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PROVISIONAL TOPOGRAPHIC MAP OF MARS

Mariner 4 Region

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Prepared at
Research Center

July 1965

Supported by
NASA Grant NsG-142-61

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by

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This paper is an explanation of the accompanying provisional topographic map of the portion of the surface of Mars that the Mariner 4 is expected to photograph. Also included is a summary of the appearance and nature of the features according to my tentative interpretation from 37 years of telescopic aquaintance with the planet. This span has permitted observation of the equivalent of more than two full martian years of its seasonal changes. I have spent several hundred hours of actually looking at Mars through the eyepiece of effective telescopes.

The finest details are visible only by glimpses for a second or two during an extraordinary lull in the smearing effect of our atmosphere. The delicate features which are highly dependent on seasonal events and those which are governed by some peculiar secular development were visible to me for a total of less than one minute over my span of 37 years! When a magnification of several hundred diameters is employed, the apparent area of the martian disk is too great for a simultaneous surveillance. One must confine his gaze to some portion of the planet's disk and wait for the super-glimpses to come along, then shift his attention to another, and then another. From chance, it is likely that an observer will not have covered the disk with equal thoroughness. Also, he may spend too much time trying to get a better look at some feature that especially interests him. Even if every observer had the same skill in drawing, it is not surprising that their drawings made at the same hour should show some disagreement.

A similar situation exists in the observation of the moon. A number of lunar observers have specialized or confined most of their attention to a few local features or major craters over several decades. They have published maps of fine detail that few others have seen, and that have much more detail than the best photographs portray.

Unfortunately, the recording of fine detail in visual observations is subject to personal error in both perception and representation, depending on the competency and experience of the observer. In areas of congested detail, it is exceedingly difficult to be sure of the embochure position with connecting features. Often the quality of seeing is not uniform over an area as small as Mars.

On this map, the linear features are the so-called canals, which I think are the result of fracturing of the martian crust. I have seen most of these personally but never more than a few at one time. Some were visible to me only in certain years, no matter how diligently I looked for them. At rare times, a few of them exhibit the appearance of being broken into discontinuous streaks. Occasionally, some canals end in the middle of nowhere, failing to connect with any visible feature at the other end. This effect is confirmed on some of Slipher's best photographs (1962). Sometimes, there are temporary terminations, as I observed in the desert region just north of Sabaeus Sinus in 1939 and 1954 (TN-557-65-6).

I do not claim that this map is complete from the standpoint of telescopic detail, nor correct as regards the pattern and position of the markings. Indeed, there is some confusion in the areographic longitude and latitude by a few degrees. It was compiled for the purpose of being of possible aid in the interpretation of the Mariner 4 pictures.

The small, round features, called "oases", are probably impact craters from collisions with small asteroids. Their dark shade is probably due to some hardy form of vegetation taking advantage of the sheltering effect of the crater, or possibly the broken rock in the immediate environs. The canals appear to be related to the oases, often in radial patterns with some similarity to the Bright Ray Systems on the moon. The double canals particularly appear to run tangent to the edges of the oases, while others would intersect at their centers--much like the ray systems on the moon. The dark, round oases probably represent the major impact craters; whereas, smaller craters probably exist in considerable number and are too shallow to offer a haven to vegetation and are thus invisible in the best telescopic views.

The angular shapes of many of the maria suggest faulting and subsidence to form grabens. I have seen many canals running quite some distance across the deserts, exactly in line with the borders of the angular portions.

In consideration of the harsh physical conditions prevailing on Mars, it seems reasonable to interpret the maria as vegetative growth in low areas where the temperature is warmer and the atmosphere denser. Radiometric measurements indicate that the maria are appreciably warmer, which perhaps could be explained to difference in albedo alone; but altitude could be a factor.

From geological considerations, it is reasonable to expect that Mars would develop large basins in various portions of its crust. This may be accomplished either by monocline folding or by faulting. There are many examples of both having operated in the formation of basins on the Earth. Indeed, faulting has produced the drop in level at one place and down folding at another in the same basin.

If the bluish-green areas on Mars, called "maria", are regions covered with vegetation, then a sharply contained and fixed boundary would indicate a great difference in topographic level. Angularly shaped areas would be produced by faulting, such as the Trivium Charontis and the "Beak" of Mare Sirenum. In the later portion of summer in the southern hemisphere, as in 1958, the dark green color in the southern maria faded to greenish-grey and became much less dark. At that time, I saw several canals within Mare Sirenum and Mare Cimmerium. Some oases (dark spots) were seen also. Of particular interest were two dark stripes (or canals) outlining the "beak" with an included angle of 25 degrees of mare. These two stripes are exactly in line with canals proceeding to the martian east on the desert area of Thaumasia, and each ends at a small, round, dark oasis. The stronger one is named Araxes, intersecting Lucus Phoenicis. The latter is the center or origin of several other important canals in a radial pattern in all directions.

I think that the Lucus Phoenicis system represents one of the important asteroid impact points, and that the oasis itself is a large impact crater, revealed by the dark growth within.

It is known that plateaus tend to be colder than lower altitude lands. Exceptions to this occur at night when there are local temperature inversions. It may be inferred then that the deserts of Mars represent areas at a higher topographic level, and that they are colder than the maria. Meteorological phenomena provide criteria in differentiating the desert surface into several topographic levels. Particular desert areas have been observed to whiten at certain martian seasons, especially during late afternoon hours. When the region returns to the visible portion of the disk, the area is still white during the early morning hours, and the white gradually fades away as it approaches noon. This diurnal whitening cycle affects certain desert areas in high temperate latitude during the month of summer solstice. Progressively, local areas in lower latitudes are affected in this way as the summer season advances. Whitening on any one area continues over a period of many weeks and gradually subsides. Obviously, the diurnal behavior is dependent on solar insolation and temperature. The trend toward the equator as the season advances, appears to be associated with some sort of dispersion of water vapor, or some comparable substance, from the polar region. Kuiper (1948) has shown from his infrared reflection spectra that the white substance of the polar cap is very cold hoar frost. Evidently, the white areas which develop on the martian deserts are either hoar frost on the ground or cloud. In either case, the frost point or the dew point is involved.

Spectroscopic evidence shows that the martian atmosphere has very little water vapor content. Therefore, in order to reach the condensation point, or 100 per cent saturation, the temperature must fall very low. Even on Mars, this is not attained except on the higher areas of the martian desert. Generally, it is difficult to determine whether a white area is cloud or frost on the ground. If known small, permanent surface features can be recognized on the white, such as an oasis or a canal, then the white is probably frost on the ground. However, a very local effect on cloud is a possibility. Comparison of blue and red photographs help to establish the relative height in the martian atmosphere. If a white area is bright in red light and invisible in blue, then it is certainly on the ground or near the ground. Some white areas are bright on blue photographs and are invisible on the red, which would indicate cloud. If the latter persist in particular geographical localities, then an orogenic origin is involved. In general, the whiter and more persistent an area behaves, the higher the topographic level. However, some allowance must be made for prevailing wind wafting air masses with transpiration enrichment from supposed vegetative areas up on to plateaus, resulting in adiabatic condensation. A number of desert areas observed to whiten do lie to the martian westward and equatorward of dark areas, such as Aeria and Nix Tanaica, which lie west of Syrtis Major and Mare Acidalium, respectively. This tendency indicates a possible martian trade wind, and it is of interest that this effect is observed on areas in latitudes as high as 50 degrees. However, there are several areas on the immediate western side of maria which do not whiten. Also, the white areas nearly always avoid the maria, except in cases of general, translucent haze.

Therefore, this property of local whitening appears to be a useful criterion in differentiating the desert surface into several topographic levels. My studies of Mars over several decades have provided criteria for making a topographic breakdown into ten levels. The legend on the accompanying map illustrates the topographic level for various types of martian features. The contour lines on the map are designated with simple Arabic numbers. The lowest numbers are reserved for a few areas elsewhere on the planet that probably lie at the lowest levels, such as the Syrtis Major and Meridiani Sinus.

Where the borders of maria, or portions of a mare, are observed to migrate, it seems reasonable to conclude that the slope is gentle and the contour lines should be more widely spaced. Other borders appear rigidly fixed, such as the eastern beak of Mare Sirenum, the south border of Mare Cimmerium, the Trivium Charontis, etc. Since such areas become very dark at times, only a steep gradient in the land could contain the maria so sharply. Hence the contour lines are more numerous and crowded in those places. At times, the hexagonally shaped Elysium becomes as white as the polar cap and is sharply restricted in position which would indicate an abrupt plateau. That portion near the Trivium Charontis, known as Albor, seems to whiten with the slightest provocation. Since it lies within the martian tropics; has only a minor dark area near it; and is more prone to whitening than any other area in low latitudes, I consider it to be the highest land on the planet. Only this area bears the topographic level of 10.

The entire Elysium is white during martian July (northern hemisphere). It fades out near noon and then it starts to reform in the mid-afternoon. It becomes brilliantly white, equal to the polar cap in intensity as it approaches sunset. The white area has straight sides of nearly equal length in the shape of a regular pentagon if one excludes the short western edge of Trivium Charontis. If it is included, then the area is six-sided. The boundary of the foreshortened white polygon is sharply marked, with not the slightest whitishness visible on the surrounding desert. Only an abrupt plateau of considerable height could account for such a pronounced meteorological behavior. Hence, several contour lines are crowded together at the boundary of Elysium, representing a great escarpment. It is especially interesting to note that all the sides of the hexagon are exactly in line with canals that continue for hundreds of miles or kilometers across the neighboring desert. This certainly is a good case for faulting, and that beyond Elysium, the canals may be merely strips of shattered rock from crustal fracturing.

Another interesting property of Elysium is that during the season of whitening, it appears pinkish in color around noontime, in contrast to the orange-brown color of the surrounding desert. It appeared this way at the time of the Mariner 4 sweep.

Hellas, in the southern hemisphere, exhibits a similar whitening behavior in its season, and also it is pinkish to red when the area is free of white. If the white is frost on the ground, this slight wetting may have an appreciable mineralogical effect. However, the Hellas area is very round, and the surrounding maria encroach and recede. I have never seen any canals at or near its border. Tentatively, one may conclude that Hellas is a vast dome with gentle slope.

The general desert has been assigned at topographic level 5 to 6. This is the area where nothing seems to happen. Temporary whitening and also darkening are absent. Areas which exhibit slight whitening at times are designated as lying between contours 6 and 7. Areas which exhibit occasional, slight darkening lie between contours 4 and 5. Sometimes slight shading covers the strips of land lying between the components of double canals, such as the Gehon, Laestrygon, Phison, and Euphrates. Their fading out gives rise to the famous phenomenon of "gemination." Perhaps the doubles Gigas and Titan (on this map) should be included.

The Atlantis tract which separates Mare Sirenum from Mare Cimmerium varies from conspicuous size to obliteration. The martian southwest portion of Mare Sirenum varies greatly in degree of darkening and boundary, which may be interpreted as indicating a long, gentle slope in the land. Hence, the contours are widely spaced.

The double Titanis caret is very dark, and the angles approximate the direction of the double Gigas and Titan canals. Here again, faulting appears to have been involved.

The Laestrygon cuts the Mare Cimmerium in two. The canals seen embracing the Beak of Sirenum and south edge of Cimmerium have already been described.

One feature not portrayed on the map that perhaps should have been, is the dappling of Mare Sirenum and Mare Cimmerium with numerous darkish spots during moments of good seeing at the martian season when the internal canals are visible. They are too numerous to pin down in drawings. They are probably caused by shallow impact craters and do not require as great depth for vegetation to flourish within because they are in a low area mare. Such craters are probably just as numerous on the deserts but are prohibited from visibility because of inadequate sheltering for vegetational growth.

The Propontis is one of three principal maria in the north. (Only the south portion appears on the accompanying map.) Although it appears fairly dark and practically neutral in color during the spring season of the northern hemisphere, it fades out to a cluster of diffuse oases. It is probably less deep than Sirenum and Cimmerium by at least one contour level.

In my observing experience of Mars, the Trivium Charontis is the most constant in shape, size, and shade of any other marking on the planet. It should be given the highest priority rating for any geodetic reference.

The orbit of Mars is near the principal zone of the asteroids, and many asteroids of some size cross the martian orbit. Over the long periods of time, Mars should have been hit many times by large ones. The oasis--canal patterns appear to represent such scars. They should remain visible for hundreds of millions of years in the complete absence of water erosion and relatively ineffective ~~aelian~~ eolian action. Crustal readjustments due to internal convection cells in the mantle would cause horsts and grabens, and the crustal fracturing may be the cause of many angular features.

The idea or concept of great topographic differences on Mars seems not to have been entertained. Perhaps this oversight has been due to Lowell's concept of a peneplained planet. I am strongly of the opinion, after studying the features on Mars and their behavior over 37 years, that Mars never had any oceans, no water erosion, and no sedimentary rocks could ever have formed.

The Earth has great basins. If the water could be removed from the oceans, the atmosphere would flow into those great basins, leaving only very thin air over our present continents. As a consequence, the fertile great river systems, such as the Mississippi and Amazon, would be rendered as cold and barren as the Tibetan plateau. The oceanic slopes are fairly steep beyond the continental shelves, and life would probably be pretty much restricted to the basins.

I consider the maria of Mars to be great basins, comparable to our ocean basins, except that they are unfilled with water.

The irregular boundary of the polar cap at maximum, especially the southern one, is evidence of topographic differences. It reaches its lowest latitude on Hellas, and retreats poleward across Hellespontus.

Since the force of gravity on Mars is only 38 per cent of that on the Earth's surface, the atmospheric gradient should be 2 1/2 times less. Consequently, if other things are equal, one would have to ascend a vertical height 2 1/2 times greater to attain the same meteorological difference.

On Earth the ocean basins average 4 kilometers below sea level and the continents one kilometer above sea level. Extreme differences in the vertical between high mountains and oceanic trenches is 15 kilometers. The greatest thicknesses in the sedimentary rock column is also 15 kilometers, showing that the Earth's crust has heaved and sunk by this order of magnitude.

On Mars, the crust may be over twice as thick because of lesser gravitational pressure to produce flow. The martian crust should be able to sustain greater rock loads. Unfortunately, direct measurement of vertical relief is just barely beyond the capacity of ground-based telescopes. It should be remembered that the least foreshortening of the terminator occurs at about twice Mars' oppositional distance. Unlike the moon, there would be the effect of twilight to lessen the contrast of shadows. With these considerations, a topographic difference between Albor and the northern portion of Syrtis Major may be as much as 20 kilometers. Hence, the average contour interval may be about 2 kilometers.

The contours shown here should not be regarded as of equal vertical differences. They are boundaries only of appreciable differentiation criteria of two classes of phenomena: 1) degree of darkening, 2) intensity and frequency of whitening. These contours are subject to revision with more careful statistical analysis.
It will be of great interest to see what the Mariner 4 photographs

lend to this problem. If the latter tend to confirm such a model, I shall be encouraged to prepare a provisional topographic map for the entire surface of Mars.

Recently, I submitted a paper for publication, entitled, "The Absence of an Aqueous Morphology on Mars and Some Geologic Consequences" (TN-557-65-6) February 1965. One of the tentative conclusions of that paper is that the desert surface of Mars consists of a primeval rhyolite. The lack of water erosion would prevent the exposure of granitic and metamorphic rocks. Also, it follows that there would be relatively little basalt on the surface.

This work has been supported by the National Aeronautics and Space Administration under Grant NsG-142-61.

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