ORIGIN, EVOLUTION, AND EXPLORATION OF PLANETARY CRUSTS

Comparison of Ancient Planetary Crusts

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Earth-Moon System from the Galileo mission 1992

Origin, Evolution, and Exploration of Planetary Crusts

Chronology of events:

- An Age Constraint on the Giant Impact from Lunar Sample Chronology. Lars Borg
- New constraints on the timing of basin-forming impact events from excavated crustal rocks. William Cassata

Processes forming new crust:

- Importance of silicic magmatism on the Moon. Justin Simon

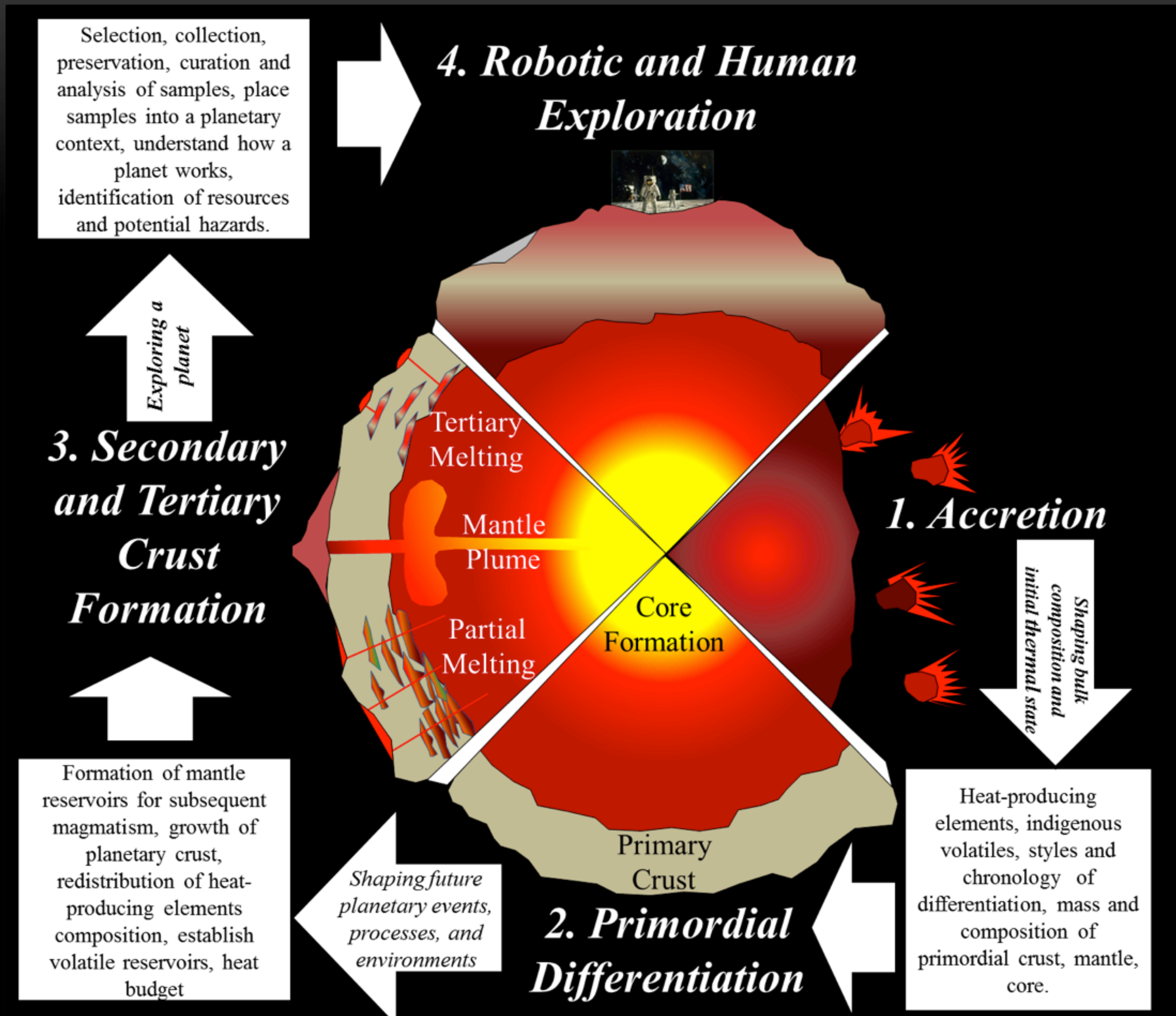
Characteristics and structure of planetary crusts:

- Crustal Stratigraphy Before the Imbrium Impact. Carle Pieters
- Surface roughness in the SPA. Noah Petro
- Evolution and stratigraphy of SPA. Insights from pyroxene composition and distribution. Daniel Moriarty

Exploration of Planetary Crusts (missions and documentation-curation):

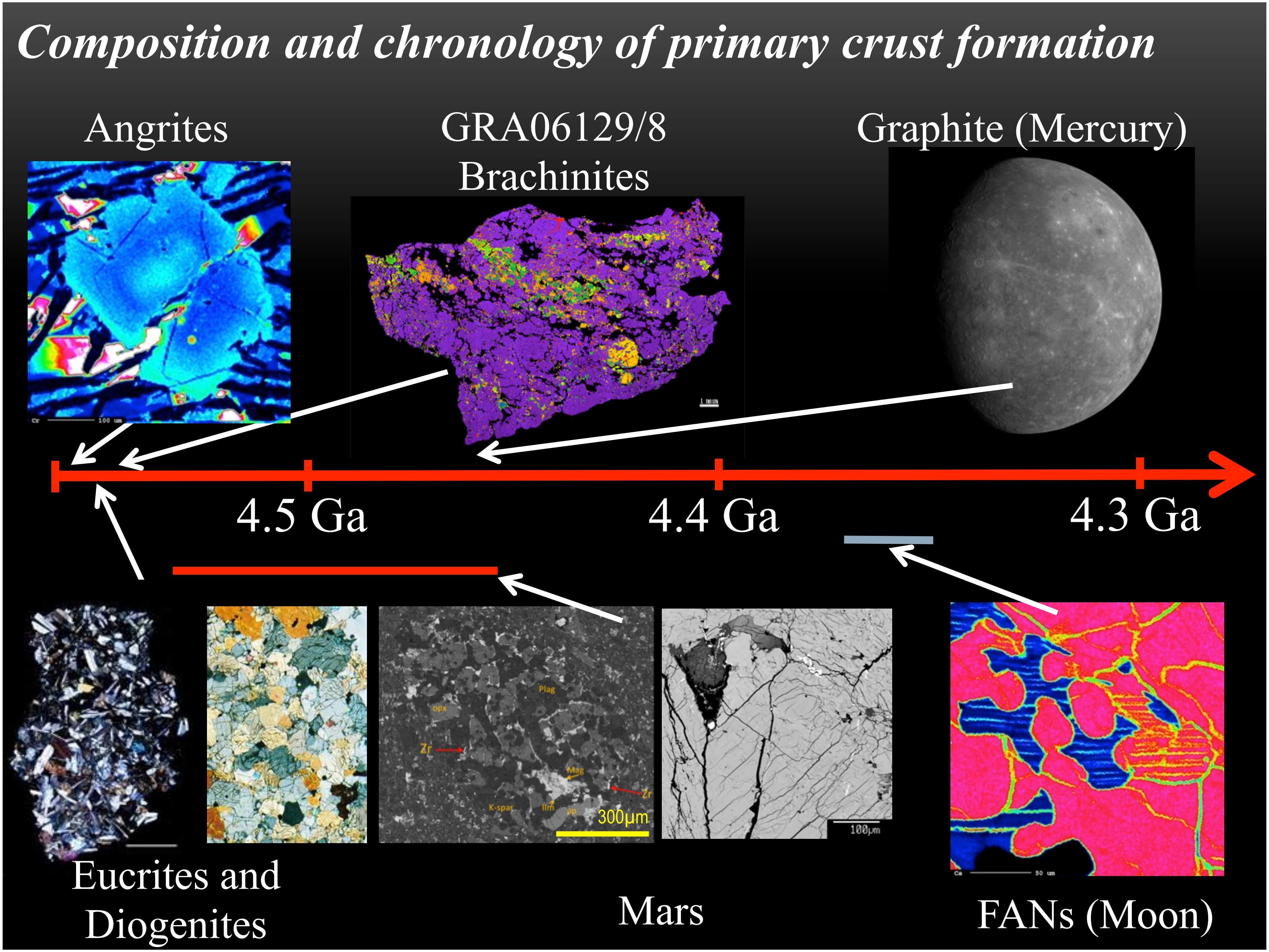
- Scientific motivation for sample return from SPA basin. Brad Jolliff
- Exploration of Planetary Crusts: A Human/Robotic Exploration Design Reference Campaign to the Orientale Basin. Jim Head
- Micro-CT of Apollo samples. Ryan Zeigler

Origin, Evolution, and Exploration of Planetary Crusts

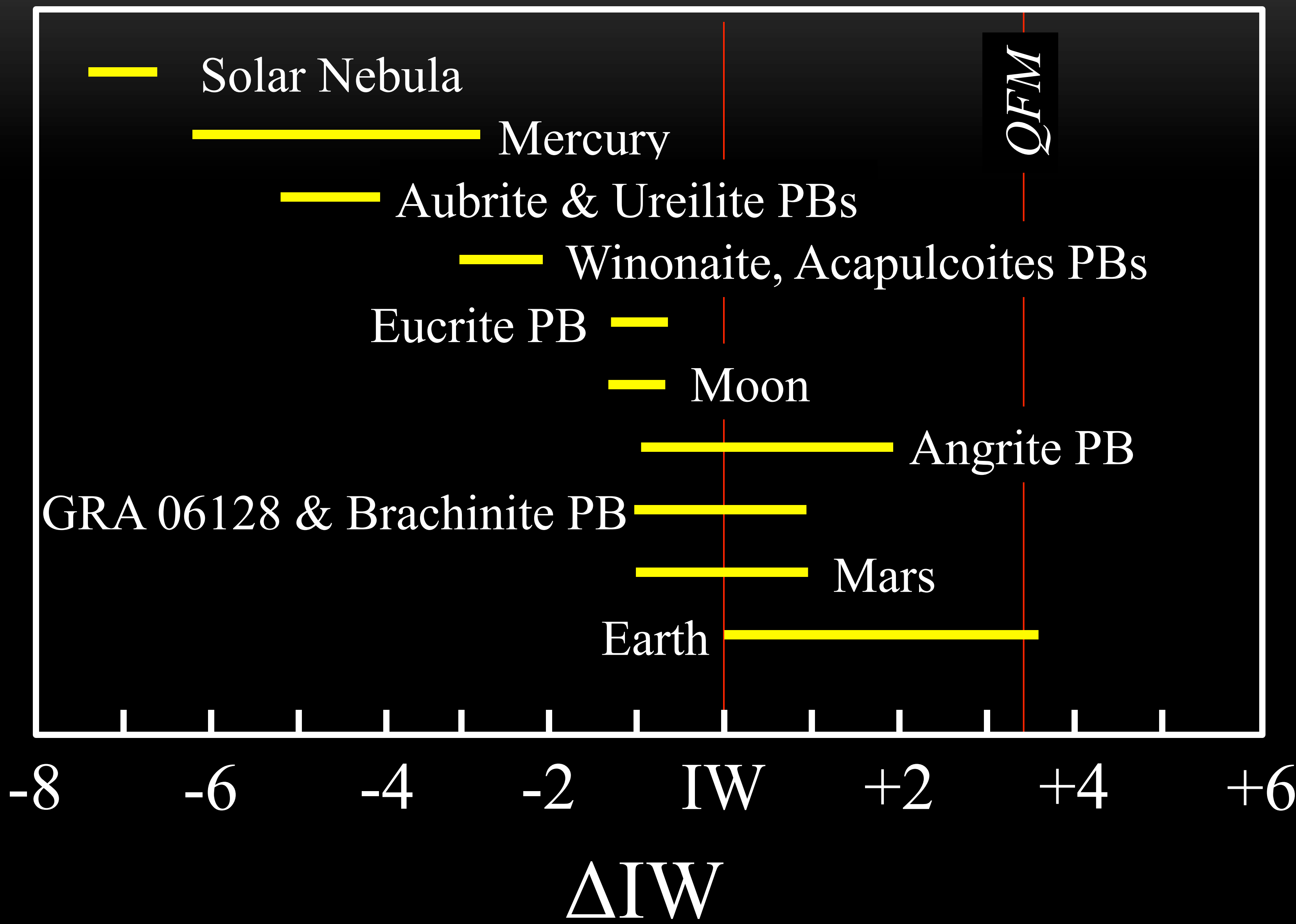


Outline

- Diversity of primary crust.
- Role of fO_2 and volatiles in primary crust diversity and crustal evolution.
- Links between fO_2, volatiles, style of primordial crust formation.
- Examples of future research and questions.


Composition and chronology of primary crust formation
Angrites
GRA06129/8
Brachinites
Graphite (Mercury)
4.5 Ga
4.4 Ga
4.3 Ga
Zr
300µm
100µm
Eucrites and
Diogenites
Mars
FANs (Moon)

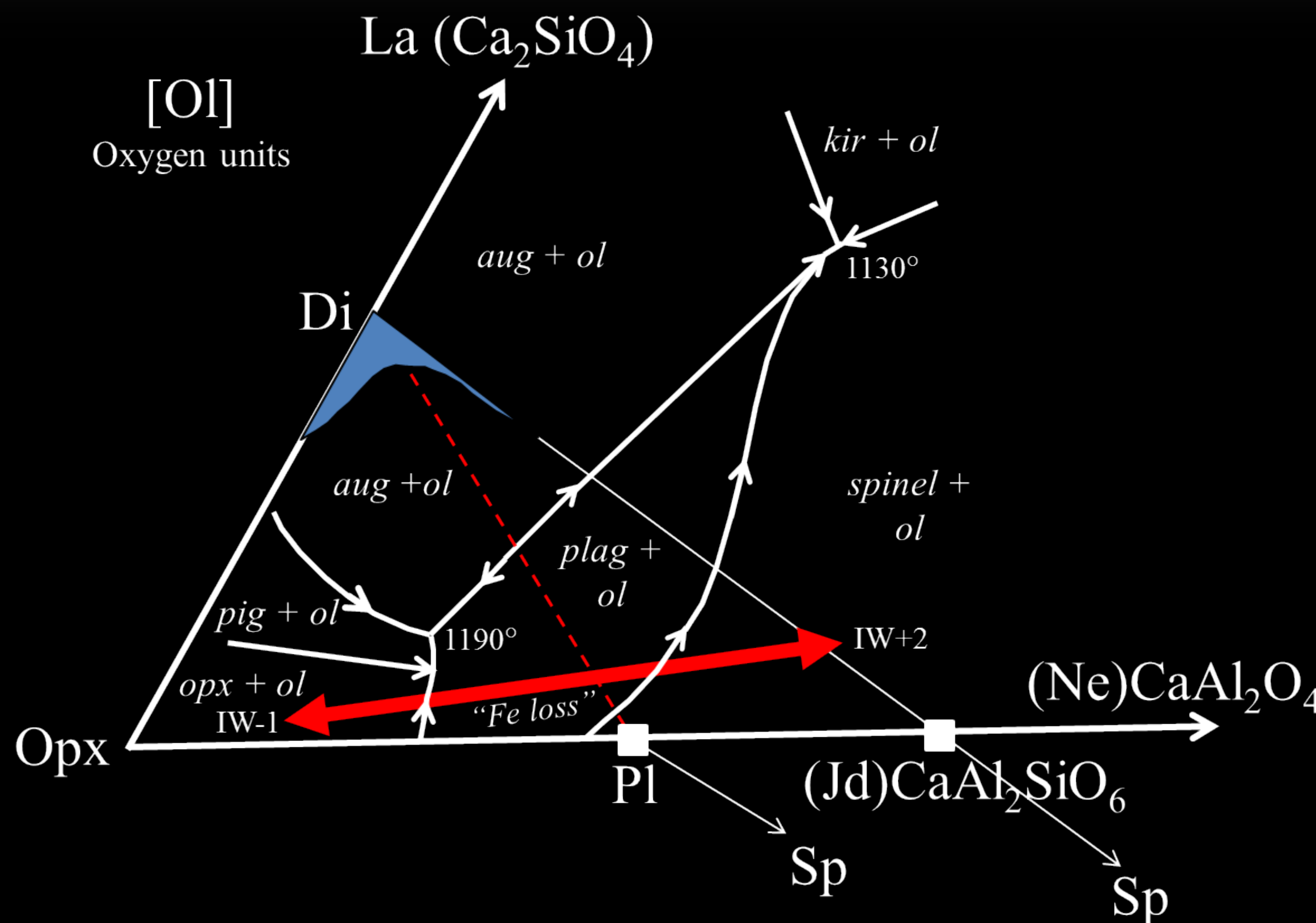
Role of oxygen fugacity 1



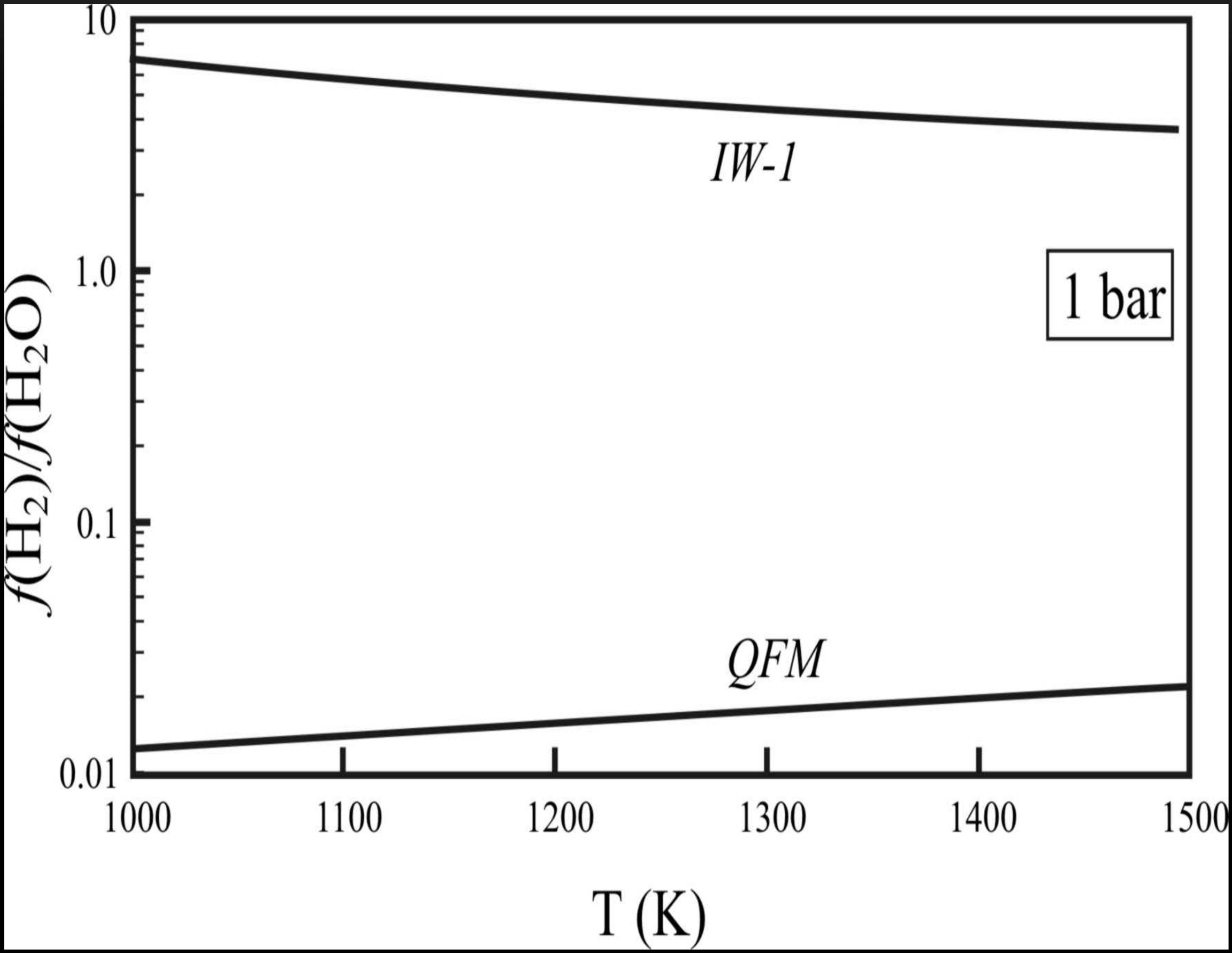
Role of oxygen fugacity 2

Ol + Qtz + La + (Ne)CA system (Mg#$^{(liq)}$=0.3-0.5)

After Longhi, 1999



Building planetary volatile reservoirs and their impact on primordial crust formation



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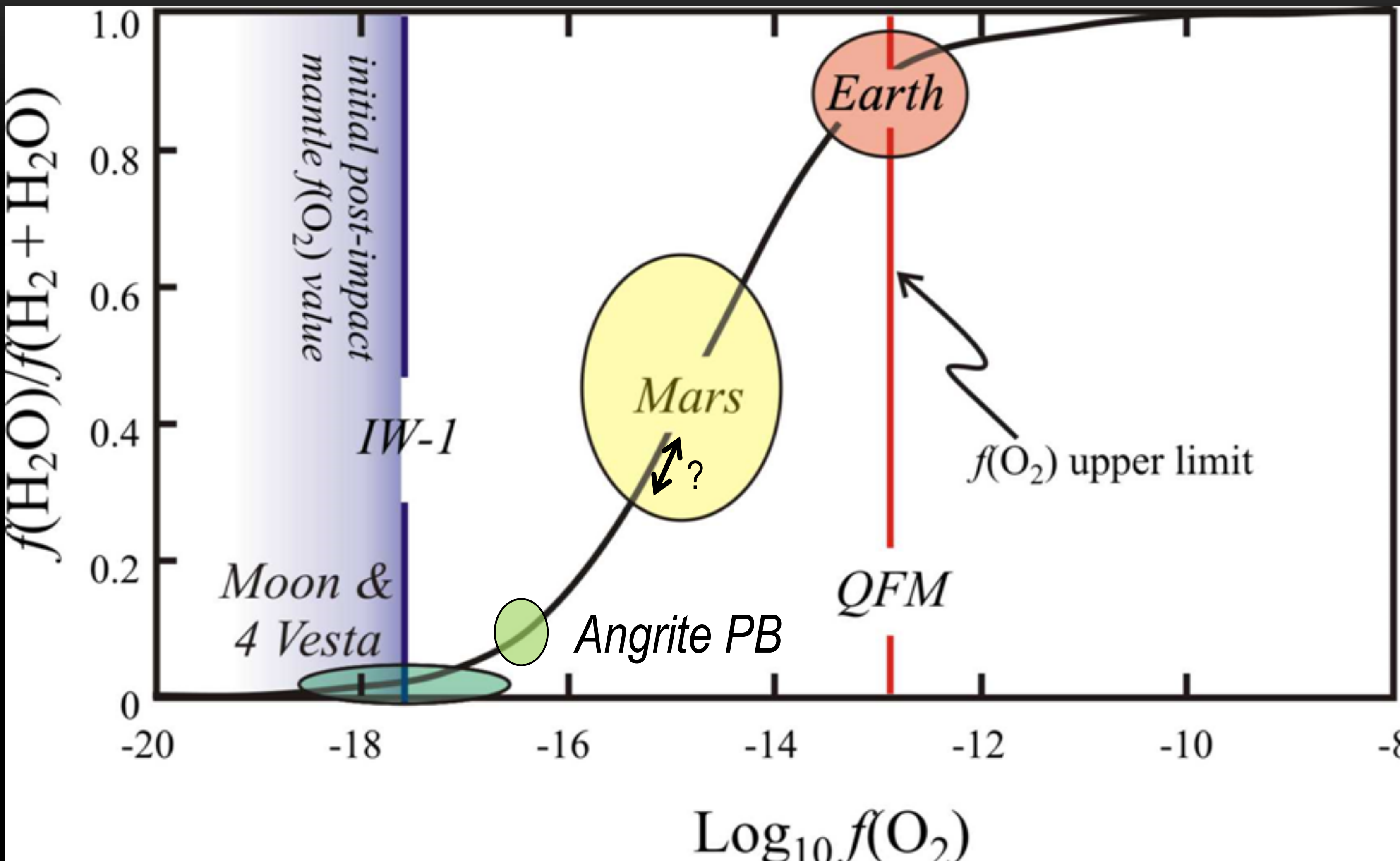
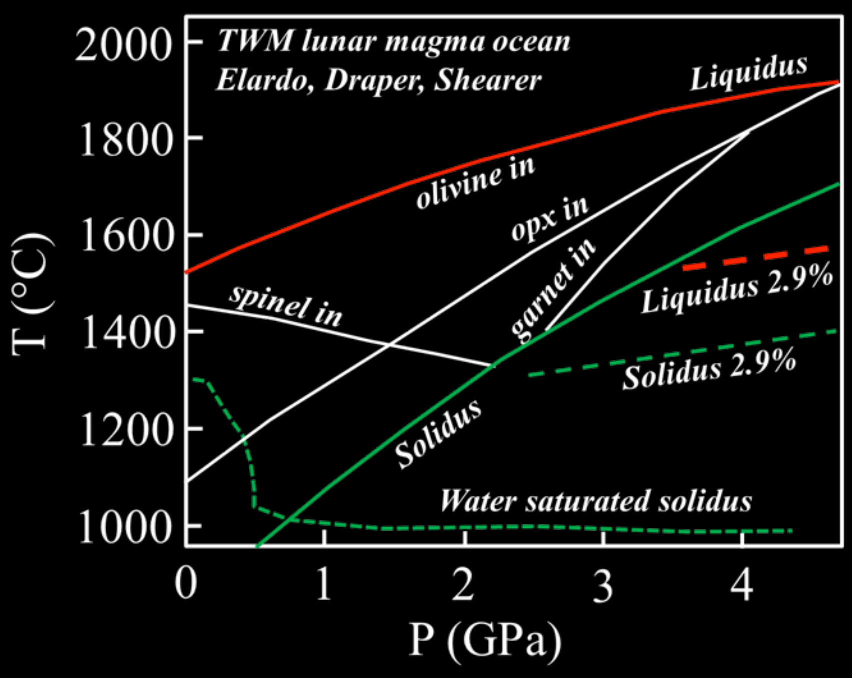
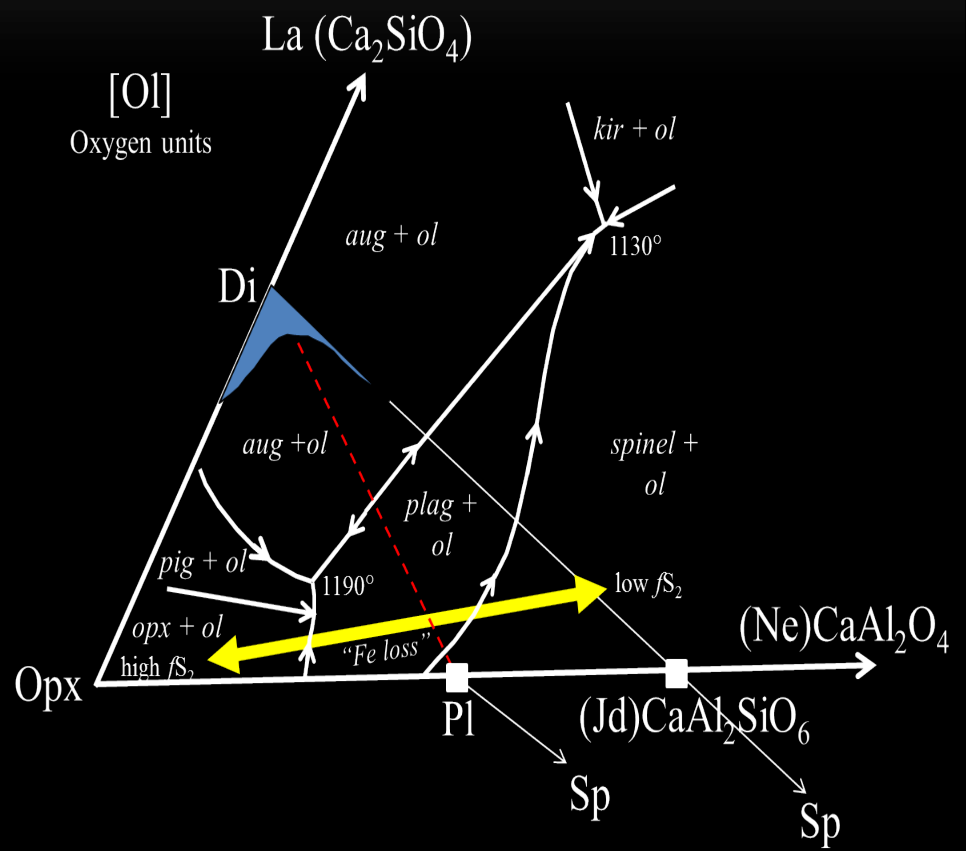


Role of volatiles in primary crust formation H_2O-S

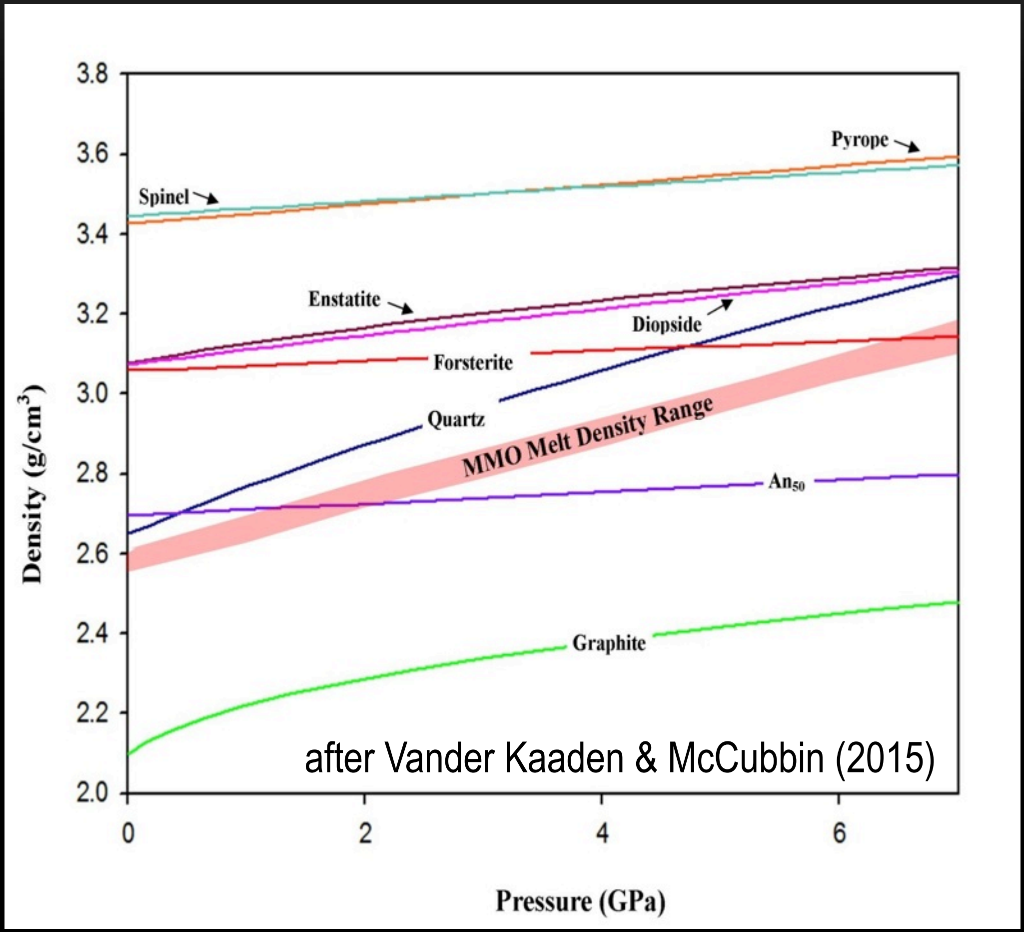
H_2O



S

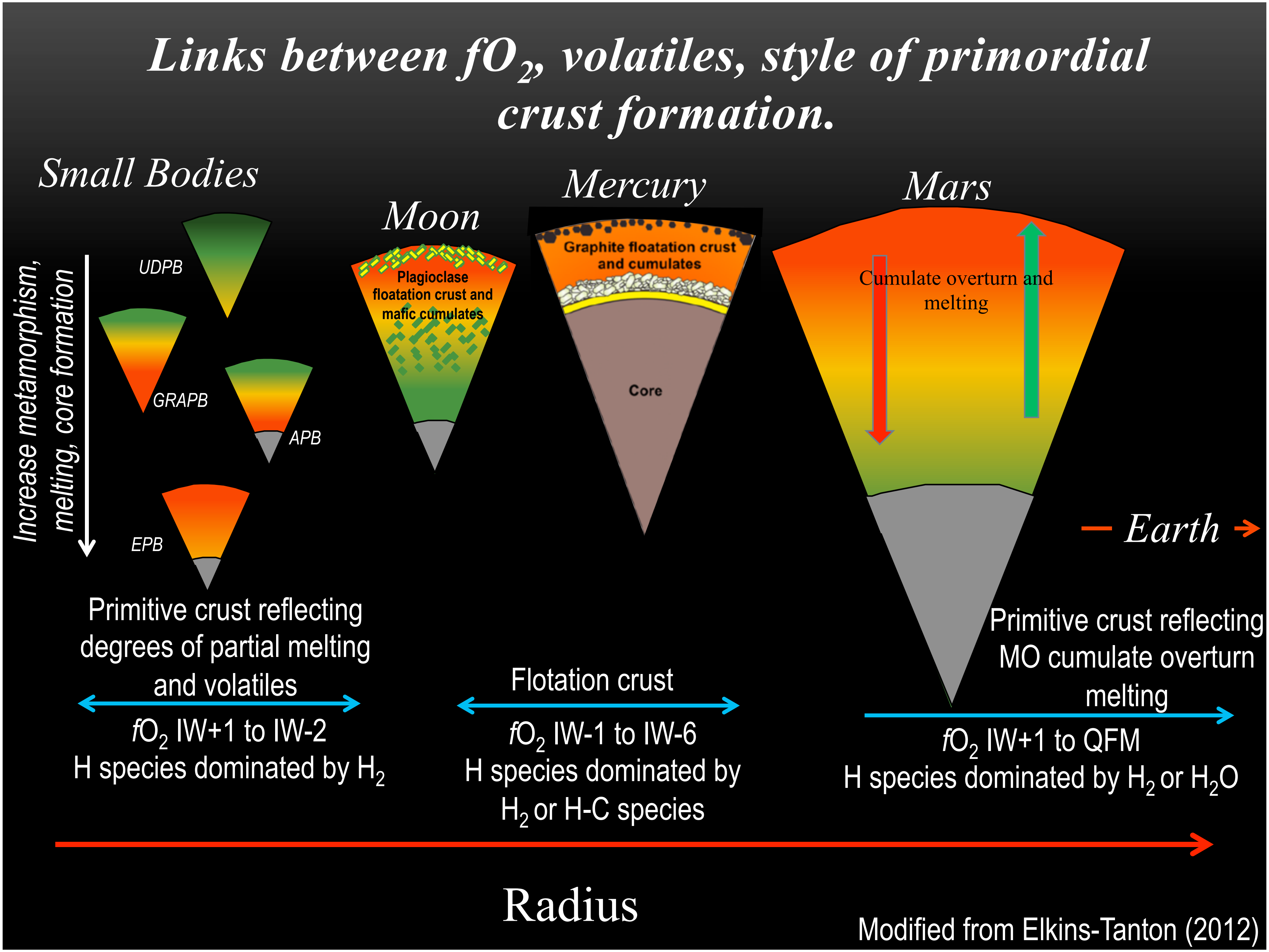


Role of volatiles in primary crust formation C



Mercury's primary crust?

- Inexplicably dark surface
  - Source of darkness unknown
  - No ferrous iron detected in silicates
- Volatile-rich
  - K/Th value as high as mars
- Low oxygen fugacity
  - ΔIW -2.7 to -6.3
  - Elevated S abundances on surface
- Graphite has been suggested as a potential darkening agent given Mercury's volatile-rich nature and graphite's spectral properties



Links between fO2, volatiles, style of primordial crust formation.
Small Bodies
Moon
Mercury
Mars
Increase metamorphism, melting, core formation
UDPB
GRAPB
APB
EPB
Plagioclase floatation crust and mafic cumulates
Graphite floatation crust and cumulates
Core
Cumulate overturn and melting
Earth
Primitive crust reflecting degrees of partial melting and volatiles
fO2 IW+1 to IW-2
H species dominated by H2
Flotation crust
fO2 IW-1 to IW-6
H species dominated by H2 or H-C species
Primitive crust reflecting MO cumulate overturn melting
fO2 IW+1 to QFM
H species dominated by H2 or H2O
Radius
Modified from Elkins-Tanton (2012)

Examples of future work and questions

- Thermal models for asteroid melting can be improved through the refinement of appropriate specific heat capacity and diffusivities, accurate peak temperatures from geothermometry, and more precise ages from high-resolution chronometers.

- What is the chronology of lunar accretion and primary crust formation?

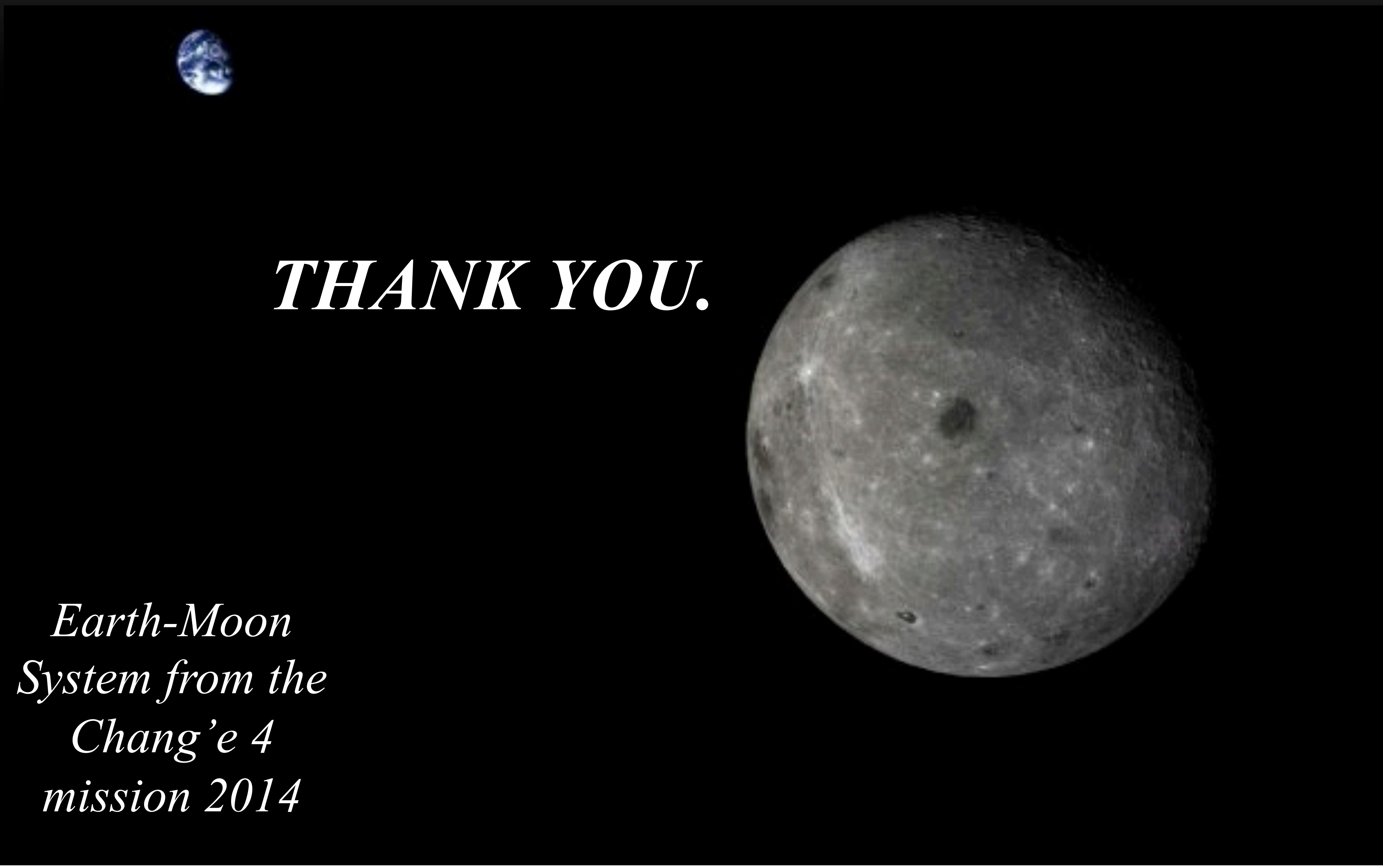
- How does primordial differentiation influence the initiation, duration, and style of secondary crustal growth (e.g. Mg-suite vs FAN)?

- What is the origin of ancient felsic crust formation on small bodies, Moon, Mars, and Earth?

- How does accretion and differentiation influence indigenous volatile reservoirs?

- Where do volatile reservoirs reside in planetary interiors (crust. mantle, core, mineral phases)?

All these questions require the integration of substantial sample and experimental derived data with mission observations and modeling.



THANK YOU.

Earth-Moon System from the Chang’e 4 mission 2014