

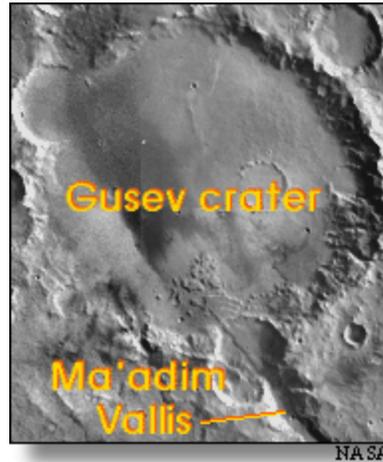
## Hot Idea

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# For a Cup of Water on Mars: Gusev Crater

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Does this martian crater ("cup" in Greek) hold fossils in water-laid sediments?

Though liquid water is not stable on the surface of Mars today, there are hints in the martian landscape that water once flowed there, eroding valleys and depositing sediments. Understanding where water is, or was, on Mars is a crucial step in looking for life on this smaller, cooler neighbor of Earth. Satellite images, beginning in the early 1970s with [Mariner 9](#) up to the current [Mars Global Surveyor](#), have given us increasingly detailed looks at the surface of Mars, including those intriguing channels that resemble dry river valleys.

Warmer temperatures and a higher surface pressure once made it possible for liquid water to exist on the surface of Mars. When the water existed and where it went are just two of the questions being studied today. A larger question has to do with martian life. If the wetter, early environment on Mars supported life, then where are the most appropriate places to look for evidence of life? The answer seems to be channels and ancient lake beds. Nathalie Cabrol and colleagues at NASA Ames Research Center, the Vernadsky Institute in Moscow, and Arizona State University recently published their study of a valley and impact crater on Mars which together had a prolonged history of water-related activity. The researchers established a sequence of events for the Ma'adim Vallis/Gusev crater area that included flowing water, ponding, and sedimentation over a period of a couple of billion years. This history makes Gusev crater a prominent depositional site and, as we'll consider, a key location for future biological explorations on Mars.

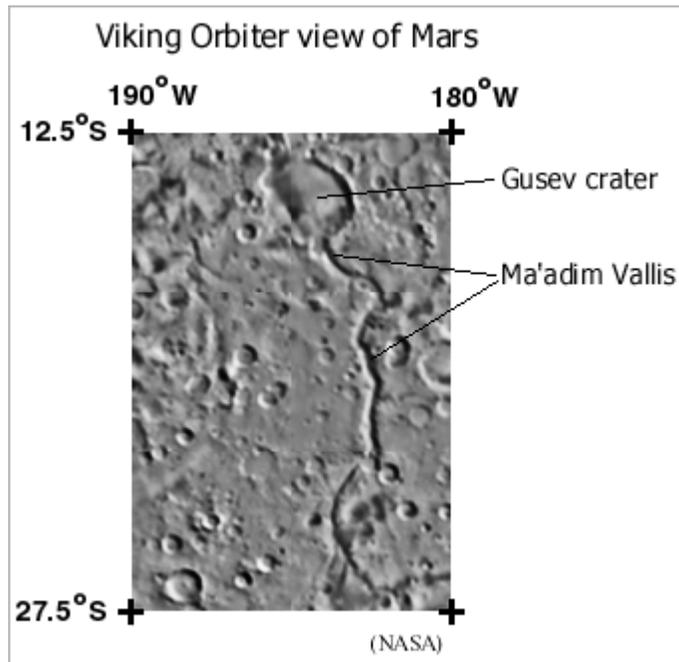
### Reference:

Cabrol, N. A., E. A. Grin, R. Landheim, R. O. Kuzmin, R. Greeley, 1998, Duration of the Ma'adim Vallis/Gusev Crater Hydrogeologic System, Mars. *Icarus*, v. 133, p. 98-108.

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## Carved and jarred surface

**M**a'adim Vallis, in the martian southern cratered uplands, is one of the largest valley networks on the planet. First classified by Sharp and Malin (1975) as a runoff channel, it has long, branched, adjoining channels along its upstream reaches. Flowing northward toward the Elysium Basin region, Ma'adim Vallis is 15 to 20 kilometers wide and extends some 900 kilometers, passing through 160-km-diameter Gusev crater at 14.7°S, 184.5°W. Younger, smaller impact craters on the southern and northern rims of Gusev opened the pathway for water from Ma'adim Vallis.

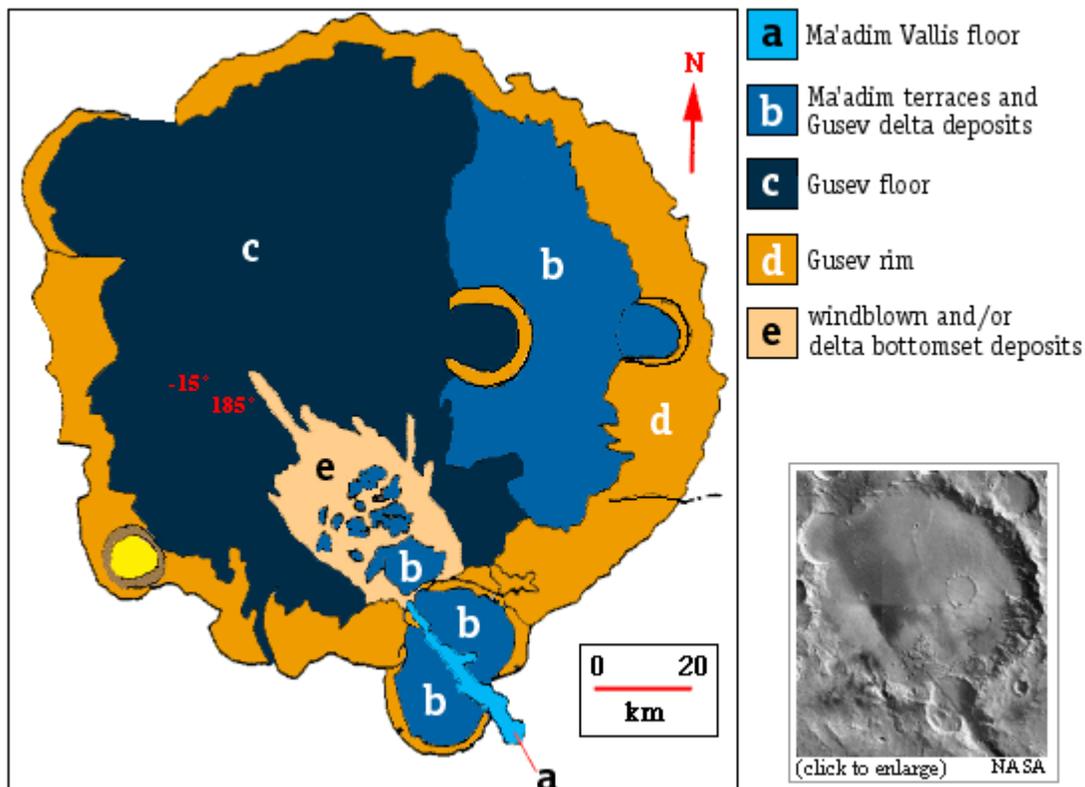


**C**abrol and her colleagues used images from the [Viking Orbiter](#) mission to make a geologic map of Ma'adim Vallis and Gusev crater. Through a careful process of distinguishing between different textures, forms, and layers, they were able to relate the surface materials to different geologic processes, namely erosion and deposition by flowing water or (to a lesser extent) wind, and impact cratering.

### Simplified geologic map of Gusev crater area

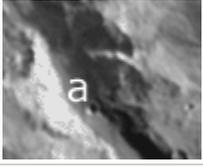
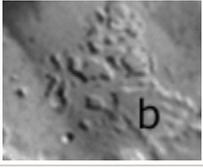
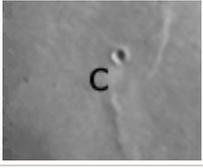
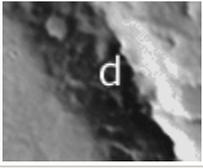
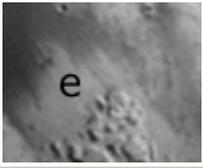
### Legend

Unit Descriptions



(Adapted from Cabrol and others, 1998, *Icarus*, v. 133, p. 98-108.)

The researchers defined five different surfaces:

image of unit	name of unit	description and interpretation
	<b>Ma'adim Vallis floor</b>	Smooth surface, with some terraced layers. Interpreted to be deposits on the bottom of a river channel.
	<b>Ma'adim Vallis terraces and deltaic deposits inside Gusev crater</b>	Grouped together because of similar elevations and surface texture. The multi-leveled terraces are interpreted to be evidence of more than one episode of erosion and carving of the valley.
	<b>Gusev floor</b>	Smooth surface interpreted to be deposits of fine-grained sediments transported into the crater by water from Ma'adim Vallis.
	<b>Gusev rim</b>	From the crests of the hilly rim to landslide deposits around the base, this unit is related to the actual formation of the crater by an impact event.
	<b>windblown deposits</b>	Smooth and bright surface at the junction of Ma'adim Vallis and the southern rim of Gusev crater, interpreted to be windblown material. This smooth and bright veneer is probably the youngest material deposited into Gusev crater.

## Counting the Craters

After defining the surface units, Cabrol and co-workers used a crater-statistics technique to determine the relative ages of the units and to place the geologic processes into a relative time sequence. In general, older surfaces have more craters simply due to their longer exposure time. They counted the number of craters of three sizes (2-, 5-, and 16-kilometer diameters) in each of the five surface units. These crater populations were used to estimate absolute ages of the surfaces according to Tanaka's model, a technique developed by Ken Tanaka of the U. S. Geological Survey, Flagstaff, as shown in the table below.

From oldest to youngest, Cabrol and her colleagues found the sequence of surface units to be:

Unit	Possible age in billions of years
Gusev rim	4
Ma'adim terraces	about 3.5
Gusev floor	about 1.8
Ma'adim floor	about 1.8
windblown deposits	from 2 until now.

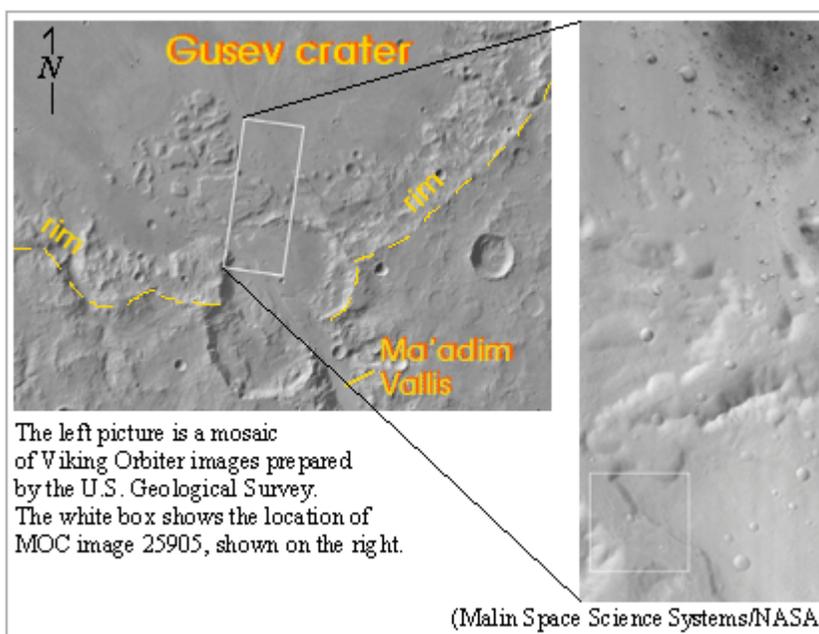
The crater statistics show about the same age for the floors of Ma'adim Vallis and Gusev crater, thus constraining the age of the last sedimentation event. Cabrol and colleagues use these statistics to confirm the idea that Gusev was a natural ponding zone and collector basin for Ma'adim Vallis sediment, which could be hundreds of meters thick.

### Could there be evidence for life in Gusev's cup of water?

What does the geologic history of Gusev crater and Ma'adim Vallis mean for biological explorations?

Biologists, paleontologists, and geologists are studying the current and early environments of Mars to determine if conditions could have supported life. They are, in particular, looking for clues to past or present water. Gusev crater is intriguing because of its long history as a depositional site for water and sediments from Ma'adim Vallis. There is the fascinating possibility that the water-laid sediments in Gusev crater could contain fossils. In 1995, Gusev crater was included in NASA's report, "An Exobiological Strategy for Mars Exploration" (NASA Publication SP-530) as a priority site for future biological exploration.

Images taken in 1998 by the Mars Orbiter Camera (MOC) on [Mars Global Surveyor](#) show the martian surface in greater detail than previously achieved by the Viking Orbiters. The MOC image below, shown at 40% of the original size, has a [resolution](#) of 18.3 meters (60 feet) per [pixel](#).



[MOC image](#) link

When the Mars Global Surveyor spacecraft attains its Mapping Orbit in early 1999, the MOC will take images

at an unprecedented scale of approximately 1.5 meters per pixel. Taking close looks at Gusev crater and its surroundings can give us additional information to determine geological details, such as the sources of the sediments, and verify the locations of the ancient pond shorelines.

Quality images and geological studies, like those conducted by Nathalie Cabrol and colleagues, will help future mission planners select landing sites for robotic rock collectors and, ultimately, piloted explorations to Mars. It's only a matter of time before we know for sure if the ancient channels and lake beds on Mars hold evidence of past life.

## Additional Resources

### [An Exobiological Strategy for Mars Exploration](#)

Baker, V. R., 1982, **The Channels of Mars**. University of Texas Press, 198 p.

Cabrol, N. A., E. A. Grin, R. Landheim, R. O. Kuzmin, R. Greeley, 1998, Duration of the Ma'adim Vallis/Gusev Crater Hydrogeologic System, Mars. *Icarus*, v. 133, p. 98-108.

Carr, M. H., 1996, **Water on Mars**. Oxford University Press, 229 p.

[Center for Mars Exploration](#) at NASA Ames Space Science Division.

Kargel, J. S. and R. G Strom, 1996, [Global Climatic Change on Mars](#) *Scientific American*.

[Mariner 9 Mission to Mars](#)

[Mars Global Surveyor](#)

[MOC high-resolution images](#)

[MOC image of Gusev crater](#).

Sharp, R. P., and M. C. Malin, 1975, Channels on Mars. *Geol. Soc. Am. Bull.*, v. 86, p. 593-609.

Tanaka, K. L., D. H. Scott, R. Greeley, 1992, Global Stratigraphy, in **Mars** (H.H. Klieffer, B. M. Jakosky, C. W. Snyder, M. S. Matthews, Eds.), p. 345-382, Univ. of Arizona Press, Tucson.

[Viking Mission to Mars](#)



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