Papers & Presentations

Report of a Probable Comet Impact on Mars in 1973

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Abstract

Evidence is presented that a comet consisting of large amounts of ice probably impacted Mars on September 2, 1973. Four members of the McDonnell Douglas Amateur Astronomers Club observed the aftermath of the proposed comet impact. Descriptions of visual telescopic observations are given beginning with two very large side-by-side circular white clouds. Black-and-white images of the clouds are shown that were recorded over a period of 2 hours and 52 minutes, including one beginning at 07:50 UT, then one at 08:21 UT and the last at 10:42 UT. During this period, the clouds began to merge and finally did merge into one large cloud. Mariner 9 maps of the Corprates quadrangle were compared with the Viking map, providing before-and-after impact evidence. Six new craters were found in a cluster with diameters ranging in size from 4.2 km to 10.0 km. The September 2 clouds are compared against seven categories of Martian clouds - limb/ terminator hazes, equatorial cloud bands, discrete clouds, orographic clouds, polar clouds and hazes, frosts and fogs, and dust clouds - and are explained as being inconsistent with any of these cloud types.

Instruments and Methods

The McDonnell Douglas Amateur Astronomers Club sponsored a Mars photo patrol in 1973 with five of the 15 members participating. The club bought a 100-foot roll of Kodak 35mm SO-410 black-and-white negative film. It was described in Kodak's literature as a panchromatic film having a very fine grain with an extended red sensitivity (Eastman Kodak Company, 1972). The red sensitivity allowed the recording of surface details on Mars much as a red filter would. The film was loaded into 36-exposure, 35mm film canisters and distributed to members who wanted to image Mars.

As part of this "Mars Patrol," four members observed and imaged Mars during the wee hours of the morning on September 2, 1973. In St. Louis, Missouri, the author and Rick Melvin used an 8 inch Newtonian telescope and George Fiedler used a 6 inch Newtonian telescope, while in Las Cruces, New Mexico, Lionel Brown used a 12.5 inch Cassegrain telescope. Each imager used eyepiece projection with 35mm single lens reflex camera bodies to record the images.

In his well-equipped dark room, Rick Melvin printed about 25 of the images that were obtained by members during this photographic patrol. The author digitized the September 2 and the October 2 photograph prints, making it easy to stretch contrast and to create negative images. The contrast of all of the images was stretched to better show the clouds and surface markings. The software application *WinJUPOS* (Hahn, 2019) was used to measure the latitudes, longitudes and sizes of the clouds.

The author recently found a set of global USGS photomosaic maps based on images recorded by Mariner 9 while it orbited Mars in 1971 and 1972, more than a full year before our photographic patrol. *Figure 1* shows the front cover of this set of maps. The United States Geological Survey (USGS) group divided the surface of Mars into 30 cartographic quadrangles. Each quadrangle is a region covering a specified range of latitudes and longitudes on the Martian surface. The names of large classical albedo features were given to the quadrangles. A list of the quadrangles, together with up-to-date geologic images of them, is available online (Wikipedia, 2019). The Viking Orbiter map, compiled from images made in 1975 and 1976, is available in resolution of 2.5 km per pixel (Planetary Society, 2014) and in 232 m per pixel (US Geological Survey).

The author's finding of the Mariner 9 maps sparked him to publish a report because "before and after" maps are now

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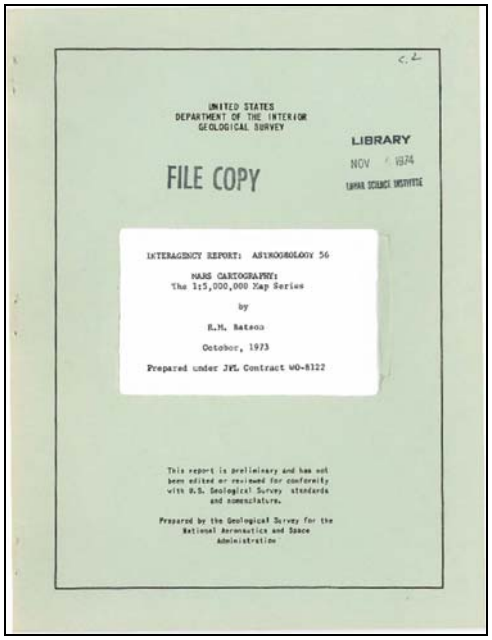
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INTERAGENCY REPORT: ASTROGEOLOGY 56

MARS CARTOGRAPHY:
The 1:5,000,000 Map Series

by

R.M. Batson

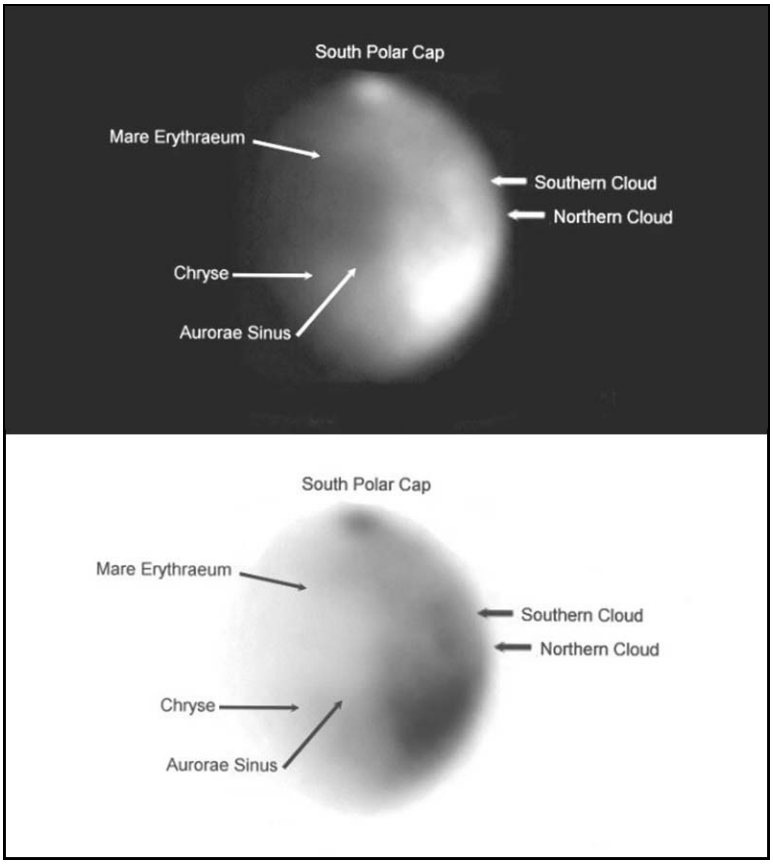
October, 1973

Prepared under JPL Contract NO-8122

This report is preliminary and has not been edited or reviewed for conformity with U.S. Geological Survey standards and nomenclature.

Prepared by the Geological Survey for the National Aeronautics and Space Administration

Figure 1. Cover of the Mars Cartography document that contains the 1971 and 1972 Mariner 9 images (Batson, 1973).



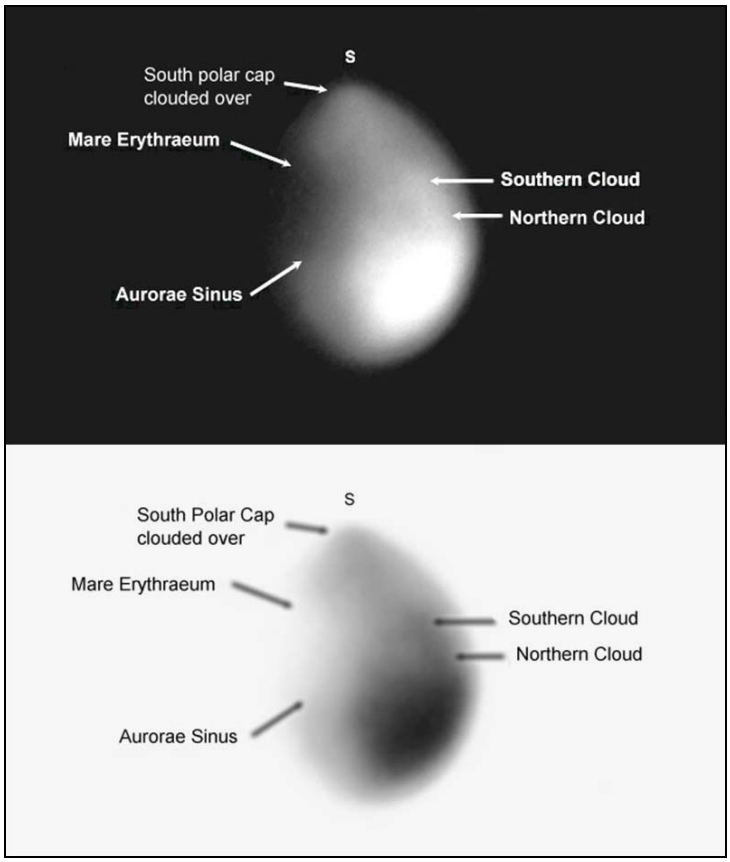


Figure 2 (above left). The first image of the peculiar clouds. Digitally scanned positive and negative reproductions of a grayscale photograph of Mars made by Jim Melka and Rick Melvin, observing from St. Louis, MO, USA, on September 2, 1973, at 07:50 UT. Newtonian telescope of 8-inch aperture, 35 mm single lens reflex camera, using Kodak SO-410 film. Mars was at Ls 274°. The apparent angular diameter was 16.8 seconds of arc, the phase 0.90, and the central meridian 49.2° west longitude. South is up.
Figure 3 (above right). Digitally scanned positive and negative reproductions of a grayscale photograph of Mars made by George Fiedler, observing from St. Louis, MO, USA, on September 2, 1973, at 08:21 UT. Newtonian telescope of 6-inch aperture, 35 mm single lens reflex camera, using Kodak SO-410 film. Mars was at Ls 274°. The apparent diameter was 16.8 seconds of arc, the phase 0.90, and the central meridian 56.7° west longitude. South is up.

available. He compared the Mariner 9 maps with the same quadrangles produced from images recorded by the Viking orbiter in 1976, searching for craters that are present in the 1976 images but absent in the 1971-1972 images. The relevant quadrangles in each map set are Mars Chart (MC) 17 Phoenicis Lacus, MC 18 Corprates and MC 25 Thaumasia.

Table 1. Cloud Locations and Sizes

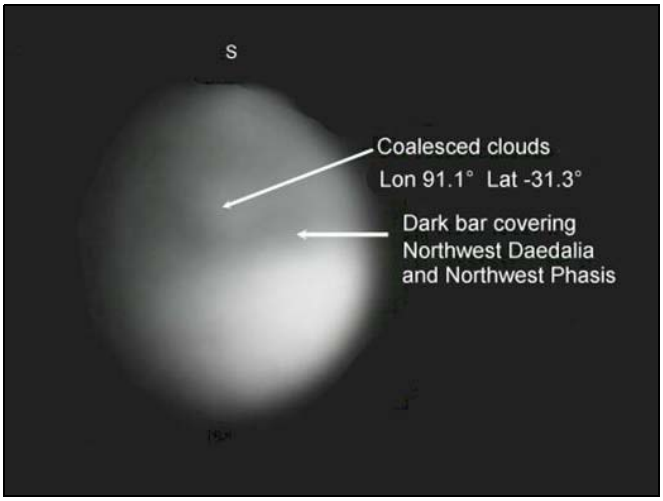
	Northern cloud	Southern cloud
Latitude	- 21.6°	- 31.9°
Longitude W	95.0°	90.9°
Initial diameter	692 km	608 km

The sizes of new craters were measured using the software tool *JMARS* (Christensen, et al, 2009). *JMARS* stands for "Java Mission-planning and Analysis for Remote Sensing". It is a geospatial information system (GIS) developed by Arizona State University's Mars Space Flight Facility to provide mission planning and data-analysis tools for NASA's orbiters.

Results, Part 1: The Images

The Martian longitude of the Sun (Ls) at the time of these observations was 274°. The author and Rick Melvin imaged Mars on Sept. 2, 1973, at 7:50 UT. The image is shown in the top panel of *Figure 2*. The bottom panel of *Figure 2* is a negative of the top panel, and both show clearly the two clouds. These images show only the cores of the clouds because of the extended red sensitivity of SO-410. However, the location of the center of each core could be measured. These measurements are presented in *Table 1*. Melka and Melvin also observed the clouds visually and noted that they appeared as bright as the South Polar Cap (SPC), with their perimeters just touching.

George Fiedler imaged Mars on September 2, 1973, at 08:21 UT, which was 31 minutes after the image in *Figure 2*. The two clouds are shown as a positive image in the top panel of *Figure 3*, but perhaps are seen better in the negative of his image, in the bottom



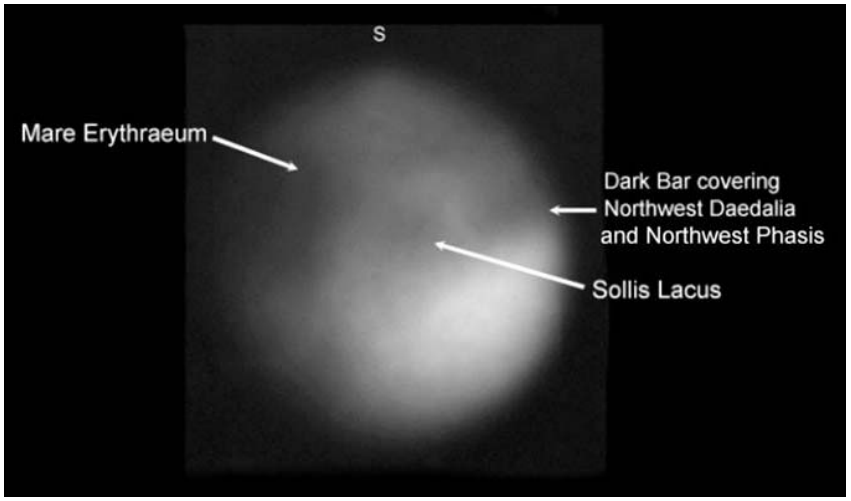


Figure 4 (above left). Digitally scanned positive reproduction of a grayscale photograph of Mars made by Lionell Brown, observing from Las Cruces, NM, USA, on Sept. 2, 1973, at 10:42 UT. Cassegrain telescope of 12.5-inch aperture, 35 mm single lens reflex camera, using Kodak SO-410 film. Mars was at Ls 274°. The apparent angular diameter was 16.8 seconds of arc, the phase 0.90, and the central meridian 91.1° west longitude. South is up.

Figure 5 (above right). The usual appearance of this area of Mars using the same equipment as for Figure 2. Digitally scanned positive reproduction of a grayscale photograph of Mars made by Jim Melka and Rick Melvin, observing from St. Louis, MO, USA, on October 2, 1973, at 03:30 UT. Newtonian telescope of 8-inch aperture, 35 mm single lens reflex camera, using Kodak SO-410 film. Mars was at Ls 293°. The apparent angular diameter was 20.7 seconds of arc, the phase 0.97, and the central meridian 71.6° west longitude. South is up.

panel of that figure. In comparison with *Figure 2*, the two clouds look to be merging in *Figure 3*.

Fiedler's image does not show the SPC. Therefore, the author proposes that airborne dust was by this time propelled all the way to the SPC. Since there is no evidence of dust to the north of the clouds, it is thought that the comet was moving in a southerly direction through the atmosphere. The dark markings west of Mare Erythraeum including Solis Lacus are not visible. It is suspected that a shock wave from the impact produced dust clouds covering the entire impact region.

On the same date, Lionel Brown imaged Mars at 10:42 UT, two hours and 52 minutes after the photo in *Figure 2*. His image is presented in *Figure 4*. The two clouds appear to have merged into one cloud covering most of Solis Lacus. The dark bar in northwestern Daedalia and northwestern Phasis is now visible.

For the purpose of this article, it is useful to be familiar with the usual appearance of Mars in images made by amateur photographic equipment of that day. Therefore, the author has included as *Figure 5* an image taken a month later, on October 3, 1973, which illustrates the usual appearance of the Solis Lacus vicinity as imaged by the same imagers and using the same equipment as in *Figure 2*. The dark feature called Solis Lacus is prominent, though it was hidden by the clouds on September 2.

The ratio of the diameter of the northern cloud to that of the southern cloud was estimated to be 1:2 from the images of the clouds. To map the clouds, they were

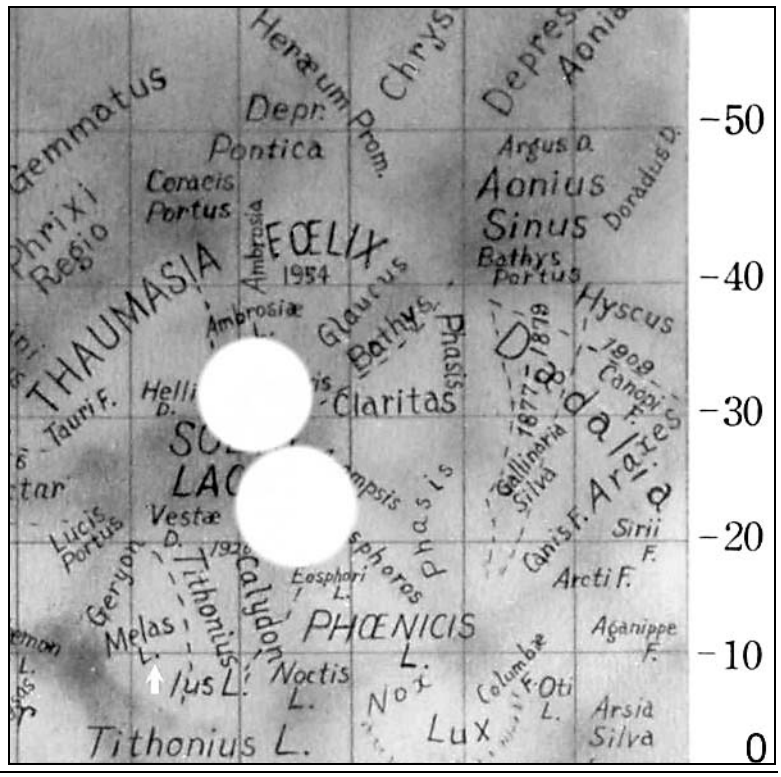
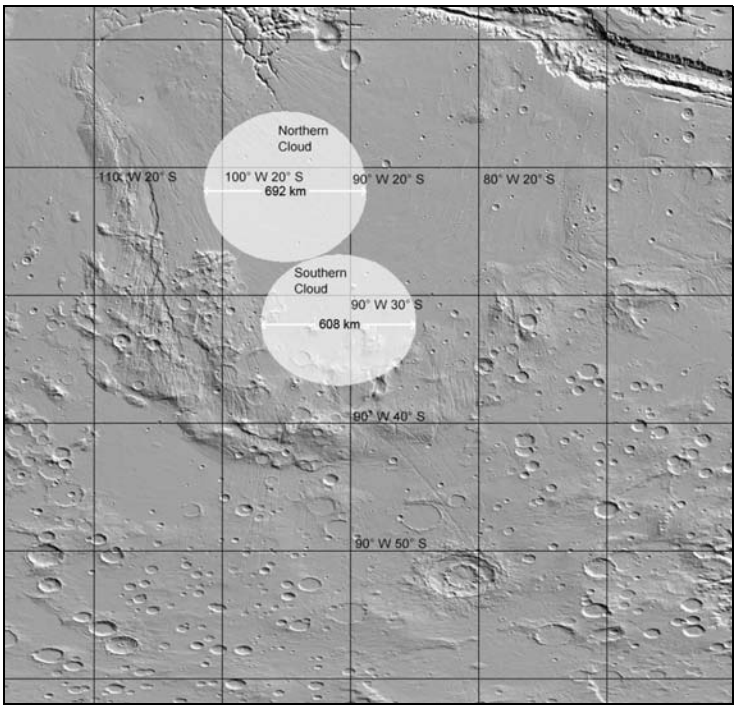


Figure 6. Shiro Ebisawa's 1957 albedo map with the clouds of September 3, 1973, superimposed. South is up and the latitude scale on the right is in degrees.



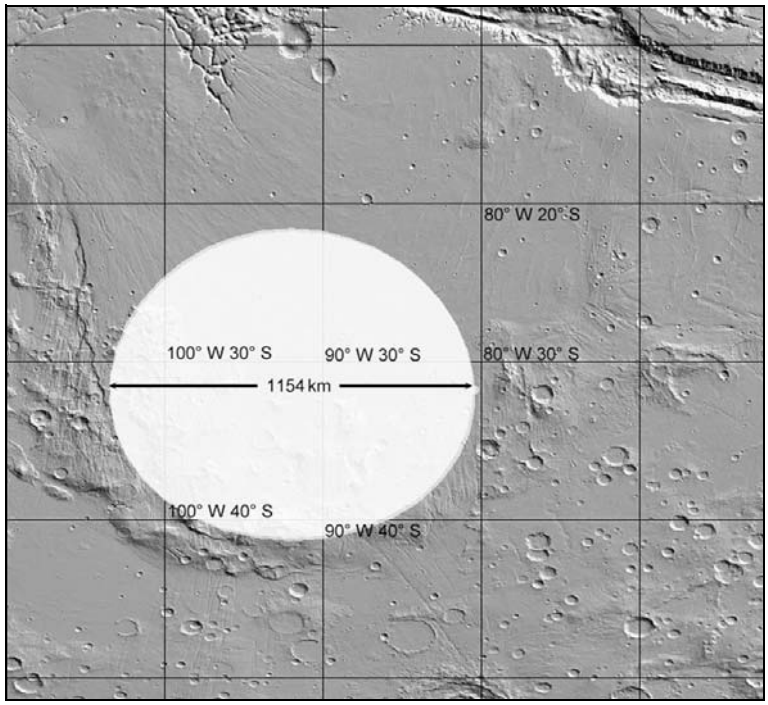


Figure 7 (above left). The positions and extents of the clouds superimposed on the MGS elevation map made from MOLA data. North is up, unlike the preceding images and diagrams of this article. This view includes parts of Mars quadrangles Coprates, Phoenicis Lacus, and Thaumasia.

Figure 8 (above right). The position and extent of the cloud at 10:52 UT, 1973, superimposed on the MGS elevation map made from MOLA data. North is up. This view includes parts of Mars quadrangles Coprates, Phoenicis Lacus, and Thaumasia.

positioned at a point where their perimeters were tangent to each other, because the observers described this tangential formation. In *Figure 6*, the latitude and longitude of each cloud's core (see *Table 1*) was used to position it on Shiro Ebasawa's well-known map of the named albedo features of Mars (Ebisawa, 1957). Note the adjacent positions of the clouds.

Figure 7 shows the locations of the clouds against a background of a gray version of the Mars Global Surveyor's (MGS) Mars Orbiter Laser Altimeter (MOLA) map of the region (NASA, 2007). In this figure, north is up, in contrast to the previous figures in this article. After plotting the clouds, the author measured their diameters with the *JMARS* tool and found a diameter of the northern cloud of 692 km and a diameter of the southern cloud of 608 km, as shown in *Figure 7*. Thus, the two clouds covered a distance of 1,300 km along their mutual axis!

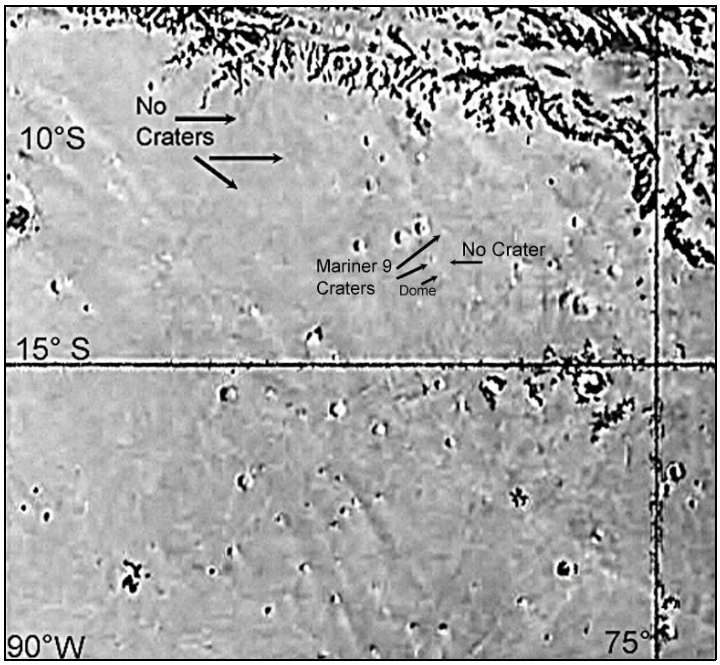
Lionel Brown's image of the merged cloud at 10:42 UT shows it to be roughly circular. Using the *WinJUPOS* measurement engine, its diameter was found to span 23.6° in longitude, and the location of its center was at longitude 91.1° W and latitude of 31.3° S. These coordinates are near the center of the original southern cloud (see *Table 1*). Upon plotting this cloud on the MOLA map, its diameter was found to be 1,154 km, as measured with the *JMARS* tool (see *Figure 8*).

These images show that the form of the clouds changed during the period of time from 07:50 UT to 10:42 UT. Their visual appearance resembled a figure "8" at 07:50 UT and changed to a single large cloud by 10:42 UT. It is suspected that the comet had two nuclei based on the fact that the initial appearance of the cloud was of two circular bright white clouds. The time of impact is unknown. The dark markings of Daedalia to the west were obscured at first, presumably by dust raised by the impact, but over the several hours of observation, the SPC became obscured while the dark markings of Daedalia became visible. As far as this author knows, such rapid changes in clouds and obscurations on Mars are unique to these observations.

Results, Part 2: The Craters

More evidence indicating an external source for the clouds is the recent finding by the author of a cluster of new craters. The new craters were found in MC 18 Corprates. None were found in MC 17 Phoenicis Lacus or MC 25 Thaumasia. The pair of clouds occupied parts of MC 17, MC 18, and MC 19.

The relevant part of the Corprates quadrangle is shown as it appears on the Mariner 9 map in *Figure 9* and as it appears on the Viking Orbiter map in *Figure 10*. Arrows in *Figure 9* point to regions where there were no craters on the 1972 Mariner 9 map, but there are craters on the 1976 Viking map of *Figure 10*. The Mariner 9 map also points to two craters existing in 1972, so they will not be confused with a nearby new crater marked on the Viking map.



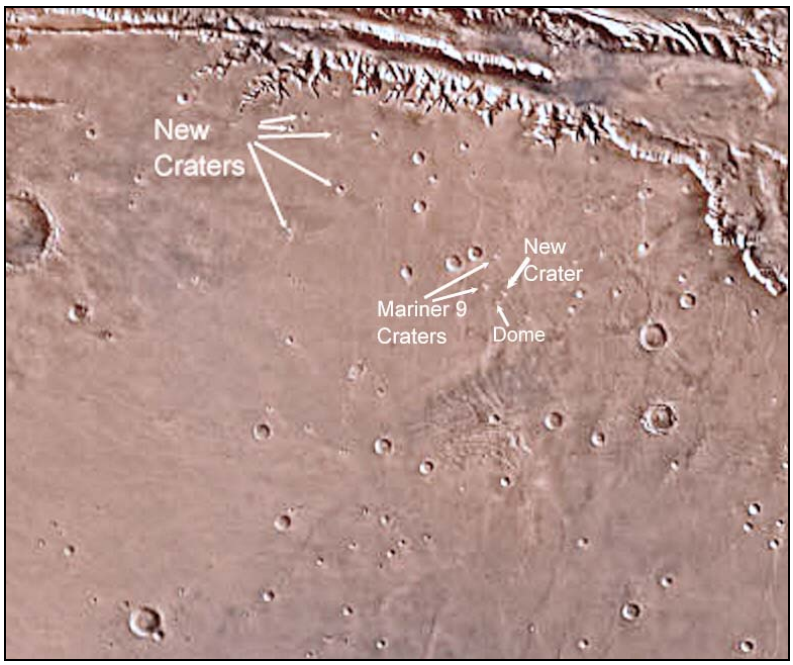


Figure 9 (above left). New crater region on the Corprates quadrangle as it appears on the pre-impact 1972 Mariner 9 map. Mercator projection and North is up.
Figure 10 (above right). New crater region on the Corprates quadrangle as it appears on the post-impact 1976 Viking map. North is up.

There are six new craters marked on the Viking map of *Figure 10*. These are in a group of five new craters northeast of the northern cloud and one new crater just east of those (see *Figure 11*).

The Mariner 9 maps are believed to show identifiable features as small as 1 to 2 km in size for 70% of the Martian surface, and as small as 3 km in size for the remaining 30% of the surface (Batson, 1973). If the new craters were smaller than 3 km size, their absence from the Mariner 9 maps might be considered to be inconsequential. However, the diameters of the six new craters were measured with *JMARS* using the MOLA images of the Corprates quadrangle, and were found to have diameters ranging from 4.2 km up to 10.0 km. These diameters are marked on the MOLA image in *Figure 11*, which also shows the craters' positions with respect to the northern cloud. The author believes that this cluster of six craters supports the assertion that its origin was from the proposed comet and are not random impacts.

Discussion and Conclusions

The pair of white clouds observed on September 2, 1973, at Ls 274° can be compared against the seven categories of Martian clouds listed by Beish and Parker: limb/terminator hazes, equatorial cloud bands, discrete clouds, orographic clouds, polar clouds and hazes, frosts and fogs, and dust clouds (Beish and Parker, 1990). The following discussion follows their descriptions and Ls of the cloud types:

1. Limb hazes are narrow cloud bands that hug the limbs. They have been observed starting at Ls 330° and peak between Ls 80° and 130° and then show a dramatic reduction before Ls 180°. The circular clouds presented in the present paper occurred at Ls 274°. They were very far from the limbs and did not appear as hazes. For these reasons they do not belong to the limb hazes category.

2. The equatorial cloud bands are faint horizontal streaks. Since the two circular clouds described here were as bright as the SPC and were not shaped as streaks, they do not fit the cloud bands category.

3. Most discrete clouds have randomly shaped outlines and are nebulous in appearance. From about Ls 330° up to Ls 170°, there is an excess of water vapor in the atmosphere that supports cloudiness over the entire globe. Starting in fall in the Northern Hemisphere at Ls 180°, the excess H_2O begins to be deposited as ice onto the North Polar Cap. The Ls of 274° at the time of our observations was the beginning of winter in the Northern Hemisphere, so there was little water vapor available for cloud formation. Thus, these clouds do not fit the discrete cloud category.

4. The clouds cannot have been orographic clouds like those that form over the Tharsis volcanoes, as they were too far away from these volcanoes to be considered orographic. Orographic clouds form on Mars when moisture-laden air freezes out while rising along the slopes and over the peaks of these great mountains. They only exist over

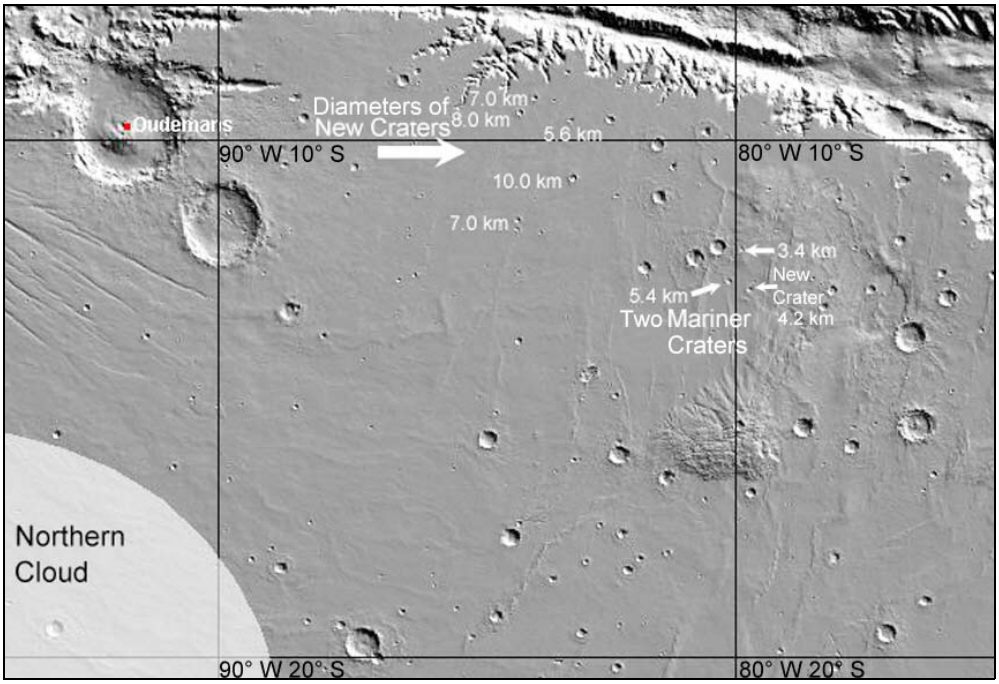


Figure 11. Shown are a group of five new craters northeast of the northern cloud and one new crater just east of those.

and in the close vicinity of mountains. The center of the northern cloud was more than 1,500 km from Arsia Mons and Pavonis Mons, the closest mountains, while the southern cloud was even farther away. Furthermore, at Ls 274°, it is the wrong season for orographic clouds. ALPO image data shows that orographic clouds begin about Ls 60° and end about Ls 140°.

5. Polar clouds and hazes are either discrete clouds or the polar hoods. Polar hoods only form over the poles. Discrete clouds have already been discussed but another type of cloud in this category is spiral clouds. Some clouds with a spiral shape have been observed only in the North Polar Region (Wang and Ingersol, 2002). One was of hurricane-size with a dark "eye" visible. The two Ls 274° clouds showed neither a spiral shape nor a dark center. The two clouds are in the tropics where spiral clouds have not been observed.

6. Frosts and fogs are on the ground or very close to the ground. Because all of the dark albedo features west of Mare Erythraeum were missing on September 2, the author believes that a blanket of airborne dust covered the region under the bright clouds. Frosts and low altitude fogs, if they were present, would have been hidden under the dust. The two Ls 274° clouds do not fit the frosts and fogs category.

7. Dust clouds have a distinctly brown color, as shown by color-balanced streaming video images of Mars. The two Ls 274° clouds were visually observed to be very white in color, which rules out a dust source.

The two clouds on September 2, 1973 are not in any of the above seven cloud categories. This means they are rare and atypical. They should reasonably be considered to have been a manifestation of a comet impact.

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