INTERNATIONAL WORKSHOP ON

ONE CENTURT OF MARS OBSERVATIONS

September 17-20, 2009. Observatoire de Paris

Audouin DOLLFUS

SEARCH FOR LIFE ON MARS

by telescopic observations

After World War 2, when astronomical work started again, the physical environment at the surface of Mars, as it appeared from telescopic observations, was considered compatible with the presence of a life on the planet.

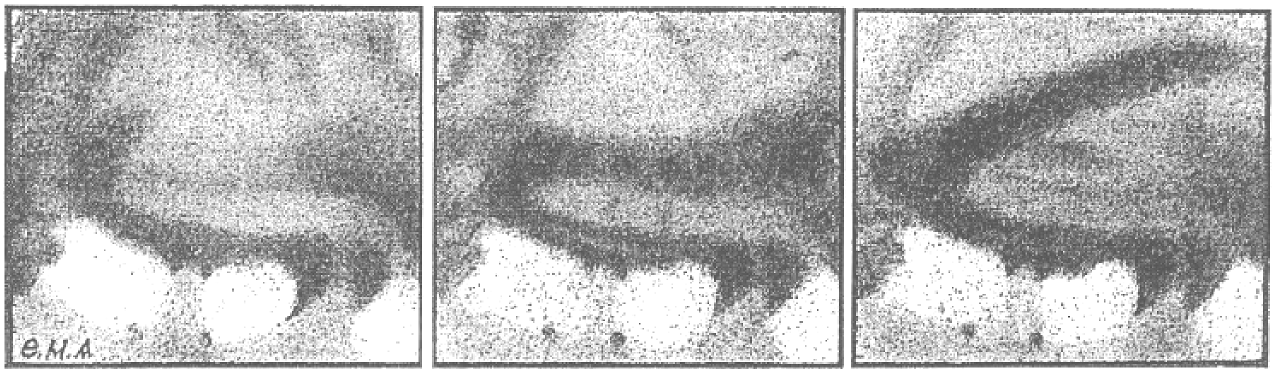
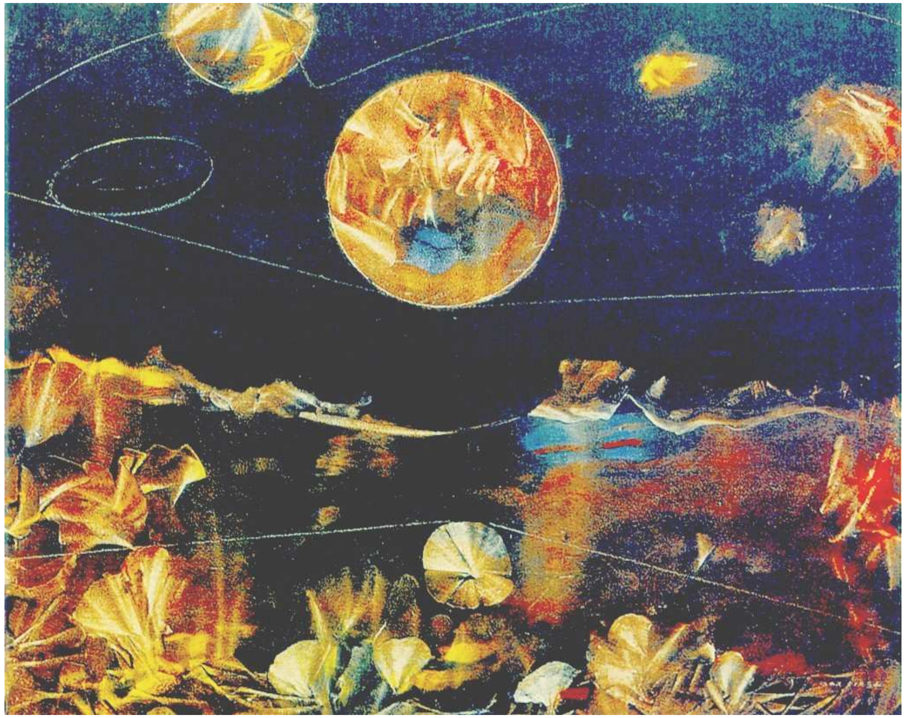


Fig. 5 à 7. - Changements survenus dans l'aspect des régions martiennes de Pandoræ Fretum et de Noachis depuis 1924.

The markings on the ground have been noted seasonally variable, suggesting of a putative vegetation.

Because of this promise, decision was taken at Meudon Observatory, France, to undertake a project to search for life on Mars, making use of the new techniques available for the analysis of light with telescopes.



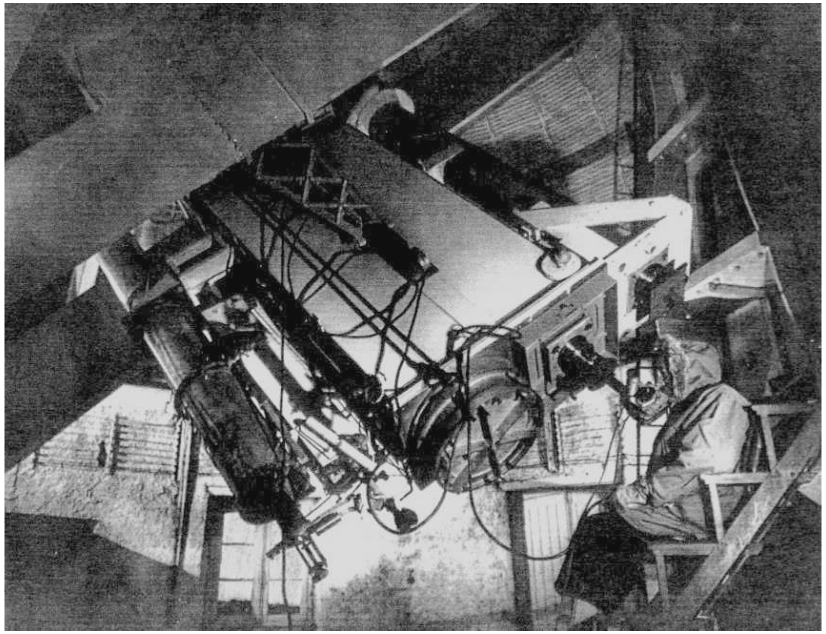
The project was initiated in 1945 and extended until 1970

SURFACE FEATURE VARIEGATIONS AND VARIATIONS

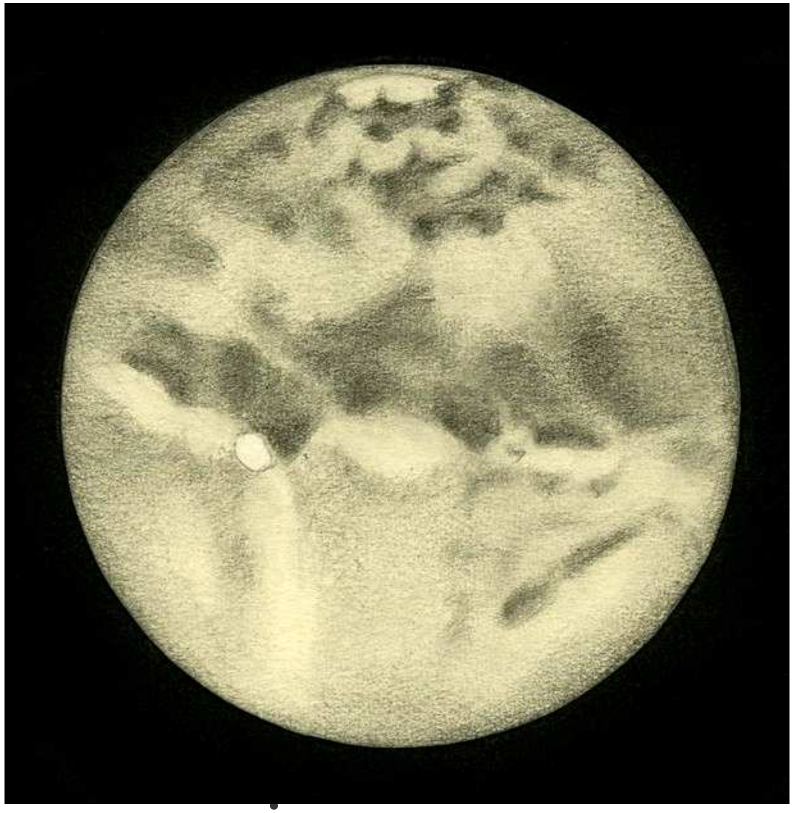
At the top of Pic du Midi, south of France, at an altitude of 2877 m, a telescope was available, of exceptional power for high magnification.

With Henri Camichel, with Jean Focas and with our students, we undertook the analysis of the surface of Mars.

The magnification at the
eyepiece approached
one thousand..



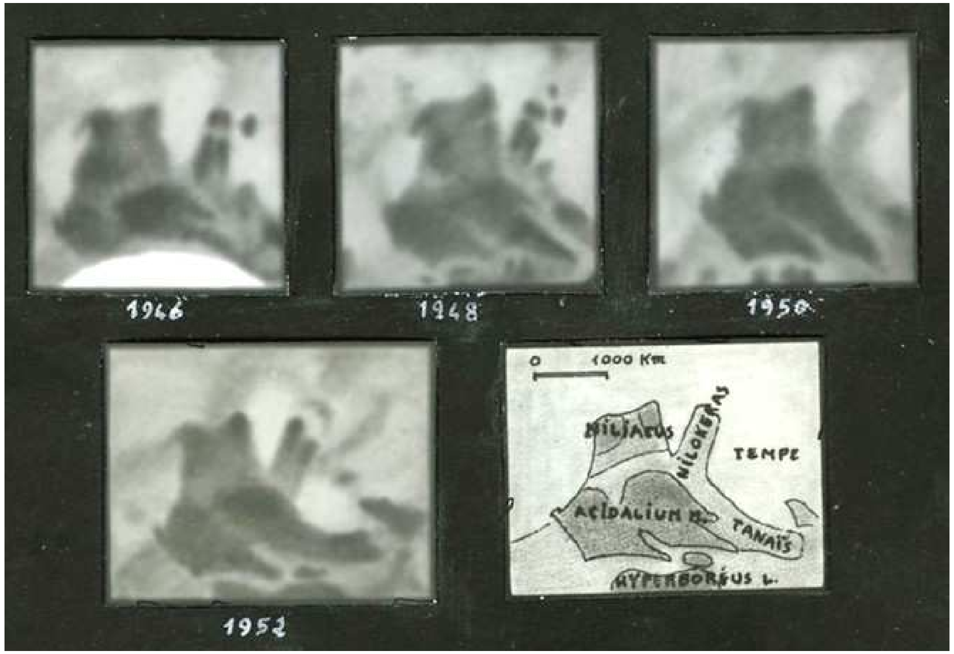
The shaded dark features which extend over the planetary countries appeared at the telescope very sharp and well defined, often like mosaics of small dots.

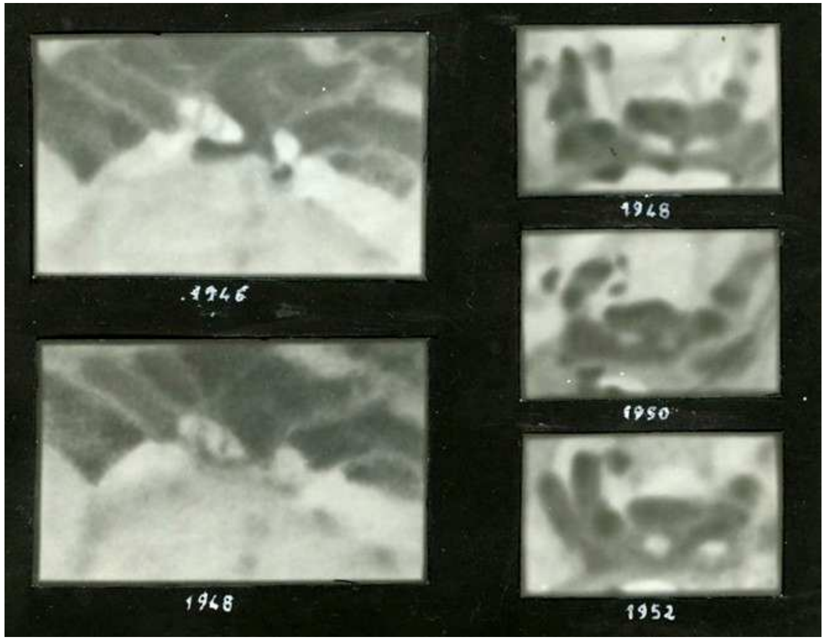


The smallest dots detected on the ground covered

50 km in diameter.

These fine structures were noted variable with time. Modifications occurred essentially during the period of maximum insulation by the solar radiation.



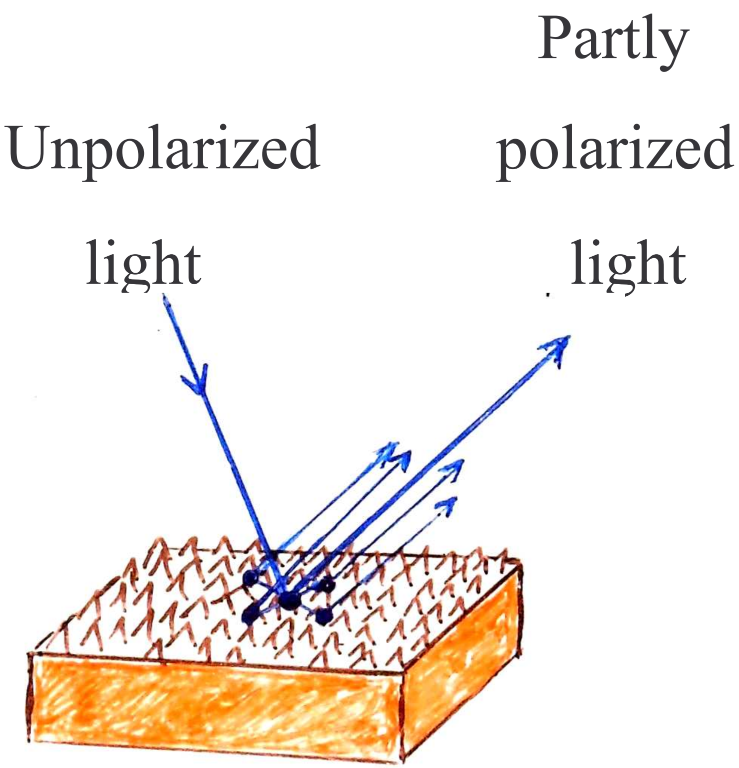


These behaviours where considered consistent with a sort of vegetation at the surface of the planet.

But they are also consistent with transportations and depositions of soil dust grains by seasonal winds.

SURFACE TEXTURE AND COMPOSITION

To further investigate, we analyzed the nature of the Martian soil, by the determination, at the telescope, of the physical properties of the light reflected by the planetary surface.

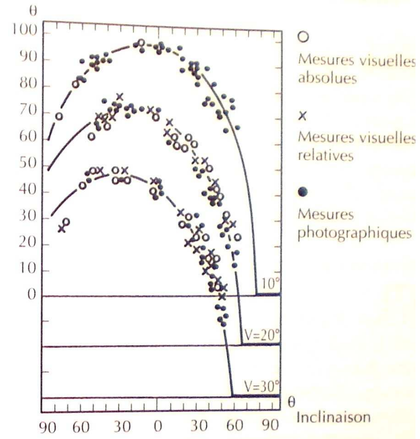


Reflection
Refraction
Scattering
Absorption
Birefringence

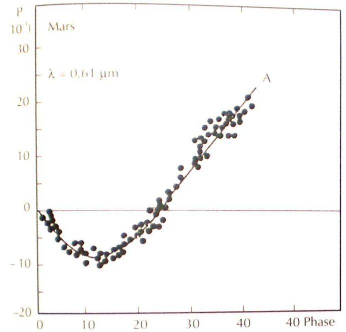
To analyse these properties of the light, we introduced at the eyepiece of the telescope an interference design. Fringes are produced and their contrasts visualize the intensities of the parameters to be measured.

The **intensity** of the light is determined by combining a photometer with the fringe interferometer.



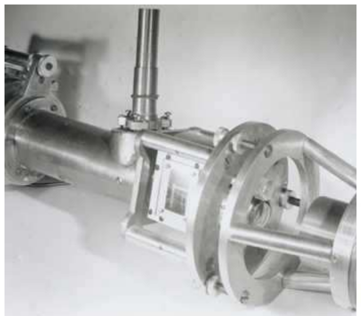
Courbes photométriques donnant la rugosité.

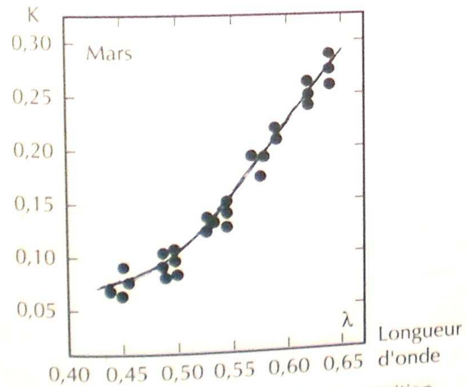
The way the **polarisation** of the light is produced is analyzed with a polarimeter in front of the fringes;



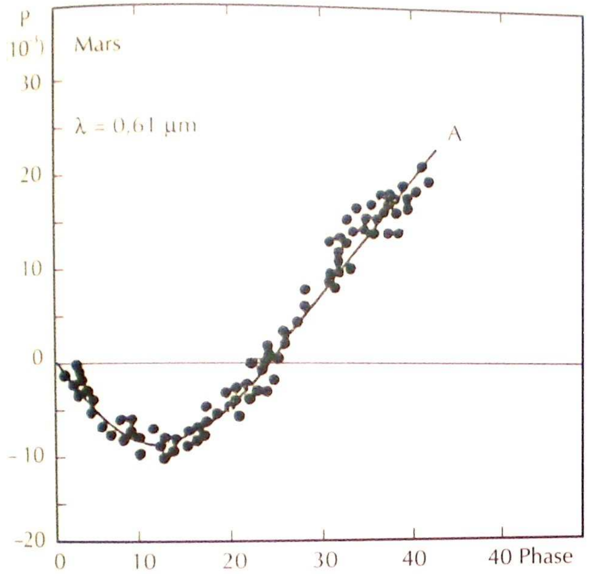
Courbe de polarisation caractérisant la texture.

The **spectrophotometry** of the surface was derived with a tunable filter associated with the fringes.

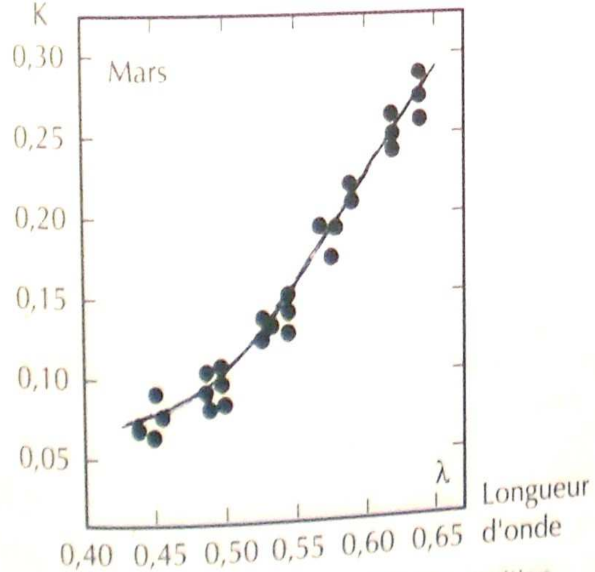




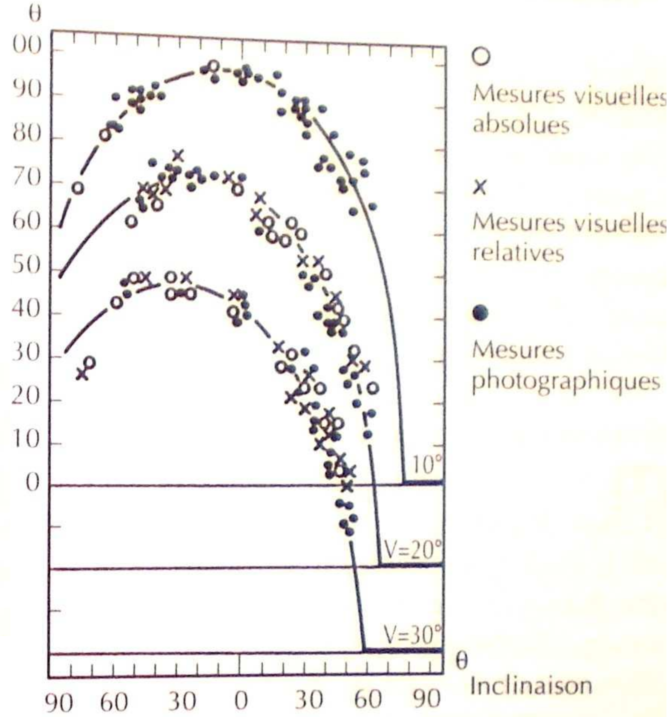
Courbe spectrale définissant la composition.



Courbe de polarisation caractérisant la texture.



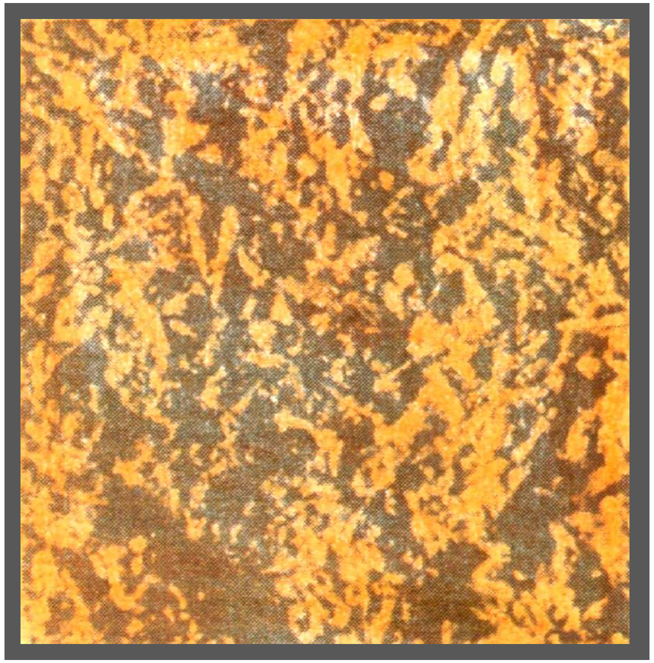
Courbe spectrale définissant la composition.



Courbes photométriques donnant la rugosité.

At the laboratory, we simulated the martian surface reflectance properties, and searched for surfaces reproducing exactly the optical properties observed on Mars.

The results converged to characterize a specific nature for the Martian surface: **a layer of dust made of small dark grains, rich in ferrous oxide.**

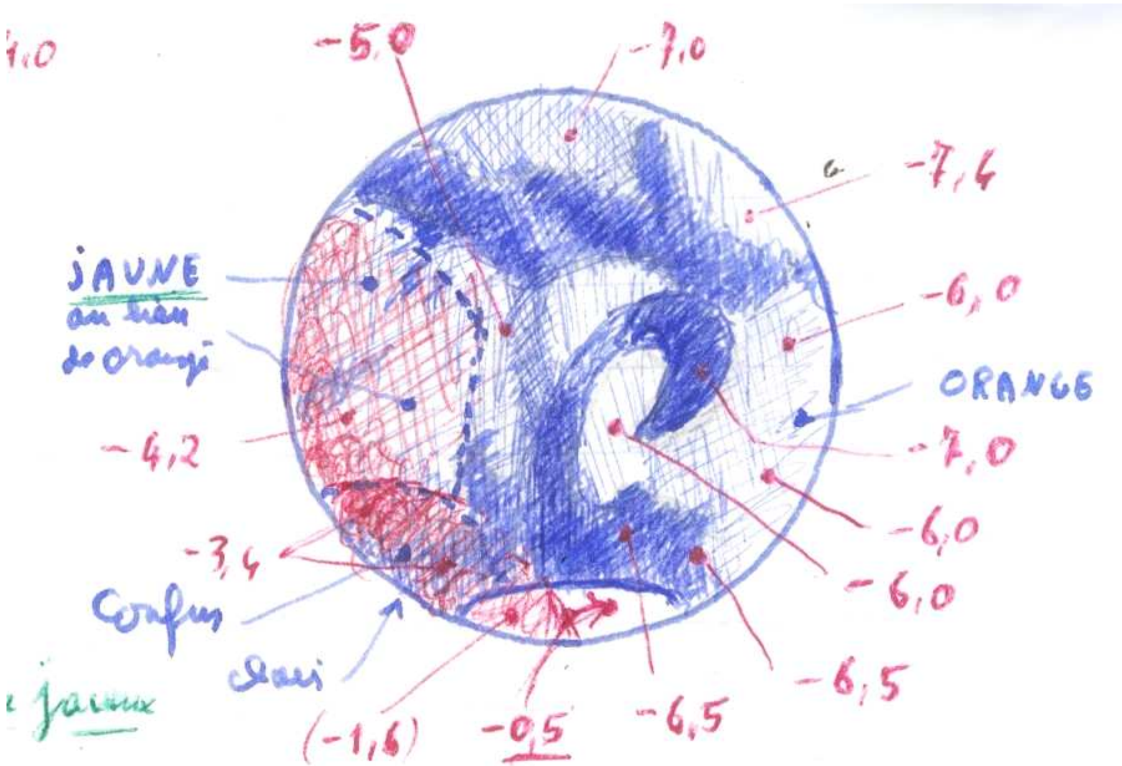


Microscopic aspect of the pulverized limonite, Martian surface simulator. Field 30x30 mm.

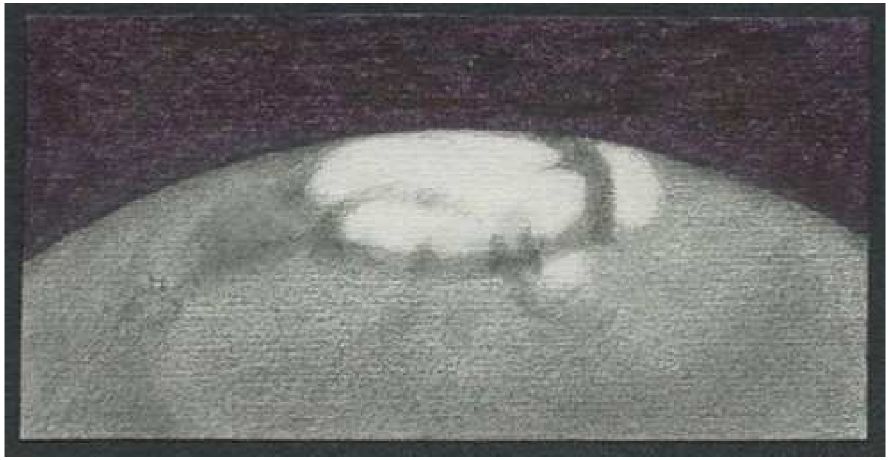
A piece of very finely grinded **limonite** $Fe^2O^3(nH^20)$ simulates precisely the optical properties of the Martian soil.

SMALL FEATURES CHARACTERIZATION

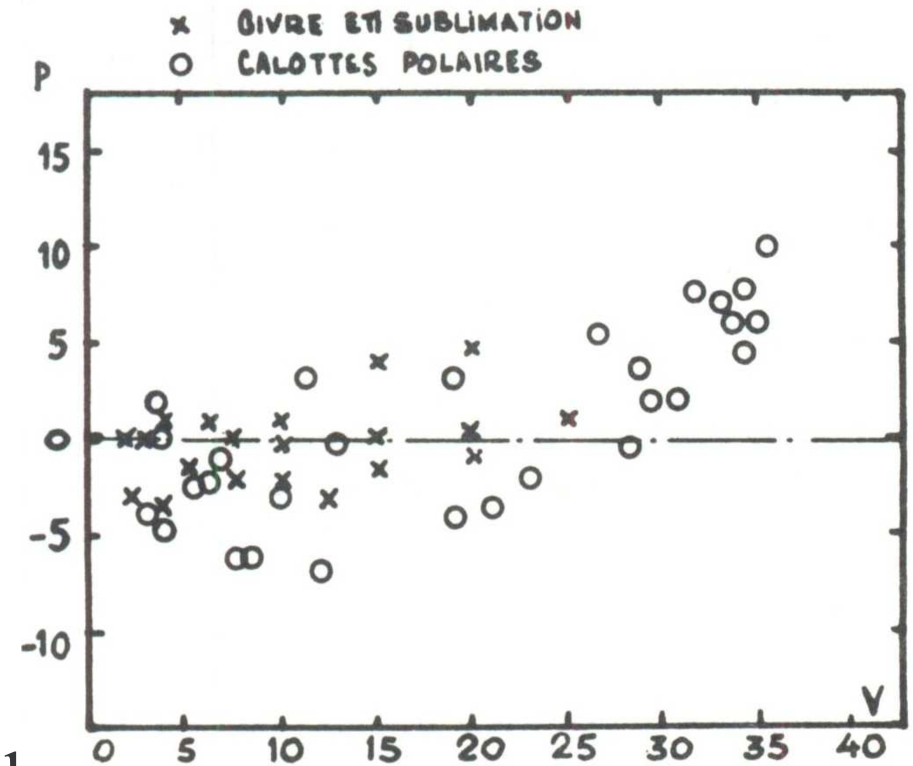
The optical measurements were extended to small dark countries, some of them of only 100 km in diameter.



POLAR CAPS CHARACTERIZATION



The **white polar caps** have very specific polarization characters. They are reproduced on a **water frost layer deposited at low atmospheric pressure**.

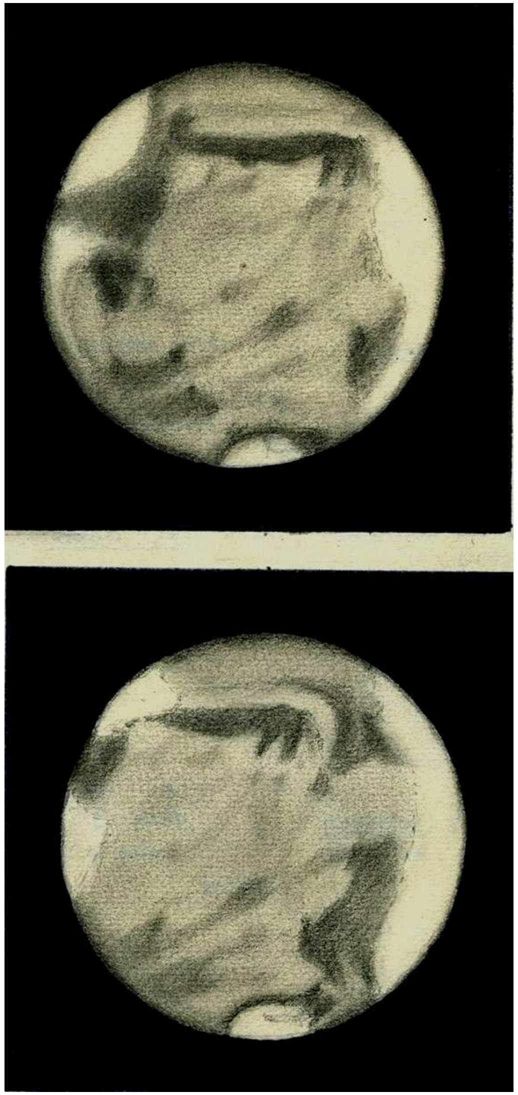


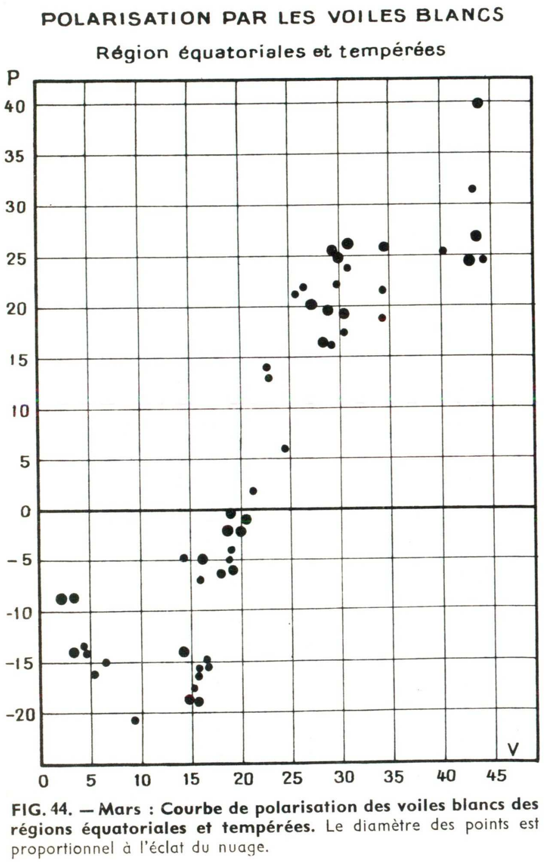
Polar cap polarization.

Dots: polar cap on Mars

Cross: frost at low pressure.

CLOUDS IN THE MARTIAN ATMOSPHERE





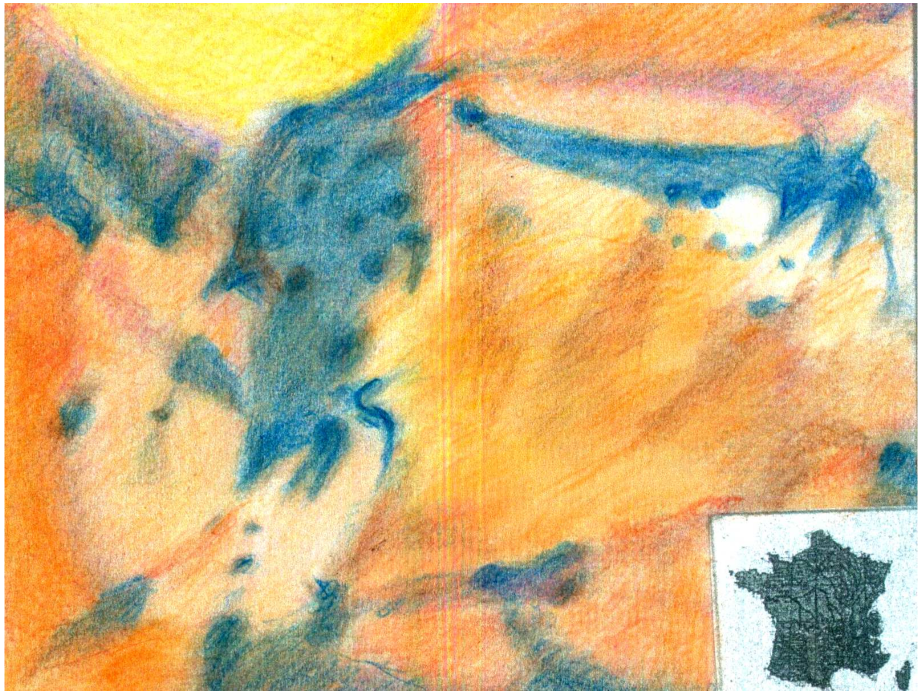
The clouds, fogs and hazes observed in the atmosphere of Mars have polarization properties which are recognized on cirrus clouds made of **small ice crystals.**

Polarization curve of Martian clouds.

Evening haze at the limb of Mars.

DARK FEATURES CHARACTERIZATION

The dark parches of the surface of Mars were analyzed through a tuneable optical filter, simultaneously at several wavelengths. Colour effects were produced and they **exclude the presence of chlorophyll.** Accordingly, there is no phanerogam organisms at the surface of Mars..



But these dark variable features produce a polarization which is similar to the lighter areas.

This polarization is **not compatible with a vegetation with leaves and stems**.

It characterizes **a surface made of small dark grains.**

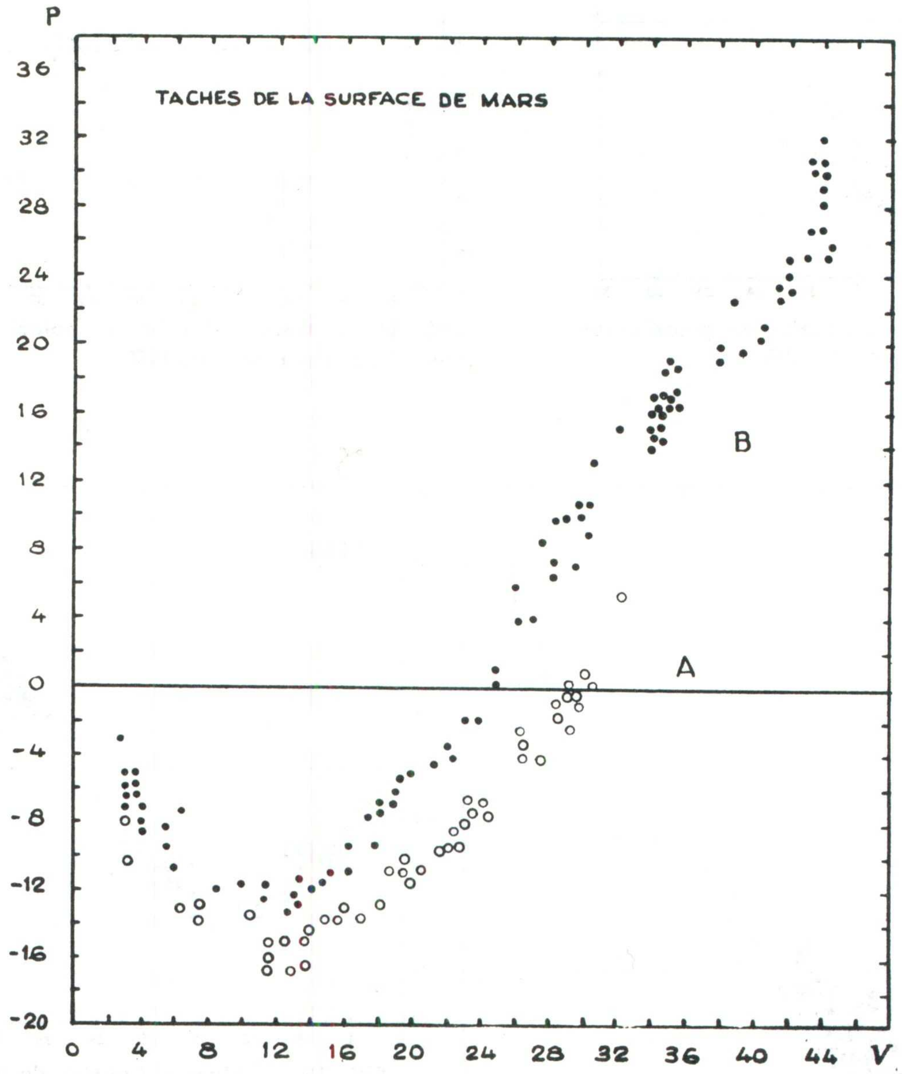


FIG. 41. — Mars : Courbe de polarisation des régions sombres.
Courbe A : Taches boréales au printemps.
Courbe B : Taches équatoriales et australes au printemps.

This microscopic texture may be explained by living organisms, provided they are granular and of small size. They could be **micro-cryptogams** or **microbes**.

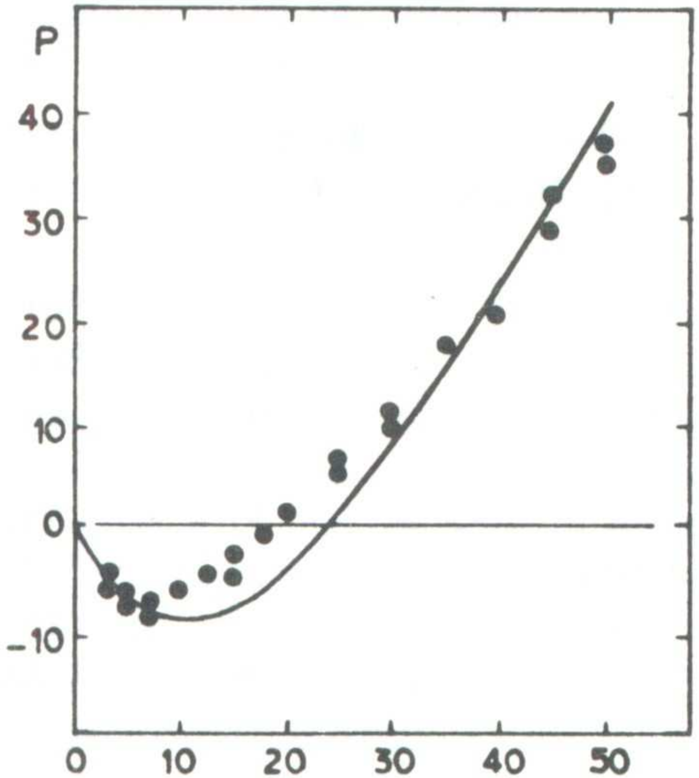


FIG. 58. — Courbe de polarisation d'un dépôt de limonite (trait) et mesures du dépôt recouvert de petits végétaux pulvérulents (Pleurococcus vulgaris).

Clamiomonas Nivallis, the "Red snow"**,** extends over snow fields on Earth. Their optical properties are reminiscent of those observed for the dark Martian features .

Pleurococcus vulgaris fits also the polarisation of Mars.

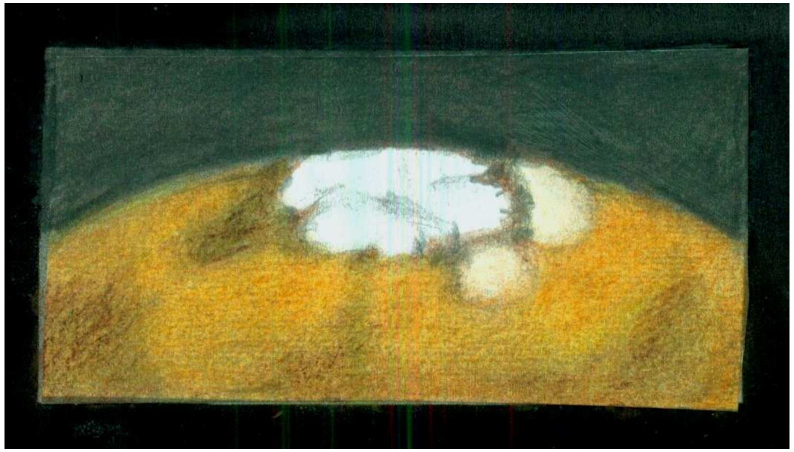
DARK FEATURES MYSTERY

A conclusion was that the dark hued patches could be due to micro-organisms living at the surface of Mars.

But they may also be due to mineral dust grains, sprinkled or displaced under the effects of winds.

Water is a mandatory requirement for the presence of life. At this stage, it was of importance to search for the presence of water on Mars.

WATER EFFECTS



The **white caps** which cover alternatively the austral and boreal countries of Mars are interpreted as deposits of water snow or frost.

The **white clouds** in the Martian atmosphere are made of ice crystals.

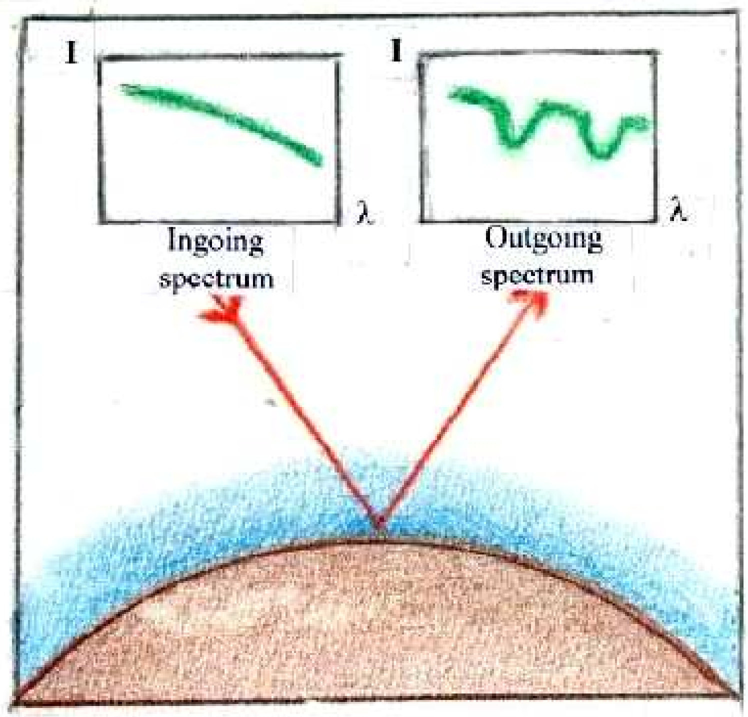
WATER SPECTRAL ANALYSIS

However, a better proof of the presence of water was to try to **detect it directly by spectroscopy**. The project was undertaken in 1954.

Water implies vapour in the atmosphere. Specific absorption bands are formed in the spectrum of the planet.

But our atmosphere contains a large amount of water, which hiddes the faint planetary bands.

Previous attempts to detect water on Mars failed because of this effect.



PLANETARY ATMOSPHERE
WITH WATER VAPOR

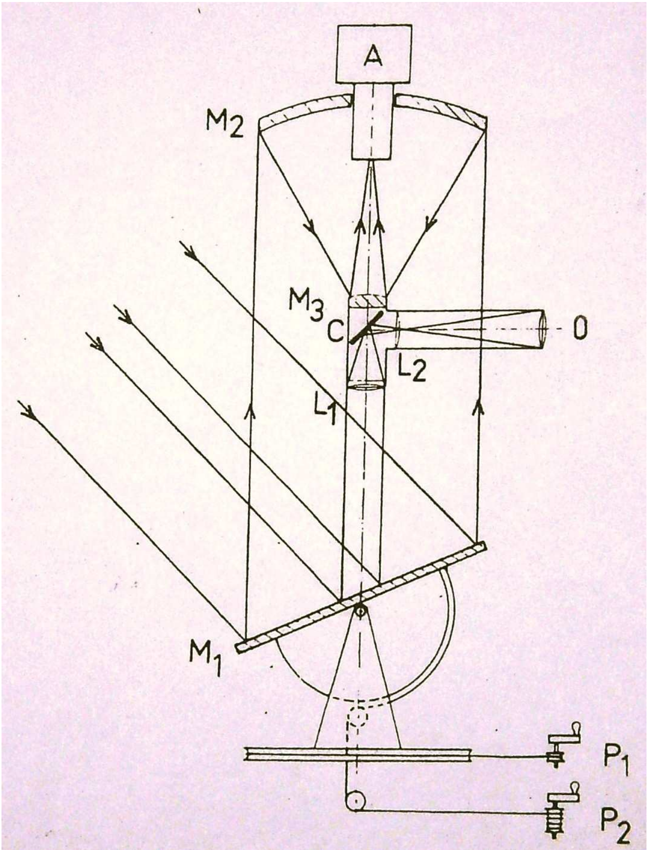
THE 1954 BALLOON FLIGHT.

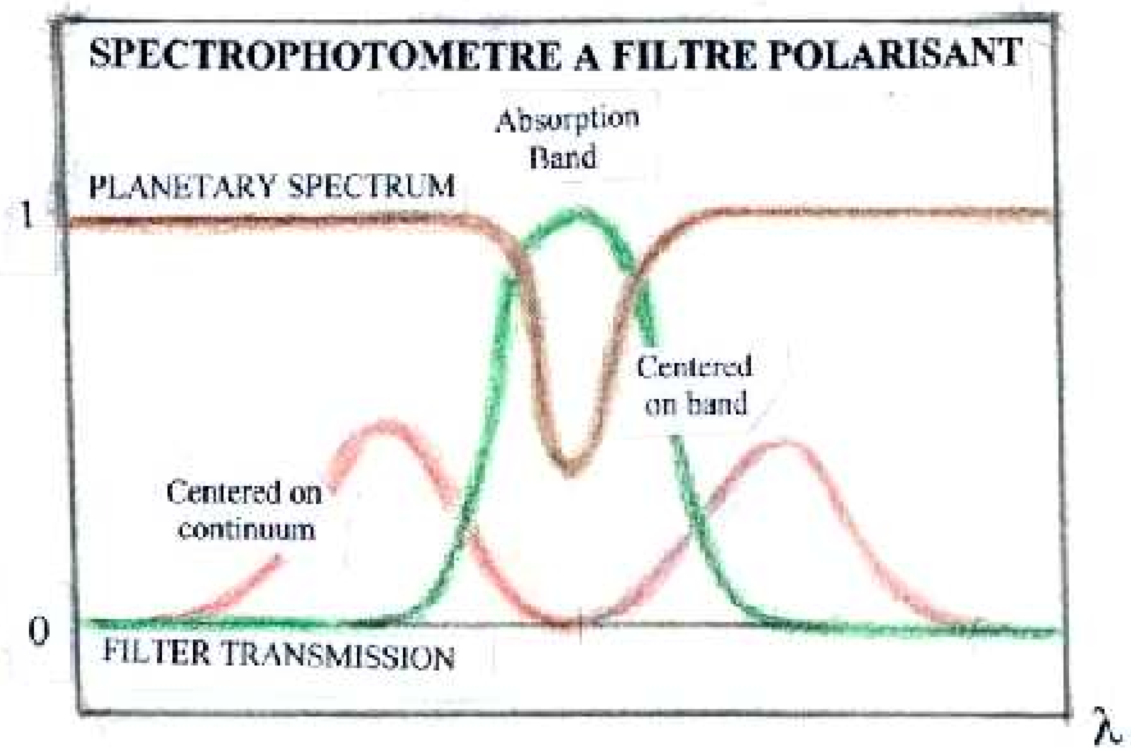
We decided **to observe at high altitude,** from above the disturbing layer of the atmosphere, on board a balloon.

On May 29, 1954, the balloon was inflated in the park of Meudon Observatory.

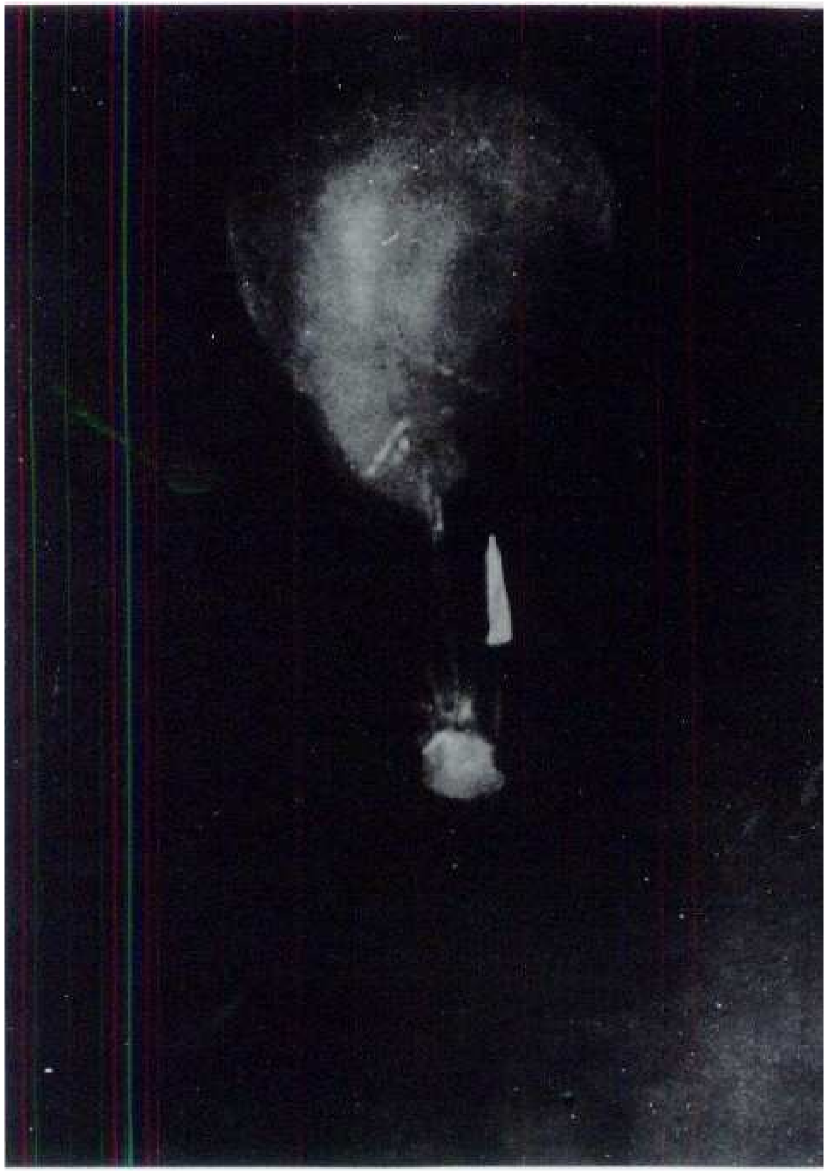
The fabric of 1200 m^3 was fed with 600 m^3 of hydrogen, to let the gas expand with altitude

The telescope of Cassegrain type, 32 cm in diameter, was looking downward towards a flat mirror aimed at the planet.

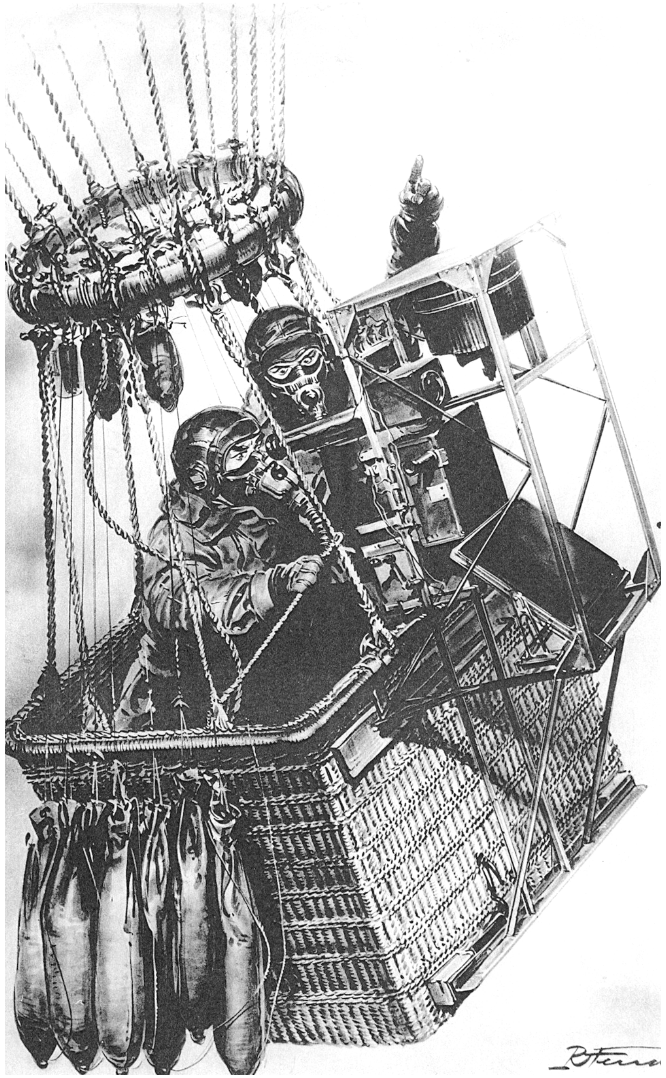




At the focus of the telescope, a birefringent filter selected the water vapour spectral band at 0.825 µm.
A wavelength modulator alternated quickly the band and the nearby continuum. The flickering of the light was recorded by a photoelectric photomultiplier.

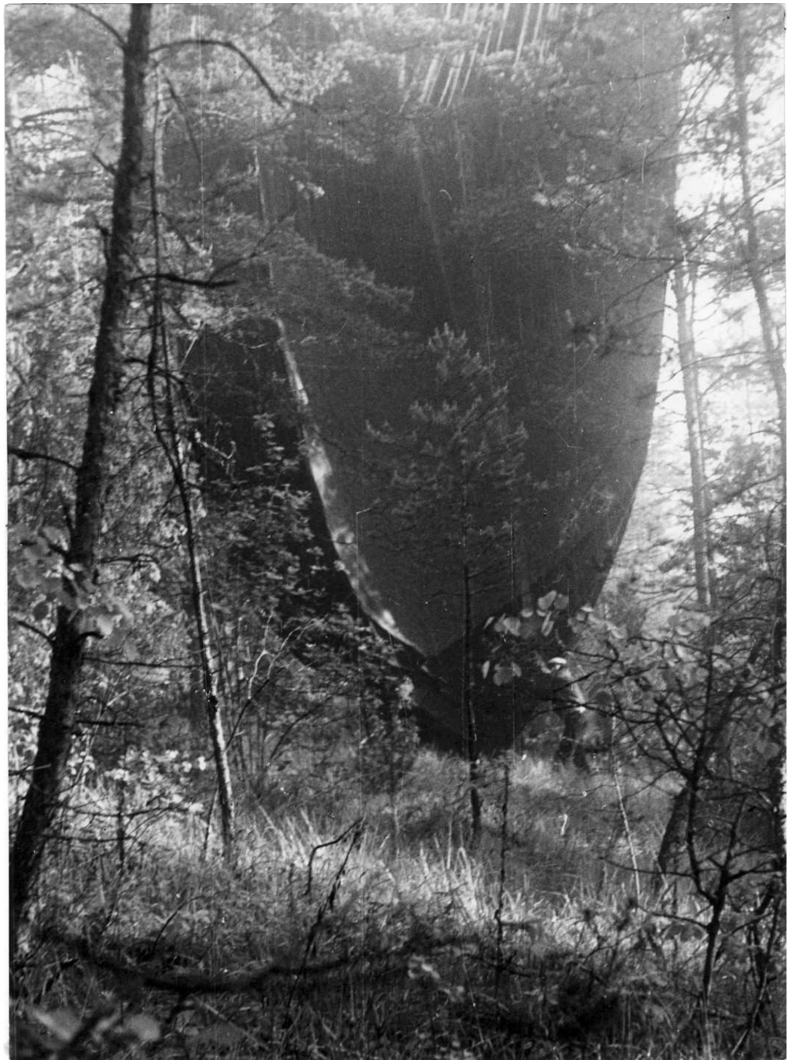


Take off occurred at 01 h am. Charles Dollfus was the pilot and Audouin Dollfus the observer.



During the night, at an altitude of 7000 metres,we analyzed the H_2O spectral band with the telescope, on Mars, on the Moon and after the sunrise on the solar light.

We landed safely at 08 h am after a seven hours high altitude flight.



It was the first use of an astronomical telescope on board a balloon.

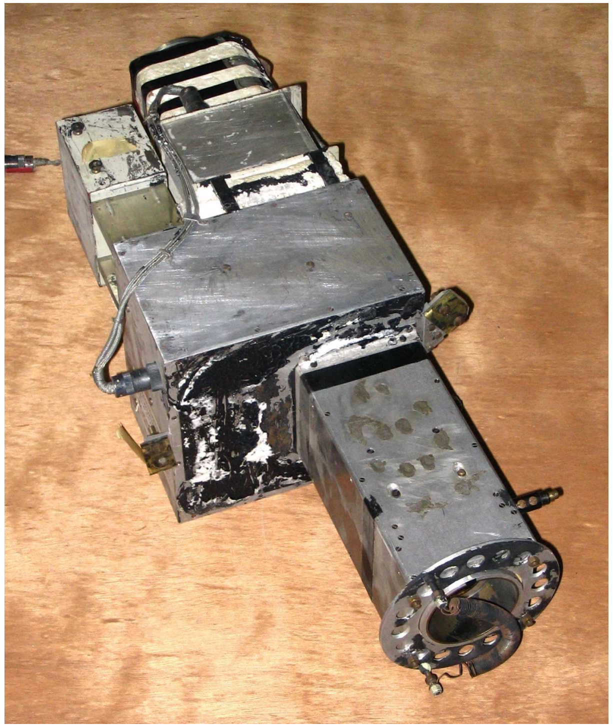
The measurements on the **Moon** and the **Sun** gave the amount of water in the atmosphere above 7 000 m . The result was **0.025 g.cm^{-2}.** The value at ground level was 1.5 to 3.0 g.cm^{-2}.

On **Mars** the signal was undetectable. The amount of water was found to be **less than one percent** of the value for our own atmosphere.

THE SPECTROPHOTOMETER FOR WATER DETECTION

Detecting such a small amount of water required improvements in the techniques.

A new spectrophotometer was designed, on the principle of the 1954 balloon borne instrument but using:



- a stronger spectral band, at $\lambda = 1{,}4$ µm.
- a more sensitive detector, with a PhS cathode.

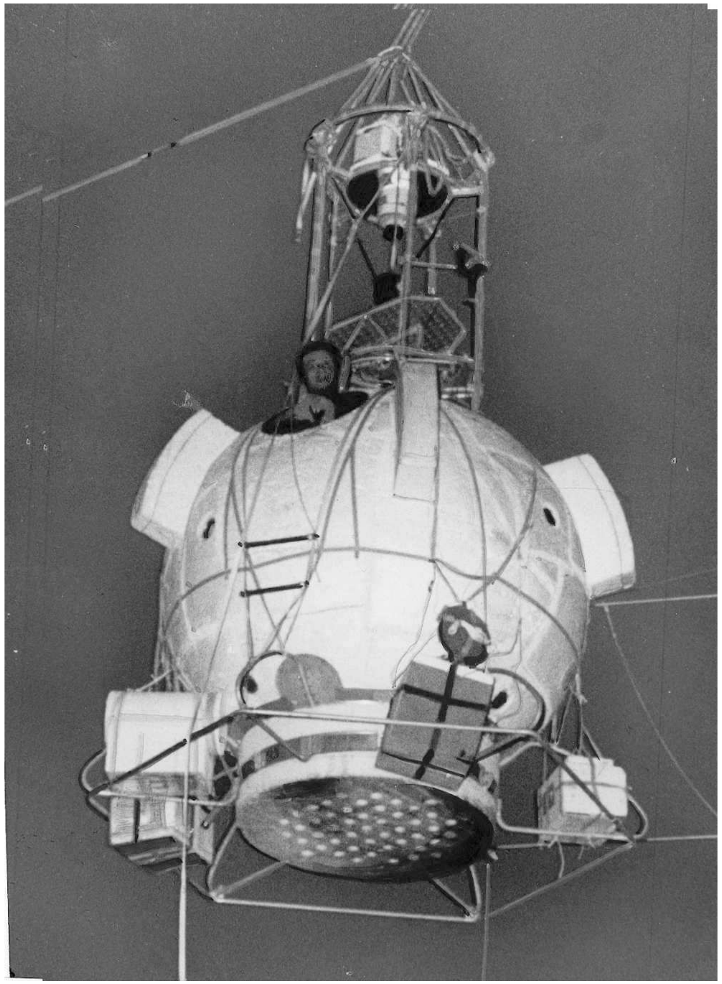
THE HIGH SENSITIVITY TELESCOPE

A new telescope was also designed, on the principle of the 1954 balloon instrument,

but with a diameter of 50 cm.

THE CAPSULE FOR HIGH ALTITUDE FLIGHT

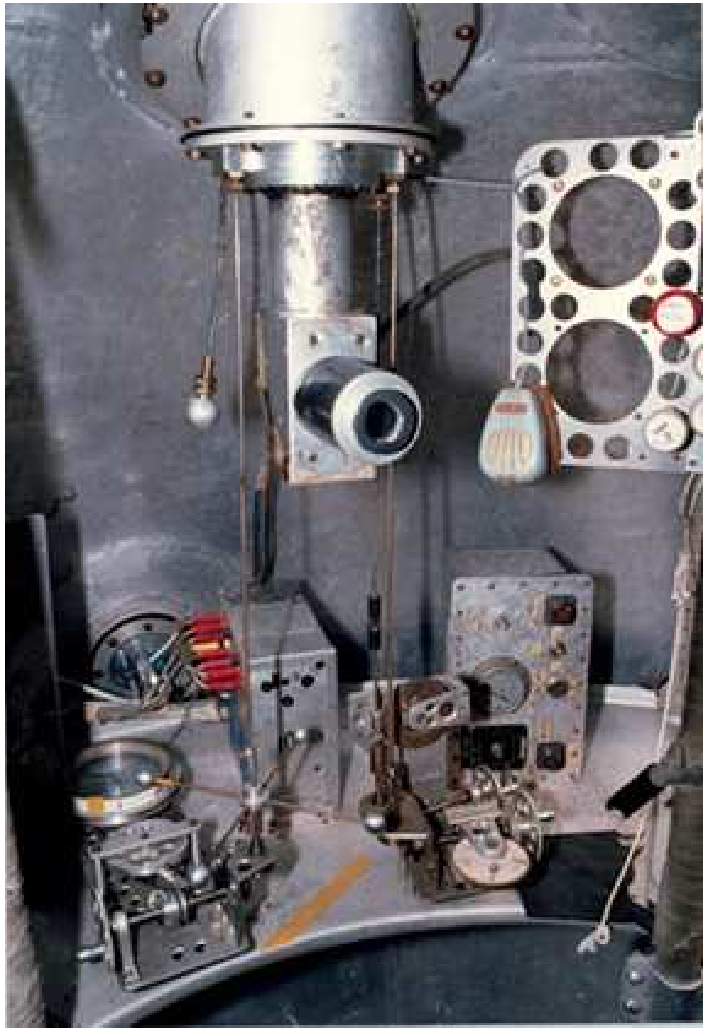
An air-tight capsule was conceived, to protect the observer against low pressure and cold temperature. The telescope and the spectrophotometer were adapted to the capsule.



The capsule is a sphere, 1.8 m diameter, made of a thin shell of aluminium.

The telescope was operated from inside the capsule.

The observer at work inside the capsule

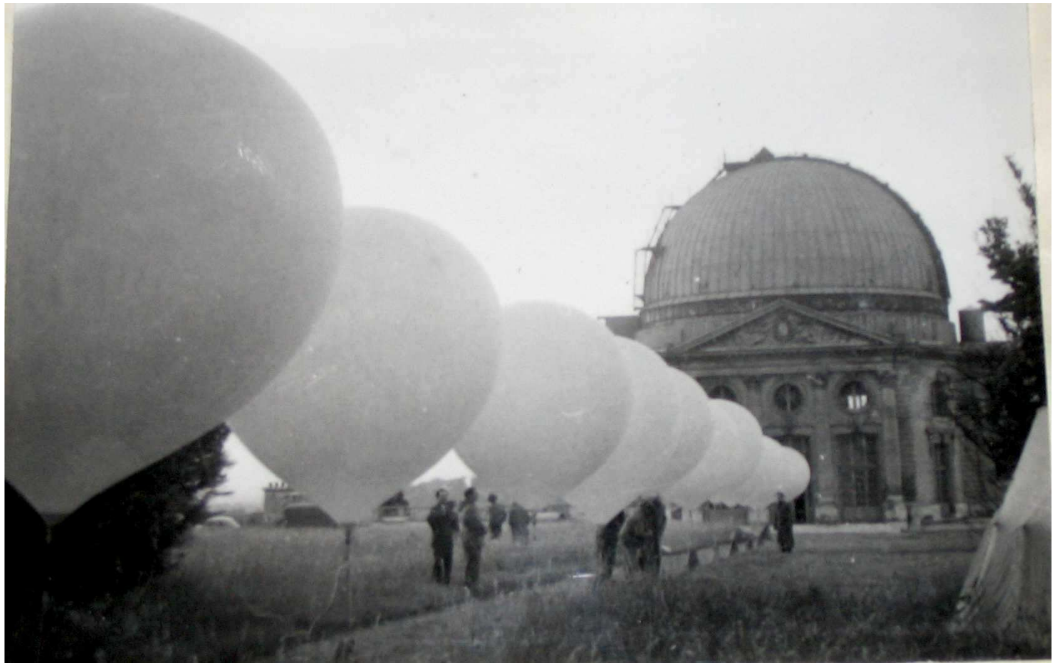


The eyepiece and the cranks

to operate the telescope.

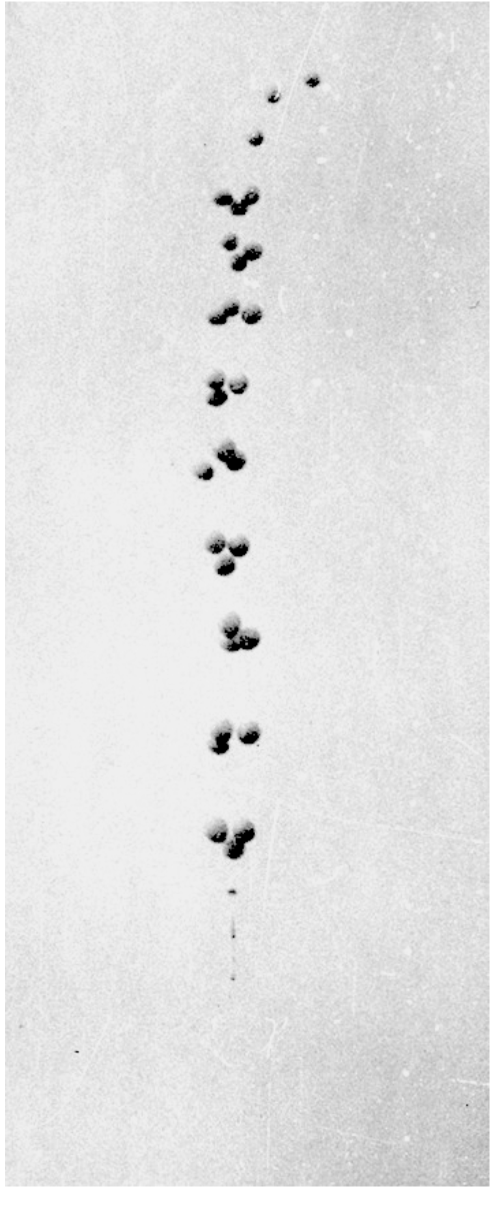
THE BALLOON TECHNIQUIE

To carry the telescope and the observer high in the air, clusters of rubber balloons were experimented.



Each balloon is inflated with hydrogen until a diameter of 3.5 m. With increasing altitude, the gas expands and the diameter increases. With a diameter near 10 m, the balloon bursts.

With a cluster of balloons, some balloons explode first, the rate of ascent decreases, other balloons burst and the whole design stabilizes by itself at the ceiling altitude.

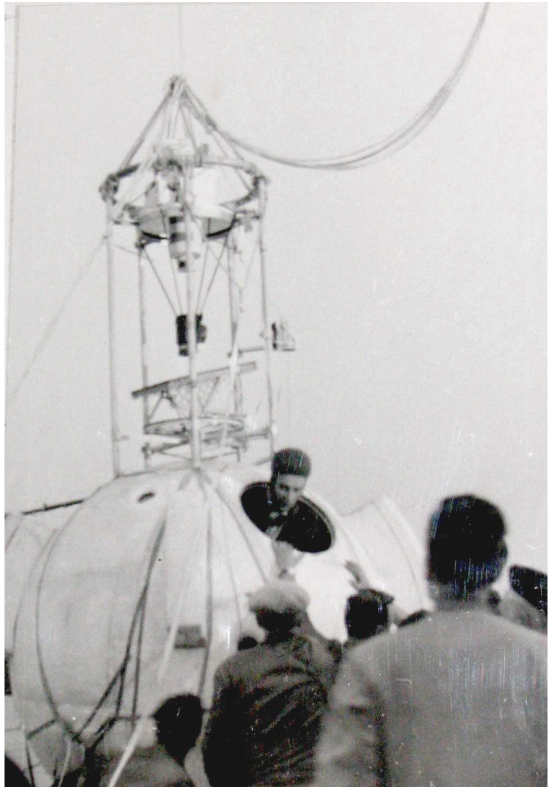


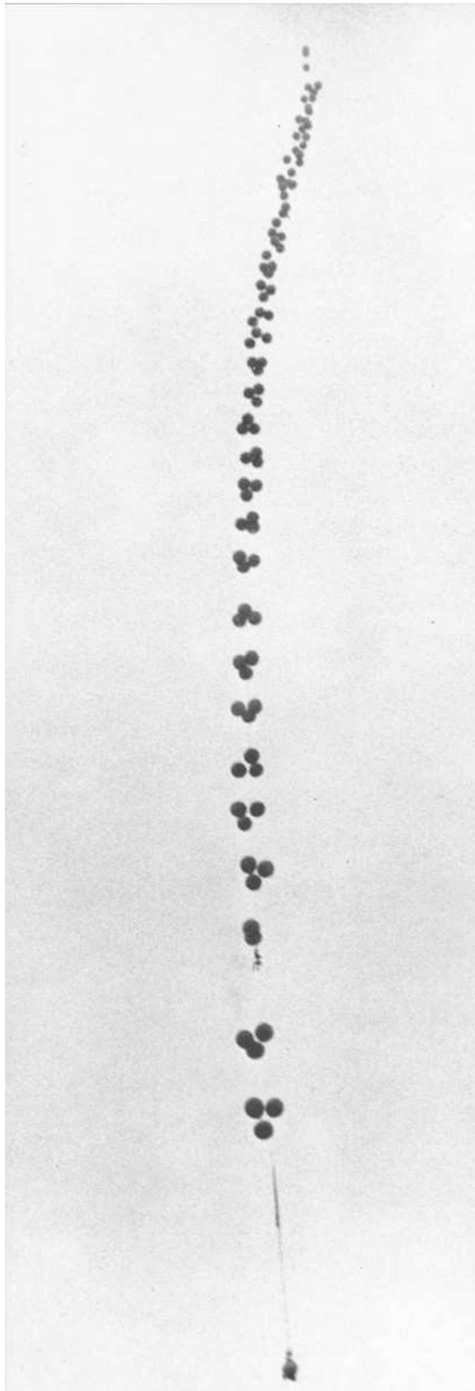
An assemblage of 30 balloons clustered three by three along a vertical string lifted a payload of 130kg.

THE BALLOON FLIGHT AT 14000 METERS.

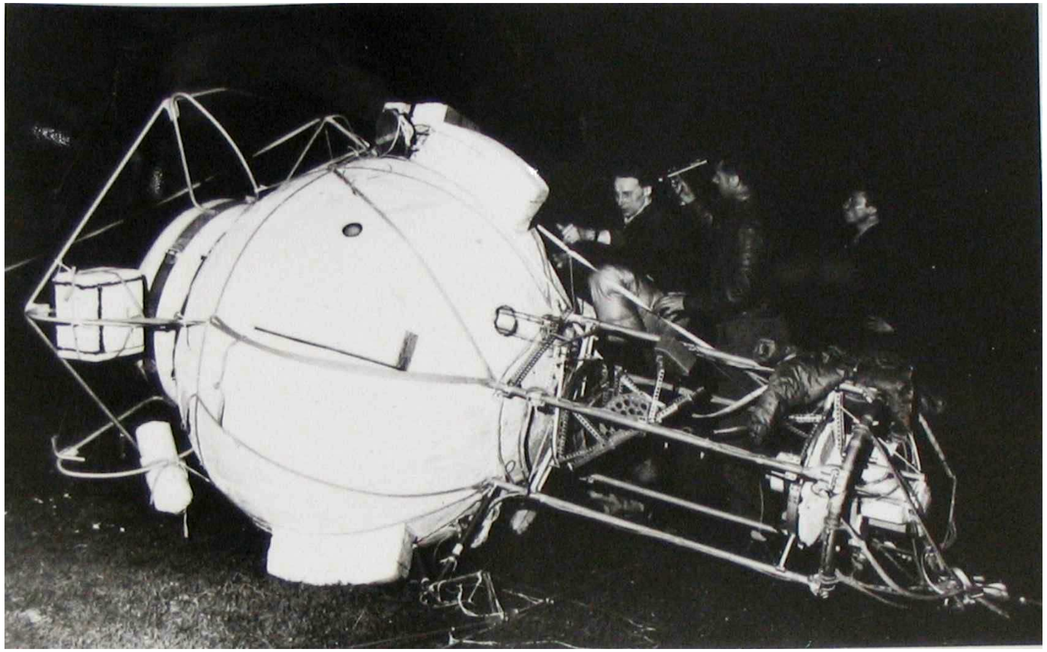
To lift the observer, the capsule and the telescope required more than100 balloons, fastened along a cable 450 meters long.

The launch occurred on April 22, 1959 at sunset.





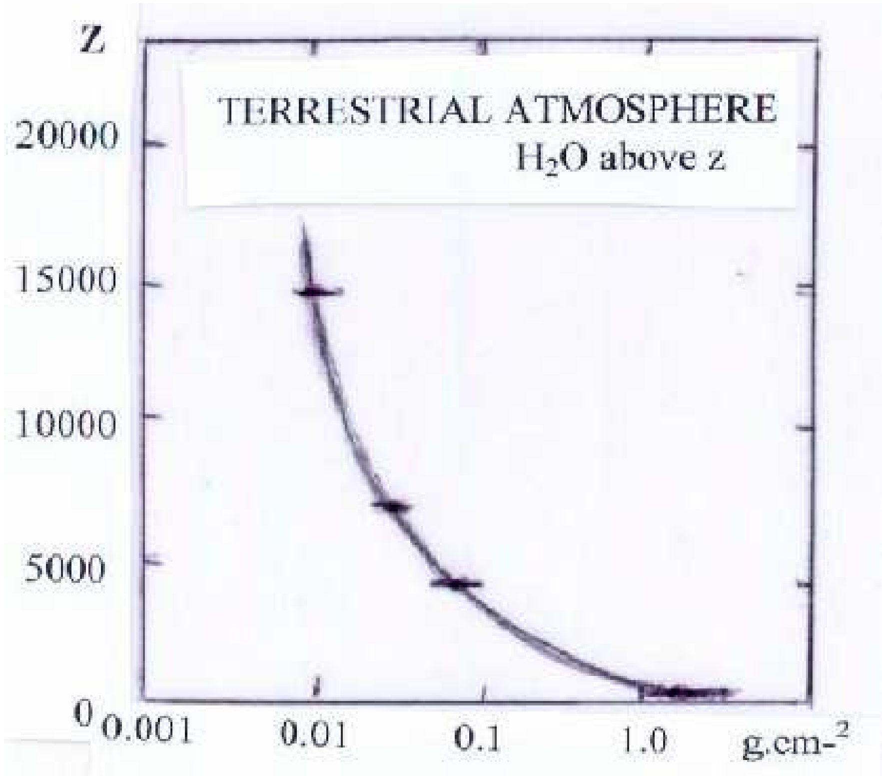
The balloon reached the stratosphere at night, stabilized at an altitude of 14000 m and stayed for two hours during which telescopic measurements of the water vapour were recorded, on Venus and on the Moon.



When these measurements were completed, an operation released some balloons. The whole design went down and landed safely.

The measurements on **the Moon** gave the amount of water in the Earth stratosphere. The value, **0.0125 ± 0.003 g.cm^{-2}**, indicated that the upper terrestrial atmosphere is almost water vapour saturated.

The measurements on **Venus** did not exhibited detectable signal.
The amount of water in the Venusian's atmosphere was concluded to be smaller than 0.02 g.cm^{-2}

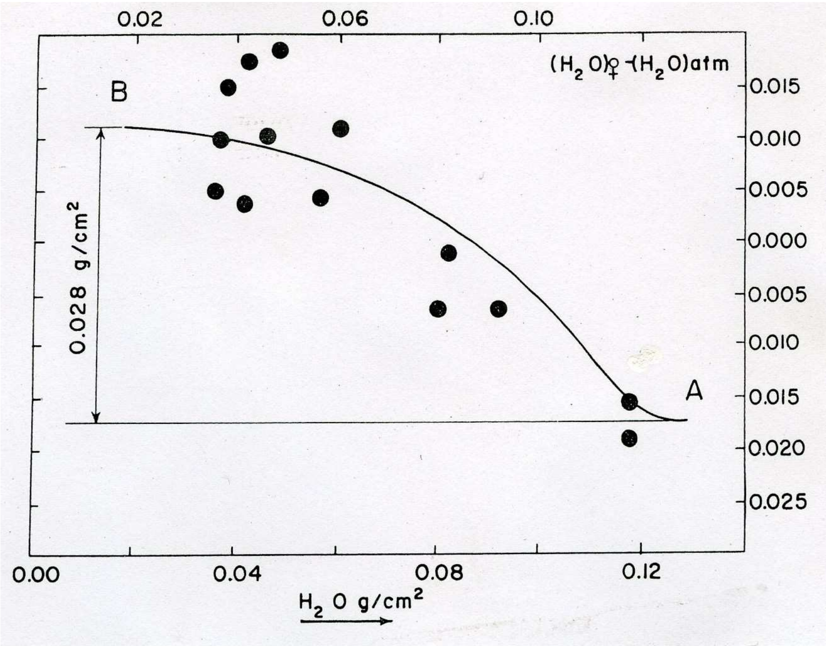


Vertical distribution of water in the Earth atmosphere.

DETECTION OF WATER VAPOR.

The results of the flight showed that the instrument could be used also at lower altitude, provided the temperature be very cold. In January 1963 the telescope was separated from the capsule and moved to the Jungfraujoch high altitude station, at 3650 m in the Swiss Alps.

For **Venus**, fourteen sequences of measurements compared the planet and the Moon. In a diagram, the intensity of the H_20 band on the Moon is plotted horizontally and the differences between Venus and Moon vertically.

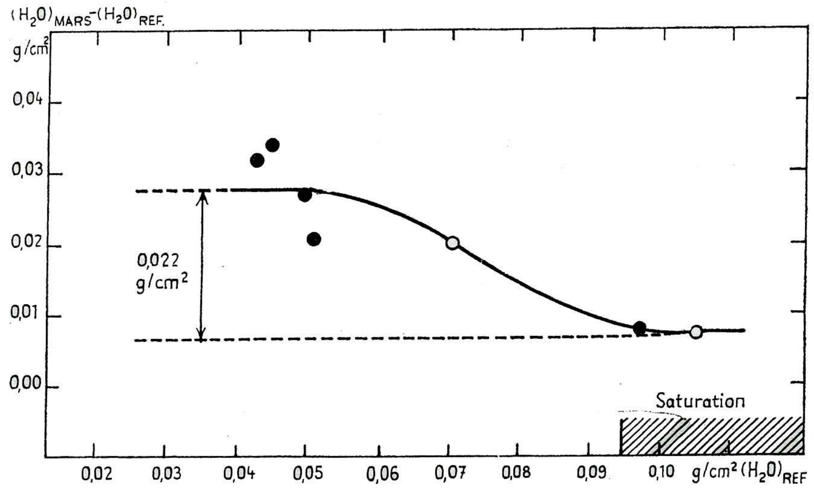


At right the band is saturated and the planetary water does not add any signal. Toward left, the band is progressively de-saturated and the planetary water adds its effect. At left, the planetary signal is fully isolated and gives 0.028 g.cm^{-2}.

The amount of water in the Venus atmosphere was found to be **0.007 ± 0.002 g.cm^{-2}**.

For **Mars**,seven sequences produced a diagram corresponding to

0.0045 ± 0.0015 g cm^{-2}



The total amount of water in the Martian atmosphere, **6x10^{15}** g, is comparable to the amount of water in the terrestrial atmosphere, accounting for the respective densities of the two gaseous envelopes.

This amount explains the clouds, hazes, mists and frost observed on Mars.

The biologists considered it as **compatible with the development of life.**

SEARCH FOR LIFE ON MARS

CONCLUSIONS FROM THE FRENCH TELESCOPIC OBSERVATIONS in 1970

- **The surface of Mars is made of small oxidized grains.**
- **The amount of water in the Martian atmosphere is compatible with the existence of life.**
- **There is no growth based upon chlorophyll.**
- **There is no trace of leaves or stems, such as those found on phanerogam vegetation.**
- **A life, if it exists, must have a morphology of small grains, like micro-cryptogams or microbes.**

- **THEN WENT THE SPACE AGE**

and the direct search for a microscopic life on Mars

Douglas Prince, Signs of Life: Oak Leaves over Mars, Schiaparelli Hemisphere, *1997*

- **THANK YOU**