The Differentiation History of the Terrestrial Planets as Recorded on the Moon

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Outline

1) Factors Leading to Lunar Magma Ocean Model for Planetary Differentiation

2) Rationale for Magma Oceans on Other Planets
   Means for early efficient differentiation
   (Works on Moon why not here?)

3) Some Inconsistencies between the Lunar Magma Ocean Model and Observations

Factors Leading to Lunar Magma Ocean Model

1) Role of Plagioclase
   Large amounts of plagioclase-rich crust
   Eu anomalies in basalt source regions

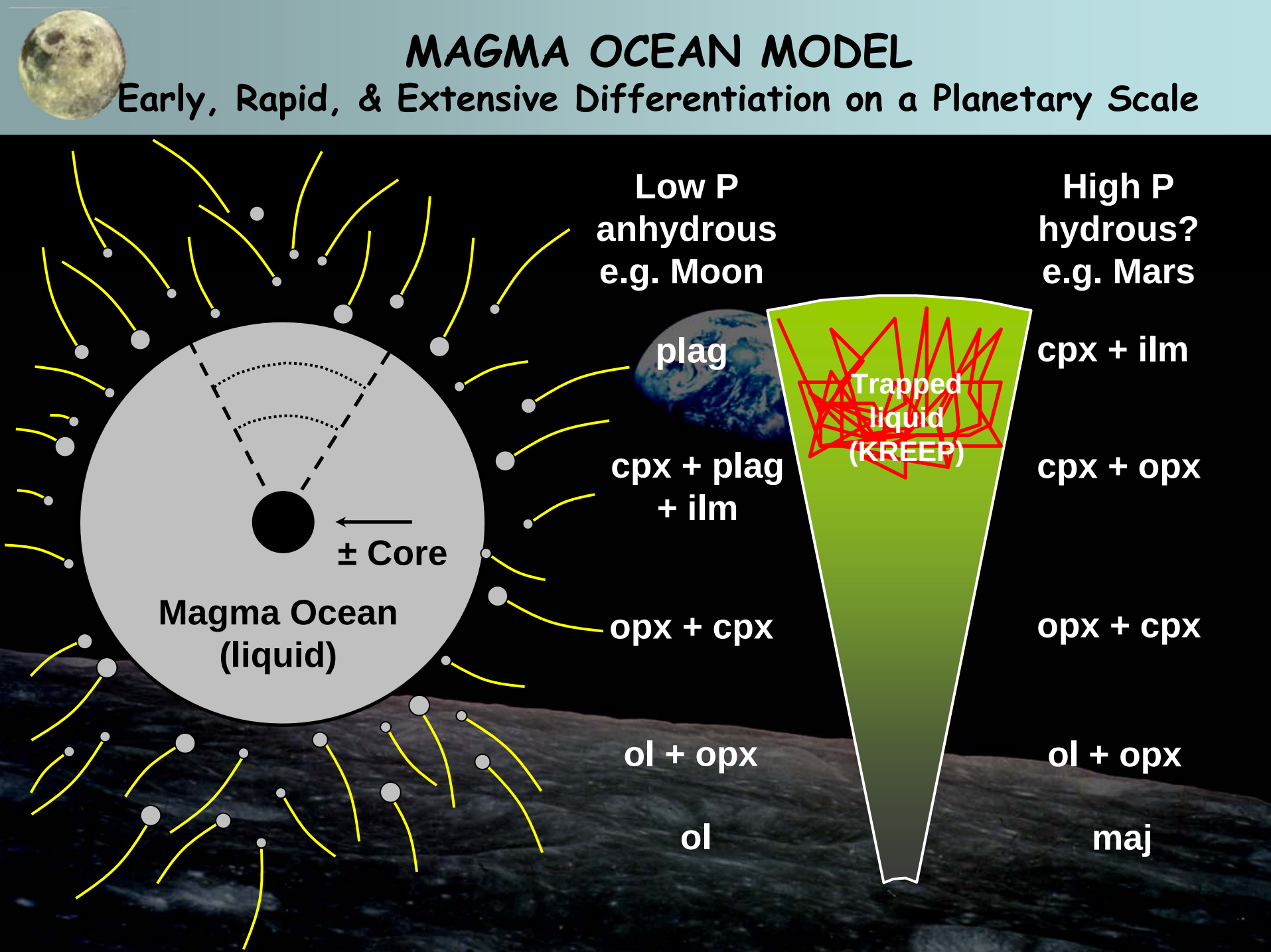
2) Role of KREEP
   Mechanism to produce large volume evolved component

3) Role of Experimental Petrology
   Permits predictions (E.g., ilmenite in high Ti sources
   Low pressure, volatile depleted, limited fO_2

4) Ability to account for observed compositional variations by mixing experimentally produced sources with observed (KREEPy) materials

MAGMA OCEAN MODEL

Early, Rapid, & Extensive Differentiation on a Planetary Scale

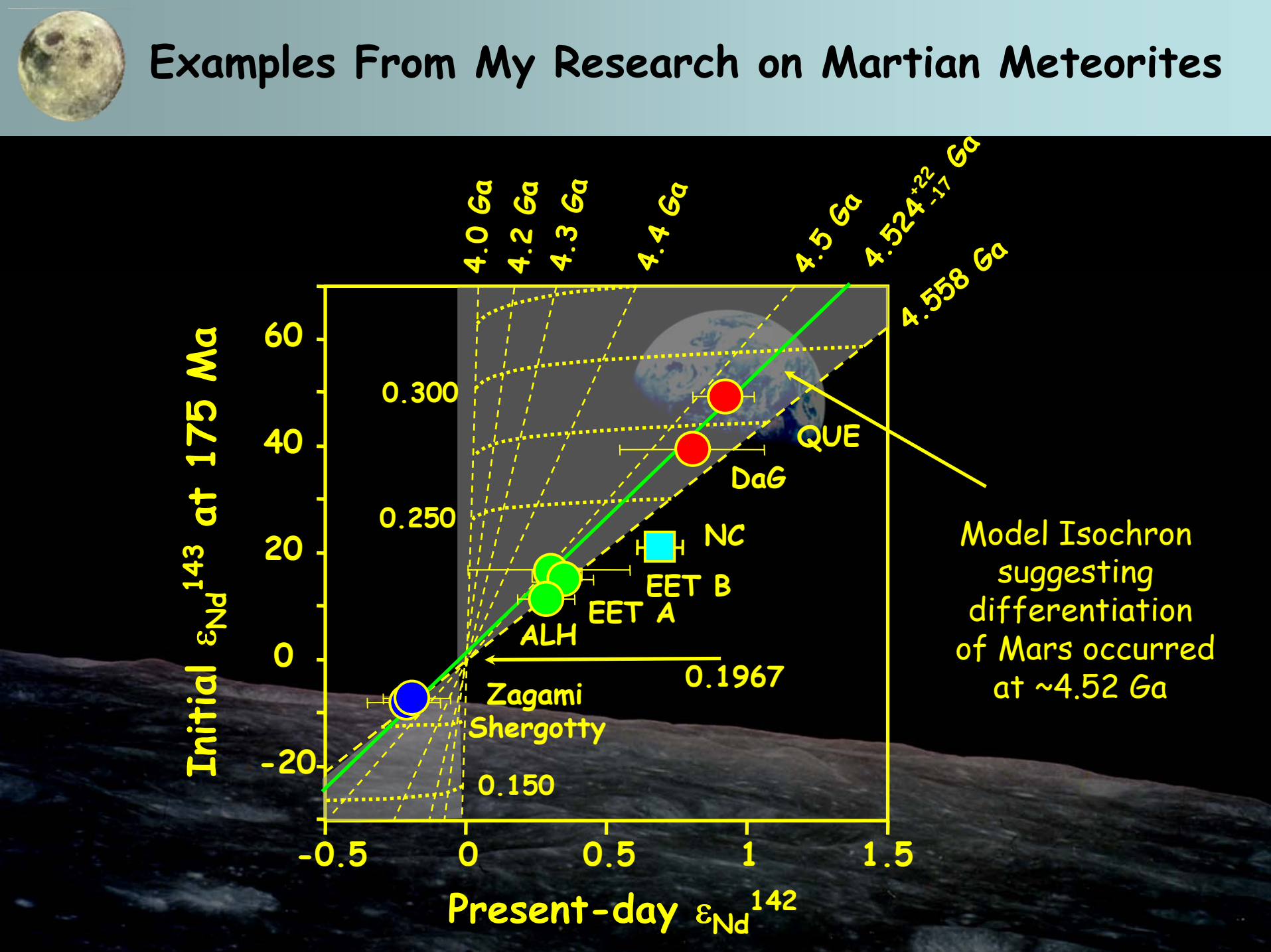


Magma Oceans on Other Planets

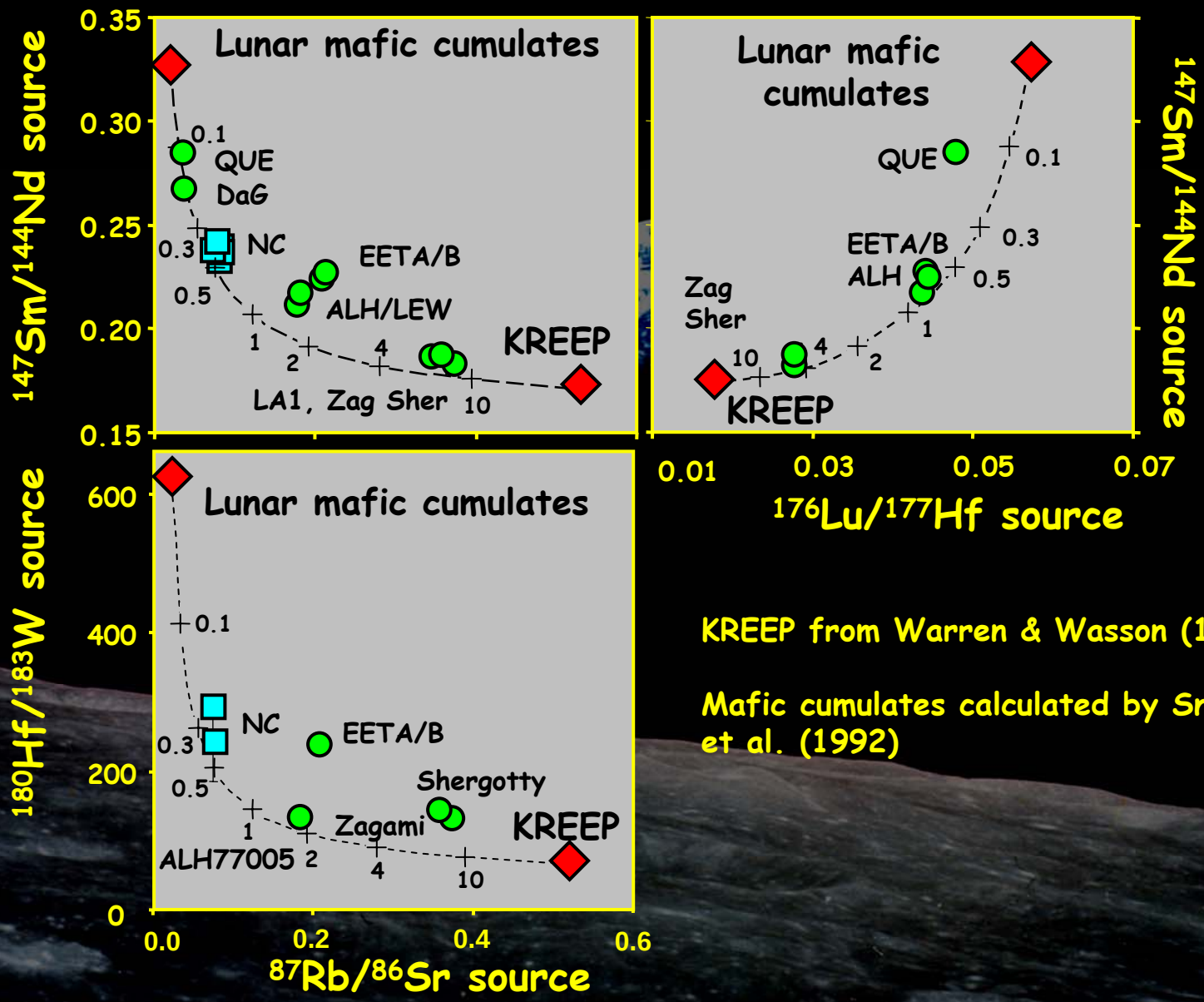
Little strong evidence that requires differentiation by magma ocean solidification
No Plagioclase-rich crust, KREEP, or high Ti sources

Instead differentiation by magma ocean solidification simplifies differentiation models
Examples:
(1) Core formation on large bodies
(2) Satisfies criteria for rapid and extensive differentiation

Examples From My Research on Martian Meteorites



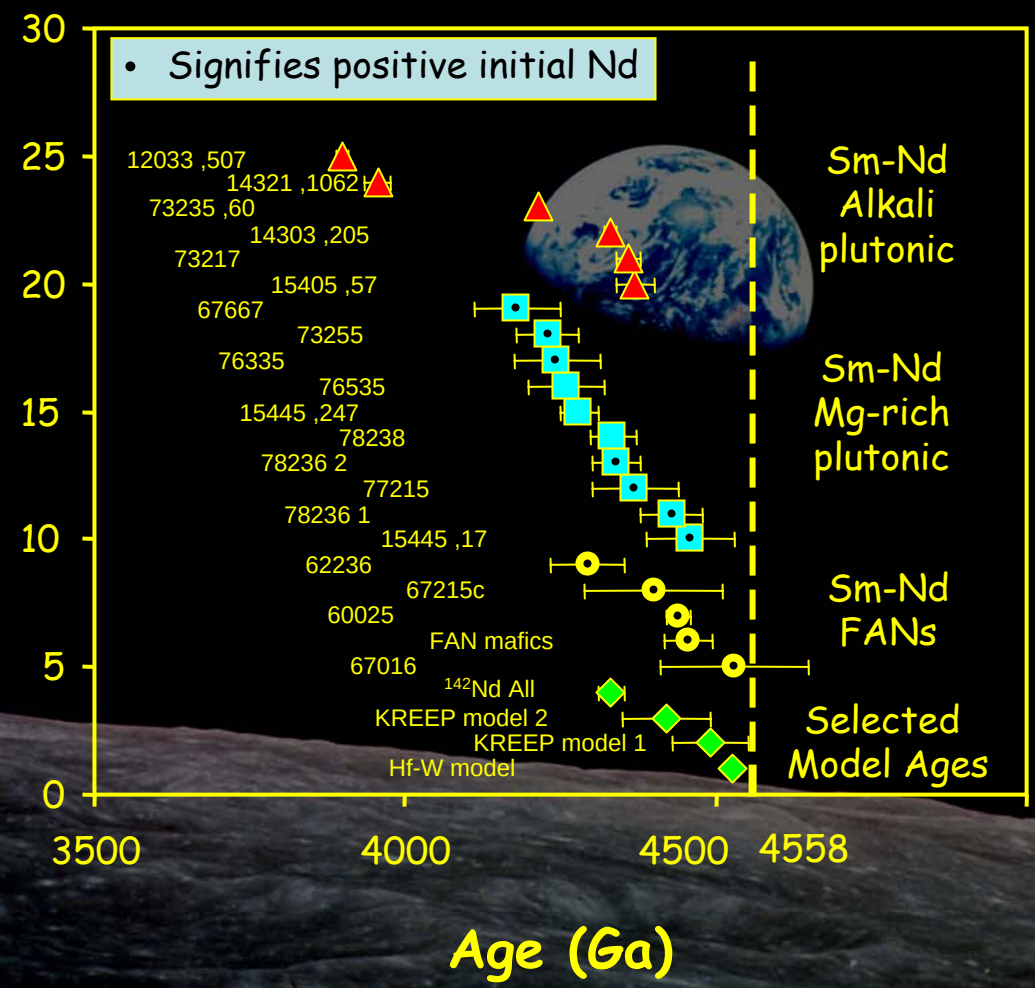
Mixing of Martian Basalt Sources



KREEP from Warren & Wasson (1979)

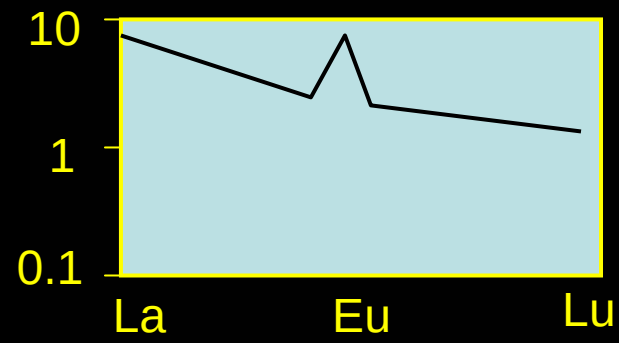
Mafic cumulates calculated by Snyder et al. (1992)

Inconsistencies Between LMO Model and Ages of Lunar Differentiation and Crust Formation



Inconsistencies Between LMO Model and Compositions of Some Lunar Rocks

Apollo 17 troctolite 76535



Olivine-plagioclase cumulate
Plagioclase 58% An_{96}
Olivine 37% Fo_{88}

Conclusions

1) Differentiation via solidification of a magma ocean is derived from geologic observations of the Moon

2) Although geologic observations on other bodies are often consistent with differentiation via magma ocean solidification, it is not generally required.

3) There are some fundamental inconsistencies between observed lunar data and the model, that will require this model to be modified

4) Nevertheless, the Moon is the only location we know of to study magma ocean process in detail