Recent Space Missions Give Us a New View of Mars

Dr. Farouk El-Baz, space geologist, who was the man in constant contact with Apollo 17 astronauts during the landing and stay on the moon, is the leading scientist of Arabic background and a source of pride for all scholars. He has written the following report on the Second International Colloquium on Mars, at which recent U.S. missions to Mars were discussed.

National Air and Space Museum, Smithsonian Institution, Washington, D.C., U.S. The Second International Colloquium on Mars was held at the California Institute of Technology, Pasadena, Calif., January 15-18, 1979. The first colloquium was held five years earlier to discuss results of the highly successful Mariner 9 mission to Mars. Two Viking landers and two orbiters were sent to Mars in 1976. All four spacecraft lived a healthy life through a full 688-day martian year transmitting a rich harvest of scientific data. In fact, three are still at work, although at a much slower pace than before.

The Viking spacecraft have clearly revealed a planet to ponder. In some ways it appears Earth-like, in other ways it is similar to our Moon, and yet in other ways it is unique.

The Viking mission was expected to search for evidence of life on Mars via instruments in the biology package, including: (1) Pyrolytic release, which sought evidence of a process involving photosynthesis, where a labeled gas molecule could be assimilated in a process like that used by plants on Earth; (2) Labeled release, which sought evidence of the assimilation of labeled organic matter, where the conversion of food into energy and growth yields gases that are indicative of metabolic activity; and (3) Gas exchange, where the samples are incubated in dry, humid and wet environments, with or without “food”, and monitored for indications of metabolic processes.

The results remain difficult to interpret, even after numerous simulations in laboratory conditions. Two of the experiments, particularly the labeled release yielded results resembling that expected from a metabolizing system, thus, supporting the possibility of some life forms on Mars. However, the results of the molecular ana-

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This spectacular picture of the Martian landscape by the Viking 1 Lander shows a dune field with features remarkably similar to many seen in the deserts of Earth. The dramatic early morning lighting—7:30 a.m. local Mars time—reveals subtle details and shading. Taken on August 13 by the Lander's camera No. 1, the picture covers 100 degrees, looking northeast at left and southeast at right. Viking scientists have studied areas very much like the one on this map in Messina and California (Kolso, Death Valley, Yuma). The sharp dune crests indicate the most recent wind stoms capable of moving sand over the dunes in the general direction from upper left to lower right. Small deposits of windblown sand also indicate this wind direction. Large boulder at left is about eight meters (25 feet) from the spacecraft and measures about one by three meters (3 by 10 feet). The small dark region near the center of the picture is a communication dish which supports Viking's miniature weather station, cut through the picture's center. The sun rose two hours earlier and is about 30 degrees above the horizon near the center of the picture.

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lies failed to reveal any organic compounds, even at the sensitivity of one part-per-billion. In addition, the gas exchange results suggest the presence of a potent oxidizing agent. Such an agent might be capable of decomposing organic material by chemical reaction, with much the same result as might be expected of biological digestion. Another possible indication of life on Mars, the camp is still divided.

One thing is certain—the atmosphere of Mars would not support life as we know it on Earth. Consider its components, nearly 96% carbon dioxide, 2.5% nitrogen, 1.5% argon-40, 0.1% oxygen, and traces of argon-36, krypton and xenon. The atmospheric pressure varies from 7 to 10 millibars, as carbon dioxide condenses or sublimes from the polar cap, respectively. The peak temperatures during the summer were also well below -180°C. Typical wind velocities were about 12-16 km/h, although strong gusts reached 48-65 km/h. None of the observed velocities could induce significant transport of soil materials.

This is supported by the lack of spectacular changes to the surface seen in the Lander images. Subtle changes resulted from wind-entrainment of soil materials, formation of wind-transported dunes, and possible modifications of the thin layer of bright dust. The rates of change were disappointingly low; despite two global dust storms and several smaller ones, the transport of material was confined to an extremely thin layer and not of the same magnitude as seen on Earth. The day low rates of erosion and material transport cannot be responsible for the many dune fields on the surface of the planet. Viking Orbiter images revealed a 100,000 km² field of large longitudinal dunes near the Martian equator. This is the size of the Great Sand Sea in the Western Desert of Egypt, which is also composed of longitudinal dunes. On Earth, this classic type of dune grows parallel to very strong, highly directional winds. The existence of such dunes support prevalence of strong, sand-moving winds for a rather lengthy time. This must have happened during Mars' geological past.

Photographs generally provide the most ready and useful and understandable information acquired by a spacecraft. Two camera on each lander acquired detailed views of the two landing sites from a human-perspective height of approximately 1.3 m. The pictures were taken in monochromatic, 7500-A to 7800-A, red or white, and color conditions could be made. The two landers obtained over 4200 pictures of the rock strewn sites. The rocks are believed be volcanic basalt in a matrix of very fine reddish soil. The soil reddening is believed to be due to the oxidation of iron from the basalt.

The examination of the Viking Lander 2 site exhibit pits tured surfaces. These pits were interpreted as vesicles, spaces where gases were trapped in the fast cooling basaltic lava. However, a new idea was introduced at the colloquium, field investigations in the southwestern desert of Egypt indicated that surface pits may be produced by wind erosion in all types of rocks. Thus, what are called "vesicles" in the martian rocks may also be wind-eroded pits.

The martian polar cap remains mysterious. The Viking mission indicated that the northern cap consists almost entirely of water ice, and the southern cap is made of frozen carbon dioxide. No easy explanations exist for this asymmetry.

Another mystery concerns the possibility of the previous existence of far more water on Mars than remains on the polar caps. This water is theorized to have channelled the martian terrain in a characteristic fashion. Although there are channels on Mars that appear to have formed by the action of flowing water, many of the features, and wind erosion, some channels are nearly identical to those formed by running surface water on Earth.

An example is what has been called "outflow channels" on Mars, which are huge valleys ranging in width from 10 to 100 km; some of these channel complexes can be traced for over 2000 km. The one terrestrial landscape that is reminiscent of these outflow features is the Channeled Scablands of Washington, USA. It is interesting to note that the idea proposed during the 1920's that these were the product of a cataclysmic flood was considered outrageous. Today the Channeled Scablands have been recognized as a significant landform morphology compared to similar features on Mars. Naturally, the martian outflow channels are also believed to be the result of catastrophic floods.

At the end of the colloquium a panel discussed proposed ways for future exploration of Mars. NASA supports bringing back a sample of the planet for detailed analysis on Earth. However, some scientists argued that what is needed is additional study of a larger part of the planet by a wheeled rover or a winged flying machine. No one discussed the possibility of sending astronauts to Mars, which is a sad commentary on the levels of imagination in the days of budget belt-tightening. Thus, the colloquium ended with the realization that many of the secrets of Mars are yet to be divulged.

The organizers of the colloquium expected 200 people to attend; over 500 showed up for registration! This is a clear indication of the vast amount of interest that has been triggered within the scientific community, and the general public. A booklet containing 110 abstracts of the colloquium papers may be obtained free of charge by writing to: Planetary Geology Office, NASA Headquarters, Washington, D.C. 20546, USA. Proceedings of the colloquium will be published later this year as a special issue of the Journal of Geophysical Research.
The Viking spacecraft to Mars have clearly revealed a planet to ponder. In some ways it appears Earth-like, in other ways it is similar to our Moon, and yet in many aspects it is unique. This was the conclusion of the Second International Colloquium on Mars, held at the California Institute of Technology, Pasadena, California, USA, 15–18 January 1979. The first colloquium was held five years earlier to discuss results of the highly successful Mariner 9 mission to Mars. Two Viking landers and two orbiters were sent to Mars in 1976. All four spacecraft lived a healthy life through a full 688-day Martian year transmitting a rich harvest of scientific data. In fact, three are still at work, although at a much slower pace than before.

EVIDENCE OF LIFE – STILL DOUBTFUL

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The Martian Landscape. (a) Pitted rocks in the Viking 2 landing site. (b) Channels in Chryse Planitia that are believed to have been sculptured by surface water in the geological past of Mars. (c) A white rock, 18 × 14 km, of unknown composition within a crater near the Martian equator. (d) Dunes at the Viking 1 landing site.
sought evidence of a process involving photosynthesis, where a labeled gas molecule could be assimilated in a process like that used by plants on Earth; (2) labeled release, which sought evidence of the assimilation of labeled organic matter, where the conversion of food into energy and growth yields gases that are indicative of metabolic activity; and (3) gas exchange, where the samples are incubated in dry, humid and wet environments, with or without ‘food’, and monitored for indications of metabolic processes.

The results remain difficult to interpret even after numerous simulations in laboratory conditions. Two of the experiments, particularly the labeled release, yielded results resembling those expected from a metabolizing system, thus supporting the possibility of some life forms on Mars. However, the results of the molecular analyses failed to reveal any organic compounds, even at the sensitivity of 1 part in 10⁶. In addition, the gas exchange results suggest the presence of a potent oxidizing agent. Such an agent might be capable of decomposing organic material by chemical reaction, with much the same result as might be expected of biological ‘digestion’. Thus, regarding the question of life on Mars, the camp is still divided.

**WINDS, DUNES AND PITTED ROCKS**

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This is supported by the lack of spectacular changes to the surface as seen in the lander images. Subtle changes resulted from wind-entrainment of soil materials, formation of water condensates, and the accumulation of a thin layer of bright dust. The rates of change were disappointingly low; despite two global dust storms and several smaller ones, the transport of material was confined to an extremely thin layer of bright dust. However, the present-day low rates of erosion and material transport cannot be responsible for the many dune fields on the surface of the planet. Viking Orbiter images revealed a 3 000 000 km² field of large barchan dunes that girdles the north polar region of Mars. This is equivalent to the total area covered by dune fields in the North African Sahara. On Earth, this classic type of dune grows parallel to very strong, highly directional winds. The existence of such dunes supports the prevalence of strong, sand-moving winds for a rather lengthy time. This must have happened during Mars' geological past.

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**UNSOLVED MYSTERY OF POLAR CAPS**

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Another mystery concerns the possibility of the previous existence of far more water on Mars than remains on the polar caps. This water is theorized to have channeled the Martian terrain in a characteristic fashion. Although there are channels on Mars that appear to have formed by the action of flowing lava, collapse along fractures, and wind erosion, some channels are nearly identical to those formed by running surface water on Earth.

An example is what has been called ‘outflow channels’ on Mars, which are huge valleys ranging in width from 10 to 100 km; some of these channel complexes can be traced for over 2000 km. The one terrestrial landscape that is reminiscent of these outflow features is the ‘Channeled Scabland’ in the eastern part of the state of Washington, USA. It is interesting to note that the idea proposed during the 1920s that these were the product of a cataclysmic flood was considered outrageous. Today the Channeled Scabland features are being measured and their morphology compared with similar features on Mars. Naturally, the Martian outflow channels are also believed to be the result of catastrophic floods.

**FUTURE EXPLORATION - UNMANNED**

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The sinuous rille at the top of this mosaic of eight photos probably indicates flooding of the high plateau in the vicinity of the potential landing site for Viking 2, Capri, C-1. In the foreground is a valley, probably caused by downfaulting of the Mars crust. The hummocks on the valley floor look like chaotic terrain. It has been suggested that the subsidence is partially caused by melting of the subsurface ice and the large areas of the collapsed terrain show the regional extent of this phenomenon. These pictures were taken by Viking 1 on 3 July 1976 from a range of 2300 km and cover an area of about 300 by 300 km. South is toward the top as seen from the spacecraft.
وبعد هذا الاكتشاف لم يتطور تغيرات مثيرة في سطح النبتة، وهو تطور في الصور التي يظهر بها التفاعلات الفضائية لاند. أما التغييرات الطيفية فنتج عن جزء الرياح لمواد النبتة وتتشكيل المكثفات المائية وتنشر سماء رقيقة من الغبار الساطع. وقد ثبت أن معدلات التغيير ببيئة نحو محاسبة للأمر. فبالرغم من هبوط عاصمتي تراكمات على نطاق واسع، وعهد عواصف على نطاق أضيق، إنحناء انتقال المواد في حدود طبقة رقيقة للغاية من التراب الساطع. ومع هذا فإن المعادلات الحالية المتضمنة الخاصة بالتقلل وانتقال المواد لا يمكن أن تكون مسؤولة عن حدوث الكثير من الكثبان على سطح الكوكب. وقد أنتج من الصور التي يبتكر بها المركبات، وماكينغ أوريت أن هناك حالة تبلغ مساحتها 10000 كيلومتر وهو ملي مكيل مترية على جانب من مستغمر الكوكب. وهذه المساحة تصل مساحة بحر الرمال العظمى في صحراء مصر الكبرى، الذي يتألف من كثبان طولية. ويعمل هذا النوع التقليدي من الكثبان على سطح الأرض في خطوط موارية للتفاعلات الرياح القوية. ولذا فإن وجود مثل هذه الكثبان يمكن أن يؤثر على الأجسام القائمة بهبوط رياح قوية ناقلة للرمال على امتداد فترة طويلة. ولا بد من البحث في الماضي الجيولوجي للكوكب لتفهم التطور الصور الفوتوغرافية التي تتطلبتها المركبات الفضائية لمعظم البيانات. وتأثر بالسمحة معًا، فقد تمكننا التصور من تدفق نبات على المركبات، لاند من الحفاظ على تفاصيل لموقع تهبط، وذلك من ارتفاع منظوري بشري في حدود 1 آم تقريباً. والتفتح هذه الصور في شكل أرائها من اللقطات المجمعة، تسهم بالرؤية من ثلاثة

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ومن المقرر أن تنشر مداولات الندوة هذا العام في عدد خاص من
نشرة الإبحاث الجيوفيزيائية