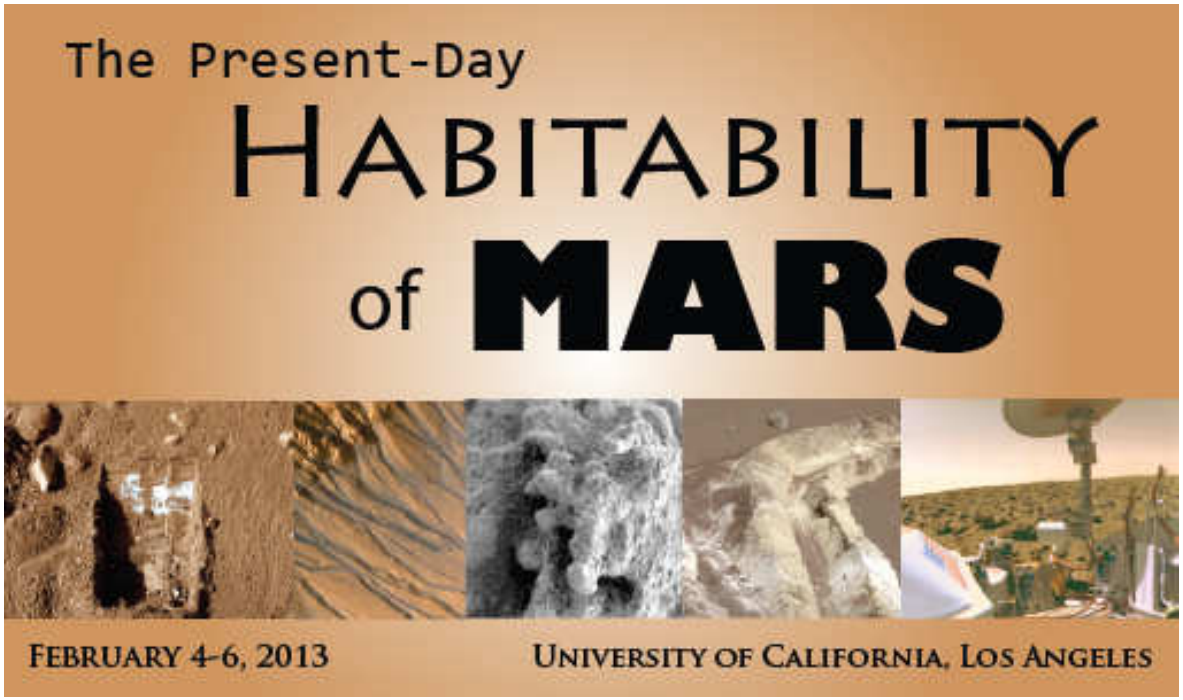
Report to MEPAG on The Present-Day Habitability of Mars Workshop



David Paige (UCLA) and Charles Cockell (UK Centre for Astrobiology)

2/27/13

Present-Day Habitability of Mars

The present-day habitability of Mars is relevant to a number of issues relating to **Mars Science**, **Planetary Protection**, and **Human Exploration**.

The history of Mars exploration can be characterized by a series of exciting discoveries that have dramatically overturned previously held beliefs about the planet. Until very recently, the dominantly held position within the scientific community was that while geologic and climatic conditions during Mars' distant past may have been conducive to the potential origin and evolution of life, conditions on Mars today offer slim hope for life as we know it due to the unlikely existence of near-surface liquid water environments. However, recent results from NASA's Phoenix Lander and Mars Reconnaissance Orbiter missions suggest that present-day Mars may in fact contain a range of potential liquid water environments associated with perchlorates in near-surface soil layers and seasonally recurring slope lineae. The purpose of the workshop is to review observations and theories relating to the current habitability of Mars, and to broadly discuss the implications for future Mars science and exploration.

Conference Details

Conference Sponsors:

UCLA Institute for Planets and Exoplanets (IPLEX)
UK Center for Astrobiology
NASA Astrobiology Institute (NASA ABI)

Conference Organizers:

David Paige (UCLA), Charles Cockell (UK Centre for Astrobiology)

Sessions and Session Chairs:

Current Mars Liquid Water Activity: Alfred McEwen (UA)
Early MSL Results: Ashwin Vasavada (JPL)
Mars Salts and Perchlorates: Selby Cull (Brin Mawr)
Redox Potentials for Martian Life: Claire Cousins (UCL)
Implications for Mars Planetary Protection Policies: Catharine Conley (NASA)

Conference Format:

Two-day conference at Royce Hall on the UCLA Campus
30-minute invited talks and 15-minute contributed talks
Half-Day field trip to JPL
Astrobiology “All Access” webcast for remote international participation

Conference Web Site with videos of all sessions via Adobe Connect:

http://planets.ucla.edu/meetings/mars-habitability-2013/

Conference Participation:

100 in-person participants and remote presenters
>60 online participants

In-Person Participants (Yellow indicates remote presenter)

LAST NAME	FIRST NAME	NOTES
Aldrin	Buzz	NASA (retired)
Amini	Sadraddin	UCLA - ESS
Aye	K.Michael	UCLA - ESS
Beaty	David	JPL
Berezhnoy	Alexy	Sternberg Astronomical Institute, Moscow State Univ.
Bryanskaya	Alla	Sternberg Astronomical Institute, Moscow State Univ.
Budney	Charles	JPL
Caron	Ryan	UCLA - ESS
Catling	David	Univ. of Washington
Case	Elizabeth	UCLA Daily Bruin
Chen	Yixin	UCLA - ESS
Chevrier	Vincent	Univ. of Arkansas
Clark	Robert	Widener Univ.
Cockell	Charles	Univ. of Edinburgh
Conley	Catharine (Cassie)	NASA Headquarters
Coradini	Marcello	ESA
Cousins	Claire	Birbeck College, Univ. of London
Crow	Carolyn	UCLA - ESS
Cull	Selby	Bryn Mawr College

LAST NAME	FIRST NAME	NOTES
Isbell	Doug	JPL
Janetzke	Ronald	Southwest Research Institute
Karunatillake	Suniti	Louisiana State Univ.
Kereszturi	Akos	Research Center for Astronomy and Earth Sciences, Hungary
Kim	Min Sung	UCLA - ESS
Kite	Edwin	Caltech
Kleinboehl	Armin	JPL
Kochemasov	Gennady	IGEM of the Russian Academy of Sciences
Kounaves	Samuel	Tufts Univ.
Kral	Timothy	Univ. of Arkansas
Kumar	Maditav	UCLA - Economics
Larson	Brandon	Cal. State Fullerton
Lawson	Michael	UCLA - ESS
Loyd	Sean	UCLA - ESS
Marlow	Jeffrey	Wired Magazine
Martinez	Germán	Univ. of Michigan
Matson	John	Scientific American
McBride	Karen	NASA
McKay	Chris	NASA Ames Research Center

LAST NAME	FIRST NAME	NOTES
McEwen	Alfred	LPL, Univ. of Arizona
McKeegan	Kevin	UCLA - ESS
Mering	John	UCLA - ESS
Miller	Laurence	USGS
Moehlmann	Diedrich	DLR
Monson	Nate	UCLA - ESS
Nicholson	Wayne	Univ. of Florida
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Nuno	Raquel	UCLA - ESS
Ojha	Lujendra	Georgia Tech
Orenstein	Nick	USC
Paige	David	UCLA - ESS
Pappalardo	Robert	JPL/Caltech
Parish	Helen	UCLA - ESS
Petryshyn	Vicky	USC
Pikelnaya	Olga	UCLA - AOS
Pinto	João	UCLA - ESS
Portyankina	Ganna	UCLA - ESS
Pyle	Rod	Space.com

LAST NAME	FIRST NAME	NOTES
Ratliff	Taylor Houston	UCLA - Astronomy
Saraf	Kanav	UCLA Daily Bruin
Schuerger	Andrew	Univ. of Florida
Schulze-Makuch	Dirk	Washington State Univ.
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Sefton-Nash	Elliot	UCLA - ESS
Soni	Chandini	UCLA Daily Bruin
Spry	Andy	JPL
Stein	Alec	UCLA - Astronomy
Stillman	David	Southwest Research Institute
Stoker	Carol	NASA Ames Research Center
Stubailo	Igor	UCLA - ESS
Toillion	Mike	NASA Astrobiology Institute
Toner	Jonathan	Univ. of Washington
Tripati	Aradhna	UCLA - ESS
Vasavada	Ashwin	JPL/Caltech
Walker	Matt	UCLA - ESS
Wang	Alian	Washington Univ. St. Louis
Watkins	Jessica	UCLA - ESS

LAST NAME	FIRST NAME	NOTES
Woods-Robinson	Rachel	UCLA - Astronomy
Wray	James	Georgia Tech
Yin	An	UCLA - ESS
Yu	Jiano	UCLA - ESS
Zent	Aaron	NASA Ames Research Center

Online Participants (Partial List)

Berivan Esen
Candy Hansen
Cindy Elbaz
Cynthyia Dinwiddie
Ed Rivera-Valentin
Gavriil Michas
Jean-Pierre Williams
Jennifer Hanley
JP Kirby
Kim Kuhlman
Margaret Race
Mark Allen
Martin Robinson
Matt Siegler (JPL)
Michaela Shopland
Mohit Melwani
Rebecca Mickol
Rebecca Wolsey
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Alkos Keresturi
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Bob Papalardo
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Asmin Pathare
Cathy Weitz
Cindy Elaz
Ed Goolish

Junfreng Gong
Kim Kuhlman
Lisa Landsberg
Mark Allen
Mark Sykes
Martin Robinson
Stephen Wood
Tony Reichhart
Vasilis Dalianis

Session 1: Current Mars Liquid Water Activity

- **Results from Phoenix mission:**
  - Thin films of briny water are likely based on several lines of evidence.
  - This water would be too cold today for metabolic activity (reviewed by C. McKay in a later session)
- **Recurring Slope Lineae (RSL):**
  - These form only at the warmest times and places on Mars
    - Surface temperatures often exceed 273 K, above freezing point for pure water
    - Most worker favor briny water—much easier to explain subsurface flow and why the slopes haven't completely dried out
  - Many RSL now confirmed in equatorial Valles Marineris
    - Need to reconsider COSPAR special regions for planetary protection
  - Current theories for RSL formation require water, but water has not been directly detected
    - 3 PM orbit of MRO is about the direst time of day
    - Observations in early AM would be best.
    - MRO CRISM does show interesting spectral variability affected by RSL activity
  - Laboratory experiments have great promise for understanding briny water on Mars today

Session 3. Salts & Perchlorates

- Perchlorate likely forms atmospherically; however, the details of the mechanism remain unknown. Computer models of Earth-like formation produce orders of magnitude less perchlorate than is observed.
- Due to the difference between the deliquescence humidity and the efflorescence humidity, perchlorate brines remain liquid far below the eutectic (down to T=180K, for some).
- Reanalysis of Phoenix data suggests that most of the Phoenix landing site perchlorate is Ca- or Mg-perchlorate
- Perchlorate does not seem to kill most microbes, though it can inhibit their growth

Session 4: Redox Potentials for Martian Life

Importance of uninhabited habitats on Mars. Whilst not common on Earth, isolated or transient habitable habitats may be common on Mars, where either life never evolved, or where life was too disconnected to be transported. *Cockell et al.*

•Plausible microbial metabolisms on Mars are likely driven by subsurface geochemical redox couples. Mars has electron acceptors for S- and Fe-reduction (sulphates, ferric minerals), but lacks donors (organic C, H2). In contrast, electron donors exist for S- and Fe-oxidation (sulphides, ferrous minerals), but electron acceptors (e.g. nitrates) are lacking. *Cousins et al.*

•Polar desert environments there are lower limits of metabolic rates within environments that are cold and dry, even where redox couples exist. This can be used to constrain the habitability of similar Martian localities. *McKay*

•Actively metabolising photosynthetic cyanobacteria and methanogenic archea survive simulated Martian conditions. *de Vera et al.*

•Regions within Terra Sabae and Nili Fossae on Mars could be promising areas for anaerobic oxidation of methane, with serpentinisation being the methane source *Marlow & LaRowe*

Session 5: Implications for Mars Planetary Protection Policies

- **Earth organisms can grow in simulated Mars-like conditions:**
  - Under non-drying culture conditions, organisms that can grow in Mars-like pressure (7mbar), temperature (0C), and atmospheric composition are common (Schuerger)
  - Halophiles have broader ranges of metabolic activity than previously understood (Bryanskaya)
  - Diurnal cycling of humidity and temperature provide transient 'crossover' periods during which Earth organisms can grow (prior sessions)
- **Considerations for policy:**
  - Low-temperature brines have the potential to facilitate subsurface transport, raising additional issues for forward contamination control
  - Current mission assembly practices provide for effective cleaning of spacecraft to access most regions on Mars (Spry)
  - Periodic reassessment of 'special regions' parameters to take place at a COSPAR workshop in late 2013
  - Samples undergoing life detection experiments require additional contamination control measures: results from life-detection protocols will inform both policy and science

Future Plans and Recommendations

- Call for papers for special issue of *Astrobiology*
- Second Present-Day Habitability Conference in 2014
- Briefing to 2020 rover SDT regarding present-day habitability issues and opportunities
- New MEPAG study team to define strategies for investigating the present-day habitability of Mars and links to human exploration