THE MARS QUARTERLY

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As we release this first quarter issue, the space industry is facing major challenges. President Obama's recently announced cancellation of several major NASA programs has caused serious concern that Mars will remain out of reach for several decades. In addition, as the country continues to struggle with tough economic times, this new plan will no doubt cause significant financial turbulence for our NASA friends who live and work in Central Florida.

While the President pushes what he believes is a transformational plan, those of us close enough to feel the heartbeat of the United States space program have serious concerns that there is much to lose in terms of both human and technological capital. As you consider the Op/Ed articles in this issue by Drs. Buzz Aldrin and Robert Zubrin, and remarks by Elon Musk, remember that these distinguished scientists all want humans on Mars within our lifetime. They may differ in perspective, but not in passion.

The complex challenges ahead must be met with as much forward motion on goals as any of us can possibly muster. Please follow the debate closely and decide - which plan for reaching Mars is the most likely to get us there? Then call and write your representatives in Congress, and vote your plan!

On to Mars!

Susan Holden Martin,
Editor-in-Chief

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Cover Art

In 1990 a young Michael Neal gave a report to his fifth grade class on astronauts. To make the information more immediate his mother called NASA and had Michael share freeze-dried ice cream and dehydrated applesauce with the other students. Almost twenty years later he has picked up where he left off, only this time as a design writer and critic.

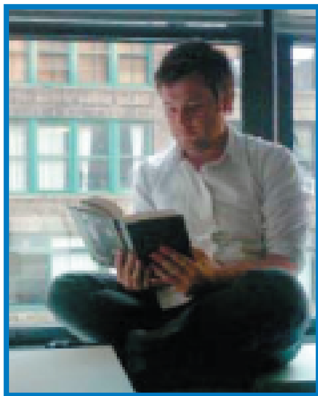


Photo: Mike Neal

Before moving to New York, he worked as art director for the advertising agency, Ogilvy & Mather, on brands such as Heal the Bay, and the global communications company, Cisco Systems. Earlier as a graphic designer for the Port of Long Beach, he helped to implement more eco-efficient publication practices to match with their Green Port policies. He obtained a BFA in visual communications from California State University, Long Beach.

Currently, Michael is a graduate student at the School of Visual arts in New York as a member of the inaugural class in design criticism. The MFA is a mixture of design history and journalism, applied to the fields such as architecture, industrial and graphic design, and advertising, and realized in medium-specific applications such as radio programs, documentaries, curated exhibitions, magazines or blogs.

Inspired largely by his fifth grade paper as well as Dr. Zubrin's, *The Case for Mars*, Michael's graduate thesis project is an examination and report on the efforts for designing a permanent settlement on Mars. This time, instead of applesauce and ice cream, he is using the MDRS to explore how design is being used to shape the Martian experience from scientific interactions to domesticity. As part of his research, he is examining ideas of utopianism and modernism intrinsically linked to off-world colonization. Such designs, too often lacking wider reporting and scrutiny, will be both world building and world changing; and probably a bit more complicated than "just add water and stir."

[Editor's Note: As journalist for MDRS Crew 84, Mike was asked by the radio show, Studio 360 with Kurt Andersen (for WNYC/NPR /PRI) to do a segment on MDRS for the show. A nine minute piece is available by podcast from the show's website: http://studio360.org/episodes/ 2010/03/12/segments/151559. It is also airing nationally on carrier stations, for your location visit: http://studio360 .org/listings.html. The segment includes time at the MDRS Hab, brief interviews with Dr. Zubrin and Dr. Chris McKay, as well as a cameo by Josh Nelson.]

Obama's Failure To Launch

By Robert Zubrin

[Editor's note: The following statement by Mars Society President Dr. Robert Zubrin appeared in the New York Daily News on April 19, 2010. It is reprinted here with permission.]

In a speech to political allies gathered at Cape Canaveral last week, President Obama laid out his vision for America's space program. Under the Obama plan, NASA will spend $100 billion on human spaceflight over the next 10 years in order to accomplish nothing.

Of course, that's not how Mr. Obama phrased it. But beneath the President's flowery rhetoric, that's how things add up.

Here's the background. In 2004, the Bush administration launched a program called Constellation to develop a set of flight systems, including the Orion crew capsule and the Ares 1 and Ares 5 medium and heavy lift boosters, that together would allow astronauts to return to the Moon by 2020, and then fly to destinations beyond.

Under the plan announced by Obama, almost all of this will be scrapped. The only thing preserved out of the past six years and $9 billion worth of effort will be a version of the Orion capsule - but one so purposely stripped down that it will only be useful as a lifeboat for bringing astronauts down from the space station, not as a craft capable of providing a ride up to orbit.

With the Space Shuttle program set to sunset in the near future, what this means is that the only way Americans will be able even to reach low Earth orbit will be as passengers on Russian launchers, with tickets priced at the Kremlin's discretion. In other words, instead of flying astronauts from the Earth to the Moon, our human spaceflight program will become a vehicle for transporting cash from Washington to Moscow.

The most amazing thing about Obama's speech, however, was its cognitive dissonance. The President desperately tried to spin the abandonment of the Moon program not as a retreat, but as a daring advance. We've been to the Moon before, he declared, and so we have. There's a lot more of space to explore; we should set our sights on points beyond, to the near Earth asteroids, and reach for Mars. Indeed, we can and should.

But the President's plan makes no provision for actually doing so. Instead, he proposes to simply stall.

So, for example, as the first milestone in his allegedly daring program of exploration, Obama called for sending a crew to a near Earth asteroid by 2025.

Such a flight is certainly achievable. To do an asteroid mission, all that is required is a launch vehicle such as the Ares 5, a crew capsule (such as the Orion), and a habitation module similar to that employed on the space station. Had Obama not canceled the Ares 5, we could have used it to perform an asteroid mission by 2016. But the President, while calling for such a flight, actually is terminating the programs that would make it possible.

The same holds true with the question of reaching Mars. From a technical point of view, we are much closer today to being able to send humans to Mars than we were to being able to send men to the moon in 1961 when President John F. Kennedy made his speech committing us to that goal - and we were there eight years later. With Kennedy-like commitment, we could have astronauts on the Red Planet within a decade. Yet Obama chose to set that goal for the 2040s, a timeline so hazy as to not require him to actually do anything to realize it.

The bottom line: Under the Obama plan, NASA will be able to send astronauts anywhere it likes, provided that its effort to do so begins after he leaves office. The President's science adviser, John Holdren, attempts to justify this expensive ($10 billion per year) stalling game by claiming that the pause in flight programs will allow us to develop more advanced technologies that will make everything much more achievable later.

This is false to the core. We already know how to build heavy-lift boosters - we flew our first, the Saturn 5, in 1967. With current in-space propulsion technology, we can do a round-trip mission to a near-Earth asteroid or a one-way transit to Mars in six months - a time no greater than a standard crew shift on the space station.

Holdren claims that he wants to develop a new electrically powered space thruster to speed up such trips. But without gigantic space nuclear power reactors to provide them with juice, such thrusters are useless, and the administration has no intention of developing such reactors. So far from enabling a quick trip to Mars, the unnecessary futuristic electric thruster concept simply provides an excuse for not flying anywhere at all.

The American people want and deserve a space program that really is going somewhere. To offer that, Obama needs to stop the fakery. That means a program whose effort will commence not in some future administration, but in his own; one whose goal is not Mars in our dreams, but Mars in our time.

Zubrin, an aerospace engineer, is president of the Mars Society and author of "The Case for Mars: The Plan to Settle the Red Planet and Why We Must."

A link to the article may be found at http://www.nydailynews.com/opinions/2010/04/19/2010-04-19_obamas_failure_to_launch.html

The Mars Society is the only major space advocacy organization that has been willing to take a stand and expose the go-nowhere space policy for what it is.

Help us tell truth to power.

Help us save America's human spaceflight program

Donate to the Mars Society. Come to the August 5-8 conference. Join the Mars Society. www.marssociety.org

REACHING HIGHER

13th Annual International Mars Society Convention
August 5-8, 2010, Dayton Marriott, Dayton, Ohio

By Patricia Czarnik

President Obama's space policy includes support for opening up space transportation to private industry. We are witnessing the birth of commercial space. It is only fitting that this year's convention takes us to Dayton Ohio, the birthplace of aviation. Dayton is a family-friendly city, and this convention will be the perfect opportunity to share your passion for humans in space with your family by bringing them along. We plan not only to give you the best speakers in their field, but also tours that will give you a history of flight and space. On Saturday, we will feature 'Mars Camp' a free family and kids event that will include flight simulators, hands-on displays and speakers who will inspire kids to reach higher.

Confirmed speakers:

Dr. Robert Zubrin
(President, Mars Society)
Dr. Michael Griffin
(former NASA Administrator)
Dr. Carolyn Porco
(Director of CICLOPS, Saturn Imaging Team)
Dr. Geoffrey Landis
(NASA scientist, Nebula and Hugo award-winning science fiction writer)
Dr. Mary Turzillo
(Nebula award-winning science fiction author)
Miles O'Brien
(former CNN anchor and host of This Week in Space)
Steve Heck
(Pathfinder Astronaut in the new Teachers in Space Program, and a NASA Endeavor Fellow at Columbia University in New York.

... more to come

Special Programming:

Mars Camp

This one-day free event on Saturday, August 7, is designed to promote STEM education (Science, Technology, Engineering and Math). It will include flight simulators, hands-on displays and special guest speakers all aimed at educating and inspiring the next generation of space explorers.

Tours/Events:

Museum of the USAF Tour

•Museum of the United States Air Force, a world-class museum, has seven galleries including the Missile & Space Gallery (see below), an Air Park which features aircraft exhibits, the World War II 8th Air Force Control Tower and Nissen Huts, as well as a playground and other special exhibits. http://www.nationalmuseum.af.mil/visit/index.asp

•Missile & Space Gallery opened to the public in 2004. It is contained in a silo-like structure that stands 140 feet high. Visitors can view missiles such as Titan I and II and Jupiter from ground level or can take in an aerial view from an elevated platform that hugs the inside circumference of the gallery. As part of the museum's ongoing expansion efforts, the gallery also features a portion of the museum's space collection, including the Apollo 15 Command Module, Mercury and Gemini capsules, rocket engines, satellites, and balloon gondolas.

Carillon Historical Park Tour

•Carillon Historical Park showcases Dayton's rich heritage of creativity, invention, and the milestones in transportation that changed the nation and the world. It is a unique combination of museum, park, and natural area. Website: http://www.daytonhistory.org/

•Wright Brothers Aviation Center houses the 1905 Wright Flyer III, the world's first practical airplane.

•Sugar Camp explore the critical role of cryptology with WAVES (Women Accepted for Volunteer Emergency Service) at NCR's (National Cash Register) Sugar Camp training facility during World War II.

•Deed's Barn features such inventions as a Liberty aircraft engine, an early Frigidaire refrigerator, and a 1912 Cadillac with the Delco automobile electric system, site of invention of the electric self-starter for the automobile

Stargazing

Miami Valley Astronomical Society (MVAS) has cordially invited convention goers to view the night sky at the Apollo Observatory located at the Boonshoft Museum of Discovery on Friday night, August 6.

More information is available at the 13th Annual Mars Society Convention website - http://www.marssociety.org/portal/c/Conventions/2010-annual-convention/.

Please check back often for updates.

Follow The Mars Society on Twitter and Facebook!

The Mars Society can be followed on both Facebook and Twitter. bookmark these sites now:

http://twitter.com/TheMarsSociety

http://www.facebook.com/group.php?gid=2231107150&ref=ts

NEWS BRIEF

By Jason Rhian

Photo: Jason Rhian

CAPE CANAVERAL - Before Air Force One touched down at 1:24 a.m. (EDT) on Thursday, April 15, President Obama was already in political hot water. His announcement that the program to replace the shuttle program, Constellation, would be cancelled caused an outburst of angry sentiment from points across the country - and within his own party. The President's visit and subsequent speech at Kennedy Space Center's Operations and Checkout building, (O&C) seems to have had little impact on this perception. Overnight cartoons displaying the 'new NASA' as being powered by a bottle rocket popped up on news sites and on Facebook, and detractors pointed out perceived flaws in the plan.

Senator Bill Nelson, who recently has voiced his support for the president's new space vision introduced NASA Chief Administrator Charles Bolden who endorsed the new path for NASA before introducing the president.

If Obama was attempting to reassure NASA and its contractors, he went about it poorly. His choice of stopping off points, Space Launch Complex, (SLC) 40 where SpaceX's Falcon 9 is being prepared for a scheduled May 8 launch date, seemed to imply that the President has put his trust in these new firms and their rockets, as opposed to those of the space agency. His comments later in the day reinforced this sentiment. In his address the President stated that NASA would no longer continue, "... on the same path." He went on to state that NASA would be given a "... transformative agenda." However it was other aspects of Obama's plan, such as the fact that a final determination on what type of heavy-lift rocket that would be used for these new missions would not take place for another five years, that caused concern with industry experts.

"Why does it need to be studied for five years?", wondered two-time shuttle astronaut Robert Springer when asked about the plans outlined by Obama. "This has been studied to death, why study it more?"

The President did however provide key milestones that the agency should meet under this new plan, such as a vehicle that is capable of sending astronauts beyond the Moon would be developed by 2025, and a manned mission to Mars would occur by the mid-2030s. The President went on to add that he expected to see astronauts land on the Martian surface - within his lifetime.

The President also sought to stem concerns that this plan would be a destructive influence on the economy of Central Florida. In his remarks, he mentioned a $40 million plan to promote regional growth in the surrounding area. The new plan states that an additional 2,500 jobs will be created, a number that exceeds

The President went on to add that he expected to see astronauts land on the Martian surface - within his lifetime.

previous estimates. However, original numbers post-shuttle showed that layoffs in and around Kennedy Space Center would be around 9,000. When it was announced that the Constellation Program was also cancelled, that number nearly tripled to 23,000.

Ironically, the employees that normally work in the O&C building where the President was speaking - were not allowed in the building that day due to security concerns. One worker who spoke on condition of anonymity saw other reasons as to why they were not allowed in. When asked about how they felt about the President's visit, the employee stated, My guess is that they didn't want him walking by and getting an earful!"

At the conclusion of the President's remarks there were a number of breakout sessions that took place both at Kennedy Space Center, as well as the nearby Kennedy Space Center Visitor Complex. The entire event was a star-studded affair with several astronauts in attendance including Buzz Aldrin, the second man to walk on the moon; Mae Jemison, the first female African-American astronaut; and Mike Foale and Mike Grunsfeld. Also in attendance were numerous military and political officials, as well as science-celebrities Bill Nye, the Science Guy, and astrophysicist Neil deGrasse Tyson.

Jason Rhian is a graduate of the University of South Florida who completed two NASA internships. He currently covers space issues for Examiner.com, Spacevidcast and SpaceRef.com. Jason has covered some 14 space shuttle and numerous unmanned launches. His group affiliations include the National Space Society, the NASA/JPL Solar System Ambassadors, the Astronaut Scholarship Foundation Ambassadors, the Florida Public Relations Association, and the Google Lunar X-PRIZE team - Omega Envoy.

Mars as Our Goal at Last

By Buzz Aldrin

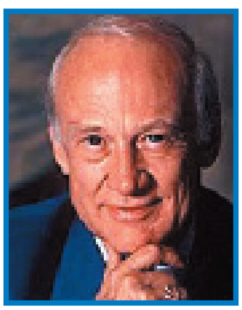


Photo: www.BuzzAldrin.com

President Barack Obama has finally given what we advocates for the human exploration of Mars have patiently waited for — and fought to achieve-for decades. During a speech at the Kennedy Space Center April 15th he set human landings on Phobos and Mars as the ultimate goal of our civil space program. First, we'll get to sharpen our deep space chops by an asteroid rendezvous mission in 15 years -using a spacecraft that incorporates the technology developed for the Orion Crew Exploration Vehicle. Then it's onward to Phobos by the mid-2030s, followed by landings on Mars, too. "I intend to be around to see it!", Obama joked. But for him to fulfill that boast, all of us will need to shift our advocacy to Congress, still deeply skeptical about Obama's space policy, to explain why the key elements of the Obama plan are good for American space leadership.

Those elements include helping to create a new industry built around ferrying astronaut crews to the International Space Station. Perhaps the plan's most controversial -and misunderstood-component, privatizing low Earth orbit is an idea whose time has come. But many misunderstand the idea, thinking it is the end of manned spaceflight. Actually, the opposite is true-many more types of vehicles that will be ferrying back and forth from LEO. At the same time, the Orion crew capsule will survive, first as an escape vehicle to be docked at the station, later as part of a deep space duo of capsule and exploration vehicle. A key element of the new plan is an accelerated development of a new heavy lift booster. If the Shuttle program isn't extended, that booster should be a "clean sheet" design that utilizes the new research called forth in the budget — new hydrocarbon booster engines, successors to the F-1s that powered the Saturn V, as well as new types of upper stages that possibly feature in-flight refueling capability. Obama set a deadline of 2015 to choose the heavy lifter's design — but I predict we can beat that deadline well in advance leading with evolution to various size multi stage reusable launches.

And the budget proposal calls for fully funding ISS research, especially in ways to protect deep space-going crews from solar radiation, more funds for Earth and space science, and new types of advanced humanoid robots. For space advocates, there's something in there for nearly all of us.

Which is why I challenge members of the Mars Society to work with the Space Exploration Alliance and members of the Planetary Society, National Space Society, AIAA and other groups to explain and advocate for the Presidential plan. Obama isn't the only one who hopes to live long enough to see humans on Mars. I expect to be right there with him!

"Fostering competitive commercial spaceflight is the only possible path to establishing life on Mars. The government path is completely unsustainable. Best case is a flags and footprints mission like Apollo, followed by nothing. Therefore, I think Obama's plan for space has the potential for even greater historic significance than Kennedy's. That is, if you care about making life multi-planetary."

Elon Musk, Space X

A New Generation Voicing the Dream

Introducing Hero Magnus

By Susan Holden Martin

Photo: The Magnus Family

The Mars Society is pleased to introduce you to Hero Magnus. Hero heard the call from Mars a few months before her third birthday. Most recently she embarked on a letter writing campaign to Congress in advance of the 10th Annual Isaac Asimov Memorial Debate held on March 15 in New York City. Under parental supervision, Hero personally hand-delivered her letters to members of both House and Senate subcommittees dealing with space. A copy of her letter to Representative Giffords, Chair of the House Subcommittee on Space and Aeronautics, appears at right.

We invite you to read her letter and view the video of her at the Hayden Planetarium -- witness for yourself how the dream lives on in one child's heart.

Hero at the Hayden Planetarium: http://www.landmarkny.com/marssociety/

The Hayden Planetarium's podcast of the Great Space Debate can be found here: http://www.amnh.org/news/2010/03/podcast-isaac-asimov-debate/.

The Mars Society would like to thank Landmark Pictures & Sound for their outstanding videography, and the American Museum of Natural History/Hayden Planetarium for their cooperation and courtesy.

Hero Magnus
March 2, 2010

The Honorable Gabrielle Giffords
United States House of Representatives
1728 Longworth House Office Building
Washington, D.C. 20515

Dear Representative Giffords:
Hello. I am writing to you because I know you have control over the future of human space flight. My name is Hero Magnus. I have wanted to go to Mars since the age of 2, and my vision is to be the first person on Mars. I am 9 years old, and I am concerned that America doesn't have a vision like mine about going into space. I think we used to have a vision. Our back to the moon plan and going eventually to Mars was our vision before, but now it's being undone. I know that you're able to vote about that, and I think that the vote you make should help America have a space dream. I want to know what you think would help America get into space. Do you think we need big federal agencies like NASA to go to Mars, and have all of America going and working and having a vision together, or can small businesses like SpaceX and the Mars Society get out there on their own? I think it's better to have a plan from all of America, because then we know we are going to do it. Whatever your choice is in the vote, I want you to help America still expand our amazing new ways of exploring-searching our neighbor planets and moons.

Sincerely yours,
Hero Magnus

This is me (4 years old), pointing at the rocky surfaces of the red planet.

Here I am 7, and this is a picture of me in the LA Times flipping & spinning upside-down down at SpaceCamp in Huntsville, Alabama

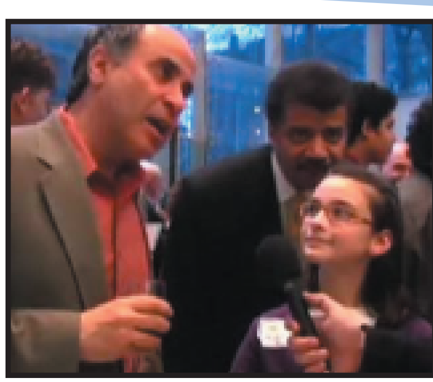


Photo: Landmark Pictures & Sound

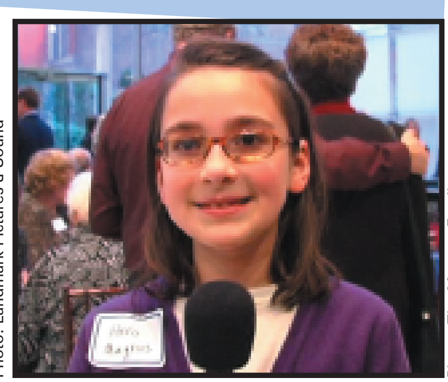


Photo: The Magnus Family

University Rover Challenge Update

By Kevin Sloan

The Challenge:

For the fourth year, teams of university students will design and build the next generation of Mars rovers. From June 3-5, 2010 the teams and their rovers will face off at the Mars Desert Research Station in Utah.

The Prize:

The winning team will win transportation, lodging and admission for 5 team members to the 13th Annual International Mars Society Convention in Dayton, Ohio this summer, and large cash prizes. Connect with URC on Facebook http://www.facebook.com/group.php?gid=32010099179&v=wall

This June, the largest and most geographically diverse field of teams to date will descend upon the Mars Desert Research Station (MDRS) in Utah USA for the 2010 University Rover Challenge (URC). Twelve teams from the United States, Canada, Poland, and Italy, will all have one goal in mind - taking home the title of URC Champion.

Last year's winner, York University, performed well in all events, which has set a high bar for the teams competing this year. The 2010 teams will face not only formidible competition, but also two new tasks - a Sample Return Task and an Equipment Servicing Task. Both events will demand extraordinary finesse on the part of the rovers, and sheer determination on the part of the teams. However, as the competition events get more difficult from year-to-year, the student teams continually rise to the challenge.

Future human explorers on Mars will be dependent upon their robotic counterparts; and as these students are proving, the technology is ready. The only limit at URC is how difficult a challenge the judges can devise.

For more information on the University Rover Challenge, please visit:http://www.marssociety.org/portal/c/urc

Miracle of Flight

A Profile of Musician Michael Hyden

Mike Hyden grew up in Tulsa, Oklahoma, and has been writing music for over 30 years.

He has won numerous contests and awards over the past couple of decades. He wrote a version of his song "The Miracle of Flight" for the Mar's Society's 2004 Song Contest. He was working overseas then and could not get back in time to get it recorded before the contest's deadline. The original song can be heard at:

http://mikehydenmusic.homestead.com/MIRACLE-OF-FLIGHT.html

After moving to Nebraska and after watching a show about Nebraska Astronaut Clay Anderson, he sent the song to Clay's wife, Susan, who also works for NASA. She requested the song be played for her husband on his last shuttle mission, in the NASA tradition of playing songs to the flight crews to wake them up each morning. She says it sums up Clay's life. On April 13, 2010, Flight Day 10 of the Discovery shuttle mission STS-131, the song was played for Mission Specialist Clayton Anderson while the shuttle was docked to the International Space Station. The actual NASA broadcast can be heard at: http://www.spaceflight.nasa.gov/gallery/audio/shuttle/sts-131/html/ndxpage1.html

If you would like more information about Mike's music, he can be reached at: mikehydenmusic@aol.com

The STS-131 crew members pose for a portrait in the cupola of the International Space Station. Pictured counter-clockwise (from top left) are Commander Alan Poindexter, Pilot James P. Dutton Jr. and Mission Specialists Dorothy Metcalf-Lindenburger, Rick Mastracchio, Naoko Yamazaki, Clayton Anderson and Stephanie Wilson. Image credit: NASA

Progress of the Mars Balloon Project ARCHIMEDES of the German Mars Society (MSD)

By Jürgen Herholz

ARCHIMEDES, the Mars balloon project of the German Mars Society (MSD) consists of a Mars Balloon Probe, a 10-m balloon carrying an instrument pod, and the associated balloon storage and deployment system. ARCHIMEDES will travel to Mars onboard a satellite and then be released for its Mars entry and descent mission, while the satellite remains in Mars orbit. The balloon will be inflated in free space around Mars, then the Mars Balloon Probe will be separated from the inflation system, enter the Mars atmosphere and descend slowly down to Mars while sending scientific measurements via the orbiting satellite to Earth.

So far extended flight testing under low gravity conditions was performed with the objective of verifying the scientific hypotheses and conclusions and the resulting design of ARCHIMEDES. In 2005, the critical balloon deployment system was successfully tested during short parabolic flights and later in 2006, during a sounding rocket campaign.

In October 2008, a full system test was performed with the flight test vehicle MIRIAM, a 1:2.5 downscaled flight test model of ARCHIMEDES. MIRIAM was launched on a REXUS 4 sounding rocket of DLR-Moraba to a 170 km altitude in Kiruna, Northern Sweden. The MIRIAM mission should simulate the ARCHIMEDES mission in the higher Earth atmosphere at conditions similar to the Mars mission.

Fig.1 shows the mission scenario; Fig.2 the MIRIAM flight model prior launch; and Fig.3 the inflated 4-m balloon with the instrument pod (merely visible due to its size of approx. 30 cm diameter, compared with the 4-m balloon).

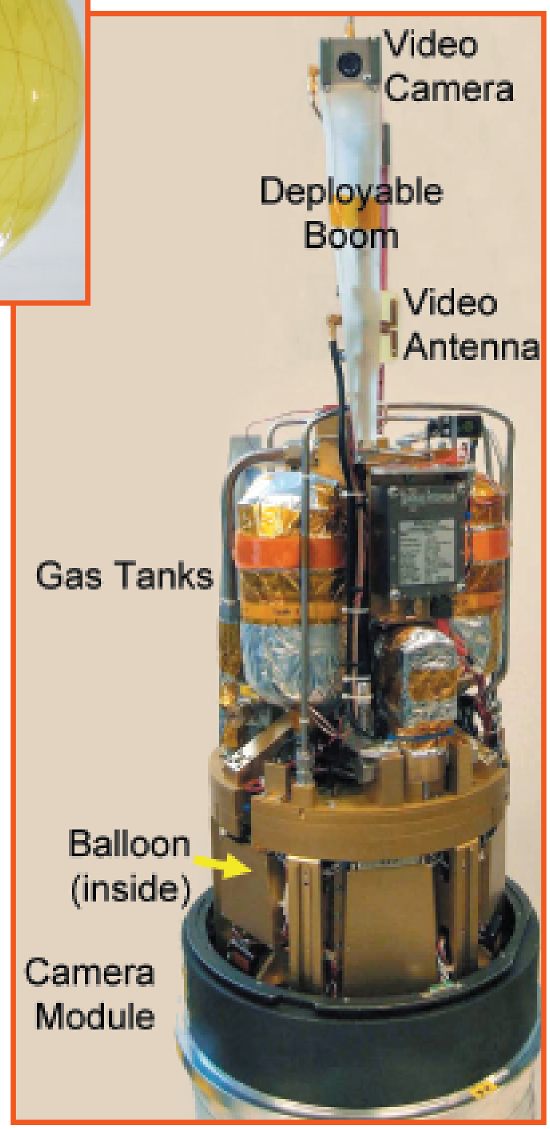
MIRIAM was developed by the MSD in cooperation with the University of the German Armed Forces in Neubiberg and IABG in Ottobrunn, both near Munich.

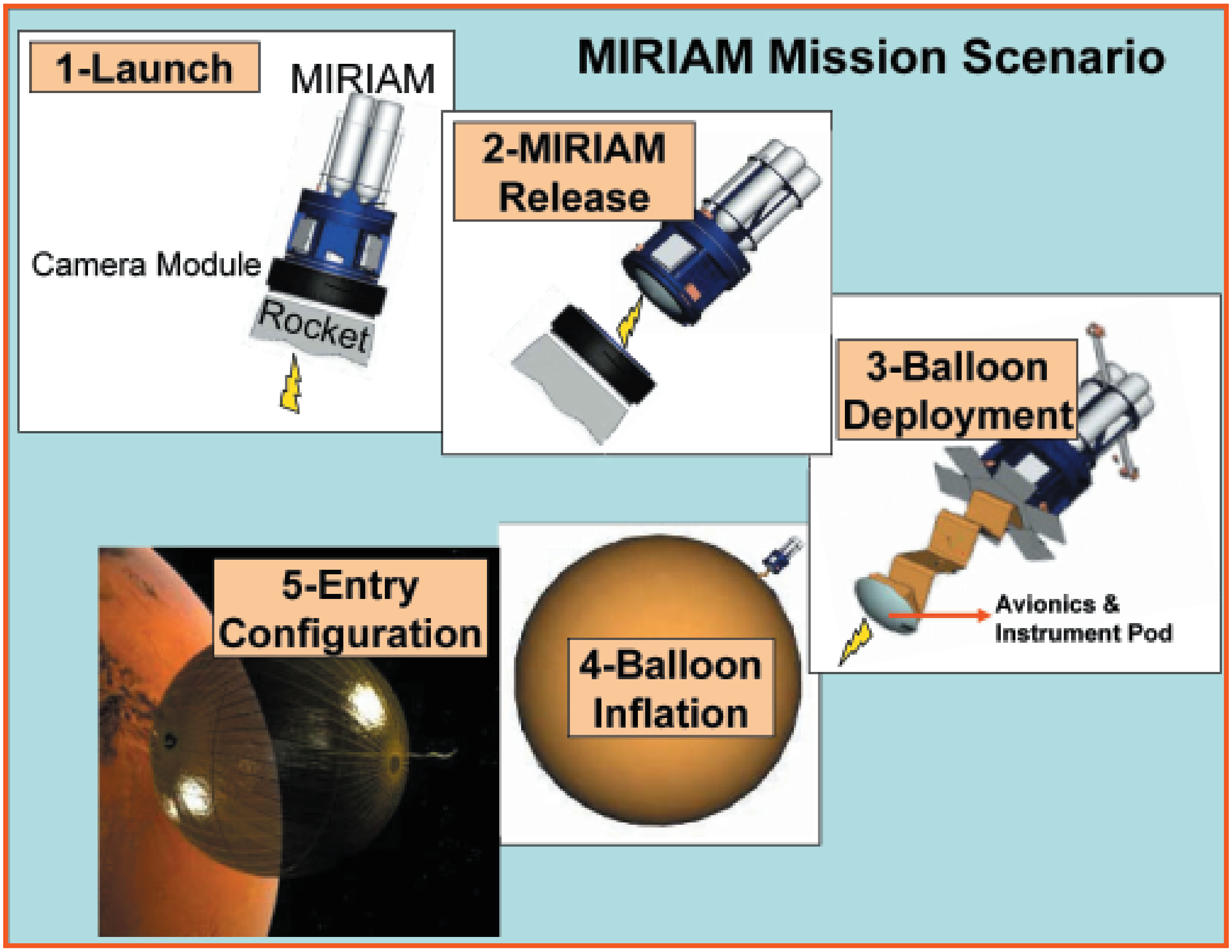
Unfortunately, the MIRIAM flight test was only a partial success due to late separation of the MIRIAM flight vehicle from the REXUS 4 carrier. This led to the disturbance of the subsequent mission sequence, resulting in only a partial inflation of the balloon and its off-nominal release. No data were received subsequently from the electronics pod of the balloon.

Although the MIRIAM mission did not produce the data expected on the balloon entry behaviour, the very complex balloon storage, deployment, inflation and release system worked as planned. The MSD decided therefore in early 2009 to maintain the basic MIRIAM design and experience for another similar mission, called MIRIAM-2. The entry part, consisting of the balloon with the electronics unit, is now called MIRIAM-B. Its development began in mid-2009 with the objective of a launch in 2013.

"Lessons-learned" changes, which will be introduced for MIRIAM-2, include the replacement of the separation system by a proven design, an update of the electronics systems, and the provision of an access capability to the instrument pod electronics and batteries without disassembly of the vehicle, allowing late access to the batteries and electronics in case of launch delays, or for test purposes. Mission objectives will be enhanced by adding additional sensors, a GPS, and an internal camera monitoring the balloon behaviour during entry. Modifications of the balloon manufacturing techniques used in MIRIAM-2 will be closer to the ones that will be used for the Mars mission.

Discussions are underway with the provider of the launcher and launch services, DLR-Moraba in





Oberpfaffenhofen near Munich, for a possible launch in 2013.

The Mars Society Germany is very much looking forward to the MIRIAM-2 flight test as an indispensable stepping stone to the ARCHIMEDES Mars mission, which may then take place in 2018 at the earliest. The results of the MIRIAM-2 mission will indicate whether additional tests are required.

Jürgen Herholz, Dipl.-Ing.
Email: Juergen.Herholz@Marssociety.de
Mitgliedschaft/Membership:
-VFR (Verein zur Förderung der Raumfahrt)
-Mars Society Deutschland-MSD (Vorstandsratsmitglied-Member of the Consultation Board)
-Mars Society (USA)
-Association Planète Mars (Frankreich)

Used with permission - Randall Munroe - http://xkcd.com/

Organic Geochemistry and the Exploration of Mars

Mark A. Sephton, Ph.D.
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Photo: Imperial College of London

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Abstract

The Red Planet provides a relatively accessible world on which theories of life's diversity and origin can be tested. Such examinations are imminent with a number of missions to Mars forthcoming. These missions contain several life detection instruments that will sample the surface and subsurface. Organic geochemical knowledge from terrestrial studies can inform our search for organic matter in Mars rocks. Recent data on Mars minerals and atmospheric gases suggest which methods may be most useful to access any organic records present. A mineralogically-diverse Mars provides varying opportunities for the preservation of past and present life. Extinct or extant life will occupy specific size fractions that must be targeted. Studies suggest that methane is most likely derived from the subsurface. Even if abiotic in origin, the combination of reduced gases and oxidised minerals provides opportunities for life. In the near subsurface methane may be polymerised by cosmic radiation to form abiotic organic matter. This paper considers terrestrial approaches that may be useful in a Martian context.

Keywords: Mars, Organic, Geochemistry, Minerals, Radiation

1. THE SEARCH FOR ORGANIC MATTER ON MARS

Mars is Earth's nearest planetary neighbour and it is unsurprising therefore that effort to find life outside the Earth focuses on the Red Planet. Yet Mars has environmental conditions that are distinct from the Earth. Mars is cold and dry with a thin atmosphere. Liquid water, the solvent of life, is not stable at the planet's surface. Under Martian conditions water passes directly from ice to gas, a process termed sublimation. Moreover, the lack of a magnetic field ensures that the Martian surface is subjected to levels of radiation not generally seen on the Earth.

The search for life on Mars therefore presents particular challenges. The harsh conditions on Mars will ensure that any extant life will have adaptations similar to those found in extremophilic organisms on Earth. Extant life, if present, is also likely to exploit the subsurface environment which provides more equable conditions than those at the surface. The subsurface is also important because evidence of Mars life may be present in fossil form, entombed in sedimentary rocks. Conditions on Mars were more conducive to life in the early history of the Red Planet. Liquid water was once widespread on the Martian surface and these conditions coincided with the probable timing of the origin of life on Earth.

2. PRESERVATION OF ORGANIC MATTER ON MARS

Organic geochemical principles can be used to inform life search protocols. Organic geochemistry deals with the influence of life on rocks, including the production of organic matter, its preservation and modification in the subsurface, and the interpretation of the consequent organic records in sedimentary sequences. The preservation of life's remains occurs through a complex series of processes involving degradation, selective preservation and adsorption on mineral surfaces, all of which depend on the physical and chemical environment of deposition.

The cold and dry climate of Mars has an effect on the preservation of organic matter. Amino acids for example suffer decarboxylation (removal of the acid functional group) rapidly under terrestrial conditions at 25 °C. Yet at colder temperatures destruction becomes exponentially slower. For instance, at 0 °C the half life for this process is between 0.8 and 1.1 Ga and at -20 °C the half life increases further to between 2.3 and 220 Ga (Aubrey et al. 2006). Notably this duration exceeds the age of Mars itself suggesting that in some cases remnants of life may survive better on Mars than Earth.

In chemical terms, however, life usually differs from fossil life quite dramatically and the search for fossil life on Mars must be cognisant of this fact. Extant life is dominated by macromolecules but not all of these entities or their sub-units resist degradation at the same rate. On Earth, within days to weeks, bacterial degradation removes delicate macromolecules such as nucleic acids and proteins. Simple organic molecules that are important energy providers such as amino acids, sugars and short-chained carboxylic acids are also lost on this timescale. Within months to years unresistant macromolecules such as polysaccharides are removed, leaving only the lipids to persist for periods of thousands to millions and even billions of years. It must be noted however, that the degradation rates mentioned reflect the presence of protein catalysts called enzymes which can accelerate the process by a factor of 1017(Wolfenden et al. 1998). In the absence of enzymes, days become hundreds of years and years become millions of years. In either case, it is the lipids that represent the most likely organic matter to be encountered on Mars (Table 1).

3. THE LIPIDS OF MARS

With lipids representing the most

Table 1. Biomacromolecules associated with prokaryotic organisms arranged according to their preservation potential. Adapted from Tegelaar et al. 1989. Values in the original paper ranged from - (extensive degradation under any depositional conditions) to ++++ (no degradation under any depositional conditions).

Biomacromolecule	Occurrence	Preservation potential
Lipopolysaccharides	Lipids and polysaccharides joined by a covalent bond commonly found in the outer membrane of some bacteria.	++
Glycolipids	Lipids and carbohydrates joined together to form energy stores for some bacteria.	+/++
Teichoic acids	Polysaccharides of glycerol phospate or ribitol phospate found in cell wells of some bacteria.	+
Lipoteichoic acid	Teichoic acids with long chains of ribitol phosphate which are attached to lipid membranes.	+
Murein (peptidoglycan)	Polymer of sugars and amino acids present on outside of bacterial membranes.	+
Dextran	Branched polysaccharide in certain bacteria comprising glucose units.	+
Proteins	Amino acid polymers with many functions. They are found in all organisms.	-/+
Cellulose	Polysaccharide of 10^2 to 10^5 glucose units. Acts as the structural component of cell walls of plants and algae and biofilms of bacteria.	-/+
Glycosaminoglycan (mucopolysaccharides)	Unbranched polysaccharides consisting of a repeating disaccharide unit that occurs in some bacteria	-/+
Polyhdroxyalkanoates	Polymer of 3-hydroxyacid units that represent energy stores for bacteria. Exist as cytoplasmic granules.	-
Nucleic acids	Macromolecule that hosts genetic information in all organisms.	-
Starch	A polysaccharide with glucose units joined by glycosidic bonds. Used by all green plants as an energy store.	-

stable molecules in sedimentary rocks it is appropriate to consider the information they could provide if encountered on Mars. Biological markers or "biomarkers" are lipids that represent a rich source of information on source organisms, environmental conditions and subsurface conditions following deposition. Even the simplest interpretation of lipid biomarkers would provide important information on Mars (e.g. the domain of life to which the source organism belonged).

All known living organisms have

Table 2. Lipid biomarkers of the three domains of life.

Domain	Characteristic membrane molecule	Synthesis conditions
Archaea	Isoprenoids	Oxygen not required
Bacteria	Hopanoids and fatty acids	Oxygen not required
Eukarya	Steroids and fatty acids	Oxygen required

lipid membranes. Table 2 list the characteristic membrane molecules found in organisms of the three domains. These molecules have additional units attached at their polar ends (e.g. phosphates or sugars). Isoprenoids, hopanoids and steroids have similar biosynthetic pathways and represent progressive evolutionary adaptation. The Archaea have isoprenoidal structures, bacterial membranes have fatty acid layers with hopanoids that help modify membrane rigidity. Eukaryotic membranes contain steroids in the place of hopanoids. Importantly, the biosynthesis of steroids requires aerobic conditions (Summons et al. 2006). Such conditions never existed on Mars so it would appear unlikely that steroids will be part of any inventory of biomarkers in Martian rocks.

4. THE SIZE FRACTIONS TO SAMPLE

Preparation of rock or soil samples for analysis on Mars may require some form of drilling, crushing, grinding or sieving (e.g. Beaty et al. 2005). These important first steps must be performed carefully so as to not introduce any sample bias or to render the samples unsuitable for organic detection. Terrestrial procedures provide a valuable insight into the effects of preparation steps but fundamental differences are likely to exist between organic matter on Earth and any counterpart on Mars.

Organic matter in terrestrial rocks is distributed across a number of size fractions. The relative contributions of particular organisms to these size fractions is well known in palynology where samples are screened to isolate the larger, most information rich and morphologically recognizable organic entities. Inevitably these are Eukaryotic organisms and Bacteria and Archaea rarely produce palynomorphs (Traverse 2007).

Microscopic Eukaryotes, Bacteria and Archaea contribute to what is called "amorphous" organic matter which resides in the smallest size fractions in rocks and is often removed in palynological preparation steps. Organic geochemical analysis of palynological size fractions has revealed the chemical consequences of screening by size with Eukaryotic remains, such as land plant debris, dominating the larger size fractions (Sephton et al. 2005).

Bacterial and Archaeal signals are the most likely responses from organic investigations on Mars. These organisms have diameters between 500 nm and 2 ?m. Their small size ensures that their biochemistry is simple with cellular processes that are not compartmentalized into organelles. This lack of complex parts provides benefits in extreme environments because there is little to fail under environmental stress. More complex organisms are most likely precluded by the extreme conditions on Mars. Martian organic signals therefore will be derived from the finest, i.e. in practice <10 ?m, size fractions of Martian rocks.

5. THE MINERALS OF MARS

The OMEGA/Mars Express imaging spectrometer has recognized mineralogically and temporally-distinct areas on Mars (Bibring et al. 2006). Some of the most ancient rocks on Mars contain phyllosilicates produced during early wet conditions on the Red Planet. Less ancient rocks contain sulphates generated by aqueous conditions that were markedly acidic. The least ancient deposits are characterized by ferric oxides in a liquid water free environment. The three types of deposit have been used to define three sequential eras on Mars, namely the "phyllosian", the "theiikian" and the "siderikian" eras (Bibring et al. 2006). Each era reflects distinct environmental conditions that would have had a major control on the probability of life. The earliest liquid-water rich era would represent the most habitable conditions and the latest anhydrous era the least habitable.

The different rock types from the three eras will also affect how any organic matter may be preserved. Terrestrial organic-inorganic relationships provide hints as to how such associations may occur on Mars. Ninety percent of Earth's organic matter accumulates in coastal margins and is intimately associated with mineral surfaces. Studies suggest that organic contents are directly related to mineral surface area and imply monolayer coatings that provide mean values of 0.86 mg Corg m-2 (Meyer 1994). Once adsorbed organic matter is relatively sheltered from degradation and this process is so efficient that 80% of organic matter on minerals can be irreversibly adsorbed (Hedges and Keil 1995). If monolayer adsorption is in operation on Mars then the three types of deposit will be characterized by differing preserved organic contents.

Surface areas of Martian mineral

Table 3. Minerals

Mineral	Surface area m^2/g	Concentration mg/g	Irreversible mg/g
Ferrihydrite	134	120.6	76.3
JSC Mars-1	106	95.4	96.5
Smectite	52.7	47.4	37.9
Dunite	2.8	2.6	2.0
Volcanic tuff	13.7	12.3	9.9
Volcanic tuff & Mg sulfate (1:3)	11.3	10.2	8.1

analogues were calculated by Pommerol et al. (2009) and the data can be used to predict monolayer organic contents (Table 3). It is clear that phyllosilicates are particularly important minerals for the entombment and preservation of organic matter. Phyllosilicate formation requires water and therefore conditions that are conducive to life. Moreover, phyllosilicates and organic matter are hydrodynamic equivalents indicating that they settle from water at the same locations. Once juxtaposed, the high surface areas of phyllosilicates provide ample sites for organic adsorption. Hence, phyllosilicates provide a combination of relatively promising opportunities for life and a high probability for the preservation of its remains. Such deposits therefore are important targets for life search missions.

6. MARS METHANE

In 1965 James Lovelock suggested that life produces atmospheric gases that are incompatible on a long term basis (Lovelock, 1965). The apparent absence of a non-equilibrium situation in the Martian atmosphere was a setback for life detection studies. Yet recently just such a non-equilibrium system has been recognized and methane has been detected in the atmosphere of Mars. Earth based telescope observations reveal an average concentration of 10±3 ppbv (Krasnopolsky et al., 2004), while the Planetary Fourier Spectrometer on the orbiting Mars Express spacecraft provides concordant data at 10±5 ppbv (Formisano et al., 2004) and 14±5 ppbv (Geminale et al., 2008).

Calculations for the lifetime of methane in the Martian atmosphere suggest durations of approximately 300-600 yr (e.g. Atreya et al., 2007). The annual resupply of methane needed to maintain the Martian atmospheric abundance is approximately 126 tonnes if estimated methane loss near the surface is considered (Atreya et al., 2007; Formisano et al., 2004), and 270 tonnes if the estimate is widened to accommodate methane loss throughout the entire atmospheric column (Krasnopolsky et al., 2004).

Potential sources of Martian methane include life (Krasnopolsky et al., 2004), serpentinization of ultramafic crust (Atreya et al., 2007; Oze and Sharma, 2005), recent volcanism (Neukum et al., 2004) and ablating meteorites/comets (Court and Sephton 2009). Volcanism appears unlikely to be a major contributor because of the absence of hot spots recognised by the thermal emission imaging system (THEMIS) on the Mars Odyssey orbiter (Christensen, 2003) and the paucity of the gaseous consort of volcanic methane, sulfur dioxide, as implied by spectroscopic investigations (Krasnopolsky, 2005). Methane has been measured in carbonaceous chondrites at only 0.14 ppm (Butterworth et al., 2004) but much more could be generated by degradation of the gas prone macromolecular organic fraction that these objects contain at percentage levels. Recent experimental studies, however, have demonstrated that meteorite or cometary addition and ablation is also an implausible source of Martian methane producing only 10 kg of the required 270 tonnes each year (Court and Sephton 2009).

7. SUBSURFACE METHANE ON MARS

With the direct injection of methane into the Martian atmosphere, either by meteorite/comet ablation or volcanic activity ruled out, it becomes seemingly unavoidable that the methane is sourced from the subsurface. If the source is biological and represents a form of methanogenic microbe then these subsurface sites are important scientific targets.

If the source of methane is serpentinisation then opportunities for other forms of life exist in near surface sites and their scientific importance remains high. Serpentinisation occurs at temperatures of 40-90 °C which are believed to occur at a depth of 2 km on Mars, with liquid water being stable at depths of 2-20 km (Oze and Sharma, 2005; Atreya et al., 2007). Any abiotic methane derived from serpentinisation must rise through at least 2 km of Martian material to reach the atmosphere and en route to the surface the methane would encounter oxidants including sulphates and ferric iron.

This redox situation presents metabolic opportunities for life similar to those observed around methane seeps on Earth where anaerobic methanotrophic Archaea gain energy exclusively from the anaerobic oxidation of methane with sulfate as the final electron acceptor (Hinrichs et al. 1999). Microbial utilization of methane is not inconsistent with its passage to the atmosphere and in terrestrial seep analogues not all methane is removed by the microbial community and up to 80% of methane can escape to the atmosphere (Wegener et al. 2008).

Upwardly percolating subsurface methane would also have other effects on Mars. Organic matter is hydrogen-rich and as such is preserved best in oxygen free environments. On Earth, aerobic respiration occurs rapidly in oxygen-rich surface environments. Aqueous environments are more conducive to anoxia and are often the sites of enhanced organic preservation when decomposing organic matter exhausts the supply of oxygen. Methane sourced in the Martian subsurface may provide similar opportunities for enhanced organic preservation. The upward percolation of methane through the Martian subsurface would promote more reduced conditions in which organic matter is protected from degradation.

8. RADIATION EFFECTS ON MARS

Solar energetic particles and Galactic cosmic rays impinge on the Martian surface owing to the lack of a magnetic field which would shield the planet from radiation. The harsh conditions on the Martian surface ensure that the search for life on Mars is beginning to focus on the subsurface. Organic matter is transformed by radiation but at depths below two meters the radiation flux is substantially attenuated and preserved material may be encountered (Kminek & Bada 2005). Yet transformation does not always mean destruction and radiation can immobilize organic compounds providing records of past organic fluxes.

New insights into the effects of radiation chemistry in organic matter-containing rocks have been provided by studies of terrestrial organic residues that appear to have formed from the trapping of methane around radiation-releasing mineral grains that contain small amounts of uranium and thorium (Court et al. 2006). Radiation energy cleaves molecules, the products of which are highly reactive and readily combine to generate new, more complex compounds. For passing methane, progressive radiolytic alteration produces an organic solid comprising of larger organic units. Unsurprisingly it is the highly stable polycyclic aromatic hydrocarbons that dominate the resulting intractable organic material. Such organic deposits may be present in the very near subsurface above methane producing regions on Mars and their extent could indicate the duration or magnitude of methane generated through time.

In addition to polymerizing methane in the Martian subsurface, radiation could also produce de novo abiotic organic matter. The work of Calvin and co-workers (Garrison et al. 1951) revealed that high energy particle radiation reflecting cosmic rays or radioactive radiation can produce low yields of organic compounds from carbon dioxide and water. Existing knowledge of the Red Planet and data from the Neutron Spectrometer instrument of the Mars Odyssey spacecraft's Gamma Ray Spectrometer instrument suite imply that all three of these components are present at high latitudes on Mars (Mellon et al. 2004) and could provide an additional, small but continuous, source of non-biological organic matter in the near subsurface of Mars. Radiation, it appears, may be an important generator of relatively accessible non-biological organic matter on Mars.

9. TESTING THE HYPOTHESES

The European Space Agency (ESA) is planning the ExoMars mission for robotic in situ analyses of Martian soil for the presence of life's chemicals. Current proposals are for a drill to collect samples of Martian soil at certain depths. Access to the near subsurface of Mars initiates a number of newly testable hypotheses as described above. Results from the near subsurface provided by ExoMars may reveal an organic record containing evidence of past or present life, mineral-organic interactions, radiation-induced polymerization, or combinations of all three.

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