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Geomorphological observations of the first photographs of the surface of Venus transmitted by the Soviet Unmanned spacecrafts Venera 9 and Venera 10

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Planetologia. — *Geomorphological observations of the first photographs of the surface of Venus transmitted by the Soviet Unmanned spacecrafts Venera 9 and Venera 10.* Nota (*) del Socio PIERO LEONARDI.

RIASSUNTO. — Le sonde spaziali sovietiche *Venera 9* e *Venera 10* hanno trasmesso fotografie della superficie del pianeta Venere, che sembra rispondente, nei luoghi di atterraggio, ad una zona desertica pietrosa paragonabile alle *hammada* terrestri, forse con qualche affioramento roccioso.

On October 22, 1975 the Soviet unmanned spacecraft *Venera 9* made a soft landing on the surface of Venus; three days later, on the 25th, a second unmanned spacecraft, *Venera 10*, landed 2,200 Km away. Both spacecrafts functioned for about one hour until the extremely high pressure and temperature on the surface of the planet caused the instruments to break down. In this brief period, however, several panoramic images of the areas surrounding the landing sites and considerable data on the environmental conditions could be transmitted.

Data regarding the atmosphere of Venus had been transmitted previously by a total of nine spacecraft, 6 of which were Russian (*Venera* 3, 4, 5, 6, 7, 8) and 3 of which were American (*Mariners* 2, 5 and 10).

Some indications of the characteristics of the surface of the planet were supplied by research using radar: De Callatay and Dollfuss wrote in 1968 (p. 73) that *le coefficient de réflexion de Venus vaut 0,14 fois celui d'une sphère parfaitement réfléchissante. Sensiblement plus élevé que le coefficient de la Lune, il est cependant nettement inférieur à celui des grandes étendues d'eau, ce qui a fait écater l'hypothèse, avancée dans le temps, que la planète était comme la Terre recouverte d'océans. On pense aujourd'hui que la surface vénusienne est dure, sablonneuse ou rocheuse, et qu'elle est moin rugueuse que celle de la Lune.*

Through the use of radar, maps of the Venusian surface, although only partial, have been prepared. Fig. 1 reproduces one such map obtained from the *NASA Jet Propulsion Laboratory*, Pasadena, California (U.S.A).

Another map from the same laboratory (fig. 3) covers 500.000 square miles and reveals a generally flat wasteland dimpled with broad, shallow craters much like those of the Moon, each a quarter of a mile in depth and from 20 to 100 miles in width.

Unhappily the map is incomplete because a black central band of unknown territory cannot be mapped until better techniques are developed (1).

(*) Presentata nella seduta del 13 marzo 1976.

(1) « Nature–Science Ann. (Time–Life) », 1974, p. 172.

These maps indicate that the surface of the planet is rather rugged and one also seems to observe the existence of craters analogous to those on the Moon, Mars and Mercury.

Before the Soviet probes *Venera 9* and *Venera 10* landed, G. N. Katterfeld and K. Beneš (1972, 1973) summarized the knowledge of the geological characteristics of the planet. They based their observations upon data

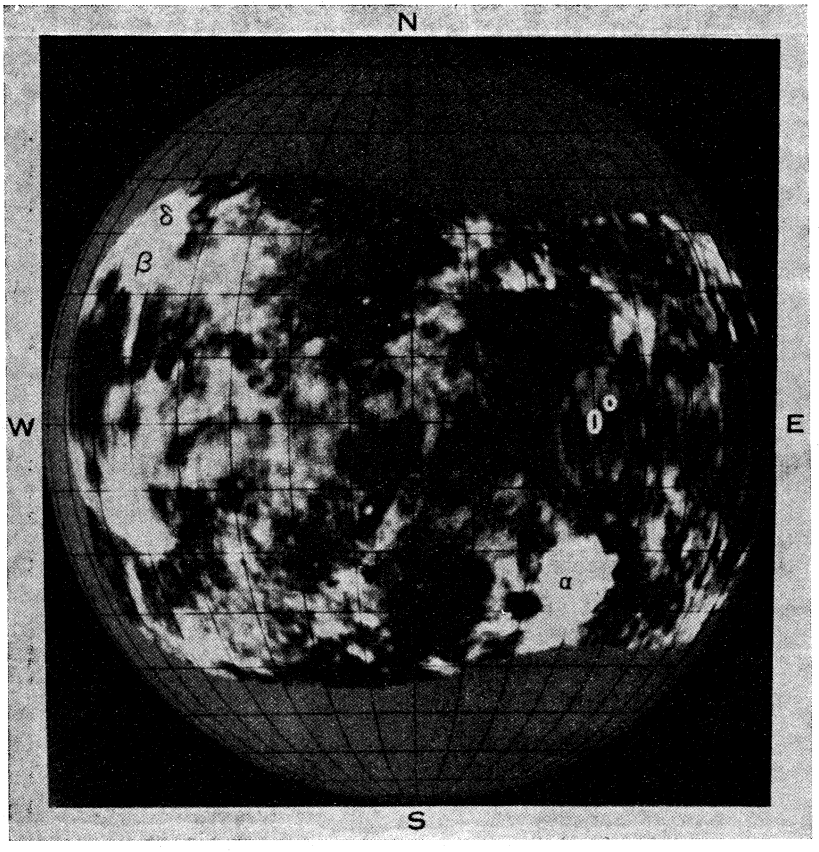

Fig. 1. – The planet Venus observed from Earth through the technique of radar. The three light areas marked *1*, *2* and *4* are rough sections that may be mountains, or craters, or boulder fields. The mapping was done by the Jet Propulsion Laboratory, using the NASA/J.P.L. deep space antennas at Goldstone, California. (Courtesy of the *Jet Propulsion Laboratory*, Pasadena, Calif. USA).

provided by the American and Soviet probes and upon research via radar: " It is assumed that Venus is a planet with past and recent volcanic activity. In analogy with other planetary objects such as the Moon and Mars, the Venusian crust is believed to be heterogeneous and differentiated. The surface layer is expected to be composed of ultrabasic, basic, intermediate and probably even acidic rock types ".

"The recent results of *Venera* 8 indicate in the place of landing 4 % K, 650 p.p.m. Th and 220 p.p.m. U, i.e. radioactivity near to the radioactivity of granitoid rocks. The Venusian relief seems to be volcanic and volcanic-sedimentary. The most probable processes on the Venusian surface are processes of lava formation, weathering, wind erosion and deflation, and mechanical disintegration".

The photographs transmitted by *Venera* 9 and *Venera* 10 give us no information in this respect. They are, however, particularly interesting because they furnish a certain knowledge of the characteristics of the Venusian terrain-although limited to the relatively restricted zones visible to the camera lens. These photographs are much better than was expected considering the small amount of light which, in theory, might have filtered through the dense cloud curtain which characterizes the atmosphere of the planet.

The data supplied by these photographs took scientists quite by surprise. In fact B. Nepoklonov [2] stated that this information "makes us reconsider all our concepts of Venus".

The more easily interpreted of the two photographs at my disposal is the one transmitted by *Venera* 9 (Plate I, fig. 1) in which the ground surface is represented by a rock field containing rocky fragments of varying dimensions (12 to 16 inches across); some fragments are rounded, center right (A) and to the left (B), (C), others have sharp edges. A rounded rock clearly appears cracked (C). These rocks seem to rest upon a rugged surface which could be either sandy or detritic. This kind of terrain can be compared to two types of terrestrial terrains: 1) the surface of an Aa (blocky lava) type lava flow, or 2) the surface of a rocky desert.

A comparison to a type of lunar terrain may also be drawn: that type covered by a considerable amount of blocks and rocks forming a part of the ejecta blanket of certain craters. One should note, for example, the rocky surface shown in two photographs taken by *Surveyor VII* in the zone near the crater Tycho (Leonardi 1971, p. 61, figs. 2–46 and 2–48 (fig. 2)).

It is my opinion that one can safely exclude the first possibility. It is sufficient to compare the *Venera* 9 photograph with that of a lava field of the type mentioned above, reproduced in Plate II, fig. 2 [3]. The lavic fragments of the flows have a less flattened form than the Venusian ones. Furthermore, the lavic fragments tend to be piled up or heaped together whereas the Venusian rocks in question seem to constitute a single layer of rocks overlying the terrain.

Nor is the comparison to the rocky lunar surface in the above-mentioned photographs very convincing. Also in this case, the different shape of the rocky elements and their more chaotic disposition do not favor an analogy.

(2) Quoted in «Time» (Europe), 3 november 1975.
(3) E.M. TAYLOR, 1965, p. 135.

On the other hand, I feel that the surface of Venus compares very well to that of the *hammada* of the desert zones of the Sahara. Compare the photograph in question to the one reproduced in Plate I, fig. 2 which shows the surface of a *hammada* in the Libyan desert. In this case, one sees clear analogies: there are rounded rocks (A, B) and others with very sharp edges and they rest upon a sandy-detritic surface as was observed in the Venusian example.

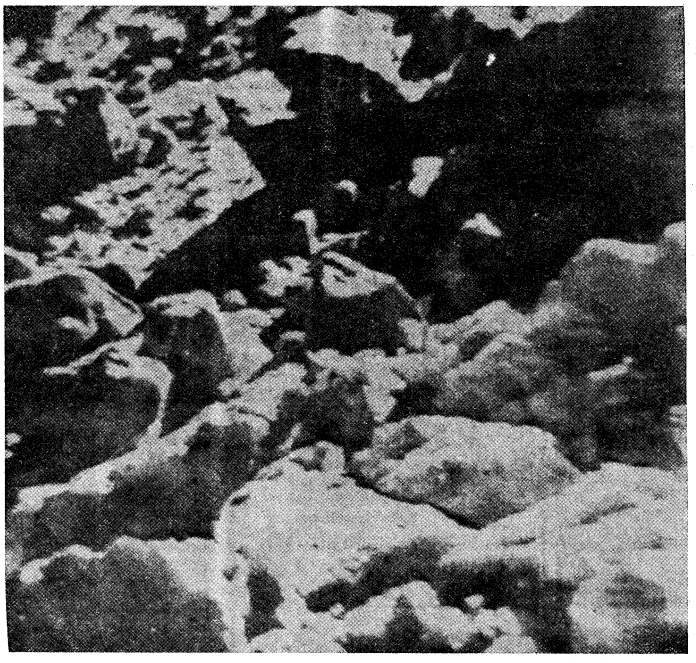

Fig. 2. – Lunar surface photographed by *Surveyor VII* in the zone surrounding the crater *Tycho*. (Courtesy of NASA).

The characteristics of the surface of Venus as revealed by the Soviet probes generated considerable surprise among planetologists, some of whom thought that, due to the constant wind and extremely high temperature—more than 400 °C at the surface—the rocks would be so weathered that Venus would have an almost smooth surface. Others thought, on the contrary, that because of the absence of liquid water on the surface of the planet, the constant temperature and the shield from solar wind provided by the densely clouded atmosphere, the weathering of Venusian rocks would be extremely limited.

As the evidence demonstrates, neither one nor the other concept was correct. In fact, the surface of Venus, at least as it appears in the two photographs of the Soviet probes, is not smooth at all, but rather rugged—a characteristic which had already shown up in the radar-obtained images. However among the rocky fragments, as has been stated, some have blunted edges and others are rounded (Plate I, fig. 1, left (B) (C) and right center (A)).

Perhaps the latter detail may be explained, in the absence of the majority of the natural erosive agents, by keeping in mind that the chemical composition of the Venusian atmosphere—the clouds are full of sulphuric acid—probably produces extremely corrosive precipitation. Nevertheless, it must be remembered that this process should have affected all rocks whereas some are rounded, but others in the immediate vicinity are quite clearly sharp-edged.

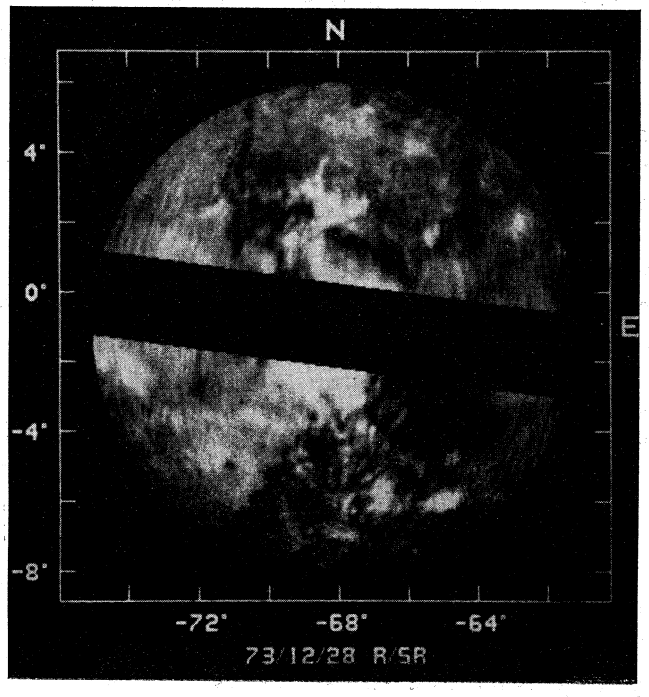

Fig. 3. – Another map of the planet Venus observed from Earth through the technique of radar. The mapping was done also by the Jet Propulsion Laboratory. (Courtesy of the *Jet Propulsion Laboratory*, Pasadena, USA).

It has also been pointed out [4] that the rounded stones visible in the photo transmitted by *Venera 9* have the classic shape that, in a desert environment, the stones acquire after undergoing weathering by sand-laden wind.

Sand does seem present around the Venusian stones in question, exactly analogous to the surface of the Libyan *hammada* which we reproduce in Plate I, fig. 2. The winds of Venus must be quite strong, given that the atmospheric formations move around the planet at a much greater velocity than the rotation of the planet itself [5]. This weathering agent should also apply to all rock fragments and not just some of them. The fact remains, as we stated, that this mixture of weathered and unweathered rocks may also

(4) E. DE ROSA, «Tempo», 1975, *45*, p. 57.
(5) *L'Astronomie, 88*, 1974, p. 193.

be observed in the terrestrial desert *hammada*, exactly as noted on the surface of Venus.

According to C Sagan [6], one must add the following to the causes of weathering of rocks materials: the high temperature could melt some of the constituents of the rocks, weakening their structure and thus accelerating their decay. The two probes *Venera 9* and *Venera 10* recorded temperatures of the surface of 485 °C and 465 °C, respectively [7].

In any case, B. Murray [8] rightly observes that the presence of the rock strewn scene is " highly significant because it means that something is active " on the surface of the planet and " that geological processes are going to expose new rock materials and clear away debris ".

Attention must be called to an extremely interesting detail in the photograph transmitted by *Venera 9*: one of the rounded stones is clearly fractured along a plane. This type of fracture suggests the existence of stratified and therefore sedimentary rocks on Venus (*lato sensu*: one could be dealing with volcanic tuffs such as those on the Moon [9]).

It can be noted that also in magmatic rocks, for example in certain granites and " quartziferous porphyries ", there are joints that could be mistaken as stratification planes.

According to some Authors (Katterfeld and Beneš, 1973, p. 289), if one remembers that the results of *Venera 8* " indicate in the place of landing 4 % K, 650 p.p.m. Th and 220 p.p.m. U, i.e. radioactivity near to the radioactivity of granitoid rocks ", this kind of rock could exist on Venus.

This is true, but it does not seem to me that granitoid rocks generally acquire such a flat shape after weathering as that of the Venusian rock in question.

One might rather be inclined to think of acid effusive rocks, the existence of which, at present, is not indicated on Venus.

The photograph transmitted by *Venera 10* (Plate II, fig. 1) shows a landscape which differs considerably from that photographed by *Venera 9*.

Only the left edge of the photo shows some analogies with the preceding one. In fact, here one also seems to observe a surface covered partially with sharp-edged rocks and partially with rounded ones.

But the remaining part, seems to correspond, rather than to a rock field of the *hammada* type, to an outcrop of sharp rocks with flat surfaces. At least it appears to be a zone in which there are no rocks of relatively small dimensions comparable to those of the other photograph. These are, instead, rock slabs of a much greater size.

(6) C. SAGAN in *Sky and Telescope*, December, 1975, p. 375.
(7) Veneras 9 and 10 on Venus, *Sky and Telescope*, December, 1975, p. 375.
(8) B. MURRAY, *ibidem*.
(9) P. LEONARDI, 1973.

Unfortunately, the poor focus of this photograph does not permit further comment.

In conclusion, we may say that the Soviet unmanned spacecraft, *Venera 9* and *Venera 10*, have shown us that, contrary to what certain authors believed, the atmosphere of Venus permits a sufficient amount of light to reach the surface of the planet for good photographs to be taken. Furthermore, the pressure and temperature at the surface reach extremely high levels. In the areas around the landing sites, the terrain predominantly presents the characteristics of a rocky desert with some analogies to the *hammada* of terrestrial deserts. Perhaps there are some outcrops of sharp-edged rocks with a flat surface, which might be stratified, as one rock broken along a plane (*Venera 9* photo) would seem to indicate. It is well to note that the genesis of a *hammada* is related to a level surface, the absence of running water and the existence of very high temperatures, environmental characteristics which could also be used to describe Venus.

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Fig. 1. – Photograph of the surface of Venus transmitted by the Soviet probe *Venera 9* on October 22, 1975. (Courtesy of the Soviet press agency «*Novosti*», Rome).

Fig. 2. – View of the surface of a Lybian "hammada". (From "Popoli e Missioni", March 1, 1970).

Fig. 1. – Photograph of the surface of Venus transmitted by the Soviet probe *Venera 10* on October 25, 1975. (Courtesy of the Soviet press agency "*Novosti*", Rome).

Fig. 2. – Surface of a "blocky" lava flow near the Belknap Crater in Oregon (U.S.A.). (From E.M. TAYLOR, 1965).