TRASH, TREASURE OR TIME STUDIES?
A Proposal for Cataloging the Long-Term Effects on Earth Materials Exposed to Martian Surface Environments

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A SCIENCE EXPERIMENT NOW IN-PROGRESS

Since 1971, soft and crash landings have deposited human made materials on the surface of Mars. These materials are now undergoing "long duration exposure" to the Martian environment. In the future, when humans visit and live on Mars, these presence of these "alien" materials could provide important data on the effects of long-term exposure to the Martian environment on various engineered materials, as well as data on the short-term rates of change of various conditions in the Martian environment (sand transport, weathering rates, damage rates from ultraviolet radiation, etc.)

Earth-made materials are unique in the Mars environment. They come from Earth, having been produced by human ingenuity. They are not found anywhere else on Mars, and they will interact with Mars over time in ways that we cannot fully predict. The Viking lander investigations during the 1970's concluded, "The Martian surface is a type of iron-rich clay that contains a highly oxidizing substance that releases oxygen when it is wetted."1 Even after 30 years of direct robotic investigations, the essential physical and chemical nature of the Martian surface remains unclear to us.

Mars differs from Earth in many fundamental ways; it has a lower mass, average temperature and gravity, it has a thinner atmosphere, is further from the Sun, and has different chemical composition, geologic processes, and weather patterns. Many of these differences cannot be readily or reliably simulated on Earth. Therefore studying Human Made Materials (HMM) in the Martian environment should offer many surprising discoveries.

M.E.M.E.A.: Martian Earth Materials Exposure Archive

The central purpose of this article is to propose the creation of a project or program to gather information from all of the missions and materials sent from Earth to Mars, to document and format that information in a coherent manner, and to transport copies of the archive in a durable and recoverable format to the surface of Mars, making it available a reference to aid future Martian explorers.

By ensuring that one or more sets of this information arrives safely to Mars, we simultaneously produce the first "publication" to be distributed on Mars, and more importantly, we provide future Martians with information essential to locating, identifying and understanding the engineered materials transported to their world from Earth during these "early days" of Mars exploration.

HOW MANY HMM SITES ON MARS?

There are a variety of sites of HMM presently exist on Mars, some more readily studied than others.

1. There are five successful landing sites, which are well known and documented; Viking 1 and 2, Pathfinder, Mars Exploration Rovers 1 and 2, which are all from the USA.

2. There are also five unsuccessful landing sites; Mars 2, 3 and 6 from the USSR, Mars Polar Lander from the USA, and Europe's Beagle 2 lander. In general, their locations are not precisely known. Much like exploring archeological sites and ship wrecks on Earth, interesting research awaits on Mars. Finding each of these Martian sites might help reveal their causes of failure, and will provide future detectives with interesting cases to solve.

3. Every landing attempt (both successful and unsuccessful) creates a number of secondary sites with artifacts such as heat shields, back shells, parachutes, landing platforms, etc. Some of these sites have been located, as with the parachutes and back shells for the 2004 Mars Exploration Rovers missions2, while others remain unknown.

Part of the difficulty with the Martian environment is that fairly quickly, objects on the surface will become hidden, cloaked in dust carried by the atmosphere. A human explorer passing a collapsed parachute might not recognize it when coated with 40 years of dust. Documenting the locations for these items now would be extremely helpful in relocating them later.

4. The most difficult to locate of all HMM sites on Mars might be those from orbiters or fly-by missions that have eventually entered the Martian atmosphere and had a portion of their mass survive to impact on the planet's surface.

On Earth, items launched into space often successfully reenter Earth's atmosphere and can return to the surface.3 Given the lower gravity and thinner atmosphere of Mars, it seems likely that components from many Mars-orbiting spacecraft could survive the plunge into the atmosphere, even if not designed to do so. Even early "fly-by" missions might eventually find their way back around the solar system and to the ground.4

Since no NORAD-type system exists on Mars for monitoring orbiting objects and tracking their entries, future Martians may find these types of remains the most difficult to identify and catalog.

Thus, as of 2005, Earth missions may have created from 30 to 60 sites of human made materials on the surface of Mars.5 With future missions to Mars adding ever more items, we will have a growing number of locations to find, study and learn from.

We can help future investigators by gathering basic documentation on each of the spacecraft sent to Mars, include images of orbiting and landing crafts, drawings of their interior components and major subsystems, lists of materials and composition, descriptions of orbital parameters and landing sequences, and other details that could help in identifying found artifacts.

WHAT KINDS OF HMM ARE UP THERE?

What kinds of materials have we sent to Mars? The list includes nearly the entire list of aerospace worthy elements and compounds: metals, plastics, rubbers, composites, adhesives, conductors, insulators, shape memory alloys, and even radioactive isotopes.

As a rule, all materials sent to Mars have been rigorously studied in Earth and space environments, and well understood. But since the chemical nature of the Martian surface remains only partially characterized, and many other conditions operate beyond normal Earth conditions, can we truly know how various materials will change over time on Mars?

<u>Example 1. Rare Material</u>

A short length of Flexinol shape memory alloy wire (a trained nickel-titanium material that changes properties at different temperatures) was used as an actuator on the MAE experiment aboard the Pathfinder Sojourner rover. These alloys are well characterized and highly resistant to corrosion and thermal stresses, but they can be susceptible over time to hydrogen embrittlement and some effects of radiation.

The wire functioned flawlessly during the rover's mission, but might the surface of Mars cause changes in it over the long term? At present, there exists only one sample of this material on Mars undergoing this long duration test.

<u>Example 2. Hazardous Material</u>

Compounds containing isotopes of plutonium and curium have traveled aboard all five of the successful Mars landing missions as heat and energy sources, as well as some of the less successful missions. On Earth, the use and distribution of these materials are carefully regulated. As some have half-lifes of thousands of years, we can fully expect that collectors of HMM on Mars will one day encounter these isotopes. We have a responsibility to document the presence of these materials in order to alert future explorers so they may handle them appropriately.

WHAT'S IN IT FOR US?

By studying HMM on Mars, future investigators might find answers to important material science questions including:

- How do various engineered materials interact with the Martian environment?
- How quickly do they change over time?
- How do they fail or become unreliable?

- How might material failures affect long-duration Martian missions and the lives of colonists?

- As we know the precise arrival dates for many of the human-made objects at the surface of Mars, researchers have the opportunity to answer important environmental science questions like:

- How does dust accumulate and move over the seasons and during storms? (How much dust rests atop a parachute?)

- What are the rates of transport of heavier surface materials? (How much sand has collected inside a lander foot pad?)

- What are the weathering rates for various exposed native surface materials? (How do the surfaces of rocks, covered by a heat shield for many years, differ from nearby rocks still directly exposed to the environment?)

Indeed every object deposited on the surface of Mars is potentially a miniature Long Duration Exposure Facility. Therefore, each and every piece of Human Made Material continues to have scientific value by its very presence on Mars. And the future value of these experiments can be greatly increased by knowing as much as possible about the materials' origins, processing, proximity to other materials, date and method of landing, and so on.

WHY NOW?

Why undertake this project now? Why bother with creating and sending follow-on documentation to Mars at all?

1. Time. We have the information now. Loss of data, documentation and supporting knowledge will occur with time. Forces including fire, famine, revolution, the ravages of time, foibles of bureaucracies, the change of empires and the cleaning of closets. Indeed, what do we know about the status of the Soviet Union's space archives today? Of NASA's?

2. Human memory. Many of the original developers of those early missions are still alive and available to help. Again, time will change that.

3. Feasibility. The steps of gathering data, designing databases, vetting information, and generating archival copies destined for Mars, all perfectly fit the limited budgets and human resources for a vital but small-scale project.

If we assume that humans will one day follow our robotic missions to Mars, then we should consider this project as a priority. And the longer it takes for humans to arrive at Mars, the more urgent the need for compiling and studying the information available to us now. Because if we wait, if we put off the documenting of our Mars exploration efforts thus far, if we leave it to another generation, to another age even, then much vital information and opportunity will be lost forever.

WHO?

If we value our Mars efforts thus far, then MEMEA must be done soon. But by whom? The scope of the MEMEA project seems too small to interest NASA or any of the national space agencies, but the project urgently requires their cooperation and assistance in both the gathering of information and its delivery to Mars.

Current technologies and the relative ease of international communications make this project an ideal program for many smaller organizations, for several reasons.

First, MEMEA is not a big-budget project. It will not require a large staff or complex bureaucracy. Essential roles include a head librarian or curator position, editors, research assistants and translators, database specialists, image processing technicians and production task supervisors. Second, it provides a direct, space-focused project with a well-defined goal. Third, it is a "frontier enabling" project, one that can directly help with the survival of future Mars colonists. And lastly, it could generate many income-producing products for the sponsoring group or organization. The data could become the source for books, DVDs or interactive media exploring "All Mars' Spacecrafts."

Ideal candidates for supporting, coordinating and promoting a MEMEA project include:

- Public space groups interested in space exploration, Mars settlement and the future in general.
- History, Library Science or Engineering Departments at major universities, where a MEMEA program could serve as excellent projects for graduate and undergraduate students, with the results of their work geared not only toward publication, but destined for another world.
- Private, space-oriented companies or ventures interested in Mars, including those with an interest in publishing, multimedia, and space oriented products. "The First Publication on Mars" might provide a good publicity hook, whereas the contents of the MEMEA database could generate additional commercial or research products.

WHY SPACE AGENCIES SHOULD SUPPORT MEMEA?

Though a MEMEA project may be too small to be performed directly by any of the governmental space agencies, their cooperation will be essential. Making it easy for them to say yes, and hard to say no, will be the key to making it happen. A MEMEA project offers many features that should prove attractive to the agencies.

The MEMEA database and related software tools could be stored on stack of DVD-type disks (designed and prepared for long term survivability) and packaged in a sealed enclosure with a total mass of under 100 grams - a minor addition to any Mars landing mission.

In essence, by gathering documentation now, and then forwarding it to the Martian surface in durable, recoverable forms, at every available opportunity, we can:

1. Continue to extract new scientific value from our space investments
2. Help in gathering new knowledge about the Martian environment
3. Aid future explorers in surviving the harsh Martian conditions
4. Show a level of ecological responsibly regarding the materials already delivered to Mars and destined to remain there
5. And perhaps most importantly to the large space agencies, a MEMEA project provides a "high concept" publicity vehicle promoting space exploration. It gives space agencies a low cost, ecologically and scientifically minded event demonstrating their long-term vision, and generating public excitement and positive attention for the space programs.

By sending this "message in a bottle" destined to be read by future Mars colonists, a MEMEA program can create publicity and positive attention for the large space agencies today, while simultaneously inspiring the explorers of the future.

PROPOSED PROCEDURE

The phases and timing of the MEMEA project can look something like this:

1. Identify various organizations capable of funding, organizing and supervising the gathering and collation of information.
2. Involve interested experts as advisors, facilitators and guides.
3. Contact relevant agencies for access to required information.
4. Develop databases, gather information, edit, format and present information (much of it via the internet and colaborative work tools).
5. Arrange for ruggedized archival copies to be packaged and delivered to Mars.
6. Develop spin-off products for commercial distribution.

Obviously, for a Martian colonist who has just found an unidentified piece of spacecraft out on the dusty plains, the best place to get information about past missions to Mars is NOT in some dusty microfilm catalog back on Earth, but on Mars, in some format that can be readily accessed.

Determining the format for information storage, delivery and recovery requires balancing multiple considerations, much like those faced by computer data archivists around the world, or by SETI researchers envisioning how to understand communications from alien intelligences from across the vast reaches of time and space. Attempting to communicate with our own descendants could prove nearly as challenging.

WHEN DO WE START?

The next scheduled missions to the Martian surface are scheduled for launch in 2007 and landing in 2008.

- The United States, "Phoenix" mission plans to place a lander near the Martian north pole.

- Europe plans the "Netlander" mission with an orbiter and four separate landers (four chances to place a MEMEA archive on the Martian surface!)

<u>Time line</u>

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 Fund          Gather Data          Format       Launch
|------------|------------|------------|
       2005               2006              2007
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In three years, the MEMEA project could produce an initial database of Mars spacecraft missions and materials, which could then be distributed to world space agencies for shipment and delivery to the surface of Mars.

Thus, by 2008 five locations on Mars could be seeded with important data archives about Earth materials sent to Mars. The MEMEA project could be continued and maintained by the interested parties, with future editions being shuttled to Mars at each available opportunity.

CONCLUSIONS

The planet Mars, without readily available air, water, shelter or food, will present future settlers with challenges of magnitude beyond those faced by Earth-bound human explorers and settlers.

Humans choosing to live on Mars will need every advantage they can obtain. Foreknowledge of how human manufactured materials fare in long term exposure to the Martin surface environment could mean the difference between life and death.

Perhaps we ourselves, our children, or our grandchildren, may one day walk across the surface of the Red Planet, and happen across an artifact from the earliest days of robotic exploration. Whether we treat it as simply a piece of space junk, or as a Rosetta Stone that reveals to us new secrets about Mars, depends on what essential information has been sent forward by future looking scientists and space enthusiasts today.

By beginning today, we can help those future explorers learn where to look, how to understand what they find, and perhaps aid them in discovering key pieces to the puzzles they will face as they carry the legacy of life and intelligence into the universe.

Ad Ares!

ACKNOWLEDGMENTS

Flexinol is a registered trademark of Dynalloy Inc.

REFERENCES

1. NASA's Viking missions summary: http://www.jpl.nasa.gov/news/fact_sheets/viking.pdf

2. Image of the backshell and parachute take by Opportunity: http://solarsystem.nasa.gov/multimedia/display.cfm?IM_ID=1283

3. Example, a titanium motor casing from a Delta 2 third stage, weighing about 70 kg, landed in Saudi Arabia on January 21, 2001. Source: http://www.orbitaldebris.jsc.nasa.gov/reentry/recovered.html

4. The Saturn third stage from the Apollo 12 mission to the moon continues to orbit the Sun, returning to the Earth-Moon system occasionally, and could eventually strike one or the other. Source: http://www.space.com/scienceastronomy/space_junk_020919.html

5. A listing of all Mars missions with links to informative descriptions can be found at: http://www.daviddarling.info/encyclopedia/M/Mars_unmanned_spacecraft.html

APPENDIX

Listing of robotic missions launched towards Mars (from reference 5 above).

Launch date	Spacecraft	Country	On Mars?	Notes
Oct 10, 1960	Marsnik 1	Soviet Union	No	Attempted flyby; launch failure
Oct 14, 1960	Marsnik 2	Soviet Union	No	Attempted flyby; launch failure
Oct 24, 1962	Sputnik 22	Soviet Union	(a)	Attempted flyby
Nov 1, 1962	Mars 1	Soviet Union	(a)	Flyby; contact lost
Nov 4, 1962	Sputnik 24	Soviet Union	(a)	Attempted lander
Nov 5, 1964	Mariner 3	United States	(a)	Attempted flyby
Nov 28, 1964	Mariner 4	United States	(a)	Flyby
Nov 30, 1964	Zond 2	Soviet Union	(a)	Flyby; contact lost
Feb 24, 1969	Mariner 6	United States	(a)	Flyby
Mar 27, 1969	Mariner 7	United States	(a)	Flyby
Mar 27, 1969	Mars 1969A	Soviet Union	No	Attempted orbiter; launch failure
Apr 2, 1969	Mars 1969B	Soviet Union	No	Attempted orbiter; launch failure
May 8, 1971	Mariner 8	United States	No	Attempted flyby; launch failure
May 10, 1971	Cosmos 419	Soviet Union	(a)	Attempted orbiter/lander
May 19, 1971	Mars 2	Soviet Union	Yes(b)	Orbiter/attempted lander
May 28, 1971	Mars 3	Soviet Union	Yes(b)	Orbiter/lander (operated only 20 sec.)
May 30, 1971	Mariner 9	United States	(a)	Orbiter

Jul 21, 1973	Mars 4	Soviet Union	(a)	Flyby/attempted orbiter
Jul 25, 1973	Mars 5	Soviet Union	(a)	Orbiter
Aug 5, 1973	Mars 6	Soviet Union	Yes(b)	Lander; contact lost
Aug 9, 1973	Mars 7	Soviet Union	(a)	Flyby/attempted lander
Sep 8, 1975	Viking 1	United States	Yes(c)	Orbiter and lander
Aug 20, 1975	Viking 2	United States	Yes(c)	Orbiter and lander
Jul 7, 1988	Phobos 1	Soviet Union	(a)	Attempted orbit and Phobos landers
Jul 12, 1988	Phobos 2	Soviet Union	(a)	Orbiter/attempted Phobos landers
Sep 25, 1992	Mars Observer	United States	(a)	Attempted orbiter; contact lost
Nov 7, 1996	Mars Global Surveyor	United States	(a)	Orbiter
Nov 16, 1996	Mars 96	Russia	No	Orbiter and landers crashed on Earth
Dec 4, 1996	Mars Pathfinder	United States	Yes(c)	Lander and rover
Jul 3, 1998	Nozomi	Japan	(a)	Attempted orbiter
Dec 11, 1998	Mars Climate Observer	United States	(a)	Attempted orbiter
Jan 3, 1999	Mars Polar Lander	United States	Yes(b)	Attempted lander and penetrators
Apr 7, 2001	Mars Odyssey	United States	(a)	Orbiter
Jun 2, 2003	Mars Express & Beagle 2	Europe/U.K.	Yes(b)	Orbiter and attempted lander
Jun 10, 2003	MER-A, Spirit	United States	Yes(c)	Lander and rover
Jul 7, 2003	MER-B, Opportunity	United States	Yes(c)	Lander and rover

Planned missions:

2005	Mars Reconnaissance Orbiter	United States	-	Orbiter
2007	Netlanders	Europe/France	-	Orbiter and 4 Landers
2007	Mars 2007 “Phoenix”	United States	-	North Pole Lander
2009	Mars 2009	United States	-	Lander and rover

Notes

a) Even Mars fly-bys and orbiters have the potential to deliver materials to the surface over time.

b) Presumed to have reached the Martian surface, but location not well identified.

c) Successful landing with location well identified.