



MERCURY: CURRENT AND FUTURE SCIENCE OF THE INNERMOST PLANET

Meeting Dates: May 1–3, 2018

Meeting Location: Columbia, MD, USA

In May 2018, the international Mercury science community gathered in Columbia, MD, USA for the *Mercury: Current and Future Science of the Innermost Planet* meeting. In total, 123 scientists from 11 countries participated in the meeting, with 42% of the participants traveling from outside the United States to attend. The meeting focused on all scientific aspects of the planet Mercury, including both the current state of knowledge and the prospects for future endeavors. One of the major take-home messages from the meeting was that there is a sizable, active, and energetic international Mercury science community, and getting this community together for this meeting and in the future is productive and important.

One of the main reasons that there now exists a strong Mercury science community is from the success of NASA's MERcury SURFACE, SPACE ENvironment, GEochemistry, and RANGING (MESSENGER) mission. MESSENGER provided a wealth of data about Mercury, and these data were the focus of many of the meeting's presentations and discussions. Results from the MESSENGER mission have also motivated new experimental and modeling research, to interpret Mercury's history and the processes that have acted on the planet in the past as well as those that continue to act in the present day. Ongoing observations from Earth-based telescopes were also presented, which further advance our understanding of Mercury's surface, exosphere, and dynamical environment and enable studies of Mercury on longer timescales than any single mission.

Additionally, the Mercury science community is strong because the future spacecraft exploration of Mercury is set to continue. The joint ESA-JAXA BepiColombo mission is scheduled to launch in just a few months, in October 2018, and to arrive at Mercury in 2025. BepiColombo will be the first mission to deliver two spacecraft into orbit about Mercury, the Mercury Planetary Orbiter and the Mercury Magnetospheric Orbiter. The meeting included many discussions about BepiColombo's plans, and the community expressed excitement and anticipation for the new measurements and potential new discoveries.

The three-day meeting was packed with diverse Mercury science topics from the 129 abstracts associated with the meeting. The oral sessions ranged from Mercury's exosphere and magnetosphere, to the planet's surface geology and composition, to the geophysical and geochemical structure of Mercury's deep interior. To enable the community to consider all aspects

of the planet Mercury, the meeting program was specifically designed to have only one string of oral sessions throughout the meeting in a single room in order to present the range of diverse science topics to everyone. In particular, the diverse topics were interleaved throughout each day, to promote engagement throughout the meeting by all science disciplines:

May 1, 2018

- *Welcome and Introduction*
- *Solar-Wind Interactions with Mercury*
- *Mercury's Interior Structure and Evolution*
- *Mercury: Origin, Geologic History, and Volcanism*
- *Poster Session*

May 2, 2018

- *Mercury's Polar Deposits*
- *An Exosphere and Magnetosphere Potpourri*
- *Mercury's Crustal Geophysics*
- *Future Mercury Exploration – Beyond BepiColombo*

May 3, 2018

- *Sodium: A Major Player in the Exosphere and Magnetosphere*
- *Mercury Geochemistry: Observations and Laboratory Constraints*
- *Exosphere/Magnetosphere: New Results with a Look to the Future*
- *A Veritable Smorgasbord of Mercury Geological Delights*

A poster session with a reception was held on the first evening, with 33 posters making for lively discussions. E-posters are available on the meeting website from those participants who chose to make them available. One of the meeting participants, Emily Lakdawalla of The Planetary Society, wrote a wonderful story that highlights some of the scientific results presented at the meeting: <http://www.planetary.org/blogs/emily-lakdawalla/2018/0517-mercury2018-from-messenger.html>

Between the presentations of Mercury science results and BepiColombo plans, one two-hour session of the meeting was devoted to discussions for the future exploration of Mercury, beyond BepiColombo. The session included presentations about efforts related to the last U.S. National Academies Planetary Science Decadal Survey, including an engineering study of a possible Mercury lander. Short presentations followed where scientists laid out some of the top priority science questions that could drive the future exploration of Mercury. The session ended with a discussion of what the Mercury community should do going forward, to keep the community strong and to keep Mercury as a compelling option for future missions. Along with continuing special Mercury-focused sessions at planetary science meetings, there was a strong sentiment that meetings like the current one should occur in the future. Happily, plans are already underway in setting the dates and location for the Mercury 2020 meeting!

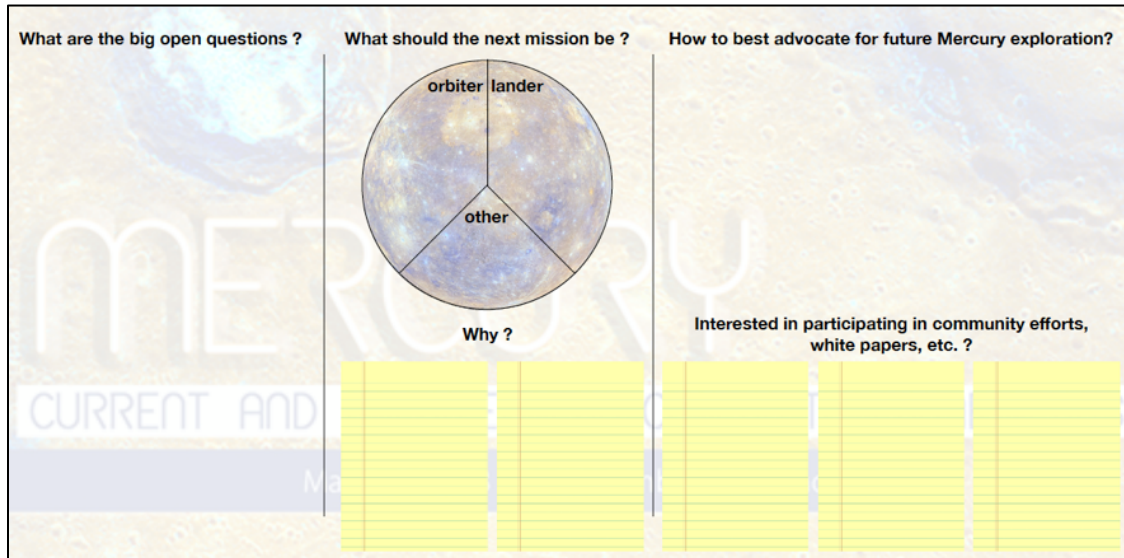
The discussion also showed that there is strong support for the importance of future Mercury exploration missions beyond BepiColombo. At the meeting, a poster was hung to enable community members to brainstorm possible future Mercury exploration ideas and to sign up to be

involved in future efforts. In total, 74 individuals signed up, demonstrating the strong support for the future exploration of Mercury. Possible next steps for the Mercury community that were mentioned included writing white papers and forming a group similar to the Analysis or Assessment Groups that other planetary science communities have, such as SBAG, OPAG, VEXAG, MEPAG, and LEAG. Mercury currently does not fit within any of these existing “AGs.” Interestingly, discussions subsequent to the meeting revealed that NASA’s Planetary Science Advisory Committee discussed the need for a “Mercury AG” at their February 2018 meeting and drafted a finding to support the formation of such an AG. It will be important to see how all of this strong interest and support for future Mercury exploration develops over the next few months.

Overall, the Mercury 2018 meeting was a great success and is positioned to be the first in a regularly occurring series. It was encouraging that among the meeting participants there were 23 students, and it was greatly appreciated that LPI was able to provide 10 early career scientists with travel support awards. The meeting was highly productive but also showed that there is still much to be answered about Mercury, through continued research with MESSENGER and other datasets, through BepiColombo’s unprecedented two spacecraft measurements, and through future exploration of our Solar System’s innermost planet.

Report by: Nancy L. Chabot
Mercury 2018 Lead Scientific Convener
May 23, 2018

FUTURE MERCURY EXPLORATION COMMUNITY INPUT POSTER CAPTURING THE CONTENT



At the Mercury 2018 meeting, a poster was hung to enable community members to brainstorm possible future Mercury exploration ideas and to sign up to be involved in developing future exploration efforts. In total, 74 individuals signed up, demonstrating the strong support for developing Mercury missions beyond BepiColombo. The text below captures the community content added to the poster during the meeting and documents the support of those individuals who signed up as interested in participating in future community efforts.

What are the big open questions?

- Why does Mercury have such a big core??
- Did Mercury have a primary flotation crust?
- What is the LRM?
- When did the PSRs get filled? + what is the source of volatiles?
- How does one get volcanism on a planet with such large compression?
- What is the composition of the core?
- What is the timing and duration of individual volcanic eruptions? How does this compare with the timing of tectonic activity?
- What is the rheology of the interior? Also of graphite?
- We don't know enough about surface composition and mineralogy to answer many of these big questions -> in situ missions required
- What are age of plains? [need absolute age calibration]
- What is the abundance of volatiles in Mercury interior? What are the source regions?
- How did the crust - primary + secondary - form, and when?
- Why are *so many* craters and basins filled in?
- What is Pantheon Fossae?
- Where is the ideal landing site? What can BepiColombo do to help collect landing site data

What should the next mission be?

- Orbiter:
 - a gravity gradiometer
 - this is a good idea; would you get this done under Discovery?
- Lander:
 - a rover in Prokofiev - Yes!
 - or deposits with dark volatiles and ice! maybe even better?
 - LRM lander
 - a rover with seismometers -> yes !!!
 - yep!
 - ChemCam!
 - lander is obvious next big step - how can it be done under NF?
 - landers are necessary for detailed knowledge of surface chemical and mineralogical composition (see Mars examples). Petrology requires mm-to-cm scale analyses. ChemCam for Mercury?
- Other:
 - yes! sample return :)
 - network of landers+rovers exploring Mercury hollows

Why?

- we need to get the Southern hemisphere as well as the northern - so orbiter!
- lander! time for in situ / ground truth measurements
- 4 landers please! Each for inset dating of 4 craters: Kuiper, Mansur, Caloris, Tolstoj
- OR a hopper lander with sample return!
- Land in the LRM! Composition! Age! Fundamental info about Mercury+chronology!
- put some seismometers to better understand the subsurface and detect tectonic activity
- gravity + seismics: interior structure, magma plumbing, tectonic activity, density -> composition -> evolution

How to best advocate for future Mercury exploration?

- get the public excited about Mercury (x2)
- connect it with exoplanets (x2)
- lander mission
- life on Mercury !! (?) ...
- Lobby government -> sell it to someone in Congress
- Mercury is one of only a few terrestrial (~Earth-like) bodies that we can actually visit and study, so it's crucial for understanding terrestrial planet diversity
- We need an assessment group! We could call it MERCAG! Well, it doesn't have to be that exactly, that's ok.

Interested in participating in community efforts, white papers, etc?

74 individuals who signed up on the poster are listed below

Name	Institution
Sae Aizawa	Tohoku University
Manar Al Asad	UBC
Brendan Anzures	Brown University
Johannes Benkhoff	ESA
Mark Bentley	ESA
Sebastien Besse	ESA
David Blewett	JHU/APL
Nicolas Bott	LESIA/Paris Observatory
Paul Byrne	NCSU
Cristian Carli	IAPS/INAF
Nancy Chabot	JHU/APL
Clark Chapman	SwRI
Thomas Cornet	ESA
Jeffrey Daniels	Western University Canada
Ariel Deutsch	Brown University
Ryan Dewey	UMichigan
Deborah Domingue	PSI
Chuanfei Dong	Princeton University
Alain Doressoundiram	Paris Observatory
Carolyn Ernst	JHU/APL
Caleb Fassett	MSFC
Valentina Galluzzi	INAF/IAPS
Antonio Genova	MIT
Lorenza Giacomini	IAPS/INAF
Austin Glass	UMichigan
Sander Goossens	UMBC
Cesare Grava	SwRI
Steve Hauck	CWRU
Jorn Helbert	DLR
Daniel Heyner	TU Braunschweig
Harald Hiesinger	IFP Munchen
David Hollibaugh Baker	GSFC
Ludovic Huguet	CWRU
Dana Hurley	JHU/APL
Stavro Ivanovski	INAF/IAPS
Noam Izenberg	JHU/APL
Peter James	Baylor University

Jamie Jasinski	JPL
Xianzhe Jia	UMichigan
Catherine Johnson	UBC
Shingo Kameda	Rikkyo University
Rosemary Killen	GSFC
Scott King	Virginia Tech
Rachel Klima	JHU/APL
Christian Klimeczak	UGA
Jurrien Knibbe	VU University Amsterdam
Misha Kreslavsky	UCSC
Benoit Langlais	University Nantes
Valeria Mangano	INAF/IAPS
Erwan Mazarico	GSFC
Bill McKinnon	Washington University
Aimee Merkel	LASP-CU
Pierre-Yves Meslin	IRAP
Anna Milillo	INAF/IAPS
Andreas Morlok	IFP Munchen
Stephen Parman	Brown University
Georgia Peterson	UBC
Alain Plattner	Fresno State
Jim Raines	UMichigan
Stuart Robbins	SwRI
James Roberts	JHU/APL
Dave Rothery	Open University
Daniel Savin	Columbia University
Carl Schmidt	Boston University
Richard Schmude	Gordon State College
Karen Stockstill-Cahill	PSI
Hannah Susorney	UBC
Arya Udry	UNLV
Kathleen Vander Kaaden	JSC
Indhu Varatharajan	DLR
Ron Vervack	JHU/APL
Shoshana Weider	Carnegie
Jenny Whitten	Smithsonian Institution
Joe Zender	ESA