Tectonics of the Earth-Moon-Vesta Family

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1 Early Solar system: 0 - ~ 5 m.y. (5,568 - ~5,653 m.y.)

* Glancing impact/merger of undifferentiated small proto-planet Theia with larger, differentiated Proto-Earth forms Early Earth (Akram, 2014).
* This occurred during later stages of planetary accretion. (Wood, 2011). Age established by meteorite dating.
* Theia's impact implanted excess angualr momentum for later fission and set the stage for most EMV later tectonic history.
* Theia fragments survive as noble gasses suppliers at base of Earth's major plumes and as possible big metal fragment in inner core (Zhang, 2012; Mohazzabi, 2014, Nakajima, 2016).

2 Spin-up : ~ 5 m.y to (?) 100 m.y.

* Core-mantle segregation continues to increase spin rate and flatten Maclaurin spheroid.
* Proto-Earth forms its first crust and mantle with zircon dates of 28 and 36 m.y. from Vesta sourced eucrite meteorites (Zhou, 2013, Kagami, 2016)

3 Viscous Fission: ~ 100 m.y. (+/- 30 ?)

* This poorly constrained age must pre-date oldest lunar & terrestrial zircons at 157 m.y. (Nimchin, 2009)
* Unstable Jacobian ellipsoid ends separate as viscous blobs, somewhat like twin spiral arms of giant impact models (Cuk, 2012, Canup, 2012)
* Separation leaves Moon and Vesta with same isotopic and volatile composition as pre-lunar Earth upper mantle. (Sarafian, 2014)
* Minor amounts of undifferentiated metal go along with fissioned lunar blob to form its future core.
* Both asymmetric blobs preserve Earth's early crust on one side and mantle on other side.
* Moon's trailing umbilical cord collapses as the Procellarum Basin as the Moon's navel.

4 Vesta escapes immediately: ~ 100 m.y. (+/- 30 ?)

* Gravity assist by Moon with possible second boost by Mars allows Vesta to escape with intact rock record of pre-lunar Earth and asymmetric geometry of fission separation.
* Vesta's rock record is available in common HED (Howardite, Eucrite, Diogenite) meteorites, generally regarded as Vesta sourced. Vesta's escape before lunar crustal reworking preserves these meteorite sources and fills this pre- lunar and early lunar time gap in Apollo samples.
* Vesta O16, O17, and O18 are identical to Earth and Moon at ppm levels with ratios unique in the solar system (Asphaug 2014).
* Viscous asymmetric separation left Vesta with early crust on one side and mantle root on other. Slow mantle root subsidence at low gravity forms equatorial groove system. (Williams, 2014)

5 Entrapment in close orbit: ~ 100 to ~200 m.y.

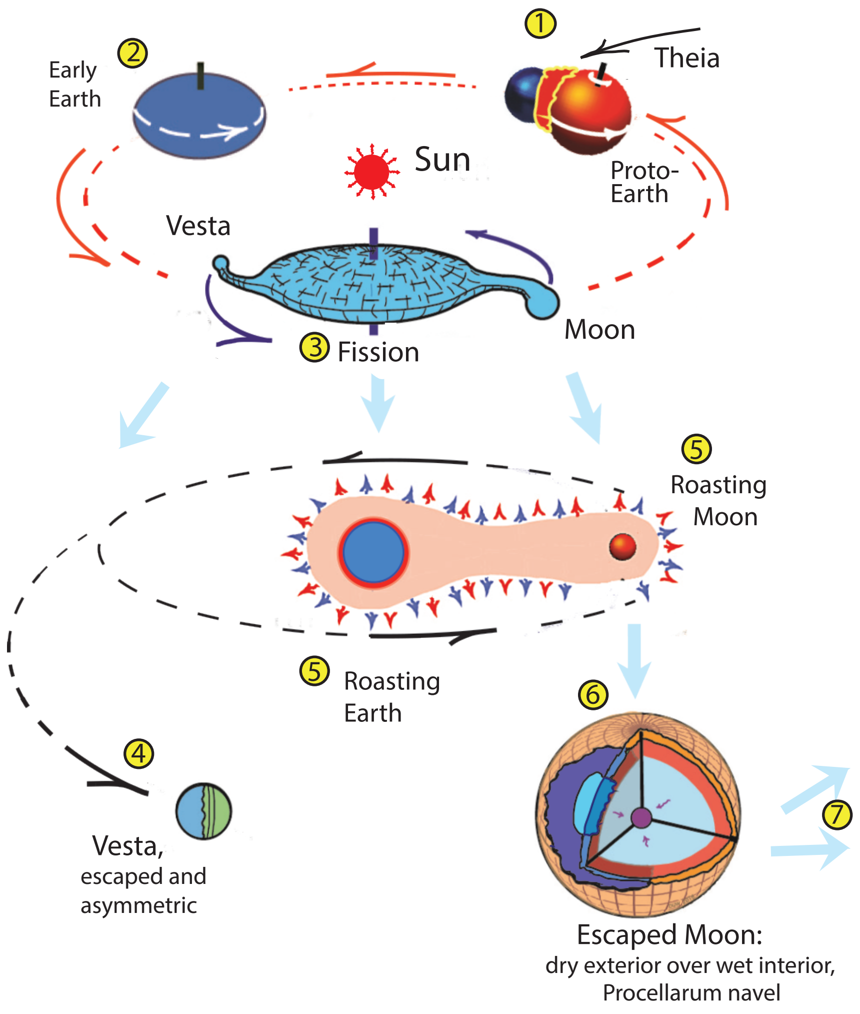
* Tidal resonance transfer to the Sun reduces excess angular momentum by ~ ½ during Moon's ~ 100 m.y. close orbit entrapment. (Cuk and Stewart, 2012).
* Tidal kneading and heating generates massive silicate atmosphere that engulfs both bodies and allows volatile escape to space. (Pahlevan and Stevenson, 2007).
* Kneading extrudes thick dry basaltic crust over both hemispheres, doubles farside crust and reworks mantle root on nearside. Pocellarum generates special KREEP magmas. Remnanants of pre-lunar or early lunar rock record are covered, reworked, and probably lost.
* Escape is dated by largest cluster of igneous zircon ages at 200-220 m.y. (Grange, 2013).

6 Later history: ~ 200 m.y. to present

* Heavy bombardment punches great basins through the nedry crust (~ 200 m.y to 640 M.Y.(Imbrium))
* Impacts implant deep energy to generate thin mare lava flows from dry sources. Peak at ~ 1000 m.y., tails off over next 2,500 m.y. (Heisinger and Head 2006)
* Continued cooling, slow minor contraction. Development of hemispheric systems of small thrust scarps (Watters, 2015)
* Procellarum (especially Aristarchus) is continuing source of magmas and volatile anomalies: final lavas, rilles, transiet pehnomena.

7 A) Sinuous rilles hve abs~~ence of downstream volume that~~ makes lava-based models impossible. Alternative is hot gas melting permafrost ice.

* B) Credible rille models possible on proposed fission generated wet Moon.



MAJOR POINTS

* In contrast to current lunar origin models, core-driven, viscous fisison can replicate Apollo isotopic and volatile compositions in considerable detail. This may be a path out of lunar science's current scramble to find a credible separation mechanism.
* With a fission origin Vesta can be Moon's twin; her HED meterorites fill Apollo's 150 m.y. time gap. A complete evidence-based tectonic history of the centire EMV family is within reach.

(Most data here are already published but reinterpreted with a different origin in a different time frame.)

* Theia's impact during early Solar System time implanted anglar momentum for core segregation to drive viscous fission of the E-M-V system ~ 100 m.y. later.
* Fragments of Theia survive in Earth as noble gas sources in some mantle plumes; a large core fragment may be in Earth's inner core.
* Vesta's birth certificate as Moon's lost twin is O17, identical and unique only with Earth and Moon. Her early escape preserved 150 m.y. of rock history, lost in Apollo samples but available in HED meteorites as samples of eary Earth's pre-lunar crust and mantle.
* Moon and Vesta asymmetry are results of whole body viscous fission. Procellarum is Moon's navel; Vesta's geology reflects slow subsidence of her mantle root.
* Moon's tidal kneading extruded a new crust to bury old farside crust and preserve original asymmetry. Older craters exist and Procellarum has local KREEP magmas, no need for a 300 km-deep magma ocean.
* Later heavy bombardment implanted deep orbital energy for generatioin of thin, dry mare lavas that partially filled resultant basins.
* This later stage Moon had a dry outer zone and dry crust over a volatile-rich inteior. Slowly escaping water vapor collects as a thick permafrost layer, especially in Procellarum.
* Sinouus lunar rilles formed by collapse of tunnels melted through thick permafrost sheets by hot volcanic gasses.
* The required "wet Moon" probably contains 1,000s km3 of permafrost ice, potential sites for nuclear melting of a lunar base or even a lunar colony.

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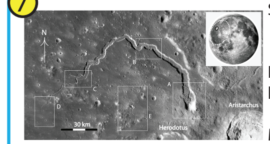
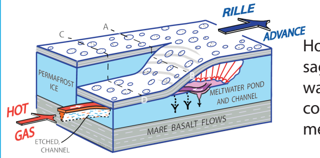


Schroeter's Rille: 175 km long, 600 m deep, 100 cu km of missing downstream lava ?

Impossible for lava origin but possible for hot gas melting through permafrost ice.

Model below is possible but requires a wet Moon current models cannot produce.



Hot gas/permafrost rille origin: roof sags behind advancing front as melt water sinks through floor. Hot gas continues to diffuse through nested meandering channel.

ALTERNATE ORIGIN OF THE MOON ? COULD BIG HISTORY BE WRONG ?

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Big History lacks a credible lunar origin. Despite almost universal acceptance of giant impact models, no computer simulation has duplicated isotopic composition of lunar samples nor explained recent findings of trace water. One solution may be an upgraded 1960's scenario of core-driven fission. That Big History begins during late stages of planetary accretion when grazing merger of Proto-planet Theia spun Proto-Earth almost to its stability limit. Core/mantle segregation over the next ~50 - 100 m.y. finally drove whole body fission of asymmetric blobs, Moon and Vesta, each with Earth's primitive crust on one face and mantle on the other. Vesta escaped while Moon's umbilical cord collapsed as the Procellarum Basin. Moon's entrapment in close orbit allowed tidal resonance transfer of excess angular momentum to the Sun while tidal friction raised internal temperatures for a silicate atmosphere to engulf both bodies, for volatiles to pass on to space, and for basaltic magmas to spread new crust over both hemispheres. Doubled farside crust preserves original asymmetry with no need for a magma ocean. Escape to higher orbit ended that era at ~ 200 m.y., a zircon cooling age. Heavy bombardment for another 400 m.y, produced large basins and deep impact energy for another b.y. of mare lava flow. Subsequent slow global cooling formed minor thrust systems.

Retro-dictions test much of this scenario while radar may test its wet predictions with a sinuous rille model, a substitute for a dry Moon's fatally flawed collapse of lava-tubes. Freezing temperatures trapped rising water vapor as shallow permafrost layers. Later, hot volcanic gasses melted a migrating, subsurface puddle for meandering tunnel advance while melt water sank into tunnel floor. The overall hypothesis produces a Moon of isotopic composition identical to Earth's mantle, explains Vesta and Moon's first order asymmetry, makes Procellarum the lunar navel, and predicts lunar water in volumes beyond current dreams.

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