EXPLORING THE LARGEST MASS FRACTION OF THE SOLAR SYSTEM:

THE CASE FOR PLANETARY INTERIORS

insert "we'll go at night" joke here

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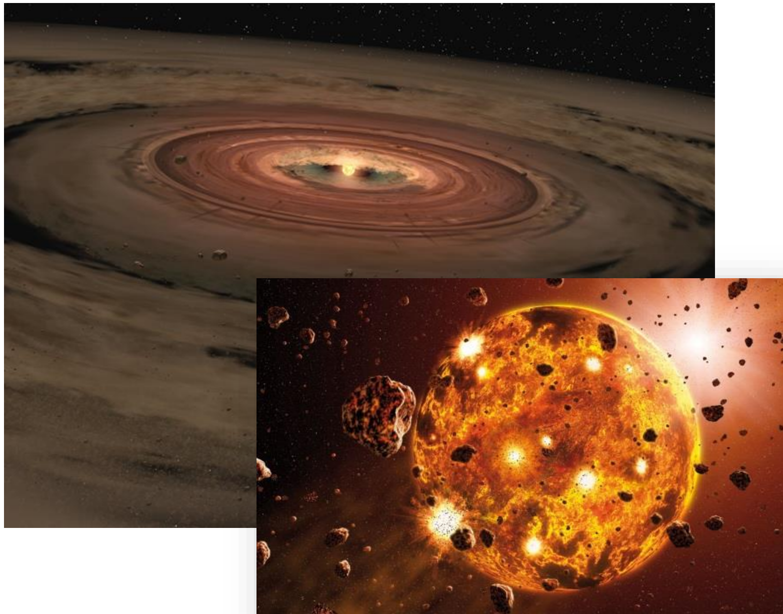
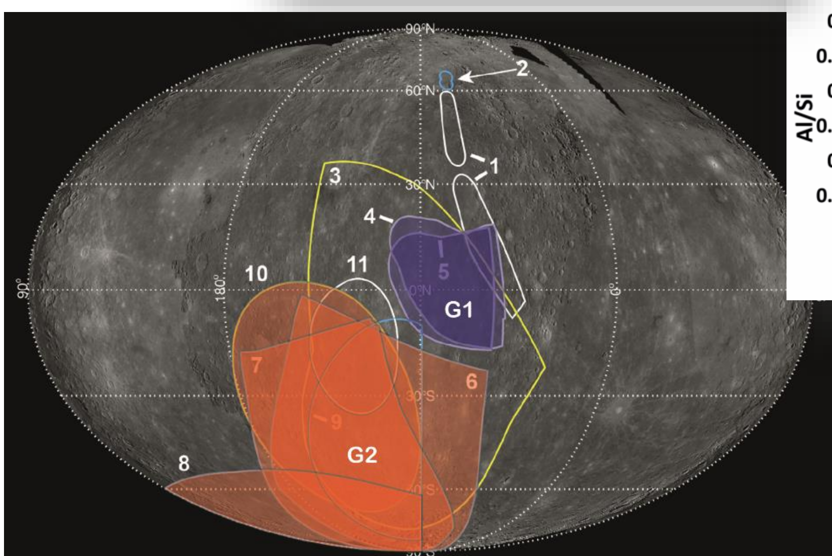
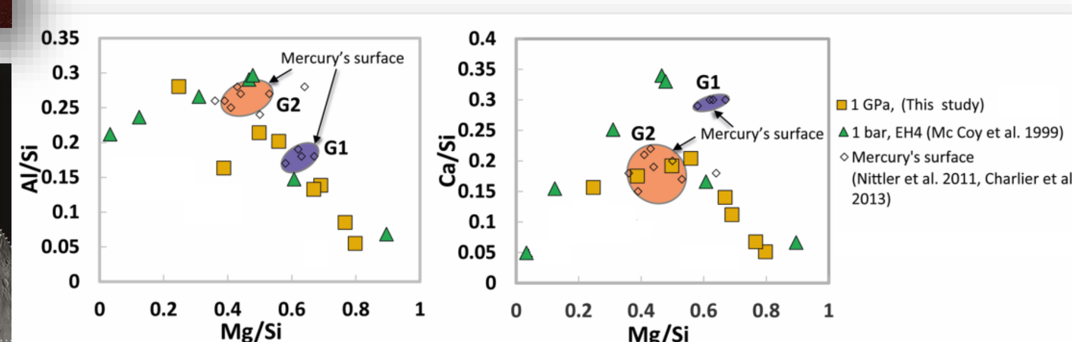
Why explore planetary interiors?

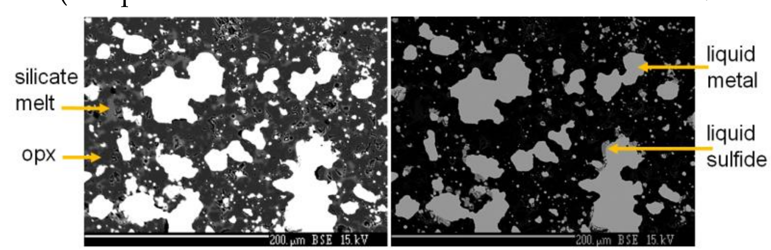


Surface data drive our exploration of evolved geologic processes, but it is the interiors of planets that hold the key to planetary origins via accretionary and early differentiation processes. That initial bulk planet composition sets the stage for all geologic processes that follow. But nearly all of the mass of planets is inaccessible to direct examination, making experimentation an absolute necessity for full planetary exploration.





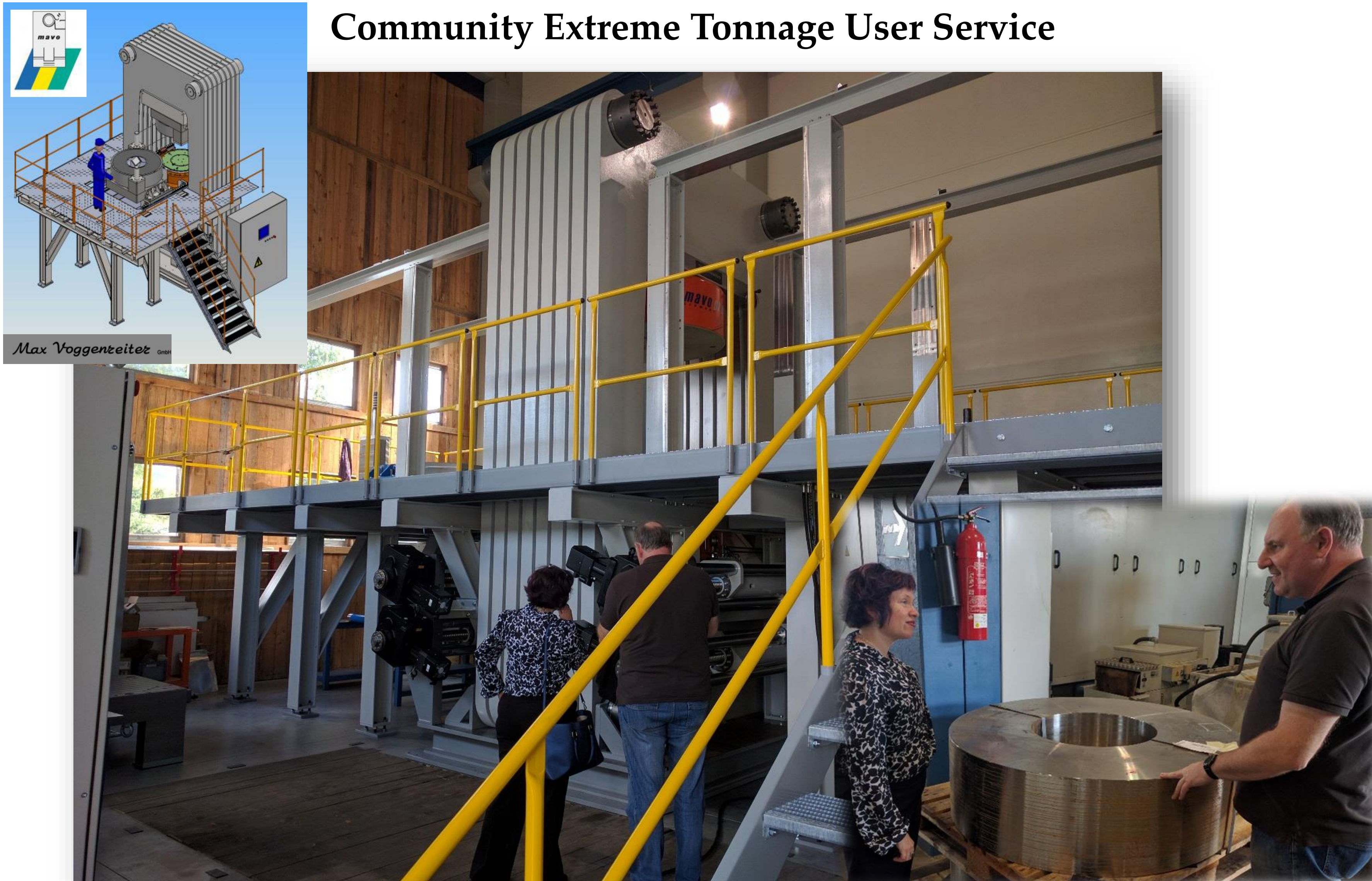
melting of a chondritic mantle at different depths up to 55 km and relatively high temperatures (comprised between 1300 and 1550 °C with 10 to 45 % of melting)



(Nittler et al., 2011; Boujibar et al., 2015)

Our Vision for Exploration: The CETUS Facility

Community Extreme Tonnage User Service



H.E.R.A. – High pressure Experimental Research Apparatus, a 5000 ton press
Finite element models suggest lifetime of the apparatus will be > 50 years.

Join the HERATICs!

JSC EEELs spring 2016

Experiments in Extreme Environments Laboratories

CETUS HERATICs January 2017

(unstoppable shark sign)

COMPRES annual meeting 2016

Consortium for Materials Properties Research in the Earth Sciences

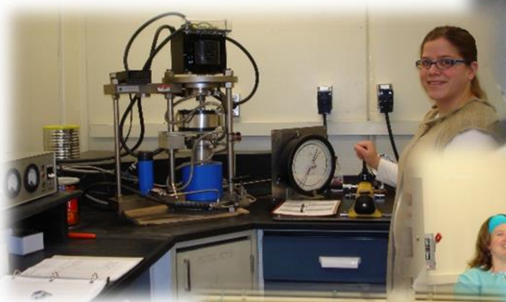
High pressure Experimental Research Apparatus Technical Implementation Consortium

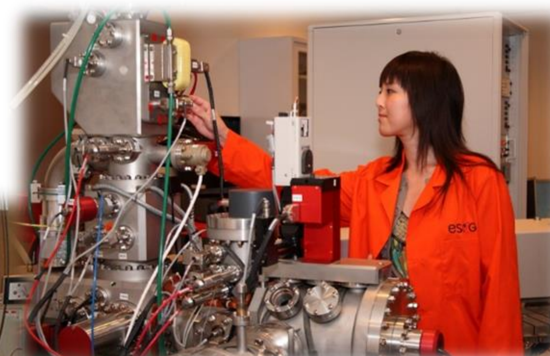
We are a growing stakeholder base representing over a dozen institutions dedicated to the development of CETUS.

For visitors and the community

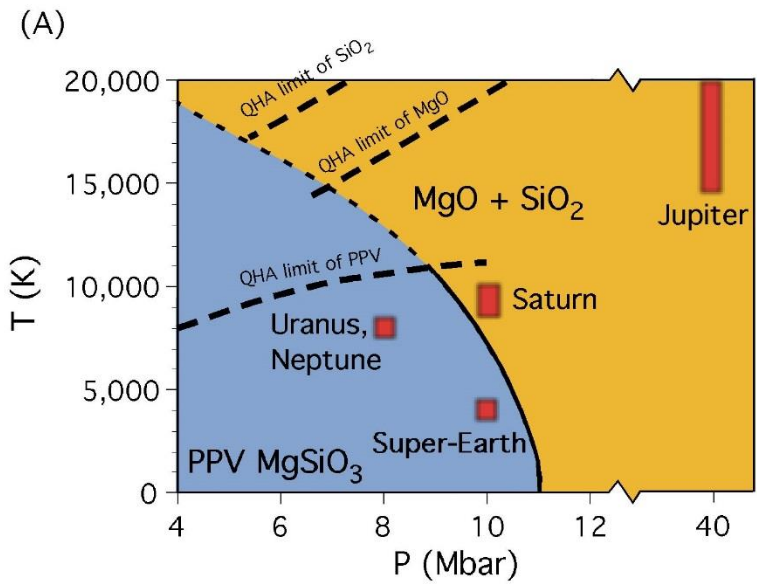
We will create a sample library that can be used for starting materials for other experiments or analytical standards, and made available to any interested researchers.

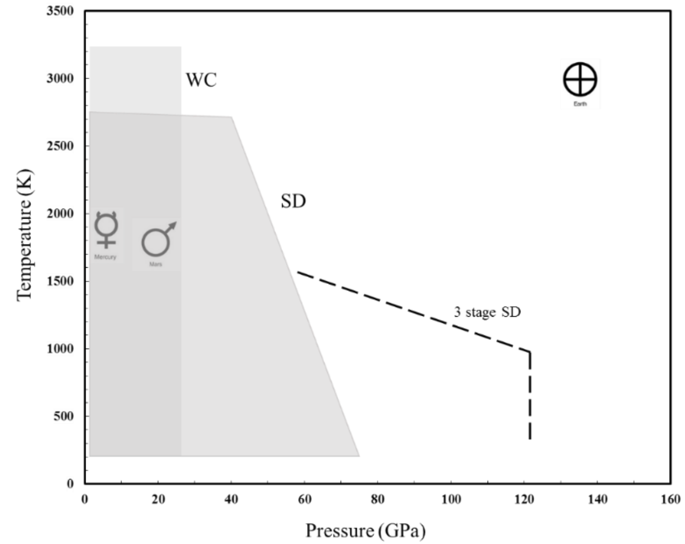
Using a host of co-located analytical equipment, users can conduct macro, micro, and nano-analysis for major, minor, and trace elemental compositions.

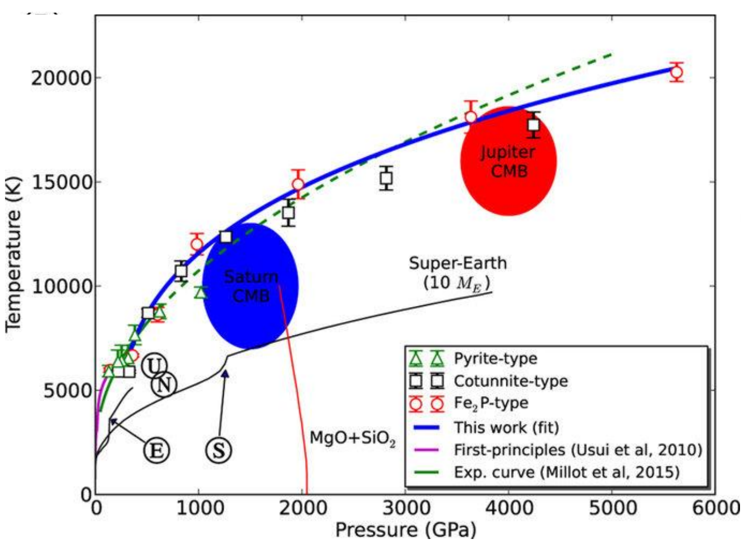




Within Our Solar System





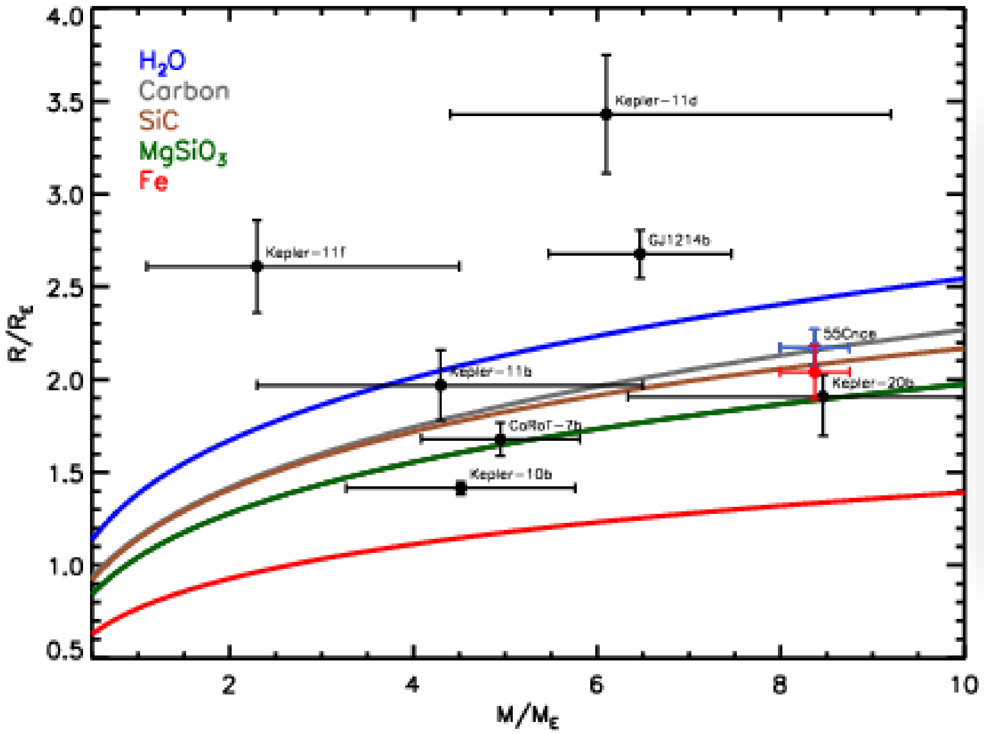


(Umemoto et al., 2006; Gonzales-Cataldo et al., 2016)

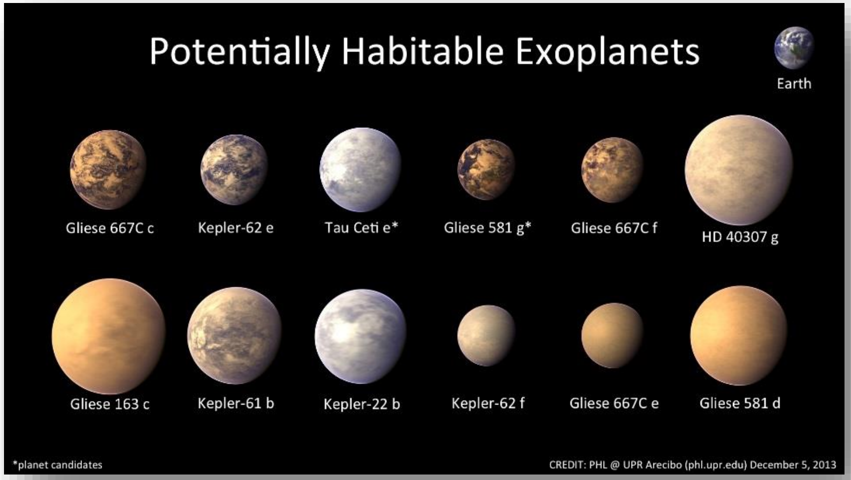
The large press will allow experimenters to reach higher pressures and larger sample volumes than are currently achievable with existing presses. Pressures corresponding to the central pressure of Mars and deeper into planetary mantles will be attainable. The large press could also contribute to a greater understanding of physical properties of planetary interiors (e.g., thermal conductivity), rheology, paleomagnetism, all of which are linked by complex early planetary dynamics.

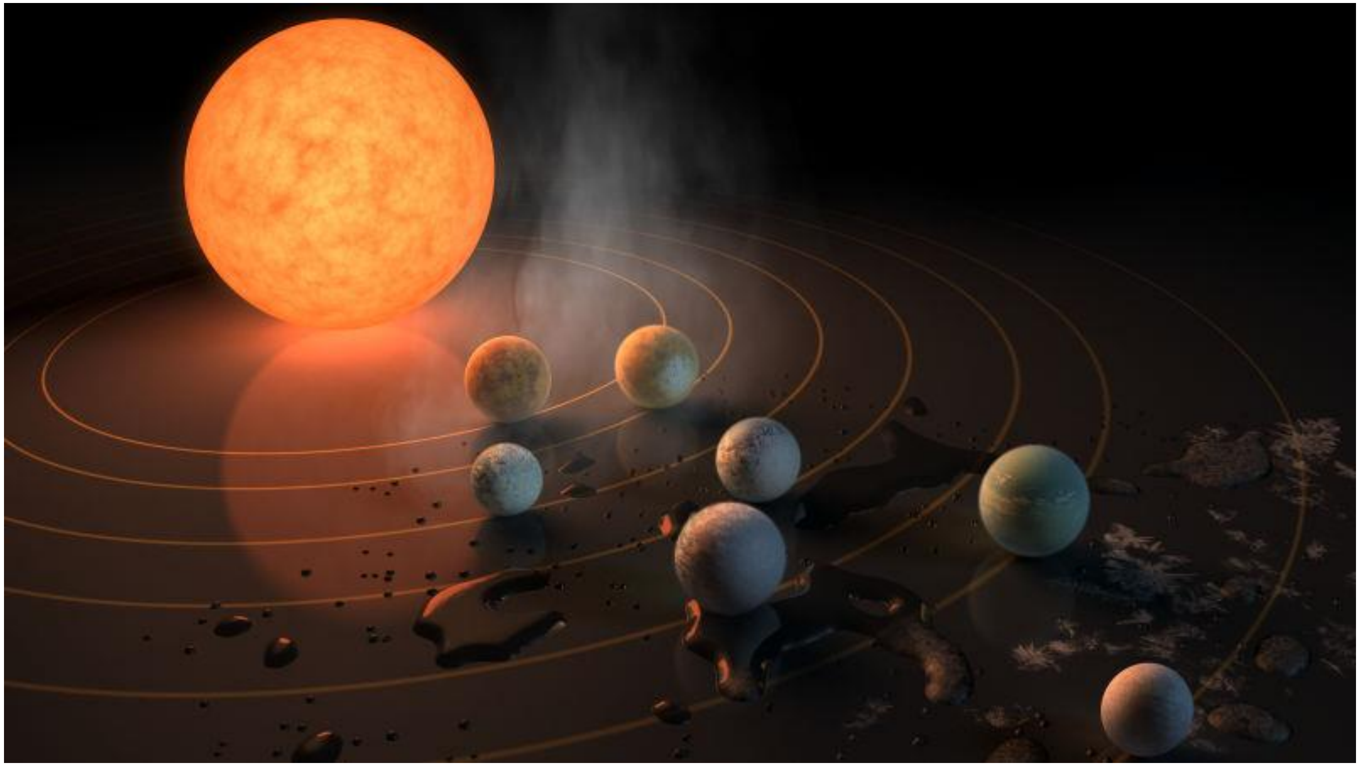
Beyond Our Solar System

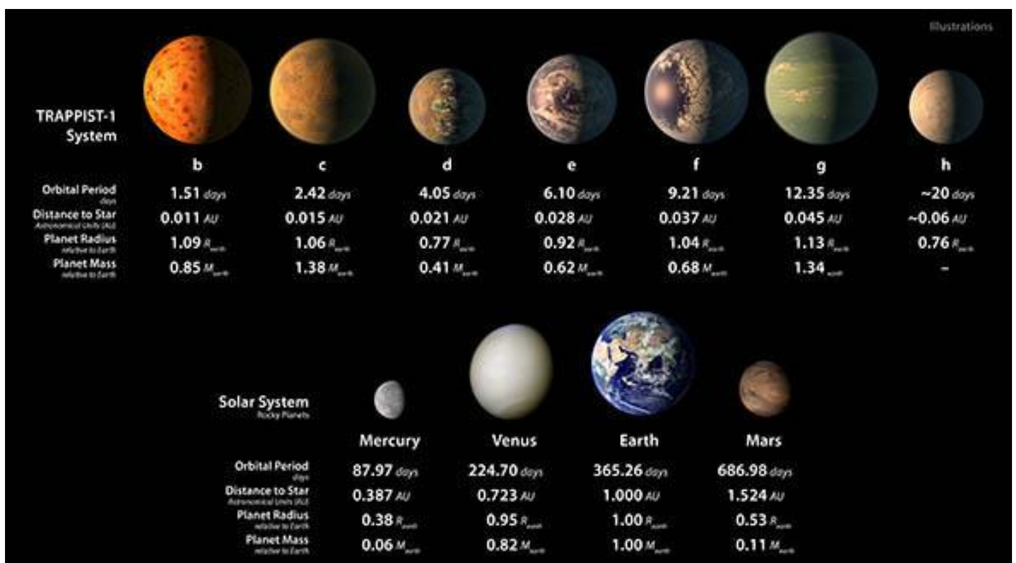
This new capability opens experimental opportunities for studies of the evolution and mantle-core compositions of exoplanets such as super-earths. Larger sample volumes will allow better control of the sample environment and complex mixtures of starting materials to be studied in greater detail, expanding the types of conductivity, diffusivity, and phase equilibria studies possible. Controlling the oxidation state of the sample by adding solid media buffers would be feasible up to higher pressures.



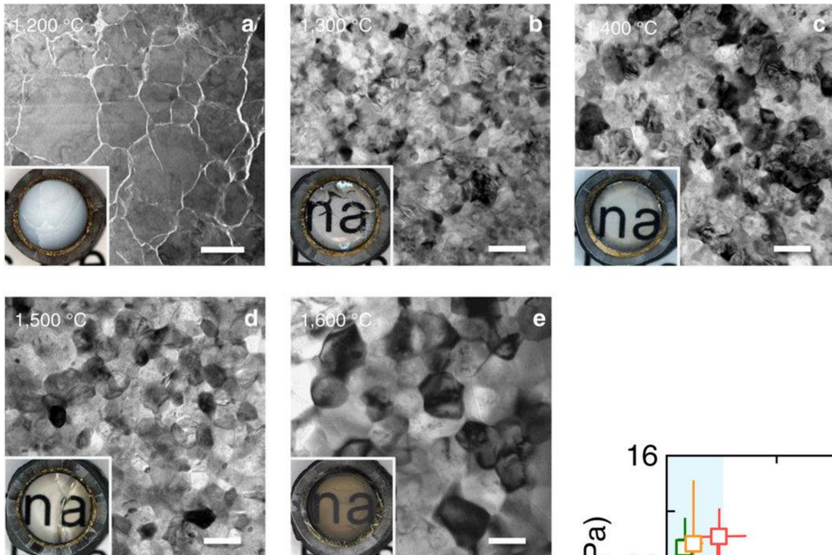
(Madhusudhan et al., 2012)



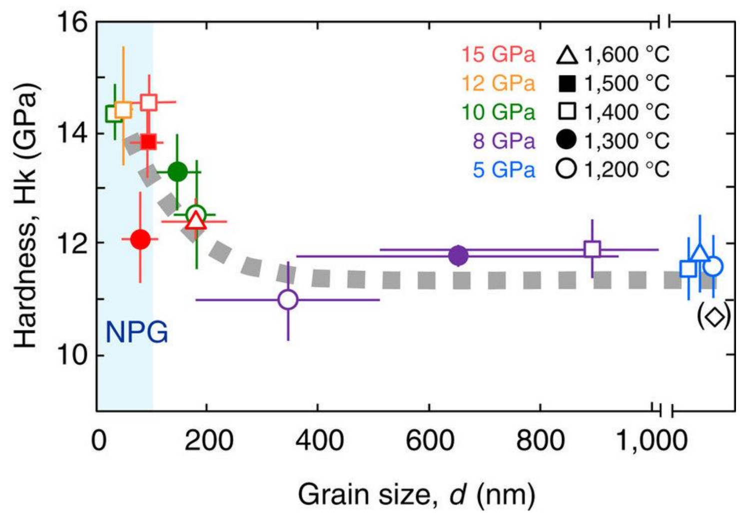



Illustrations
TRAPPIST-1 System
b
c
d
e
f
g
h
Orbital Period
Distance to Star
Planet Radius
Planet Mass
1.51 days
2.42 days
4.05 days
6.10 days
9.21 days
12.35 days
~20 days
0.011 AU
0.015 AU
0.021 AU
0.028 AU
0.037 AU
0.045 AU
~0.06 AU
1.09 R
1.06 R
0.77 R
0.92 R
1.04 R
1.13 R
0.76 R
0.85 M
1.38 M
0.41 M
0.62 M
0.68 M
1.34
-
Solar System
Mercury
Venus
Earth
Mars
Orbital Period
Distance to Star
Planet Radius
Planet Mass
87.97 days
224.70 days
365.26 days
686.98 days
0.387 AU
0.723 AU
1.000 AU
1.524 AU
0.38 R
0.95 R
1.00 R
0.53 R
0.06 M
0.82 M
1.00 M
0.11 M

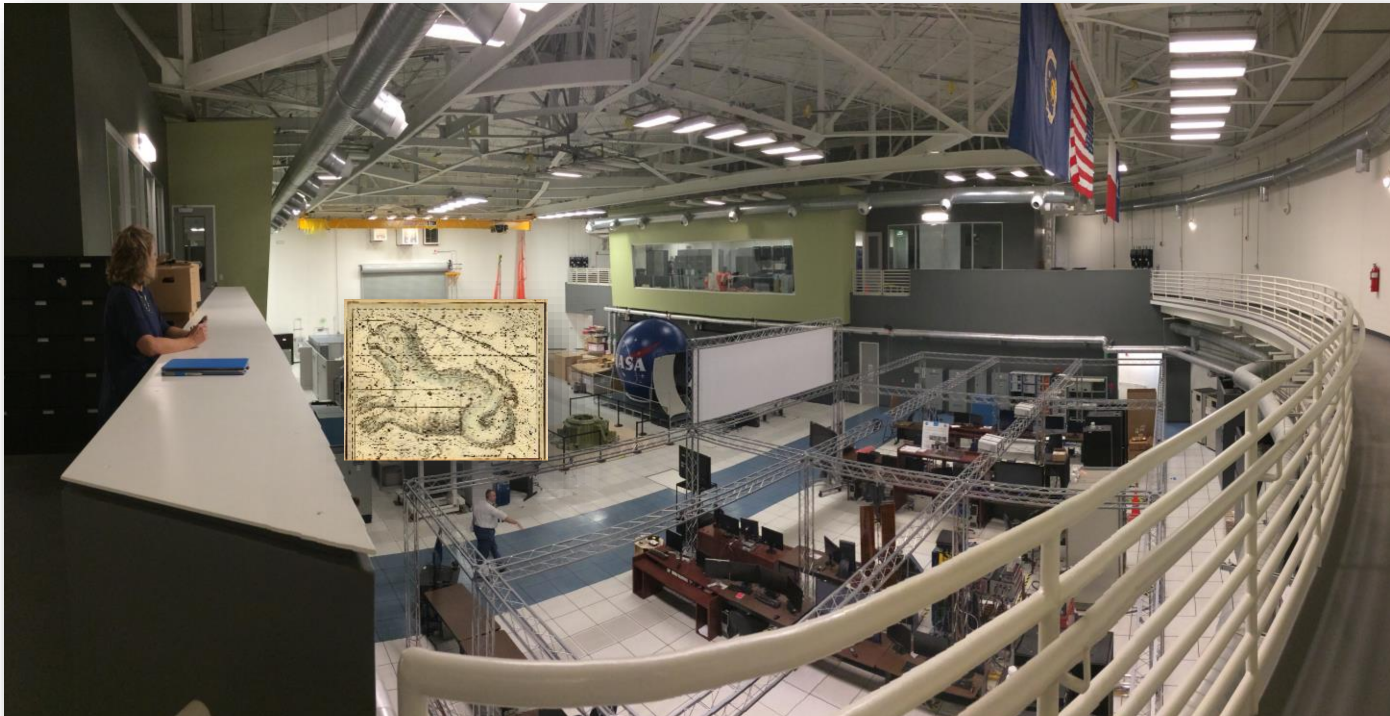
Human Exploration



Ultrahard, nano-polycrystalline ceramics and diamond could be used in long duration space flight for tools, windows, and shielding.



(Irifune et al., 2016)



Future home of CETUS and EEELs, opening 2022!