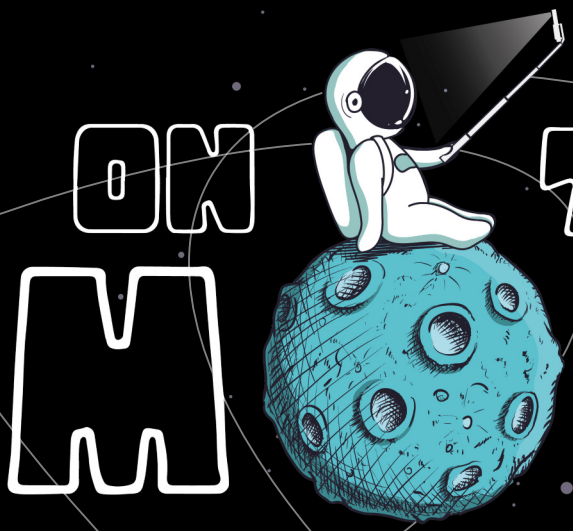
www.onthemoonagain.org

# GET YOUR TELESCOPE OUT TO SHARE THE MOON



# ON THE MOON AGAIN!

SEE YOU ON
JULY 12 AND 13, 2019

Conception: M. CHERFI

# General presentation of the Moon

The Moon is the only natural satellite of the Earth. With a diameter of 3474 km, its average distance from the Earth is 381500 km. The Moon is the first and, to this day, the only non-terrestrial planetary body visited by Mankind. The first to be there was the American astronaut Neil Armstrong on July 21, 1969, 50 years ago. After him, eleven other men walked on the Moon, all be part of the Apollo space program.

## Observation conditions on July 12/13

On July 12 and 13, 2019, the Moon is gibbous increasing (the Full Moon occurring on July 16, 2019). Not far from the Moon, towards the South, one will find without difficulty the planet Jupiter. The planet Saturn is a little further away.

The Moon in Paris on July 12, 2019

The Moon in Paris on July 13, 2019

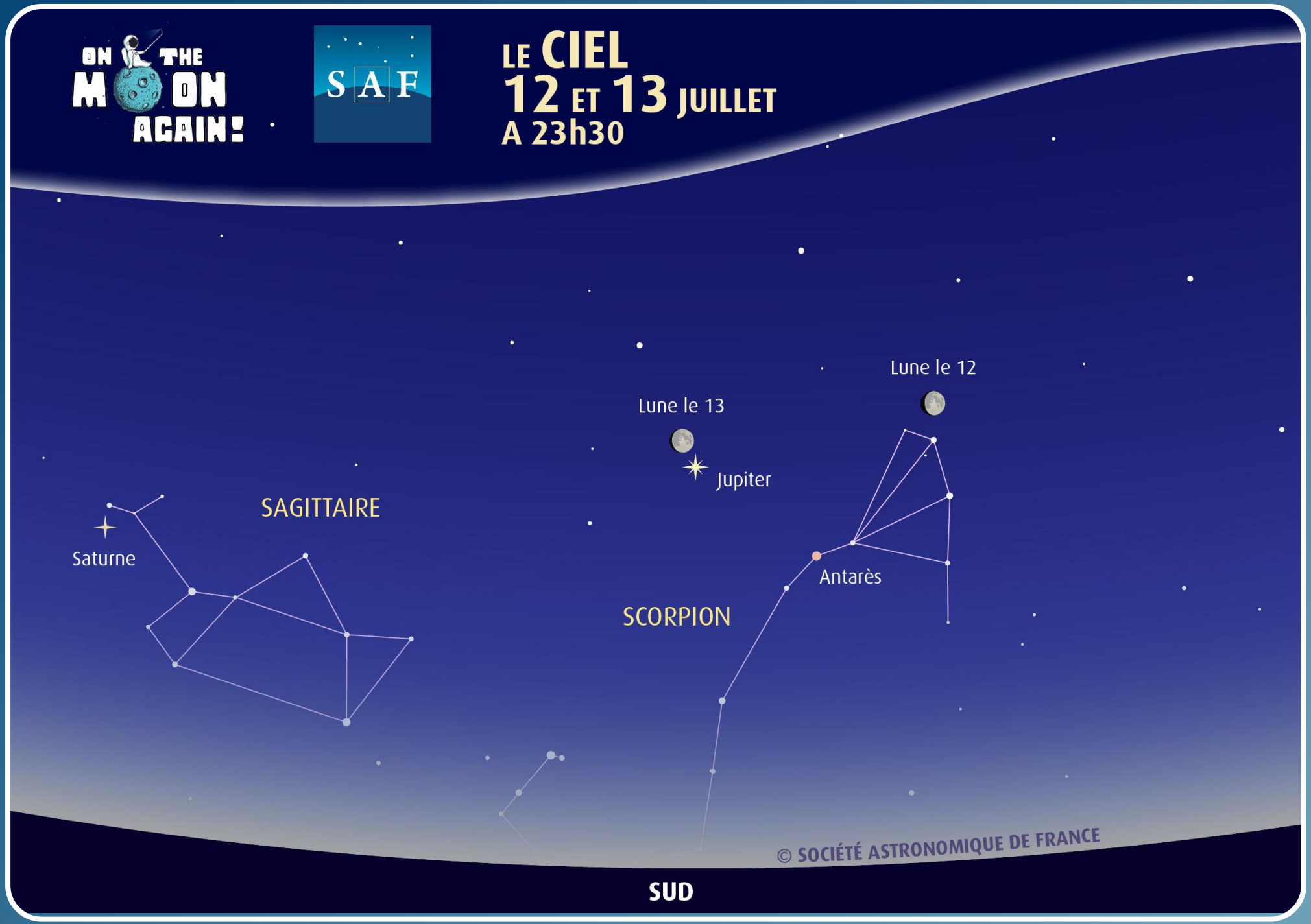
# The Earth-Moon couple

The Earth-Moon couple is extremely complex. It depends on many astrophysical factors. Thus, the Earth performs a turn on itself in 23 hours 56 minutes and 4.1 seconds, and revolves around the Sun in 365256 days at an average distance of 149597870 kilometers. Its mass is 5.95 $10^{24}$ kg and its diameter of 12846 km. Its orbit around the Sun is almost circular (the eccentricity of the latter being very weak).

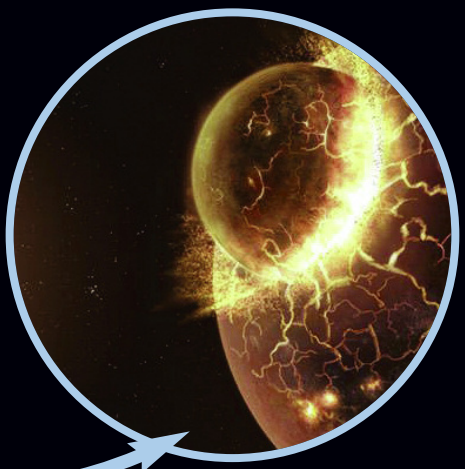
The Moon is 27322 days to accomplish a revolution around the Earth: it is the sidereal lunar month, in other words the time taken to perform a complete revolution and thus find the same position with respect to the stars.

The duration of the synodic month (the time taken to find the same position of the Earth-Moon axis with respect to the Sun), and which separates two new moons, is 29,531 days. This is the current duration that is used to express the lunar cycle. The lunar orbit is an ellipse of "mean radius" 384392 km, which varies between 356410 km at the perigee (closest point of the Earth) and 406.680 km at the apogee (point furthest from the Earth).

The mass of the Moon is 7.35 $10^{22}$ kg and its diameter is 3472 km. The Sun has an equatorial diameter of 1392000 km and a mass = 1,99 $10^{30}$ kg. While performing an entire revolution around the Earth (the sidereal month), the Moon performs exactly one rotation on itself, which is why the Moon always presents the same face to the Earth. This phenomenon is known as "synchronous" rotation. It was the tidal effect (terrestrial and oceanic) that gradually stabilized the Moon in this position. The Earth and the Moon describe an orbit around a common center of mass located in the Earth's depths. The barycenter of this couple is about 4650 km from the center of the Earth.

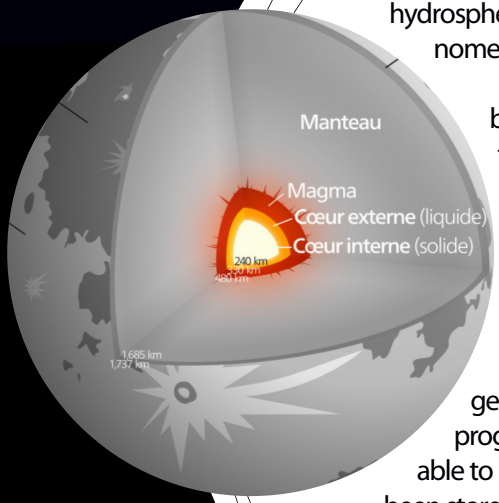

ON THE MOON AGAIN!
SAF
LE CIEL
12 ET 13 JUILLET
A 23h30
Lune le 12
Lune le 13
Jupiter
SAGITTAIRE
Saturne
Antarès
SCORPION
© SOCIÉTÉ ASTRONOMIQUE DE FRANCE
SUD

# History of the formation



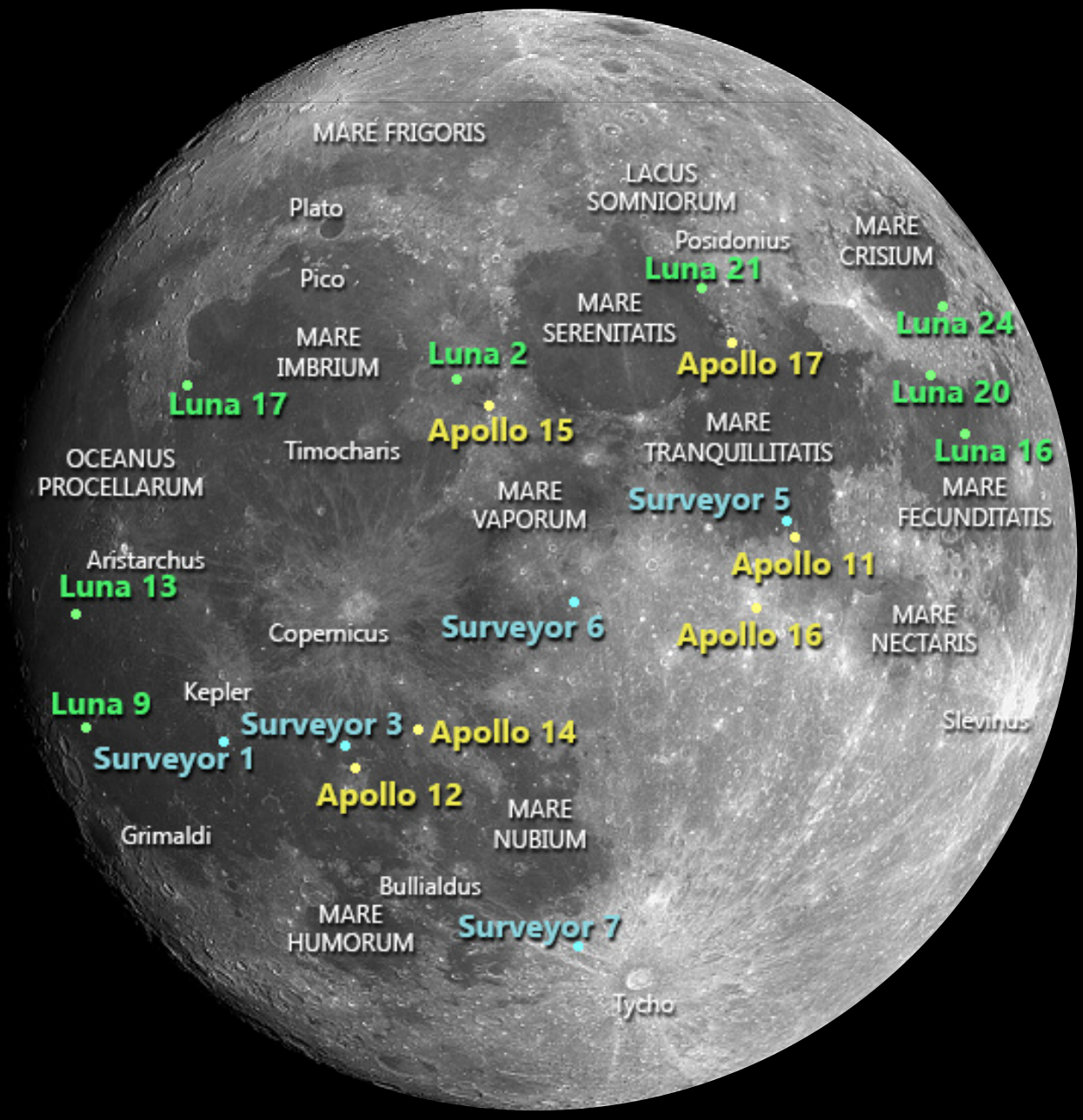
Many theories and hypotheses have been developed to try to explain the formation of the Moon. Since the Apollo missions and the return of samples on the Earth, the hypothesis most shared by the scientific community is that of a collision between the young Earth and a planetoid body (protoplanet) the size of Mars named Theia. This impact would have occurred 100 million years after the birth of the solar system, that is to say 4,468 billion years ago. This hypothesis proposes that the Moon was created from the material ejected by the collision. Thus, the Moon would be largely made up of "re-arranged" terrestrial matter.

# Geology




The geology of the moon is a geology very different from that of the Earth. Since the moon has no atmosphere, hydrosphere or biosphere, erosion due to meteorological phenomena is absent. Plate tectonics, as we know it on Earth, has no equivalent; the gravity is low and its soil cools faster because of the absence of atmosphere playing a buffer role thermo-regulator. Like the Earth, the Moon is a differentiated star, with a crust, a mantle and a nucleus. The lunar surface results from a complex geomorphology combining different processes, such as meteoritic impacts and volcanism. The geological studies of the Moon are based on the combination of telescopic observations from the Earth, measurements in orbit by automatic spacecraft, analyzes of lunar rock samples and geophysical data. Six landing sites were visited during the Apollo program missions between 1969 and 1972. The astronauts were able to bring back about 385 kg of lunar rocks, most of which have been stored since 1979 at the Lunar Sample Laboratory Facility in Houston. In addition, three missions of the Soviet Union via the automatic program Luna also allowed the return of some 326 gr of lunar soil on Earth. The Moon is the only extraterrestrial body for which humans have samples whose geological origin is known. However, several questions about the geological characteristics of the Moon remain unanswered.

# ON THE MOON AGAIN!



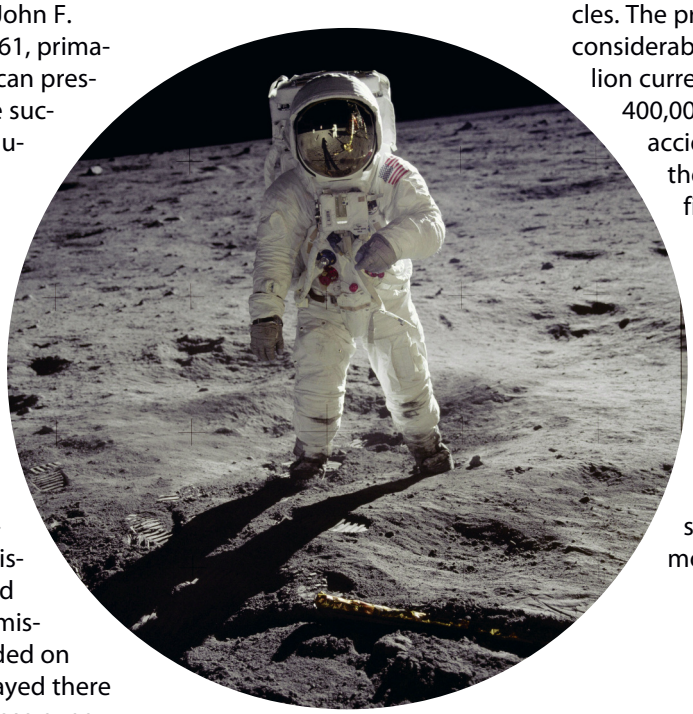
# Apollo Missions

The Apollo program is NASA's space program during the period 1961-1975, which allowed the United States to send men to the moon for the first time. It was launched by President John F. Kennedy on May 25, 1961, primarily to regain the American prestige undermined by the successes of Soviet astronautics, at a time when the cold war between the two superpowers was in full swing.

The goal of the program was to put a man on the moon before the end of the decade. On 21 July 1969, this objective was achieved by two of the three crew members of the Apollo 11 mission, Neil Armstrong and Buzz Aldrin. Five other missions subsequently landed on other lunar sites and stayed there for up to three days. These expeditions yielded 385 kg of lunar rock and set up several batteries of scientific instruments. The astronauts made in-situ observations during lunar ground excursions of up to eight hours, assisted from Apollo 15 by an all-terrain vehicle, the lunar rover.

No American orbital flights had yet been made in May 1961. To fulfill the goal set by the president, NASA launched several programs to prepare future lunar expeditions: the Gemini program to develop space flight techniques and reconnaissance programs (Surveyor program, Ranger ...) to, among other things, map the landing zones and determine the consistency of the lunar soil.

To reach the Moon, the leaders finally rallied to the audacious method of rendezvous in lunar orbit, which required to have two spacecraft whose lunar module intended for landing on the Moon. The giant 3,000-ton Saturn V rocket, capable of 140 tons of low orbit, was developed to launch the lunar expedition vehicles. The program will draw a considerable budget (US $ 169 billion current) and mobilize up to 400,000 people. Two serious accidents occurred during the project: the ground fire of the Apollo 1 spacecraft whose crew perished burned and which resulted in a delay of nearly two years in the calendar and the explosion of an oxygen tank of the vessel Apollo 13 spacecraft whose crew survived using the lunar module as a rescue ship.



## THE SOVIET MISSIONS LUNA

The Luna automatic program includes all space missions launched by the Soviet Union to the Moon between 1959 and 1976. Twenty-four space probes are officially part of this program but there were in fact 45 in all. Fifteen of these missions achieved their goals. From the beginning, political considerations aimed at demonstrating the superiority of Soviet know-how over that of the United States prevailed over scientific motives. When the challenges of the space race disappear, the Luna program ends while the United States directs its Exploration program mainly to Mars and the outer planets of the solar system.

The Luna program is at the origin of many of the first techniques in space exploration. Luna 1, launched in 1959, is the first spacecraft to break ground while Luna 2 (1959) is the first artificial object to reach the lunar ground. Luna 3 makes the first photograph of the hidden side of the Moon (1959). Luna 9 (1966) is the first probe to land smoothly on the Moon, while Luna 16 (1970) is the first robot to bring a lunar sample back to Earth.The Luna 17 (1970) and 21 (1973) missions carry the first astromobiles (rovers) that will cover several tens of kilometers on the surface of the Moon. On the scientific side, although many important questions remain unanswered at the end of the program, the Luna program, like the US counterpart programs (Surveyor and Lunar Orbiter Program and the Apollo program) have greatly advanced our knowledge of the Moon: composition of the lunar soil, topography of the hidden face of the Moon, lunar gravitational field, evolution of the Earth-Moon distance, temperatures and radiation levels ...

The program has implemented space probes of different types (impactor, orbiter, landing gear, rover, return of sample). These are becoming more sophisticated as the program progresses, with a growing weight of 361 kg to almost 6 tonnes for rovers and the last orbiter. Several launchers have been used but all have suffered from reliability issues that are causing a lot of the failures of the Luna missions. Since the last mission of the Luna program in 1976, the Soviet Union and Russia (which has taken over from the Soviet space program) have no longer launched a probe to the moon.

# Frames

## Apollo 11

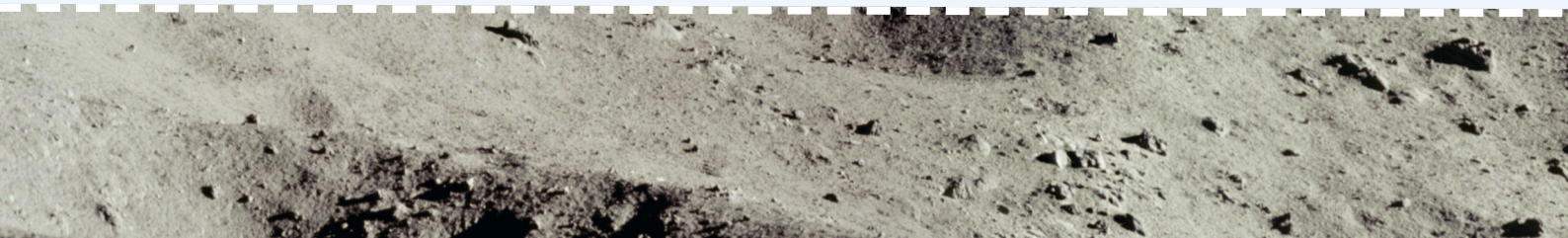
Apollo 11 is a mission of the American Space Program Apollo during which, for the first time in history, men landed on the Moon, July 20, 1969 (9:56 pm in Houston). NASA fulfills the goal set by President Kennedy. This challenge is launched while NASA has not yet put into orbit a single astronaut. The project succeeds thanks to the mobilization of considerable human and financial resources.
Apollo 11 is the culmination of a series of missions that allow the development of the necessary space techniques, spacecraft and a giant launcher as well as the recognition of landing sites on the Moon. This is the third mission to approach the Moon, after Apollo 8 and Apollo 10, and the fifth crewed mission of the Apollo program. The spacecraft carrying the crew is launched from the Kennedy Space Center on July 16, 1969 by the giant rocket Saturn V developed for this program. She takes Neil Armstrong, Mission Commander and Lunar Module Pilot, Buzz Aldrin, who accompanies Armstrong to the lunar ground, and Michael Collins, pilot of the command and service module that will remain in lunar orbit.
Armstrong and Aldrin spend 21 hours and 36 minutes on the surface of the moon and perform a unique spacewalk with a duration of 2 hours and 31 minutes. After taking off again and making an appointment in lunar orbit with the command and service module, the Apollo spacecraft resumes the path of the Earth and landed without incident in the Pacific Ocean at the end of a flight that will have lasted 8 days, 3 hours and 18 minutes.
During this mission, 21.7 kg of lunar soil is collected and several scientific instruments are installed on the surface of the Moon. Although the scientific objective of Apollo 11 was limited by the length of stay on the moon and the reduced carrying capacity of the spacecraft used, the mission provides important results. Its unfolding, especially the first steps on the Moon filmed by a video camera and broadcast live, constitute an event followed on the planet globally by hundreds of millions of people.

## Lunar samples

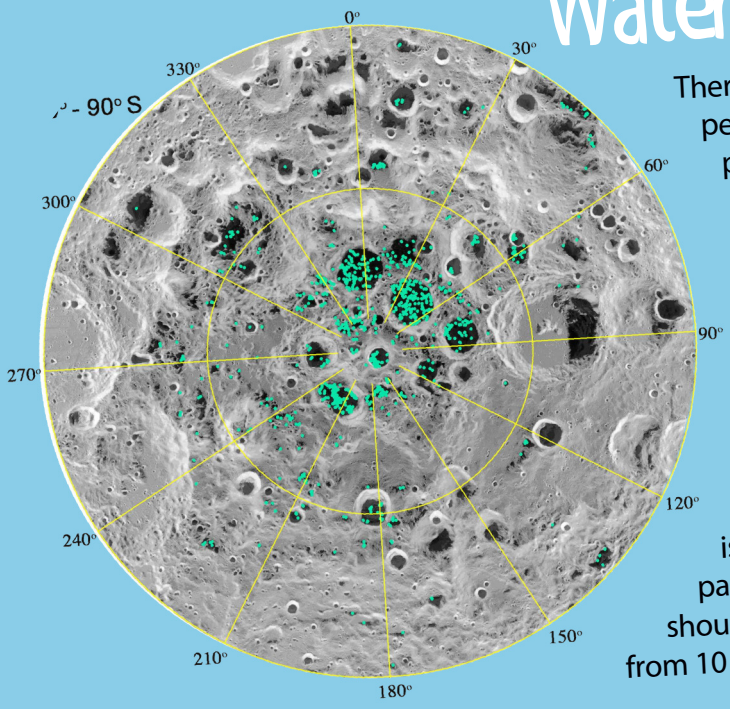
The Apollo and Luna missions, and in particular the samples they brought back, have changed our understanding of the genesis of the Moon and planets... First of all, they made us understand that the craters that sculpt the surface of our satellite are the scars of collisions with other planetary bodies, and not the craters through which the lava of huge volcanoes flowed. These cosmic scars are visible at all scales, from the hundreds of kilometres of large lunar basins to the signs of crushing in the rocks, and to the very fine dust that forms the soil. This dust is produced by what is called "impact gardening", i.e. the hypervelocity impacts of objects, where even the smallest ones reach the ground of this atmosphere-free body. Impacts are now understood as a major geological phenomenon at the scale of the Solar System: the end of the construction of planetary bodies by the process of "accretion", i.e. the accumulation of smaller bodies as a result of collisions. The Moon itself is considered to be the result of a "giant impact": the collision of the Earth with Theia, a body the size of Mars. This collision would have caused the fusion and evaporation of Theia and a of large part of the Earth, forming a very hot object rotating on itself: a "synestia". The materials of the two bodies would thus have mixed together to a large extent, with part of Theia ending at the centre of the Earth, and the rest orbiting around it to coalesce and form the Moon. This model, formulated in 1975 by the young astronomers W. K. Hartmann and D. R. Davis, is the one which best explains the various properties of lunar rocks, such as their chemistry low in volatile elements, as well as the very small size of the Moon's core determined by seismometers deployed by astronauts (only 1% of the Moon's volume, while the Earth's core accounts for 15% of the planet's volume).

## The far side

The far side of the Moon is the hemisphere of the Moon which is permanently on the opposite side of the Earth, the other being called the visible face or the near side of the Moon. Indeed, a single hemisphere of the Moon is visible from Earth, because the Moon has a rotation period equal to its period of revolution (27.3217 days), phenomenon called synchronous rotation. The other hemisphere is therefore invisible from Earth, and was photographed and mapped only thanks to the space probes, the first being the Soviet Luna 3 probe in 1959. The first men to see it directly were the crew of the Apollo 8 mission orbiting the moon in 1968. The rough terrain is remarkable both for the multitude of craters and for its poverty in the lunar seas. This hidden face also has the largest known impact crater of the solar system: the South Pole-Aitken basin. It was envisaged to install gigantic radio telescopes, with the advantage that they would be protected from possible radio interference from the Earth.



# Water on the moon




There is water on the moon. Liquid water can not persist on the surface and water vapor is decomposed by sunlight, the resulting hydrogen being rapidly lost in space. However, the presence of water ice is envisaged in the permanent shadow of polar lunar craters since the 1960s. Water molecules have also been detected in the thin lunar atmosphere. Water ($H_2O$), and the related hydroxyl group (-OH), can also exist in lunar minerals in the form of bonds such as hydrates and hydroxides (rather than in free form), and clues strongly suggest that such is well the case in low concentration on a large part of the lunar surface. In fact, the adsorbed water should exist on the surface at concentrations ranging from 10 to 1000 parts per million, or even more locally.

## The Chinese lunar program

The People's Republic of China has great ambitions in space, especially in the exploration of the moon. Thus, on October 24, 2007, the Chang'e 1 orbital spacecraft is launched by a Long March 3A rocket. Its objective was to map and model in three dimensions certain regions of the Moon. In total, 1.37 TB of data was transferred to Earth during this mission. A second orbital probe, Chang'e 2, was launched on 1 October 2010 using a Long March 3C rocket. It came into orbit October 6, 2010. One of the possibilities was that the probe lands on the Moon at the end of its mission, but it was put into an orbit of meeting with the near-Earth asteroid Toutatis she met December 13, 2012.

On December 1, 2013, China launched Chang'e 3 on a Long March 3B rocket. Unlike the two previous probes, Chang'e 3 carries a rover to land. This is the first craft to land on the moon (December 14, 2013) since the landing of the Soviet Luna 24 probe, which brought a soil sample back to Earth in 1976. Chang'e 3 was carrying a landing gear equipped with scientific instruments and a 140-kilogram lunar rover named Yutu, able to move over an area of 3 $km^2$ around its landing point and study the terrain during a 3-month mission.

The Chang'e 4 spacecraft was originally built as a liner in case of failure of Chang'e 3. Given the success of this mission, Chang'e 4 was instructed to land on the far side of the Moon and explore its surface. A telecommunications satellite, dubbed Queqiao was placed a few months earlier at the L2 Lagrange point of the Earth-Moon system to act as a relay, the Moon obstructing direct communications between Chang'e 4 and the Earth. Chang'e 4 was launched on December 7, 2018 by a Long March 3B rocket and landed on the Moon on January 3, 2019 to conduct an exploration with its rover. This is the first landing of a spacecraft on this side of the Moon. Shortly after the module landed, the Yutu 2 rover began rolling on the moon. On February 13, 2019, as the rover began his second lunar night, he traveled 120 m. In May 2019, as the rover began his fifth lunar night, he traveled 190 m.

# ON THE MOON AGAIN!

In July 1969, together with family or friends around a radio or a rare TV, 600 million people, on all continents, followed the first step of a man on the moon. 50 years later, we have the urge to experience this enthusiasm for the Moon in a global, universal movement that transcends all borders.

How? Nothing's easier. We want everyone, big or small, to discover at a world event the Moon through a telescope or an astronomical telescope. Surprise passers by offering them this unexpected sight. You have an instrument of observation, install it at the corner of a street, at the edge of a river, on the place of a village ... Join the event On the Moon Again on July 12 and 13, 2019 and invite passersby to observe the moon and share the wonder.

www.onthemoonagain.org

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Conception: M. CHERFI