, under the conventional collision conditions. We perform density-independent smoothed particle hydrodynamic collision simulations with an equation of state appropriate for molten silicates. These calculations demonstrate that, because of the large difference in shock heating between silicate melts and solids (rocks), a substantial fraction of the ejected, Moon-forming material is derived from the magma ocean, even in a highly oblique collision. We show that this model reconciles the compositional similarities and differences between the Moon and Earth while satisfying the angular momentum constraint.

Hosono, 2019



Kegerreis et al (2022)

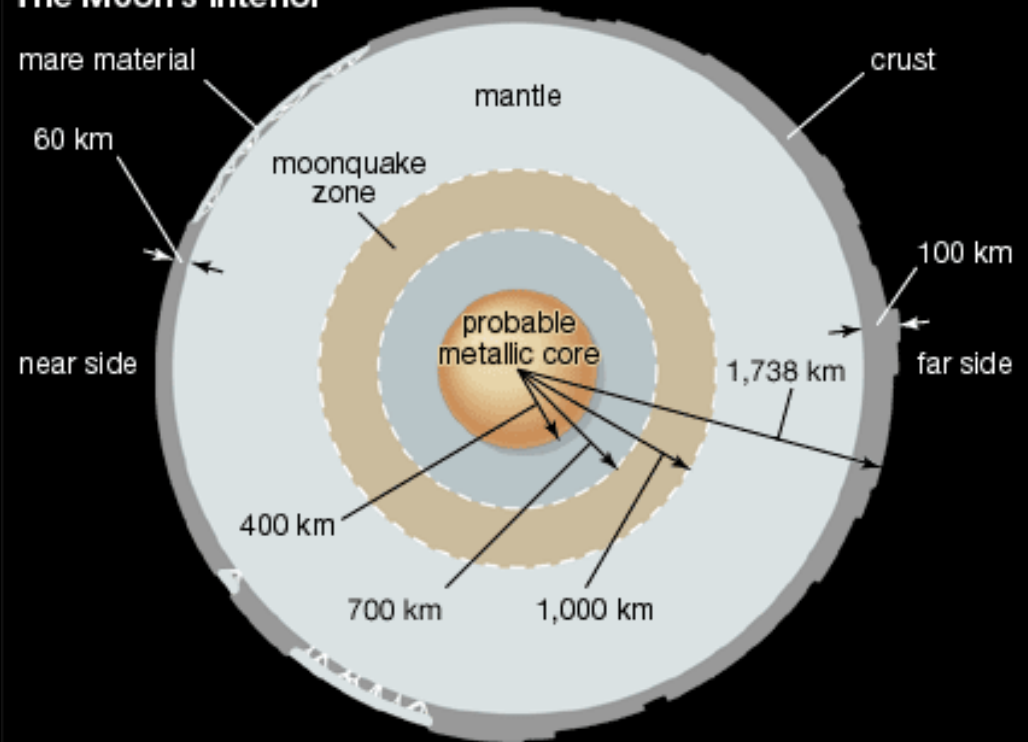
Planetas terrestres y Luna – Estructura interna



Interior of the Moon

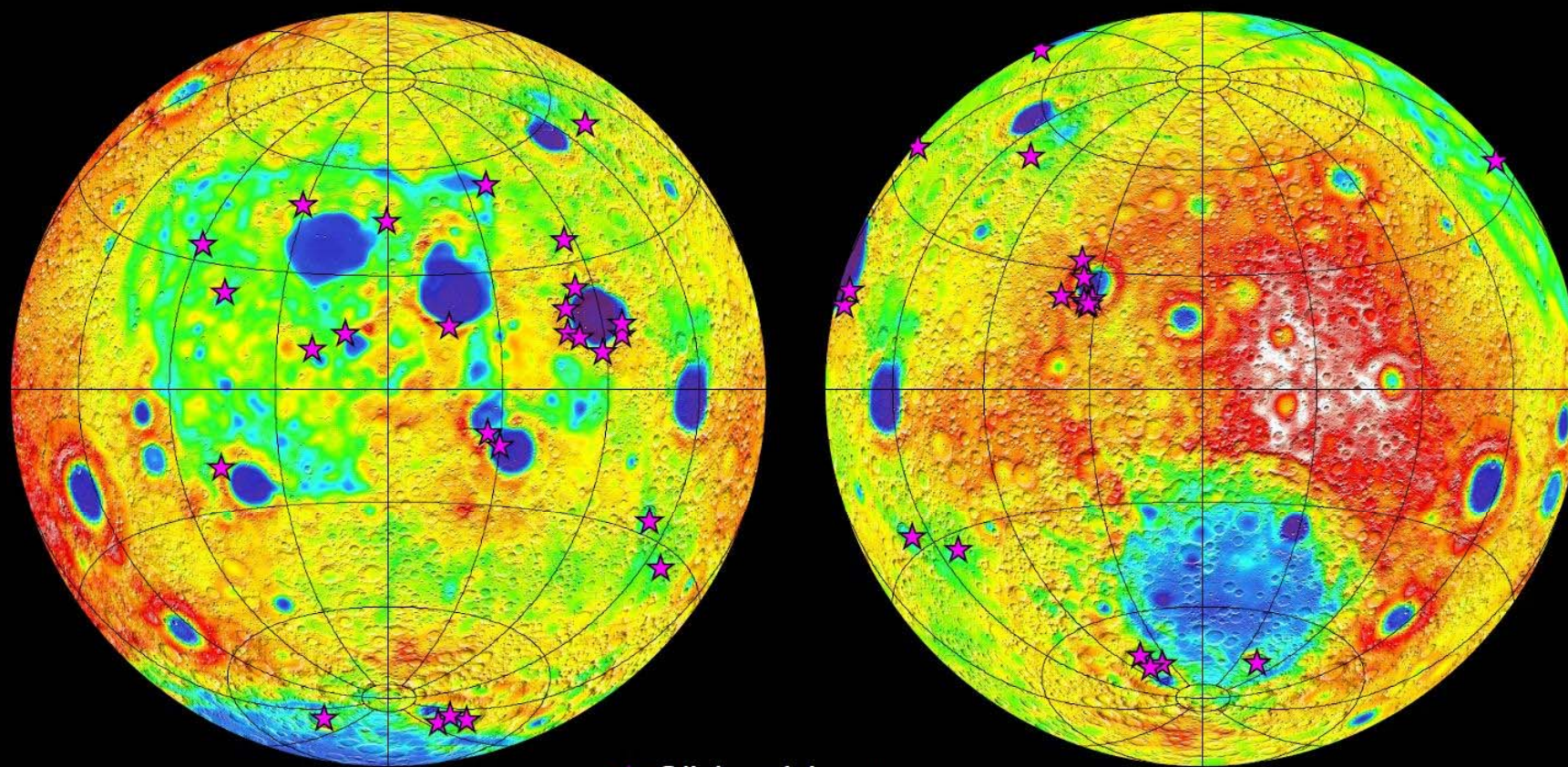
Copyright 2011 Calvin J. Hamilton

The Moon's Interior

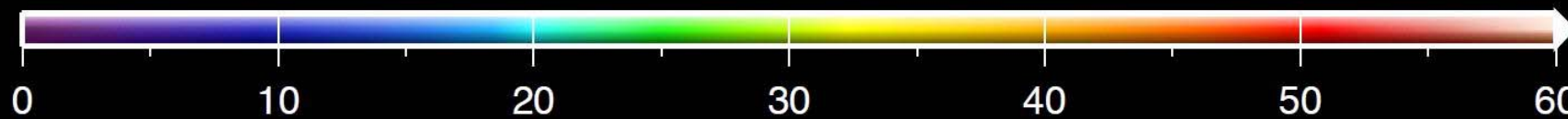


© 2005 Encyclopædia Britannica, Inc.

Espeor cortical usando NASA's GRAIL
(Gravity Recovery And Interior Laboratory)



★ Olivine-rich exposures



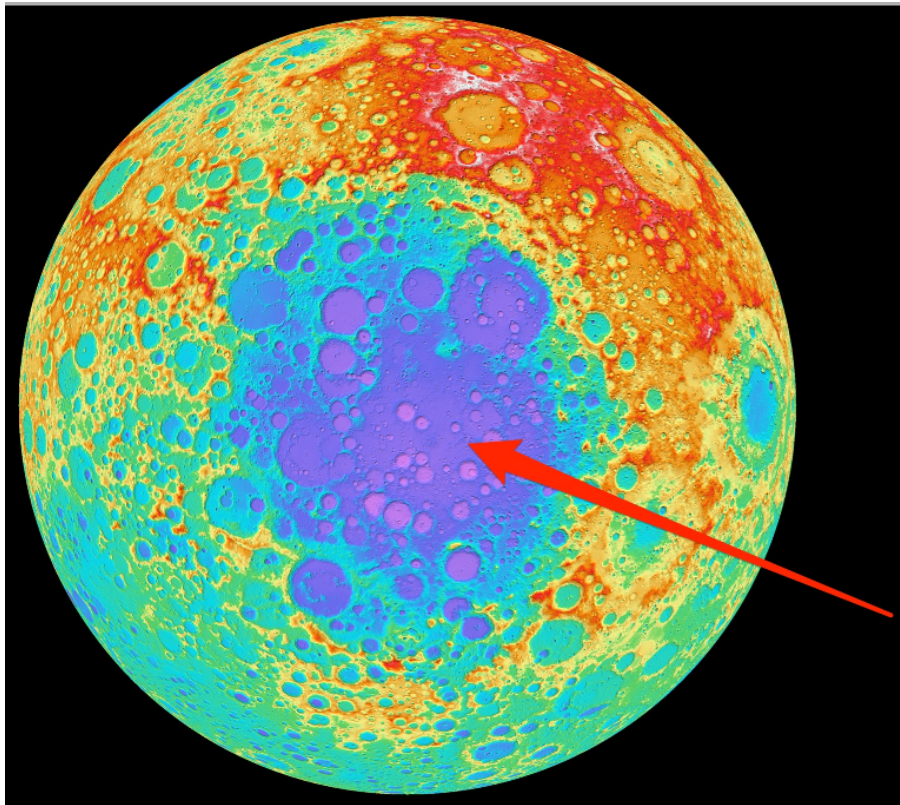
Crustal thickness (km)



EL-ESPACIO

Hallan una misteriosa masa metálica en la cara oculta de la Luna

NATIONAL GEOGRAPHIC EN ESPAÑOL



28 de Mayo de 2019

Geophysical Research Letters

Research Letter | Full Access

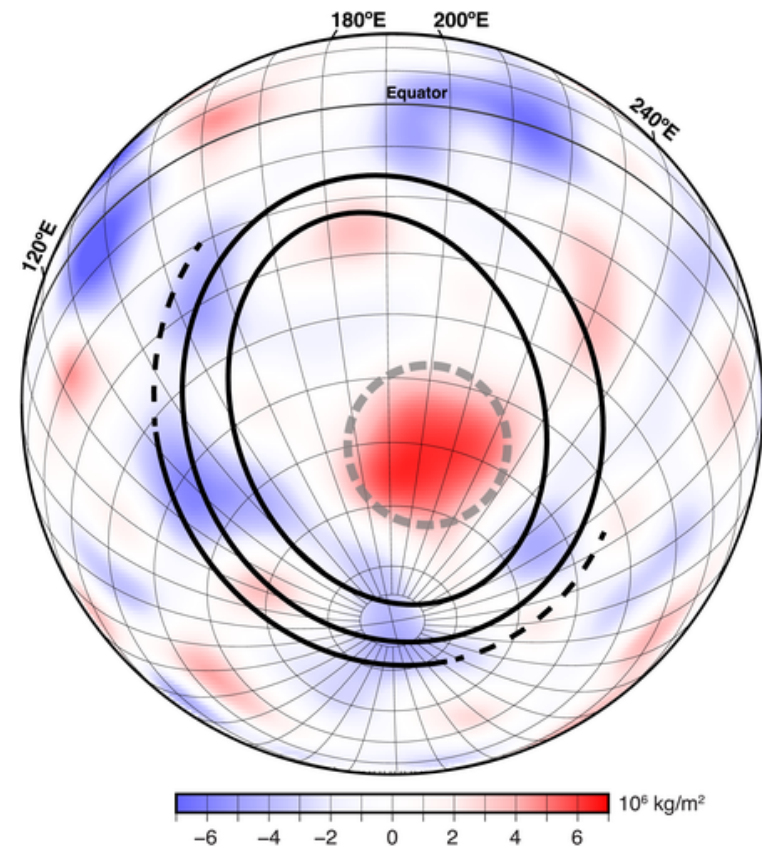
Deep Structure of the Lunar South Pole-Aitken Basin

Peter B. James, David E. Smith, Paul K. Byrne, Jordan D. Kendall, H. Jay Melosh, Maria T. Zuber



Volume 46, Issue 10
28 May 2019
Pages 5100-5106

Figures References Related Information



[nature](#) > [articles](#) > [article](#)

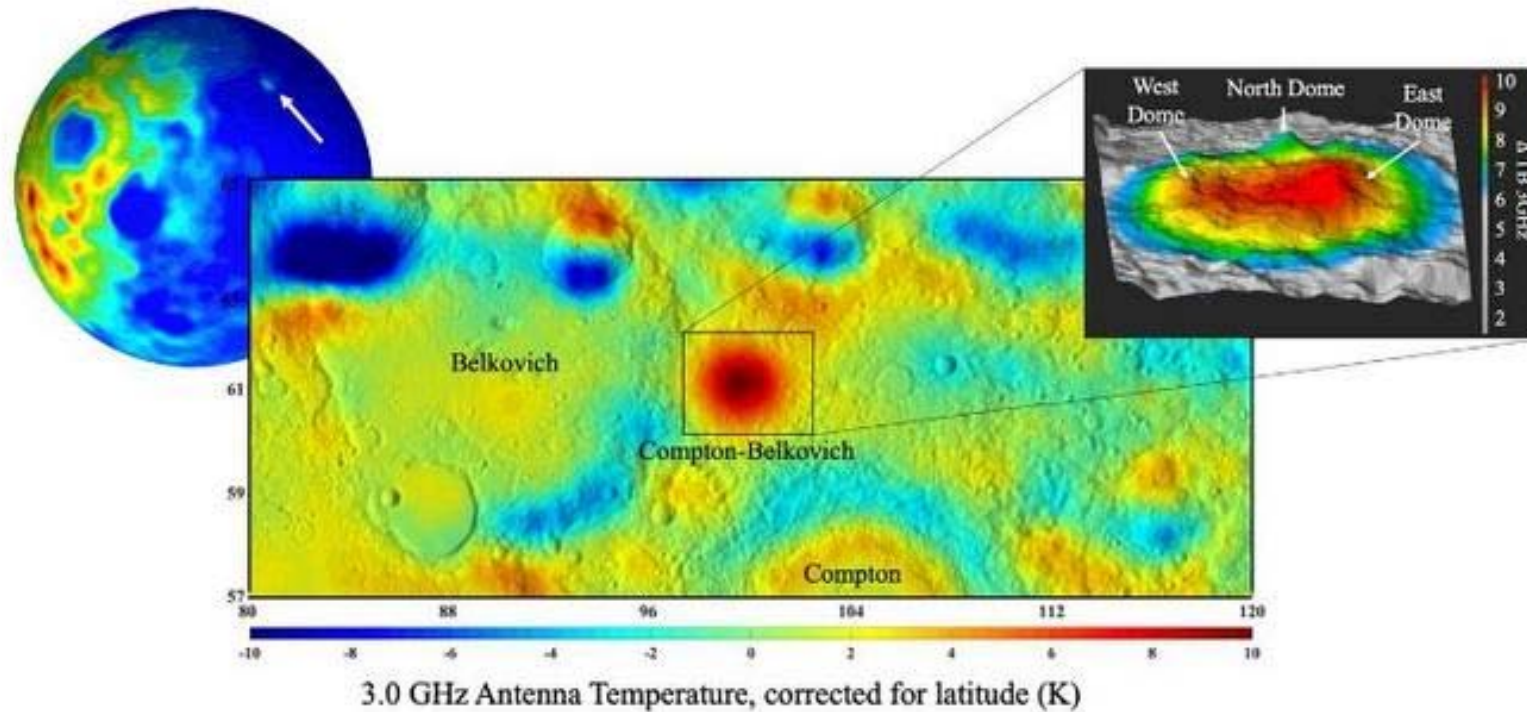
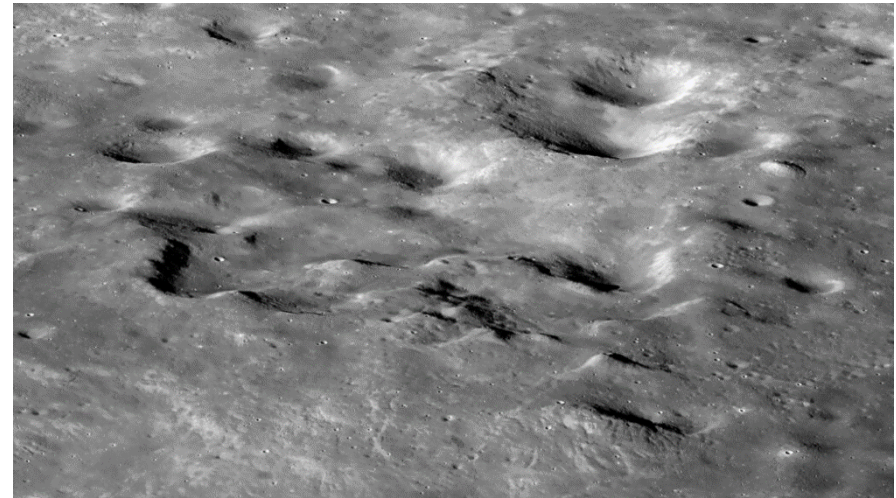
Article | [Published: 05 July 2023](#)

Remote detection of a lunar granitic batholith at Compton–Belkovich

[Matthew A. Siegler](#) , [Jianqing Feng](#) , [Katelyn Lehman-Franco](#), [Jeffrey C. Andrews-Hanna](#), [Rita C. Economos](#), [Michael St. Clair](#), [Chase Million](#), [James W. Head](#), [Timothy D. Glotch](#) & [Mackenzie N. White](#)

Nature **620**, 116–121 (2023) | [Cite this article](#)

3842 Accesses | 1 Citations | 1023 Altmetric | [Metrics](#)



Geología y dicotomía lunar



Vulcanismo - La Luna





Vulcanismo - La Luna

- Después de la formación de la corteza lunar y de la solidificación del “*océano de magma*” varios impactos meteoríticos **produjeron grandes cuencas**, generando enormes cantidades de brechas e “*impact melts*”.
- Las cuencas mayores se rellenaron parcialmente con enormes **flujos de lava basáltica**. Se supone que estos basaltos de los *mares* se formaron por fusión del manto lunar y fueron emitidos durante un período de unos cientos de millones años.
- La **actividad volcánica disminuyó con el tiempo** y se asume que cesó hace unos 1,3 Ga.

Principales características volcánicas lunares



- Existen espectaculares frentes de flujo de lava que se extienden más de 1200 km desde las zonas de emisión (**Mare Imbrium**), junto con muchas otras unidades menos desarrolladas de **flujos compuestos**.



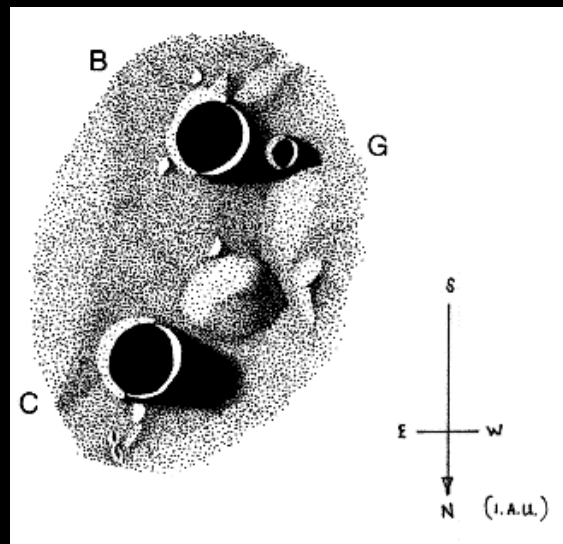
Hadley Rill

- Unas estructuras singulares son los denominados **Rilles sinuosos** cuyo origen se ha asignado a tubos o canales lávicos.
- También se han identificado las denominadas **terrazas de lava**, los **cráteres de halos oscuros** (ej. cráter Shorty) y los **depósitos piroclásticos**.
- Generalmente, los flujos lávicos están asociados con zonas de emisión en forma de **domo** y **conos de escorias**.

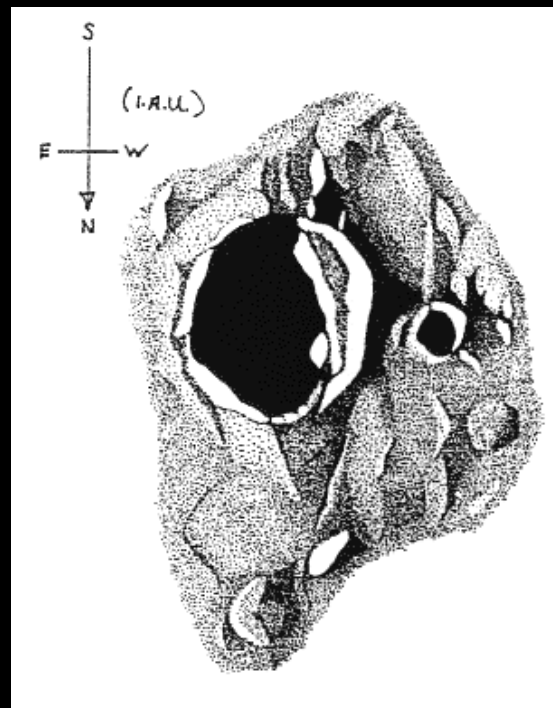
Domos lunares



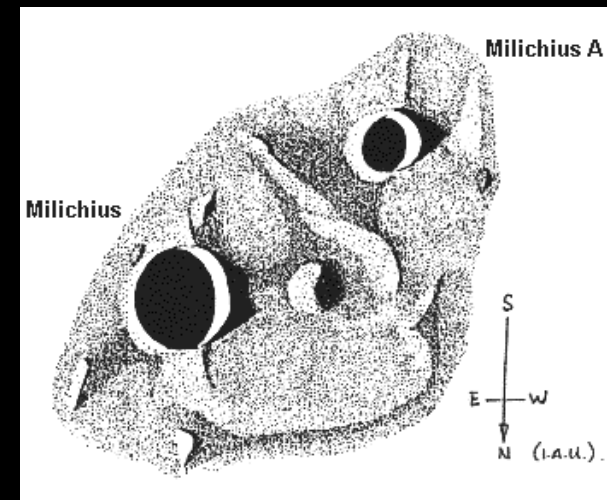
- Los domos forman generalmente conjuntos complejos y son circulares a elípticos con dimensiones desde unos pocos kilómetros de extensión y varios cientos de metros de altura. **Los domos basálticos lunares parecen ser equivalentes de los volcanes en escudo terrestres.**



Domo SW de Gambart C



Domo W de Kepler



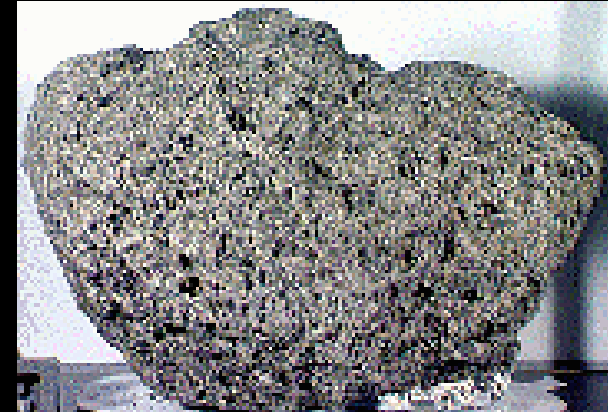
Domo al W de Milichius



Basaltos lunares

Los basaltos de los *mares* lunares se caracterizan por:

- su naturaleza vesicular;
- su alto contenido en Fe y Mg;
- su contenido bimodal en Ti ;
- están empobrecidos en elementos alcalinos con respecto a los basaltos terrestres;
- bajo contenido en SiO_2 ;
- mineralogía similar a los terrestres aunque químicamente no tienen agua;
- 3.9 - 3.1 Ga

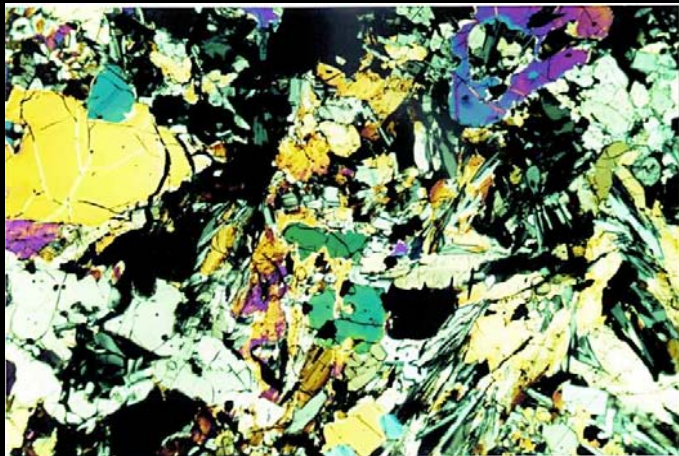
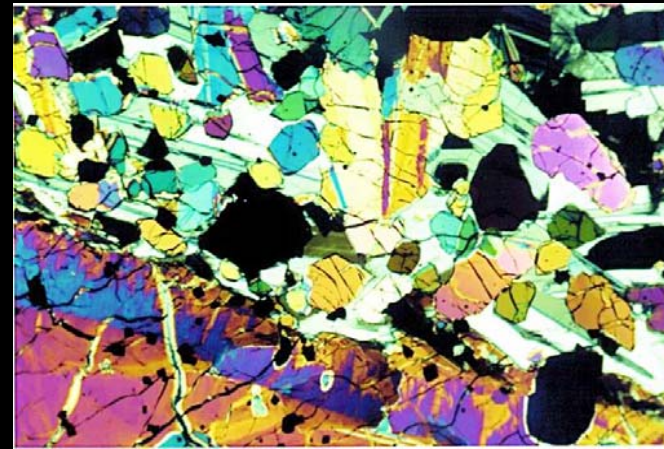
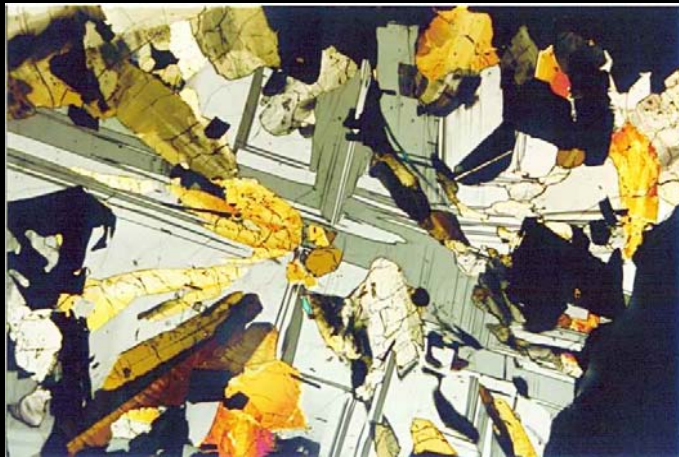


Lunaita-basalto con olivino y piroxeno. Meteorito lunar

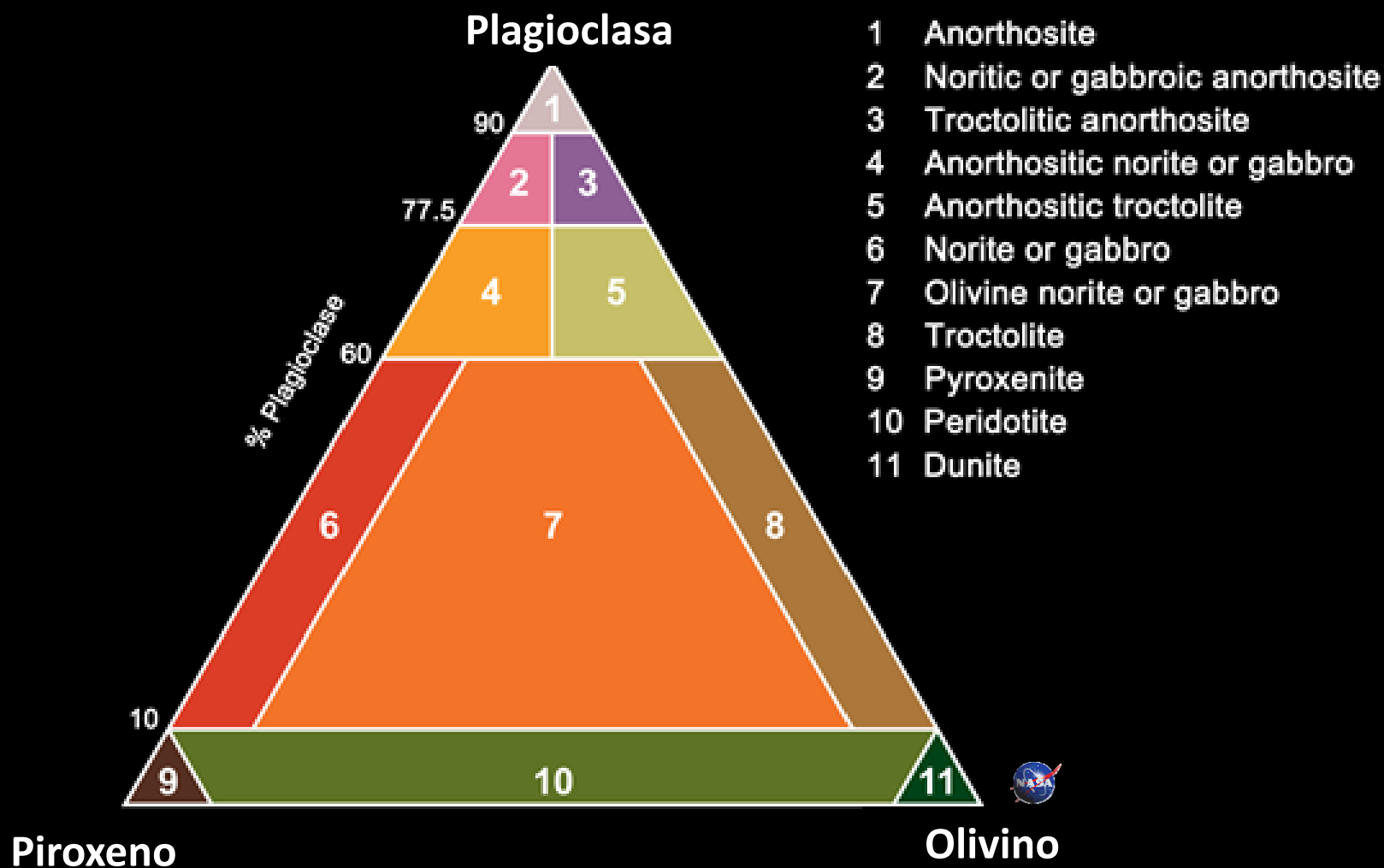
Basaltos Lunares



Imágenes al microscopio de basaltos lunares recogidos en las misiones Apolo. Los minerales principales son olivino, plagioclasas y piroxenos.



Petrología – Tierras Altas





2 mm



Apollo 11

impact-glass spherule

agglutinate

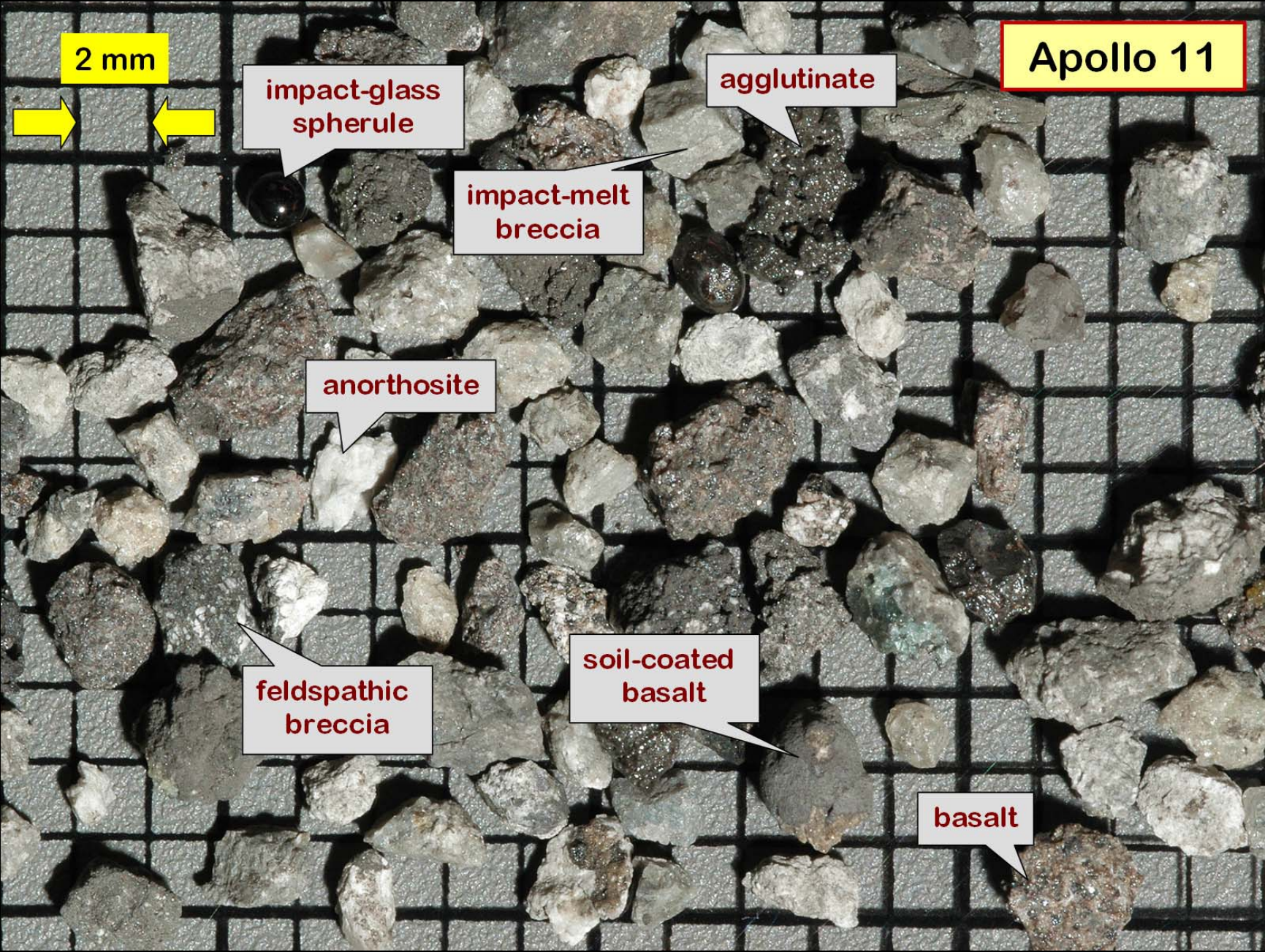
impact-melt breccia

anorthosite

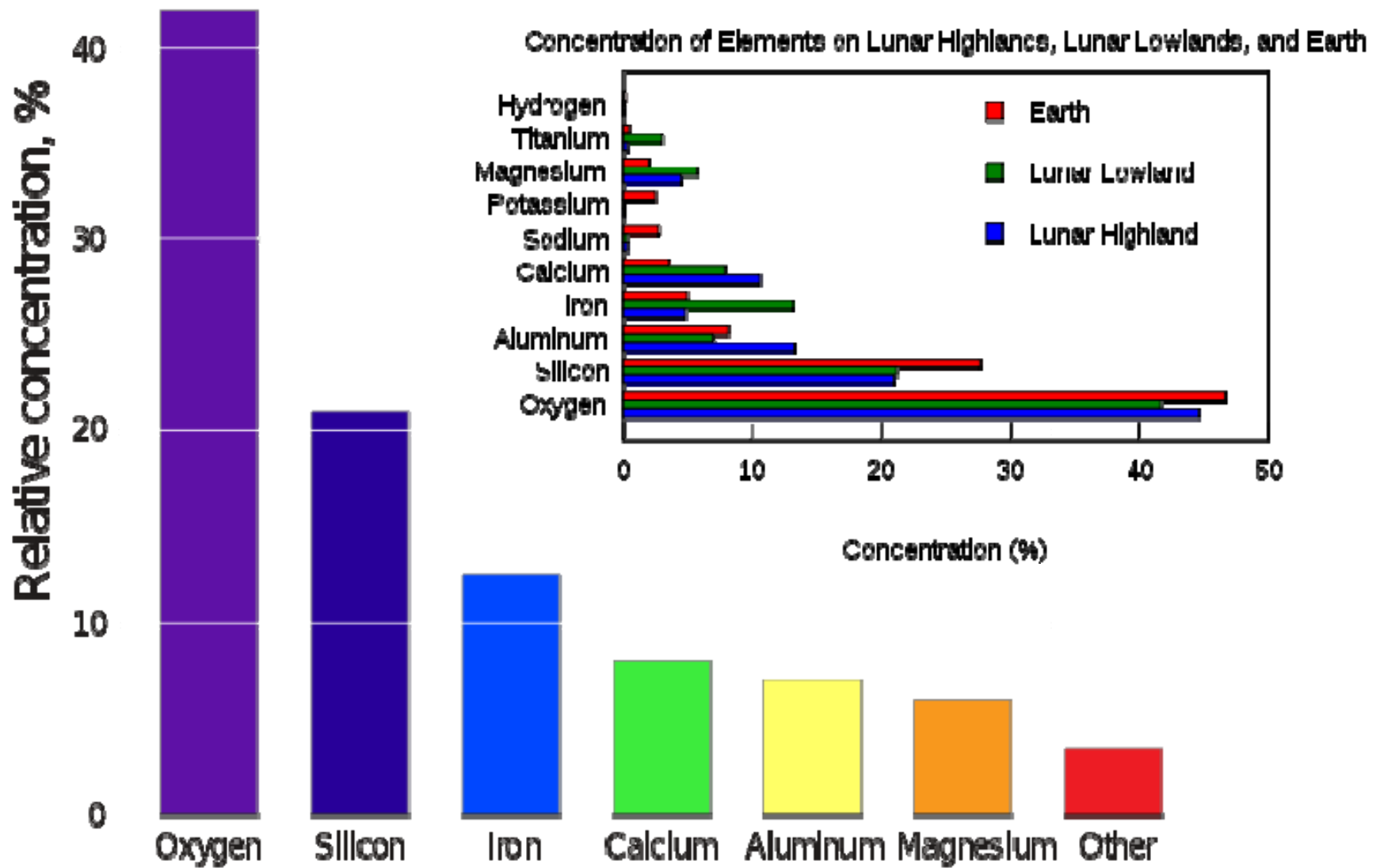
feldspathic breccia

soil-coated basalt

basalt



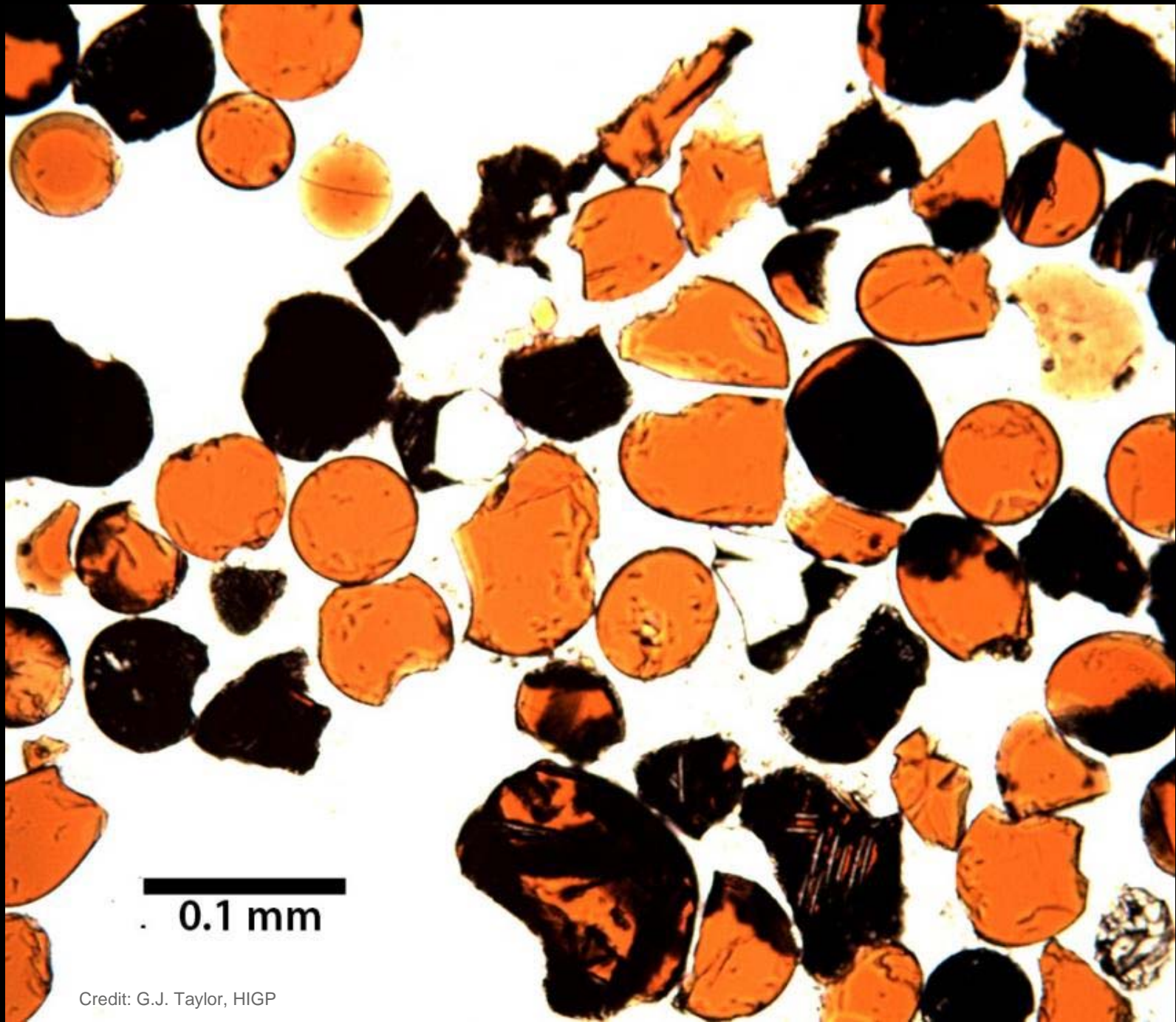
Composición del suelo lunar









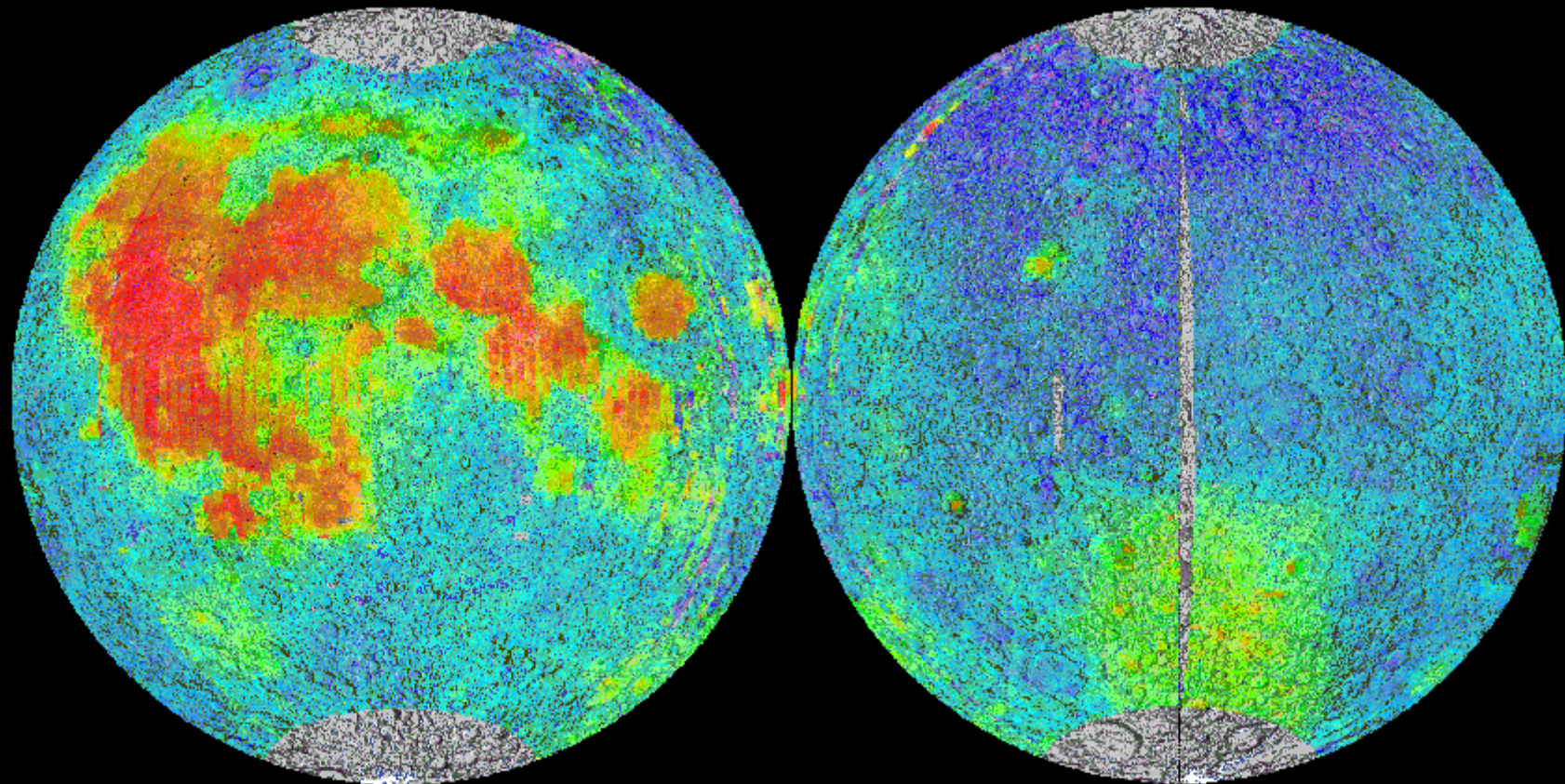


0.1 mm

Credit: G.J. Taylor, HIGP

Clementine Iron Map of the Moon

Equal Area Projection



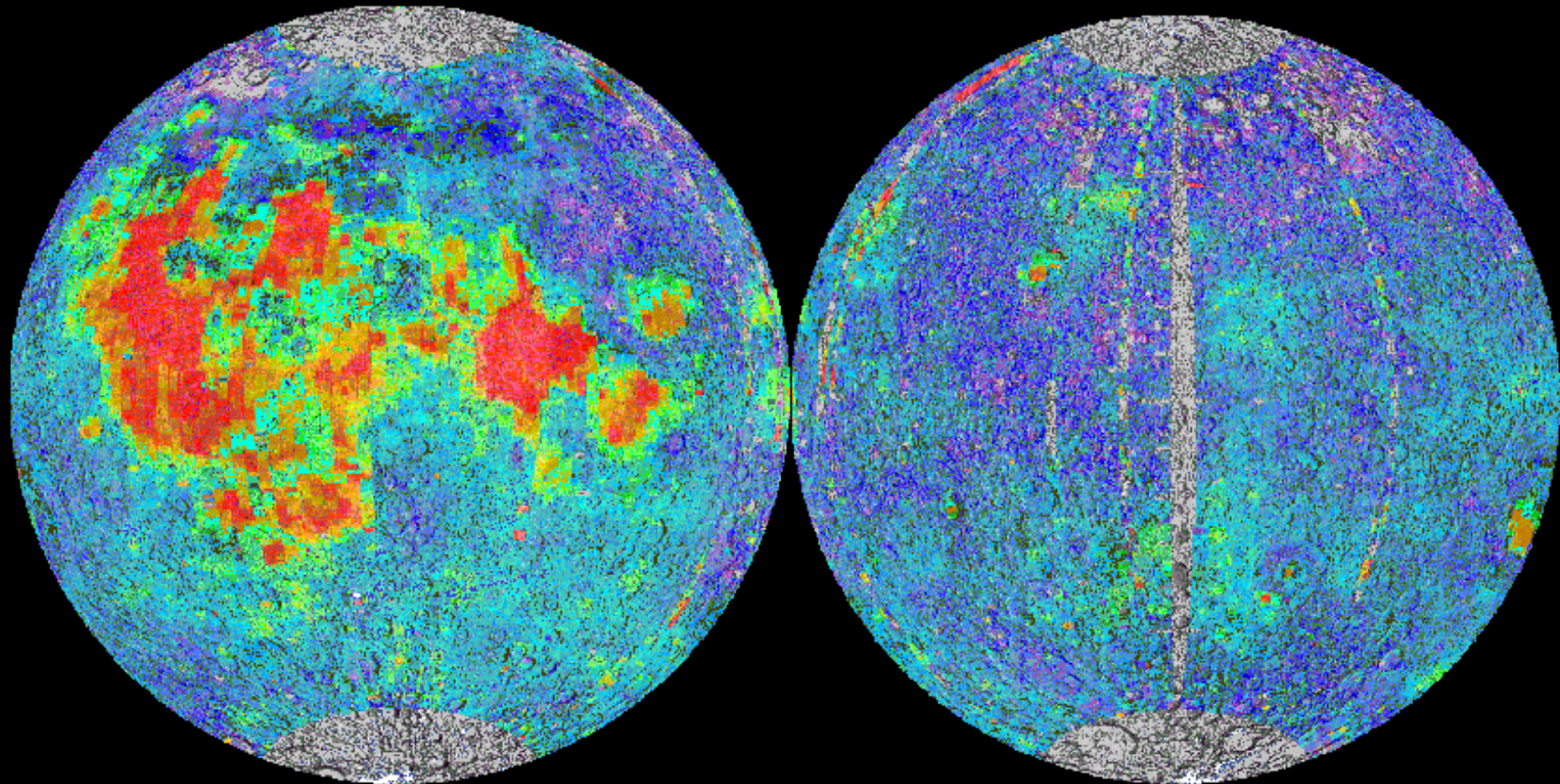
Near side



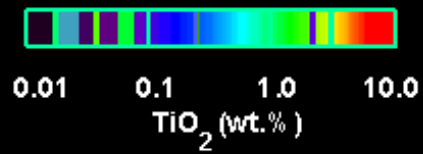
Far Side

Clementine Titanium Map of the Moon

Equal Area Projection

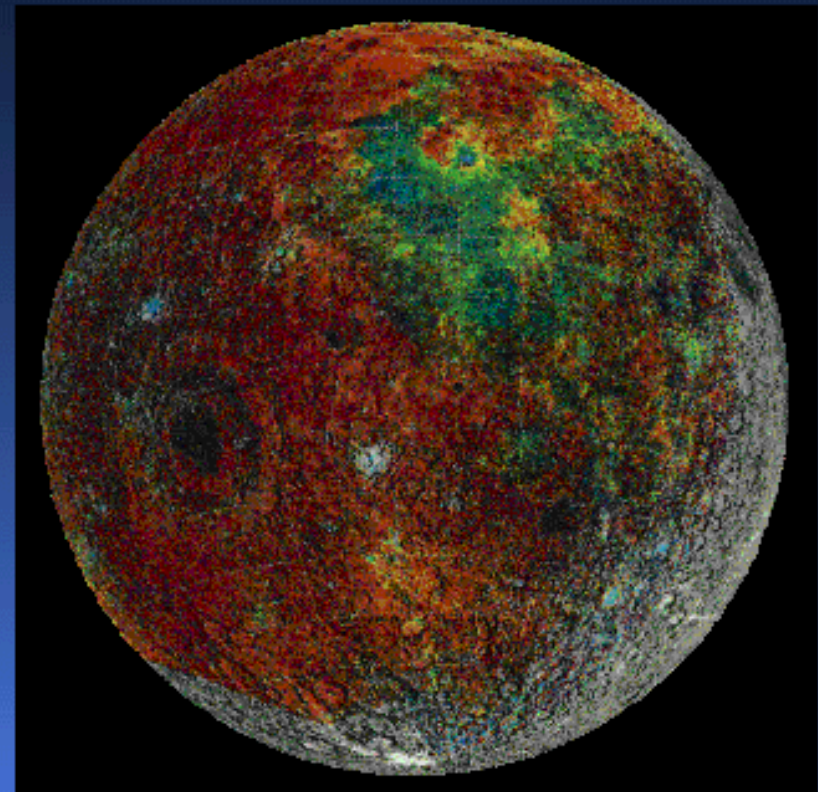
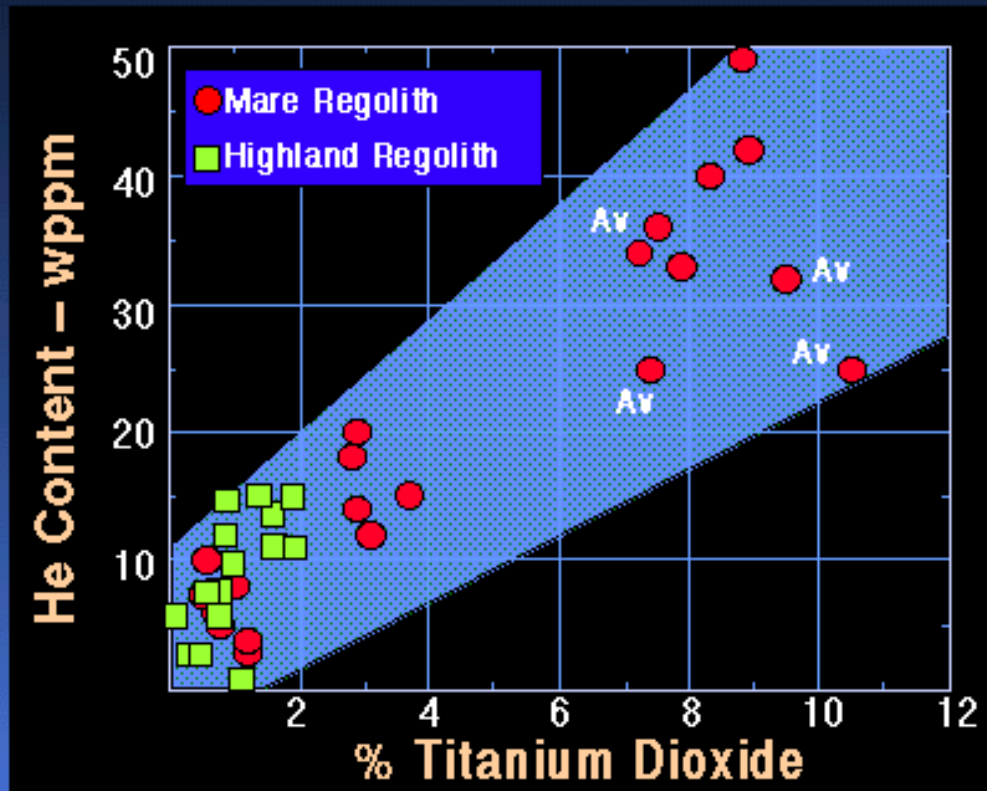


Near side



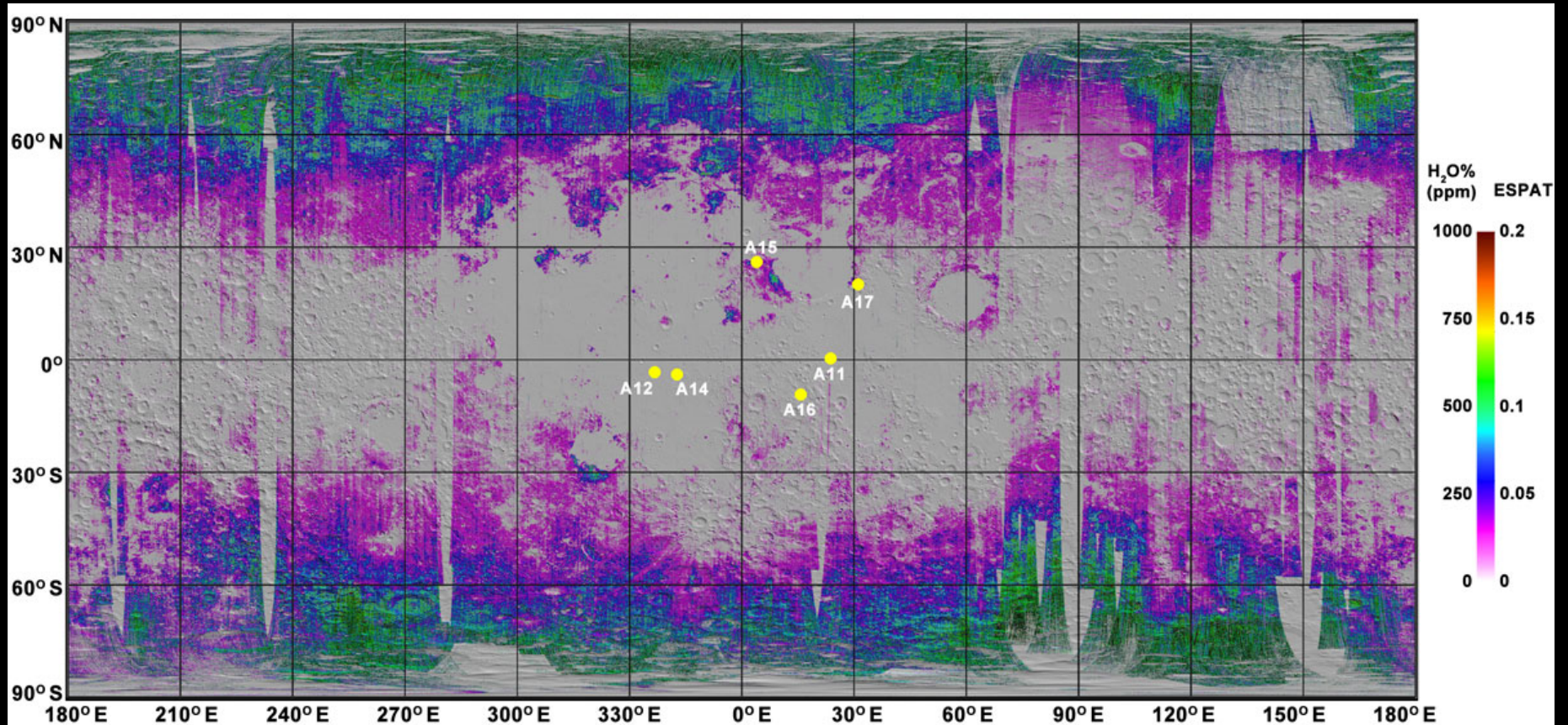
Far side

La asociación de Helio con el Titanio en el regolito lunar, nos ayuda a reconocer cuáles son los principales sitios para la minería en nuestro satélite



Agua en la superficie de la Luna, de acuerdo con el Moon Mineralogy Mapper: Distribución, abundancia, y orígenes

La abundancia en agua superficial puede variar en ~200 ppm en un día lunar y el metro superior de regolito puede contener un total de $\sim 1.2 \times 10^{14}$ g de agua como promedio a escala global.



2 Abril 2019



Jim Bridenstine 
@JimBridenstine 

Our #Moon2024 mission is being named after Artemis, who was a sister to Apollo and goddess of the Moon. We're excited to be landing the first woman and next man on the surface of the Moon by 2024.

♥ 3,039 1:54 AM - May 14, 2019



*“Nos encontramos en un momento crucial en la exploración espacial. La Humanidad está a punto de dar el salto en su migración al Espacio y la Luna y Marte son nuestros primeros destino. Es todo un desafío científico, tecnológico y socio-cultural, que requiere una colaboración multidisciplinar y que, sin duda, ampliará nuestro conocimiento sobre la Naturaleza y el Universo y abrirá también nuevas y apasionantes cuestiones” → **Importancia de las Geociencias Planetarias y la Astrobiología***



ARTEMIS ACCORDS



United for Peaceful Exploration of Deep Space

El plan de la NASA para regresar a la Luna

Una estación espacial lunar está en el centro del programa Artemis



98 m

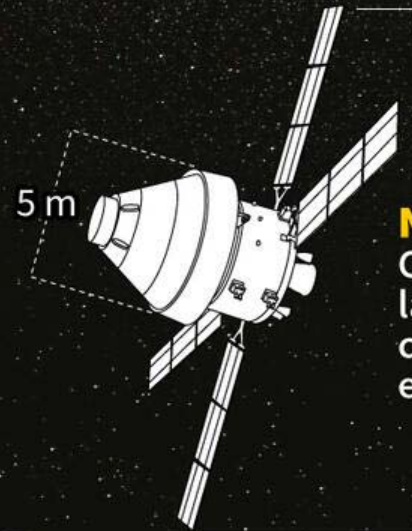
◀ **Lanzadera SLS** (Space Launch System)

Lanzadera pesada,
capaz de propulsar
hasta 45 toneladas



Sistema
de alunizaje

Gateway* (estación pequeña)
Estación espacial en órbita lunar.
Punto de acceso para misiones
en la Luna, lugar de residencia
para astronautas en estancias
cortas



5 m

Nave Orion
Conectará
la Tierra
con la estación
espacial lunar

PROGRAMA

▶ **29 de agosto de 2022**

Artemis 1: vuelo de prueba

▶ **2024**

Artemis 2: primera
tripulación, órbita
lunar sin aterrizaje

▶ **Finales 2024 (o más tarde)**

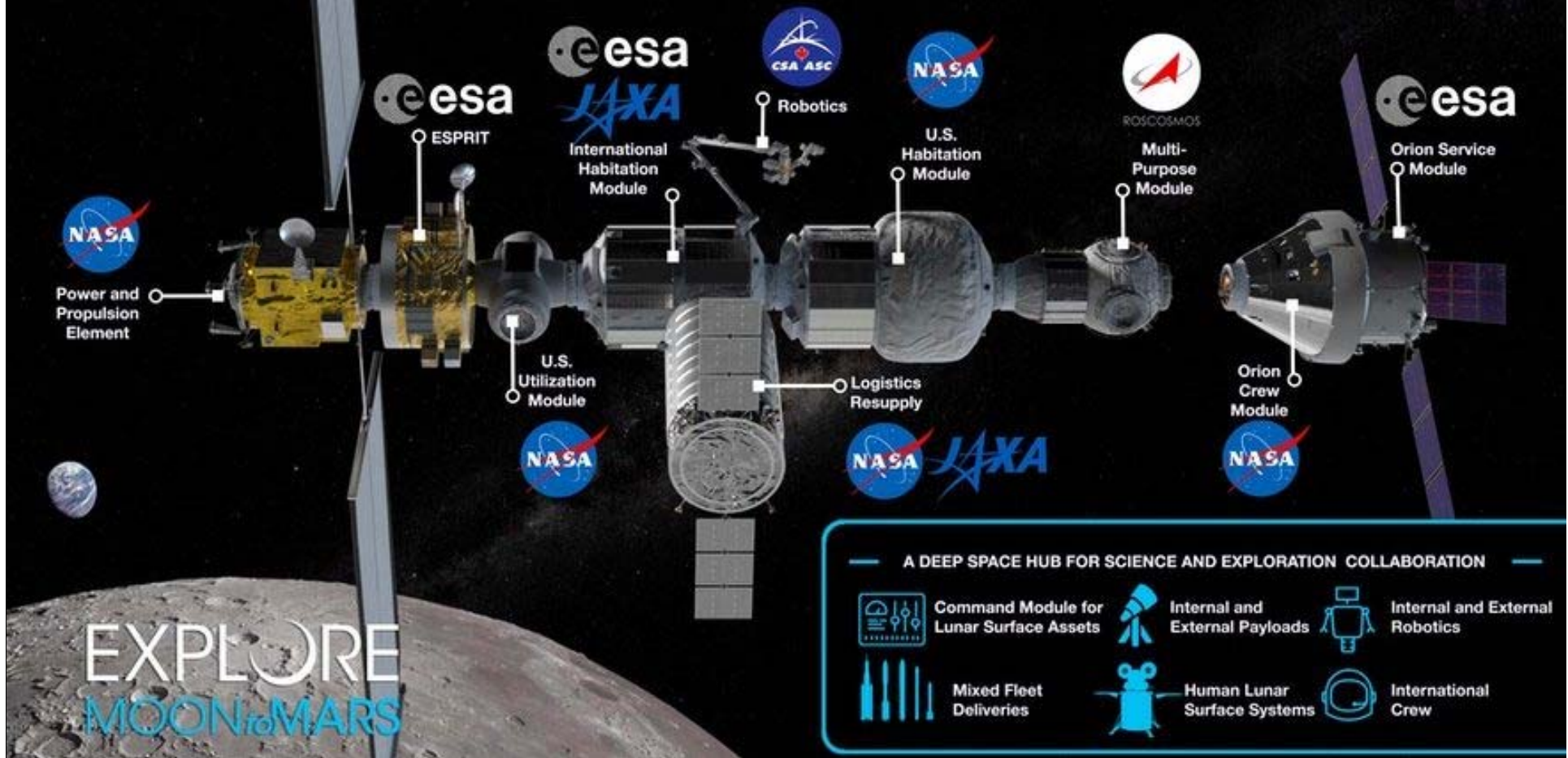
Lanzamiento de los primeros
elementos del «Gateway».

*La estación no será
utilizada para las misiones
Artemis 2 y 3

▶ **2025**

Misión Artemis 3,
con aterrizaje
humano en la Luna.
Lugar de exploración:
el polo Sur

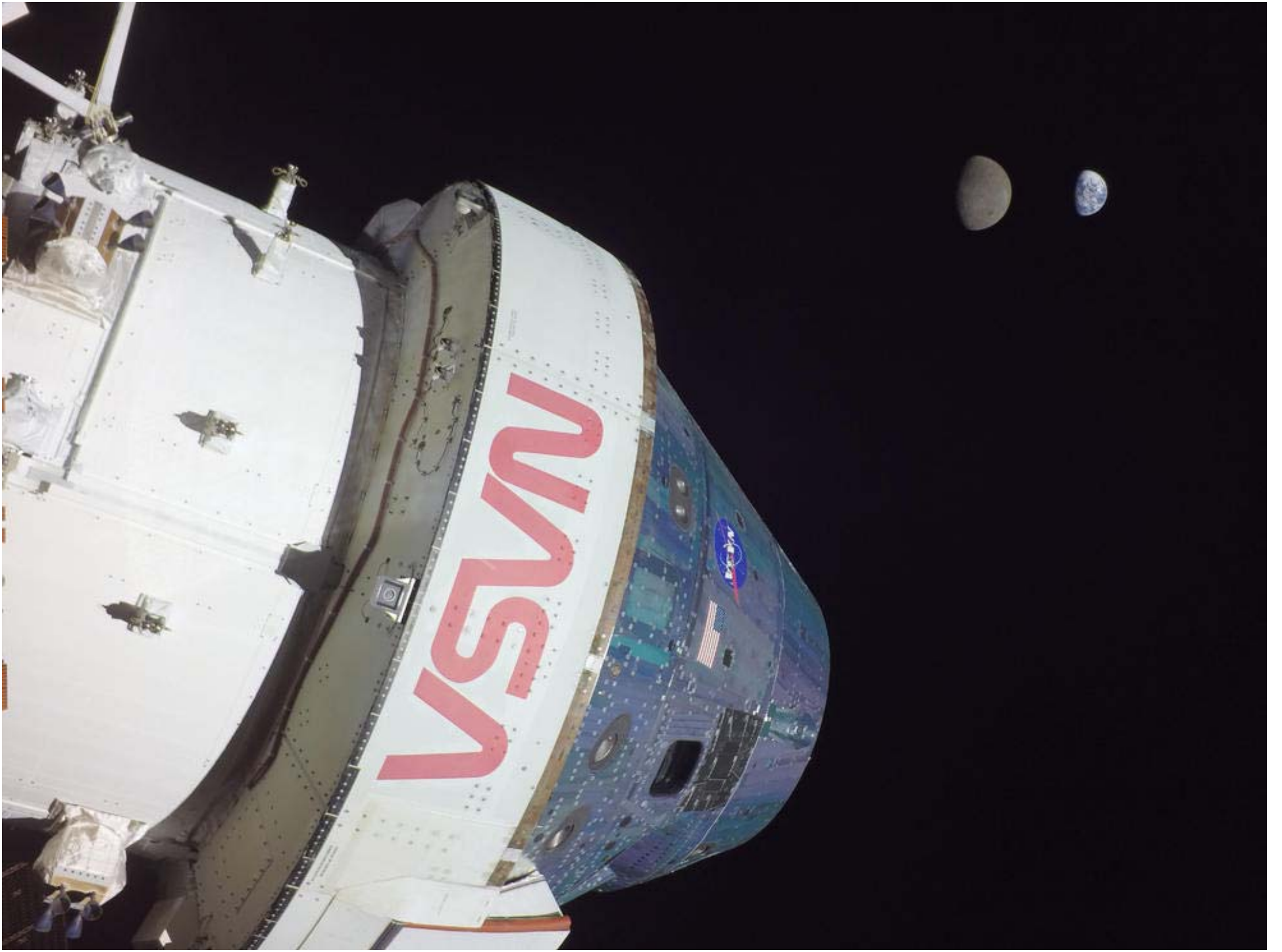
GATEWAY CONFIGURATION CONCEPT



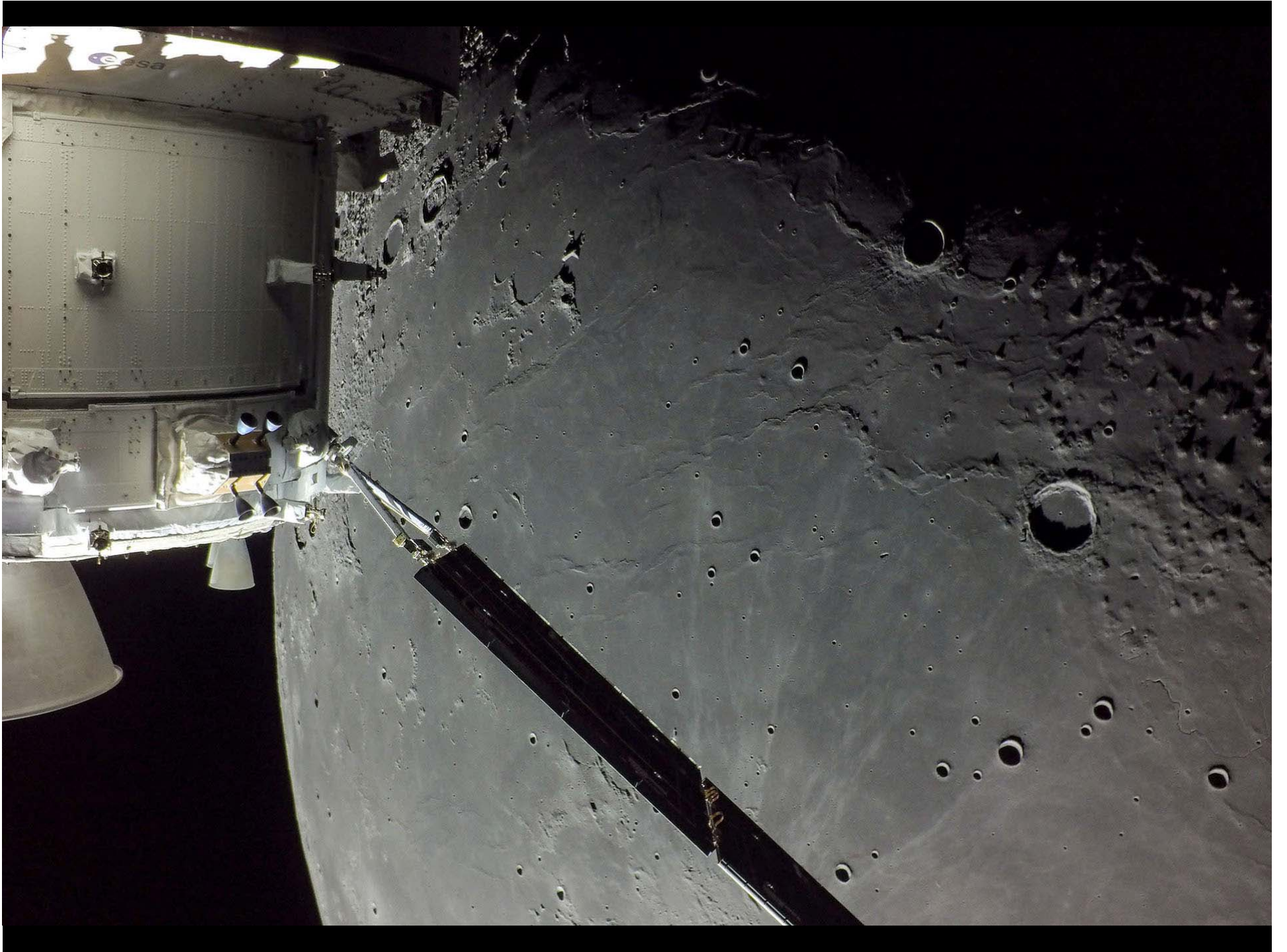
An updated illustration of the lunar Gateway, released by NASA March 11, shows the proposed international partner contributions to the facility. Credit: NASA

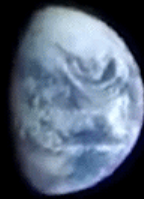
ARTEMISA – 16/11/2022











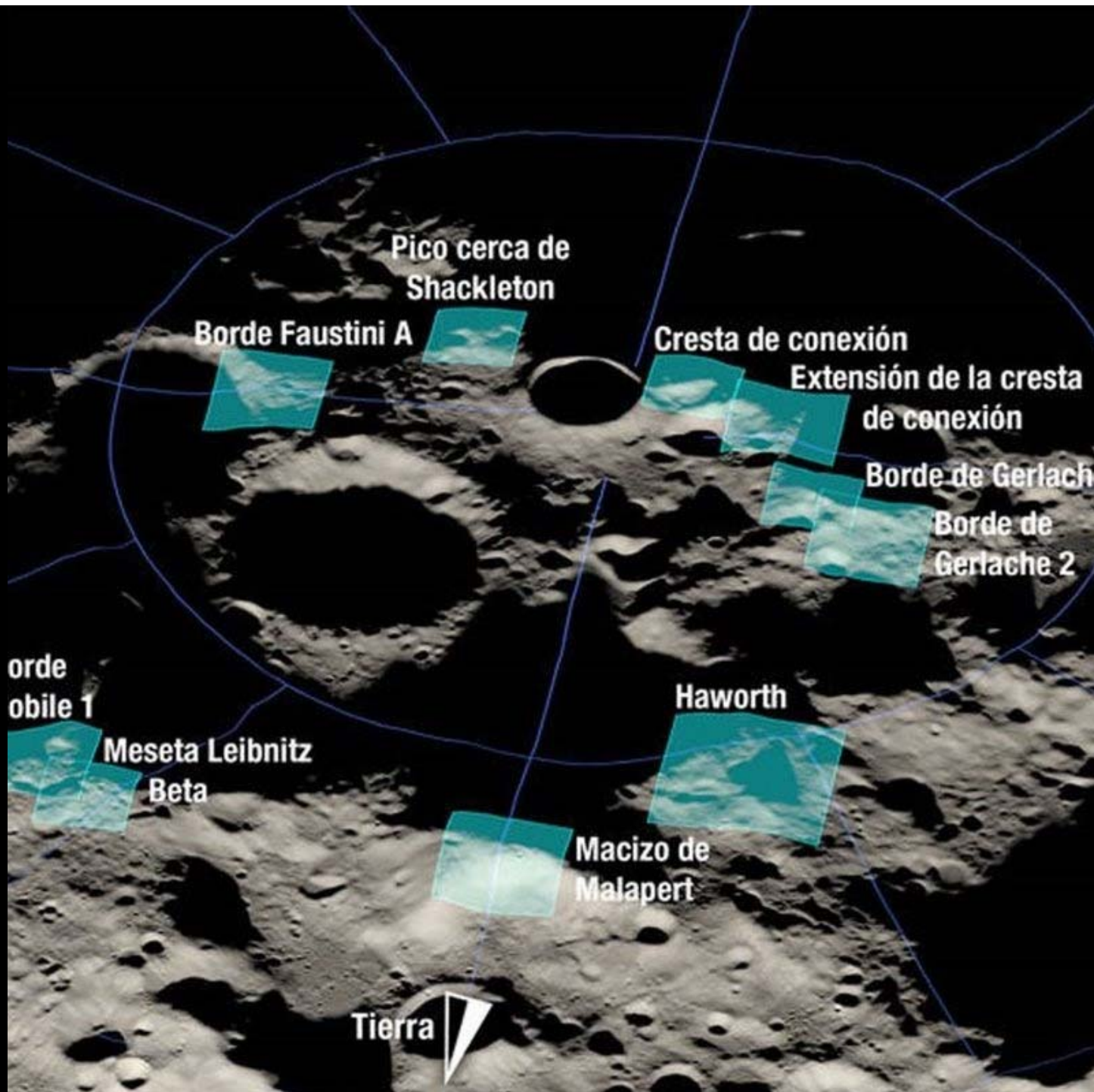
SPACE.com

Tripulación de sobrevuelo de Artemis II. De izquierda a derecha astronautas NASA: Christina Koch, Víctor Glover, Reid Wiseman y astronauta Agencia Espacial Canadiense, Jeremy Hansen.





MOON VILLAGE



Pico cerca de Shackleton

Borde Faustini A

Cresta de conexión

Extensión de la cresta de conexión

Borde de Gerlache

Borde de Gerlache 2

orde obile 1

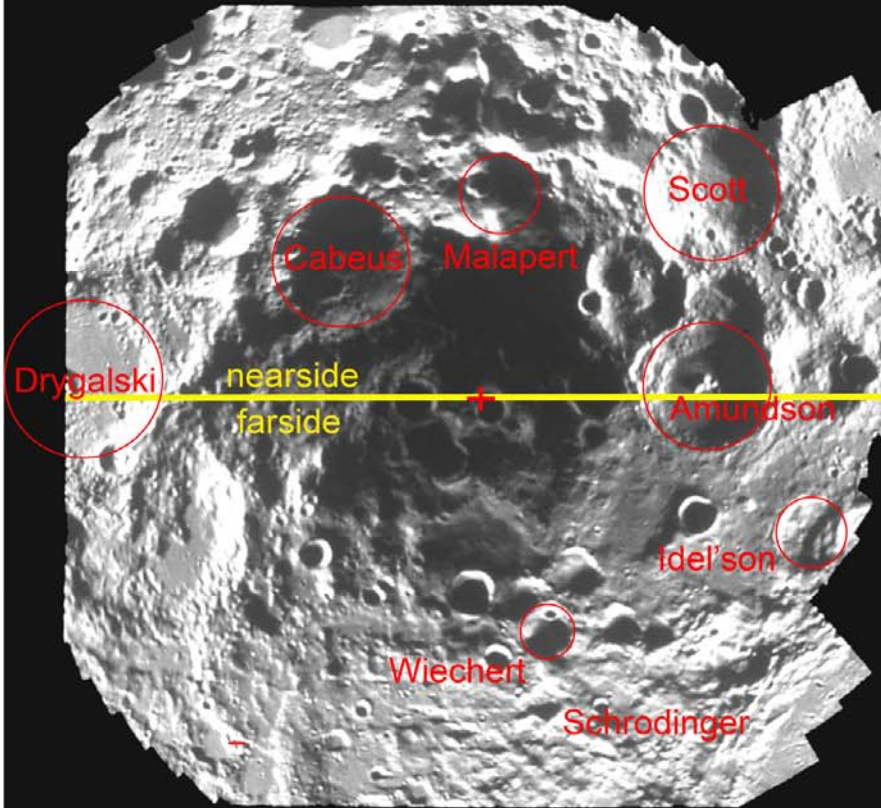
Meseta Leibnitz Beta

Haworth

Macizo de Malapert

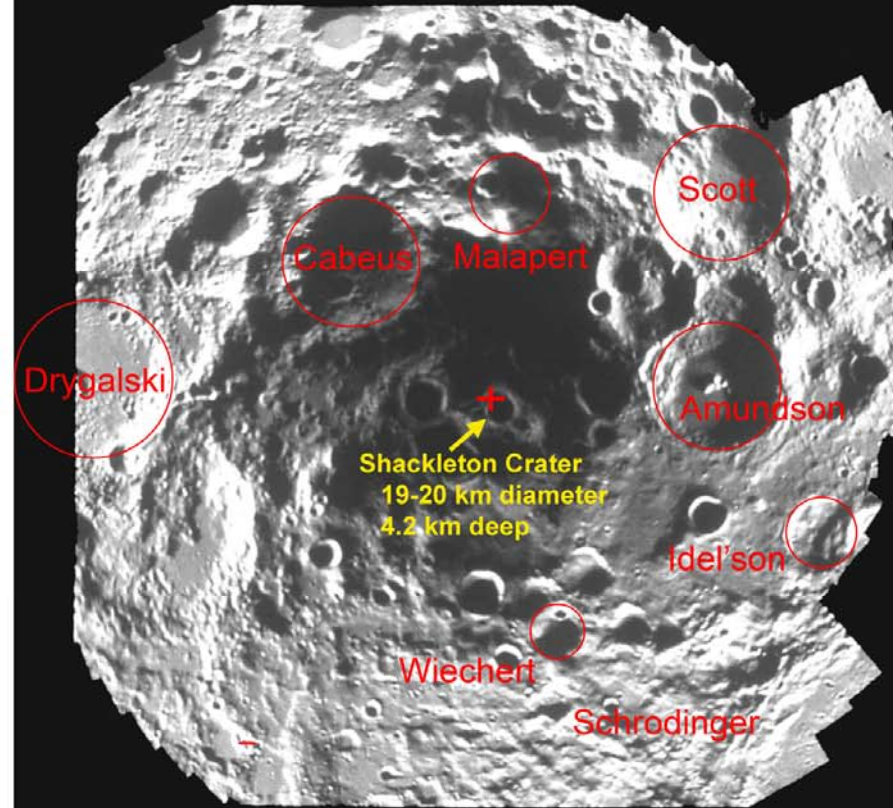
Tierra

Lunar South Pole



South Pole mosaic from 650 Clementine images.

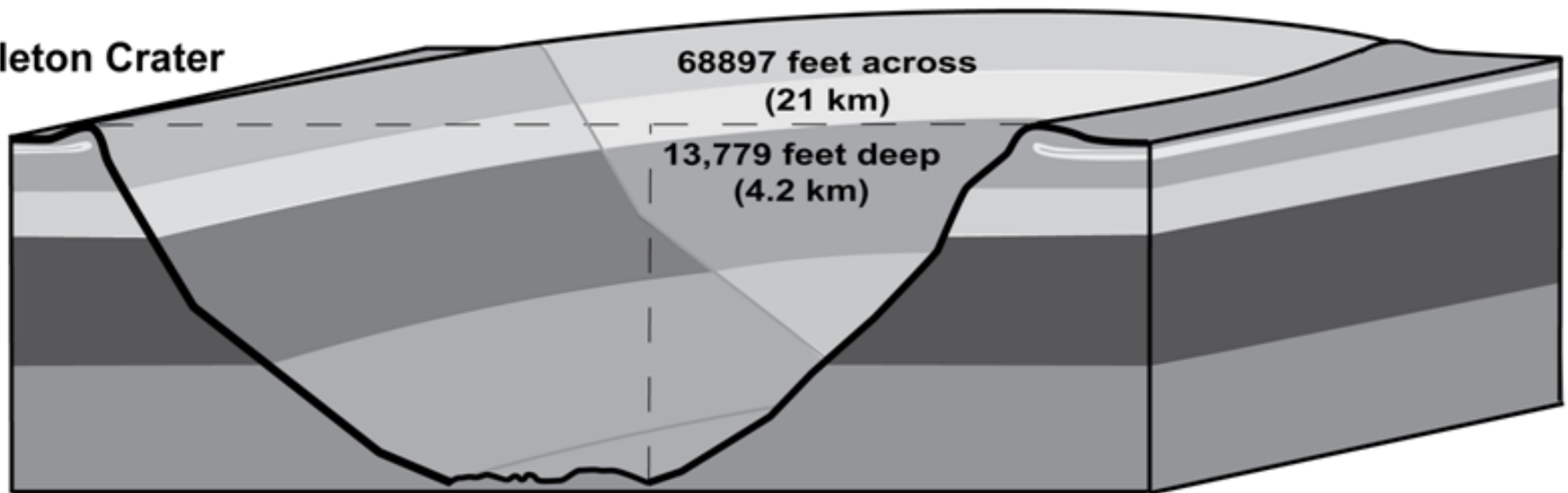
Lunar South Pole



South Pole mosaic from 650 Clementine images.

SHACKLETON CRATER vs. GRAND CANYON

Shackleton Crater

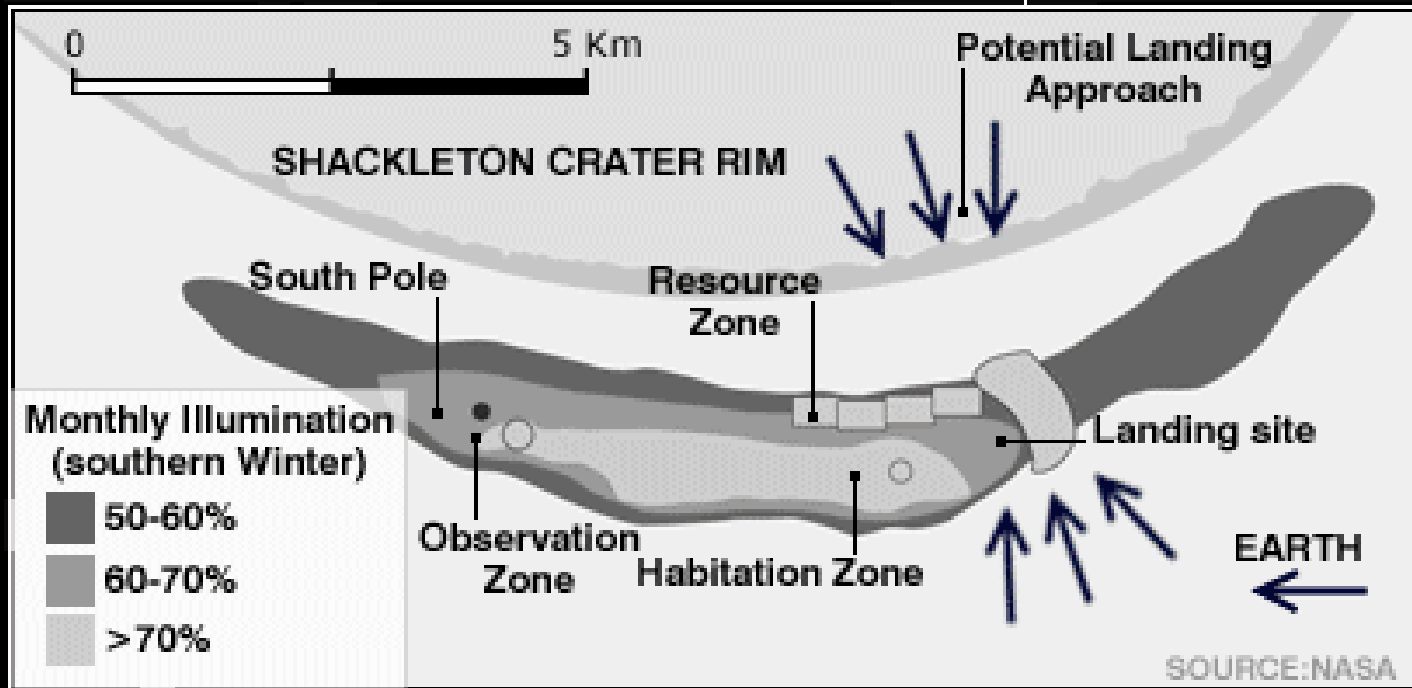
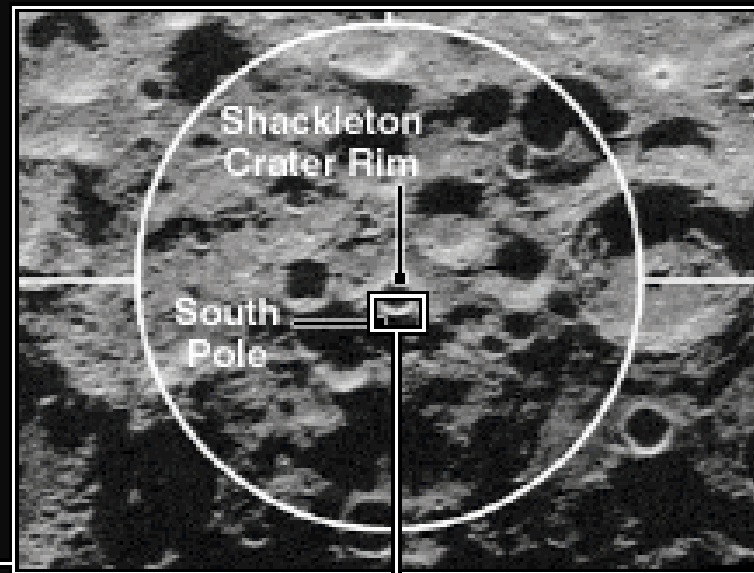
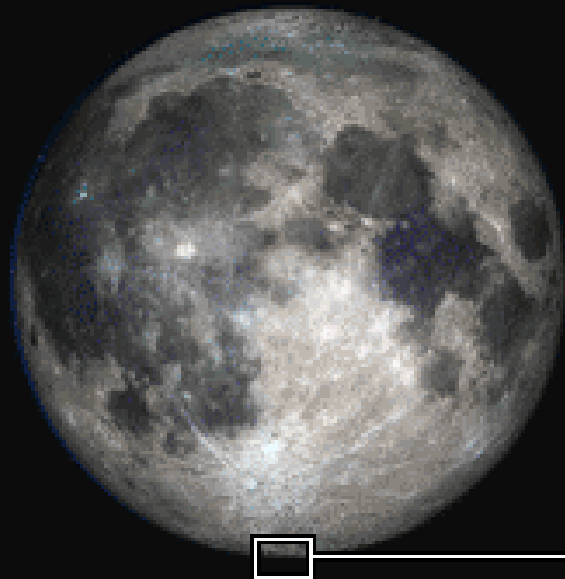


Grand Canyon



4325 feet deep
(1.3 km)

MOON BASE



VIPER rover to search for ice-water on moon

NASA's new VIPER rover is set to search a lunar crater for ice – which could provide drinking water, air and rocket fuel needed for future manned missions to the moon

VIPER

Volatiles Investigating Polar Exploration Rover

Nov 2023: VIPER hitchhikes ride on static lander bound for moon. Mission will last **100 days**

Landing site:

Near **Nobile Crater** at South Pole. Area in almost permanent shadow with temperatures as low as **-223°C**



1m-long drill will test for subsurface water-ice



Project cost: **\$660m**

Rover is similar size to golf buggy

Areas where NASA believes water-ice may be found

VIPER will follow pre-planned route of **16-24km**, but route could change depending on what it finds



2022: Artemis program to return astronauts to moon begins with unmanned test of Orion space capsule

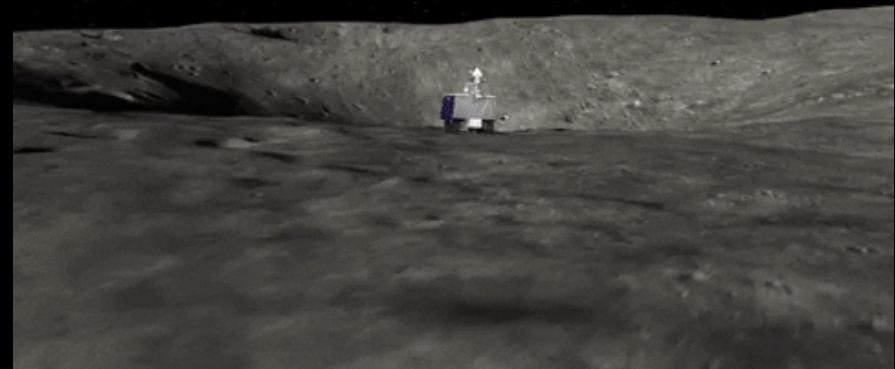
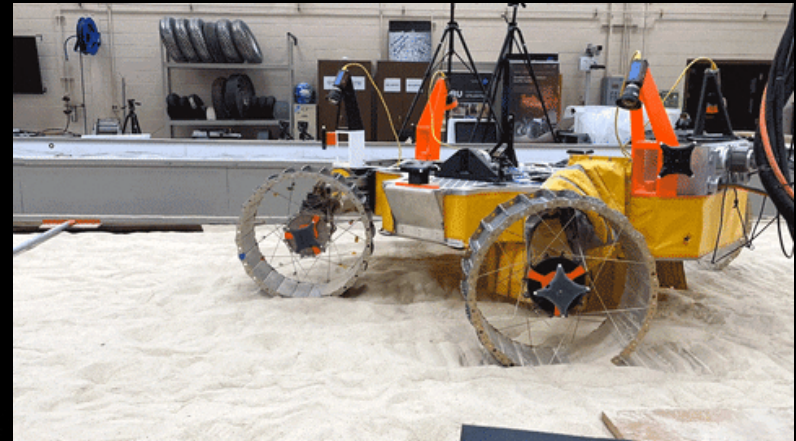
2024: First astronaut landing since 1972 expected by third mission



Sources: BBC, New York Times, NASA

Pictures: NASA

© GRAPHIC NEWS



Recursos Lunares



ESCUELA TÉCNICA SUPERIOR DE INGENIEROS DE MINAS DE MADRID



ESTUDIO DEL ESTABLECIMIENTO DE UNA BASE SEMIPERMANENTE EN LA LUNA: CONDICIONES Y VIABILIDAD DE LA EXPLOTACIÓN DE SUS RECURSOS NATURALES

Director: **Jesús Martínez Frías**
Tutor: **Pedro Vilarroig Arca**

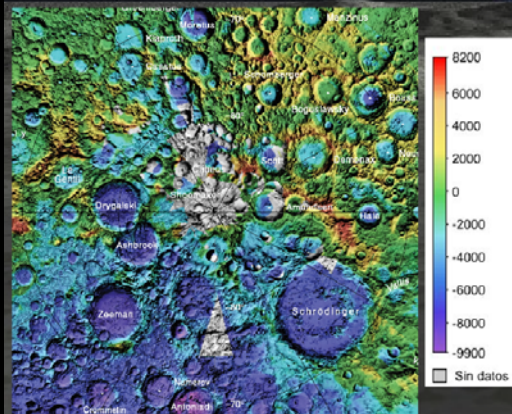
Jose Luis Fernández Abellán **Febrero 2005**

HABITÁCULOS DE RESIDENCIA Y LABORATORIOS

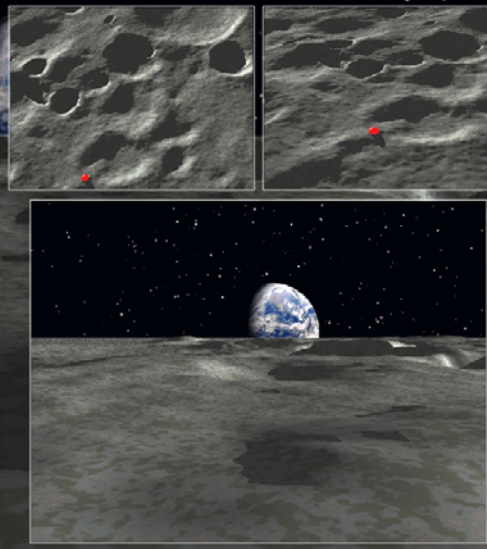


Emplazamiento seleccionado

POLO SUR → Latitud: 78° S
→ Longitud: 4° E



Levántamiento topográfico en tres dimensiones de la zona seleccionada



PROTOTIPO DE MINA LUNAR

- Minería de superficie**
- Más conveniente por las características del regolito lunar.
 - Apenas hay menas de metales nativos.
 - No es recomendable el uso de maquinaria pesada en baja gravedad.
 - Se harán explotaciones a pequeña escala.

Mina prototipo (rascadora accionada por cables):

- Unidad energética móvil con cinta transportadora para la carga del material extraído.
- Cables para accionar la rascadora (en forma de "V").
- Dos poleas de anclaje en los extremos de la explotación.
- Fácilmente automatizable.



Método alternativo (minirotopala accionada por cables):

Pequeña rotopala accionada por cables que se desplazaría transversalmente en la explotación, extrayendo el material (probada con éxito en análogos terrestres del suelo lunar).



[P2A.06] ARCHITECTURAL CONTRIBUTION TO PLANETARY HABITABILITY



Yasmina Eid-Macheh-Sánchez 1, Junjo García-Valverde 2, Jesús Martínez-Frías 3

(1)(2)Universidad Politécnica de Valencia y GAREID PROYECTOS, Valencia (Spain), E-mail: yasmina@gareidproyectos.com

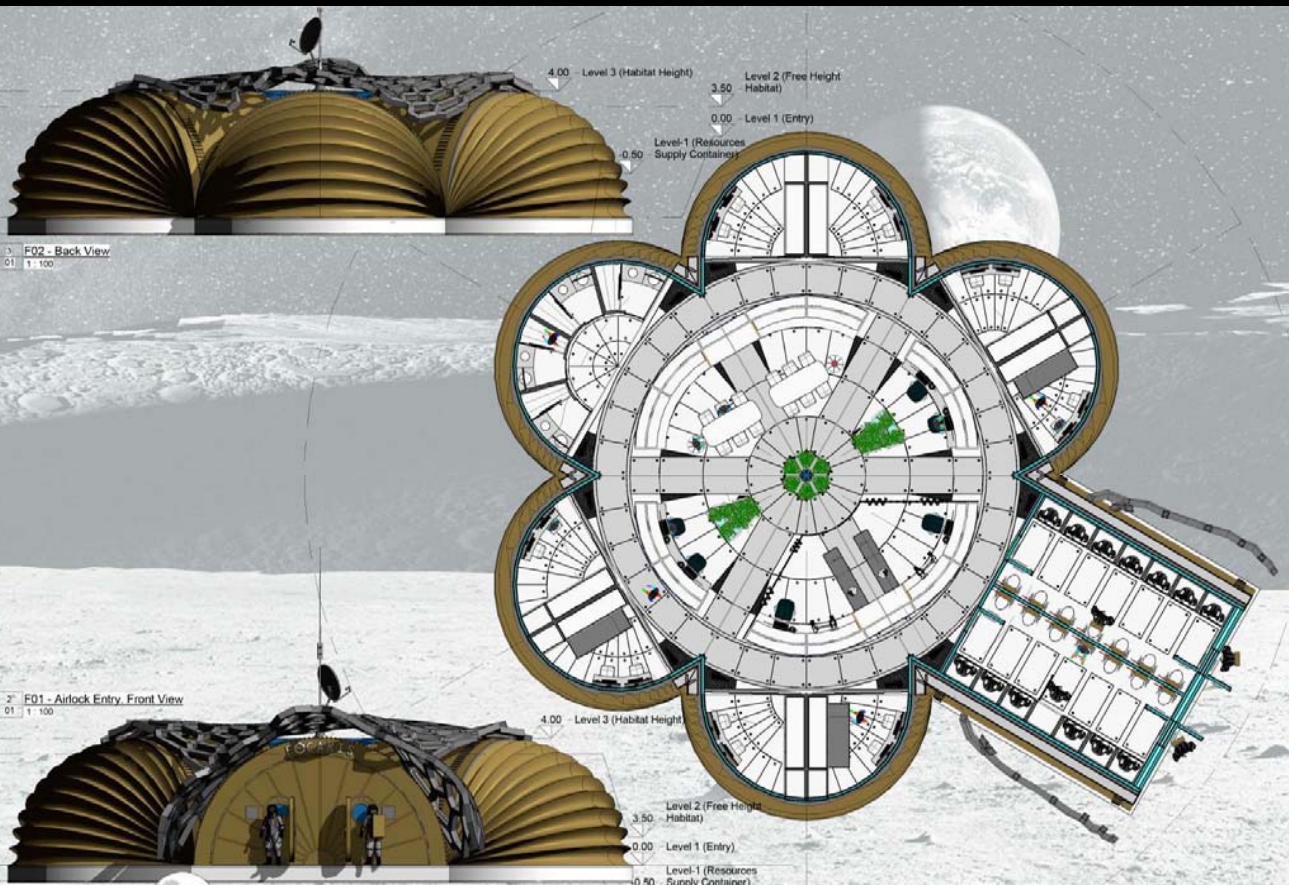
(3) Instituto de Geociencias, IGEO (CSIC-UCM), Madrid (Spain).



• Collaborators:



01. Christopher Altman, 02. Franz Artur Viehböck, 03. Duane Gene "Digger" Carey, 04. Gregory Carl "Ray J" Johnson, 05. José Moreno Hernández, 06. James Patrick "Mash" Dutton, Jr., 07. Dorothy Marie "Dottie" Metcalf-Lindenburger, 08. Jay Clark Buckey, Jr., 09. Michel Ange-Charles Tognini, 10. David Carl Hilmers, 11. Charles Donald "Sam" Gemar, 12. Ellen Louise Shulman Baker, 13. Carl Joseph Meade, 14. Claude Nicollier, 15. Jean-Loup Jacques Marie Chrétien, 16. Scott Douglas "Scooter" Altman, 17. Scott Edward Parazynski, 18. Nicole Marie Passonno Stott, 19. Kevin Anthony Ford, 20. Andrew "Andy" Sydney Withiel Thomas, 21. Steven Roy Swanson, 22. Robert Brent "Bob" Thirsk, 23. Michael López-Alegría, 24. Paolo Angelo Nespoli, 25. Thomas Henry Marshburn, 26. Luca Parmitano, 27. Christopher John "Chris" Cassidy, 28. Peggy Annette Whitson.



Relationship zone and Kitchen view



Habitat control post view



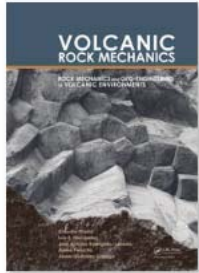
Laboratory treatment view

PROMOTE:



PROJECT'S NAME: FOCARIS

Nº 01. FLOOR PLAN AND FRONTS PLANS



Chapter

Study of lunar soil from terrestrial models (Canary Islands, Spain)

By J.A. Rodríguez-Losada, S. Hernández-Fernández, J. Martínez-Frías, L.E. Hernández & R. Lunar Hernández

Book [Volcanic Rock Mechanics](#)

Edition 1st Edition
 First Published 2010
 Imprint CRC Press
 Pages 6
 eBook ISBN 9780429206207

Study of lunar soil from terrestrial models (Canary Islands, Spain)

J.A. Rodríguez-Losada & S. Hernández-Fernández
 Department of Soil Science and Geology, University of La Laguna, Tenerife, Spain

J. Martínez-Frías
 Centro de Astrobiología (CAB), Spanish National Research Council (CSIC/INTA), Madrid, Spain

L.E. Hernández
 Regional Ministry of Works, Government of the Canary Islands, Spain

R. Lunar Hernández
 Departamento de Cristalografía y Mineralogía, Facultad de Geología, Universidad Complutense, Madrid, Spain

ABSTRACT: The Moon has a surface constituted mainly of basaltic materials. They are mostly vacuolar-like basalts that are also abundant in soils of volcanic origin on Earth. The geotechnical features of these rocks from the Canary Islands are supported by the basic characteristics deduced by NASA for this type of basalts. This paper deals with the geotechnical parameters of the lunar basalts taking into account the knowledge we have of the basalts from the Canary Islands used as terrestrial models as well as their suitability as building materials in future lunar bases. It is concluded that the lunar basalt, because of their abundance, ease of management and structural strength, is the best material for the construction of roads, tracks and even blocks with regolith for shielding of dwellings and facilities required on a lunar base.

Table 1. Chemical compositions of selected samples (weight %).

Sample	EH-10	FV-19	FV-25	GC-52	LZ-22	TF-32	TF-40
SiO ₂	41.69	50.53	49.34	43.69	50.76	42.63	46.31
Al ₂ O ₃	11.38	16.34	13.37	13.81	13.53	11.83	16.33
CaO	11.35	7.09	9.36	9.34	9.45	11.07	9.40
Fe ₂ O ₃	16.39	9.8	12.35	12.5	11.63	14.25	11.89
K ₂ O	1.14	2.5	0.68	1.48	0.66	1.35	1.90
MgO	10.11	1.99	9.76	9.41	9.23	12.02	4.99
MnO	0.19	0.20	0.16	0.18	0.15	0.19	0.21
Na ₂ O	2.53	4.8	3.19	3.85	2.89	2.80	4.17
P ₂ O ₅	0.73	1.17	0.4	0.71	0.3	0.81	1.07
TiO ₂	5.23	2.73	2.43	3.774	2.38	3.70	3.48
LOI	-0.09	2.89	-0.77	0.37	-0.65	-0.38	0.28
Total	100.65	100.04	100.27	99.11	100.33	100.27	100.03



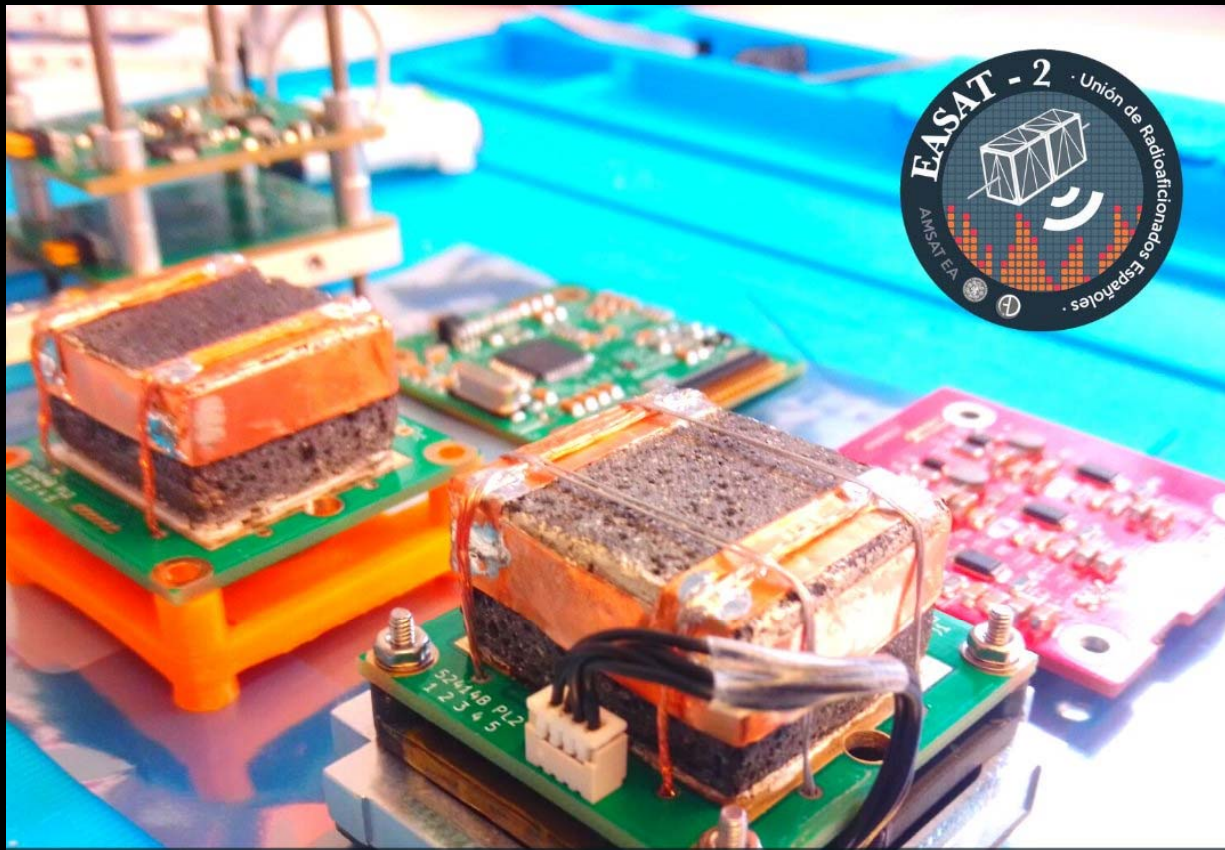


OPEN

LZS-1, Lanzarote (Canary Island, Spain) lunar (Apollo 14) basaltic soil simulant

Fernando Alberquilla^{1,2✉}, Jesús Martínez-Frías^{1,3}, Valentín García-Baonza^{1,2} & Rosario Lunar¹

The search for Terrestrial Analogues is essential for the development of future permanent or semi-permanent lunar bases. Terrestrial Analogues are zones where it is possible to probe not only scientific instruments, but also other astronaut capabilities in an environment that is similar to the geological context, geomorphology, mineralogy, geochemistry, etc. that we can find on Mars, the Moon and even asteroids. This work has focused on a multi-analytical characterization of Peñas de Tao geosite basalts in Lanzarote (Canary Islands, Spain). This characterization starts from a field campaign in which 3000 g of basalt rocks were selected. Subsequently, they were analysed by different techniques to determine their composition at a mineralogical and geochemical level, and the results were compared with data from other lunar simulants and from the Apollo 14 mission. After that, a set of petrophysical tests was carried out in order to determine its physical properties and evaluate its capacity as an analogous material for use in situ as a resource for further geological and astrobiological (future lunar habitability) essays.



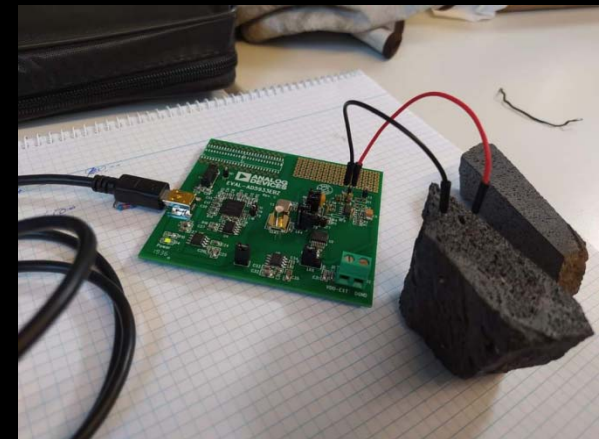
EXPERIMENTO CON BASALTO DE LANZAROTE

EASAT-2

Vocalía de Satélites de URE



Experimento sobre geología y astrobiología (habitabilidad lunar), con material basáltico de Lanzarote que se ha enviado al espacio en un picosatélite a principios de 2022



El picosatélite español con basalto de Lanzarote fue en puesto en órbita en un cohete Falcon 9 de Space X y despegó de Cabo Cañaveral el 13 de enero de 2022.

Director Científico: Jesús Martínez Frías



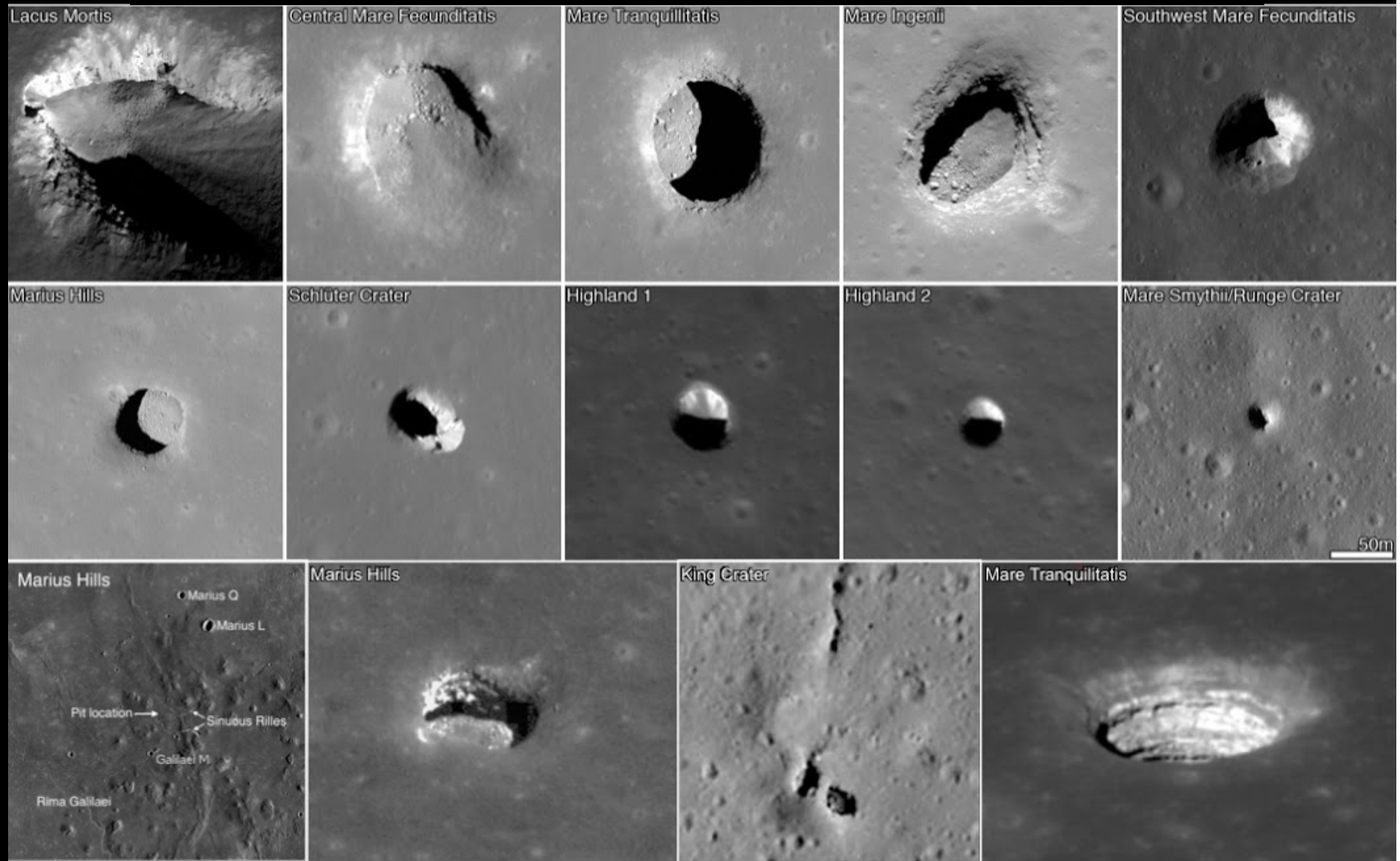


European Space Agency

PANGAEA

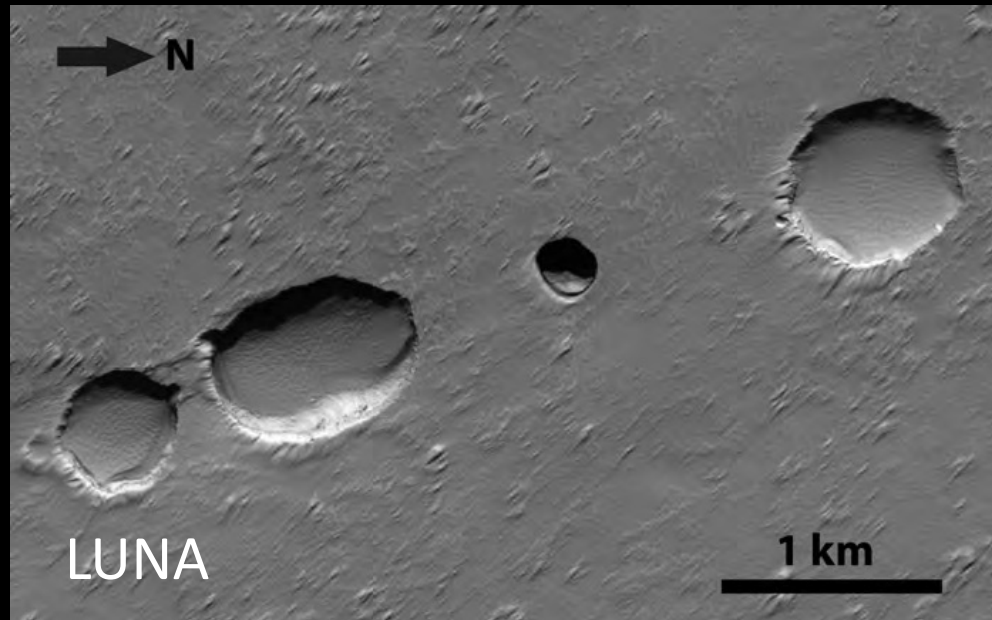
Planetary ANalogue Geological & Astrobiological Exercise for Astronauts

POSIBLES CUEVAS LUNARES



Skylights above caves on Moon. Sources: LRO/NAC/R. Wagner/J. Ashley/ASU.

Cuevas planetarias





esa

→ ESA PANGAEA-X 2017 → ESA PANGAEA-X 2017



LABORATORIO GEOCENCIAS DE LANZAROTE

IGEO

Geoparque

LABORATORIO GEOCENCIAS DE LANZAROTE

ESA PANGAEA

Lanzarote se transforma en Marte y La Luna durante un entrenamiento de astronautas de la ESA

EUROPA PRESS 22.11.2018

f | t | e

Una zona degradada del municipio de Tinajo, en la isla de Lanzarote, se ha transformado estos días en un escenario que simula las condiciones geológicas de Marte y de La Luna y que ha servido para que investigadores especializados en la geología y astrobiología planetaria de distintas universidades europeas y astronautas y técnicos especializados de la Agencia Espacial Europea (ESA) puedan entrenarse y preparar a los humanos para trabajar territorio extraterrestre.



[Grupocanarias] Np, Lanzarote, Más Cerca Que Nunca De Marte Y La Luna CABILDO DE LANZAROTE

BLOGS DE 20MINUTOS

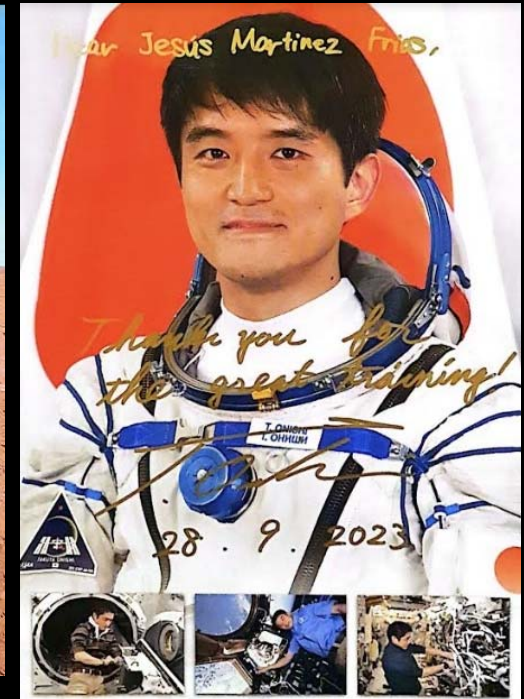
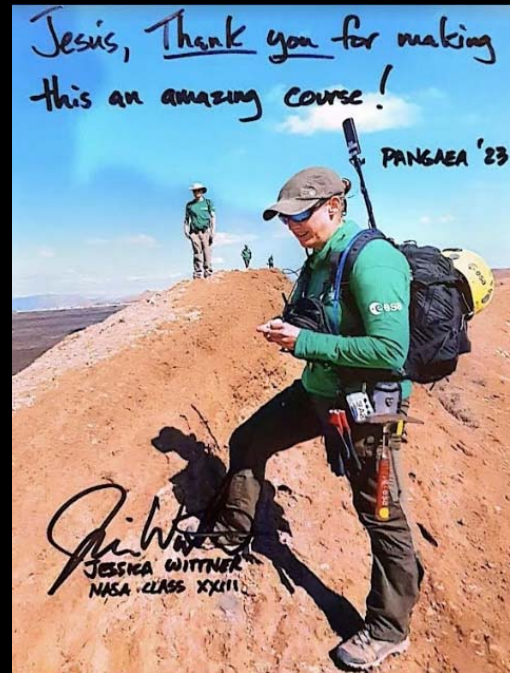
CAFANDO LA CRISIS
Compost contra la crisis climática

YA ESTÁ EL LISTO QUE TODO LO SABE
El curioso origen del término 'chulo'

REALITY BLOG SHOW
Los pupas de Supervivientes: ahora ha sido un escorpión lo que les ha picado

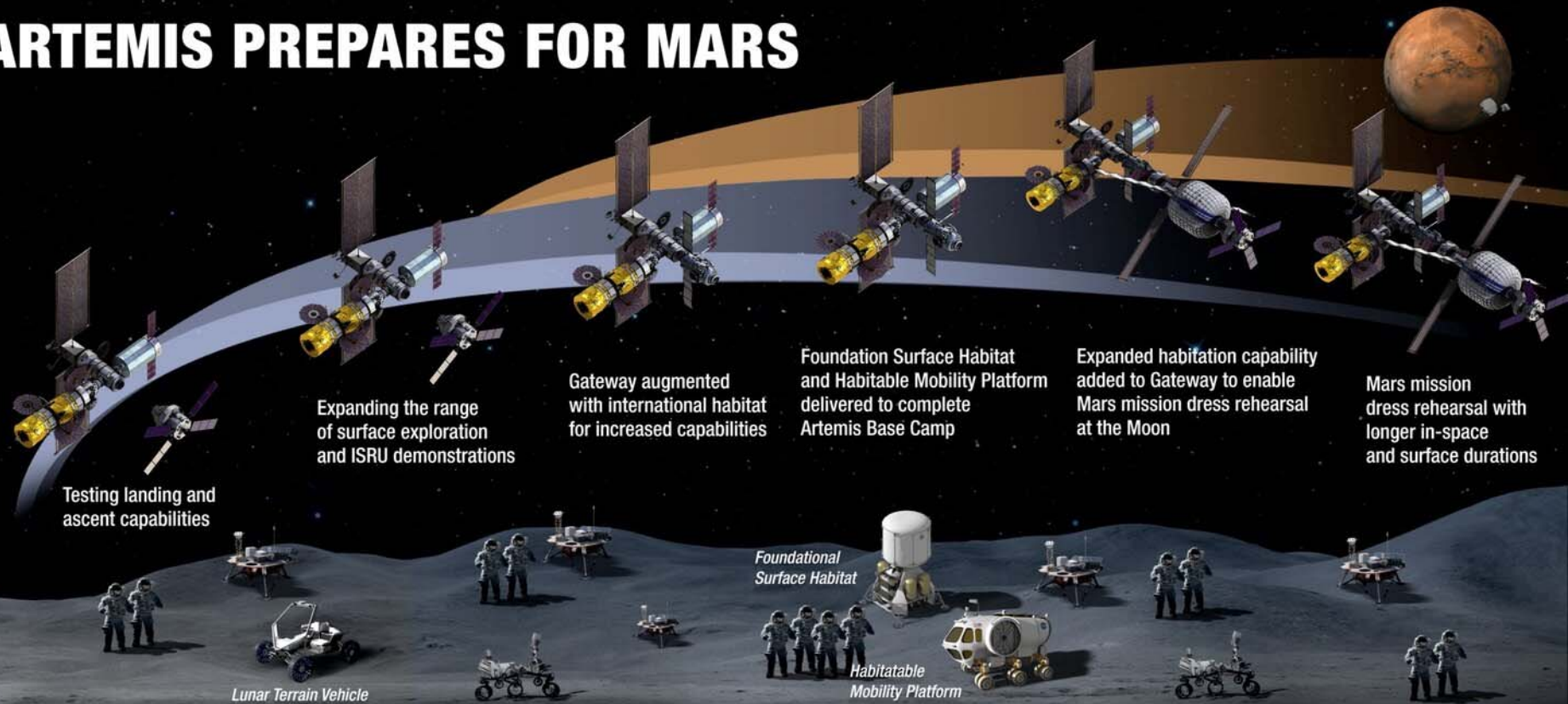


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Artemisa se prepara para ir mucho más lejos....

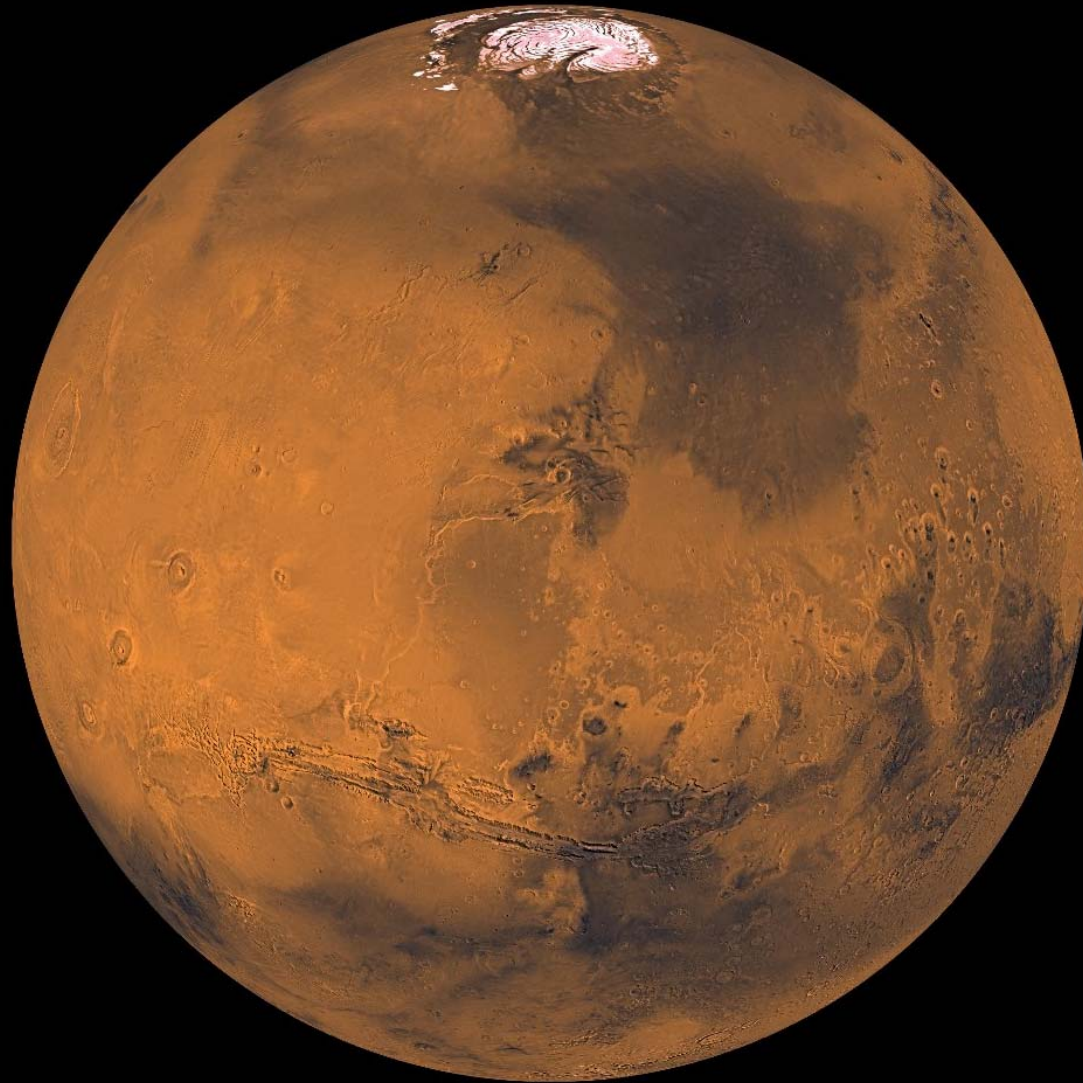
ARTEMIS PREPARES FOR MARS



SUSTAINABLE LUNAR ORBIT STAGING CAPABILITY AND SURFACE EXPLORATION

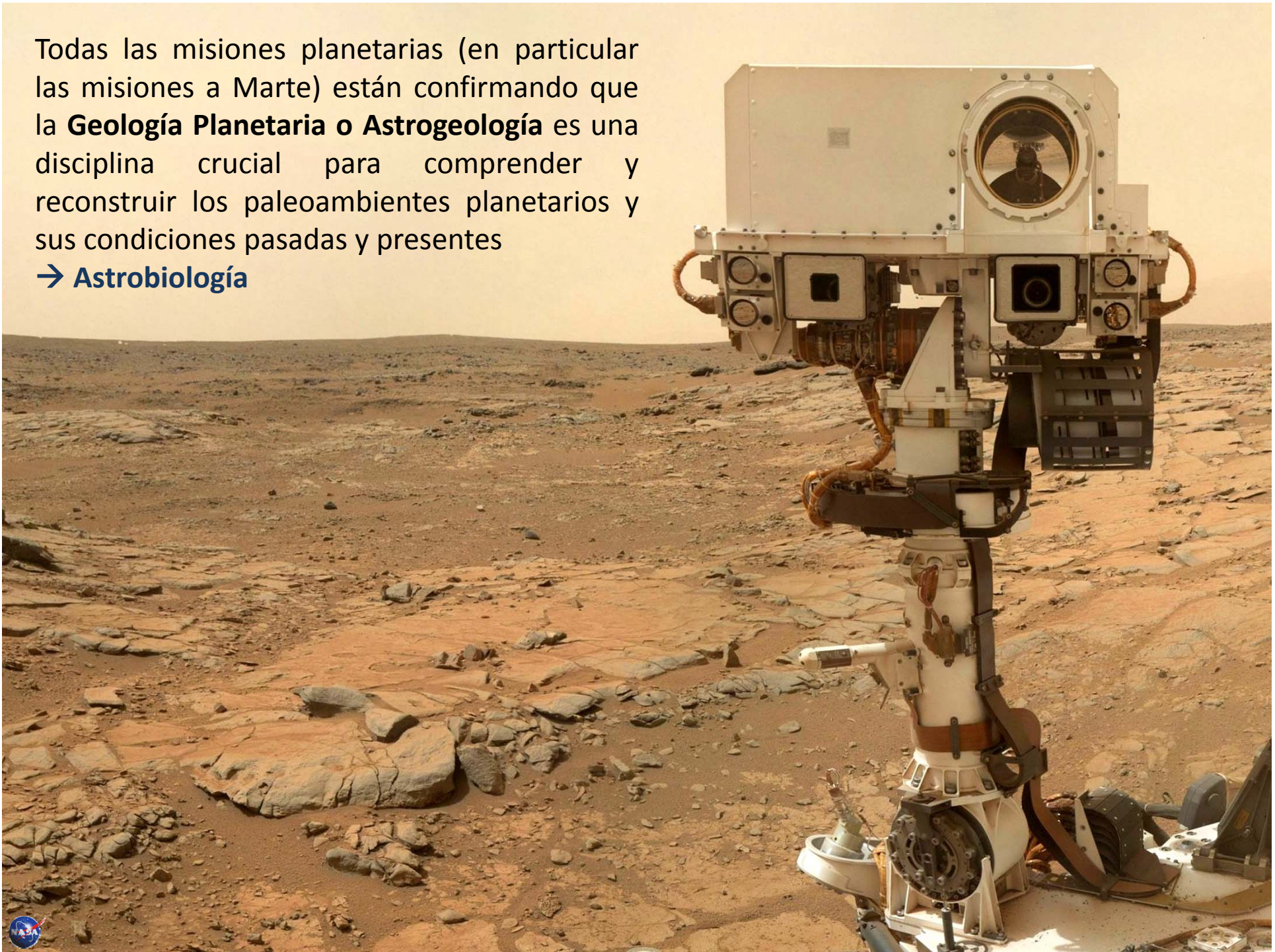
MULTIPLE SCIENCE AND CARGO PAYLOADS | INTERNATIONAL PARTNERSHIP OPPORTUNITIES | TECHNOLOGY AND OPERATIONS DEMONSTRATIONS FOR MARS

Marte



Todas las misiones planetarias (en particular las misiones a Marte) están confirmando que la **Geología Planetaria o Astrogeología** es una disciplina crucial para comprender y reconstruir los paleoambientes planetarios y sus condiciones pasadas y presentes

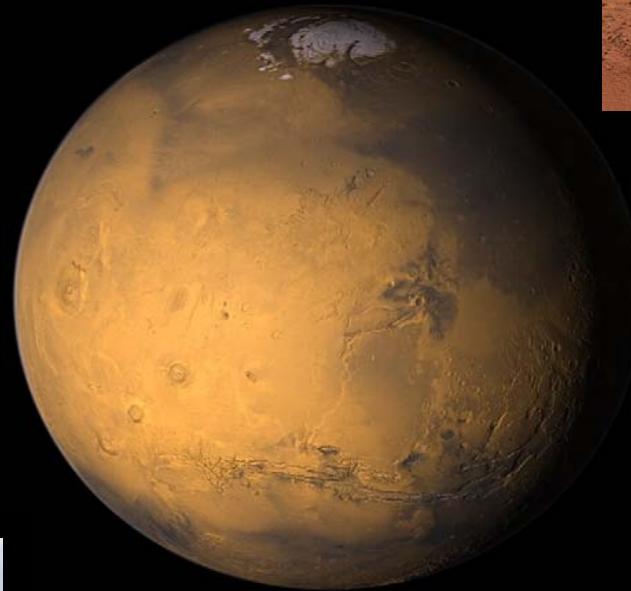
→ **Astrobiología**



Geología Planetaria y Astrobiología - Investigación y Exploración de Marte

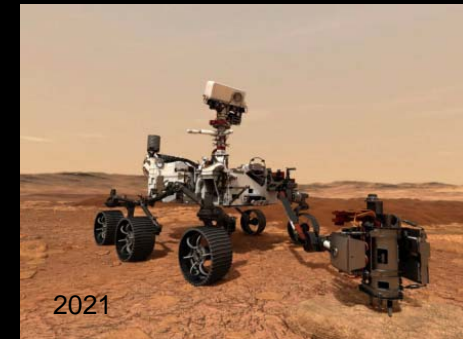
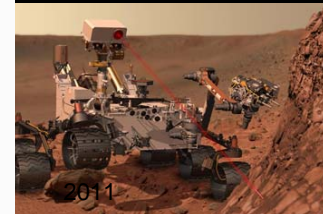
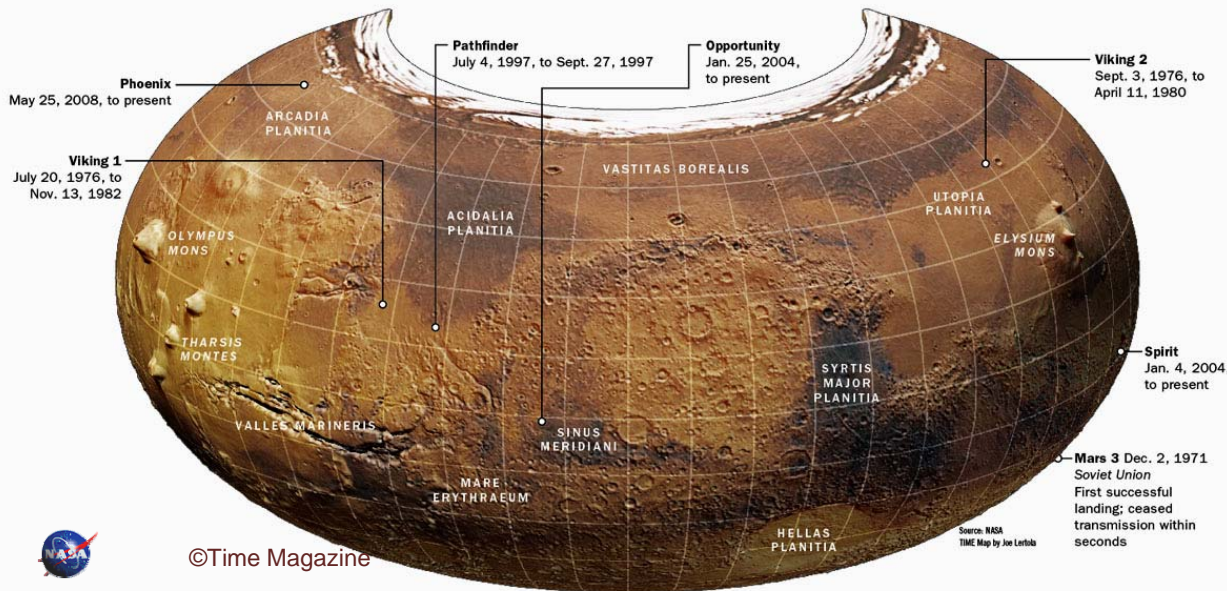
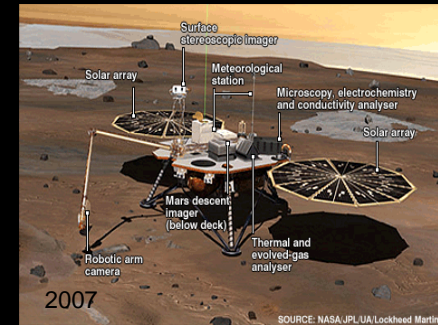
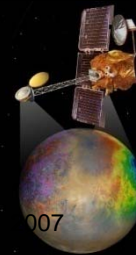
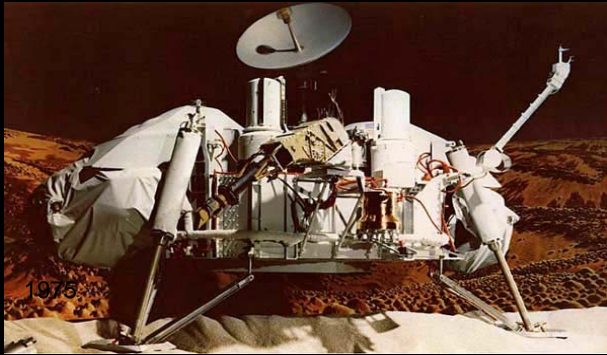


© NASA/SCIENCE PHOTO LIBRARY

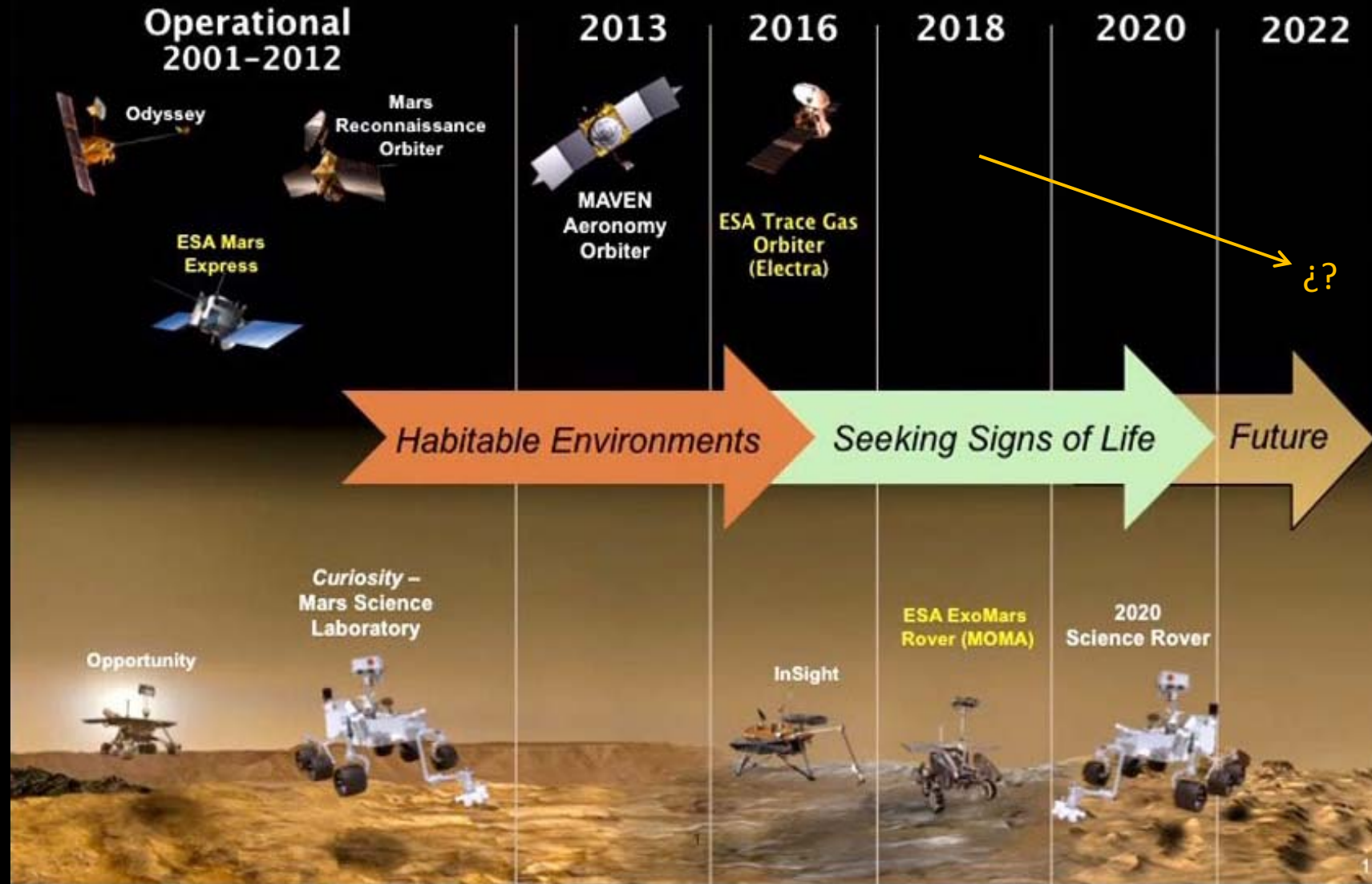


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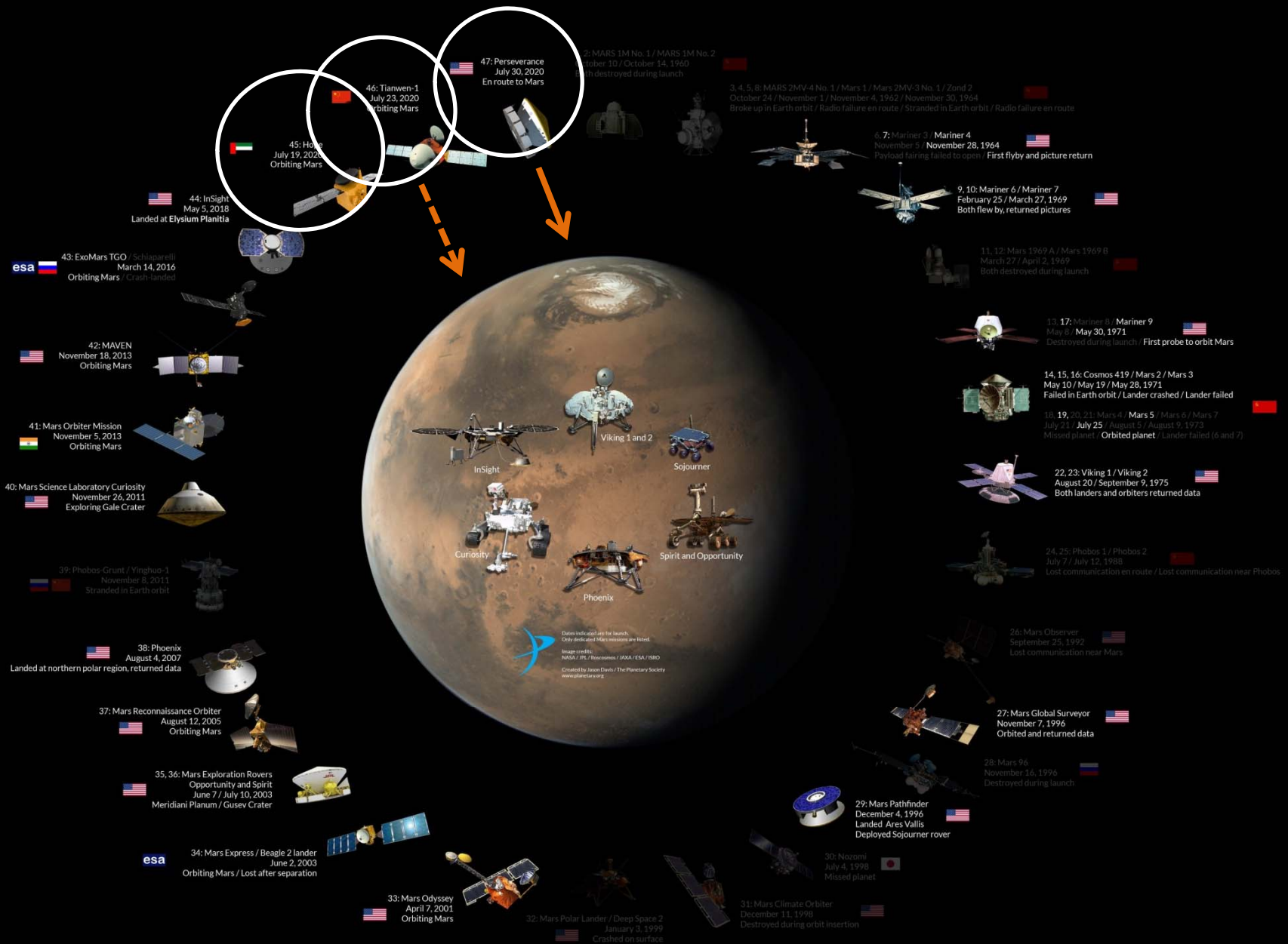


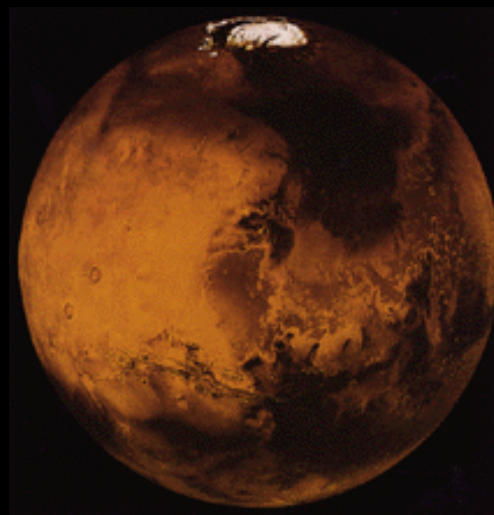
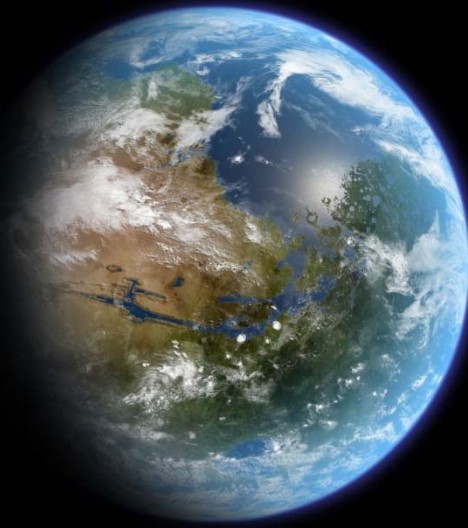


Mars Missions in This Decade

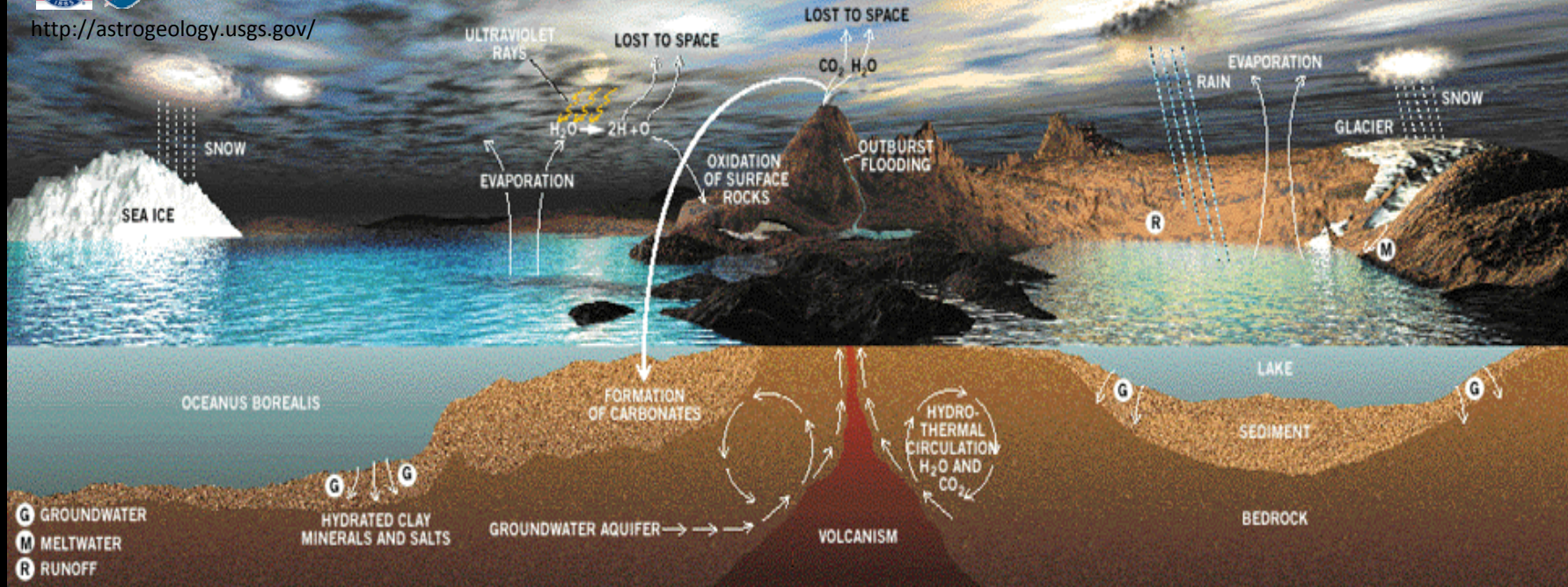


EXPLORACIÓN DE MARTE – CONJUNTO SINTÉTICO DE MISIONES



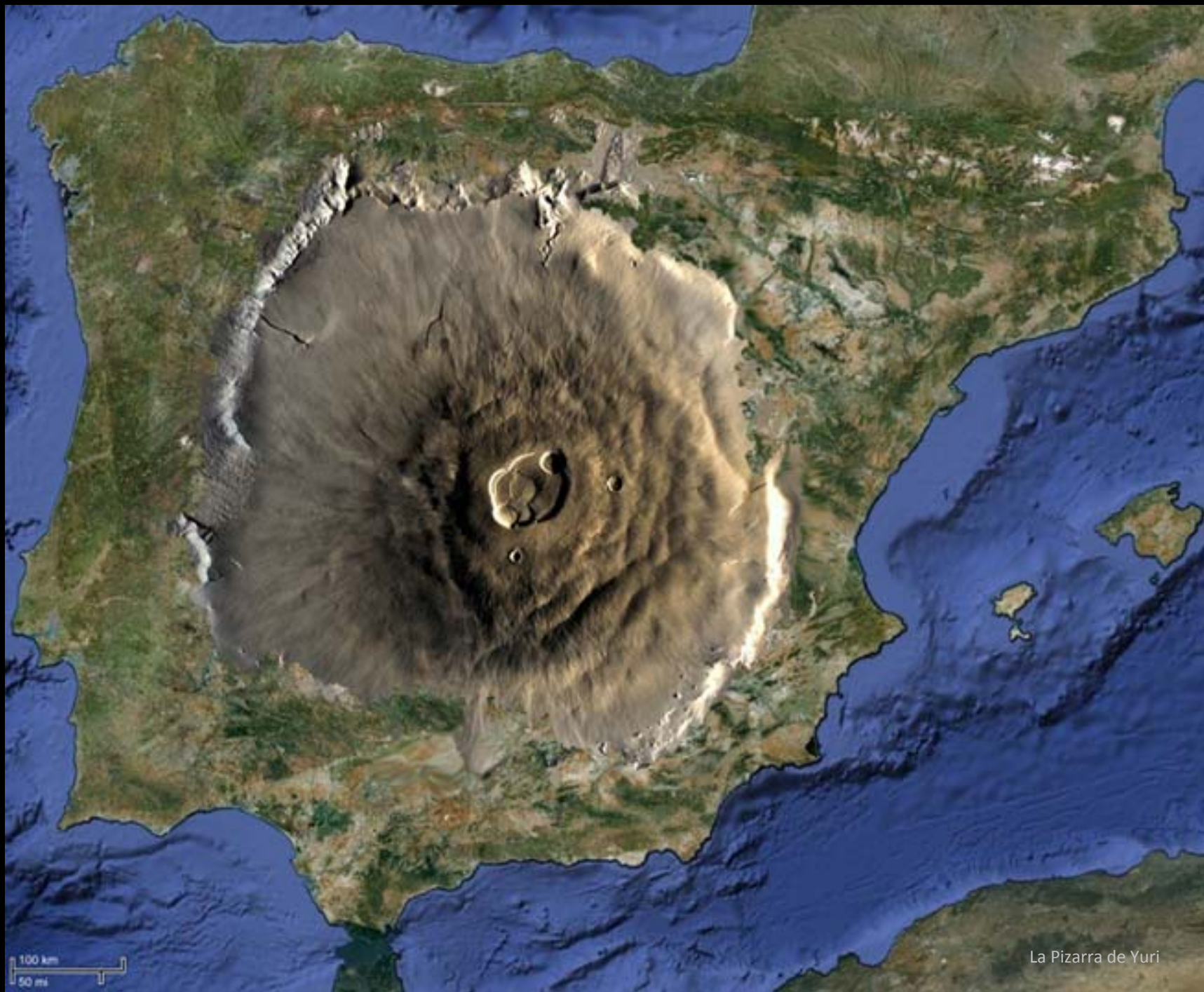


<http://astrogeology.usgs.gov/>



El vapor de agua es el gas volcánico más común, constituyendo más del 70% de las emisiones totales. El CO₂ supone entre el 10 y el 40 %

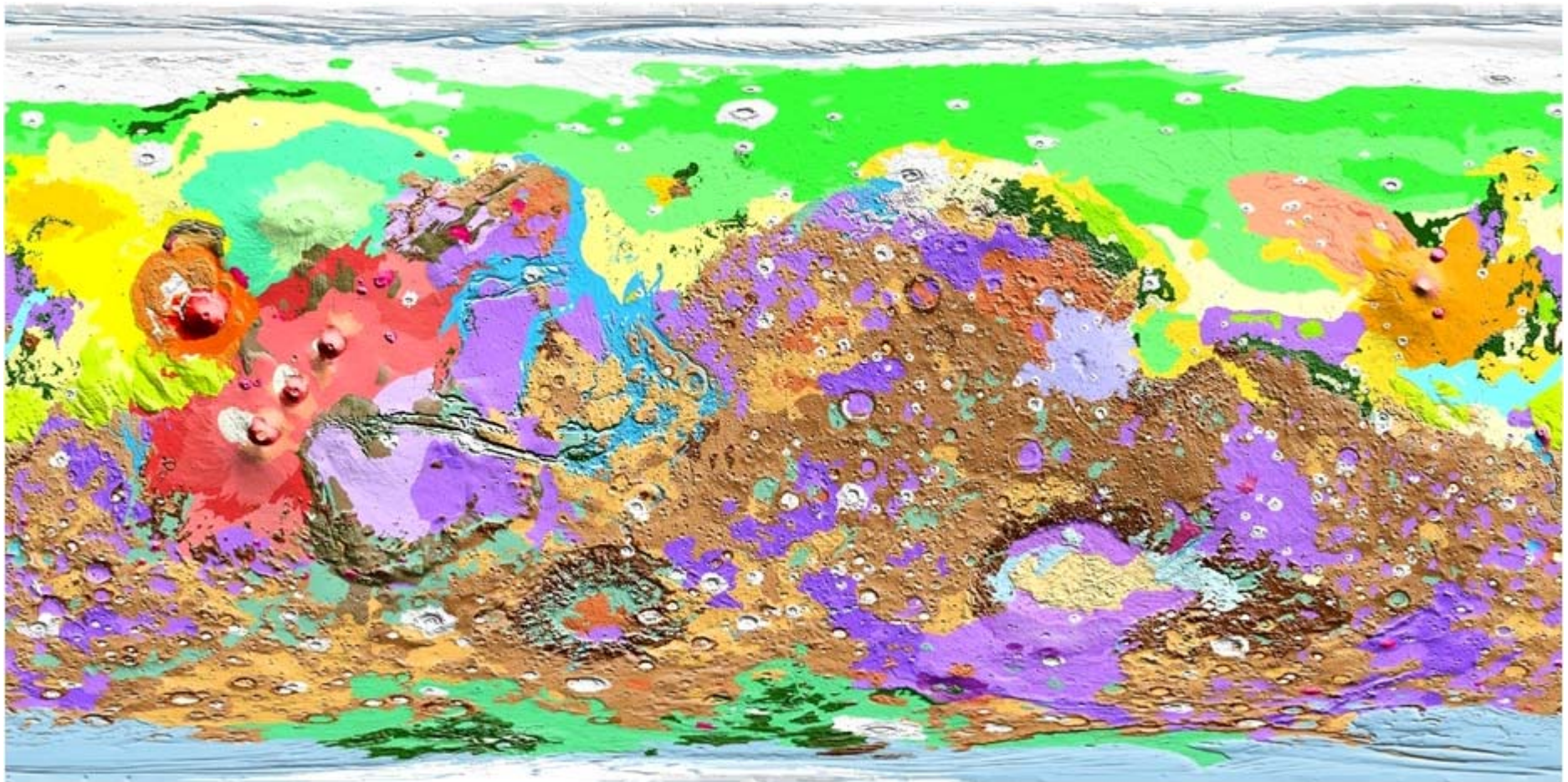




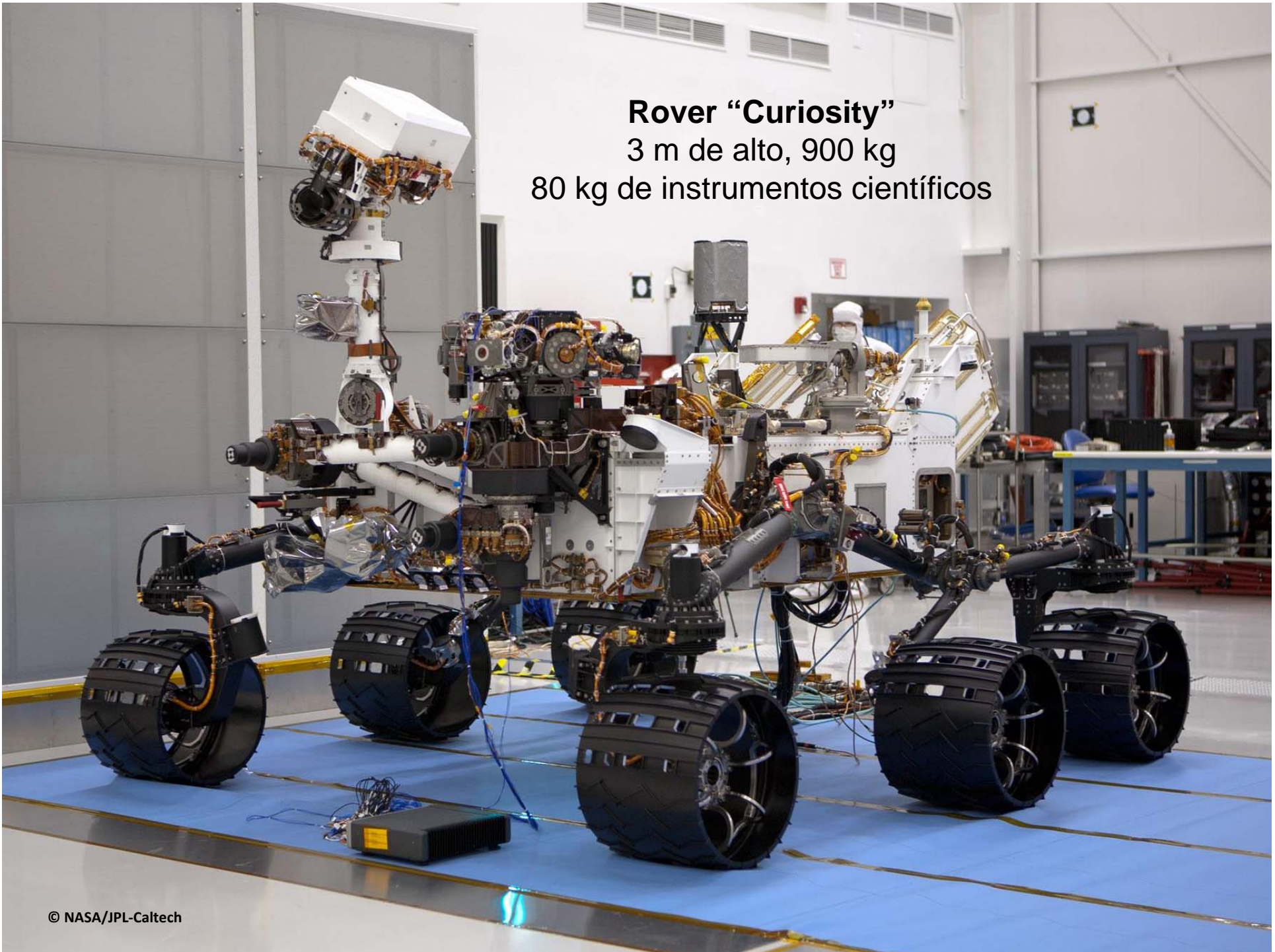
100 km
50 mi

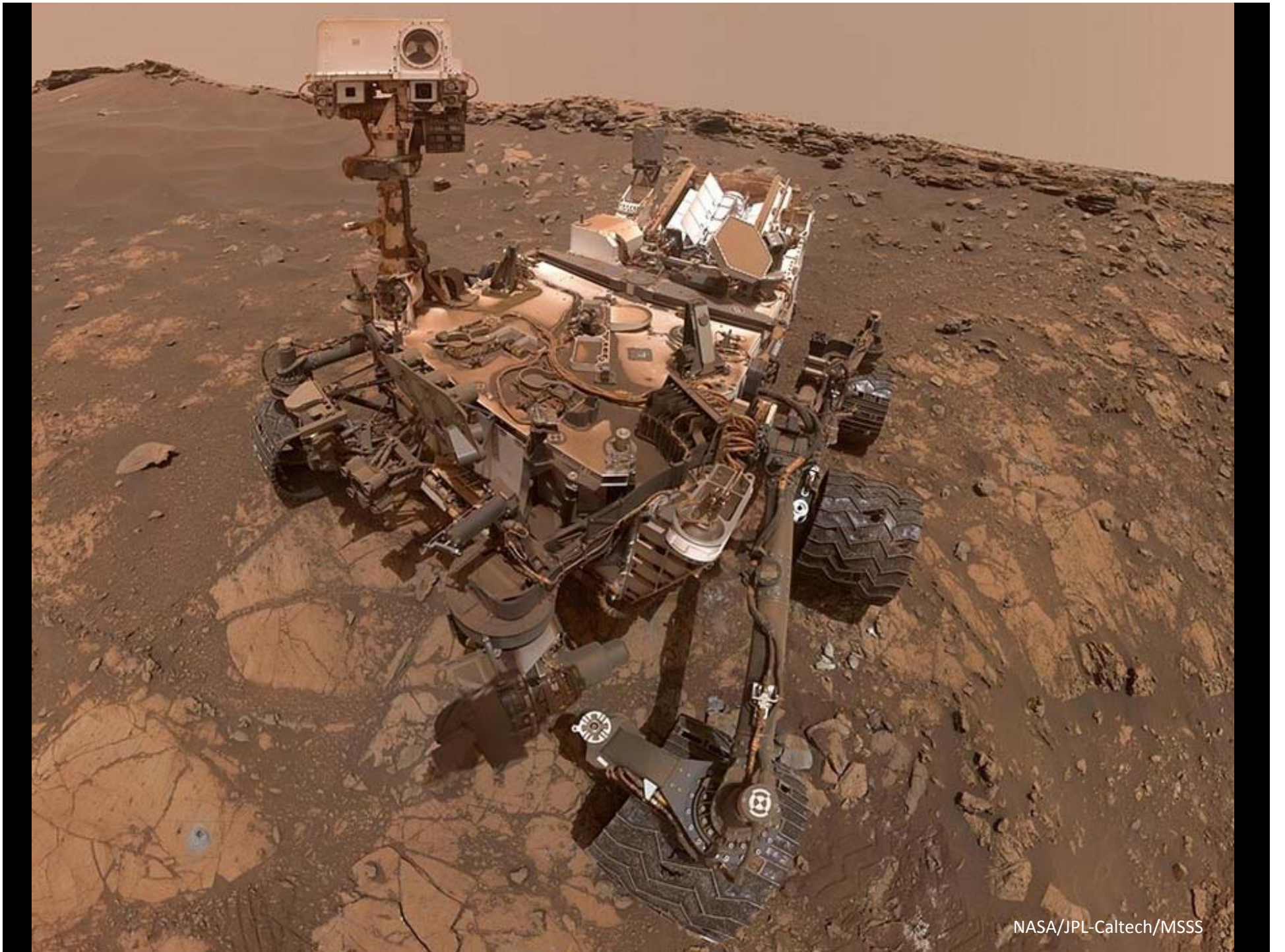
La Pizarra de Yuri

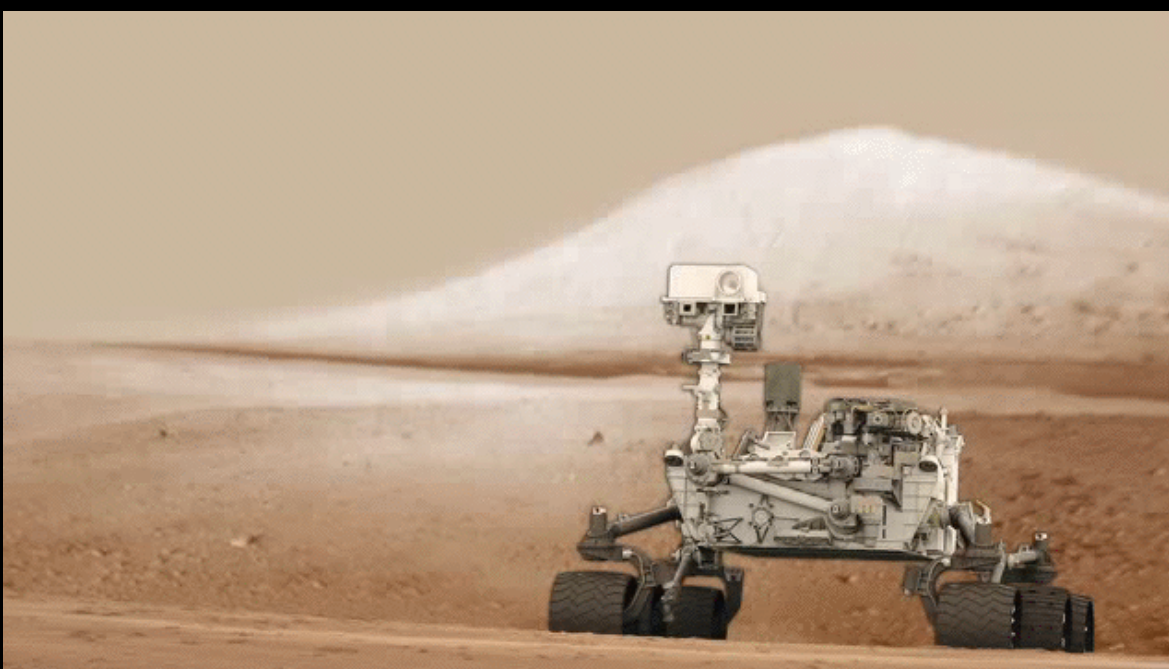
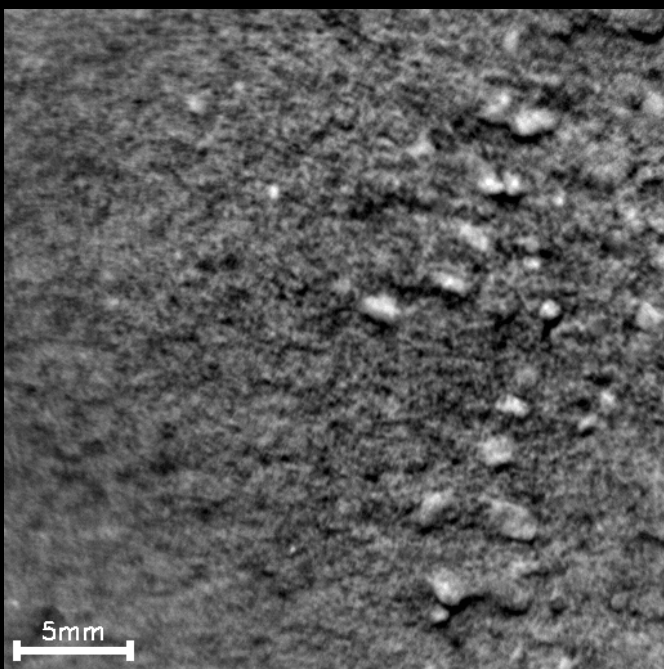
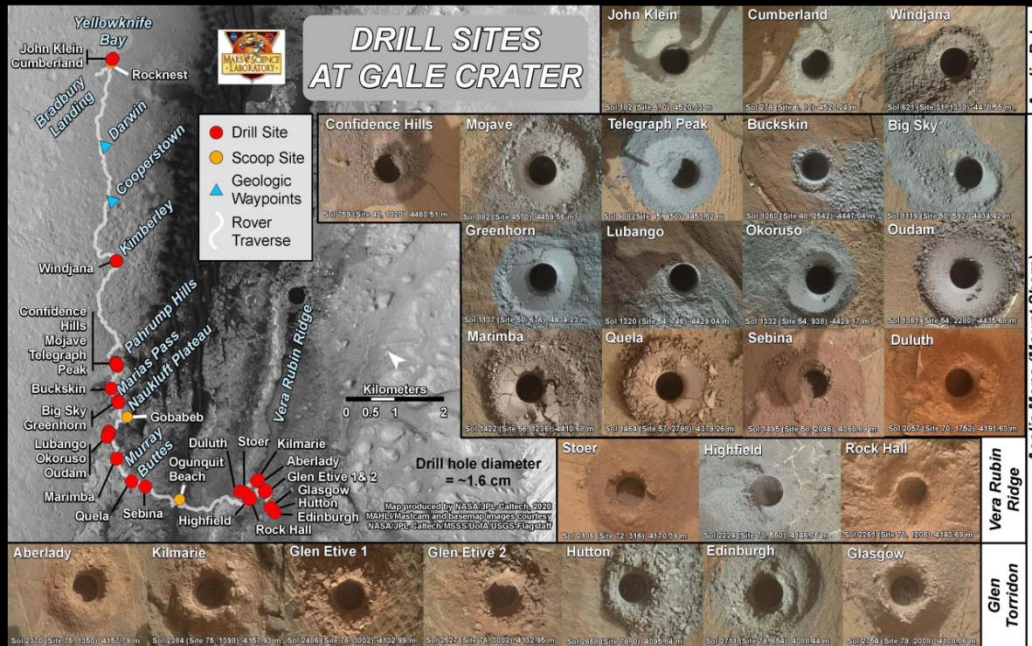
Si profundizamos en la geología de Marte, se comprueba que el planeta rojo muestra una importante complejidad geológica. Una geodiversidad resultante de su pasada actividad geodinámica y que es fundamental para la búsqueda de vida.

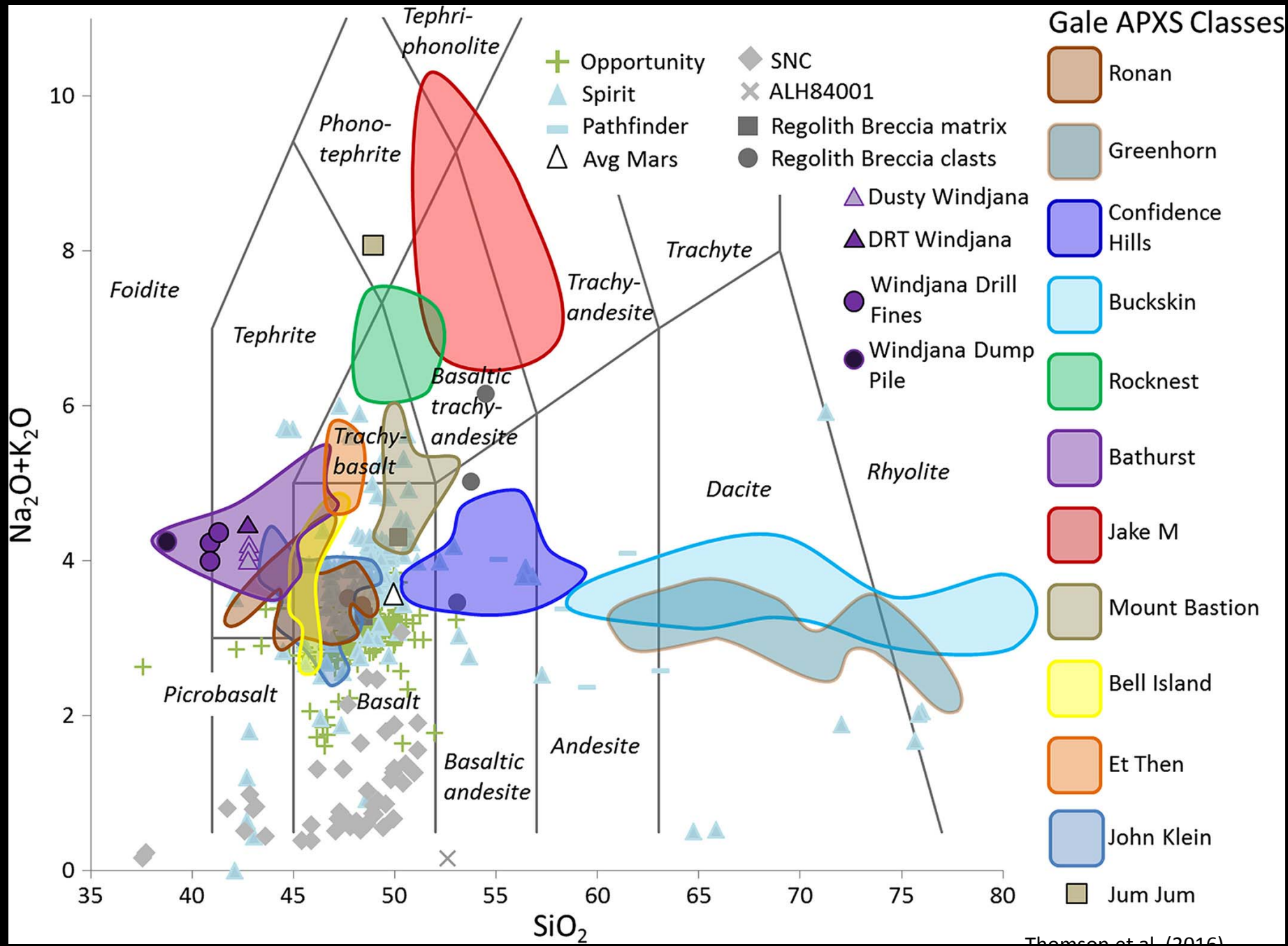


Rover “Curiosity”
3 m de alto, 900 kg
80 kg de instrumentos científicos









Transient liquid water and water activity at Gale crater on Mars

F. Javier Martín-Torres^{1,2*}, María-Paz Zorzano³, Patricia Valentín-Serrano^{1,3}, Ari-Matti Harri⁴, Maria Genzer⁴, Osku Kemppinen⁴, Edgar G. Rivera-Valentin⁵, Insoo Jun⁶, James Wray⁷, Morten Bo Madsen⁸, Walter Goetz⁹, Alfred S. McEwen¹⁰, Craig Hardgrove¹¹, Nilton Renno¹², Vincent F. Chevrier¹³, Michael Mischna⁶, Rafael Navarro-González¹⁴, Jesús Martínez-Frías¹⁵, Pamela Conrad¹⁶, Tim McConnochie¹⁷, Charles Cockell¹⁸, Gilles Berger¹⁹, Ashwin R. Vasavada⁶, Dawn Sumner²⁰ and David Vaniman²¹

Water is a requirement for life as we know it. Indirect evidence of transient liquid water has been observed from orbiter on equatorial Mars², in contrast with expectations from large-scale climate models. The presence of perchlorate salts, which have been detected at Gale crater on equatorial Mars by the Curiosity rover^{3,4}, lowers the freezing temperature of water⁵. Moreover, perchlorates can form stable hydrated compounds and liquid solutions by absorbing atmospheric water vapour through deliquescence^{6,7}. Here we analyse relative humidity, air temperature and ground temperature data from the Curiosity rover at Gale crater and find that the observations support the formation of night-time transient liquid brines in the uppermost 5 cm of the subsurface that then evaporate after sunrise. We also find that changes in the hydration state of salts within the uppermost 15 cm of the subsurface, as measured by Curiosity, are consistent with an active exchange of water at the atmosphere–soil interface. However, the water activity and temperature are probably too low to support terrestrial organisms⁸. Perchlorates are widespread on the surface of Mars⁹ and we expect that liquid brines are abundant beyond equatorial regions where atmospheric humidity is higher and temperatures are lower.

At the appropriate range of relative humidity and temperature, perchlorates (ClO_4^-) deliquesce into the aqueous phase creating brines (that is, solutions of salt in water) that are stable in the liquid state. Deliquescence^{6,7} occurs when, simultaneously, the ambient relative humidity (RH) is above the deliquescent relative humidity (DRH) of the deliquescent salt and the ambient temperature (T) is above the eutectic temperature (T_e) of the resulting solution. The stability of transient aqueous salt solutions on Mars was first postulated in the 1960s¹⁰, and has been inferred from indirect observations at polar and near-polar regions^{7,11}. The present-day activity of equatorial recurring slope lineae has been attributed to seasonal flow of brines² (Supplementary Fig. 1). Nevertheless, on the basis of the large-scale predictions of global circulation models (GCMs) and the remote-sensing large-scale observation of RH and T , it is believed that deliquescence conditions could be theoretically reached on the surface of Mars only poleward of $\pm 60^\circ$ and only during the northern spring^{11,12} (when the water vapour content of the martian atmosphere peaks¹³). Transiently stable liquid water in

Science Laboratory (MSL) landed and has been operating since 6 August 2012.

However, here we show that the RH, air temperature (T_a) and ground temperature (T_g) observations at Gale by the Rover Environmental Monitoring Station¹⁴ (REMS) on the Curiosity rover at the MSL mission¹⁵ are compatible with the presence of liquid brines during night time due to the increased RH associated with night-time lower ambient temperatures. Figure 1a shows the diurnal variation of the ground relative humidity and temperature (RH_g and T_g) for the sols (Martian days) corresponding to the beginning of each season: $L_s = 90$ (winter), 180 (spring), 270 (summer) and 360 (autumn). When one full martian year is analysed and compared with the phase diagram of Ca-perchlorate, the diurnal variation crosses at night time the boundary of liquid stability (REMS corresponding measurement data set shown in cyan) allowing for transient liquid stability at the ground surface (see Fig. 1b, and the diurnal cycle in Supplementary Figs 2 and 3). As shown in Supplementary Fig. 4, the local diurnal cycle also allows for transient liquid water stability in the uppermost 5 cm of the subsurface at night time during the full winter season. These conditions allowing for transient liquid water are not compatible with the known requirements for replication and metabolism of terrestrial microorganisms⁸; see Fig. 1b, where the phase diagram of Ca-perchlorate⁶ is compared with the evolution of the (night time) minimum T_g and maximum RH_g (expressed as water activity (a.w.), which in equilibrium with the atmosphere is equal to the RH divided by 100). The diurnal maximum and minimum ground surface temperatures (T_g^{max} and T_g^{min}) measured by REMS throughout the mission and the diurnal range of modelled subsurface temperatures at a depth of 15 cm ($T_{-15\text{cm}}$) are shown in Fig. 2a. A fully coupled heat and mass transfer model assuming a constant thermal inertia has been used to estimate the diurnal subsurface temperature profile and water activity¹⁶, based on REMS data. In parallel, a simplified subsurface model has been used to derive the mean diurnal $T_{-15\text{cm}}$ (as extrapolation of the measured diurnal ground surface temperatures) accounting for the site-to-site variation of thermal inertia. At a depth of 15 cm and throughout all of the year and at all of the sites visited by Curiosity, the subsurface temperature ($T_{-15\text{cm}}$) is below the known temperature requirements for replication and metabolism of terrestrial microbial life forms (Fig. 2a).



Fluidized-sediment pipes in Gale crater, Mars, and possible Earth analogs

David M. Rubin, A.G. Fahn, J. Martínez-Frías, J. Frydenvang, O. Gasnault, G. Gelfenbaum, W. Goetz, J.P. Grotzinger, S. Le Mouélic, N. Mangold, H. Newsom, D.Z. Oehler, W. Rapin, J. Schieber, R.C. Wiens

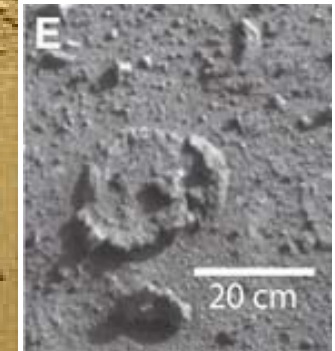
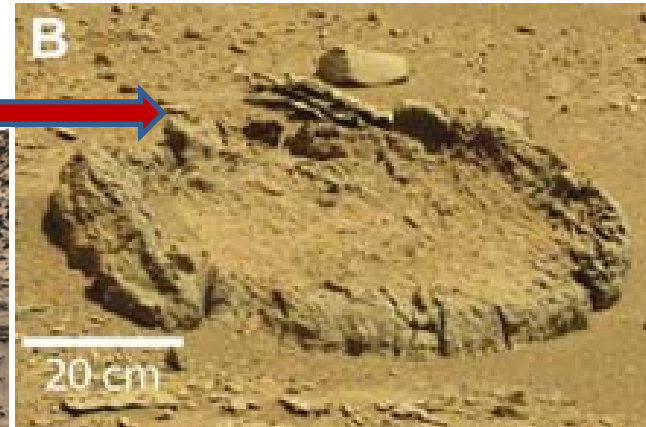
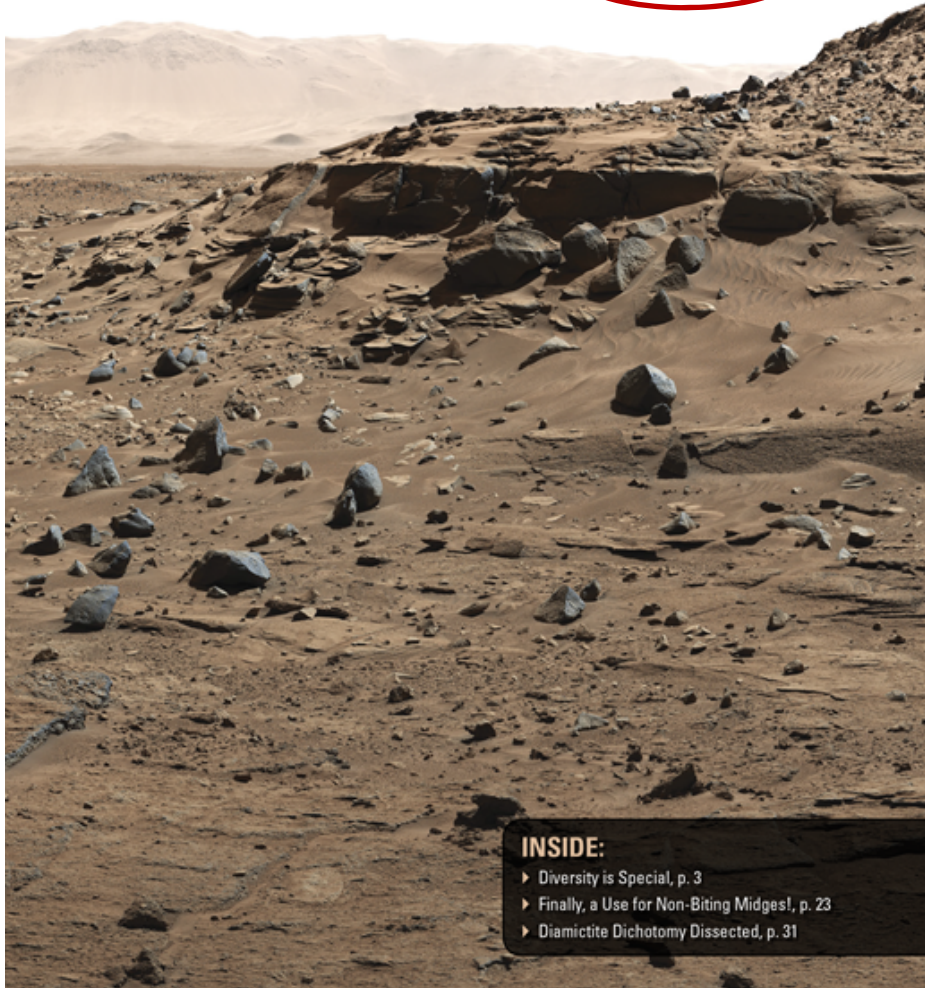
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GEOLOGICAL
SOCIETY
OF AMERICA®

GEOLOGY

ISSN 0091-7613

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INSIDE:

- ▶ Diversity is Special, p. 3
- ▶ Finally, a Use for Non-Biting Midges!, p. 23
- ▶ Diamicite Dichotomy Dissected, p. 31

El módulo 'Insight'

InSight (Exploration using **Seismic Investigations, Geodesy and Heat Transport**)



Cámara

Twins
Sensores de viento y temperatura (fabricación española)

Antena RISE
(uno a cada lado)
Rastrea la ubicación del módulo de aterrizaje para determinar cuánto oscila el Polo Norte marciano al orbitar el Sol

Gancho

Antena UHF

Paneles solares

Cámara

Brazo robótico
Coloca los instrumentos en la superficie del planeta

Sismógrafo SEIS
Las mediciones de las ondas sísmicas de los temblores subterráneos de Marte revelarán la estructura geológica del planeta

HP³
Sonda de flujo de calor que analizará las propiedades físicas del terreno

HP³
Perfora casi cinco metros para registrar la temperatura interior. A partir de estos registros puede averiguar el calor que fluye desde el núcleo

Aterrizó en Marte el 26 Noviembre de 2018

MISIÓN INSIGHT A MARTE

ESTUDIARÁ LA GEOLOGÍA MARCIANA

SUS INSTRUMENTOS

infobae

InSight:
(Interior Exploration using Seismic Investigations, Geodesy and Heat Transport)

Brazo de despliegue de instrumentos

Duración de la misión:
2 años

Sensores de temperatura y viento

Cámara

Antenas

RISE, Instrumento para conocer las variaciones del eje de rotación de Marte

Sismómetro SEIS
Mide las vibraciones sísmicas

Sensor de calor HP3
Analiza la velocidad de enfriamiento de Marte para reconstruir el "histórico térmico"

Corteza

Manto

núcleo externo rico en hierro

Núcleo interno:
los datos de RISE podrían determinar si el núcleo es líquido o sólido

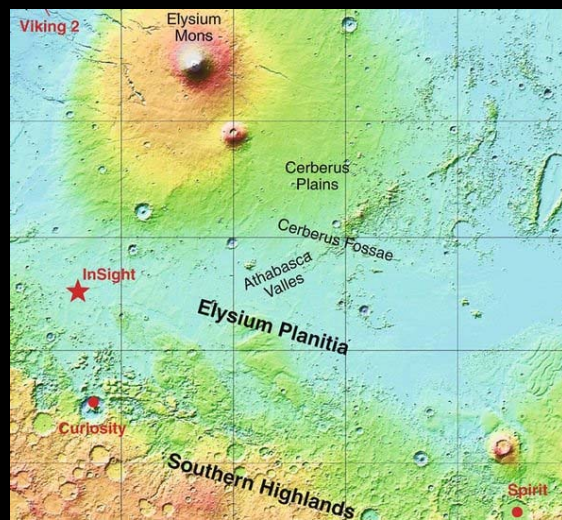
Lugar de aterrizaje:
porción occidental de planicie plana adecuada para excavar

FUENTE: Nasa/ Infobae

INFOGRAFÍA: Marcelo Regalado

muy CIENCIA SALUD TÉCNO CURIOSIDADES NATURALEZA MUY GAMER PODCAST

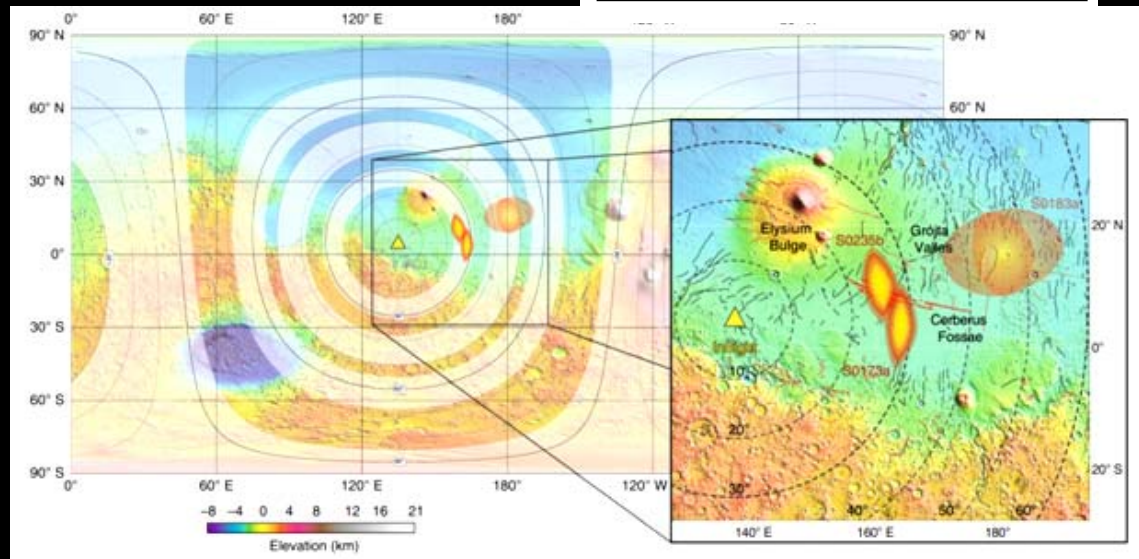
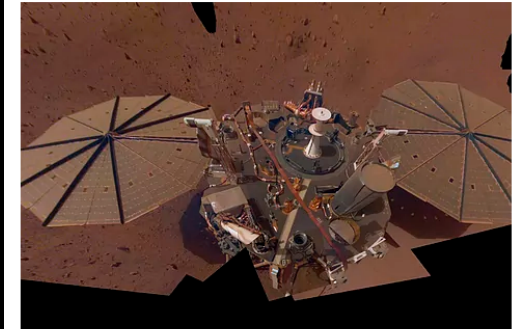
Marte está geológicamente activo, confirma la NASA



MISIÓN DE LA NASA · Primeros resultados del robot 'InSight'

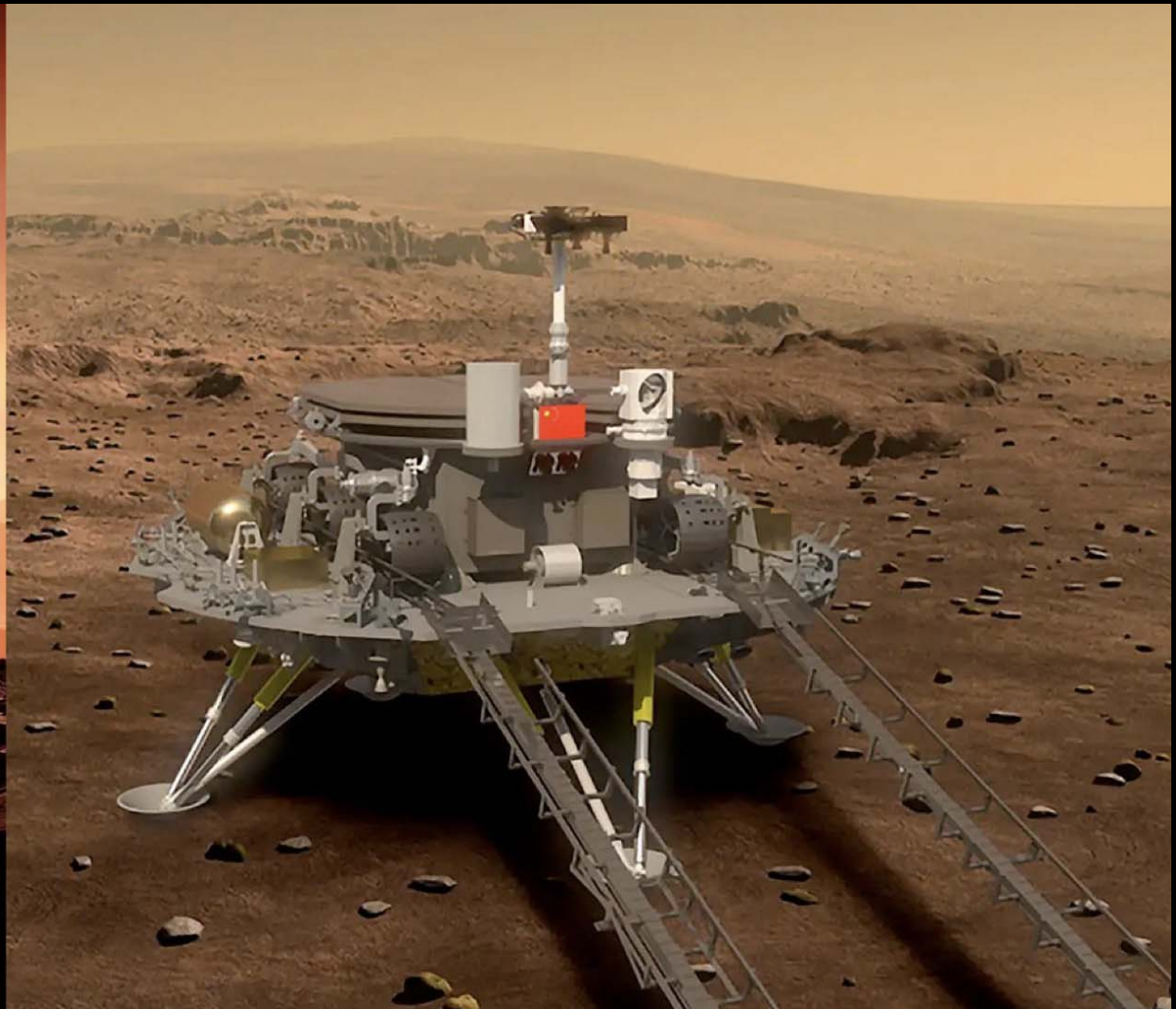
Marte no está muerto geológicamente: sufrió 174 terremotos en 10 meses

El análisis de los datos recogidos por la sonda 'InSight' durante 10 meses revelan que el planeta rojo es sísmicamente activo y que su campo magnético local es 10 veces más intenso de que lo que se creía





HOPE - Emiratos Árabes Unidos Inserción: 9 Febrero 2021



TIANWEN 1- CHINA Inserción: 10 Febrero 2021
Aterrizaje: Mayo 2021 (Utopia Planitia)

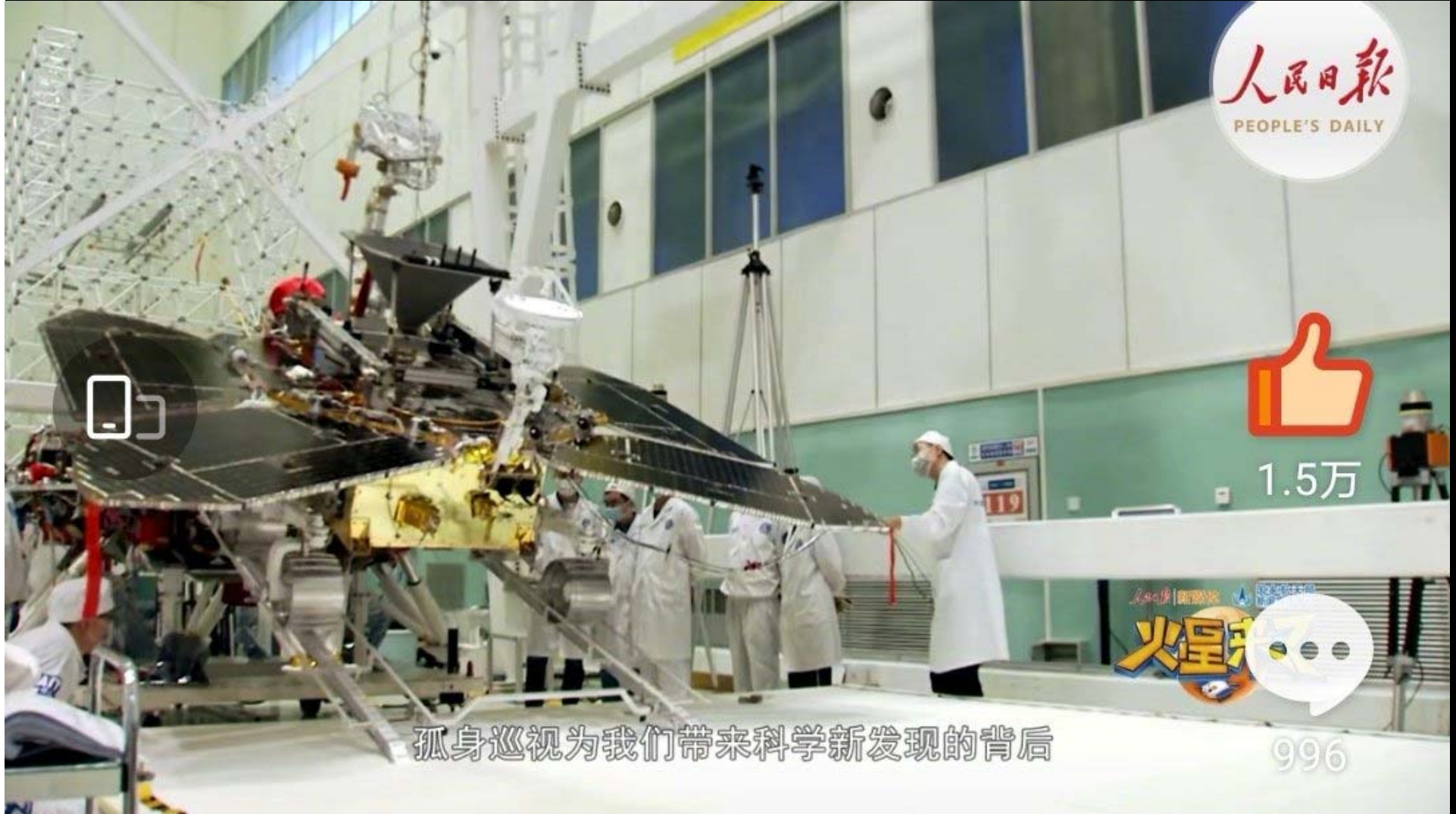


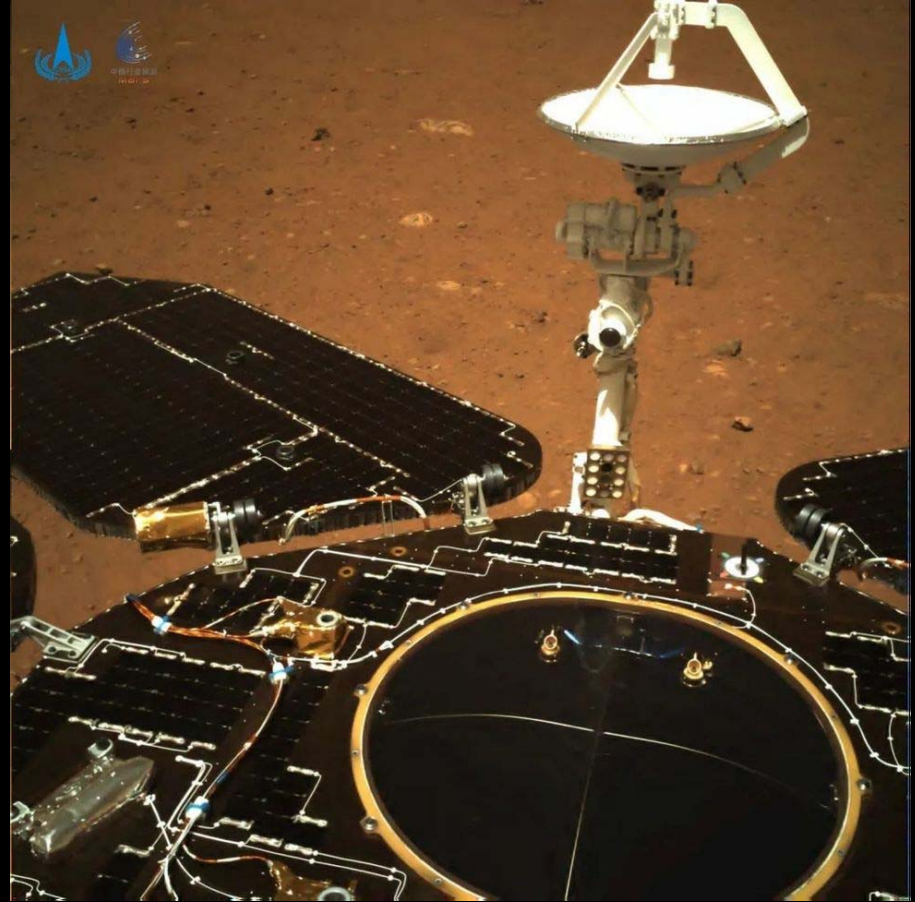
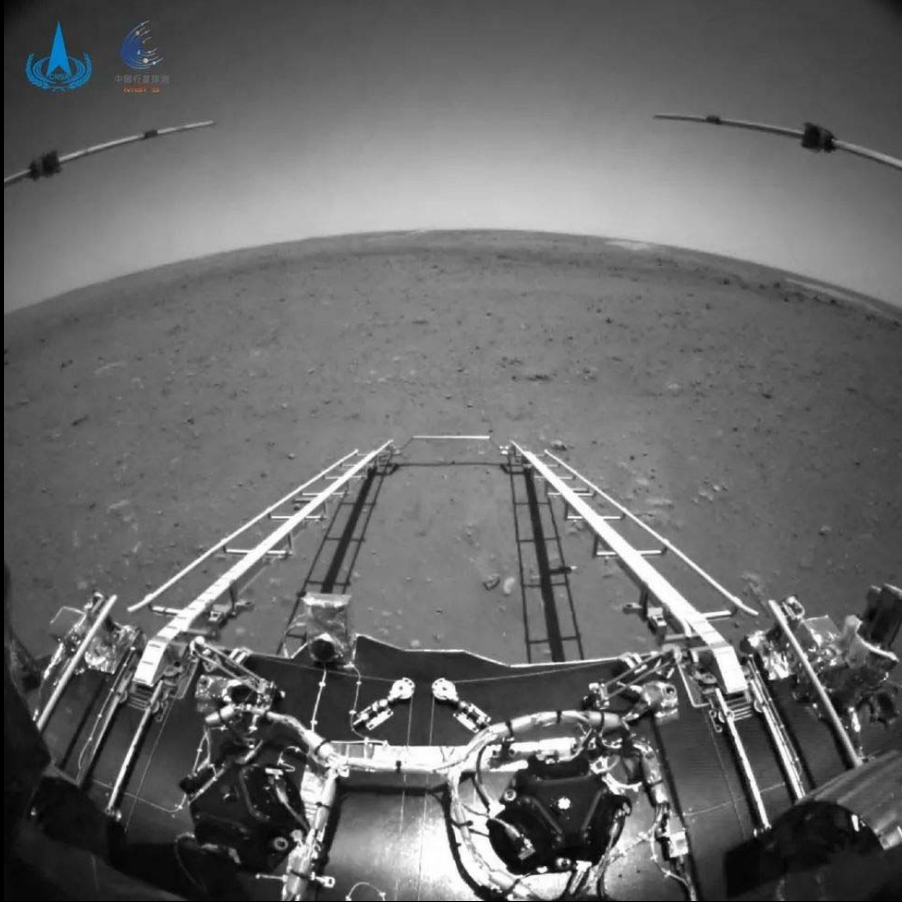
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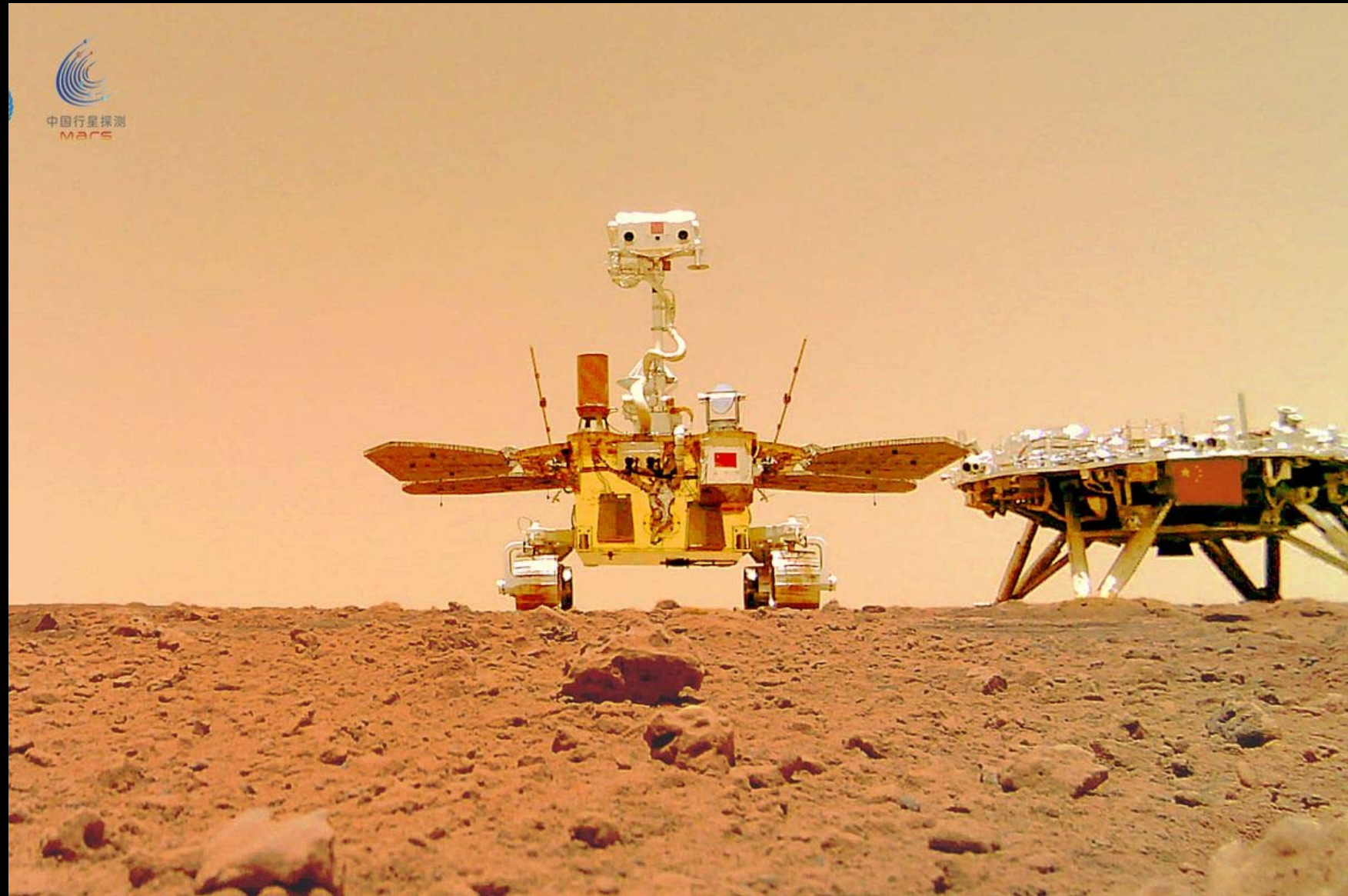


996

孤身巡视为我们带来科学新发现的背后





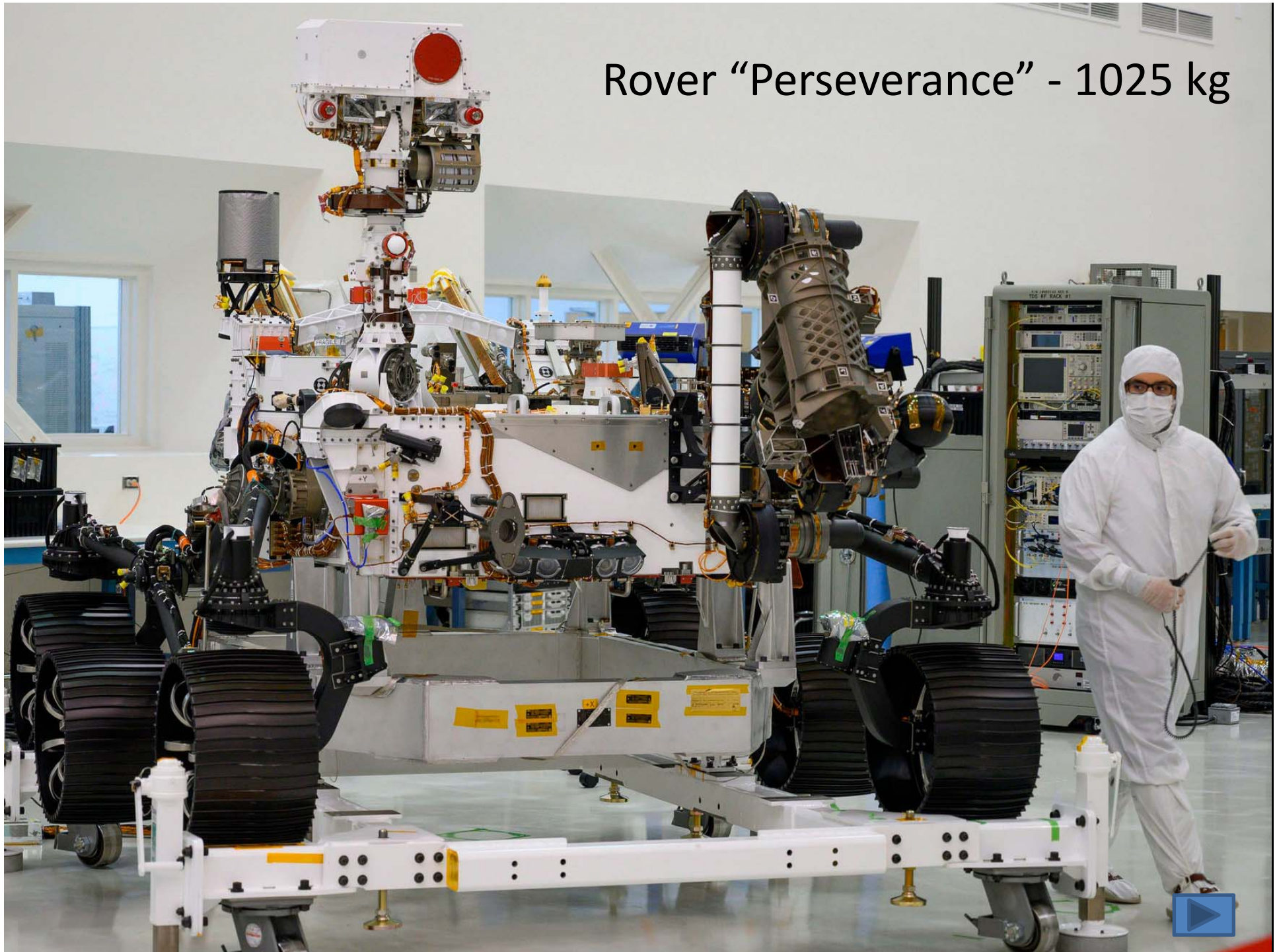


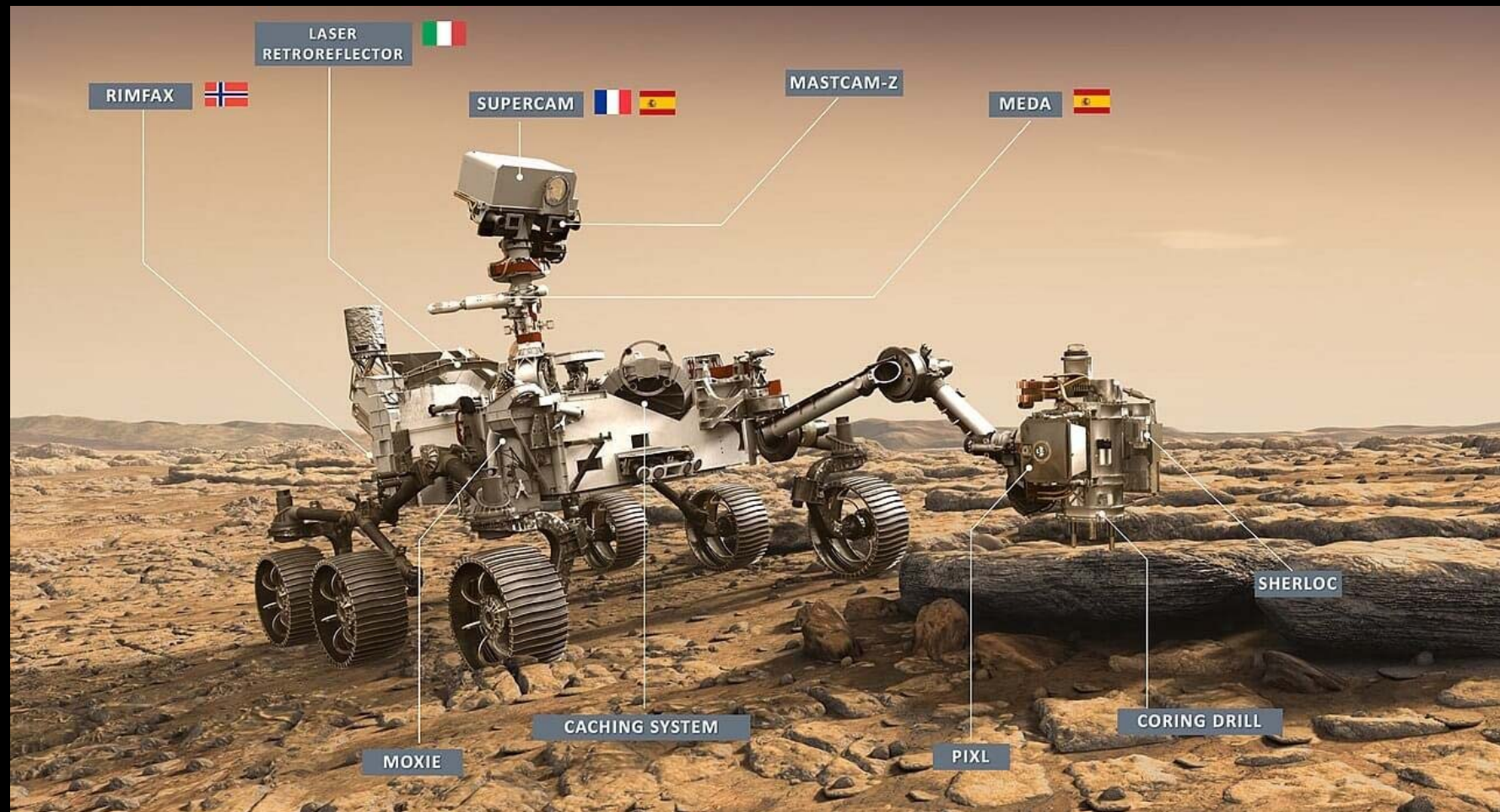
The “touring group photo,” as the China National Space Administration calls it , was taken with a small wireless camera that the rover (Zhurong) placed on the surface

ESA-ExoMars rover: "Rosalind Franklin"



Rover "Perseverance" - 1025 kg





PIXL: espectrómetro de fluorescencia de rayos X para determinar la composición elemental. JPL.

MEDA. estación meteorológica (temperatura, humedad, tamaño y forma del polvo, velocidad y dirección del viento).

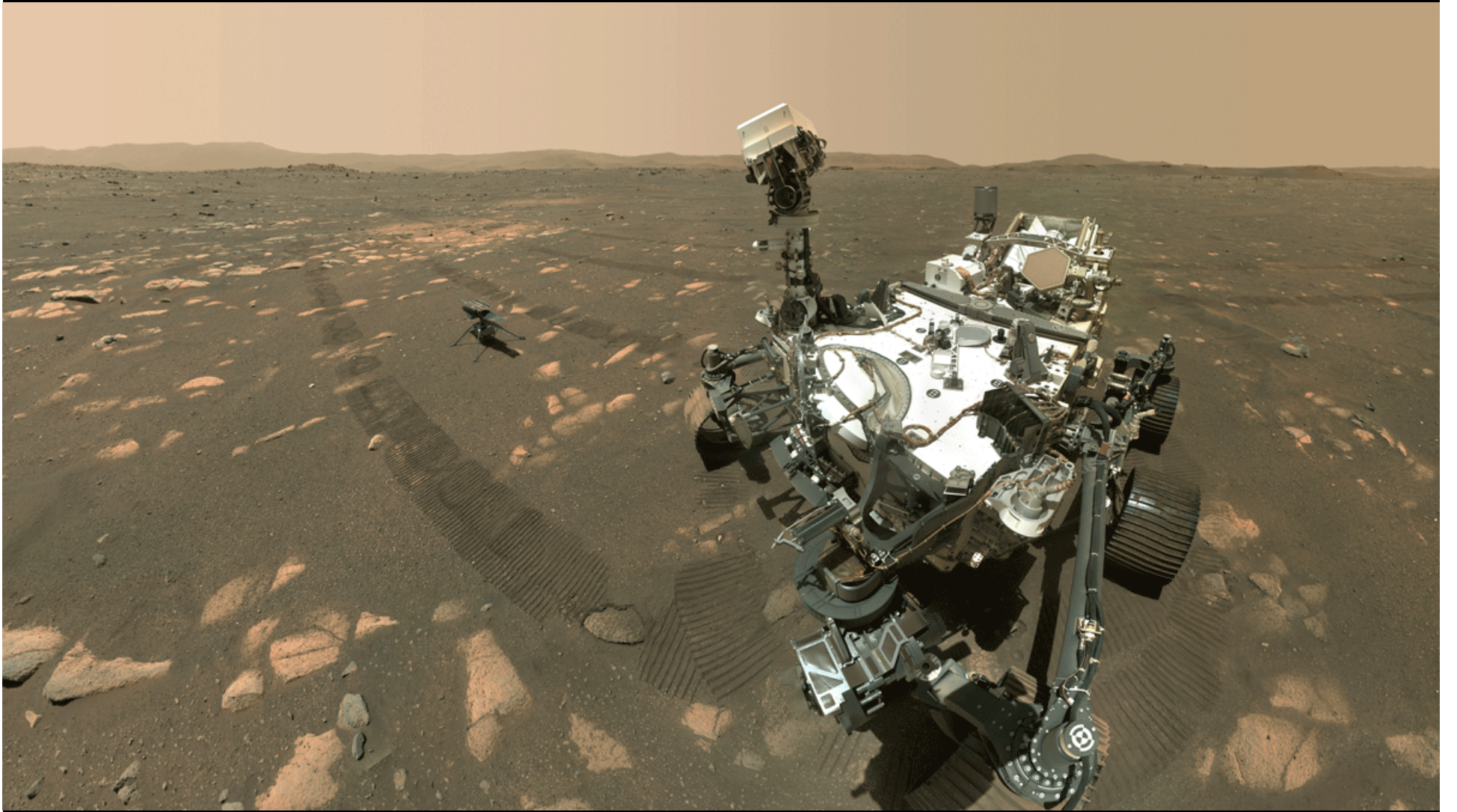
SHERLOC examinará Raman y luminiscencia muestras superficiales para conocer su composición y encontrar compuestos orgánicos. JPL

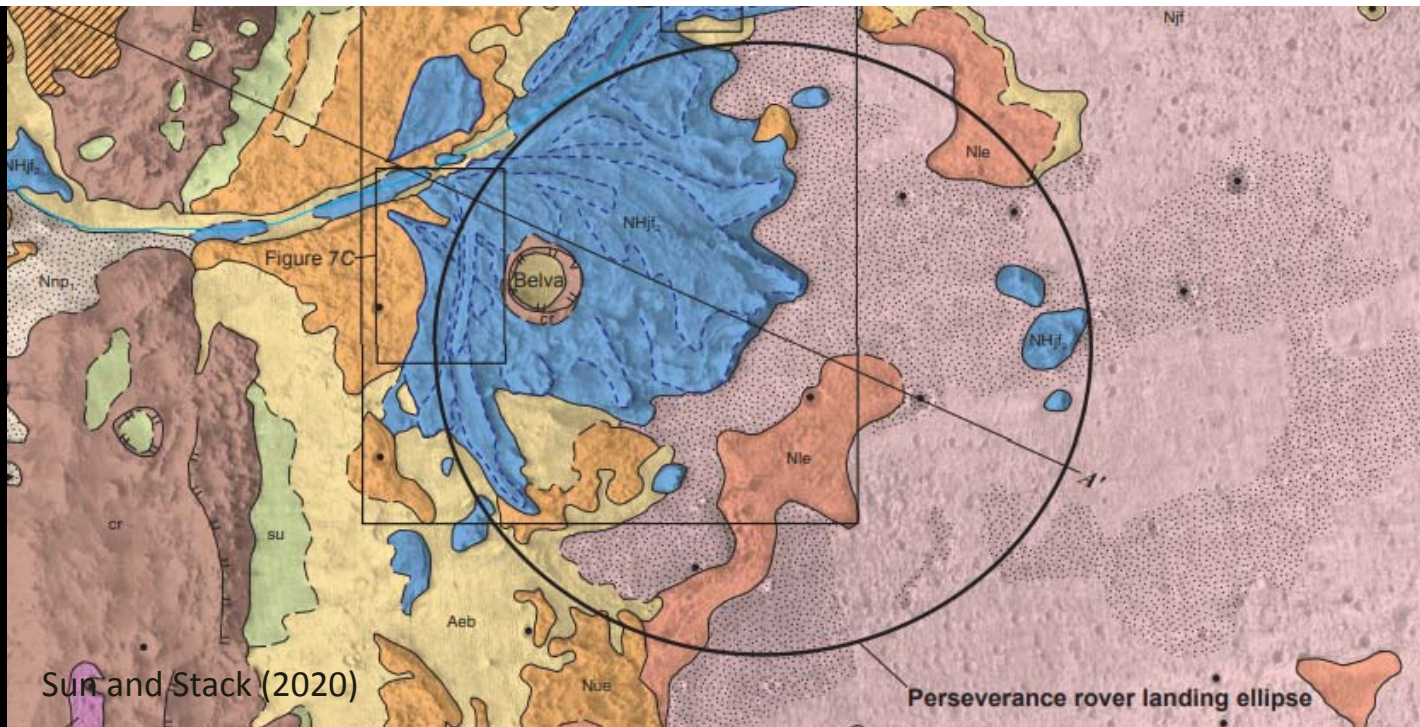
RIMFAX : georradar que utilizará un radar para explorar bajo tierra y conocer la geología de la zona. Instituto Forsvarets Forskning, Noruega.

SuperCam puede detectar compuestos orgánicos presentes en rocas y regolito, a través de la mineralogía y análisis de composición química. Los Álamos.

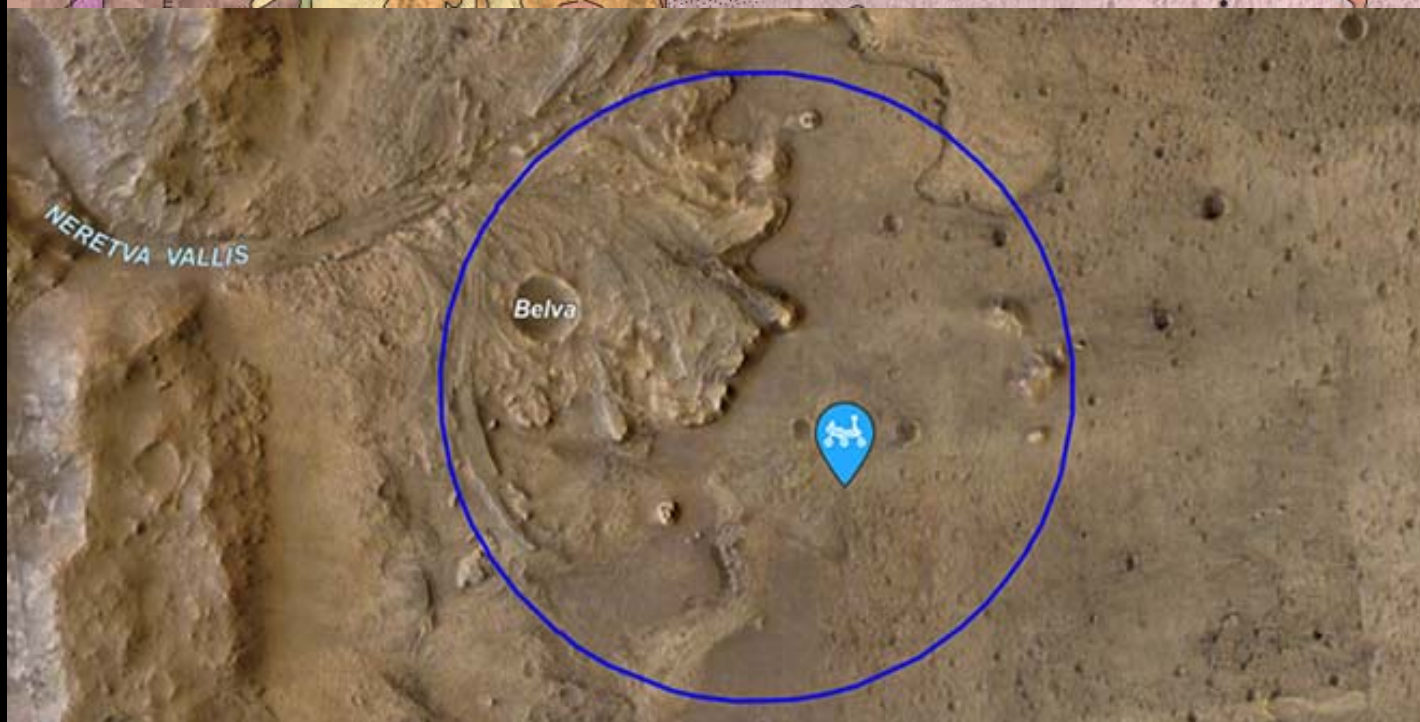
MOXIE : para producir oxígeno a partir de la atmósfera de Marte (CO₂). Liderado por el MIT

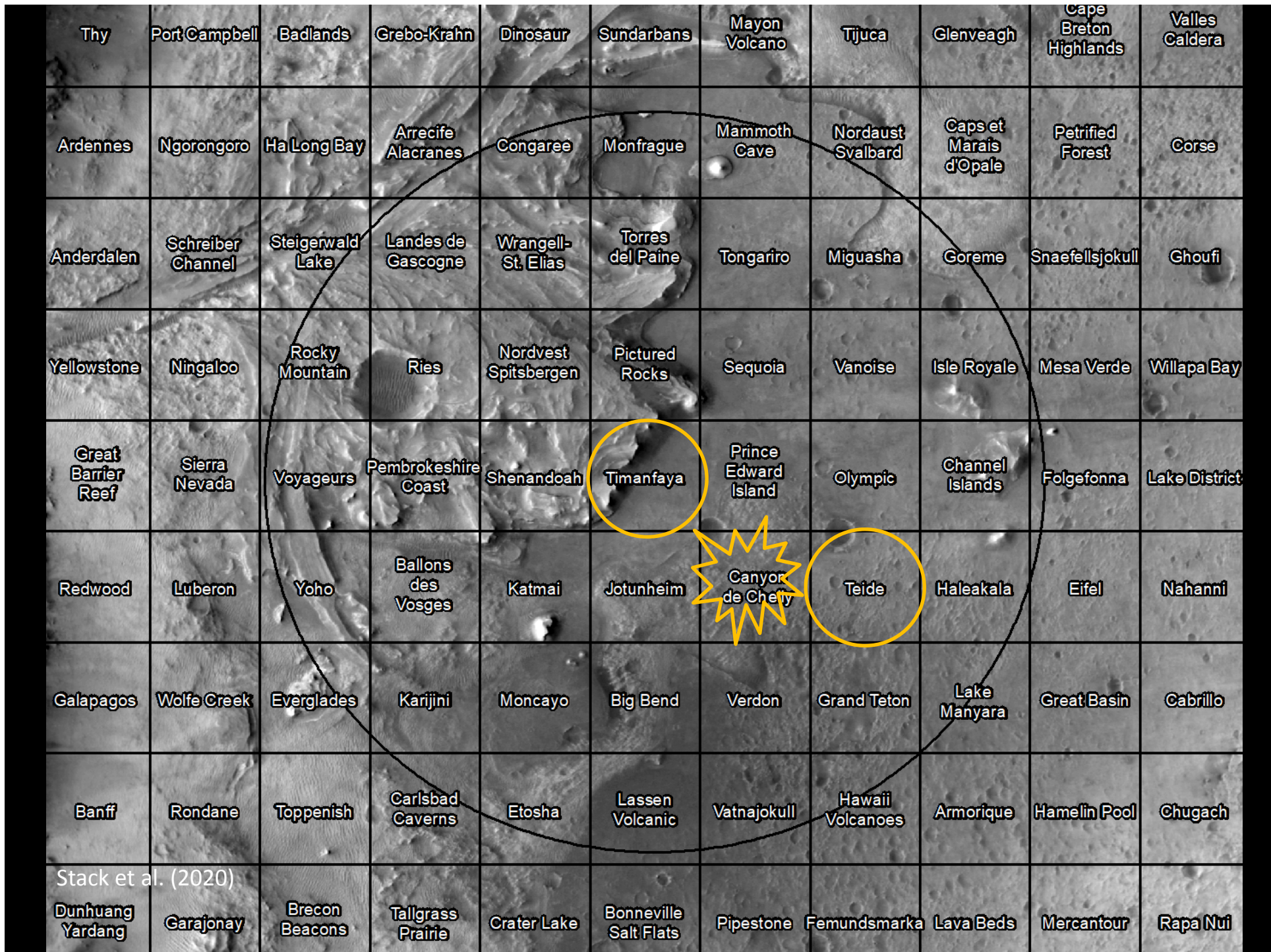
Mastcam-Z : sistema de cámaras (zoom) y tomar imágenes panorámicas o espectroscópicas. Universidad del Estado de Arizona.

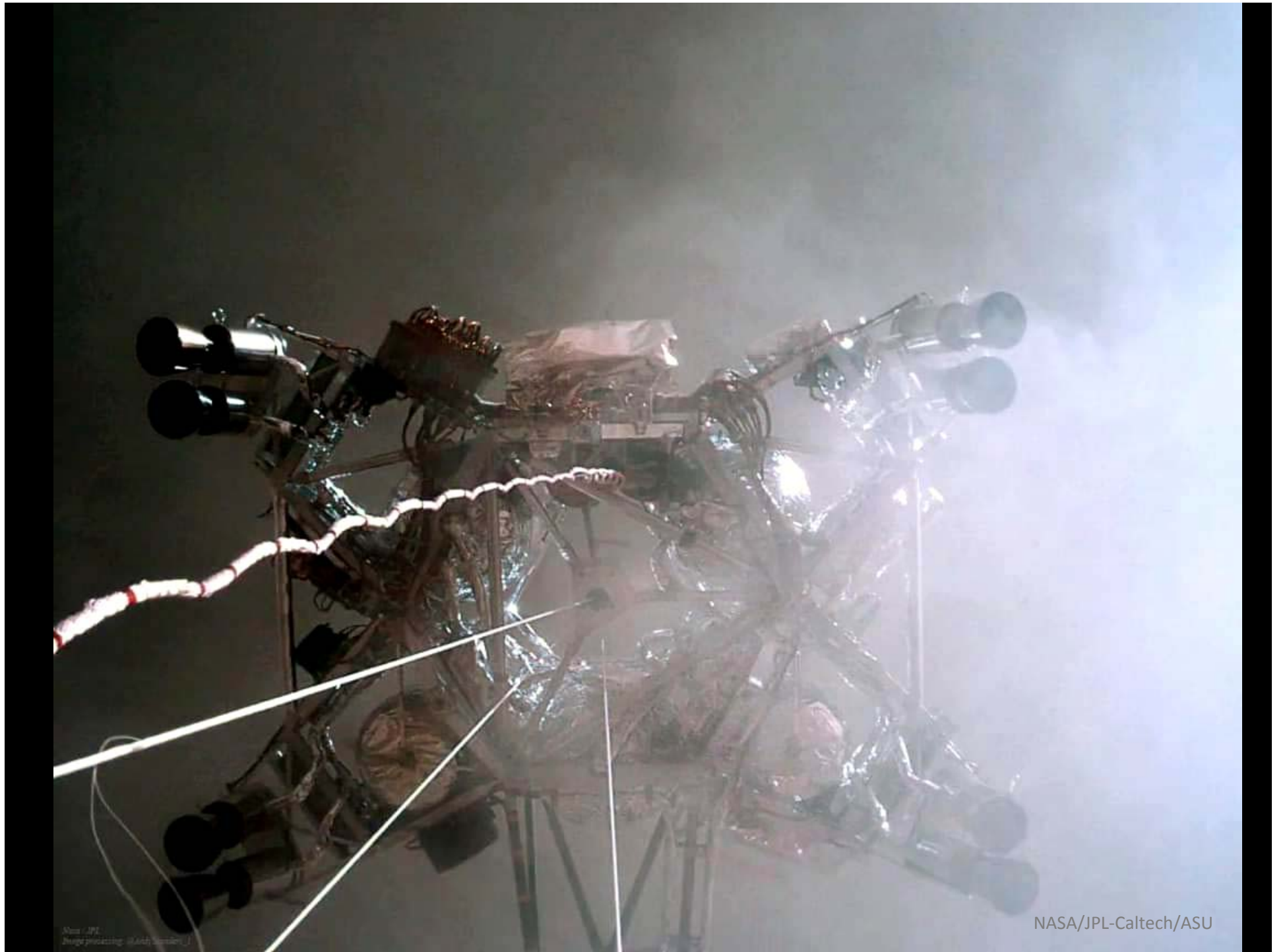




Sun and Stack (2020)

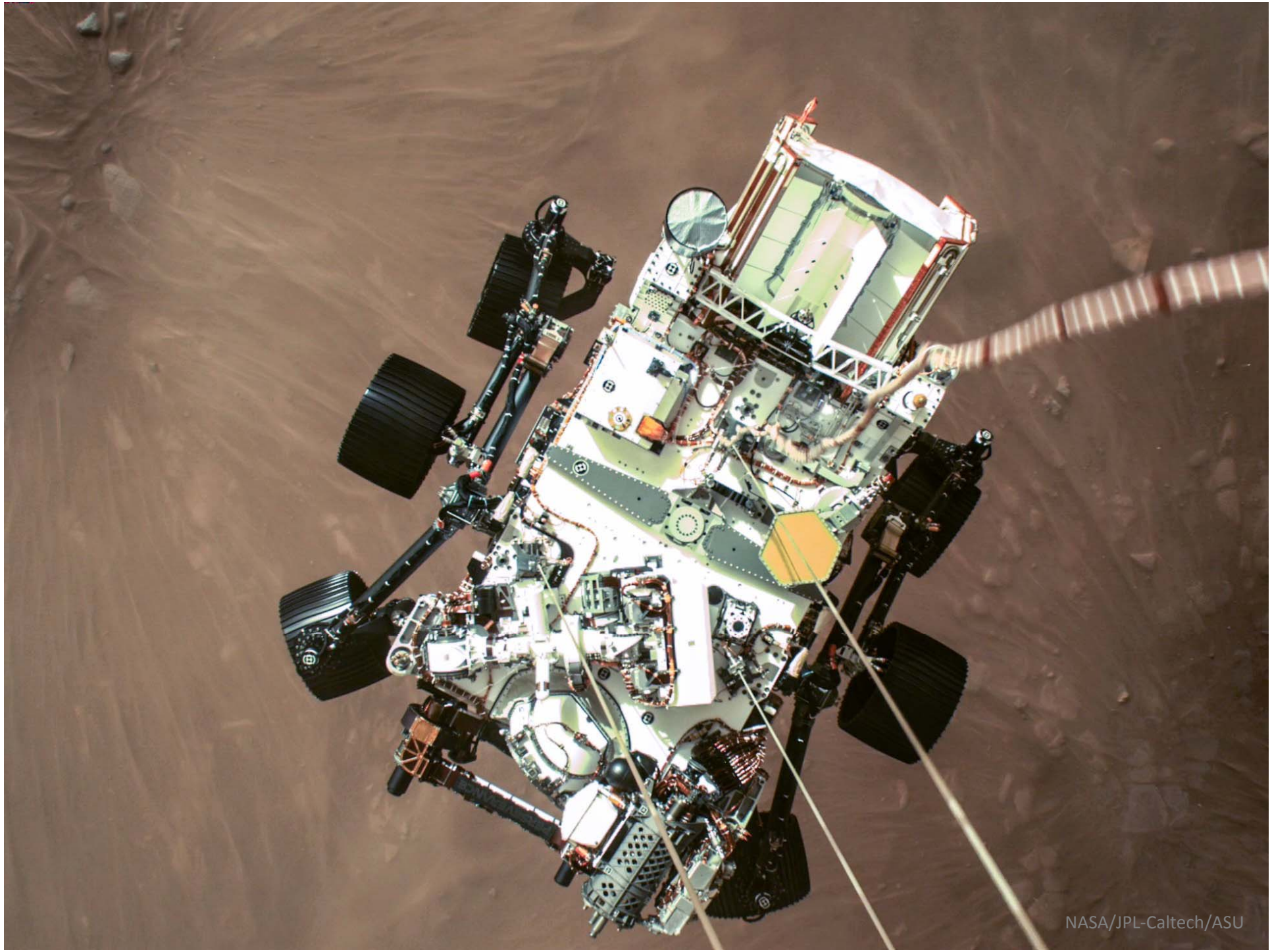






NASA/JPL
Image processing: @AshleySimpson

NASA/JPL-Caltech/ASU





7 de Octubre de 2021

Science

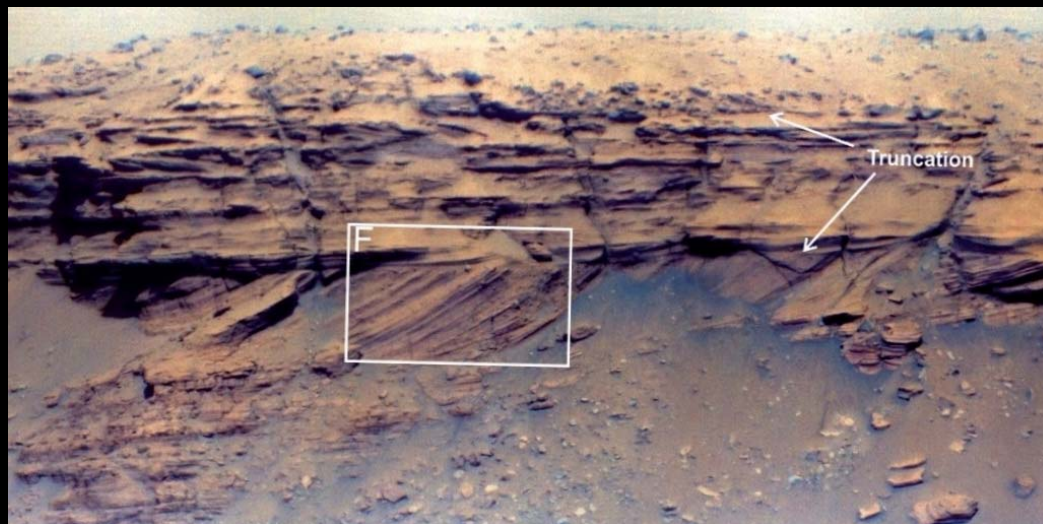
RESEARCH ARTICLES

Cite as: N. Mangold *et al.*, *Science*
10.1126/science.abl4051 (2021).

Perseverance rover reveals an ancient delta-lake system and flood deposits at Jezero crater, Mars

N. Mangold^{1*†}, S. Gupta^{2†}, O. Gasnault³, G. Dromart⁴, J. D. Tarnas⁵, S. F. Sholes⁵, B. Horgan⁶,
C. Quantin-Nataf⁴, A. J. Brown⁷, S. Le Mouélic¹, R. A. Yingst⁸, J. F. Bell⁹, O. Beyssac¹⁰, T. Bosak¹¹, F. Calef III⁵,
B. L. Ehlmann¹², K. A. Farley¹², J. P. Grotzinger¹², K. Hickman-Lewis^{13,14}, S. Holm-Alwmark^{15,16,17}, L. C. Kah¹⁸,
J. Martinez-Frias¹⁹, S. M. McLennan²⁰, S. Maurice³, J. I. Nuñez²¹, A. M. Ollila²², P. Pilleri³, J. W. Rice Jr.⁸,
M. Rice²³, J. T. Simon²⁴, D. L. Shuster²⁵, K. M. Stack⁵, V. Z. Sun⁵, A. H. Treiman²⁶, B. P. Weiss^{5,11}, R. C. Wiens²²,
A. J. Williams²⁷, N. R. Williams⁵, K. H. Williford^{5,28}

¹Laboratoire Planétologie et Géodynamique, Centre National de Recherches Scientifiques, Université Nantes, Université Angers, Unité Mixte de Recherche 6112, 44322



PLANETARY SCIENCE

Compositionally and density stratified igneous terrain in Jezero crater, Mars

Roger C. Wiens^{1†*}, Arya Udry², Olivier Beyssac³, Cathy Quantin-Nataf⁴, Nicolas Mangold⁵, Agnès Cousin⁶, Lucia Mandon⁷, Tanja Bosak⁸, Olivier Forné⁶, Scott M. McLennan⁹, Violaine Sautter³, Adrian Brown¹⁰, Karim Benzerara³, Jeffrey R. Johnson¹¹, Lisa Mayhew¹², Sylvestre Maurice⁶, Ryan B. Anderson¹³, Samuel M. Clegg¹, Larry Crumpler¹⁴, Travis S. J. Gabriel¹³, Patrick Gasda¹, James Hall⁸, Briony H. N. Horgan¹⁵, Linda Kah¹⁶, Carey Legett IV¹, Juan Manuel Madaralaga¹⁷, Pierre-Yves Meslin⁶, Ann M. Ollila¹, Francois Poulet¹⁸, Clement Royer⁷, Shiv K. Sharma¹⁹, Sandra Siljeström²⁰, Justin I. Simon²¹, Tayro E. Acosta-Maeda¹⁹, Cesar Alvarez-Llamas²², S. Michael Angel²³, Gorka Arana¹⁷, Pierre Beck²⁴, Sylvain Bernard³, Tanguy Bertrand⁷, Bruno Bousquet²⁵, Kepa Castro¹⁷, Baptiste Chide¹, Elise Clavé²⁵, Ed Cloutis²⁶, Stephanie Connell²⁶, Erwin Dehouck⁴, Gilles Dromart⁴, Woodward Fischer²⁷, Thierry Fouchet⁷, Raymond Francis²⁸, Jens Frydenvang²⁹, Olivier Gasnault⁶, Erin Gibbons³⁰, Sanjeev Gupta³¹, Elisabeth M. Hausrath², Xavier Jacob³², Hemani Kalucha²⁷, Evan Kelly¹⁹, Elise Knutsen³³, Nina Lanza¹, Javier Laserna²², Jeremie Lasue⁶, Stéphane Le Mouéllé⁵, Richard Levelle³⁰, Guillermo Lopez Reyes³⁴, Ralph Lorenz¹¹, Jose Antonio Manrique³⁴, **Jesus Martinez-Frias³⁵**, Tim McConnochie³⁶, Noureddine Melikechi³⁷, David Milmoun³⁸, Franck Montmessin³³, Javier Moros²², Naomi Murdoch³⁸, Paolo Pilleri⁶, Cedric Pilorget¹⁸, Patrick Pinet⁶, Willam Rapin⁶, Fernando Rull³⁴, Susanne Schröder³⁹, David L. Shuster⁴⁰, Rebecca J. Smith⁹, Alexander E. Stott³⁸, Jesse Tarnas²⁸, Nathalie Turenne²⁶, Marco Veneranda³⁴, David S. Vogt³⁹, Benjamin P. Weiss⁸, Peter Willis²⁸, Kathryn M. Stack²⁸, Kenneth H. Williford^{28,41}, Kenneth A. Farley²⁷, The SuperCam Team†

Before Perseverance, Jezero crater's floor was variably hypothesized to have a lacustrine, lava, volcanic airfall, or aeolian origin. SuperCam observations in the first 286 Mars days on Mars revealed a volcanic and intrusive terrain with compositional and density stratification. The dominant lithology along the traverse is basaltic, with plagioclase enrichment in stratigraphically higher locations. Stratigraphically lower, layered rocks are richer in normative pyroxene. The lowest observed unit has the highest inferred density and is olivine-rich with coarse (1.5 millimeters) euhedral, relatively unweathered grains, suggesting a cumulate origin. This is the first martian cumulate and shows similarities to martian meteorites, which also express olivine disequilibrium. Alteration materials including carbonates, sulfates, perchlorates, hydrated silicates, and iron oxides are pervasive but low in abundance, suggesting relatively brief lacustrine conditions. Orbital observations link the Jezero floor lithology to the broader Nili-Syrtis region, suggesting that density-driven compositional stratification is a regional characteristic.

INTRODUCTION

Jezero crater was selected as the landing site of the Perseverance rover based on strong astrobiological potential and attributes important for sample return (1). Jezero is located (18.4°N, 77.5°E) near

planet with a CO₂-dominated atmosphere should have left ubiquitous carbonate deposits (11), but these are unexpectedly sparse. Exploration of the existing carbonates at Jezero and the specific conditions that produced these carbonates should help understand the common

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25 de Agosto de 2022

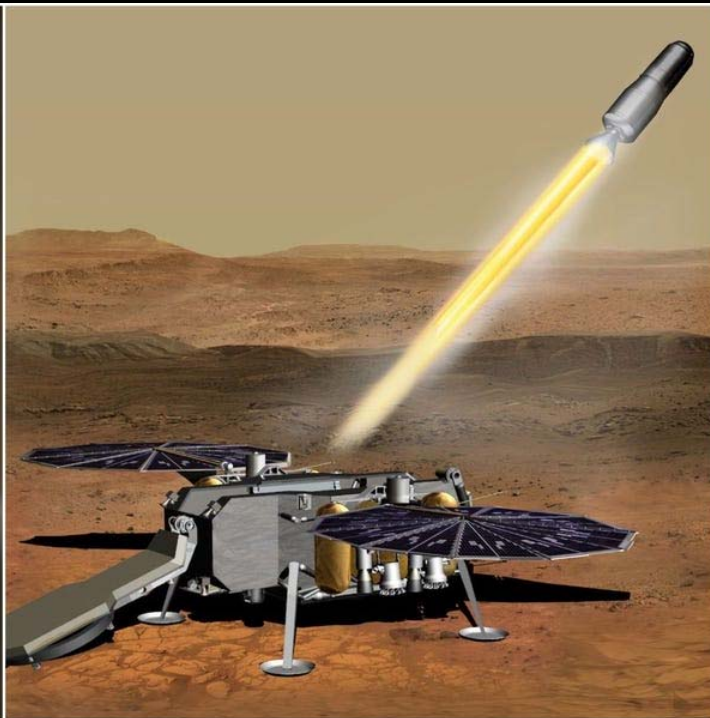
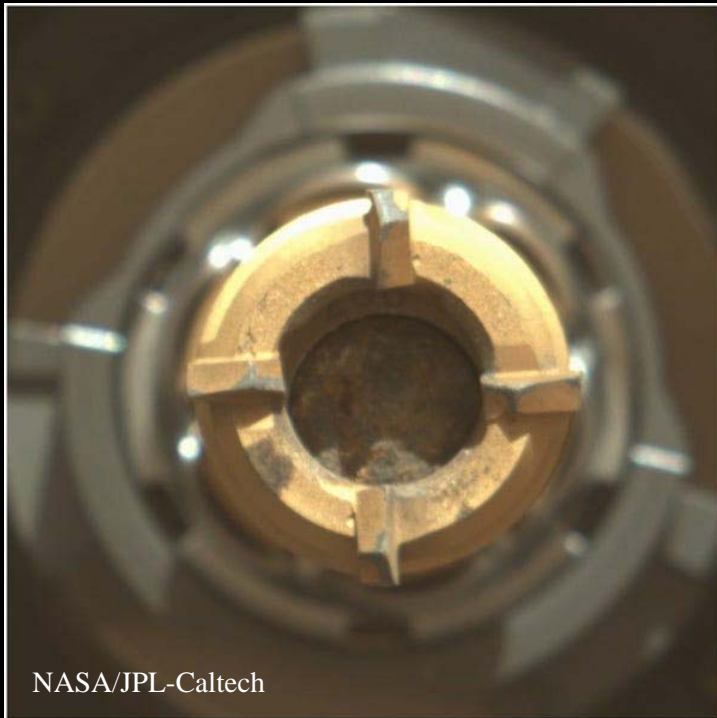


MARS 2020 PERSEVERANCE

Sample Collection Map: Tubes 1-21



NASA/JPL-Caltech
Dic/2022





PANGAEA

Planetary ANalogue Geological & Astrobiological Exercise for Astronauts

PANGAEA INSTRUCTORS

The Pangaea course is grateful for the scientific and logistic support from the following institutions: CISAS (Center of Studies and Activities for Space - University of Padova), Cabildo Insular of Lanzarote, National Park of Timanfaya, IGEO (Institute of Geociencias - CSIC - Universidad Complutense de Madrid) and Geoparque Lanzarote.

Instructors

Massironi Matteo	Scientific Coordinator and Prime Instructor	Italy	Professor of Structural and Planetary Geology, Department of Geosciences, CISAS, University of Padova
Hiesinger Harald	Instructor of Lunar Geology	Germany	Professor of Planetary Geology, Institute for Planetology, University of Münster
Mangold Nicolas	Instructor of Mars Sedimentary Environments	France	Director of the Laboratory of planetology and geodynamics, Nantes
Fioretti Anna Maria	Instructor of Meteorites	Italy	Senior Researcher, CNR – Institute of Geosciences and Earth Resources, Padova
Sauro Francesco	Course Designer and Coordinator, Instructor of Sedimentary Geology	Italy	Extraordinary Professor of Planetary Geology, BIGEA, University of Bologna
Pozzobon Riccardo	Responsible for Course Training Material	Italy	PhD in Geology, Department of Geosciences, University of Padova
Cockell Charles	Astrobiology and Geo-Microbiology Instructor	United Kingdom	Professor of Astrobiology, University of Edinburgh
Gerhard Kminek	Planetary Protection Instructor	Austria	ESA Planetary Protection Officer
Frias Jesús Martínez	Instructor of Lanzarote Geology and Planetary Analogues	Spain	Professor of Planetary Geochemistry, Instituto de Geociencias IGEO (CSIC-UCM), Madrid
Debei Stefano	EXOMARS Seminar Lecturer, Director of CISAS	Italy	Professor of Mechanics, Department of Industrial Engineering, University of Padova

Last update: 15 September 2016



Luca Parmitano during spacewalk

PARTICIPANTS

The first students that are taking part in ESA's planetary geology course for astronauts, Pangaea, are:

- Luca Parmitano, ESA astronaut and test pilot
- Pedro Duque, ESA astronaut and engineer
- Matthias Maurer, ESA Eurocom and scientist

Luca, Pedro and Matthias have a vast experience combined with missions on the Space Shuttle and the International Space Station as well as spacewalk and mission control experience.

Their scientific background is diverse which will help enabling us to verify how well the course has been designed.



Pedro Duque on International Space Station



Poco a poco, estamos avanzando hacia la detección de huellas de vida (si es que existió o existe) y hacia la primera misión tripulada al planeta rojo. Esto representa, un primer e importante paso Astrobiológico desde esta perspectiva en un camino que alcanzará nuevas metas.

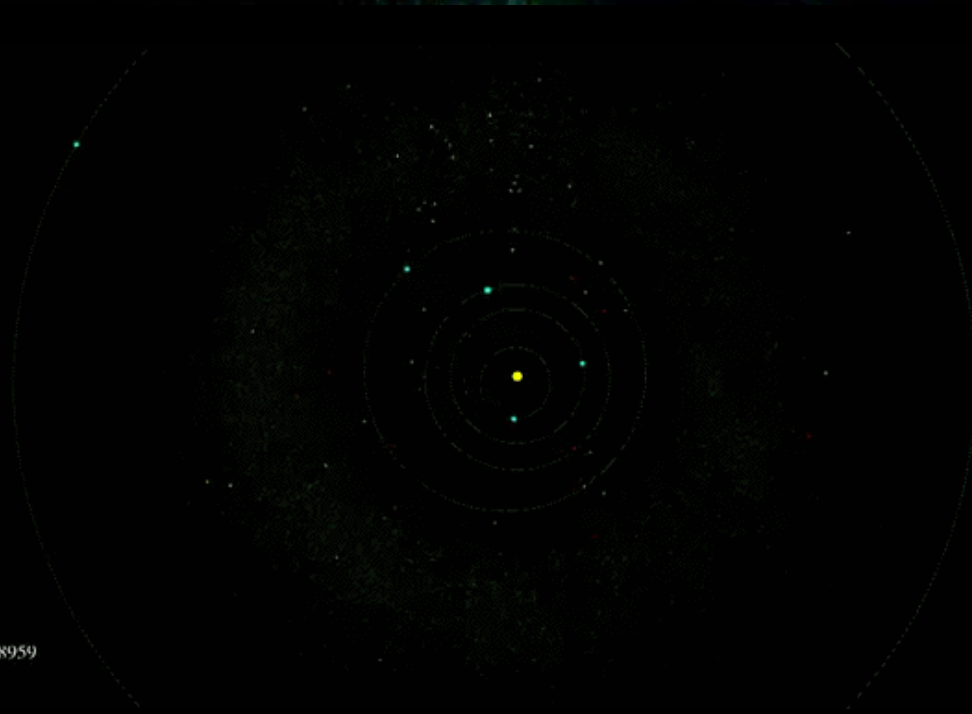
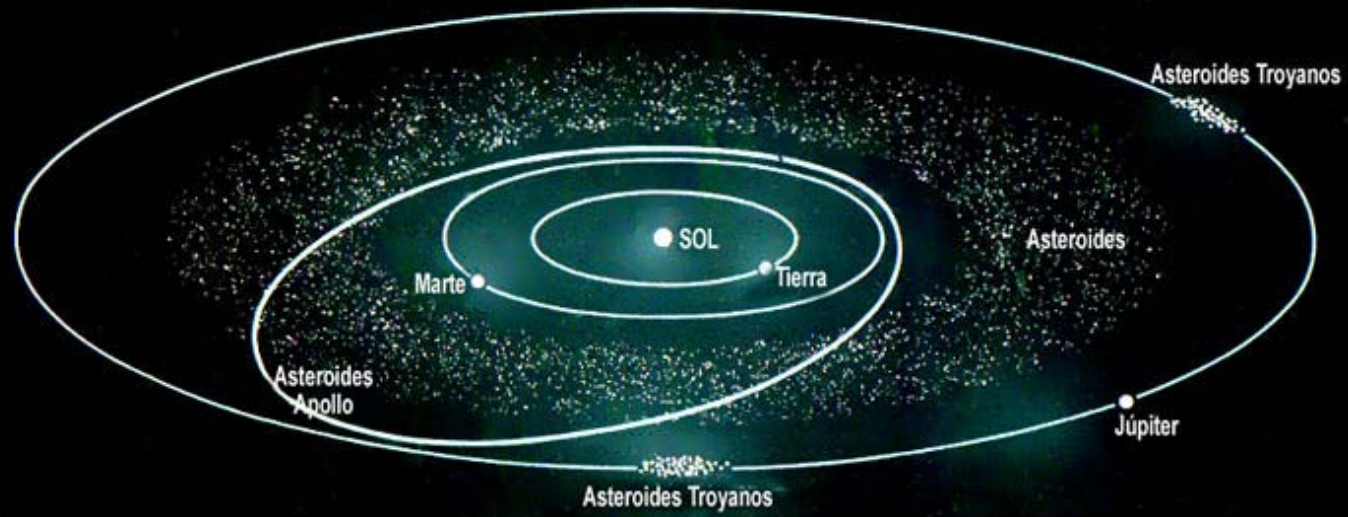


Asteroides



TIPOS DE ASTEROIDES

- Tipo C
 - Son así el 75% de los asteroides conocidos
 - Composición: carbón
 - Muy oscuros (albedo 0.03-0.09)
- Tipo S
 - Son así el 17% de los asteroides conocidos
 - Composición: metálicos (níquel-hierro, o mezclas con magnesio y silicatos)
 - Relativamente brillantes (albedo 0.10-0.22)
- Tipo M
 - Son así el 8% de los asteroides conocidos
 - Composición: níquel-hierro puro
 - Brillantes (albedo 0.10-0.18)
- Otros raros



1980 8959

ASTEROID EXPLORATION

DAWN

NASA
Launch Date: June 2007
Mission Target: Asteroid Vesta & Dwarf Planet Ceres

OSIRIS-REx

NASA
Launch Date: September 2016
Mission Target: Asteroid Bennu*

HAYABUSA

JAXA
Launch Date: May 2003
Mission Target: Asteroid Itokawa

HAYABUSA2

JAXA
Launch Date: December 2014
Mission Target: Asteroid 1999 JU3*

ROSETTA

ESA
Launch Date: March 2004
Flyby Object: Asteroids Steins & Lutetia

NEAR SHOEMAKER

NASA
Launch Date: February 1996
Mission Target: Asteroid Eros
Flyby Object: Asteroid Mathilde

STARDUST

NASA / JPL
Launch Date: February 1999
Extension: March 2006
Flyby Object: Asteroid AnnelFrank

GALILEO

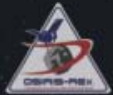
NASA / DLR
Launch Date: October 1989
Flyby Object: Asteroids Gaspra and Ida

DEEP SPACE 1

NASA / JPL
Launch Date: October 1998
Flyby Object: Asteroid Braille

CASSINI

NASA / ESA / ASI
Launch Date: October 1997
Flyby Object: Asteroid Masursky

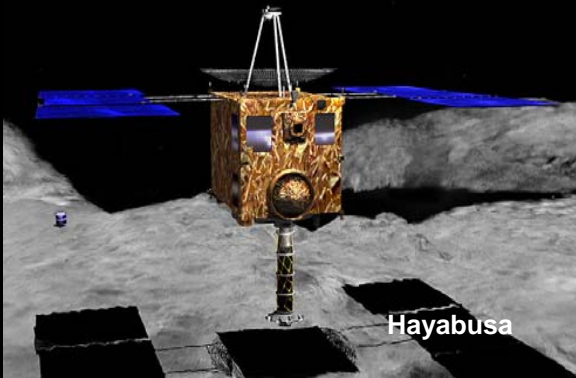
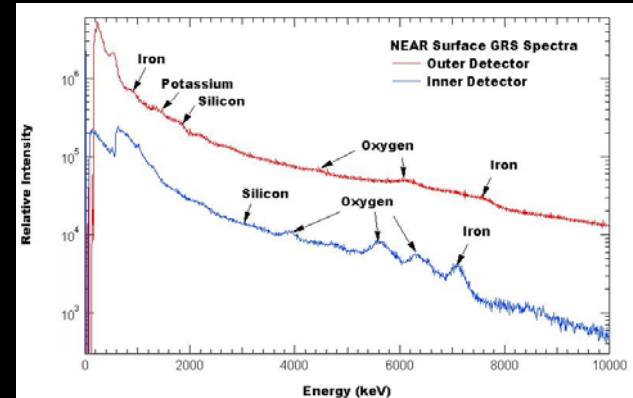
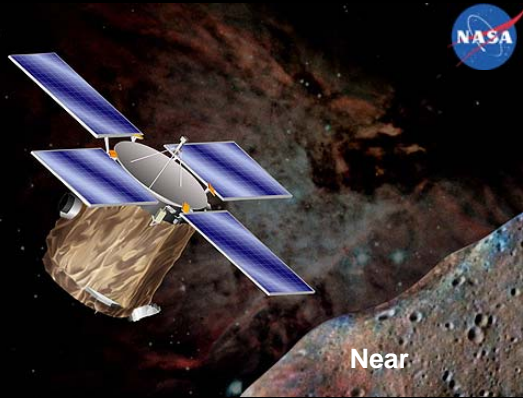


*Artist's Concept

RELATIVE SIZES



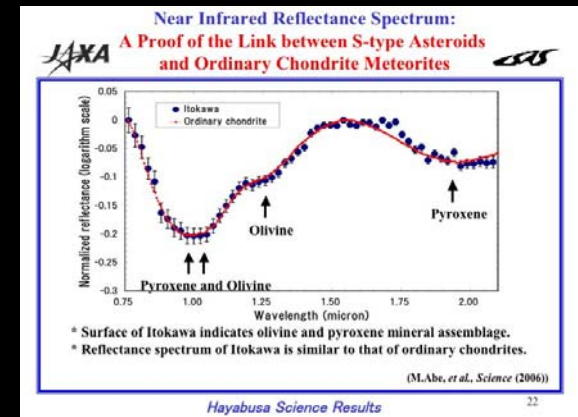
Eros es un asteroide de aproximadamente 33x13x13 km. El 14 de febrero de 2000 la nave espacial Near se insertó con éxito en la órbita alrededor de Eros. **Se convirtió en el primer satélite artificial que orbitaba alrededor de un asteroide** y pudo tomar imágenes y realizar análisis geoquímicos de su superficie regolítica.



©JAXA



Asteroide 25143 Itokawa (535m x 294 m x 209 m). Hayabusa aterrizó el 20 de Noviembre de 2005 durante 30 minutos, pero falló al operar el dispositivo de toma de muestras. El 25 de Noviembre lo intentó de nuevo y abandonó el asteroide. Aterrizó en 2010 y consiguió muestrear la superficie del asteroide



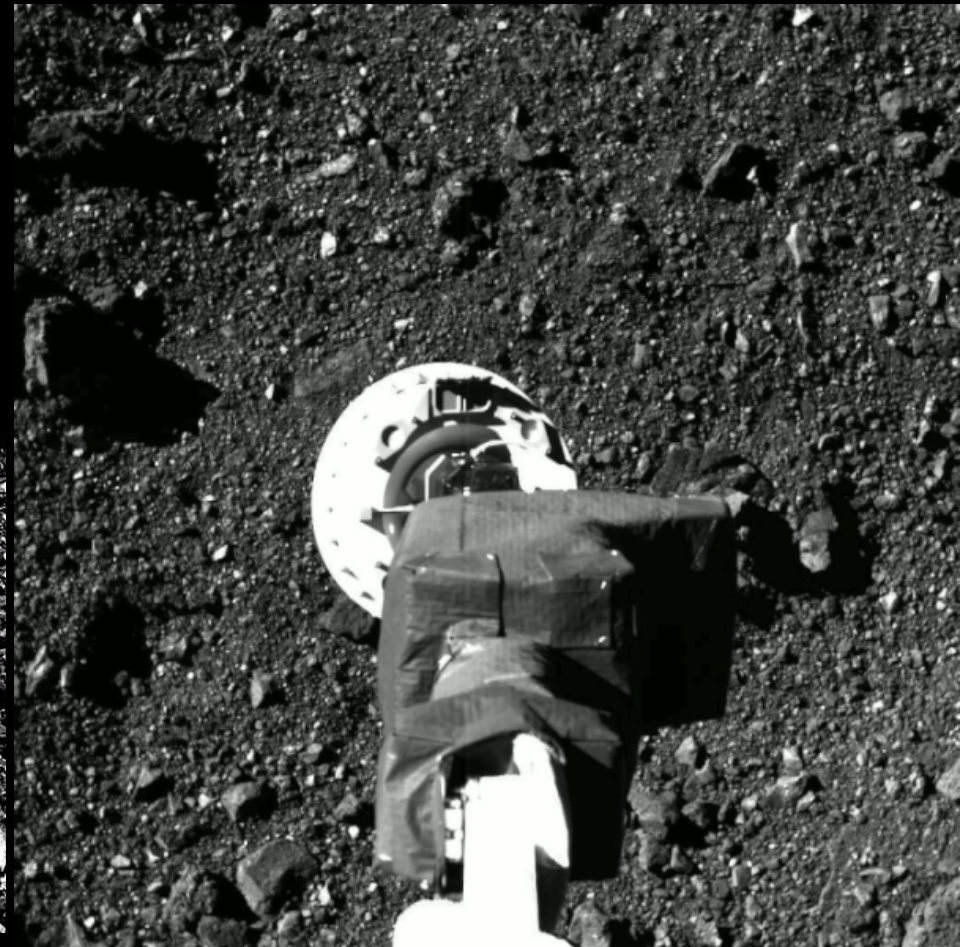
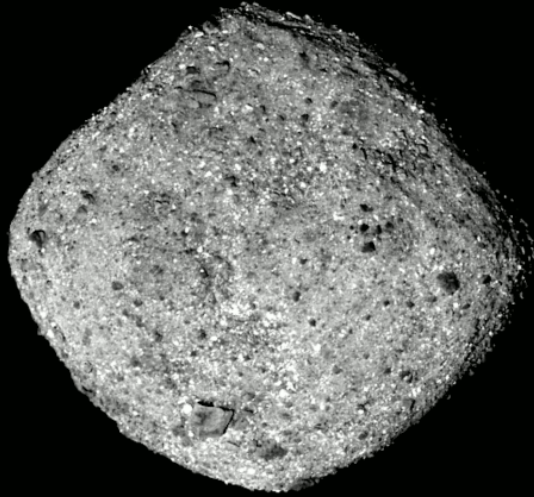
- **Hayabusa 2:** recoger material del asteroide (162173) Ryugu y traerlas a la Tierra
- Lanzada el 3 de diciembre de 2014
- 27 de junio de 2018 llegó a Ryugu.
- 21 de septiembre desplegó sus dos rovers en la superficie del asteroide
- **22 de febrero de 2019, logró aterrizar en la superficie.**



Misión Osiris-Rex – Asteroide Bennu

Capturada el 20 Octubre, 2020 durante la misión OSIRIS-Rex. TAG). Evento de muestreo “Touch-And-Go”

<https://svs.gsfc.nasa.gov/13744>



➤ Los meteoritos son ejemplares únicos que proporcionan una información esencial sobre la formación de la Tierra y otros cuerpos planetarios del sistema solar.



➤ También pudieron estar implicados en el origen de la vida en nuestro planeta, aportando agua y otros compuestos inorgánicos y orgánicos.



➤ Desempeñaron un papel fundamental en la coevolución geológica y biológica de nuestro planeta a través de los grandes impactos y su relación con las extinciones.



TERMINOLOGÍA DE METEOROS

AMERICAN METEOR SOCIETY - WWW.AMSMETEORS.ORG



ASTEROIDE

Fragmento rocoso o de hierro que se mueve por el espacio.

Desde 1 metro hasta cientos de kilómetros.

COMETA

Un cuerpo sólido compuesto por hielo, roca y gases congelados. A medida que se fracturan y desintegran, algunos cometas dejan un rastro de residuos sólidos en el espacio.

Núcleo (parte sólida): del orden de kilómetros.
Cola: millones de kilómetros.



METEOROIDE

Un asteroide pequeño.

Desde unas micras hasta 1 metro.

LLUVIA DE METEOROS

Un suceso anual, cuando la Tierra pasa a través de una región que tiene gran concentración de restos, como las partículas desprendidas de los cometas. Desde la Tierra, parece como si los meteoros partieran radialmente, del mismo punto del cielo.

METEORO

La luz emitida por un meteoroide o asteroide al entrar en la atmósfera.

BÓLIDO

Un meteorito más brillante que el planeta Venus.

SUPERBÓLIDO

La luz emitida por un meteoroide grande o un asteroide cuando explota en la atmósfera (más brillante que la Luna llena).

METEORITO

Un fragmento de un meteoroide o asteroide que resiste el paso por la atmósfera y llega a caer en el suelo.
Desde unos gramos a varias decenas de toneladas.



En primer lugar, es importante tener clara la terminología y los conceptos:

- Cometa
- Asteroide
- Meteoroide
- Meteoro
- Lluvia de meteoros
- Bólido
- Superbólido
- Meteorito



Gracias al estudio de los distintos tipos de meteoritos conocemos cómo era la materia primitiva. Ellos aportaron el agua y los elementos químicos (presentes en sus minerales), que fueron fundamentales para el desarrollo de la Tierra y de la Vida.



EL COLOR DE LOS METEOROS

SEGÚN LA COMPOSICIÓN QUÍMICA DEL METEOROIDE

Magnesio (Mg)

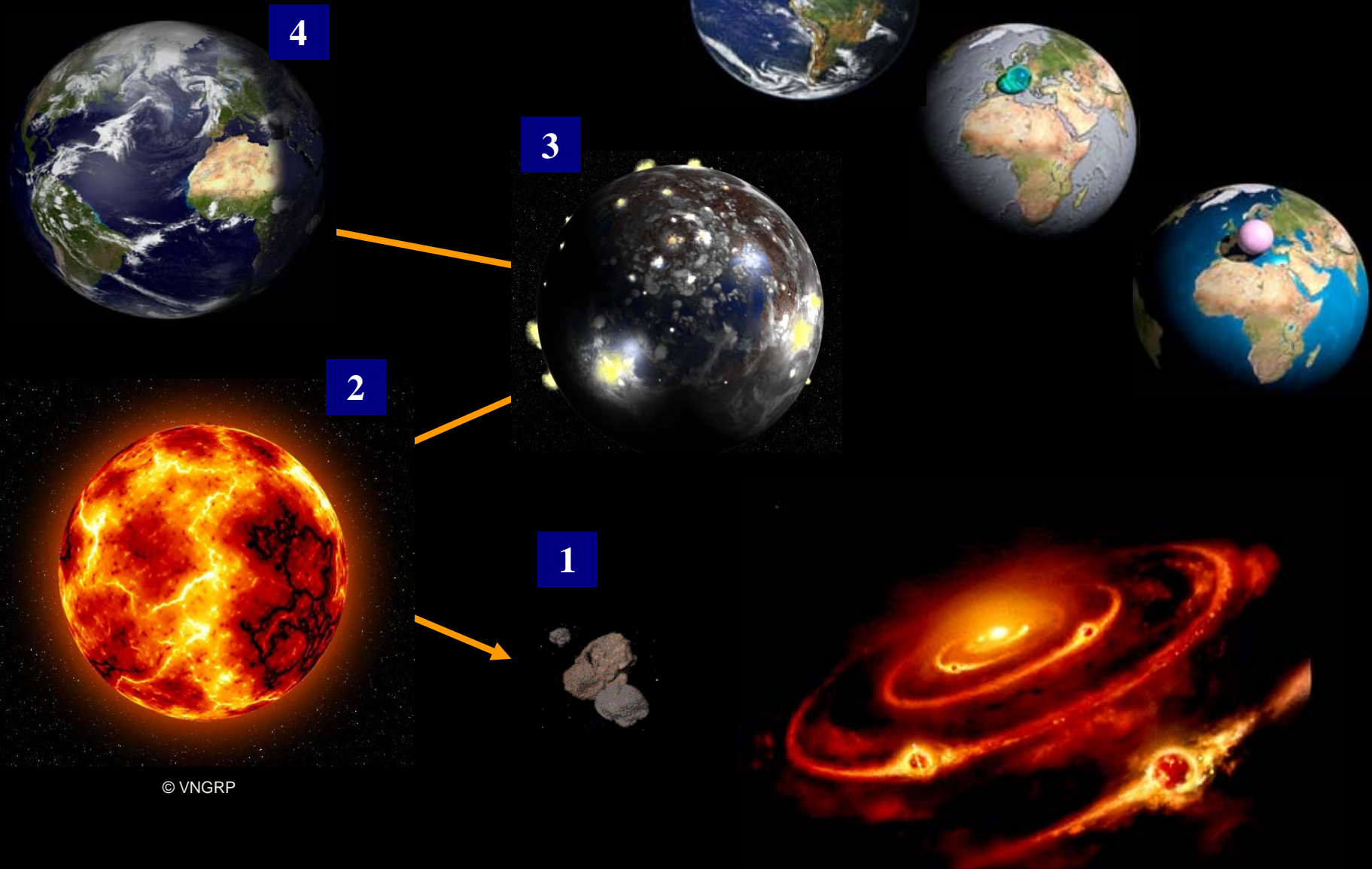
Hierro (Fe)

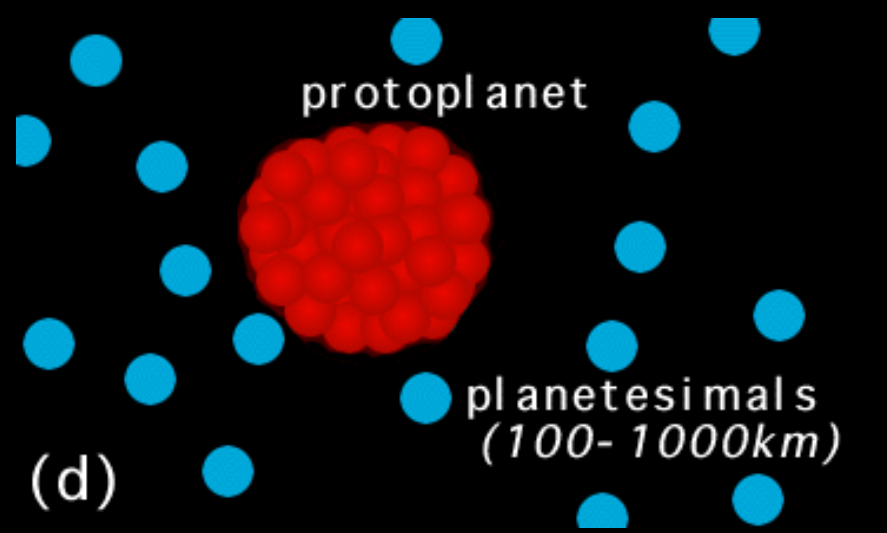
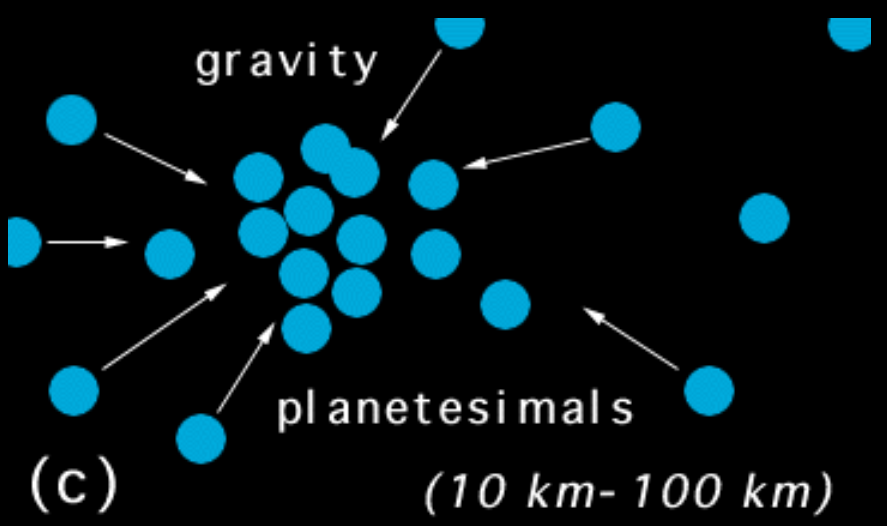
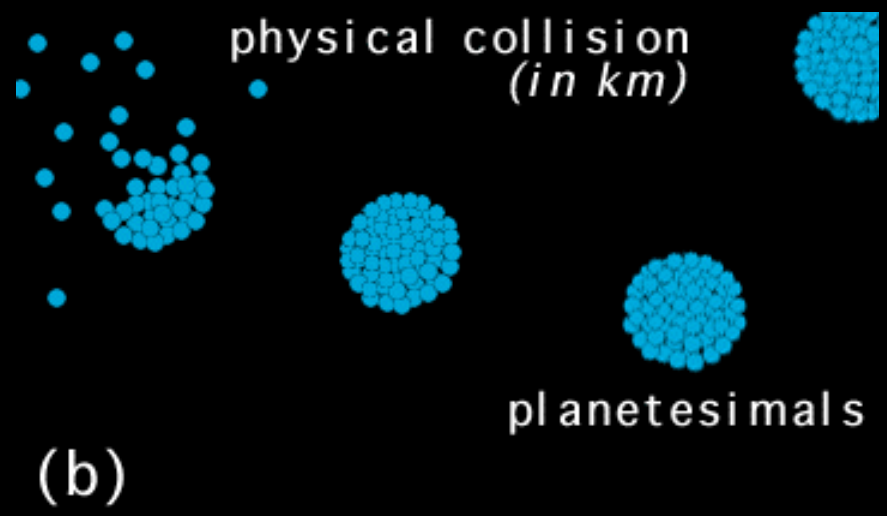
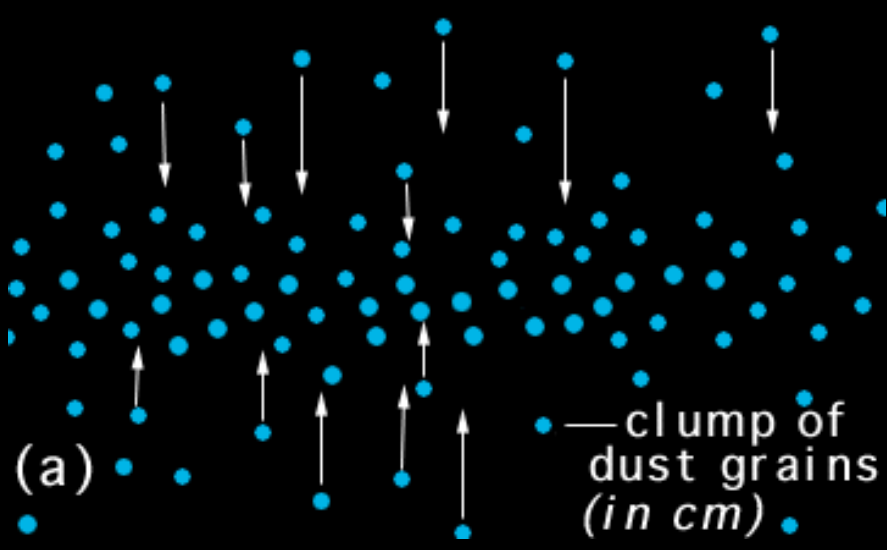
Calcio (Ca)

Sodio (Na)

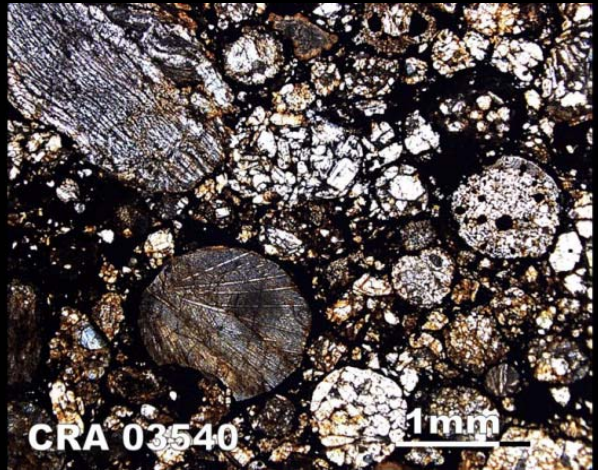
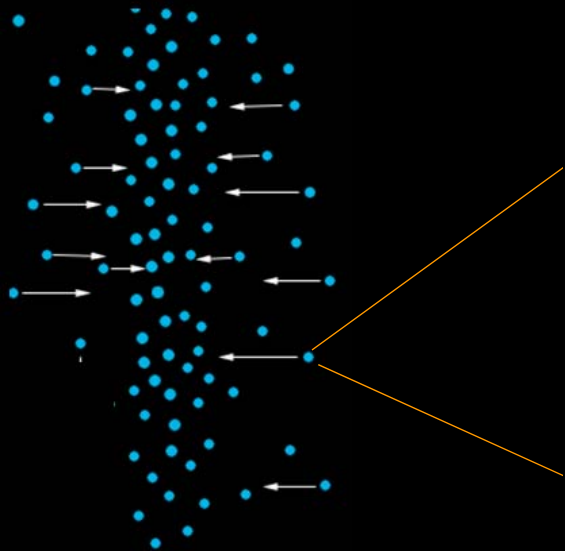
Nitrógeno (N)+Oxígeno (O)

METEORITES: A TRAVEL BACK IN TIME

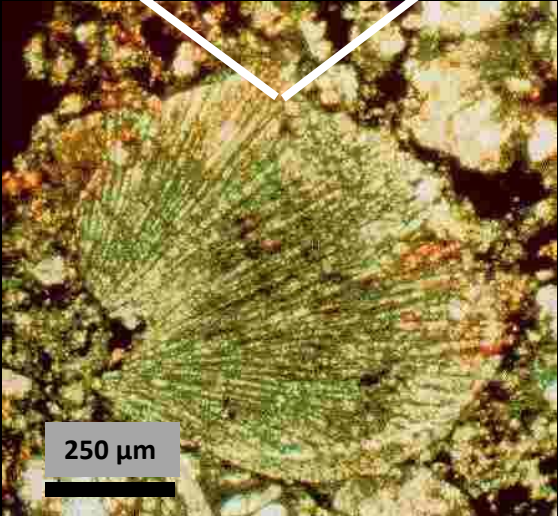




Pristine matter/chondrules

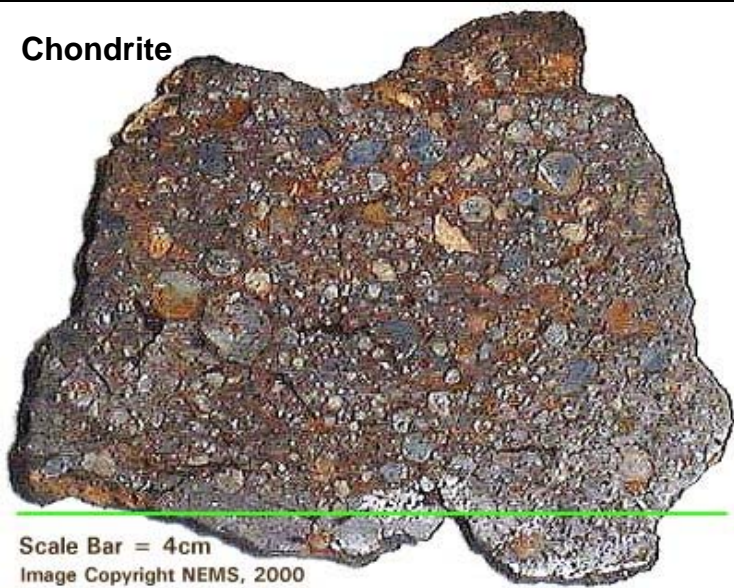


“Valencia” meteorite

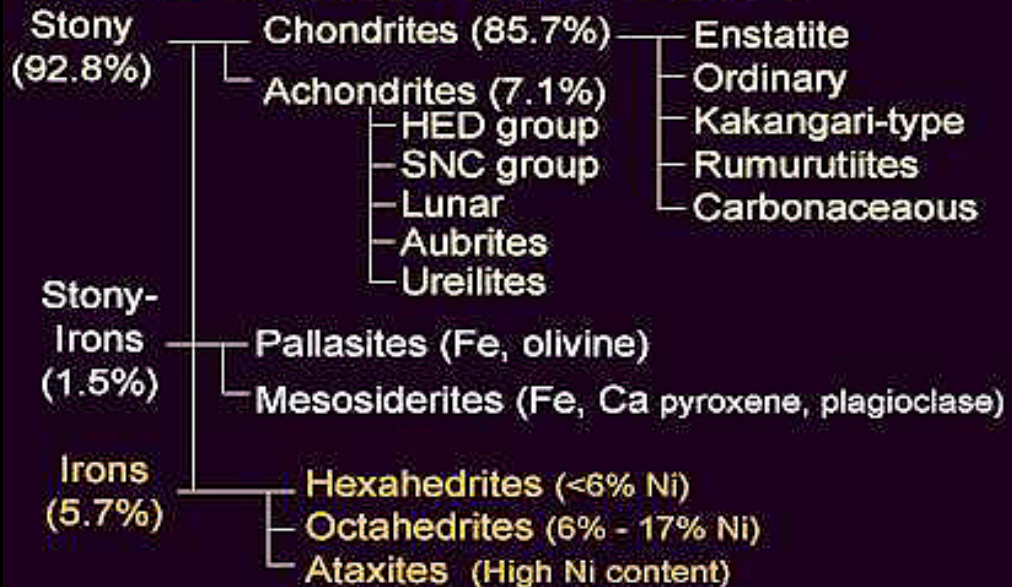


<http://imca.cc/insights/2009/1101-img/fig2.JPG>

Chondrite



Classification of Meteorites



Achondrite



Stony-Iron



<http://www.fas.org/irp/imint/docs/rst/Sect19/Classify1.jpg>

Iron



P. Jenniskens, R.W. Russell, H. Yano, J.M.C. Plane, I.S. Murray, M.J. Taylor, J. Borovicka, K. Kuenzi, W.H. Smith, R.L. Rairden, H.C. Stenbaek-Nielsen, F.J.M. Rietmeijer, H. Betlem, J. Martinez-Frias (2003) **Investigation of the Ejection and Physical Properties of Large Comet Dust Grains and Their Interaction with Earth's Atmosphere During the 2002 Leonid Multi-Instrument Aircraft Campaign** *Bulletin of the American Astronomical Society* <http://www.aas.org/publications/baas/v35n4/dps2003/119.htm>



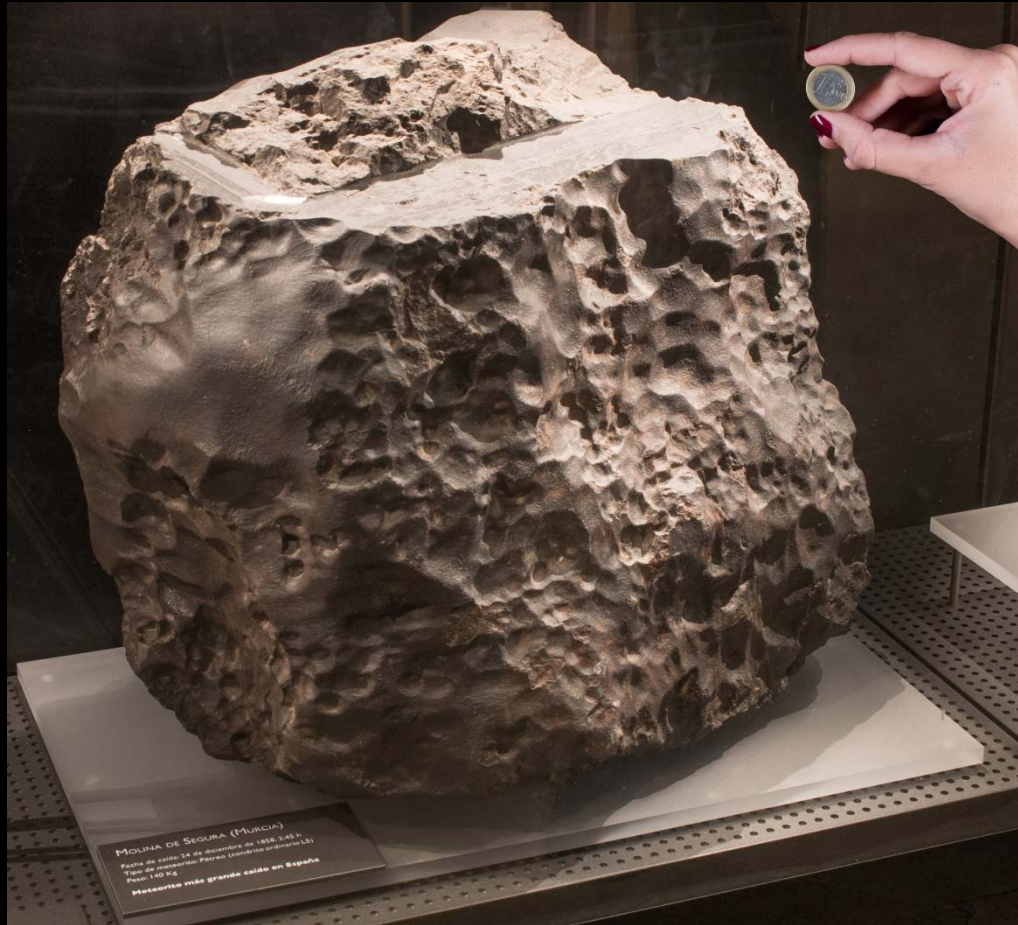
NASA Leonid MAC Mission



NASA Leonid MAC Mission

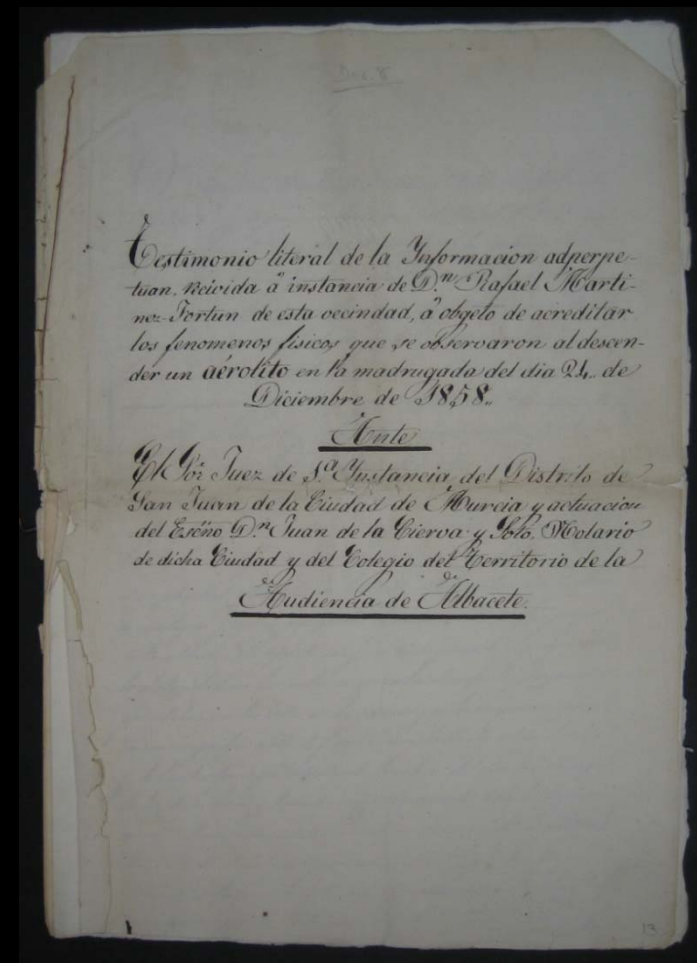


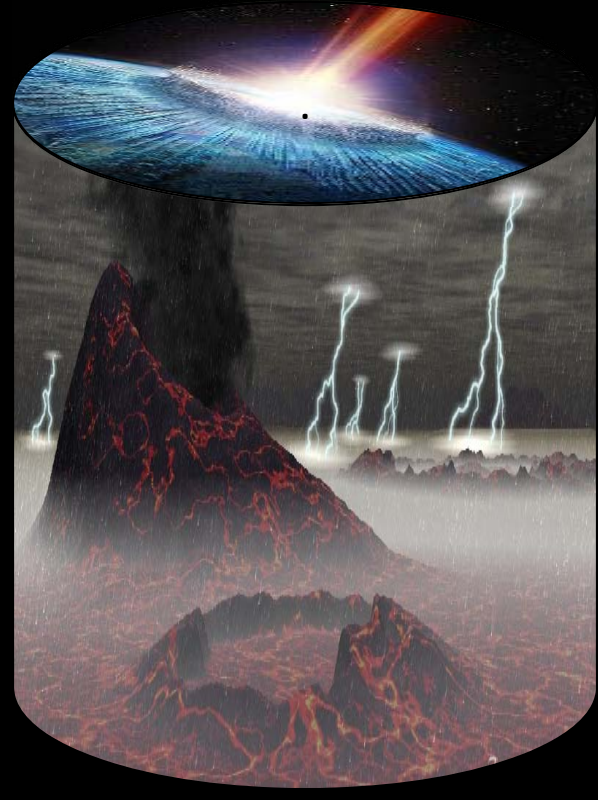
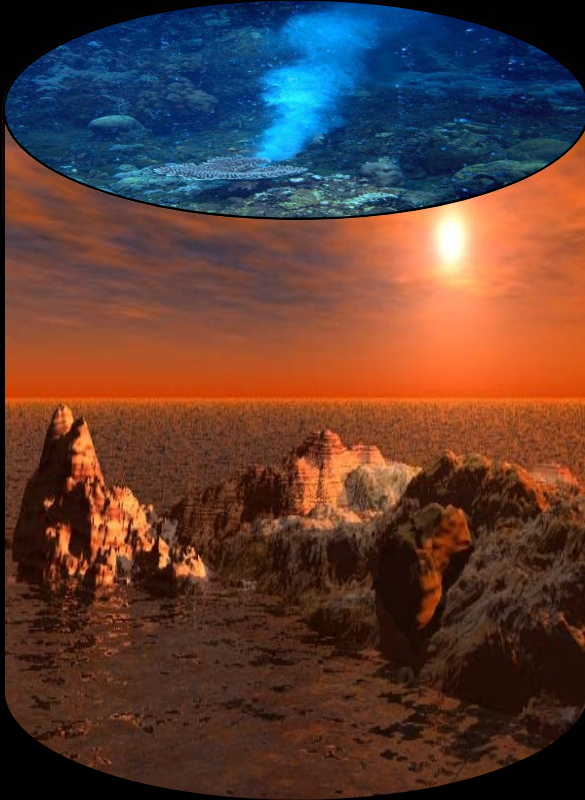
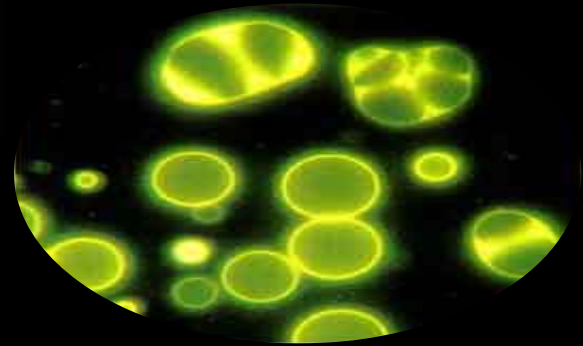
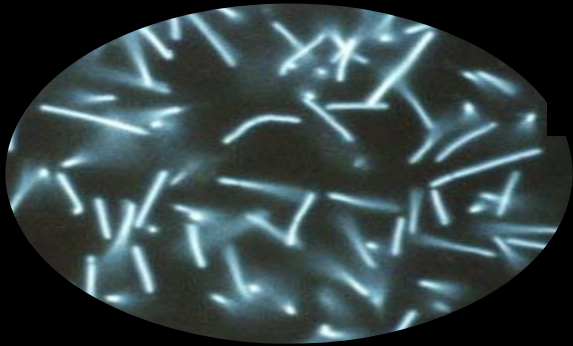
Molina de Segura: mayor meteorito caído en España (≈ 140 kg)



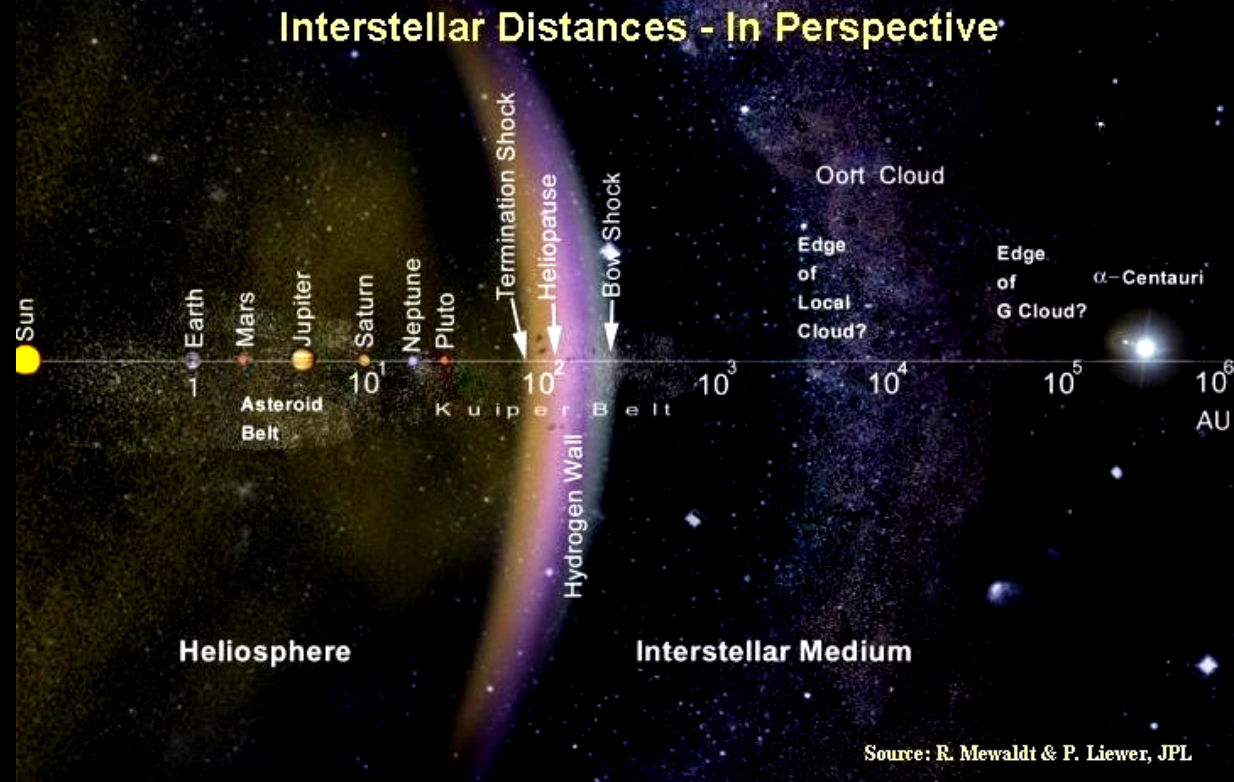
Martinez-Frias, J. & Lunar, R. (2008) Molina de Segura: the largest meteorite fall in Spain. *Astronomy & Geophysics* 49-4: 4.26-4.29.

En España, el **Meteorito de Molina de Segura** es, probablemente, el ejemplo más sobresaliente a nivel nacional y también importante internacionalmente, no solo por sus características composicionales como material condritico, sino por toda la excelente documentación existente sobre sus circunstancias de caída.





Algunos compuestos de carbono en meteoritos y cometas



METEORITOS:

polymers of insoluble acids, hydrocarbons, monocarboxylic acids, primary alcohols, aldehyds, ketones, amines, urea, purines, amino acids...

COMETS:

H, C, O, CN, CH, OH, H₂O⁺, CN⁺, CH⁺, OH⁺, N₂⁺, CO⁺, CO²⁺, complex organic molecules such as CH₃CN, H₂CO, and HCO



The Murchison Meteorite – A “Messenger from Space”

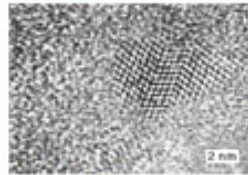
Amino Acids	17-60 ppm
Aliphatic Hydrocarbons	>35 ppm
Aromatic Hydrocarbons	3319 ppm
Fullerenes	>100 ppm
Carboxylic Acids	>300 ppm
Hydrocarboxylic Acids	15 ppm
Purines and Pyrimidines	1.3 ppm
Alcohols	11 ppm
Sulphonic Acids	68 ppm
Phosphonic Acids	2

Fall Date is 28 September 1969
 100 kg known weight
 36°37' S, 145° 12' E

Type
 Class
 Group

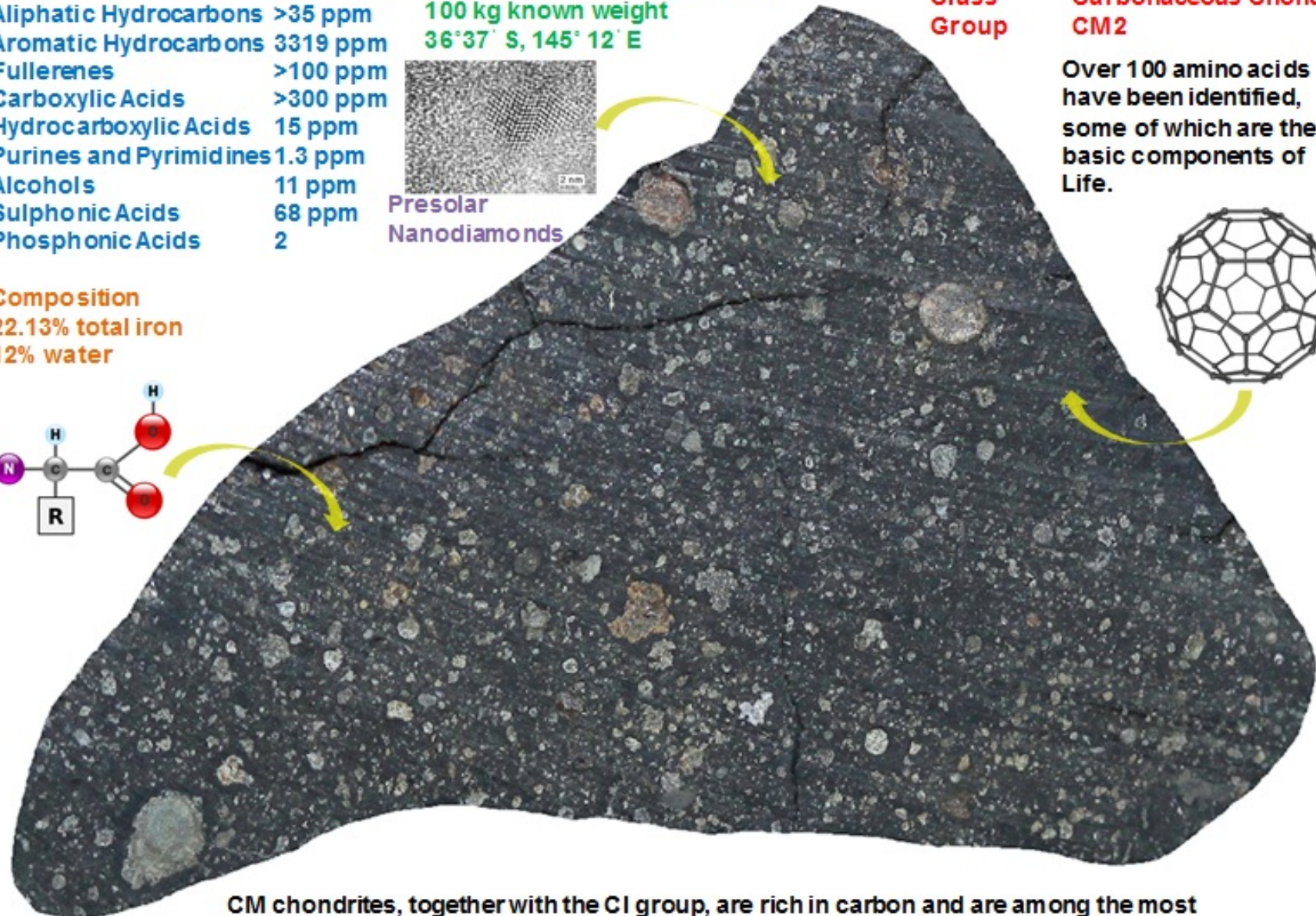
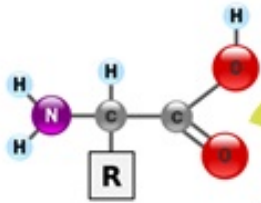
Chondrite
 Carbonaceous Chondrite
 CM2

Over 100 amino acids have been identified, some of which are the basic components of Life.



Presolar
 Nanodiamonds

Composition
 22.13% total iron
 12% water



CM chondrites, together with the CI group, are rich in carbon and are among the most chemically primitive meteorites in our collections.



TAGISH LAKE

British Columbia, Canada
Fell 2000, January 18, 8:43 hrs
Carbonaceous Chondrite (C12)
Total known weight—10 kg

Specimen
Weight:

.054 g

www.meteoritemarket.com/TAG.htm

Key Components of DNA and RNA Found in Three Meteorites

Oba et al. (2022)

Apr 26, 2022 by News Staff

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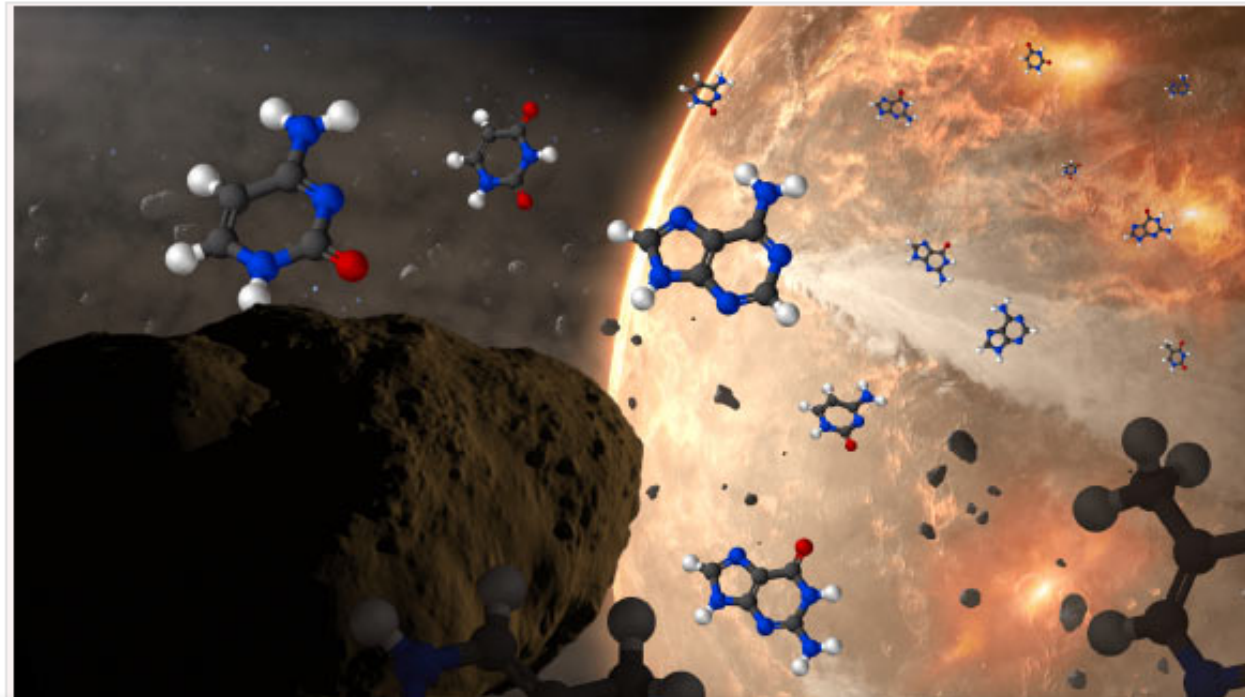
Published in

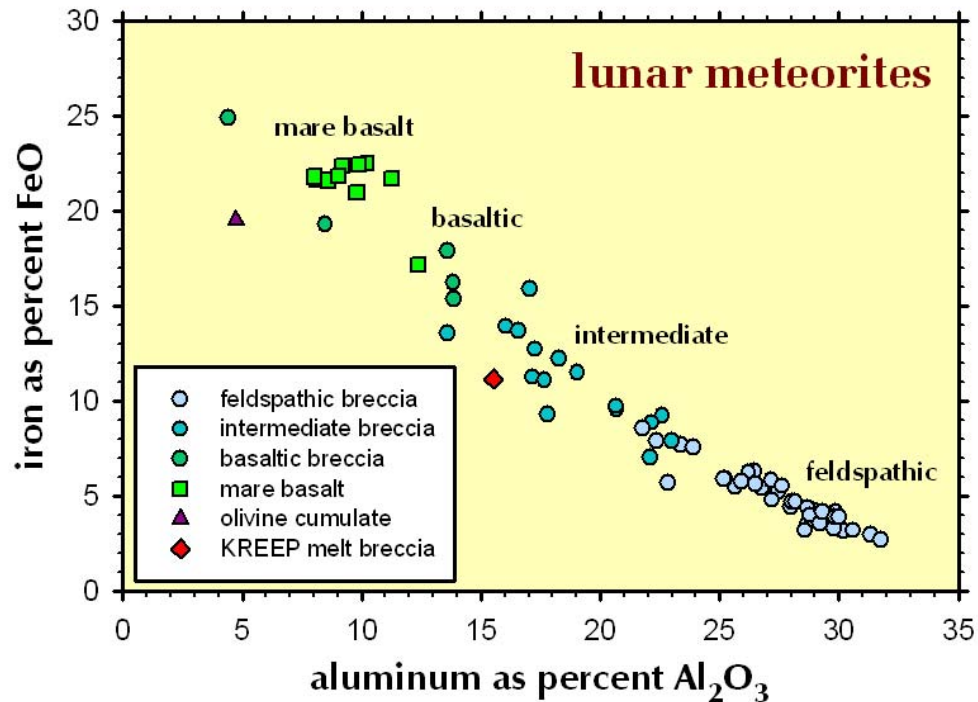
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Planetary Science
Space Exploration

Tagged as

Asteroid
Carbonaceous chondrite
Cytosine
DNA
Earth
Extraterrestrial life
Meteorite
Murchison meteorite
Murray meteorite
Nucleobase
Planet
Purine
Pyrimidine
RNA
Solar System
Tagish Lake meteorite
Thymine

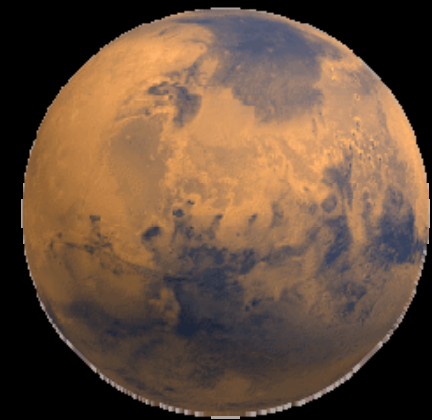
Using state-of-the-art analytical techniques, researchers have detected diverse suites of nucleobases — including canonical base pairs (e.g., adenine-uracil, guanine-cytosine, adenine-thymine) and some non-canonical ones (e.g., isoguanine-isocytosine and xanthine-2,4-diaminopyrimidine) — in three carbonaceous meteorites: the Murchison, Murray, and Tagish Lake meteorites.





SNC METEORITES

- **Shergottites:** [ol, opx, aug] plg + plag; fine to medium grained; basaltic to poikilitic cumulate texture; 0.18 and 4.5 Ga
- **Nakhlites:** aug + ol + plag; medium grained; porphyritic; 1.3 Ga
- **Chassigny:** ol + aug; medium grained; cumulate; 1.3 Ga



Shergottites

Basalt

Shergotty 4kg

Zagami 18kg

EETA79001 7.9kg

QUE94201 12g

DAG476 2kg

Los Angeles 7kg

Dhofar019 1.1kg

NWA480 0.03kg

SAU005 1.3kg

Dhofar378 0.02kg

NWA856 0.3kg

DAG975 28g

NWA1195 50g

NWA1068 0.65kg

NWA1669 36g

Y980459 82.5g

Lherzol

ALH77005
0.48kg

LEW88516
0.013kg

Y793605
0.02kg

GRV9927
0.01kg

Y1075 0.06kg

NWA1950
0.8kg

Nakhlite (Egypt, 28 June 1911)



Nakhlites

Clinipx

Nakhla 10kg

Lafayette
0.8kg

Governador
Valadares
0.16kg

NWA817 0.1kg

Y000593
13.7kg

NWA 998 456g

Chassignite

Dunitas

Chassigny 4kg

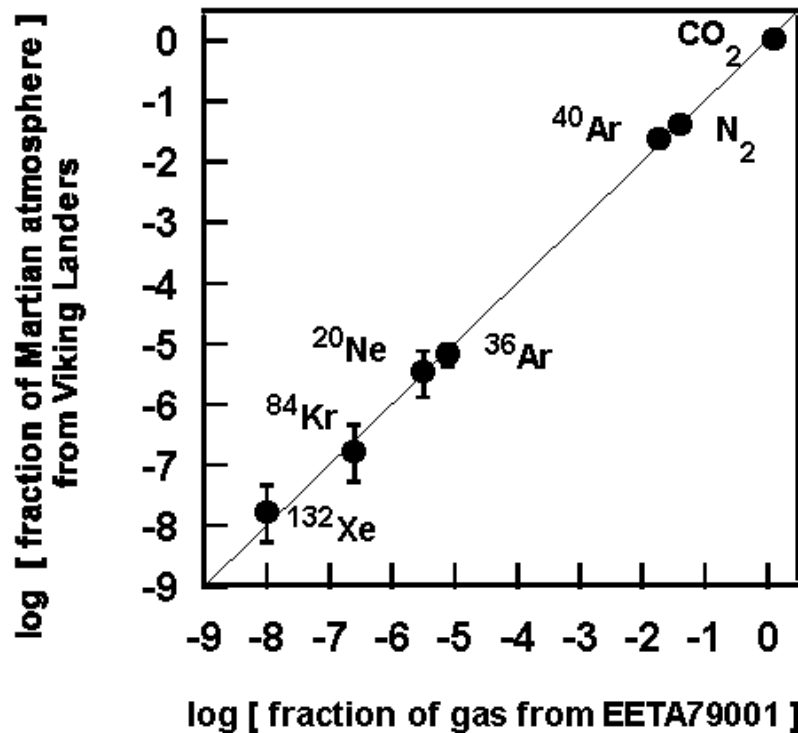
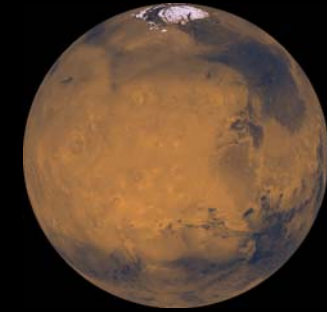
SNCs (snicks)

Shergottite(India, 25 August 1865)



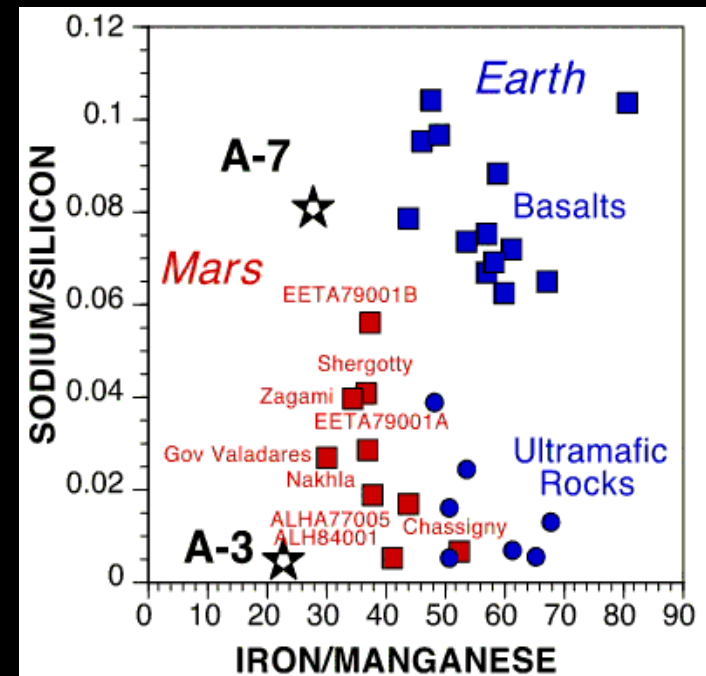
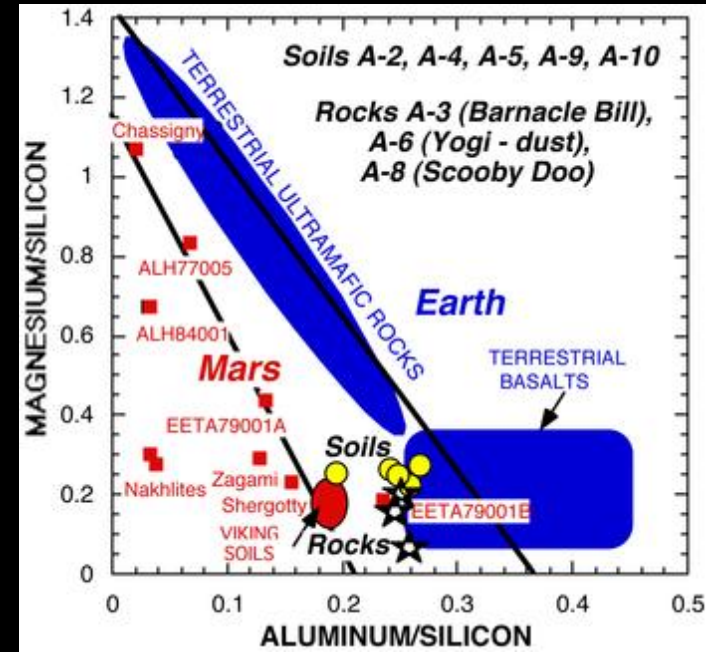
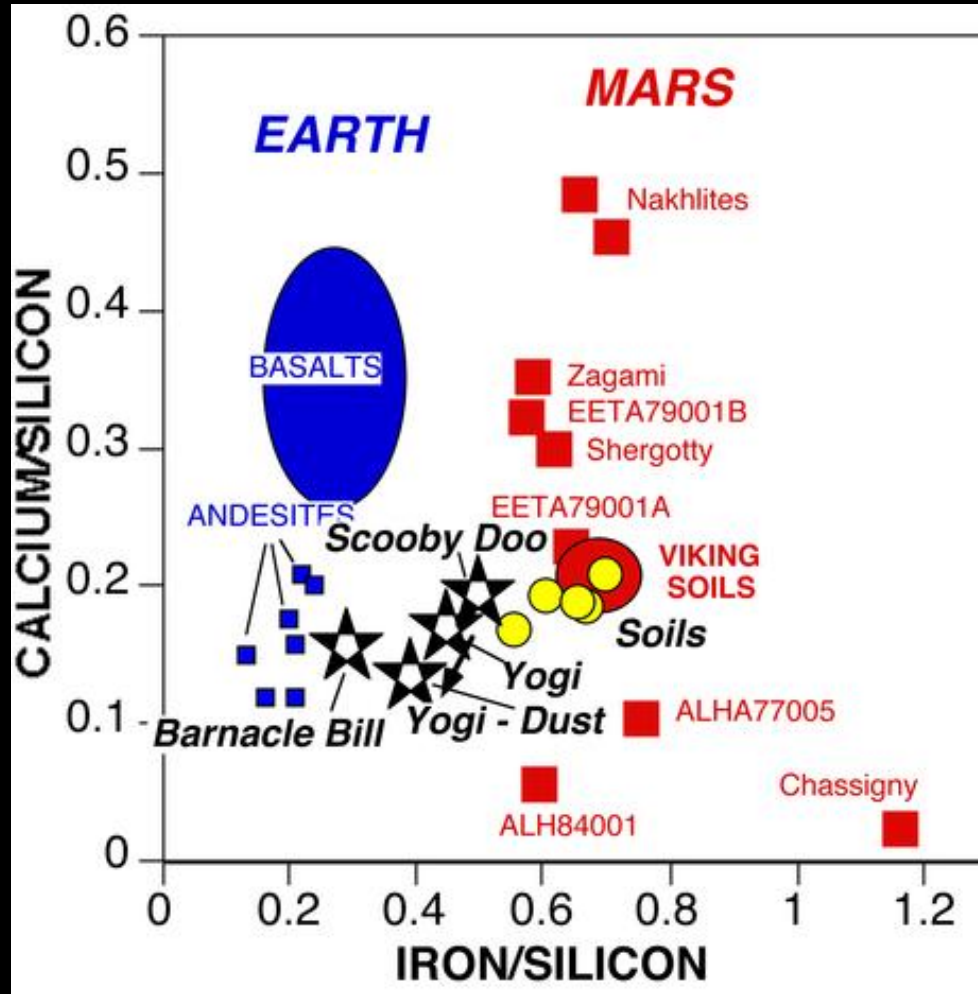
Chassignite(France, 3 October 1915)

Main features of Mars meteorites



If a dot falls on the diagonal line, that gas or isotope has the same abundance in the meteorite EETA79001 as in the Martian atmosphere. From Wiens and Pepin (1988).

- * approx. 1.3 Ga (or younger)
- * high content in volatiles
- * characteristic Fe/Si vs. Ca/ Si
- * characteristic Fe/Mn vs. Na/Si
- * characteristic ratios Al/Si vs. Mg/Si

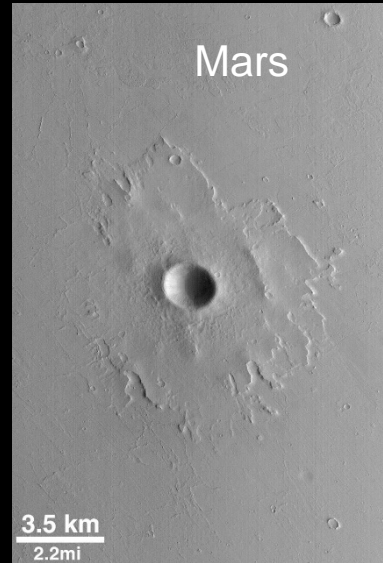
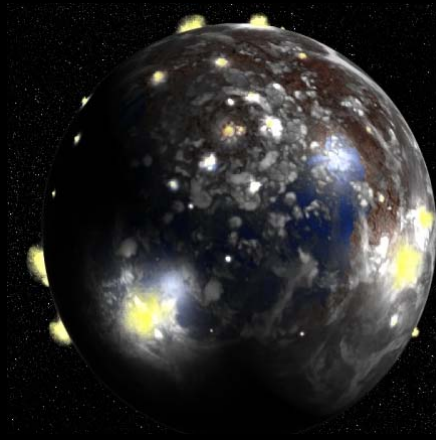


IMPACTOS

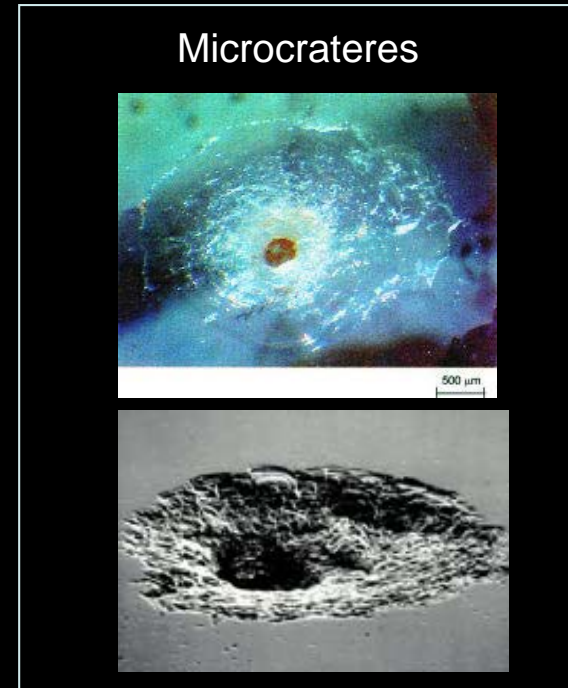
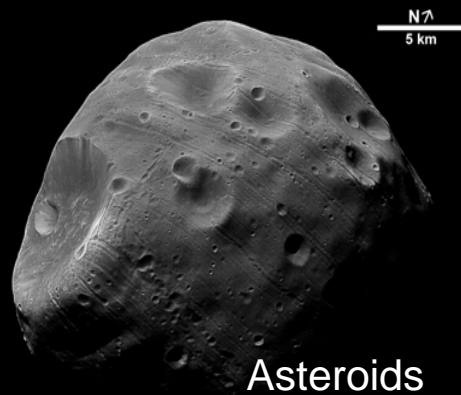
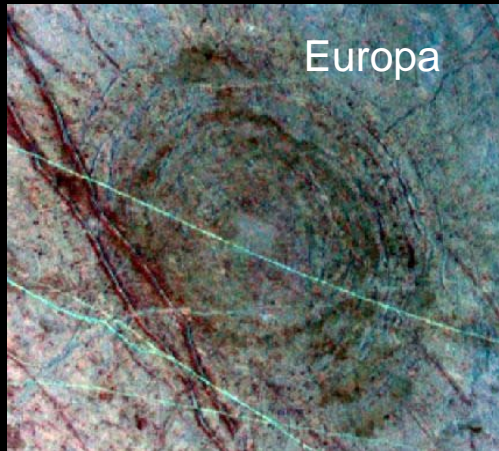
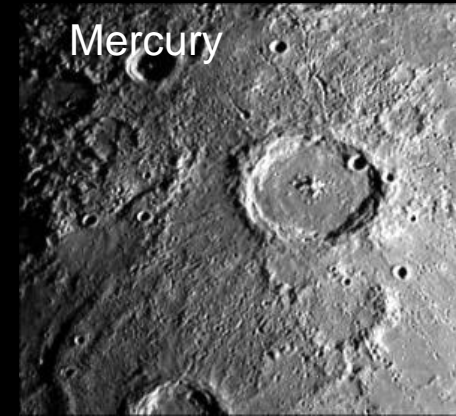


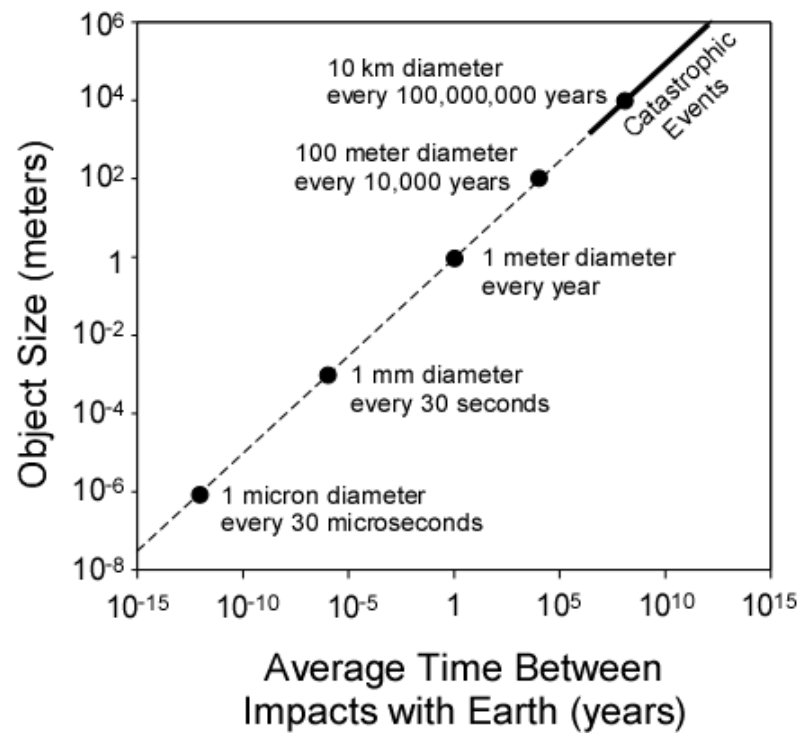
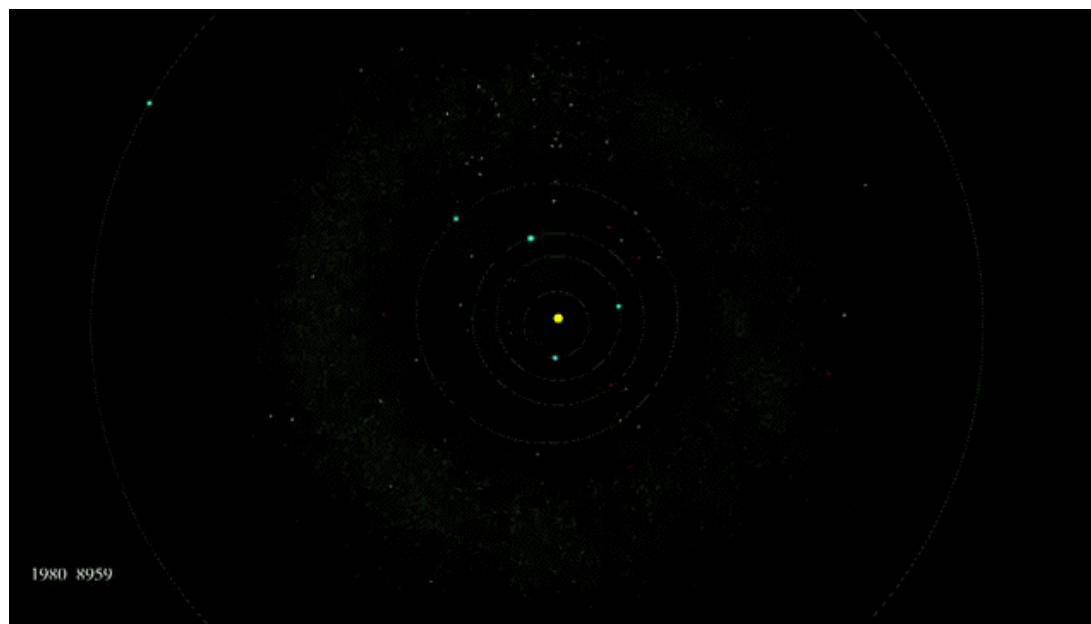
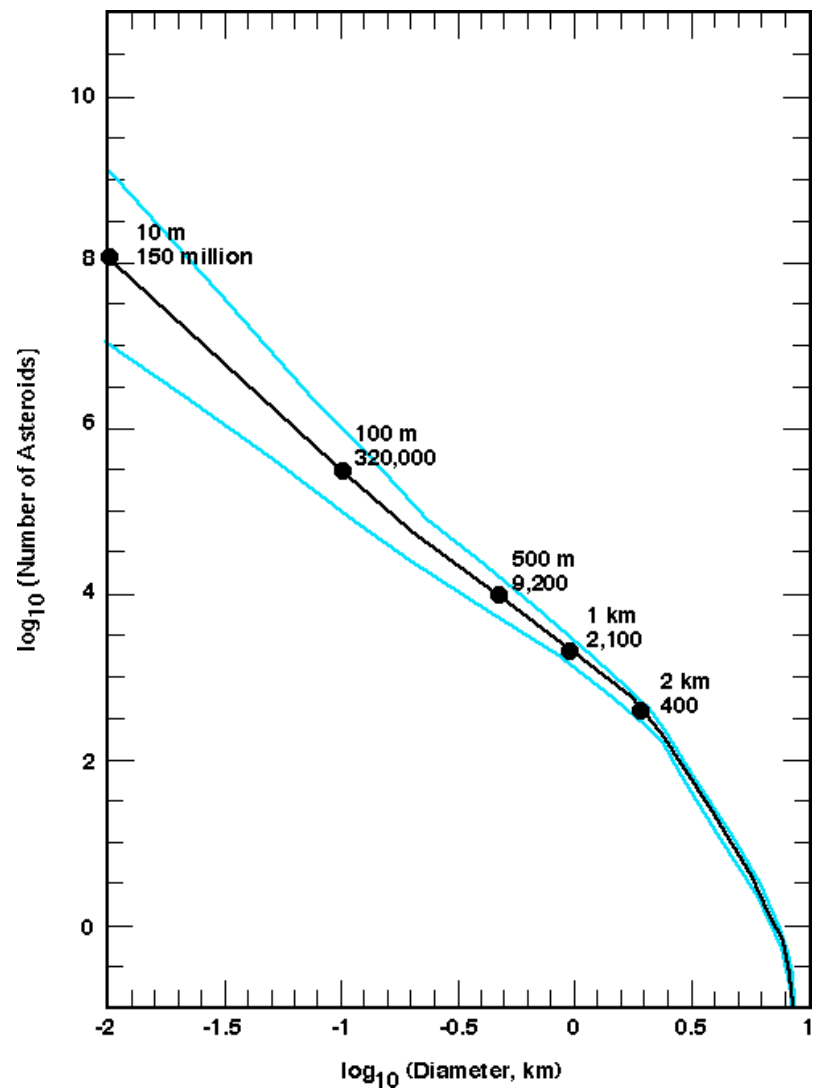
Impactos/Cráteres

"It is now widely recognized that impact cratering is a ubiquitous geological process that affects all planetary objects with a solid surface. In addition, impact craters are extremely relevant from the astrobiological point of view, and they have been widely proposed as privileged sites for searching for extraterrestrial life" (Melosh, 1989; Cockell et al. 2003, French 2004, among others).



The Moon





Simulación del impacto
de un objeto silicatado (D=300 m, v=12 km/s)
en el océano (1 km de profundidad).

Substrato rocoso

Jesús Martínez Frías, Alain Lepinette Malvitte - C.A.B.

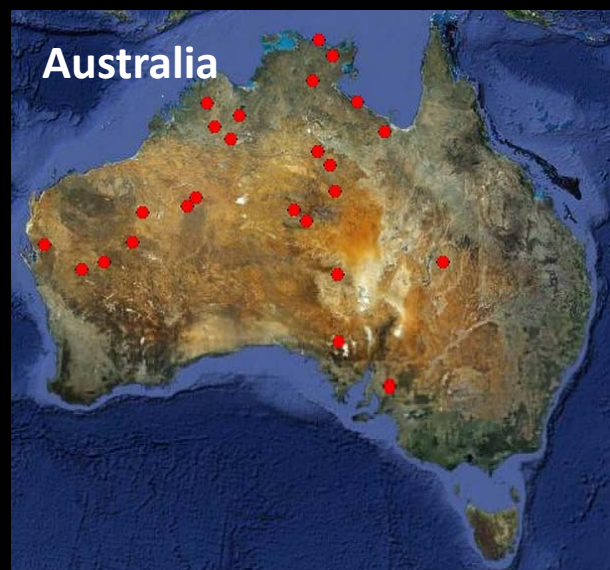
Energía de impacto: = 3.96×10^3 MegaTons.

Los eyecta crearían una capa de 19,3 m de espesor. A los 32 segundos ya estarían a 5 km de la zona de impacto

Sismicidad asociada: 6,5 Escala Richter

No radiación térmica. Escasa vaporización. Crater complejo

> 180 impact structures

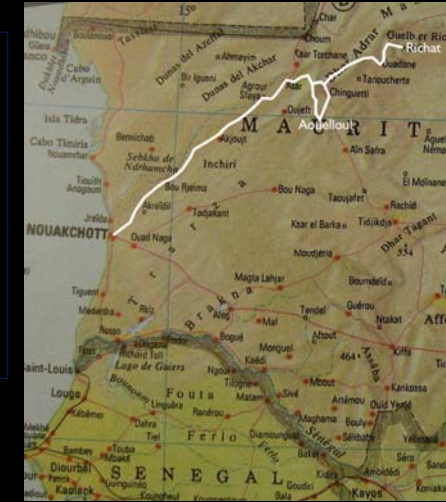






Campaña científica Mauritania' 2007

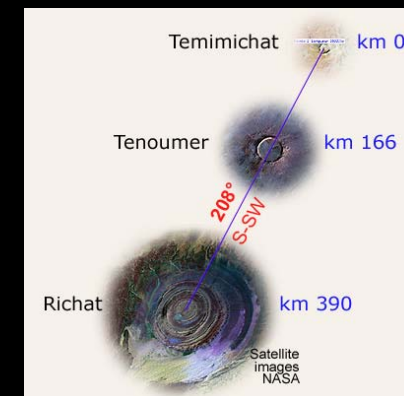
La investigación se centró en el estudio de campo y en la caracterización (mineralógica y geoquímica), mediante microscopía de luz transmitida y reflejada, DRX, ICP-MS, SEM-EDX, FT-IR y espectroscopia Raman, de las megabrechas de la espectacular (aunque controvertida) estructura de Richat y del cráter meteorítico de Auelloul.



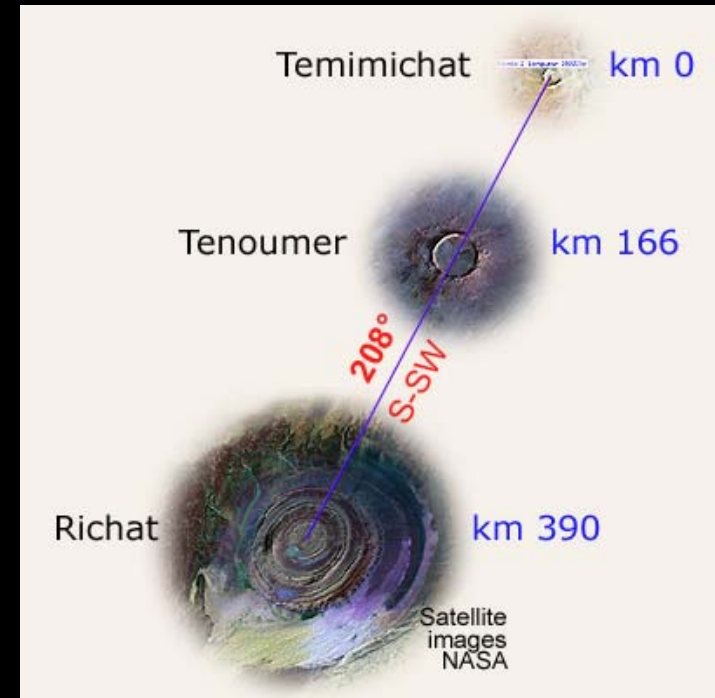
Estructura de Richat (21° 04' N; 11° 22' W; Ø: 40 km),
NASA/GSFC/METI/ERSDAC/JAROS,U.S. y Japan ASTER Science Team



Cráter meteorítico de Auelloul
(20° 15' N; 12° 41' W; Ø: 390 m, NASA/JPL)



Sahara - Mauritania



Martínez Frías, J., García Talavera, F., Rull, F., López-Vera, F., Capote, R., Navarro Latorre, J.M., Sánchez-Pinto, L., López Rondón, J., Rodríguez Losada, J.A., Fernandez Sampedro, M.T., Martín Redondo, M.P. y Menor-Salvan, C. (2008) Impactos en Mauritania: nuevos datos mineralógicos, texturales y geoquímicos de las megabrechas de Richat y del cráter meteorítico de Aouelloul. *Geo-Temas* 10: 1487-1490.



Claxton (USA) 10 December 1984

**Peekskill
Meteorite**



October 9, 1992





26 March 2003, Park Forest, Illinois, USA



12 junio 2004, casa, Nueva Zelanda

Chelyabinsk
15 February 2013



112.2 g fragment of the Chelyabinsk (Cherbakul) meteorite. This specimen was found on a field between the villages of Deputatsky and Emanzhelinsk on February 18, 2013. The broken fragment displays thick primary fusion crust with flow lines and a heavily shocked matrix with melt veins and planar fractures. Scale cube is 1 cm.

Hoba (Namibia) discovered in 1920. Ataxite rich in Ni, approx. 60 t and 2.95 x 2.84 m



http://www.castfvg.it/articoli/meteoriti/hoba_001.htm



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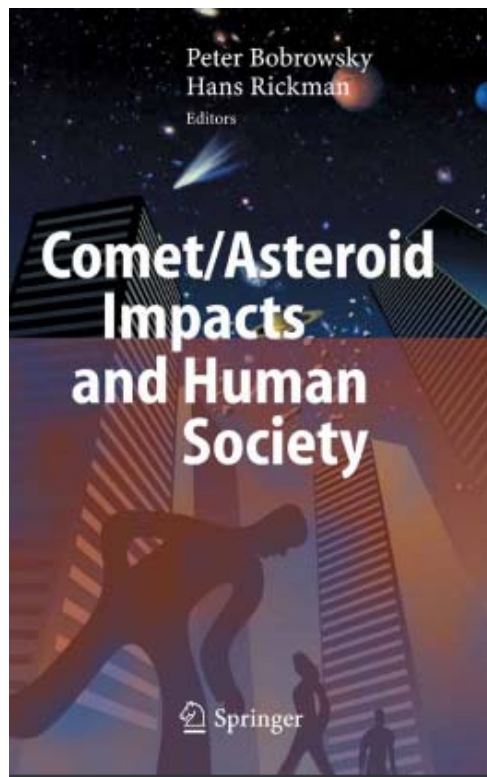
Response of the Earth System to Impact Processes (IMPACT)



Response of the Earth System to Impact Processes:
A Scientific Programme of the European Science Foundation

Quick links on this page

- [Criteria for eligibility](#)
- [Notes](#)



DSN



NEOShield-2 D12.1

Title: Report on analysis of the effectiveness of impact disaster planning at the national level
 Issue, Date: i1.0, 29.03.2016
 Page: 10/36



charge to communicate directly with ESA. Actually, the negotiations about the establishment of the national contact point for the ESA "NEO impact threat service" is running.

FINLAND: The impact risk is generally known, but there is no specific plans and procedures in our rescue plans. There are rescue plans for variety of other kinds of situations and in practice those will be utilized in emergency situations.

SPAIN: Civil Protection Organizations (at national and regional level) have disaster preparedness based in an all-hazard emergency operations planning. In a perspective of the national security, the DSN has developed a planning scenario on asteroid/comet impact risk in collaboration with Prof. Jesús Martínez Frías. This scenario contains the background, the risk assessment, potential options in case of detection of an object on a collision course with the Earth, early warning mechanisms in coordination with national and international organizations, evaluation and crisis response measures.

Curso de Introducción a la Exploración Espacial y su Utilización



Espacio Cercano a la Tierra

Luna, Marte y asteroides

Jesús Martínez Frías

