L19 The uniqueness of Earth's plate tectonics

< plate tectonics is evidently not inevitable >

By preparing a small piece of fragile glass it first dared a feat which long ago was beyond the powers of young Titans, who piled mountains high in a vain attempt to ascend to lofty citadels.
—inscription on the reliquary of Galileo's middle finger of his right hand, preserved in the Museo di Storia della Scienza, Florence, Italy.[1]

With regard to plate tectonics, Earth is unique among the stony planets. No stitched together motleys of shreds and patches that are our continents is so of Moon, or of our sister-planet Venus, or of Mercury, or of Mars, or of the well-imaged crusted moons of the outer planets. But this does accord to modern expectations.[2] As Stuart Ross Taylor has summarized: "None of the planets in the solar system nor the 60 or so satellites resemble one another; all are different and could be members of another planetary system without exciting comment." [3]

Plate tectonics has operated under wet-Earth conditions to produce the continents. On Earth, a product of an evidenced four billion years, if not more, of plate of tectonics operation, is a crust of intermediate composition (totaling 0.5% of Earth's volume) and of granite bodies (totaling 0.2% of Earth's volume). This product of laborious differentiation occurred because the basalt, which Earth pours forth, is subducted "wet" into the mantle, but only to shallow depth where entrained water "sweats" out and aids partial melting to produce siliceous magmas that intrusively rise and in places noisily extrude to build composite volcanoes. By contrast, Moon is a dry body (***Footnote L19.1***).

Earth continues to extrude lavas, and plate tectonics continues unabated after four billion plus years. By comparison, Moon's igneous activity ceased two billion years ago. Till then, maria basalts were erupting but no plate tectonics ensued. To scale, the billion years of outpourings that formed the maria are minute and are puddled in depressions in the older, far more voluminous, terrae crust.

Did plate tectonics begin on Earth when hotspot outpourings of basalts became thicker and more enveloping than Moon's maria basalts? Did Earth ever have a crust like Moon's terrae?

When plate tectonics began on Earth is uncertain as there is no terrestrial rock record for the Hadean Eon. This time is covered by Moon's Preimbrium Eon. Moon acquired an anorthosite crust during the Preimbrium. A collision origin for Moon, would guarantee that it originated as a molten body. Agglomeration of "anorthositebergs" floating in dry molten peridotite (crystals of this mineral are not buoyant in a wet peridotite magma) would then best account for the lunar primary crust. The same collision event would also have left Earth molten in its outer part even if it were not already in a completely molten state. However, Earth early had oceans. Possibly, some water was acquired from falls of icy Centaurs (***Footnote L19.2***) and comets from the Oort cloud (although by their high arrival velocities, large of these can explode-away more than they deposit). Anyway, water accumulation would have resumed immediately following Moon-forming collision stripping of any prior seas. The water, ready to fall, would have been in that cold trap for ice, the upper atmosphere. When rain showers began, Earth's primordial crust is unlikely to have survived the carbon dioxide and steam-bath weathering. ❑

Footnote L19.1 Moon with its axial tilt of ~1.5 º is not parched at its poles where craters, as Peary, though with endlessly sunlit rims,[4] have in their permanently shadowed bottoms ice accumulates from impacting comets. In 2009, polarized radar pulses from India's Chandrayaan-1 orbiting spacecraft located ~ 40 small (diameter < 15 km) north-pole craters with ice deposits 2-3 m thick [6] (a most significant find for enabling colonization beyond Earth, ever!).

Footnote L19.2 Centaurs are toward-Sun escapee bodies of the Edgeworth-Kuiper belt of which Pluto, a mixture of ice and rock, is the largest of its already known 600 icy worlds larger than 100 km in diameter and countless smaller.[7]