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Sommes-nous seuls ?



La recherche de la vie dans le système solaire

La recherche de la vie ailleurs dans le cosmos

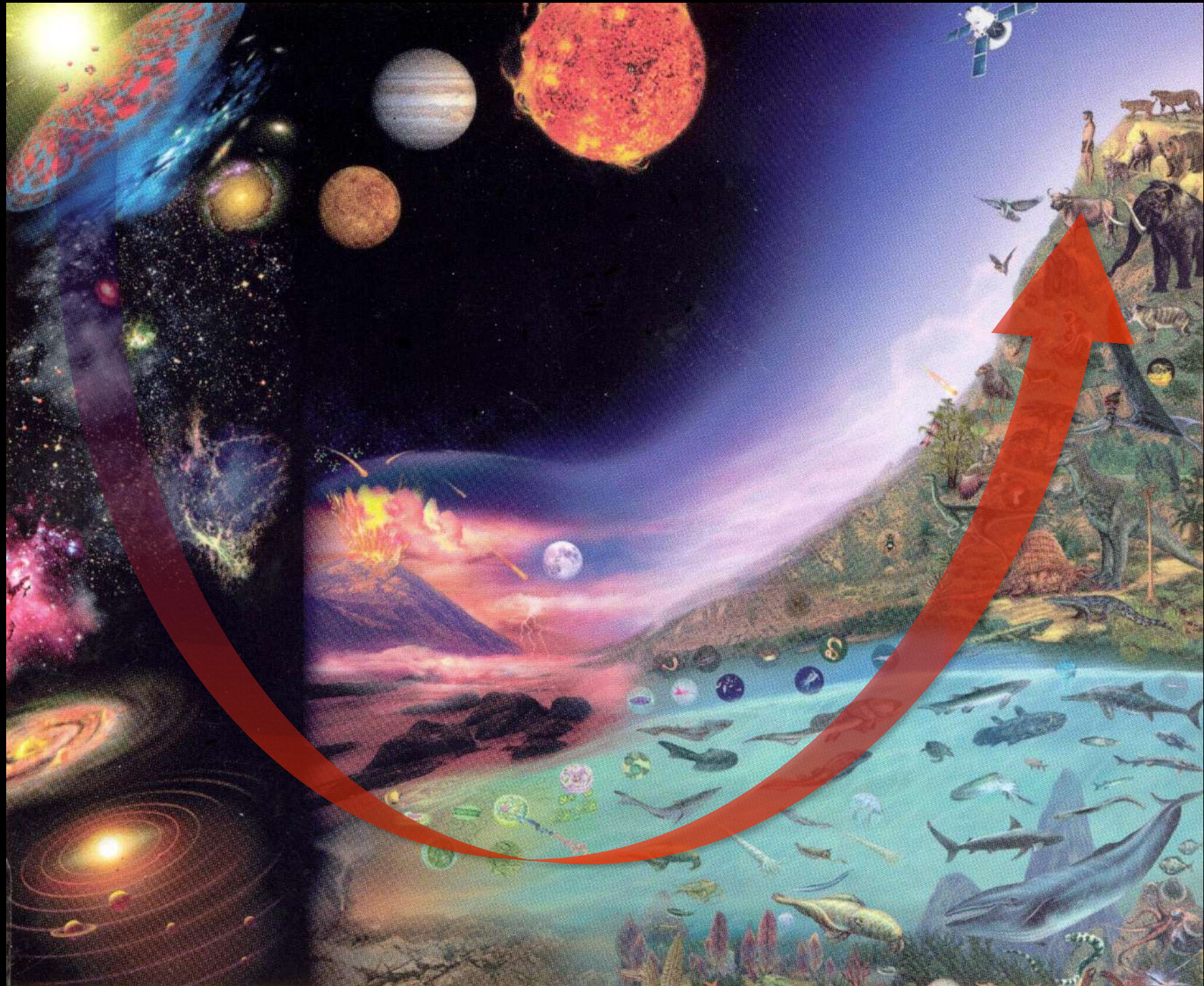
La recherche de la vie extraterrestre intelligente

« *Le développement des sciences naturelles et astronomiques conduit à la naissance d'une science ayant pour objet l'habitabilité des autres mondes, l'**astrobiologie**.* »

A.J Sternfeld, *La vie dans l'univers*, La Nature, no. 2956, 1^{er} juillet **1935**, p.4.

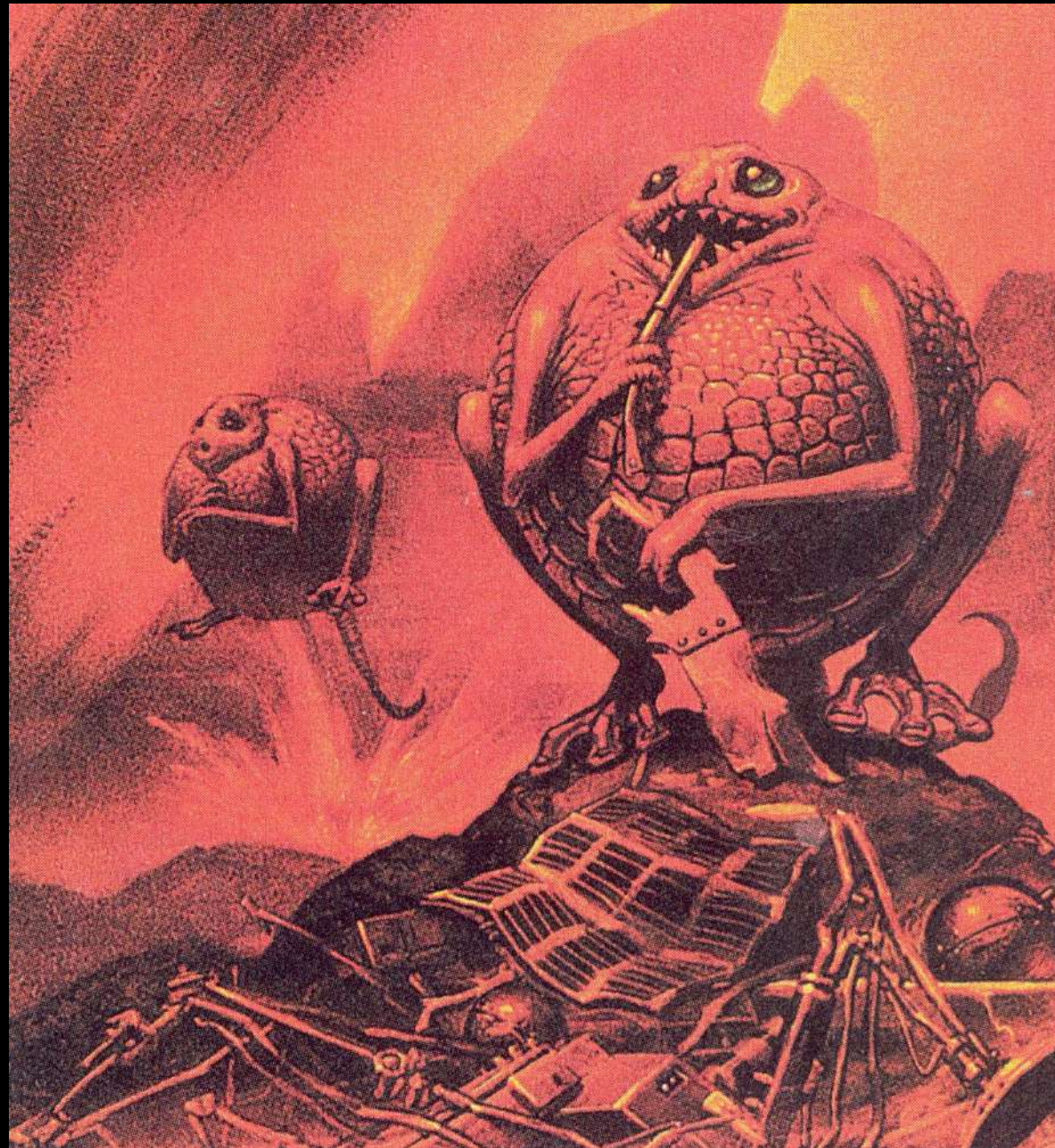
Astrobiologie : *n. f.* Science recoupant plusieurs disciplines et qui étudie tous les processus menant potentiellement à l'apparition de toute forme de vie, puis à son évolution et ce, sur Terre, mais aussi sur toutes les planètes du Système solaire et d'ailleurs.

100 000 000 000 000 000 000 000 000 000

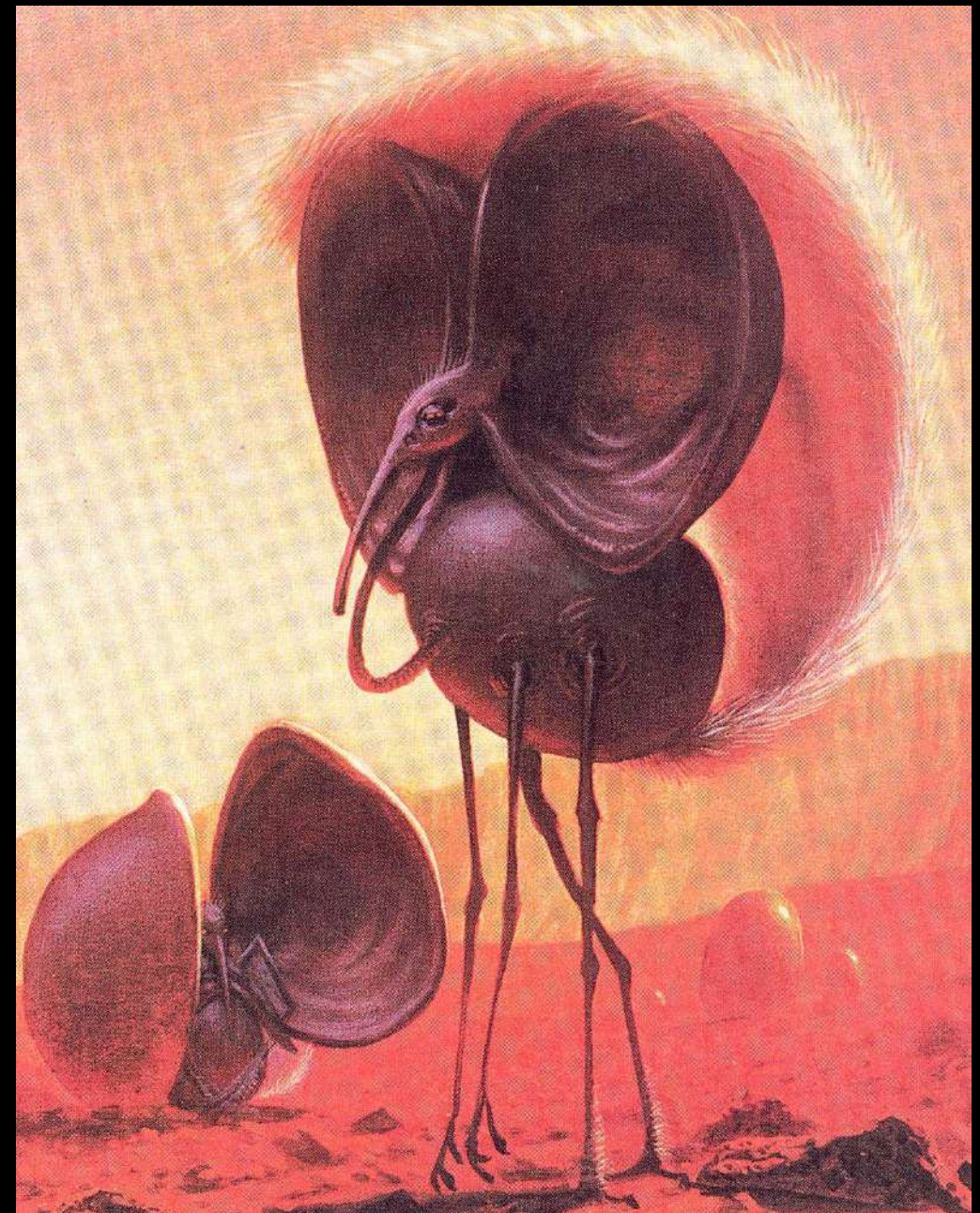


A composite image of the solar system. The Sun is visible in the upper left corner, emitting rays. The planets are arranged in a roughly elliptical path around it. From top to bottom, the visible planets are: Jupiter (orange and white bands), Saturn (yellow and brown bands), Uranus (blue-green), and Neptune (dark blue). The Earth is visible in the lower left, showing blue oceans and green continents. The background is a dark, starry space.

La recherche de la vie dans le système solaire

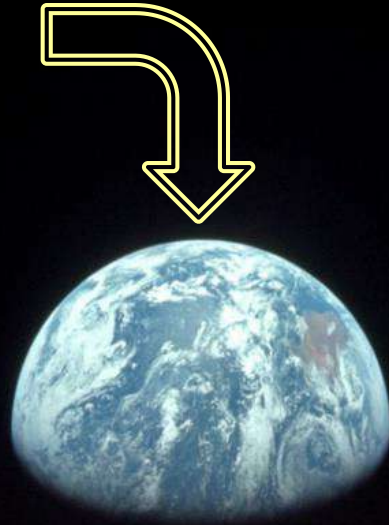


Oucheur-poucheur de Vénus



Chercheur d'eau de Mars

Le seul endroit
dans l'Univers
où nous savons
que la vie existe



Qu'est-ce que la vie ?



« Nous disons qu'un animal vit, à partir du moment où il se meut lui-même et tant qu'en lui un tel mouvement se fait reconnaître. »

Saint Thomas d'Aquin (1228-1274)



Contrairement à la biologie, l'astrobiologie ne peut se permettre le luxe d'ignorer cette question fondamentale.



?

?

?

« *Comment peut-on espérer trouver si on ne sait pas ce qu'on cherche ?* »

Les quatre fonctions cruciales des organismes vivants

Réplication

Croissance

Adaptation

Métabolisation



La vie transforme son environnement

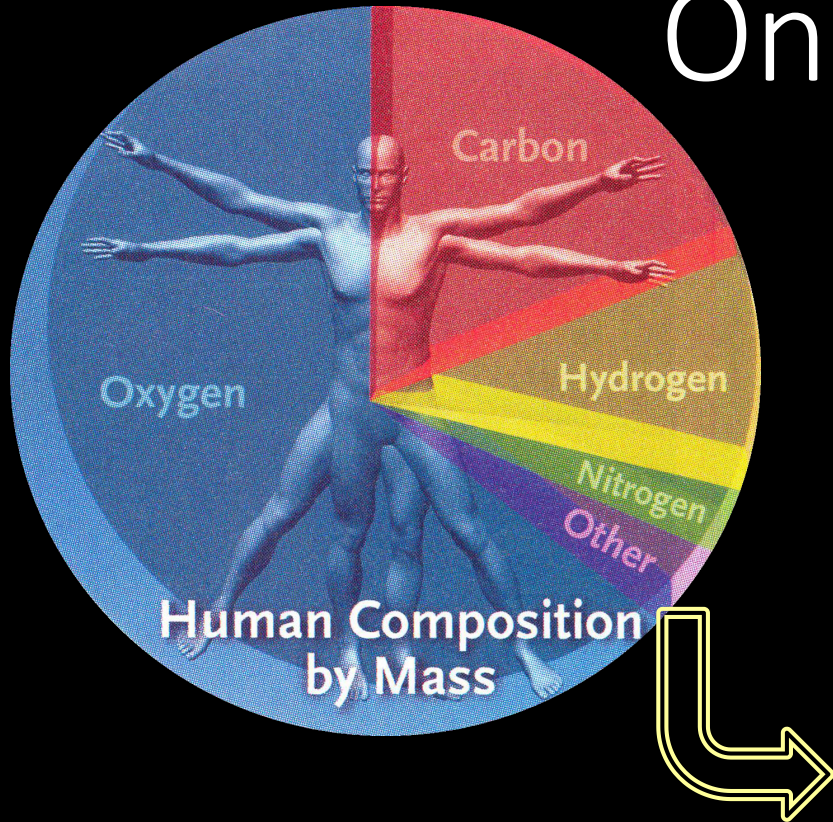


Pour l'instant, la recherche en astrobiologie contourne le problème de définir formellement ce qu'est la vie en mettant la priorité sur la détection d'un premier organisme extraterrestre (vivant ou non) qui laisse une trace – un signal – sur un détecteur.

« On cherche ce que la vie produit et non ce qu'elle est ! »

Les ingrédients de la vie (sur Terre)

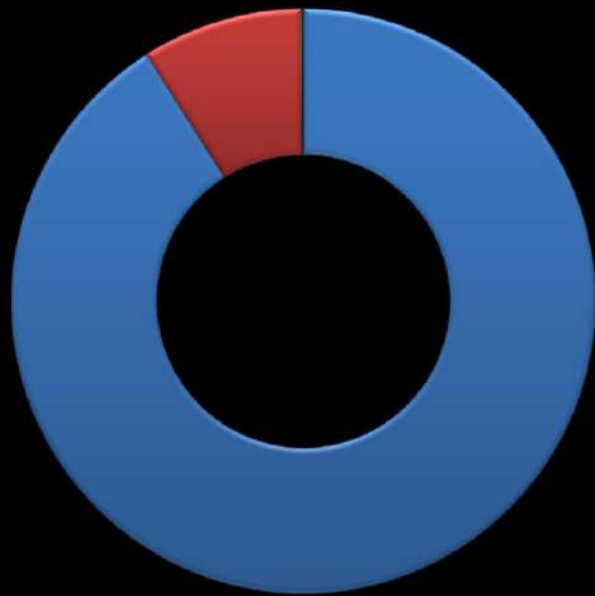
On trouve les mêmes éléments partout dans le cosmos



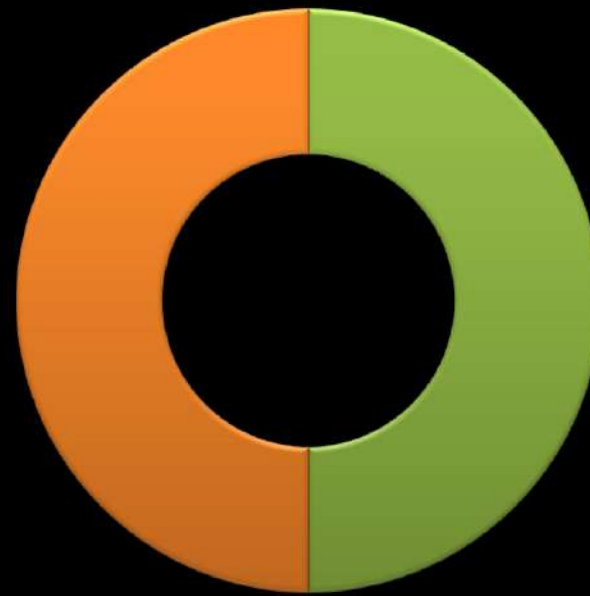
Sur Terre, la concentration des minéraux varie d'un organisme à l'autre, mais est, en moyenne, semblable à celle de l'eau des océans.

La vie est donc apparue dans l'eau

Soleil



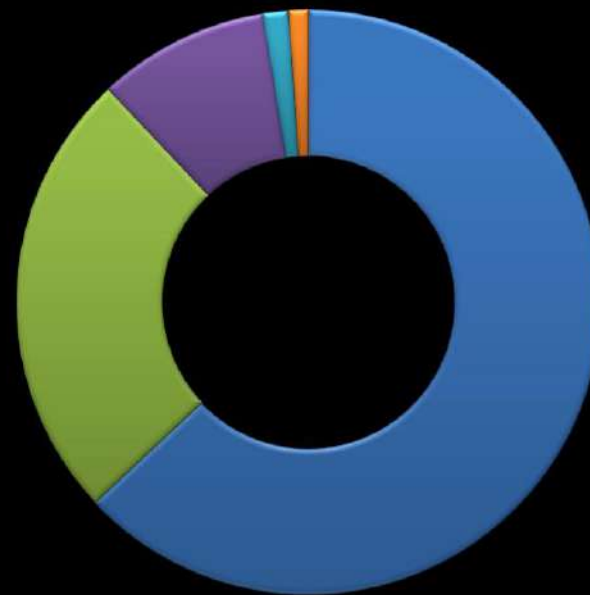
Terre



Bactérie



Animal

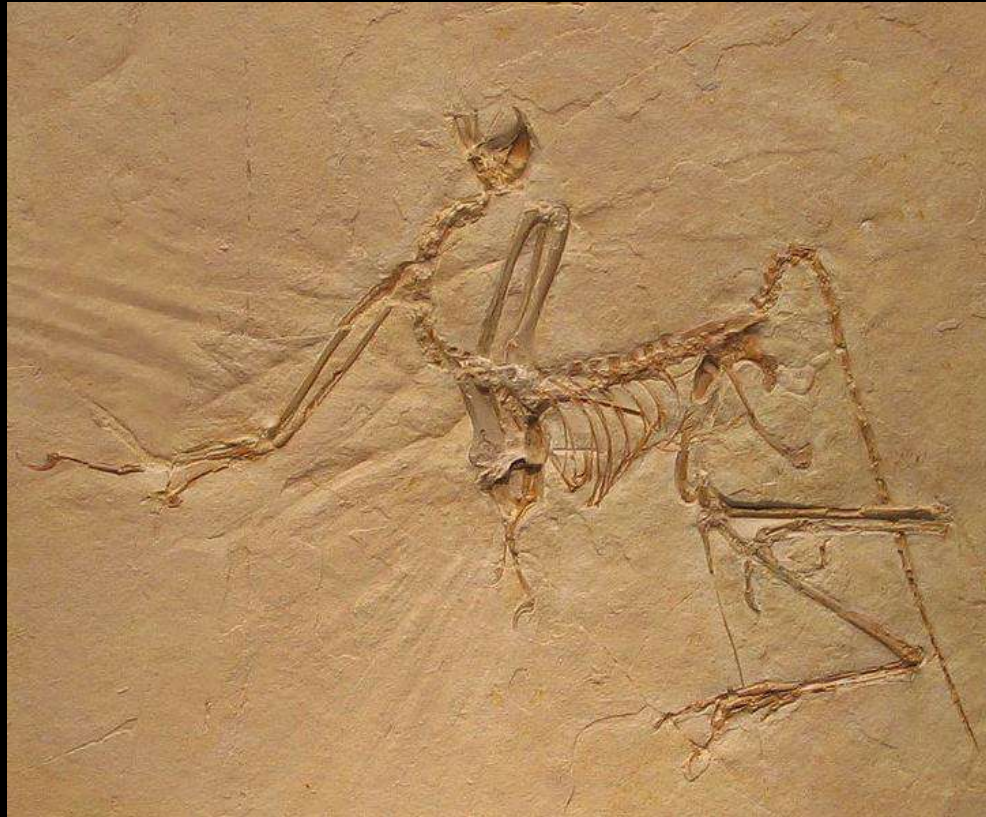


L'histoire de la vie sur Terre et l'identification des traces de vie primitive

Au cours du 20^e siècle, la géologie et la paléontologie nous ont permis d'établir une échelle géochronologique détaillée de l'évolution des structures géologiques et biologiques sur notre planète.

Ceci est particulièrement vrai pour l'évolution des plantes et des animaux au cours des derniers 600 millions d'années.

Archéoptéryx (-150 Ma)



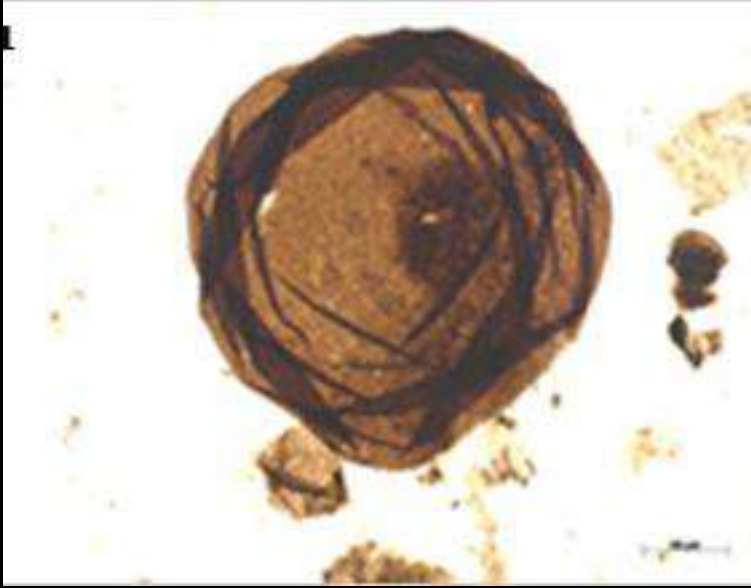
Trilobite (-520 Ma)



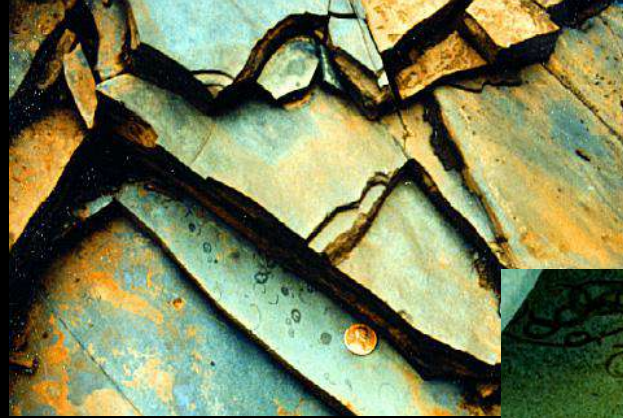
Faune d'Édiacara (-600 Ma)



Fossiles cellulaires



« Acritarche » - Microfossile
à paroi organique
(-900 Ma à -3,2 Ga)



Grypania
(-2,0 à -2,2 Ga)



Cyanobactéries
(-2,7 Ga)



Fossiles biosédimentaires – les stromatolithes

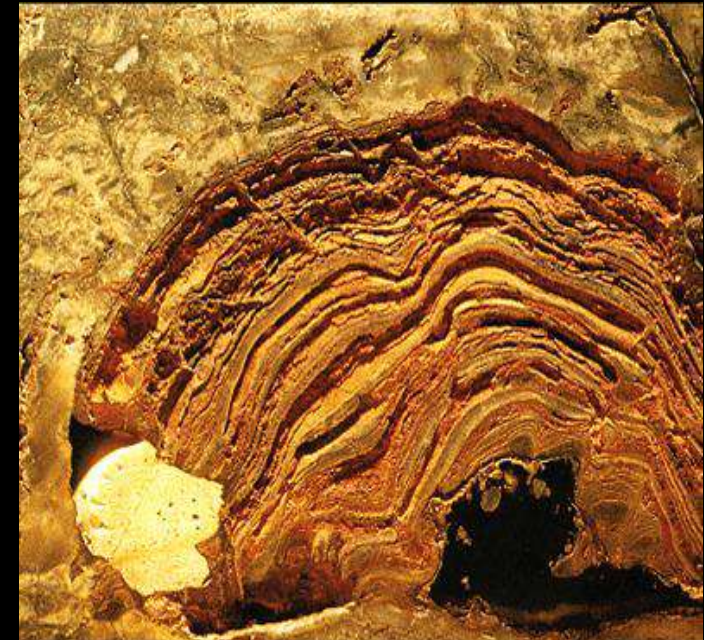


Shark Bay – Australie

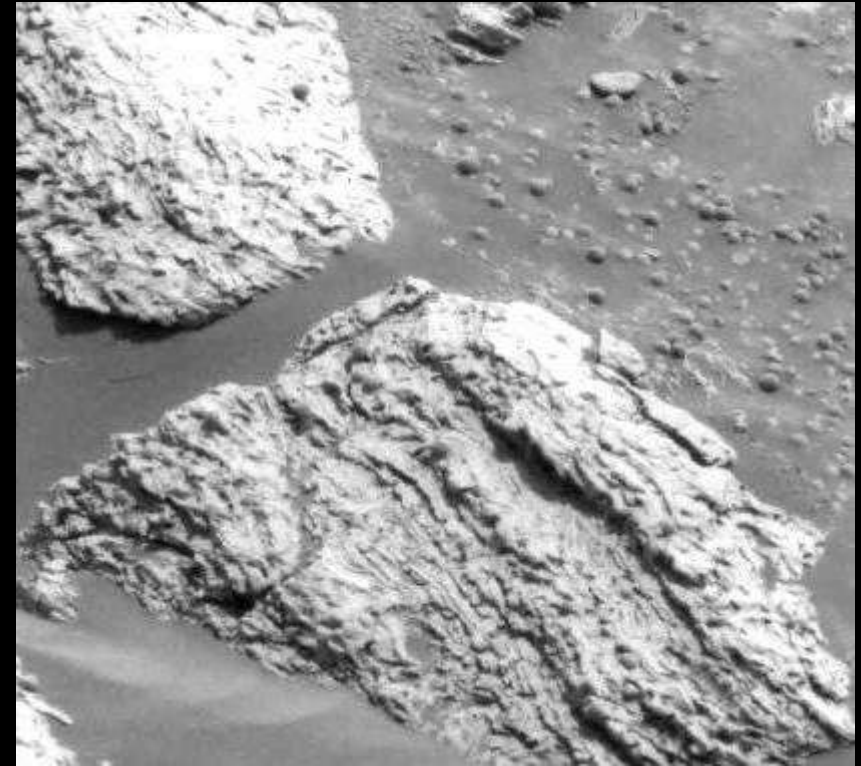


Strelley Pool – Australie
(-3,4 Ga)

North Pole – Australie
(-3,5 Ga)



Des stromatolithes
sur Mars ?



Fossiles biosédimentaires – les stromatolithes

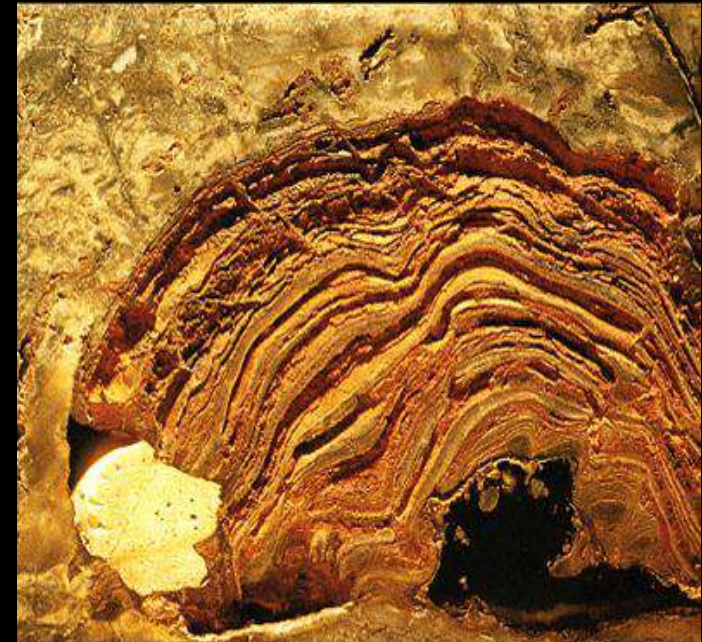


Shark Bay – Australie



Strelley Pool – Australie
(-3,4 Ga)

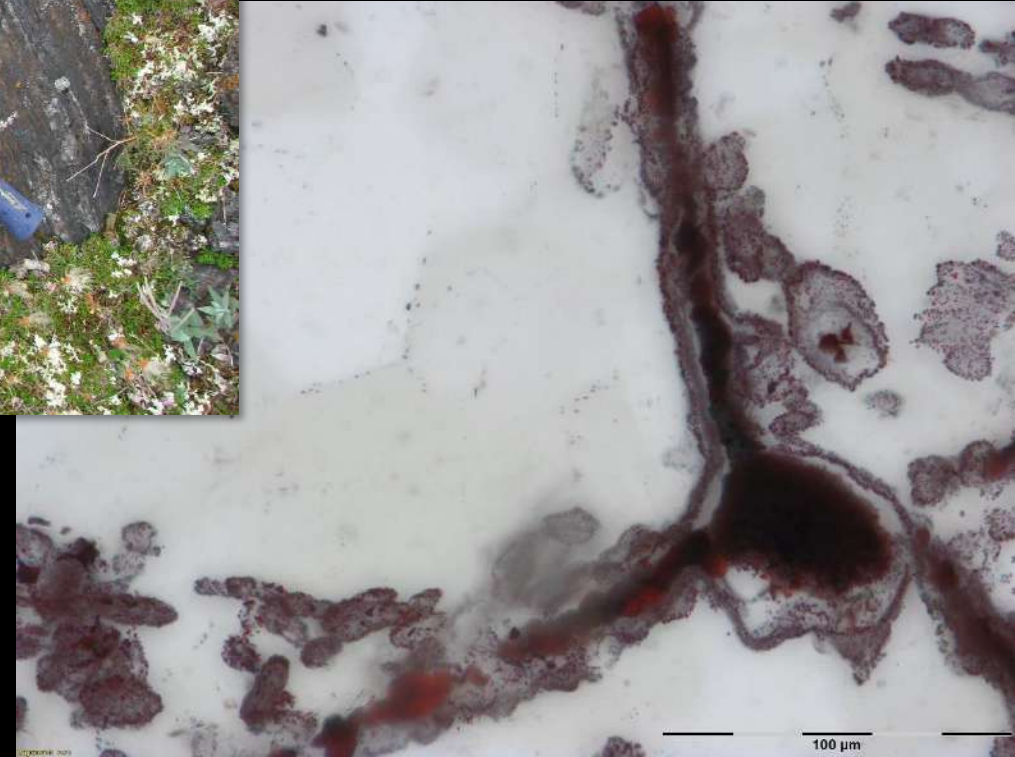
North Pole – Australie
(-3,5 Ga)



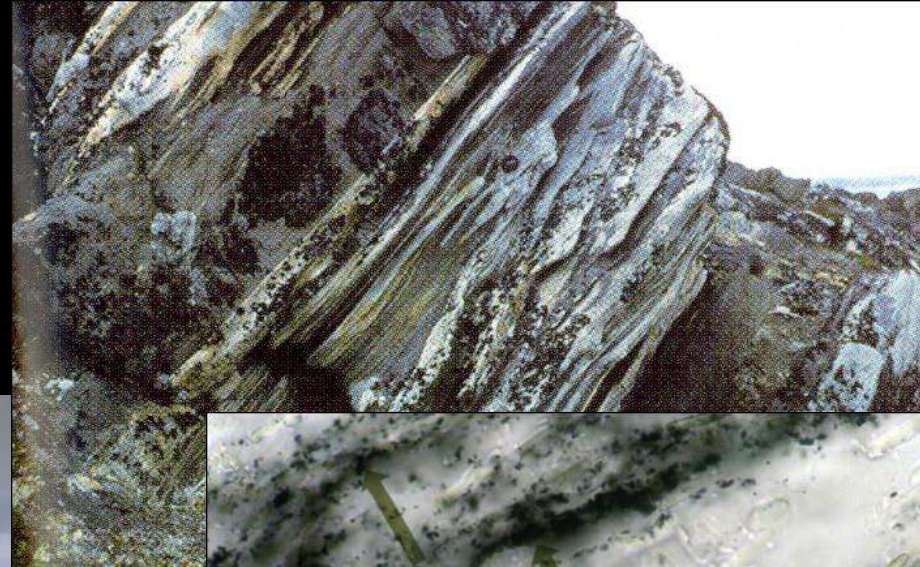
Nuvvuagittuq – Québec

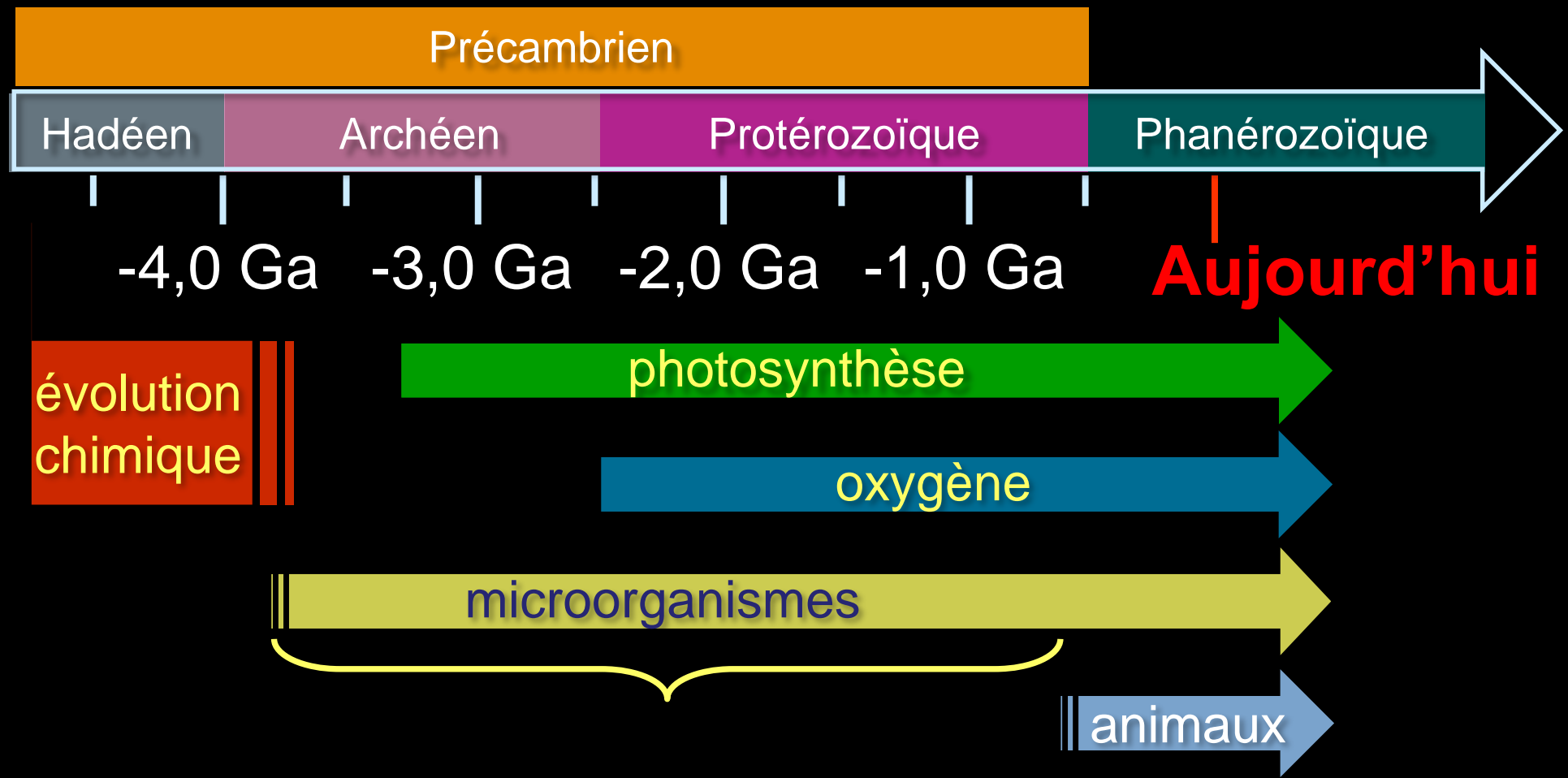


Micro-filaments fossilisés
(-3,77 et -4,30 Ga) ?

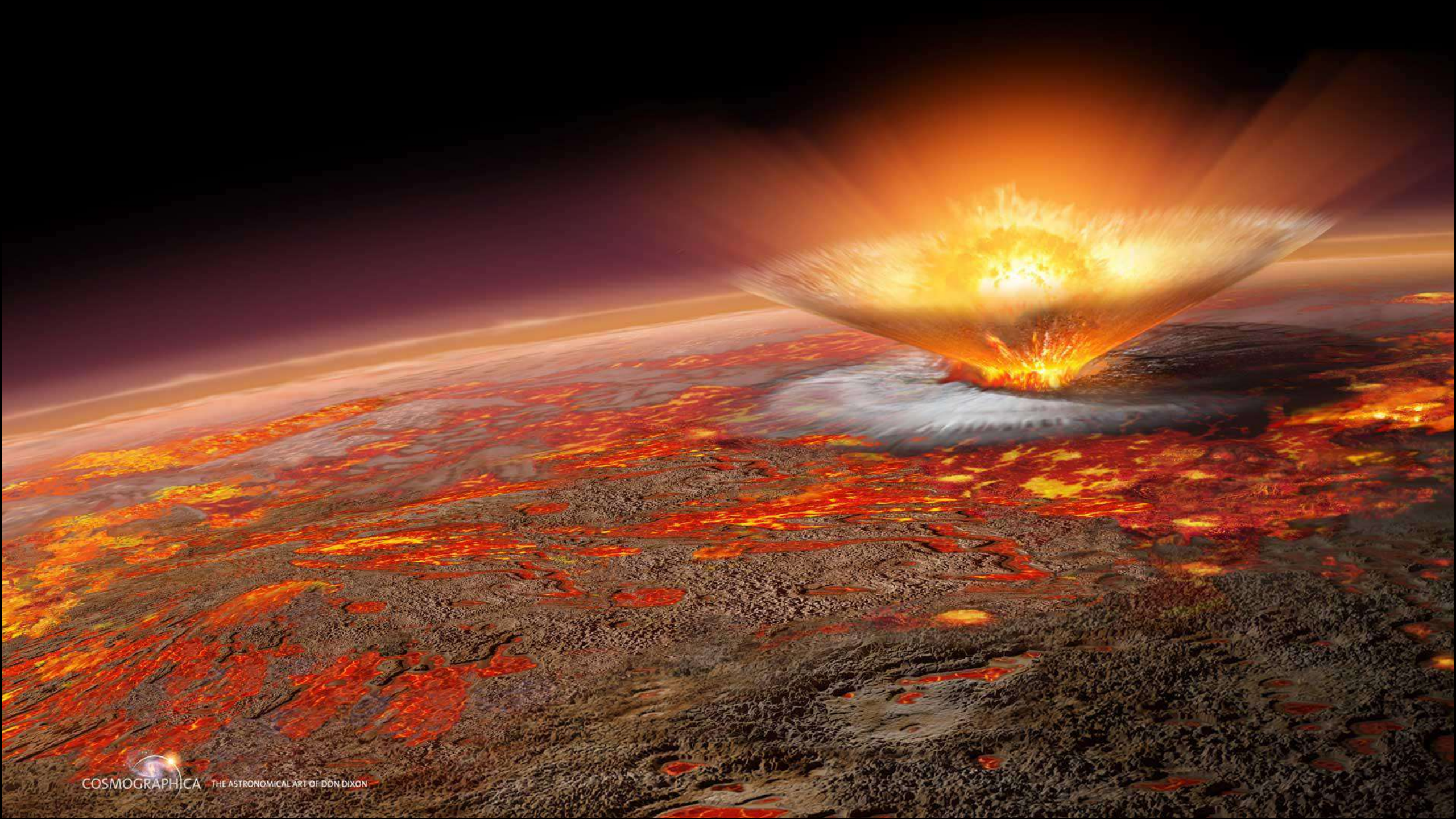


Fossiles chimiques (-3,85 Ga) ?





Environ 90% de l'histoire
biologique de notre planète

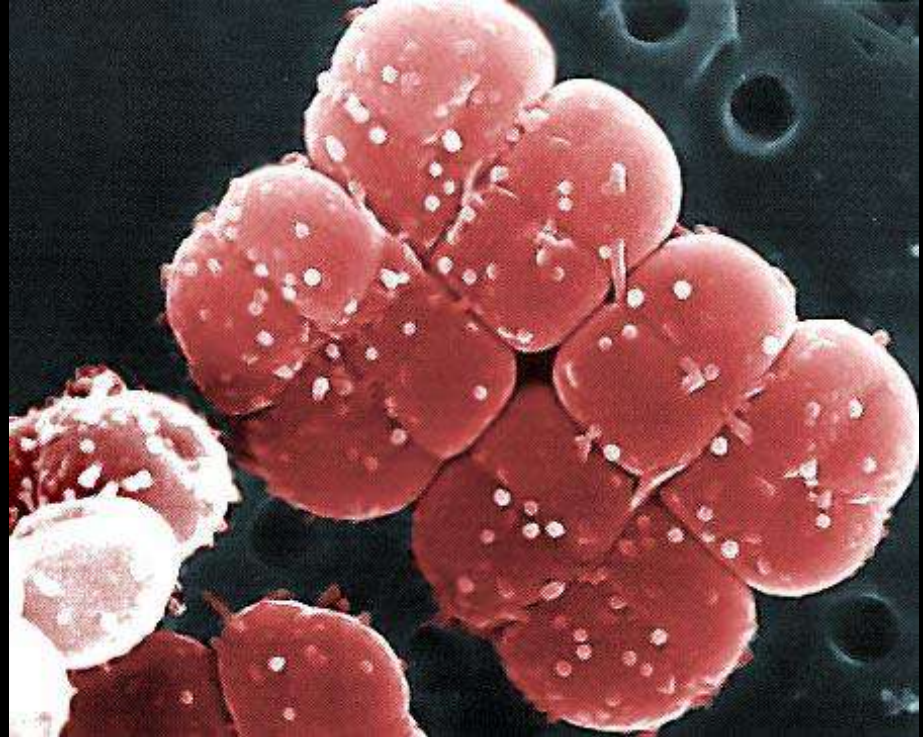
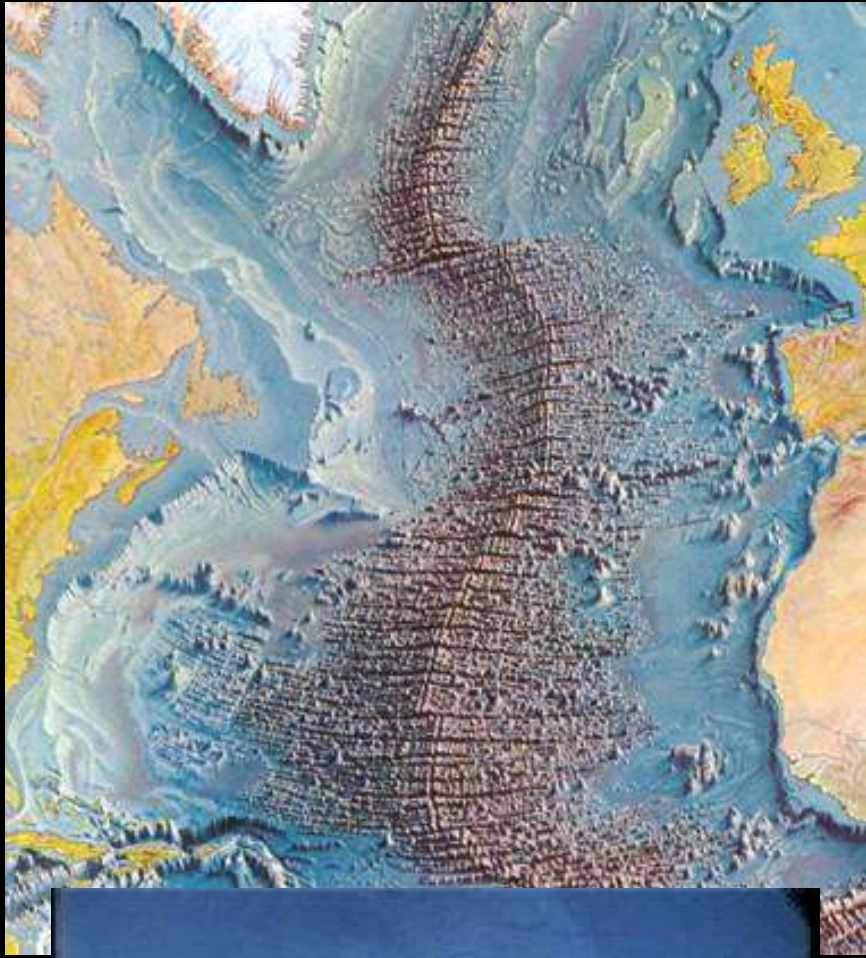




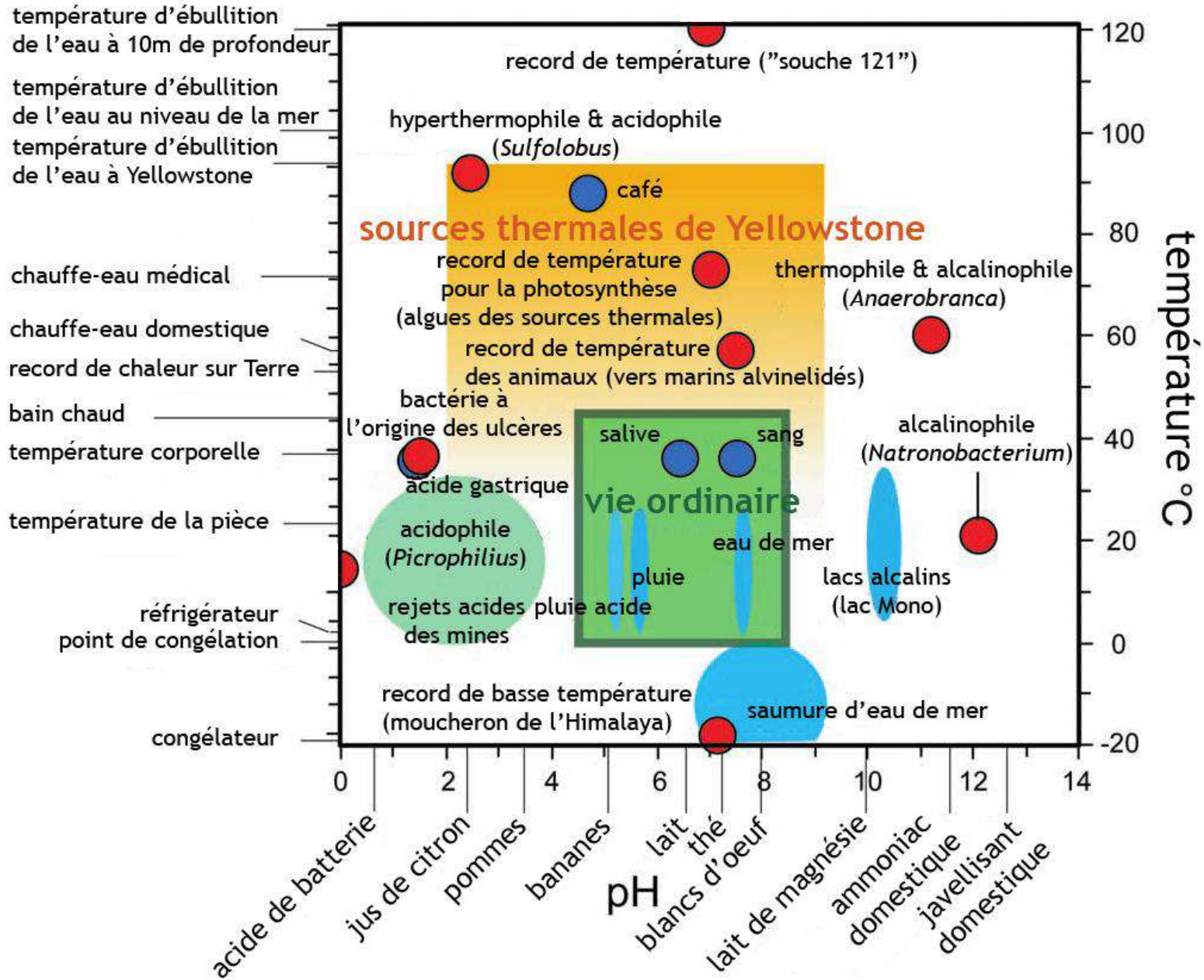


Le monde des extrêmophiles

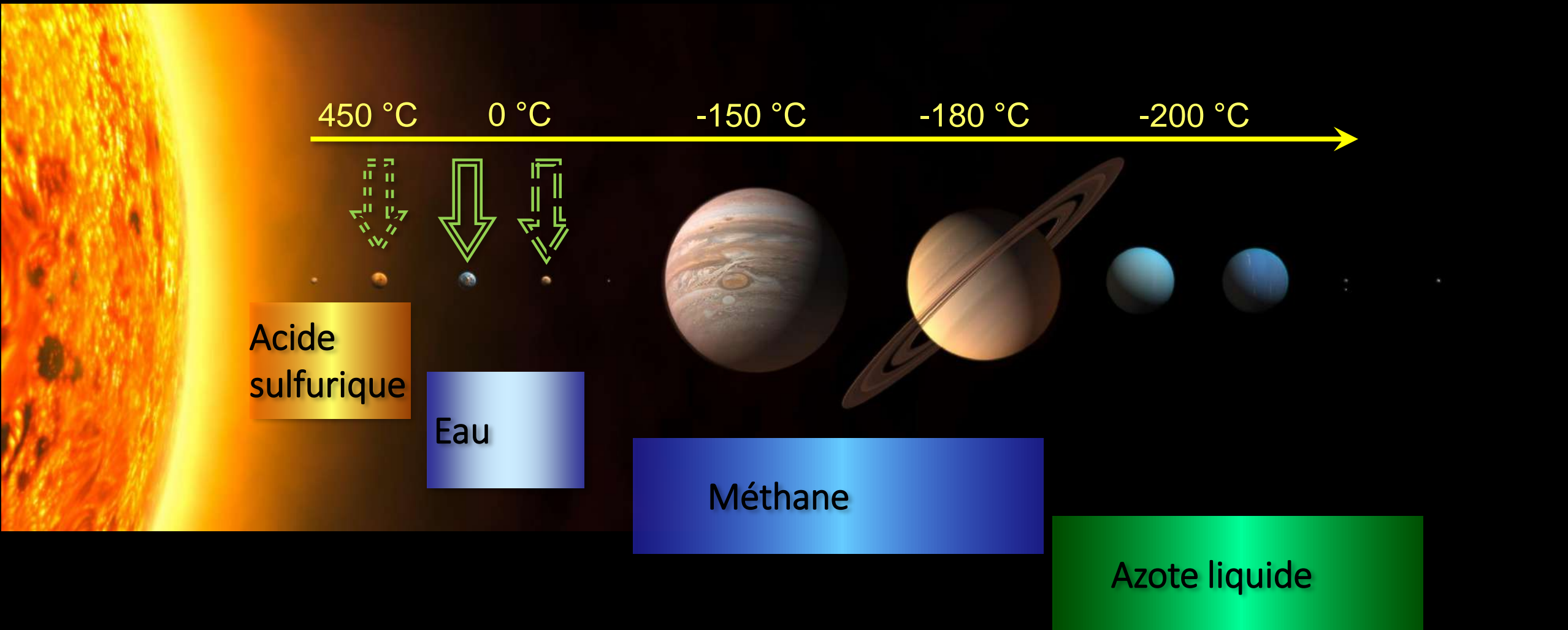


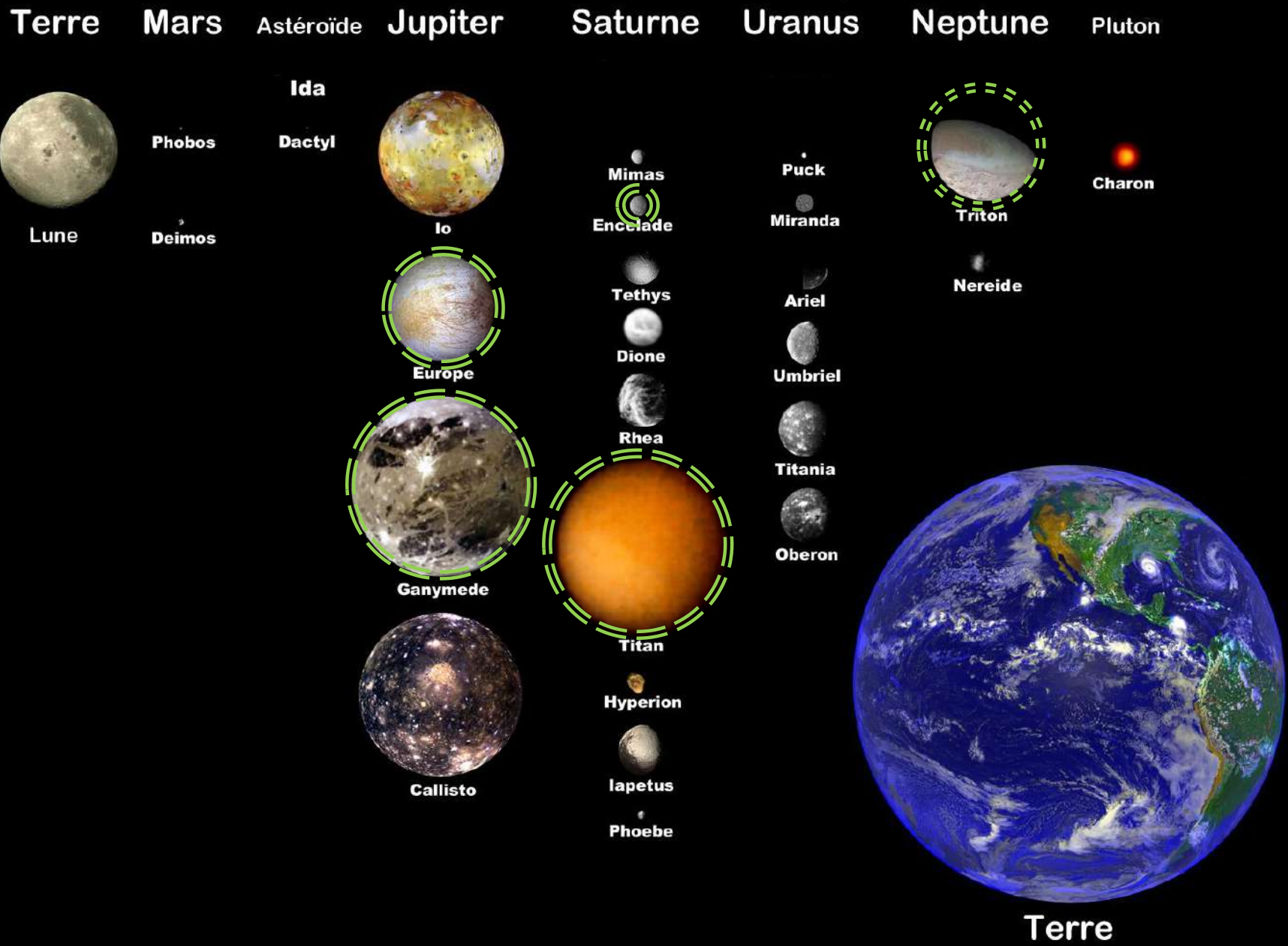


LA VIE SUR TERRE



Le potentiel de vie dans le système solaire





Terre

Mars

Astéroïde

Jupiter

Saturne

Uranus

Neptune

Pluton



Lune

Phobos

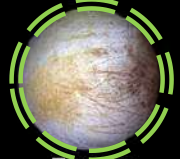
Deimos

Ida

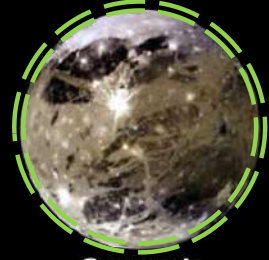
Dactyl



Io



Europe



Ganymede



Callisto



Titan

Hyperion



Iapetus

Phoebe



Mimas

Encelade



Tethys



Dione



Rhea

Puck

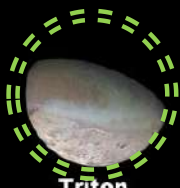
Miranda

Ariel

Umbriel

Titania

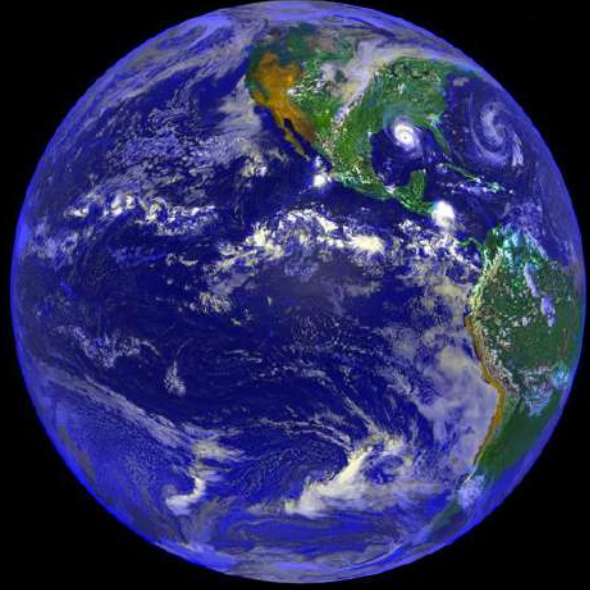
Oberon



Triton

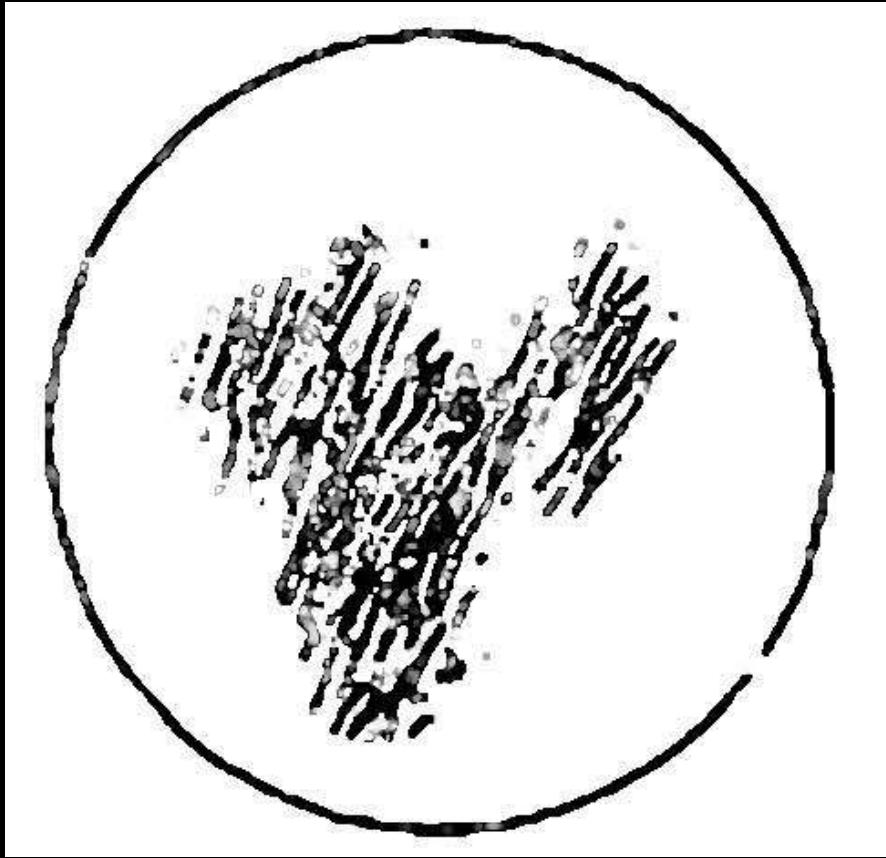
Nereide

Charon

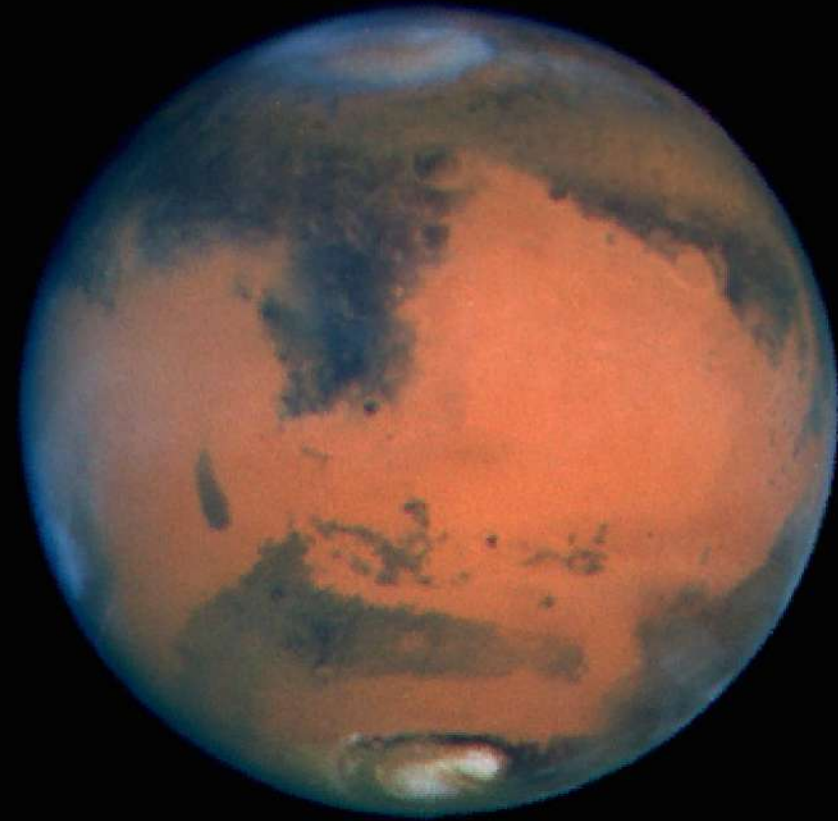


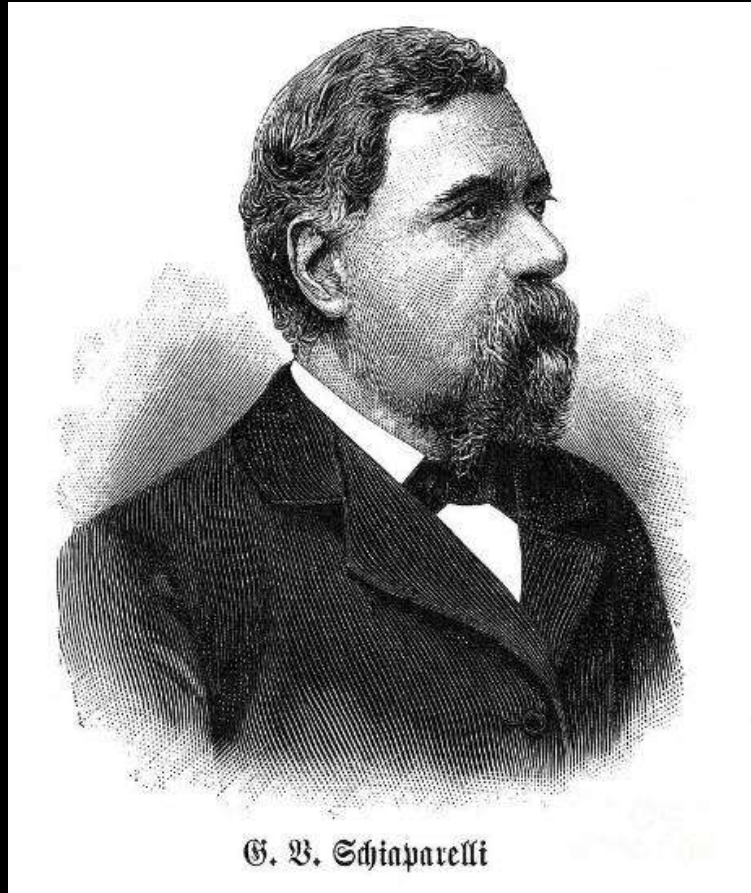
Terre

De la vie sur Mars ?

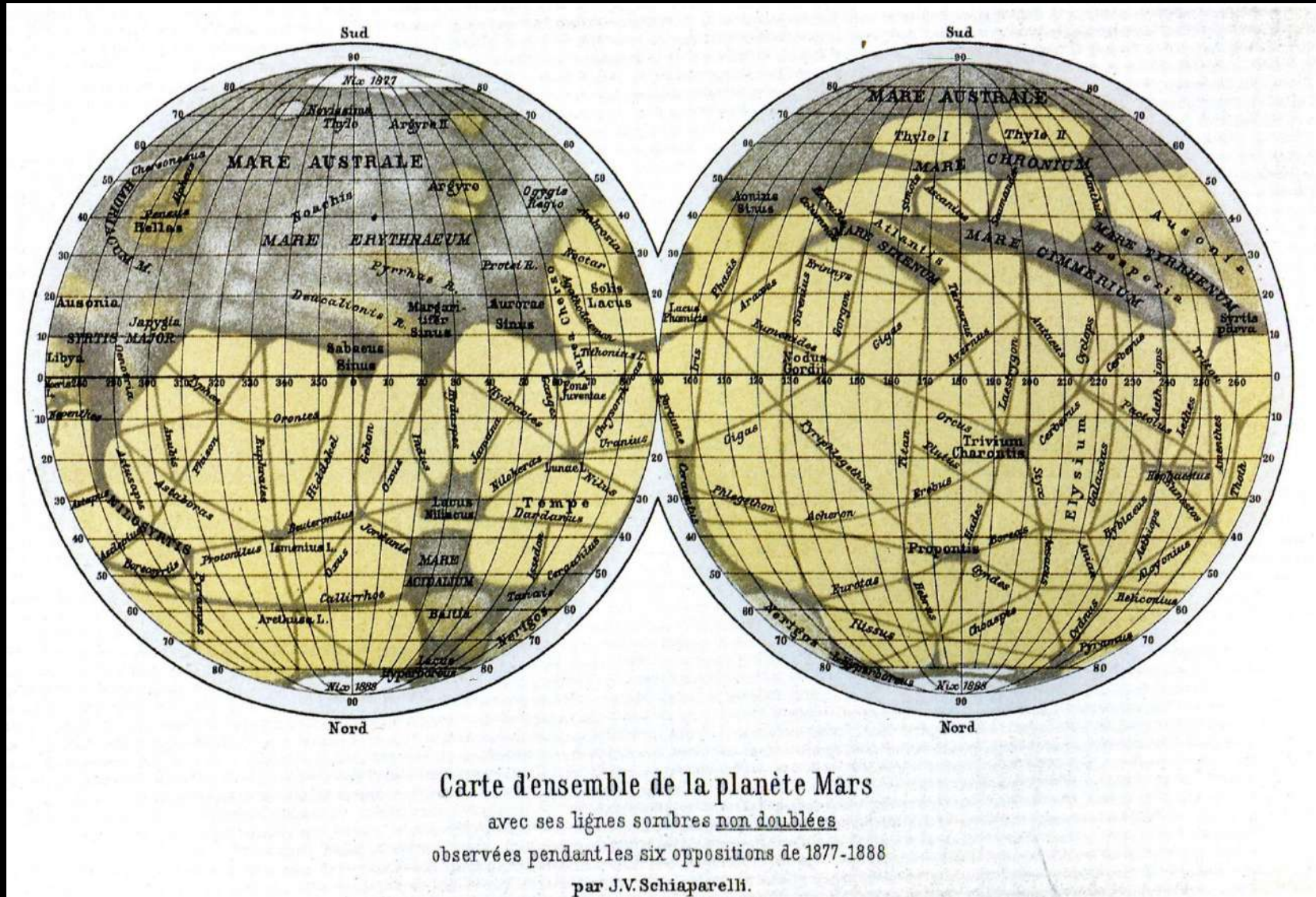


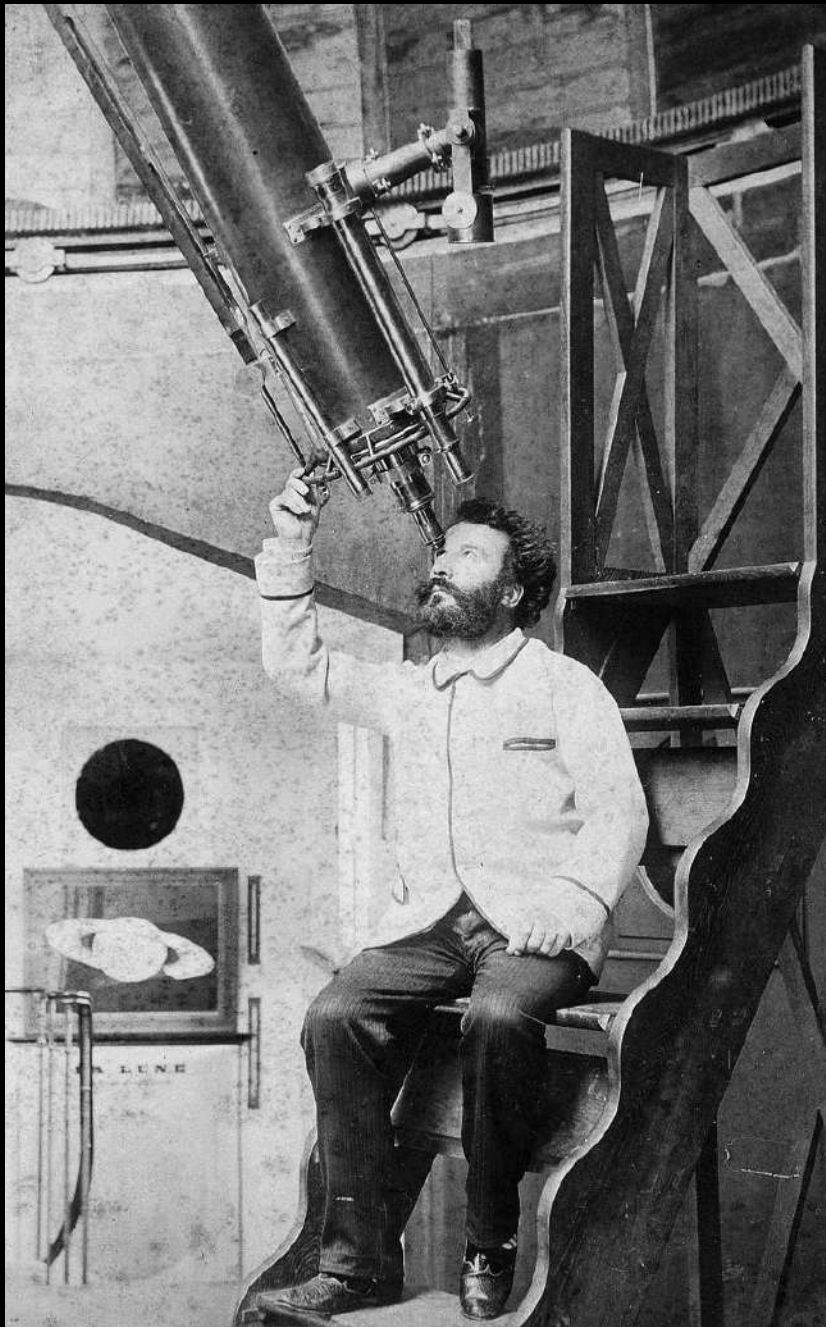
Christiaan Huygens, 1659





G. V. Schiaparelli





LA
PLANÈTE MARS

ET SES
CONDITIONS D'HABITABILITÉ.

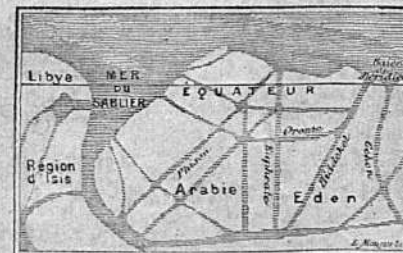
SYNTHÈSE GÉNÉRALE DE TOUTES LES OBSERVATIONS.

CLIMATOLOGIE, MÉTÉOROLOGIE,
 ARÉOGRAPHIE, CONTINENTS, MERS ET RIVAGES, EAUX ET NEIGES,
 SAISONS, VARIATIONS OBSERVÉES.

ILLUSTRÉ DE 580 DESSINS TÉLESCOPIQUES ET 23 CARTES,

PAR
CAMILLE FLAMMARION.

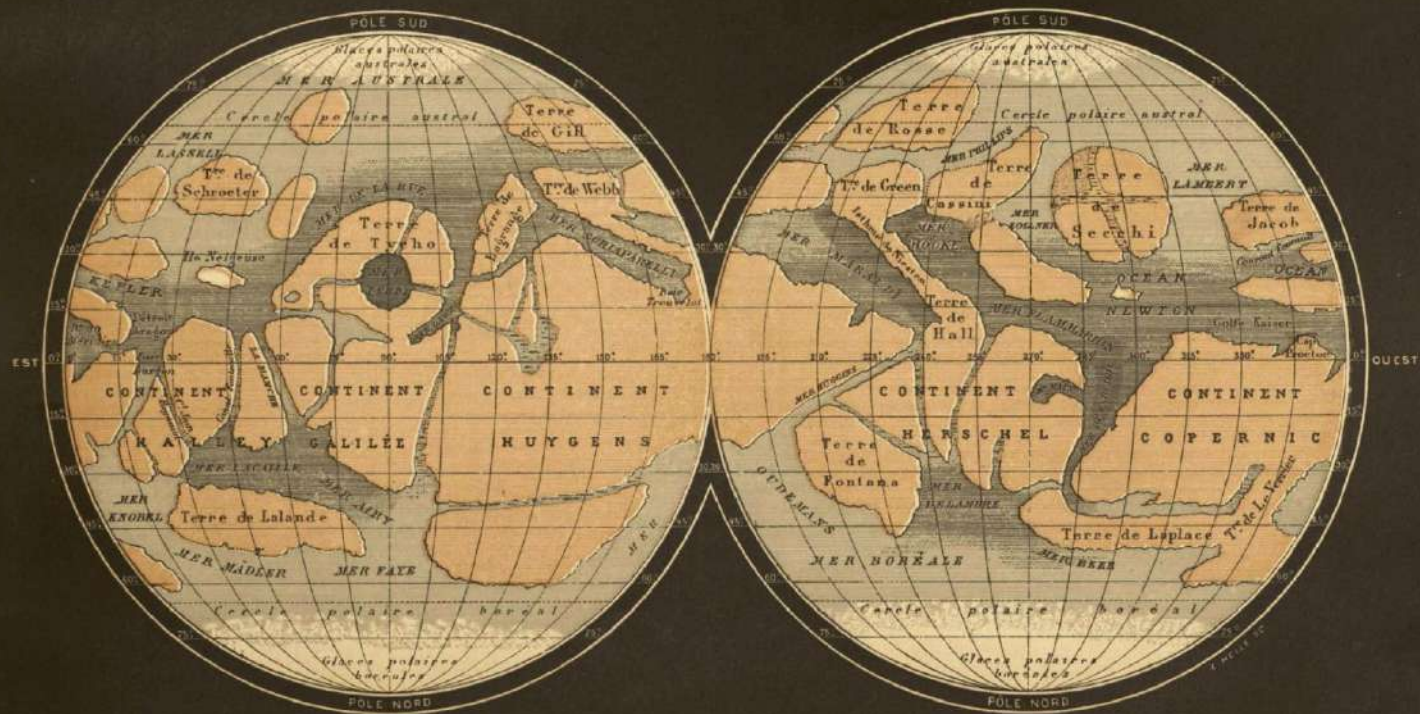
Et major Martis jam apparet imago!
 (VIRGILE. — *En. VIII*, 557).



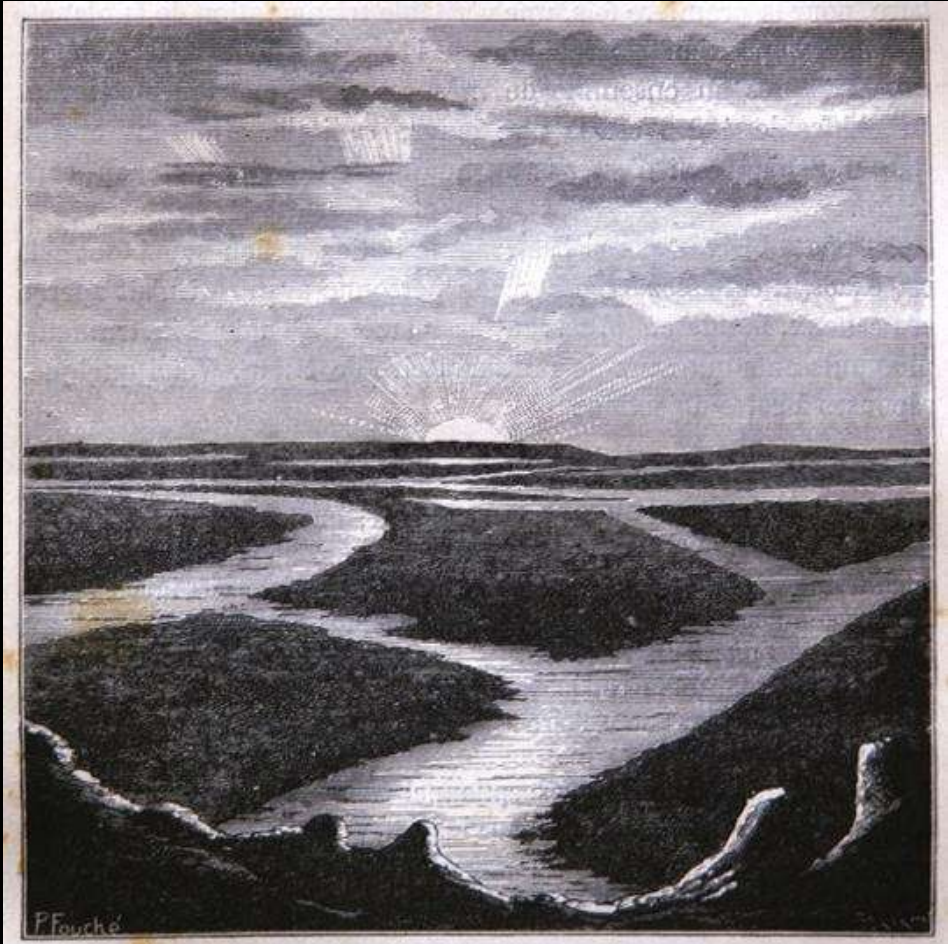
Un coin du monde de Mars.

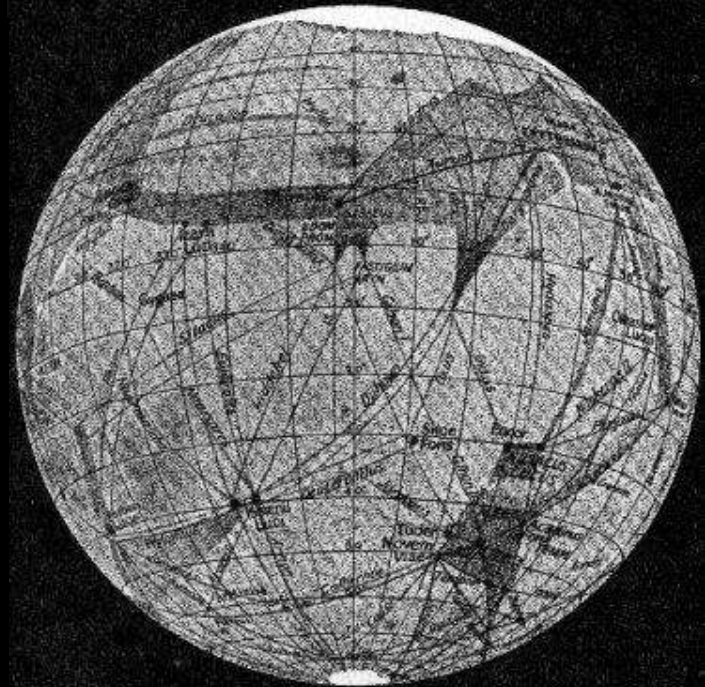
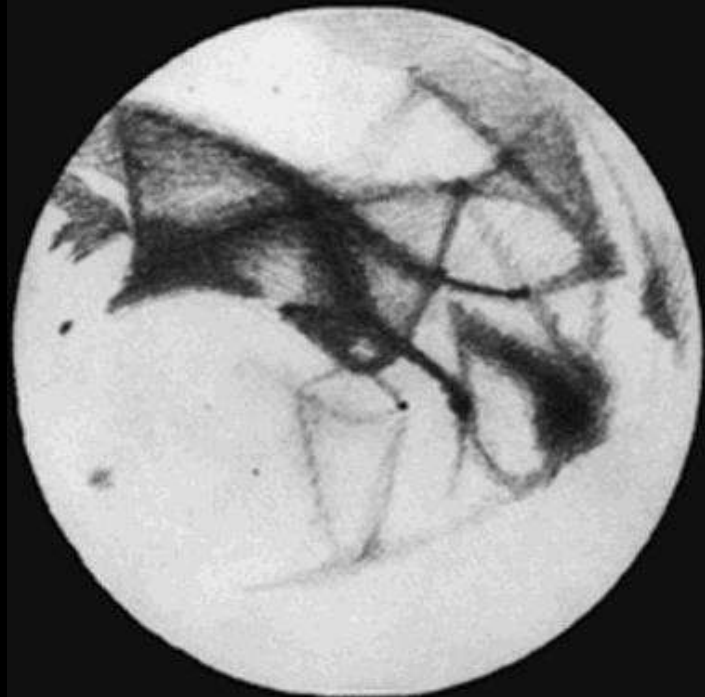
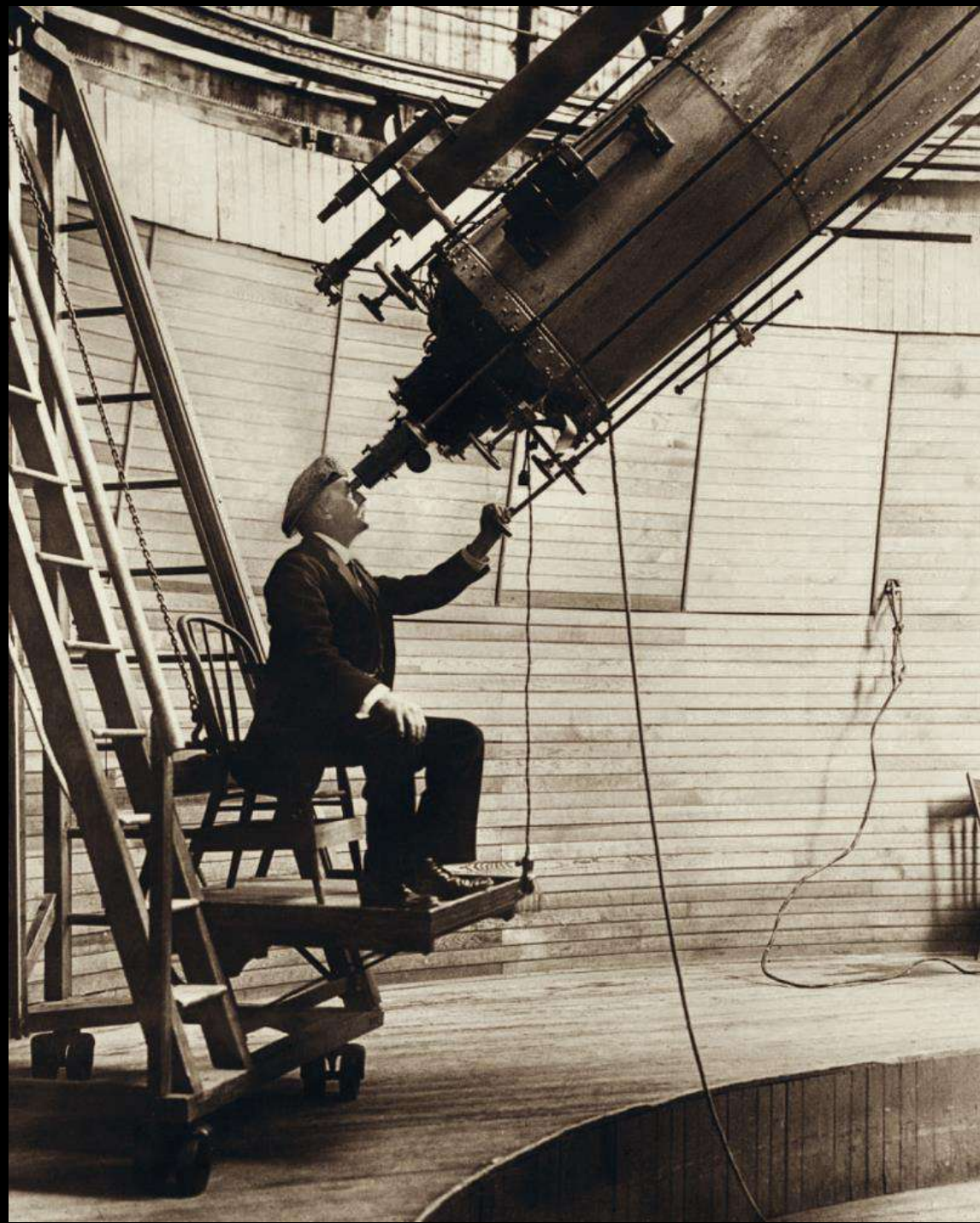
PARIS,
GAUTHIER-VILLARS ET FILS, IMPRIMEURS-LIBRAIRES
 DE L'OBSERVATOIRE DE PARIS,
 Quai des Grands-Augustins, 55

1892



MAPPEMONDE GÉOGRAPHIQUE DE LA PLANÈTE MARS.





MARTIANS BUILD TWO IMMENSE CANALS IN TWO YEARS

Vast Engineering Works Accomplished in an Incredibly Short Time by Our Planetary Neighbors--- Wonders of the September Sky.

By Mary Proctor.

ACCORDING to a telegram dated Aug. 17, from Flagstaff Observatory, Arizona, Dr. Percival Lowell announces the rediscovery of two new canals of Mars, which were seen for the first time at the last opposition in 1902. The canals are now very conspicuous, and attracting world-wide attention because of their startling significance.

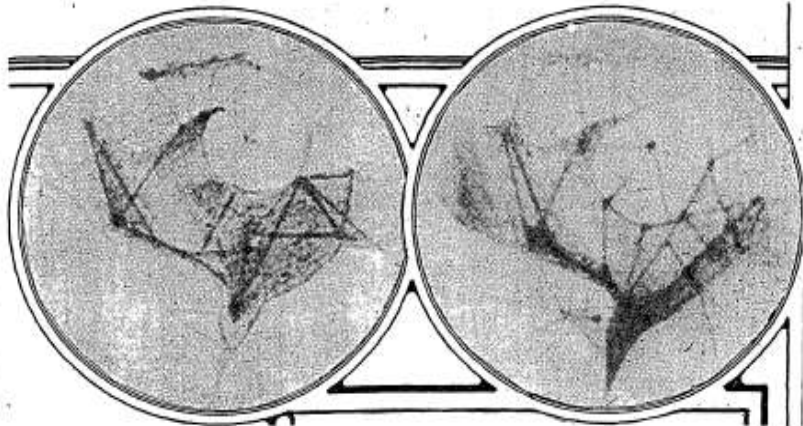
Measurement of their dimensions shows each of them to be a thousand miles long and some twenty miles wide. In comparison, the canal of the Colorado River would be a secondary affair. What has been the cause of these vast channels which have suddenly opened on Mars, where the internal forces are far less than could possibly be the case with our planet? Nothing like it has ever been seen or heard of before. To witness the coming into existence of another world of a surface feature in what we know to be no airy cloud-built fabric, but the solidest of ground, is in its character an event so far of unique occurrence.

That these vast channels have been caused by some internal disturbance is out of the question, for shattering of the sort would certainly have left its mark in yawning, cavernous abysses—such as we see on our own planet in regions where volcanic disturbances have taken place. In the case of the new canals recently observed on Mars, such widespread, shattering effects are altogether absent, and as Dr. Lowell expresses it: "The out-look is purely local and of most orderly self-restraint at that. An enormous change in the planet's features has taken place, with no concomitant disruption beyond the bounds it set. The whole thing is wonderfully clear-cut."

That the new canals were not a mere illusion or vagary of the imagination is proven by the fact that they are again visible, but they are as great a problem now as they were when first seen in 1902. Canals a thousand miles long and twenty miles wide are simply beyond our comprehension. Even though we are aware of the fact that, owing to the mass of the planet being a little less than one-ninth of the earth's mass, a rock which here weighs one hundred pounds would there only weigh thirty-eight pounds, engineering operations being in consequence less arduous than here, yet we can scarcely imagine the inhabitants of Mars capable of accomplishing this Herculean task within the short interval of two years.

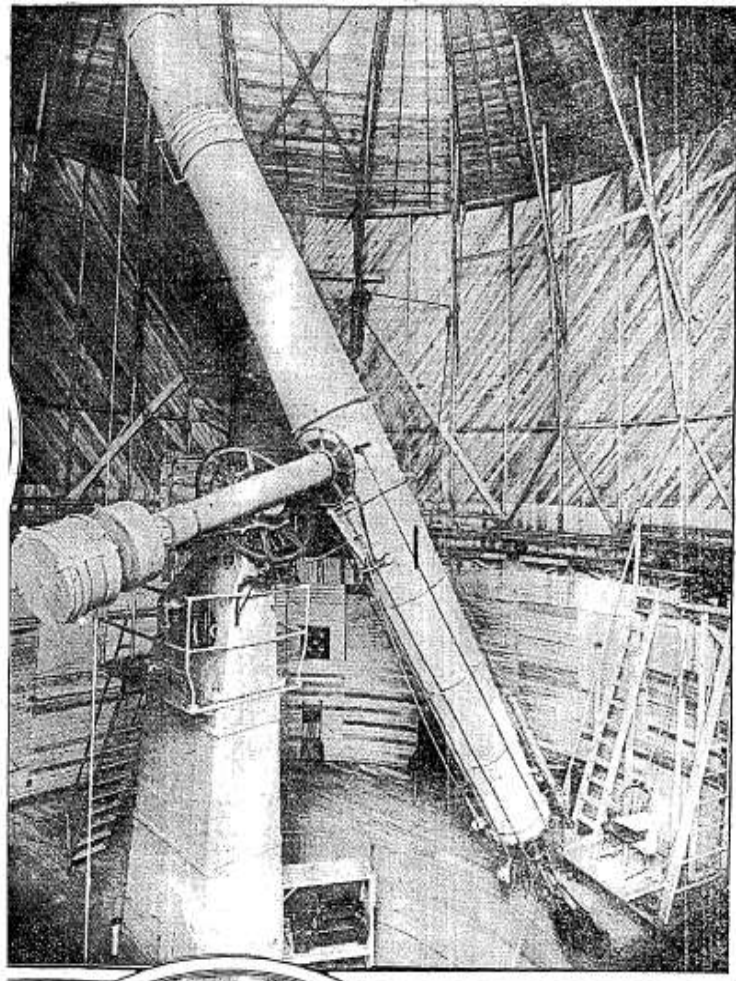
Examining the Flagstaff records for the past sixteen years, during which Mars has been kept under observation, no record has been found of these canals.

These Two Drawings by Prof. Lowell and Prof. E. C. Silliker Show the New Canals Just Observed.



the planet. The record books were then examined, when it appeared that not a trace of them was to be found in the drawings of May, June, July, or August when this part of the planet was most carefully observed and drawn. That they had not been observed in previous years was then conclusively ascertained by examination of the records of those years.

The record of canals seen at Flagstaff is retained at the Lowell Observatory after each opposition or near approach of the planet, when it is well placed for observation. From these records a fresh map, including all new details observed, is made of the planet's surface. These maps are, therefore, of the greatest value in enabling us to trace any peculiarities or changes on Mars, and they keep us in touch with any alterations which may be taking place on that planet. What new revelations are in store for us, at the present opposition, we know not, but of one fact we are certain, and that is the untiring energy and boundless enthusiasm of Dr. Lowell and his able assistants at the Lowell Observatory will make it simply impossible for any detail of the slightest significance on Mars to escape their vigilance.

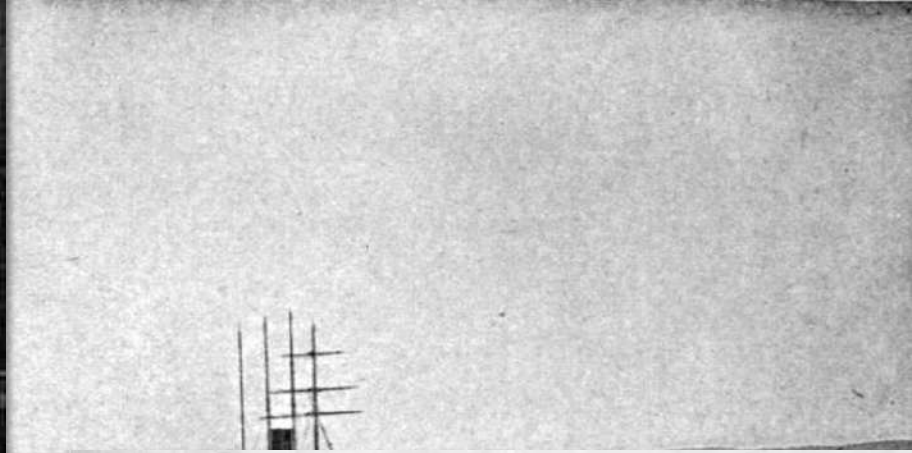


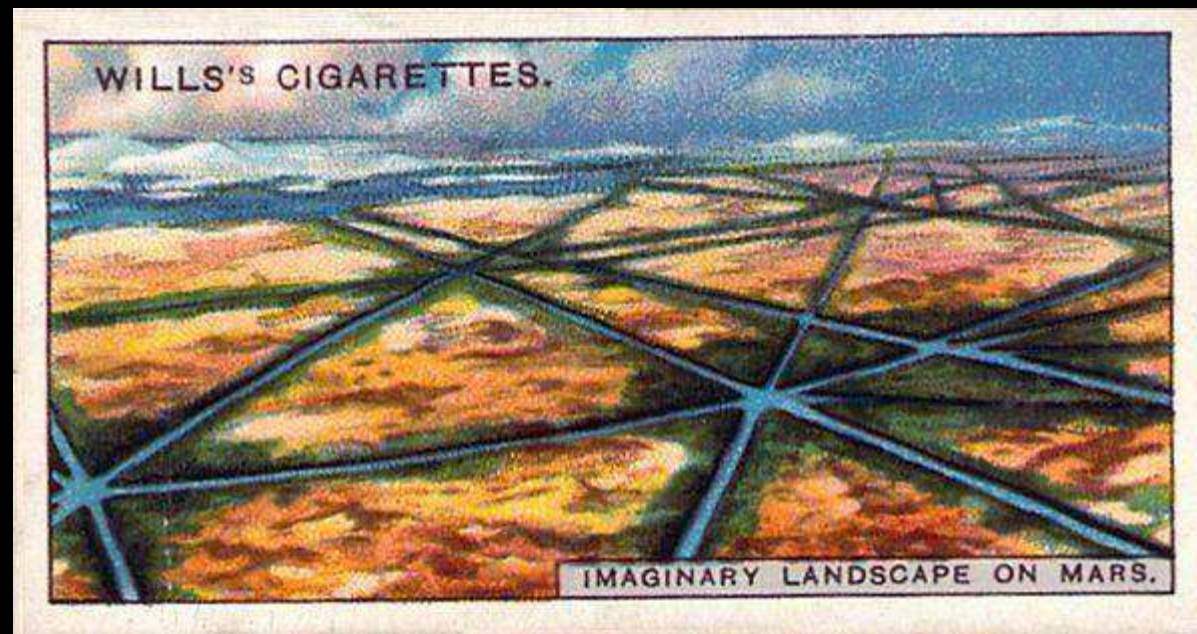
The Great Telescope at Lowell Observatory.

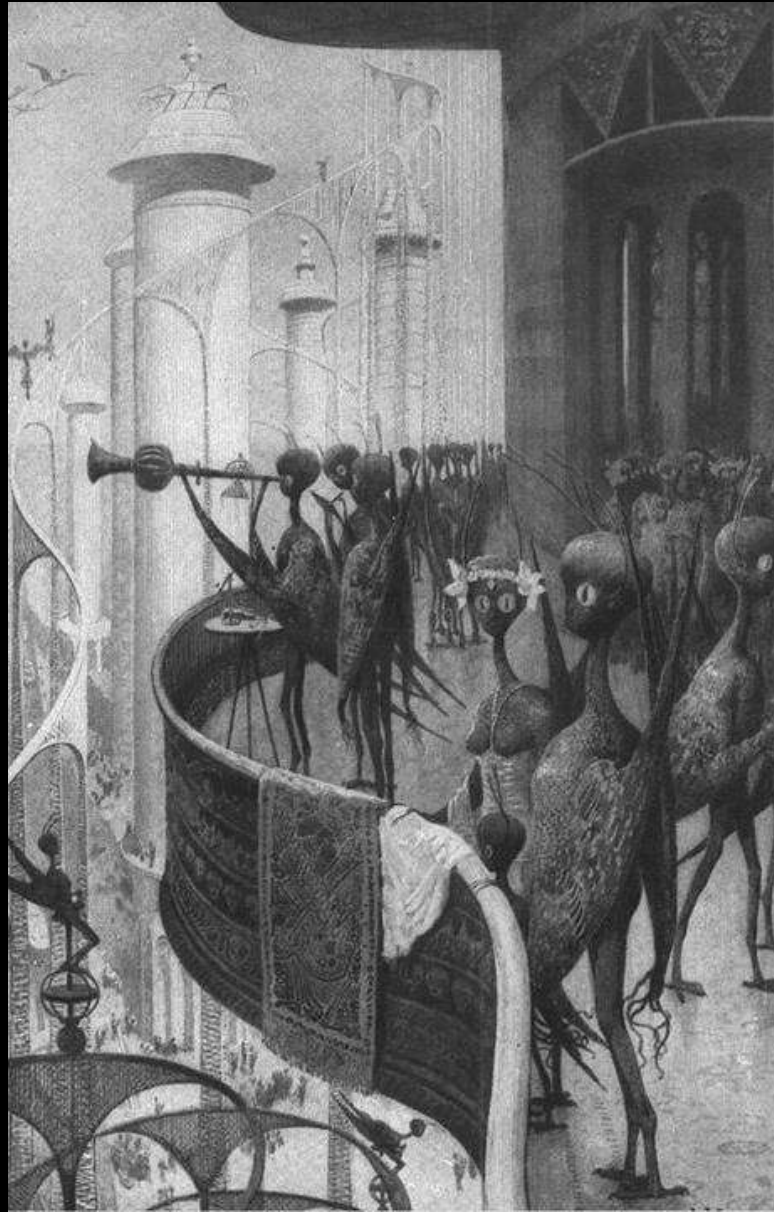


Field of view adorned by their leader, imperceptibly the moments flew by, while the writer enjoyed the wondrous scene. Then the clouds, fearful enemies of as-

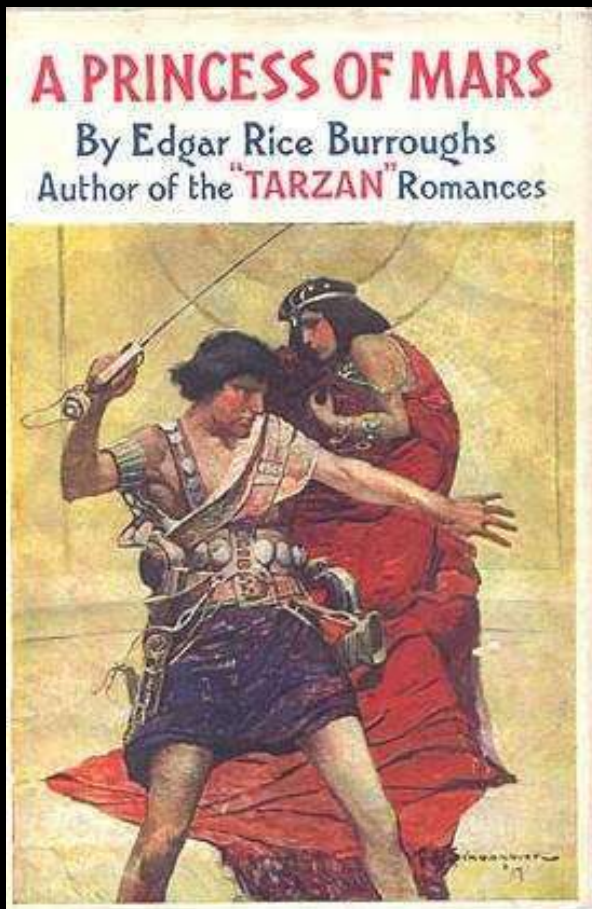
New York Times, 27 aout 1911



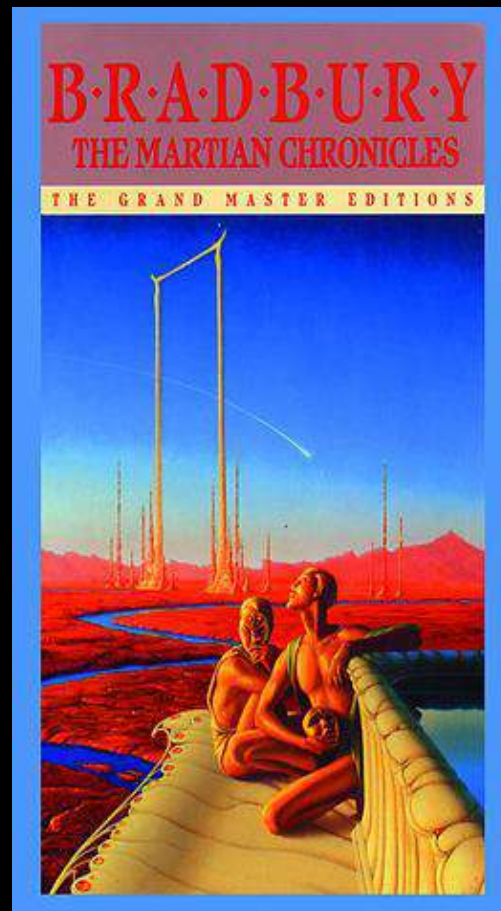




Cosmopolitan – 1908



1911

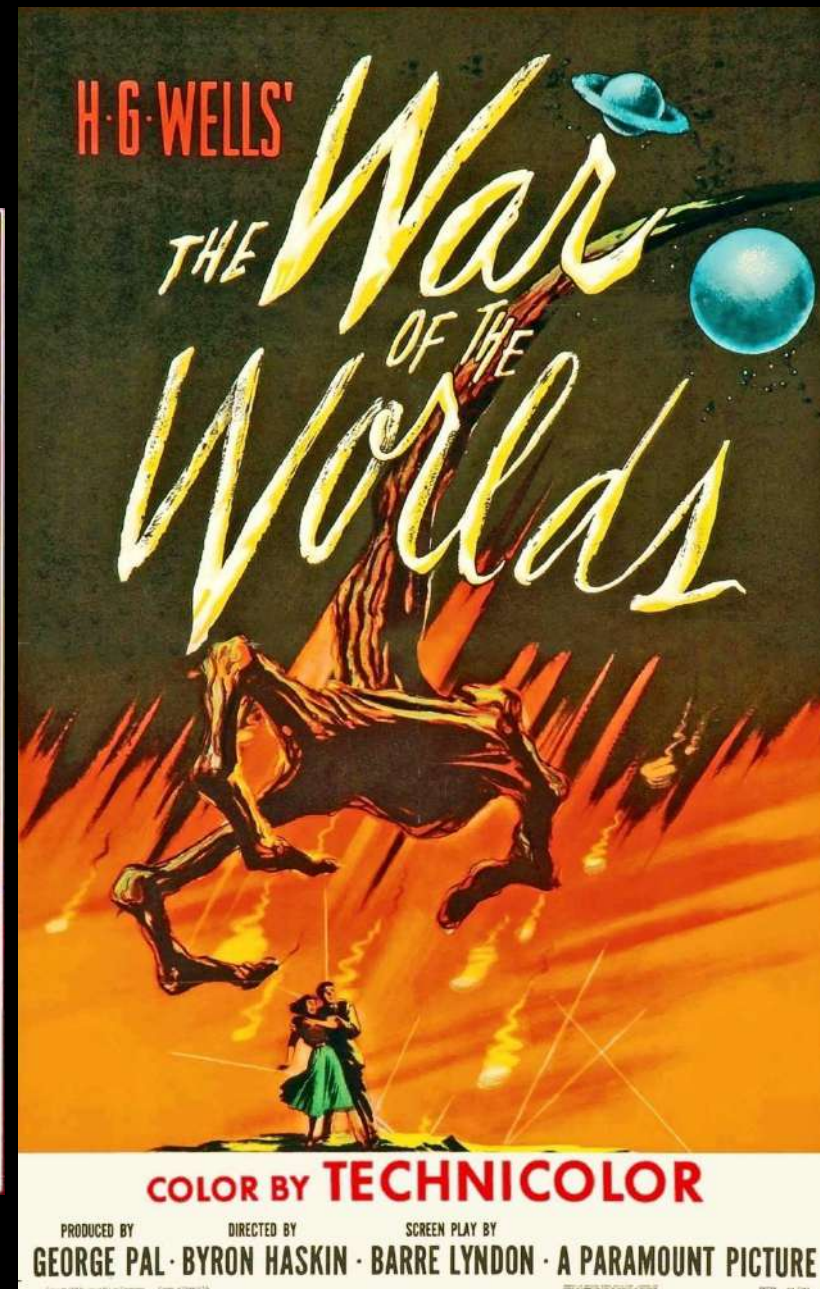
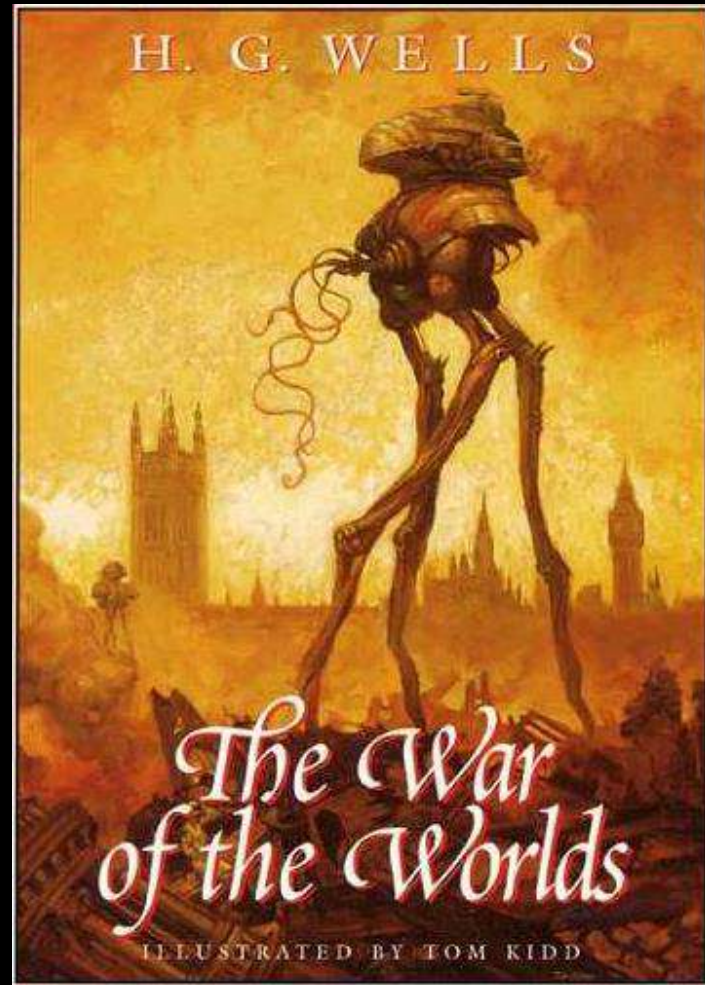


1946-1950

1952



1898



Paramount Film – 1953

The

The Boston Daily Globe

Want Advertisements
To Sell, Sell, Hire or Rent any
thing, advertise in the Globe's
Want Columns. Use the Daily
Globe—the Sunday Globe.

Full Business Wanted?
Advertise in Tomorrow's, Wed-
nesday's, Thursday's and Friday's
Globe. Read the ads in the
Globe every day.

BOSTON, MONDAY MORNING, OCTOBER 31, 1938—EIGHTEEN PAGES (2) TWO CENTS

RADIO PLAY TERRIFIES NATION

Mars Invasion Thought Real Hysteria Grips Folk Listening In Late Many Fear World Coming to End

PATROL WAGON, AUTO CRASH



TEN PERSONS WERE BURNED ON MIDDLE ST., BOSTON.

READY FOR HALLOWEEN



BEAT BOGUELL AND LEE GRAYTON
Worcester pair proud of their "pumpkin" babies.

3 FIRES SET IN SO. END HOTEL

52 Guests, Employees
Held in Darkness as
Police Hunt Incendiary

Fifty-two guests and all employees were held virtual prisoners behind the locked doors of a hotel last night when three fires broke out in the South End Hotel, South End, the fire department said today. The cause and location of the fires was not known.

The Capital Parade

Lehman Expects Poletti Victory



By JOSEPH BLANK and
ROBERT RIVKIN
WASHINGTON, Oct. 30.—In the excitement of the New York campaign, the hearing of Robert Lehman's plea for raising again has assumed great importance. The public opinion which will be formed in New York between the Democratic and Republican camps will be a factor in the final result. It is expected that the hearing will also be an important one in the campaign.

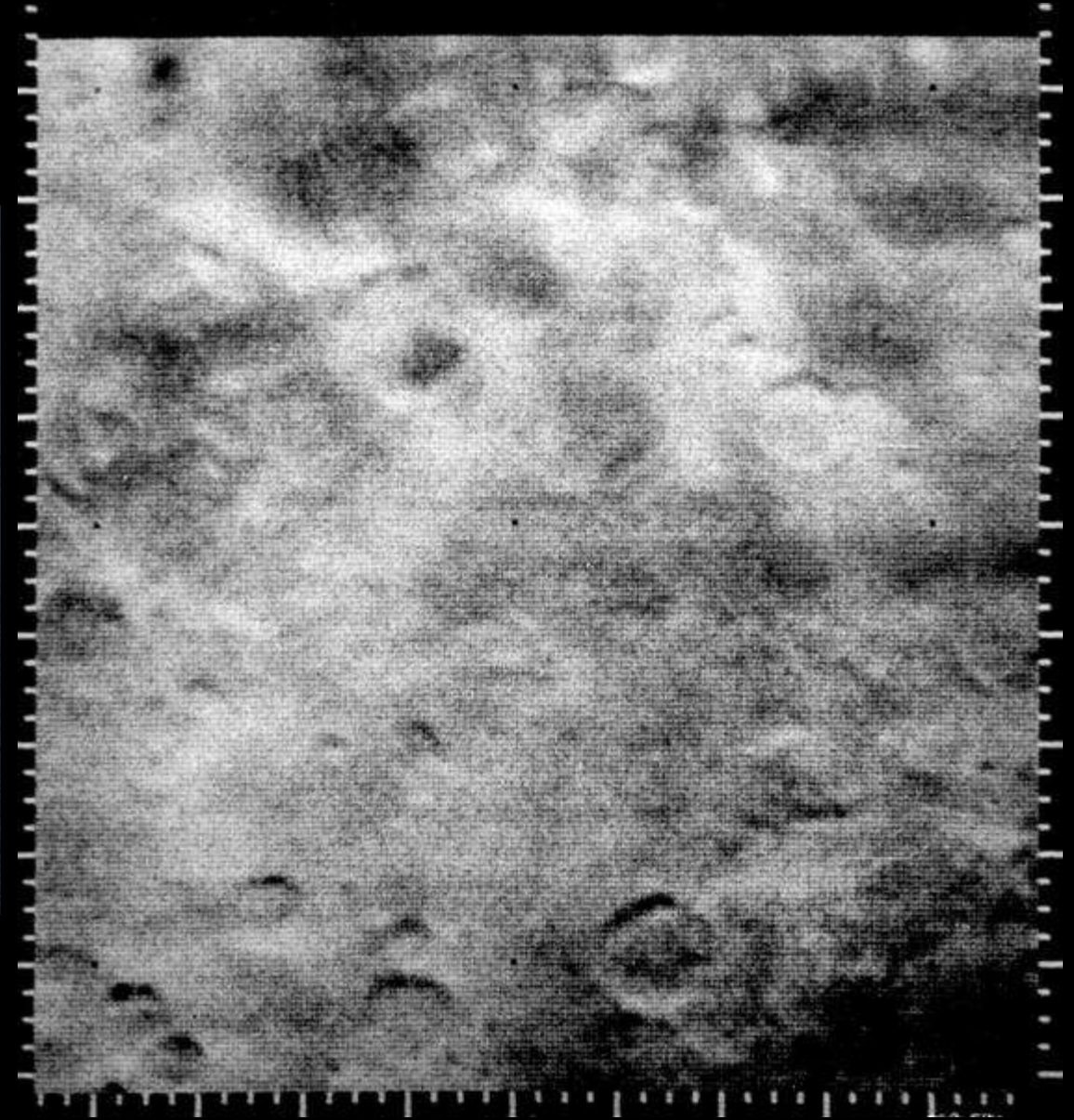
Police, Youth Groups Plan Safer and Saner Halloween

FAIL TO CLAIM BLUENOSE CUP

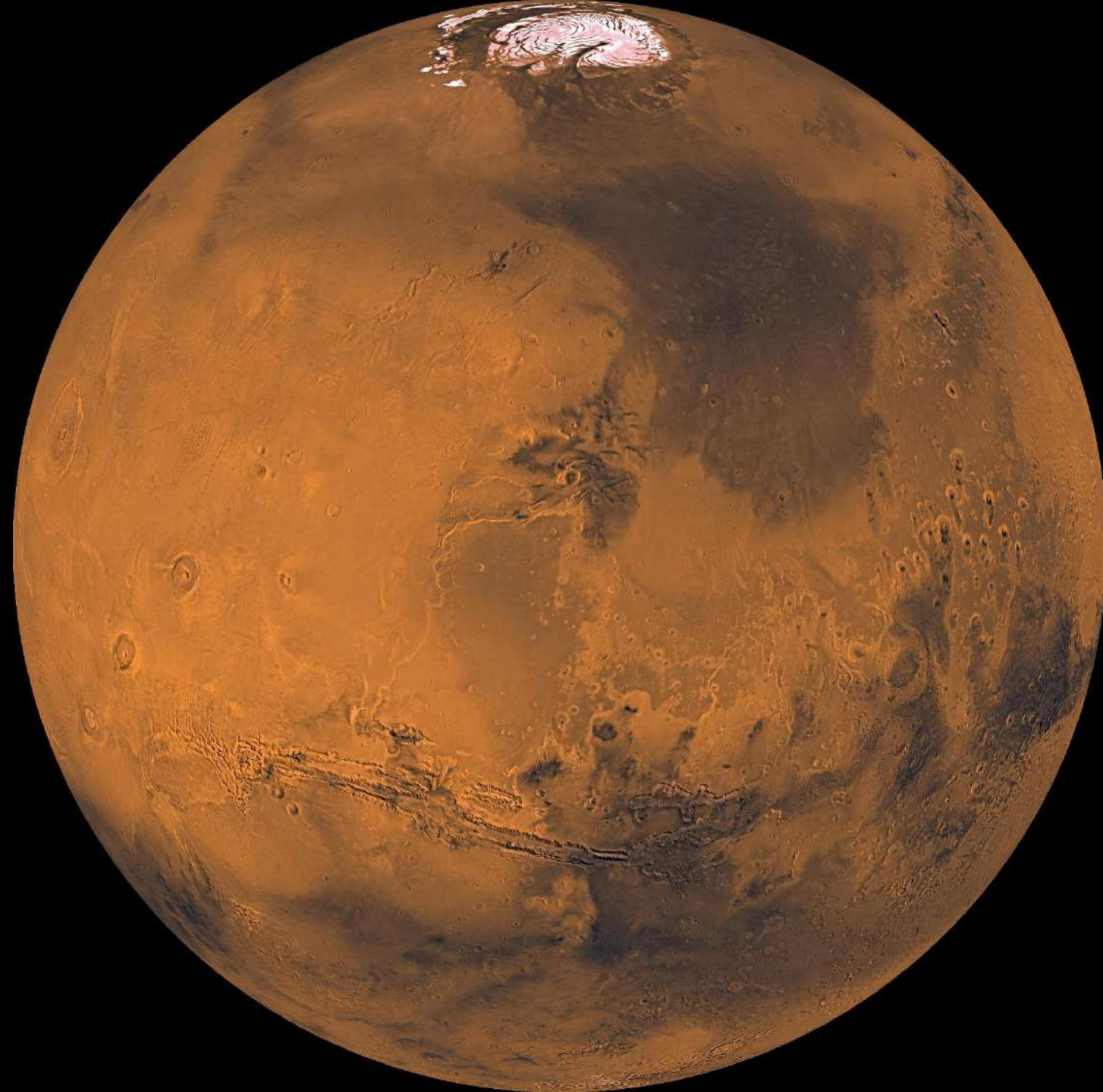
Mystery Veils Fatal Injuries to Relatives' Homes Distribution Committee

NEW YORK, Oct. 30. (U. P.)—A hearing today before the Senate subcommittee on the hearing of Robert Lehman's plea for raising again has assumed great importance. The public opinion which will be formed in New York between the Democratic and Republican camps will be a factor in the final result. It is expected that the hearing will also be an important one in the campaign.

Mariner 4 (1965)



Un siècle de fantasmes sera réduit à néant en quelques minutes...



La planète Mars est aujourd'hui considérée comme un désert froid.

Toutefois, les nombreuses sondes et robots démontrent que le passé martien a certainement été plus clément et propice à l'apparition de la vie.

+5 500 jours !

OPPORTUNITY'S MARATHON JOURNEY!

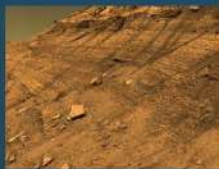
First Marathon "Run" on Another Planet
Distance: 26.2 miles Time: 11 years, 2 months

A GREAT START



At landing, Opportunity finds signs of acidic water in Mars' ancient past.

LONG WAY TO GO



Rock layers show this area was wet off and on. Any microbes could have had a tough time.

TOUGH CHALLENGE



After Victoria Crater, scientists wonder, "Was this ancient water also too salty for life?"

GETTING IN STRIDE



At last! Opportunity finds the first signs of past water good for life!

A RUNNING HIGH



Atop a crater rim, Opportunity explores clays that tell us Mars might have been a good habitat.

Eagle Crater
Endurance Crater

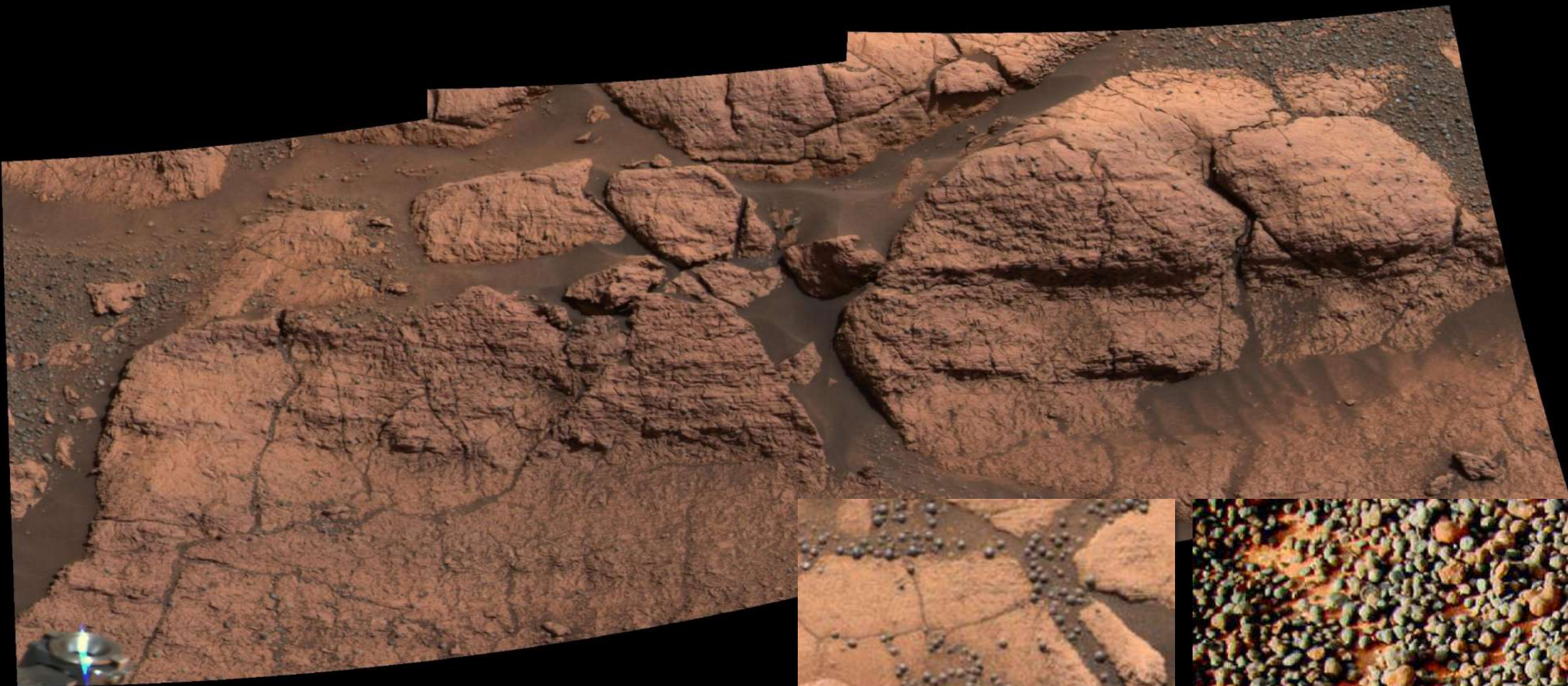
Victoria Crater



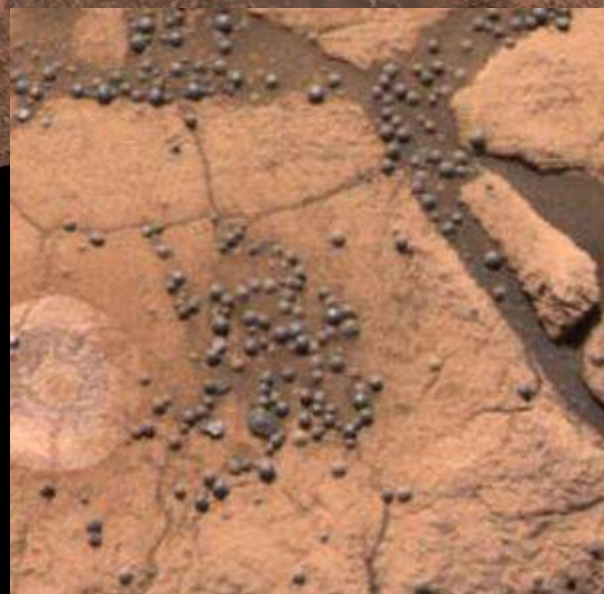
Endeavour Crater

Follow along:
mars.nasa.gov





Meridiani Planum
(*Opportunity*)



+2 000 jours !



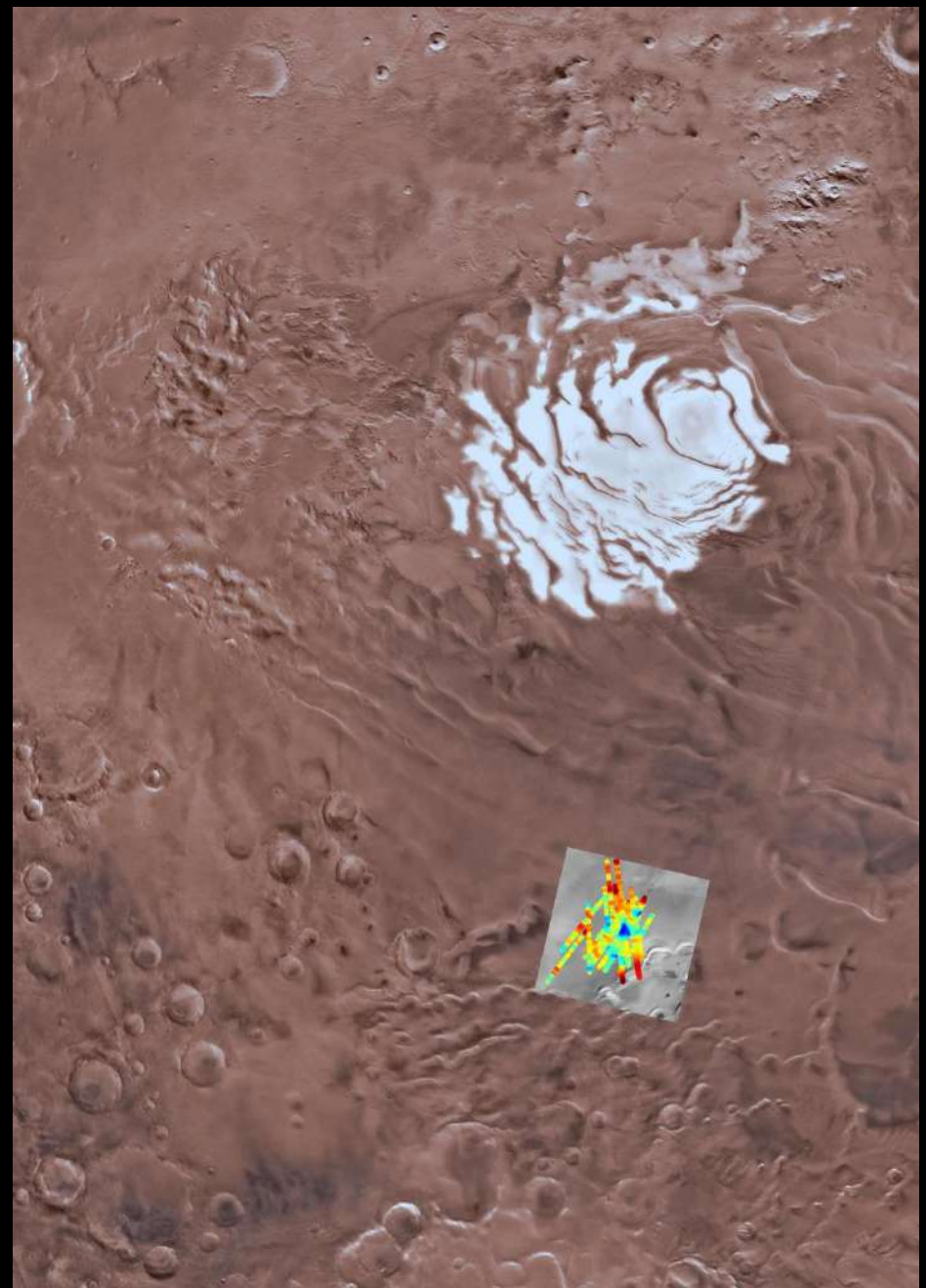
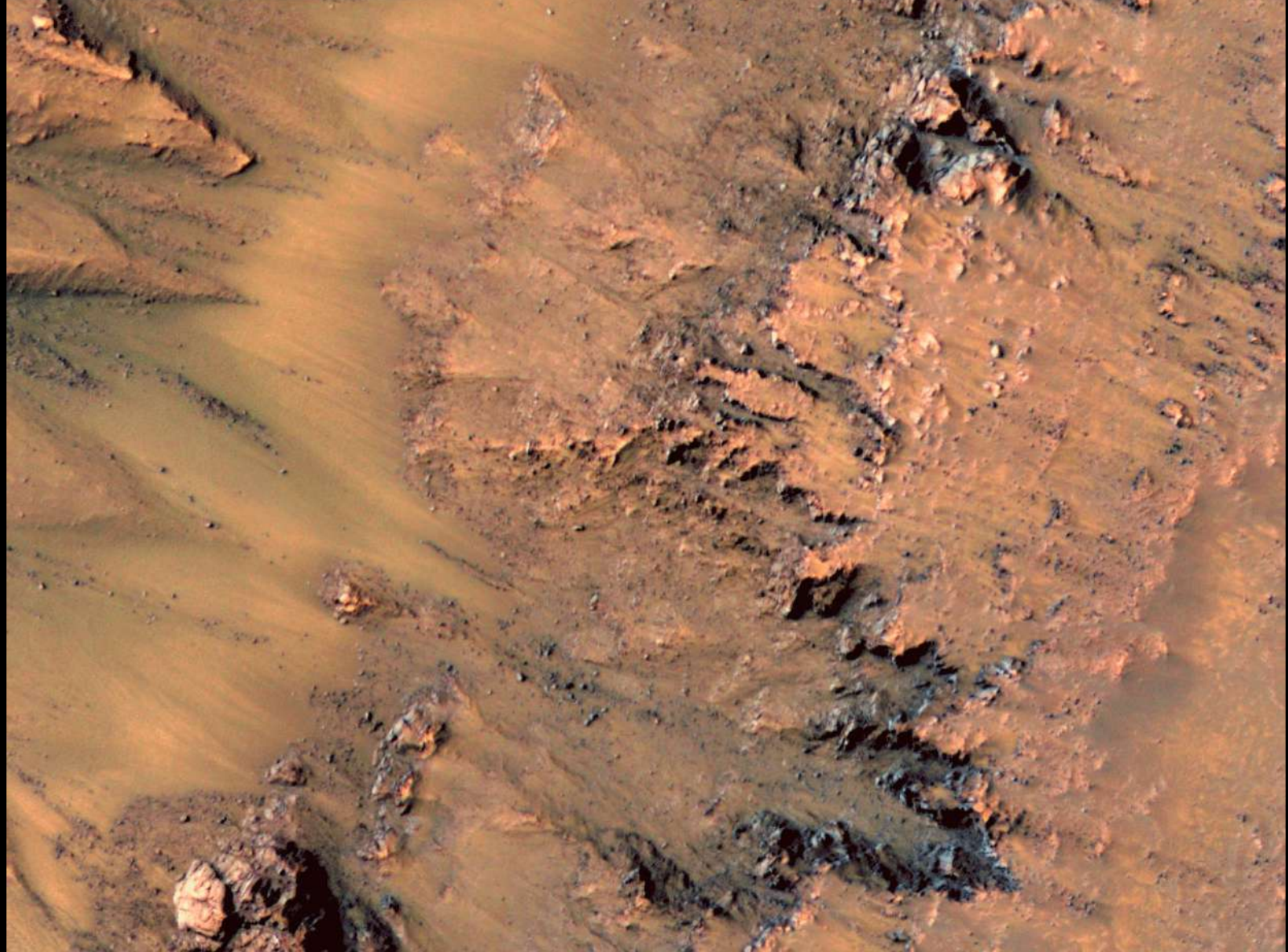


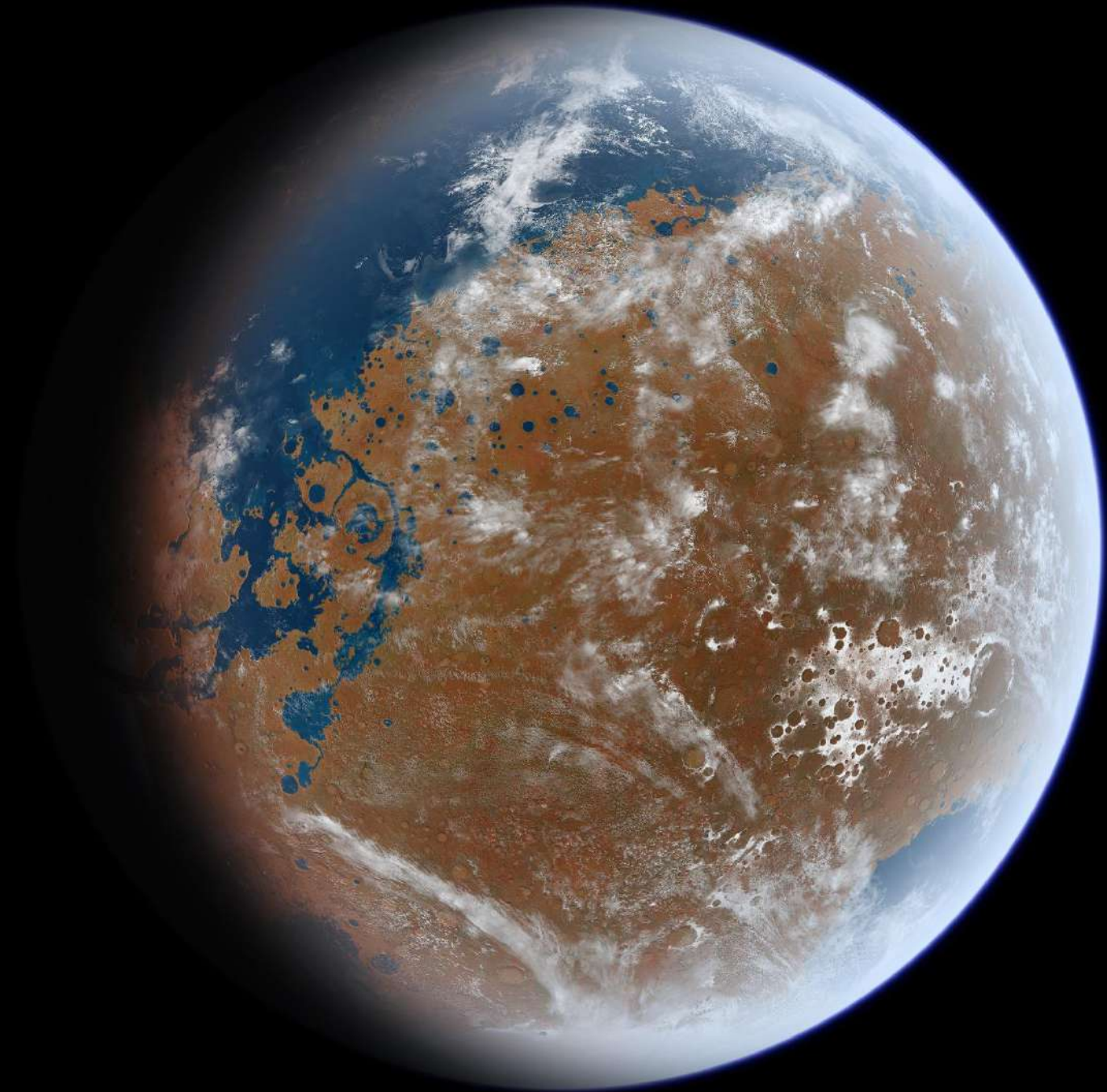


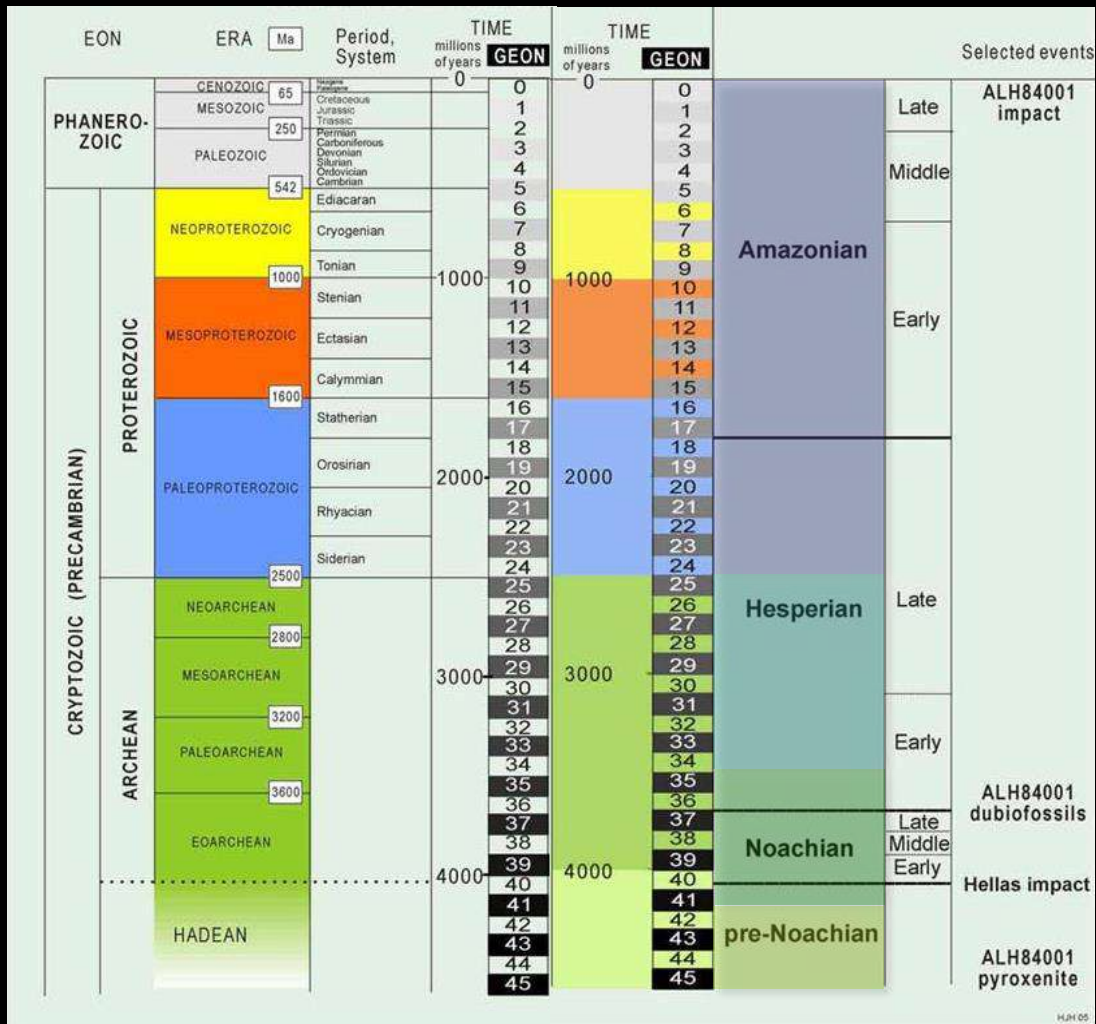




MY 29
MY 30
L_s 0 autumn 90 winter 180 spring 270 summer 360
ESP_011428_1380

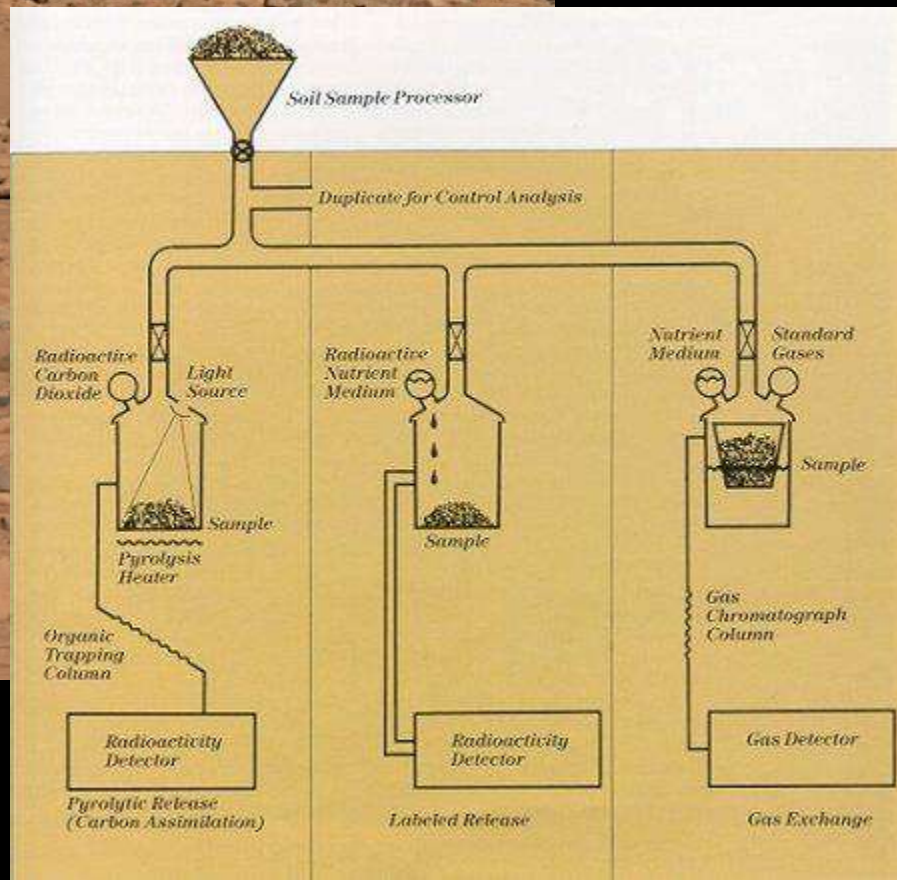




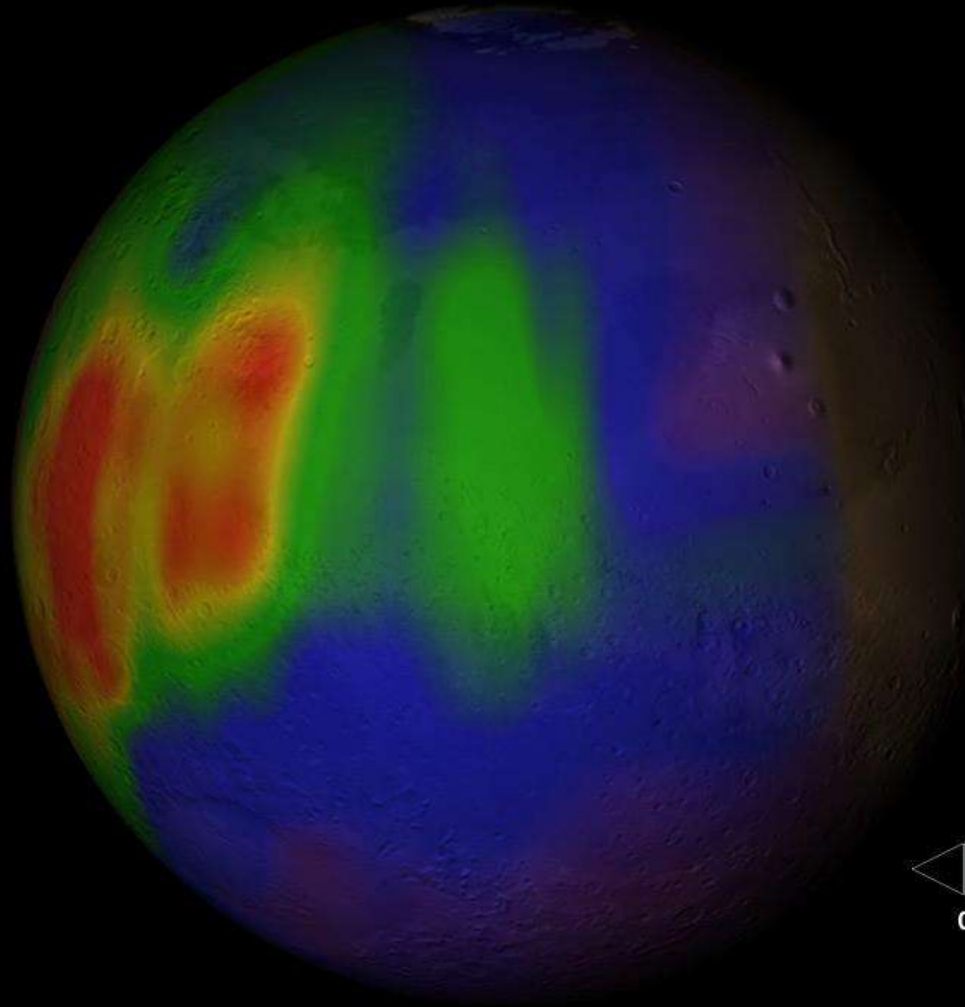




1976



Du méthane dans l'atmosphère de Mars



Dégazage du méthane
au cours de l'été martien
dans l'hémisphère nord

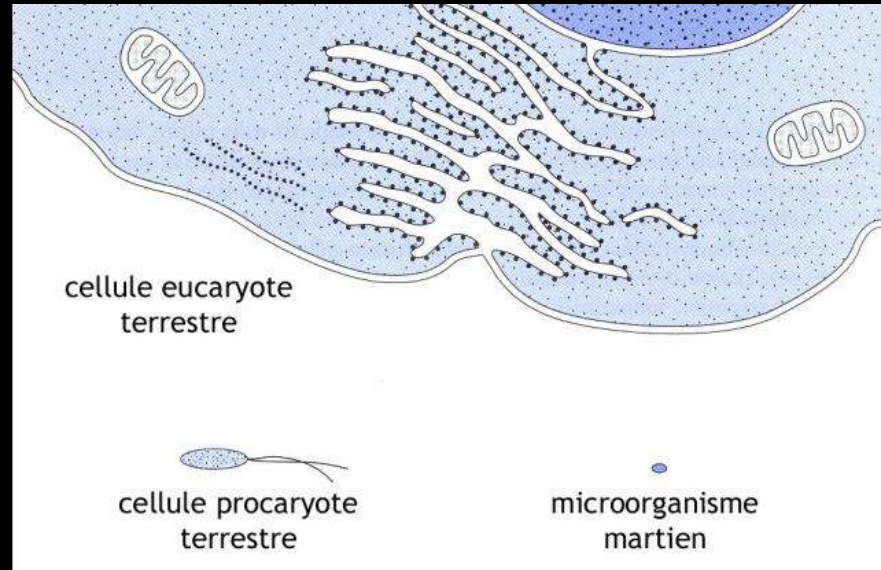


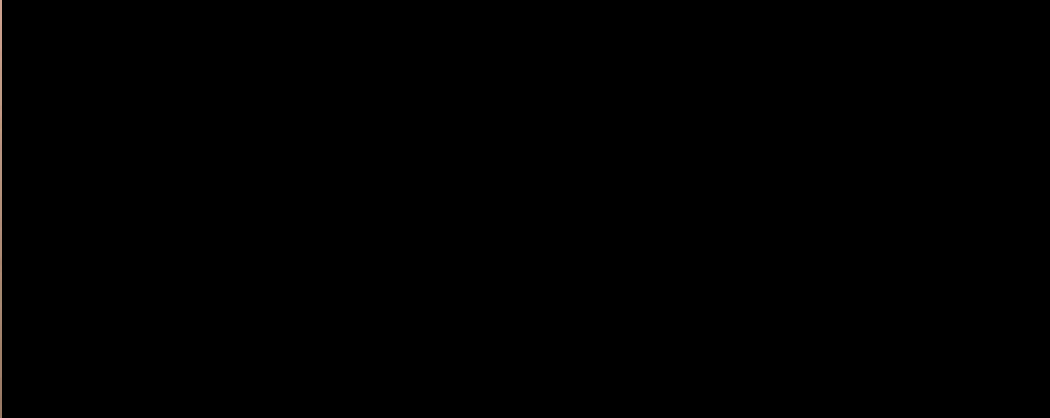
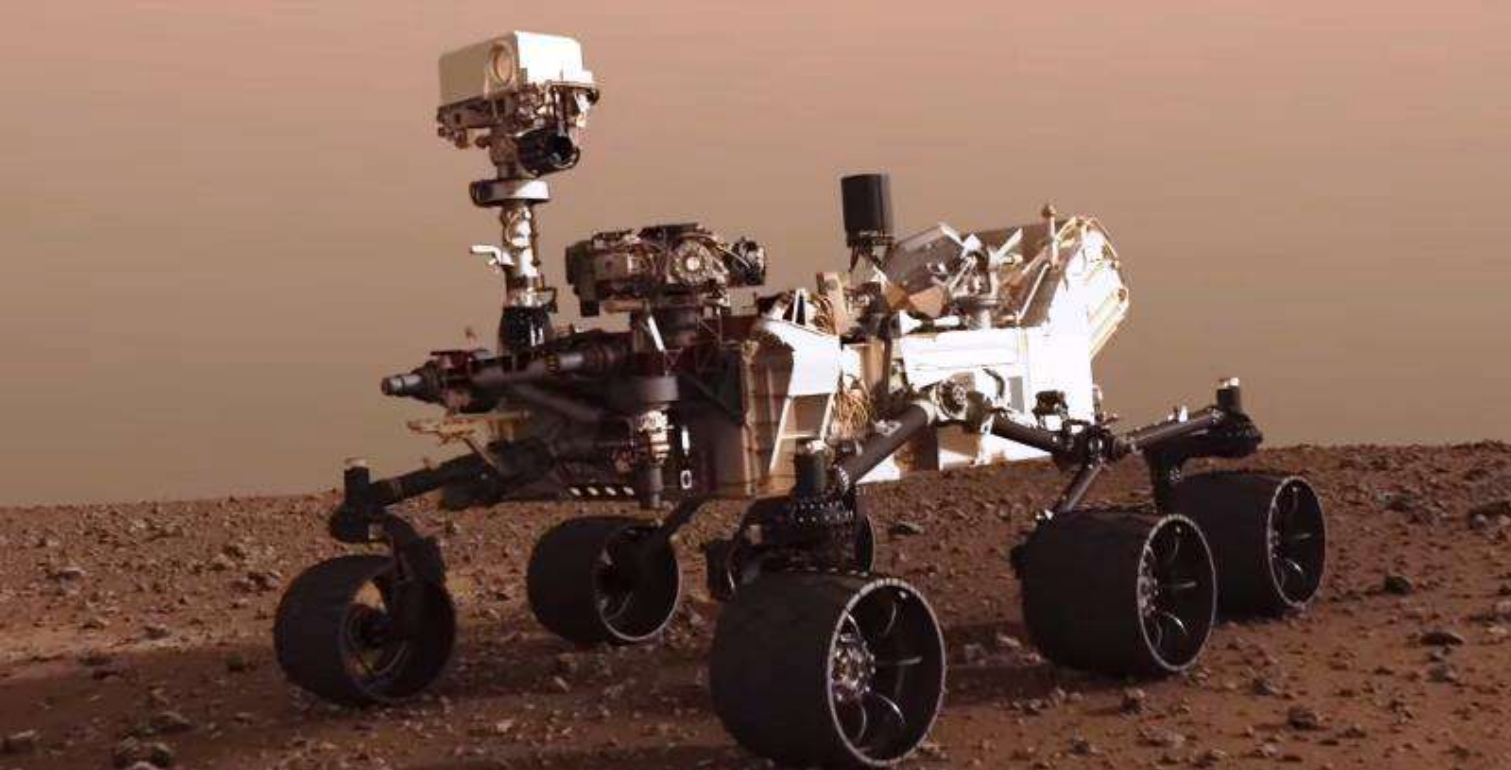
Sur la Terre... méthane = microbes !

De la vie en provenance de Mars...?

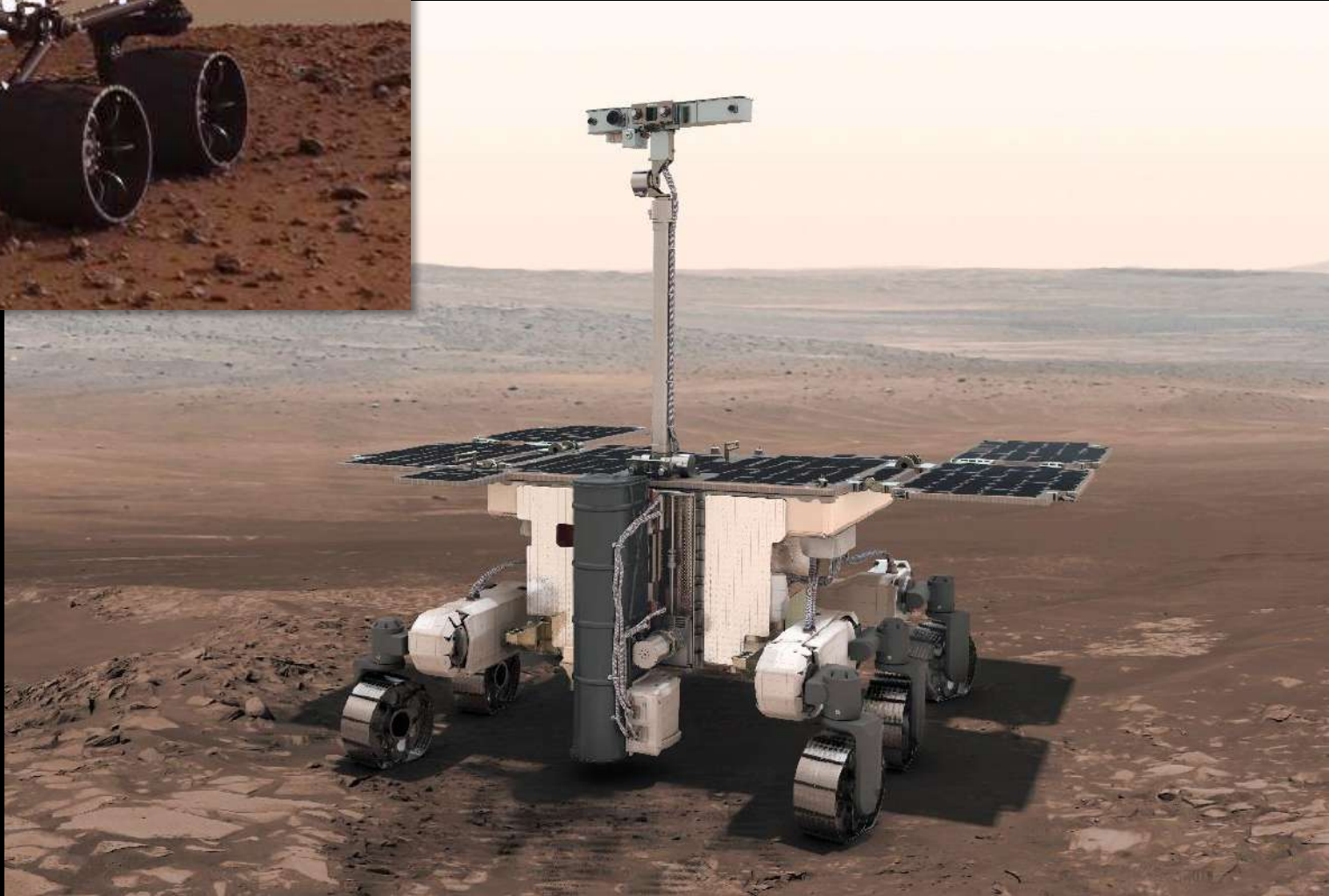


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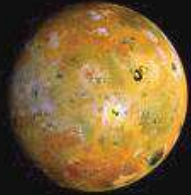




2020+



De la vie sur les mondes glacés du système solaire ?



Io



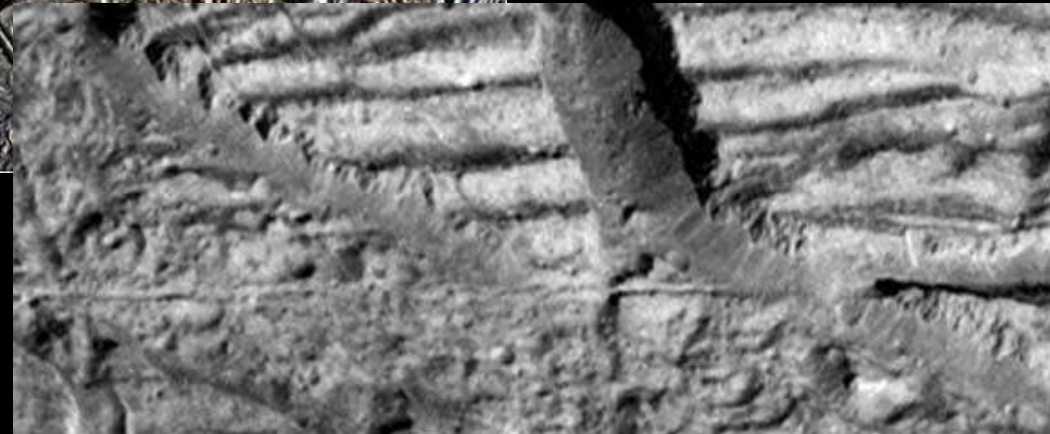
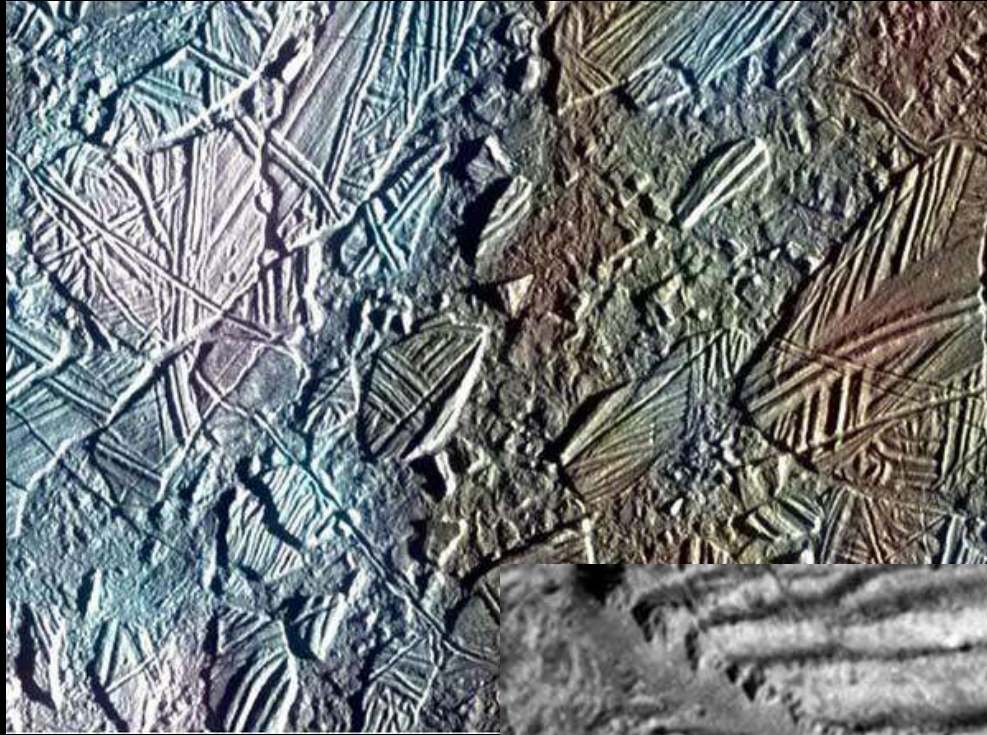
Europa

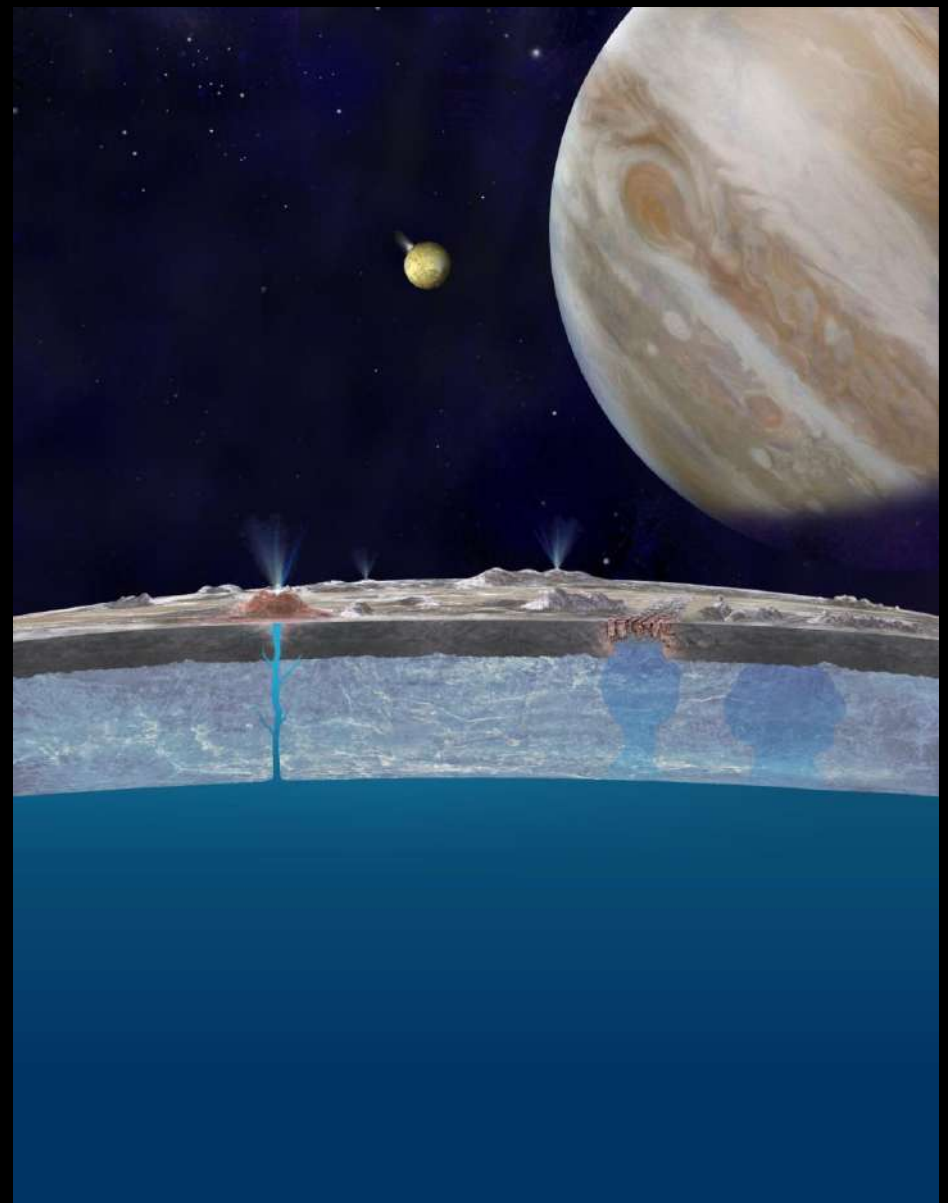
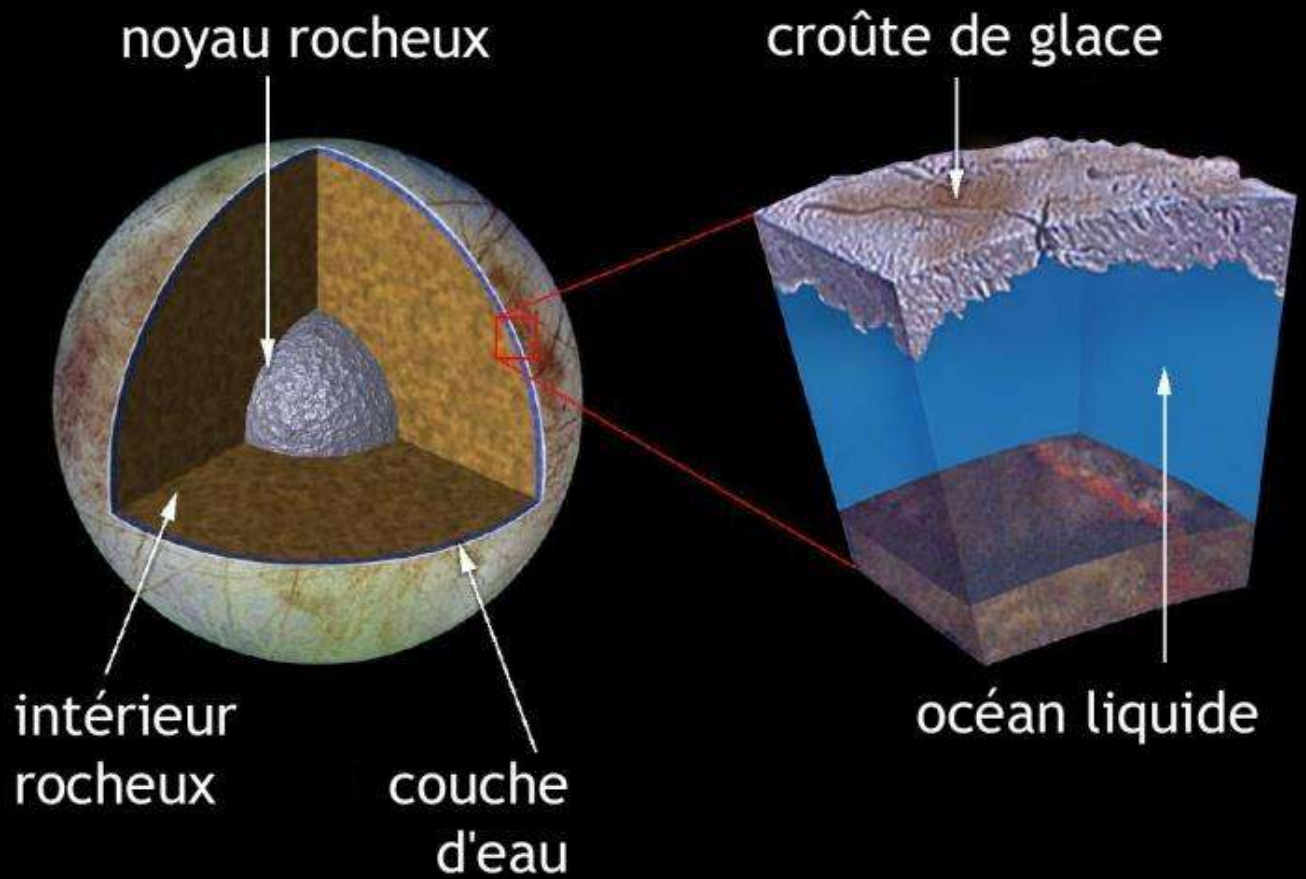


Ganymède



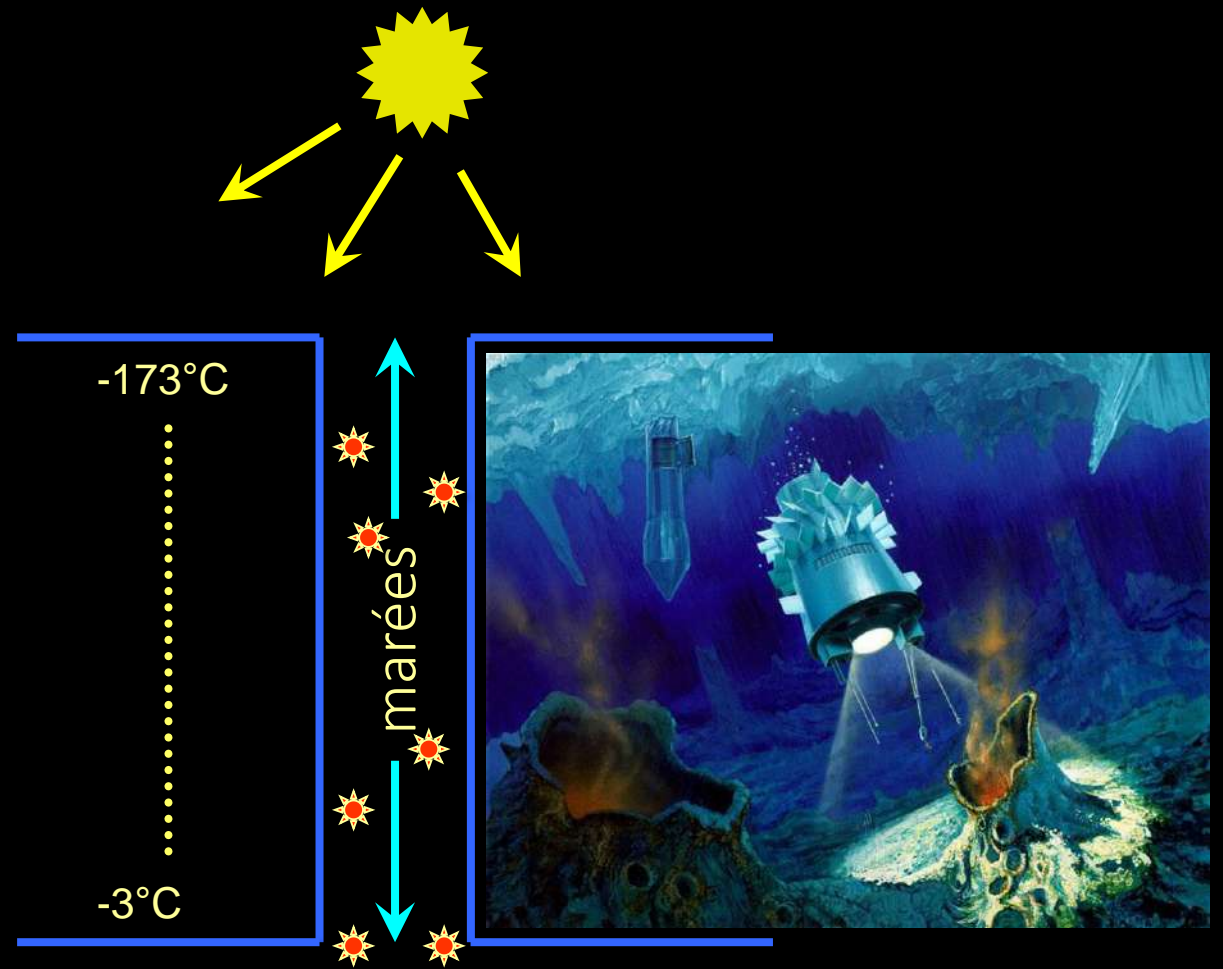
Callisto



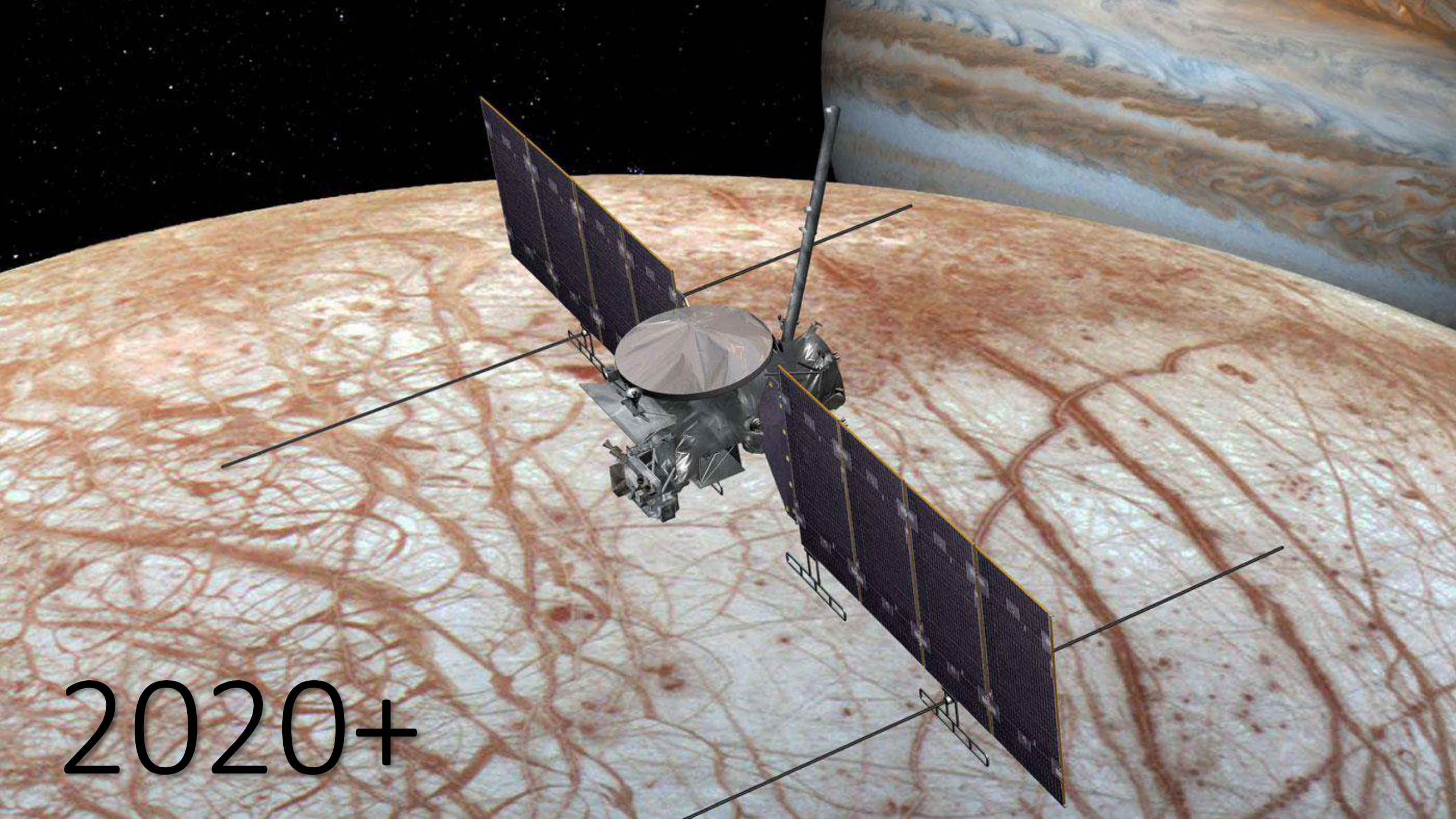


Si l'intérieur est liquide, des microorganismes pourraient se développer et subsister dans les zones de fractures.

Les organismes pourraient profiter des marées montantes pour obtenir l'énergie et les molécules organiques de la surface, et ensuite redescendre dans l'océan chaud.



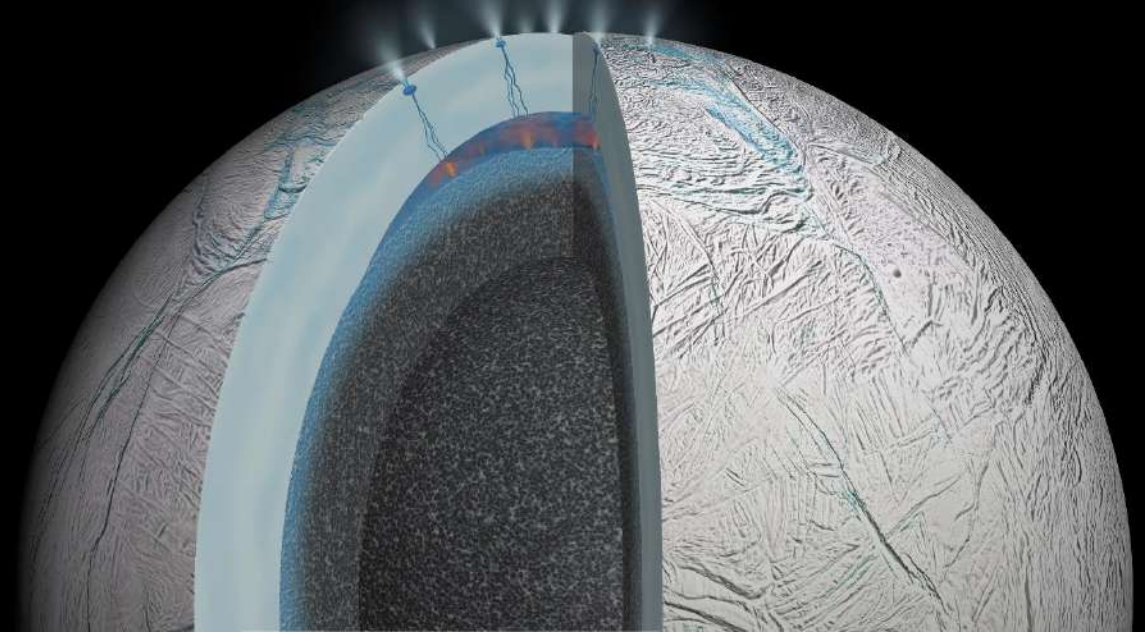
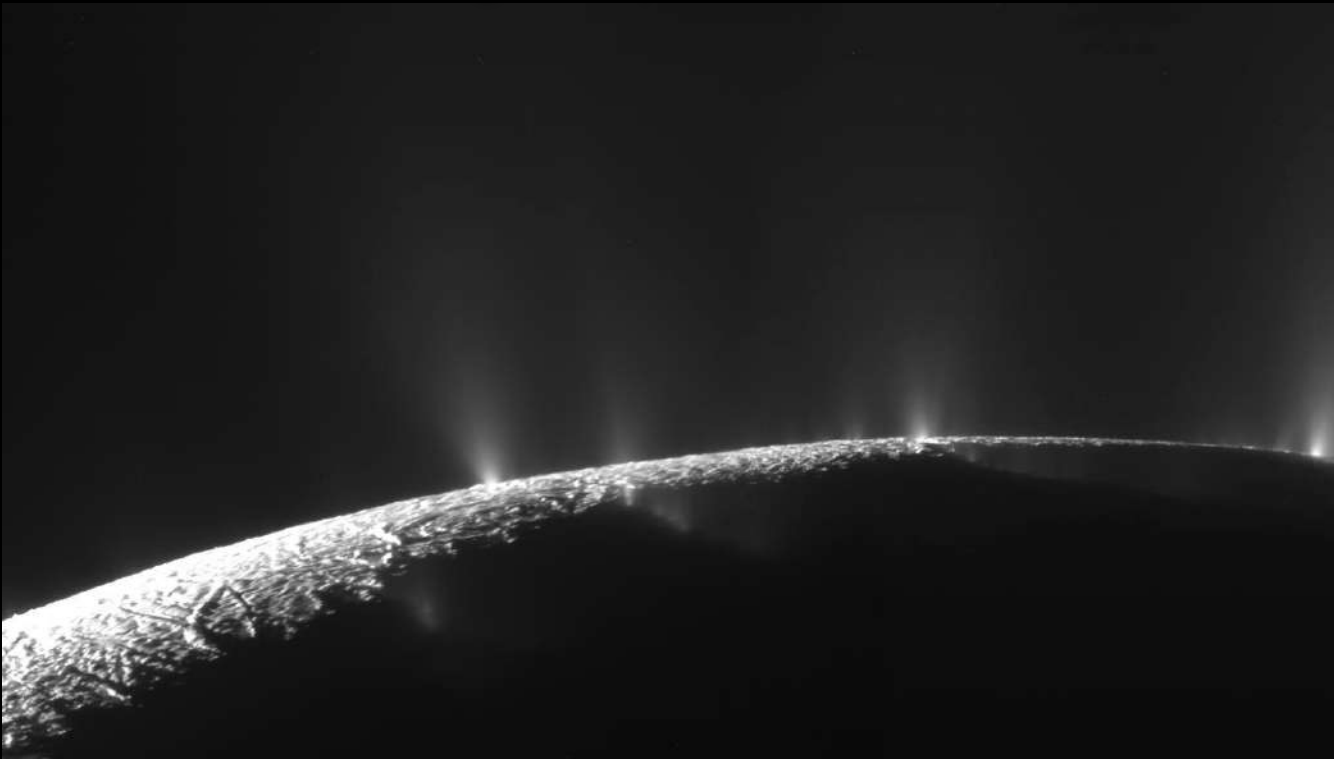
Océan liquide chaud



2020+

Récemment, la liste des environnements où l'on trouve de l'eau liquide s'est allongée. Tout comme les lunes Europe et Ganymède, la surface d'Encelade (une lune de Saturne) montre des signes de « rajeunissement ».

Le dernier survol de *Cassini* a permis la détection de molécules organiques dans le flux des geysers.



De la vie sur Titan ?

L'atmosphère de Titan s'apparente beaucoup à celle de la Terre primitive.

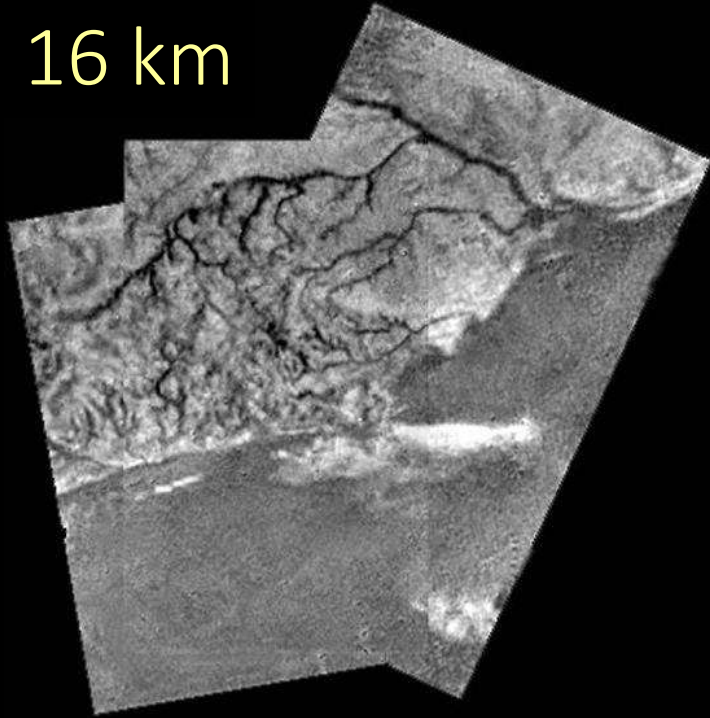


On y trouve du méthane, de l'azote et des traces d'hydrocarbures (éthane et benzène), d'acide cyanhydrique, d'acétylène, de dioxyde et de monoxyde de carbone, et de vapeur d'eau.

Des lacs de méthane et d'éthane à la surface de Titan ?



16 km



8 km



Le module *Huygens* s'est posé sur une surface humide (probablement un mélange de cristaux d'eau et de méthane liquide).

Au moment de l'atterrissage, il ne pleuvait pas, mais il y a probablement eu une « averse » quelques heures, quelques jours, ou quelques semaines auparavant.



La température est trop basse pour que la vie soit apparue. Par contre, il semble que des molécules complexes aient pu s'y former.

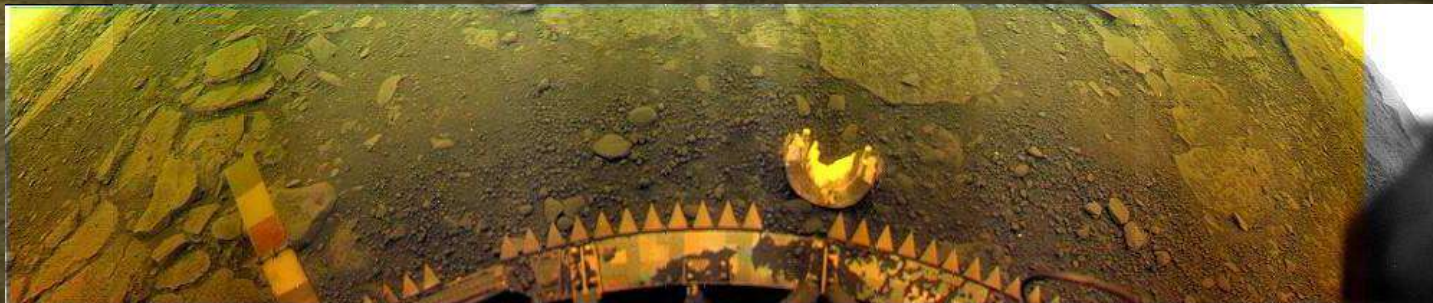
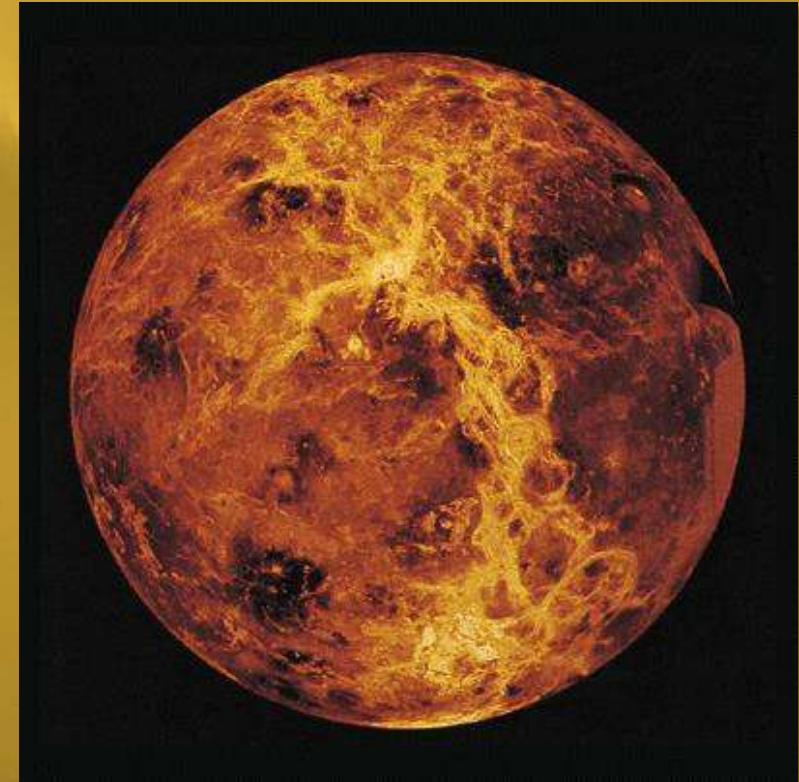


Titan représente un laboratoire de la chimie pré biotique terrestre (et peut être martienne).

La voisine d'à côté...

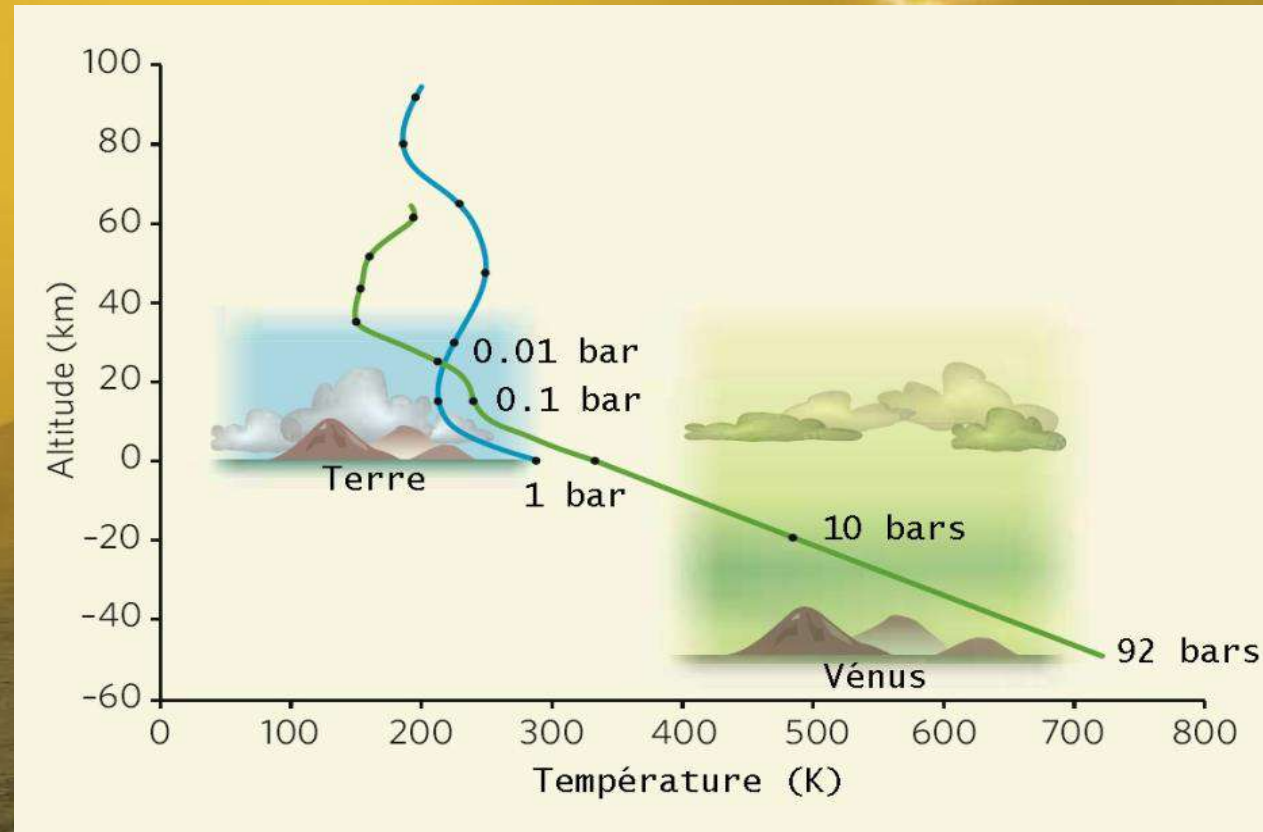
Au début de la formation du système solaire, le Soleil était 30 % moins lumineux.

Vénus recevait moins de chaleur du Soleil, il a donc pu y avoir de l'eau liquide à sa surface. Une vie (abondante, diversifiée ?) s'y est peut-être même développée.



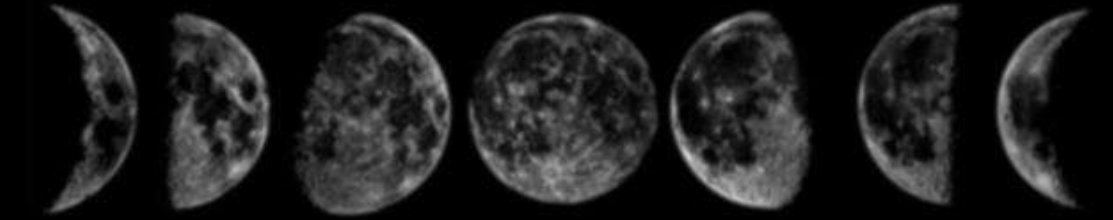
La surface de Vénus photographiée par les sondes *Vénéra* 13 et 14.

Le réchauffement du Soleil, combiné à un effet de serre extrême, et une activité volcanique globale, il y a moins de 700 Ma ont certainement éliminé toute vie et effacé toute trace fossile.



Cependant, des microorganismes extrêmophiles pourraient s'être adaptés à la vie dans l'atmosphère vénusienne.

Des fossiles sur la Lune ?



Il n'y a évidemment pas de vie sur la Lune.
Toutefois, de même que notre planète est bombardée par des météorites en provenance de Mars, de Vesta ou de la Lune, cette dernière est aussi percutée par des roches en provenance de la Terre.



On estime qu'il doit y avoir environ 20 tonnes de roches terrestres par 100 km² sur la Lune.



Les plus anciennes traces de la vie terrestre sont possiblement sur la Lune.

Le mystère entourant l'origine de la vie sur notre planète est peut-être au grenier...!

A wide-angle photograph of a night sky featuring the Milky Way galaxy. The galaxy's bright, multi-colored band of stars and dust stretches diagonally from the bottom center towards the top right. The sky is filled with numerous individual stars. Below the horizon, a calm body of water perfectly reflects the celestial scene. In the lower-left foreground, a small, dark silhouette of a person is visible, sitting on the shore and looking towards the water. The overall color palette is dominated by deep blues, purples, and oranges from the galaxy and the horizon glow.

Merci !