# Martian Water Stains or Dust Slides?

Research paper based on Efrain Palermo's seep study of Martian MOC images..

# A Study of Mars Global Surveyor (MGS) Mars Orbital Camera (MOC) Images Showing Probable Water Seepages. Are They Dust Slides as NASA Claims or Proof of Water on Mars?

By Efrain Palermo, Jill England and Harry Moore*

Mars geology has many mysteries. One of these are the mysterious curly streaks which baffled NASA geologists until they captured a dust devil in the act, leaving exposed dark trails in it's wake. Another mystery are large, dark 'stains' on Mars which emanate from a small point and fan out downward flowing over dust, dunes and small boulders. NASA's has labeled these features "dust slides" and consequently, every MOC image that has these features are ignored as just dust slides.
Our first impression of these phenomenon was that they were water related. Following are our observations and conclusions.

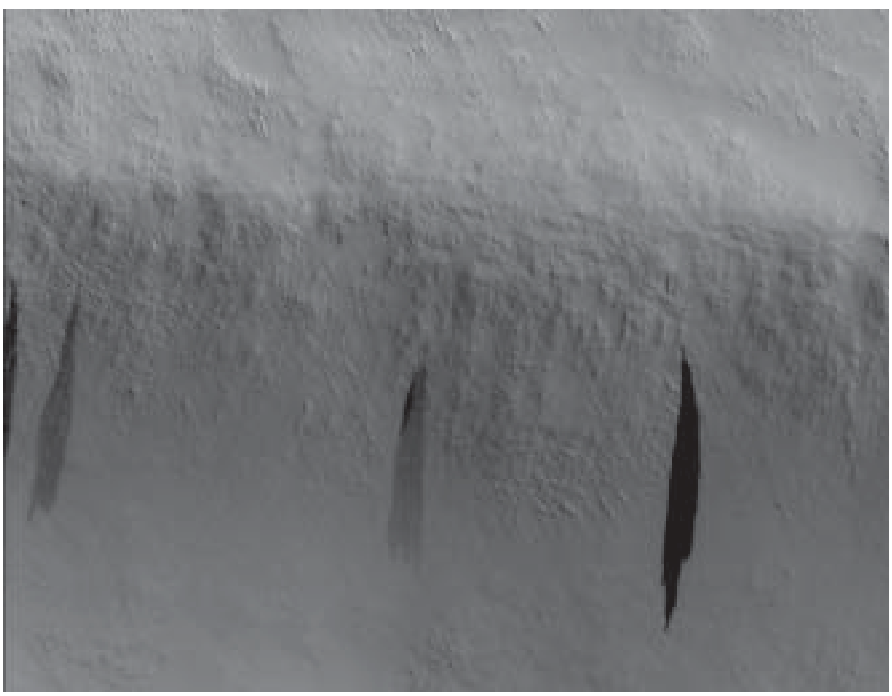

*Fig. 1. Mars Global Surveyor image showing a range of dark and light streaks which may be water seepages. (Note: These are grayscale images. The dark flows may be black, dark green or red)*

## Introduction

A dry Mars probably means a lifeless Mars if the almost universal view is correct that where there is no water, there is no life. The factors suggesting that Mars is dry, at least at its surface, are the extremely cold temperatures and low atmospheric pressure. So sure are some scientists that there can be no surface water on Mars that they have proposed slurries of rock and CO2 ice and gas as the agent that carved out the gullies and other unusual martian surface features that appear related to the flow of liquid water[1]. But most people, if viewing these images while unaware that they were of Mars and not of Earth, likely would, without hesitation, identify many of them as the result of flowing water.

This paper identifies and discusses evidence of yet another possible water related surface features recently disclosed by the NASA Mars Global Surveyor (MGS) images: features that appear to be seepage stains. An example of such a feature (which we will refer to as "seeps") is shown in Figure 1. We propose that these features have been created by the gradual seepage of liquid water and attempt to justify that conclusion here.

## Water vs. Dust

Geologists associated with the Mars Global Surveyor program have also noted these features. They have proposed that they are fluid-like slides of dust down the slopes on which they are seen to originate[2]. Though it is possible that dust movement may be involved in some of the streaking being examined, the dust model doesn't explain all of the pheno-menon that would be more associated with water than dry dust. Moreover, most of the surface features associated with the seepages indicate movement of a liquid fluid, most likely water.



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Establishing that the presence of water or water ice near the surface on Mars supports our hypothesis that the seep features are water related.

It is postulated and discussed by several workers that evidence exists for large amounts of water, water-ice, and carbon dioxide which may be stored in the near surface rocks and regolith on Mars[3]

It was disclosed by Carr (1981)[4] that water ice could exist at relatively shallow depths (a few tens of centimeters) at latitudes greater than 40 degrees. Frey (1979)[5] suggests that in the Cydonia region interaction of thin lava flows with near surface permafrost or ice may have produced explosions, which resulted in low mound features that correlate to similar features in Iceland.

In addition, Hodges and Moore (1979)[6] suggest in their study of the area around Olympus Mons that the interaction of magma with ice could have created vast meltwater lakes with frozen surfaces. Further, they suggest a former existence of more extensive glacial ice than has been measured or inferred.

More recently, Gilbert Levin and Ron Levin (1998)[7] have formulated a model that predicts the dinurnal presence of several tenths of a percent to several percent water moisture in the thin, top most layer of the surface material over large regions of Mars. They also postulate that if liquid water does form that it would pool in low areas.

William Hartman and Gilbert Esquerdo (1999)[8] identified surface craters on Mars, which may suggest processes of deformation involving ice on Mars. Their scenario suggests that early Mars had a very ice-rich permafrost layer and suggest a model for the formation of ice in surface craters. These craters, they point out, develop a pool of water, which then freezes and forms a flat floor in the crater. Wind blown dust then forms a thin cover over the ice layer.

The 1997 NASA Pathfinder's meteorological station on Mars revealed data that supports the concept of environmental conditions favorable for liquid water at or near the surface. Their data revealed air temperatures ranging up to 21 degrees C at the surface (Mars Pathfinder Mission Status, 1997).

It was also reported (Malin Space Science Systems, 1998)[9] that a crater in the Southern Hemisphere of Mars (located and photographed by the Mars Global Surveyor) probably once held water. It was suggested by Michael Malin and his research team that the Southern Hemisphere crater, which has channels in the walls and dark sediments on the floor, was probably carved by torrents of water that seeped into the crater forming a pool that evaporated eons ago.

In the course of our study, we have examined hundreds of images that show these seep-like features. After examining these images, several characteristics emerge that we believe point strongly to their creation by the flow of liquid water rather than dust or slurries of dust and gas.

These characteristics, which we will discuss here in detail include the following:

1. Point source of origins and other morphological characteristics.
2. Differences in coloration suggesting changes of their composition with age (some seeps are lighter in color than others and even lighter than the underlying terrain), with darker seeps invariably overlaying lighter ones;
3. The absence of indications of wind;
4. Geographical distribution of seeps.
5. Evidence of a recent origin for some, a few within the span of the MGS mission.
6. Relationship of seep images to other seemingly water-related surface features such as gullies.

## Discussion of the Evidence

### 1. Point Source of Origin and Other Morphological Characteristics

It is evident in most images that the seepage features flow out from a very small point, as illustrated by the image of Fig-

**Fig. 2.** *Image of one of the many examples of a point source seepage fanning out down slope.*

ure 2. The seeps tend to fan out from these point sources in the down-slope direction.

It appears difficult to explain how a mass of dust sufficient to cover the large areas occupied by a typical seep feature could originate from a virtual point. A subsurface supply of fluid escaping from a small orifice in the surface seems more plausible.

The long flow in Figure 3 is approximately 6500 feet long showing a uniformity of coloration in these flow images from source point down to its termination points.

Dust slides or slurries, no matter how fluid-like their properties, would in general be expected to show some gradation in color over their length because the layer of slide material would be thinner near the end than it is near the source of the slide. This is never the case for these seep features, however.

Some images also show the dendritic tributary patterns of these flows and flow over landforms.

Disturbances in dust layers can persist on level surfaces, as, for example, the tracks left by the dust devil in Figure 4, which has exposed darker substrata. But a large number of the seeps are on steep cliff faces. Other examples of presumed dust devil tracks on level surfaces are shown in Figure 5. On inclined surfaces, the angle of repose would not allow for the darker material to remain in place. Barring some fairly strong tendency to adhere to the underlying terrain. It is not

**Fig. 3.** *An image showing a long flow down branching and flowing over rougher terrain.*

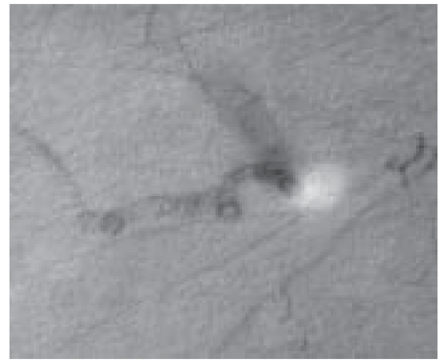

**Fig. 4.** *A dust devil caught in the act, leaving trails of exposed, darker substrata.*

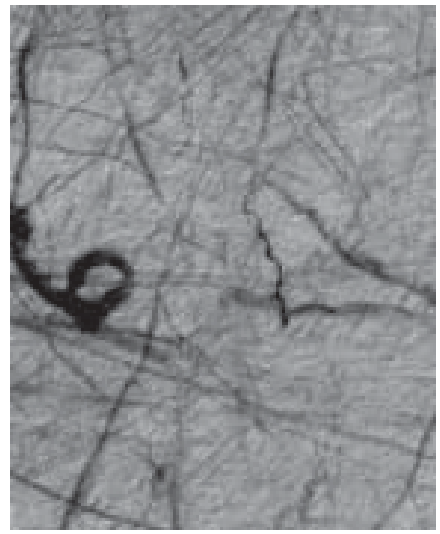

*Fig.5. Level, surface streaks. Presumably caused by dust devil activity.*

clear how dust could flow in a virtually frictionless manner and yet show such a tendency to adhere to inclined surfaces when at rest.

### 2. Shading Variations

While each seep feature appears to be uniform in color, the difference in shading from one feature to another can be considerable. Because these are gray-scale image, their actual colors are, of course unknown. The color information on future missions to Mars could be of considerable value.)

 

The fresher seeps are evidently the darker flows because wherever darker and lighter flows overlap, the darker flows invariably overlay the lighter. The lighter coloration might be attributable to salts and minerals originally in solution with the seeping fluid and deposited on the surface as the liquid evaporated. Another possibility is that the flowing liquid has caused a chemical or mechanical change in the surface material itself.

Figures 6, 6a and 7 show flows with different coloration.

The explanation given by the MGS geologists of these dark streaks is that: “This movement [of material down slopes] disrupts the bright dust coating on the surface and thus appears darker than the surrounding terrain”[10] This account does not explain an important characteristic of these features: some of them are lighter than the surrounding unstreaked terrain, as can be seen in Fig. 6. This tends to rule out lighter-colored dust settling out of the atmosphere as the cause of the lightening of the streaks. Since dust would be unlikely to settle on the streaks in preference to the unstreaked terrain, the streaks should never be lighter than the adjacent terrain (see figure 6) as both areas become covered with dust. Since it would be unlikely that dry material falling down a slope would react in any way with the underlying terrain, some form of liquid seems the only plausible explanation for the lighter than background streaks.

*Fig. 6, 6a. Images showing light streaking patterns. This is contrary to NASA’s dark dust streaking theory.*

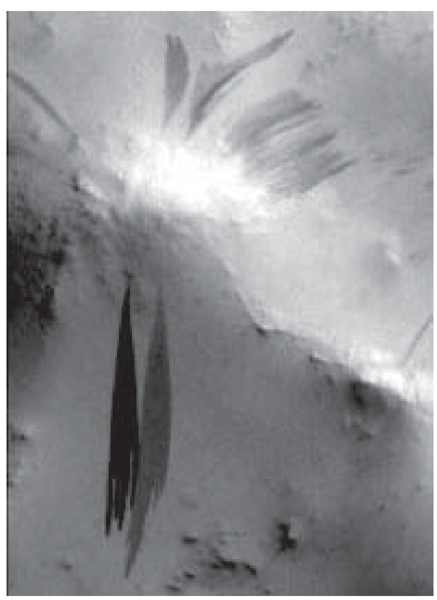

*Fig. 7. This image shows two streaks of different shades emanating from the same plane. Why would a dust flow be darker or lighter next to each other?*

The fact that some of these streaks are lighter than the underlying ground is what is most important about the color differences. If the streaks were always darker than the surrounding terrain, it would not be very remarkable since dark surfaces would become lighter as they are covered by lighter colored dust. A covering of light-colored dust, however, cannot render dark surfaces lighter than the dust layer itself. The color differences would hardly be worth mentioning, except in passing.

Is it possible that wind could have caused these streaks? One of the images showing radial streaks on a butte (figure 8) would seem to refute a wind theory. Wind would not likely evenly streak all sides of a round butte.

*Fig. 8. A rounded knob with radial flow streaks.*

### 3. Wind Erosion

The winds on Mars are generally recognized as a major influence on its surface geology. In talking about the Mariner 9’s first images, Eric Burgess stated ...”*Photographs showed wind erosion on a broad scale over the whole of the Martian* *surface*".[11] Mars exhibits many features created by wind action, i.e., dunes and yardangs. Huge dust storms have been observed on the planet (one as recently as July, 2001[12]) and as we previously noted, dust devils have been photographed by the MGS spacecraft. If the seep features are flows of extremely fine dust, they should be easily disturbed by wind activity. Yet no images of the seeps show any sign of wind erosion or streaking.

However, there are many images of dark streaks caused by wind activity around some craters and dark spots (Figure 9). Why are the effects of wind erosion absent from these features?

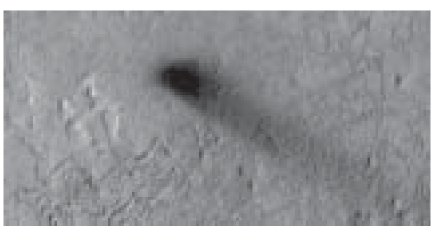

*Fig. 9. An example of wind streaking a dark spot. This wind streaking activity is absent from all the seepage flows.*

A possible explanation is that a mixture of liquid water (or some other fluid) would permeate and stain the surface layer with the residue of the dissolved solids. Such stains would be resistant to obliteration by the wind.

## 4- Geographical Distribution of Seeps

To further understand the character of these seepage flow features, Mr. Palermo (at the suggestion of Richard C.

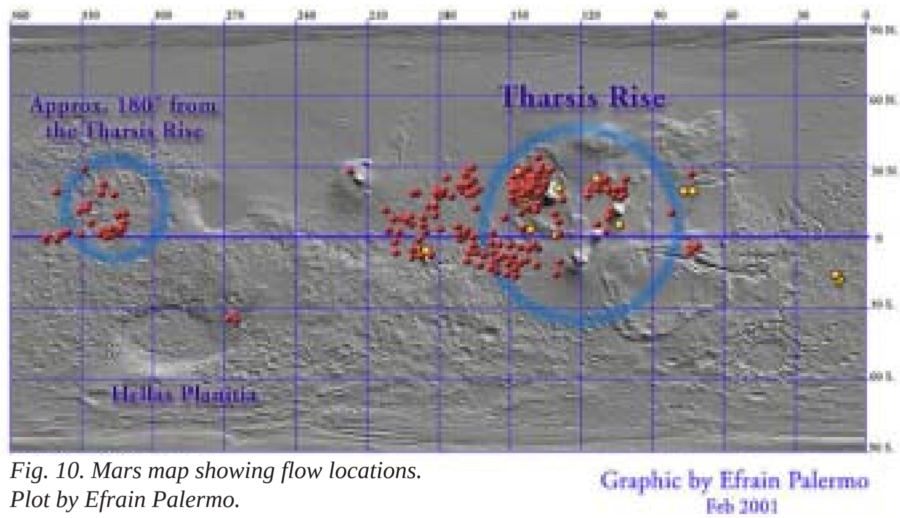


*Fig. 10. Mars map showing flow locations. Plot by Efrain Palermo.*

Hoagland[13]) created a plot of the seep locations on a Mars map (Figure 11) to see if there was any kind of relationship. The most striking characteristic of their distribution is that they lie mostly below 30 degrees North Latitude and above 30 degrees South Latitude, the equatorial zone of Mars. There have been a few seeps observed above these latitudes but *none* have been found more than 40 degrees from the equator.

Another observation that came from the mapping of these seep features was that the flows are clustered around two main areas on Mars, approximately 180 degrees apart. One was clustered on the northwestern edge of the Tharsis Rise, around Olympus Mons. The other cluster was northwest of the Hellas Basin. NASA released a statement that the Tharsis Bulge may have been responsible for past water activity on Mars, water intermixed with lava[14] (Figure 11). There may be some relationship between the location of these flow features and the Tharsis Rise. The area 180 degrees away may be the result of the impact to the Hellas Basin, which created a bulge on the other side of the planet with subsequent upwelling of water rich magma.

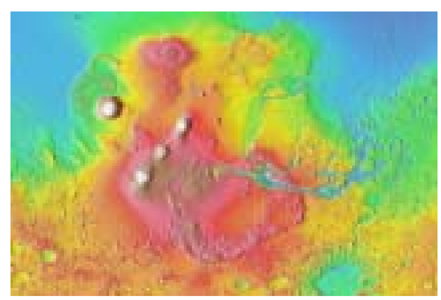

*Fig. 11. The topography of the Tharsis province. The analysis described here shows how the formation of this massive volcanic rise may have affected the early climate and flow of water on the Martian surface[15]. (Image Credit: MOLA Science Team)*

## 5. Evidence of the Seeps Being Created in Present Time

One of the major goals of our study was to find re-imaged stain areas to determine if any of them changed with time. Jill England created a software program[16] that enabled us to do this. The program searches NASA's image database and looks for areas that have been imaged more than once.

Using England's program, we found an additional image of an area previously found to contain seep features.

The images, FHA/01100 and MO4/01228 were taken 150 days apart. (See figure 12) Three new flow features are clearly visible that were created in the 150 days of elapsed time. Existing flow features in the images remained unchanged.

Subsequently, the entire MOC image database was compared to known "flow" images and several additional overlapping images were found. Only one other image contained new flow features, a crater in images AB-1-113/04 and MO9/04872, elapsed time 655 days. In the rest of the overlapping images, all flows remained unchanged. No other images had as great of an elapsed time as the two pairs discussed above.

The two multiply imaged areas that did show changes, however, conclusively demonstrate that the flows are presently occurring geological processes and are relatively long lived in that they do not fade quickly, persisting for possibly many years once they are formed.

A proposed indirect method of showing that the flow features are recent events was to compare the images against the times of the Martian year. This analysis was performed and no correlation was found between flow images and Martian seasons. This is an expected result as the overlapping images have demonstrated that flow features persist unchanged for longer than one Martian year.

The quantitative differences between images of flows were also analyzed. In order that the images can be compared, the flows were counted in each image and separated into light and dark flow groups. Flows near erosion features such as gullies were also noted. From this the number of flows (seeps) per kilometer can be calculated and plotted on a map. In addition, areas where gullies are near flow features can also be shown geographically.

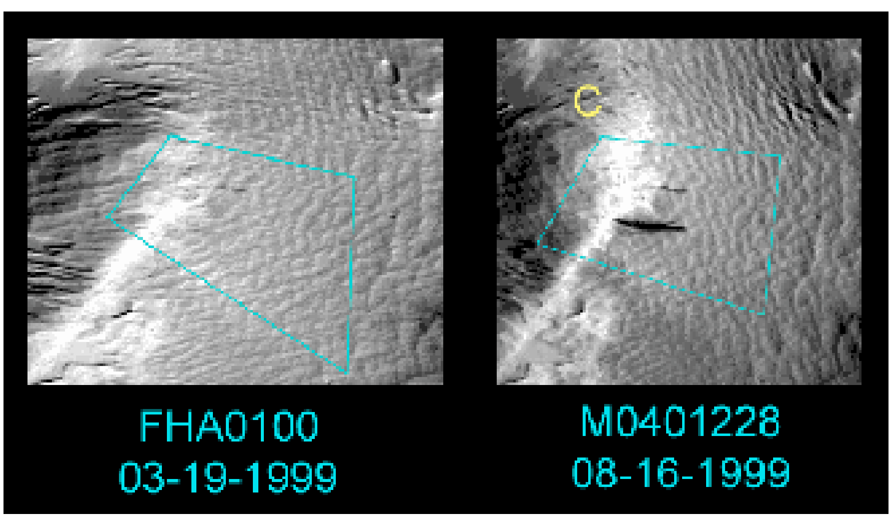


*Fig.12. Two images taken 150 days apart shows that flows are occurring on Mars in present time. Image courtesy Jill England.*

**6 - Relationship of Seep Features to Other Water Related Images.**

The evidence for recent water activity on Mars is described in a paper by MGS/ MOC scientists.[17] On the MGS web site there are numerous images of gullies apparently caused by water erosion. As stated in their paper... "Gullies seen on Martian cliffs and crater walls in a small number of high resolution images from the Mars Global Surveyor (MGS) Mars Orbiter Camera (MOC) suggest that liquid water has seeped onto the surface in the geologically recent past. The gully landforms are usually found on slopes facing away from mid-day sunlight, and most occur between latitudes 30 degrees and 70 degrees in both Martian hemispheres.

The relationship to sunlight and latitude may indicate that ice plays a role in protecting the liquid water from evaporation until enough pressure builds for it to be released catastrophically down a slope. The authors observe that the relative freshness of these features suggests that some of them are still active today — meaning that liquid water may presently exist in some areas at depths of less than 500 meters (1640 feet) beneath the surface of Mars".

There were no NASA gully images that had any seep activity associated with them, unlike one image we found (Fig. 13), which show a definite dark flow staining a gully structure.

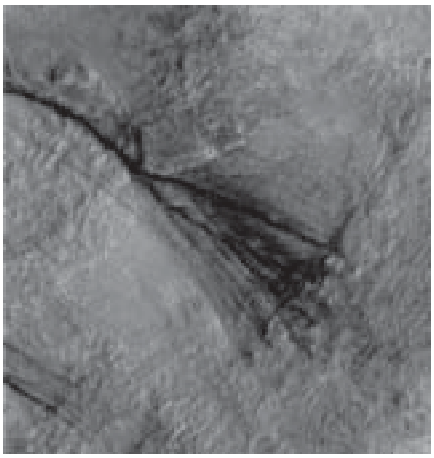

*Fig. 13. A stained gully located at Latitude -34.02 ° Longitude 267.93.*

The other differences between NASA's gully images and the stain flow images are that the flows are A) found mostly below 30 degrees north and above 30 degrees south , and B) found facing all directions of the compass. Some were found to be flowing down all sides of buttes and knobs regardless of sun direction (Fig. 8).

It is interesting that, moving from the poles to the equator, the gullies discussed by the MOC team begin to disappear at about the same latitudes where the observed seepage features commence.
There does, however, seem to be some overlap in the distributions of gullies and seepages, however. There are at least 12 images in our study that show gullies at the base of hills where flows occur. Notable among these are images M0306266, M0901048, and M0807897 that clearly show typical water erosion features downstream of the flow features.

The two types of features may, therefore, be different expressions of the same subsurface process under differing climatic conditions. More violent releases of water when ice plugs give way may be more prevalent at colder latitudes and more gradual release may be more prevalent at more equatorial latitudes. If water is found to be associated with both the stained flows toward the equator and gullies nearer the poles, then the abundance and availability of water on Mars may be considerably greater than has been believed previously.

**Terrestrial Analogs**

In our efforts to study these apparent water seepage features our team located a somewhat comparable water seep here on Earth. The photograph of figure 14 shows a hillside among the weathered hills of East Tennessee. The surface vegetation and topsoil had been removed by construction excavation exposing the underlying clay. The ground water in that hillside was slowly seeping out of the soil, forming dark patches in some ways similar to the features in the MGS/ MOC images.

It is acknowledged that the soils in the East Tennessee example are composed of clay are probably unlike those soils in the Mars landscape, which appear to be granular. Seepage of water down slope out of clay soils would tend to spread

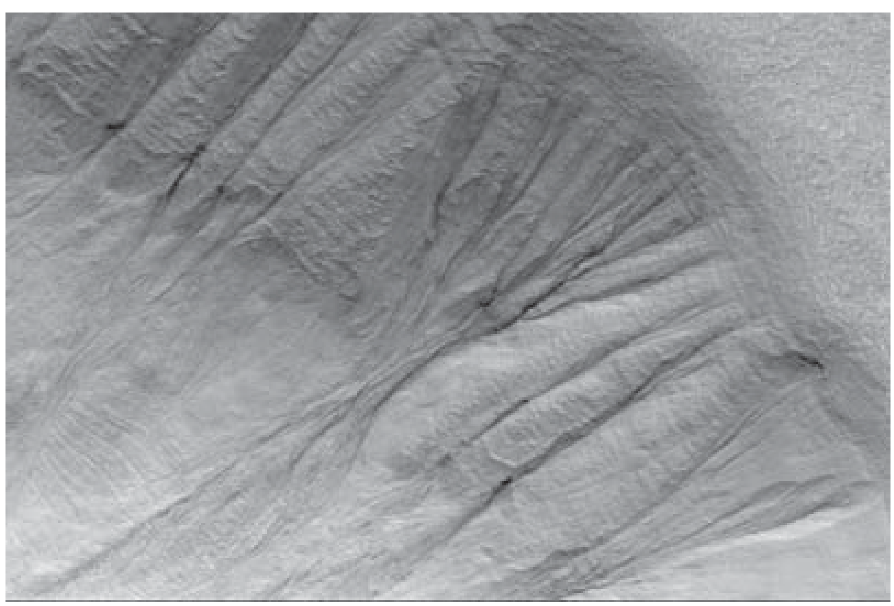

*Fig. 13a. An example of a Martian gully.*

out laterally as well as moving down slope due to capillary action while in granular soils the seeps would tend to be long and narrow. However, the point is that groundwater will tend to seep out of a hillside if there is groundwater present in the subsurface (soil or rock).

The black and white version of the East Tennessee seep feature of Figure 15 more clearly shows the resemblance to the Martian seep features in the gray scale MOC images examined in our study. We present this comparison to illustrate the parallel of the surface seep characteristics to their possible origin being water.

## Conclusions

When examined in detail individually and as a group it appears that the seep features have far more characteristics associated with liquid flows than with flows of dry dust or slurries. The equatorial location of the seepages, clustering in the Tharsis region (and 180 degrees away north of the Hellas Basin) plus physical flow attributes, indicate that water (or possibly some other liquid) may be involved in their genesis. As we have demonstrated, these features are currently being formed on the Martian surface. These circumstances together imply that it is highly likely that water is now present on the surface of Mars.

The surface pressures over large areas of the martian surface are, on average, slightly above the triple point pressure of water. Salts dissolved in water can lower its freezing point substantially. Liquid surface water on Mars has thus always been a possibility. We think the evidence we have presented here strongly suggests that it is also a strong probability.

We suggest that NASA and other scientific bodies devote some of their resources to a more in-depth evaluation of these features and their obvious implications for a sustainable human presence on Mars in the future if they are, in fact, the product of water flows.

*Fig. 14. A terrestrial model, exposed hillside in Tennessee. Image courtesy Harry Moore.*

*Fig. 15. Grayscale image to compare with MOC grayscale images. Courtesy Harry Moore.*

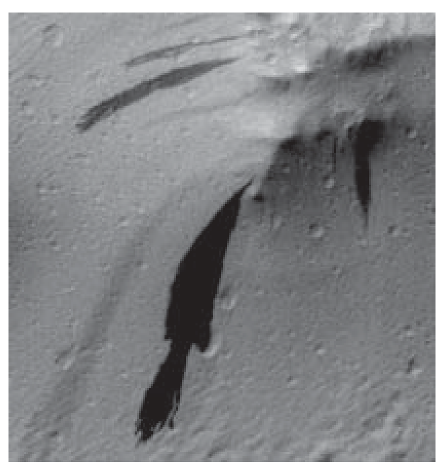

*Fig. 16. This image shows a dark seepage.*

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Figure 3. m0807686b
Figure 4. m1001267b
Figure 5. m1200346b
Figure 6. m1501358d
Figure 6a. m1501358e
Figure 7. m1100071a
Figure 8. m1201857b
Figure 9. m0300471d
Figure 12. fha0100 and m0401228
Figure13. m1100517d
Figure 13a. m0902875d
Figure 16. m1501460
Figure 17. m0204672a

All Mars images are courtesy of Malin Space Science Systems (MSSS).

Additional Martian stains, information and theories can be found on the Efrain Palermo Martian Stains web site:
http://home.attbi.com/~palermo63/Mars_Anomalies

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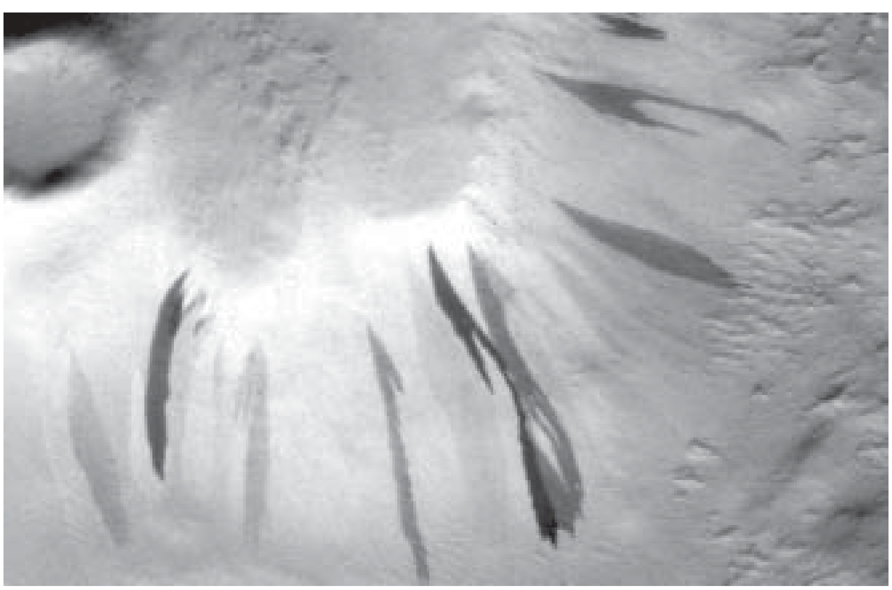

*Fig. 17. Image showing light and dark streaks side by side and overlapping each other.*