Primordial Anorthositic Continent on Mars and Planetary Habitability

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The Moon has primordial continental crustal materials consisting of anorthosite. Anorthosite has been recently discovered on the Martian surface as well, with occurrence possibly extensive similar to the lunar-like global anorthosite crust [1]. A felsic primordial Martian crustal basement, in addition to anorthosite, may include andesite [2] and granite [3]. A key example of this may be the conglomeratic alluvial-fan materials of Peach Vallis in Gale crater which are interpreted to be representative of the ancient felsic crust [4] of Terra Cimmeria exposed by the Gale impact [5]. Terra Cimmeria is one of the ancient geological provinces of Mars, dated to be > 4.0 Ga based on impact crater statistics, stratigraphy, and magnetic data, which records major contractional, transtensional, and extensional tectonism [6]. In the case of the Earth, the occurrence of anorthosite is observed to be limited in the geological record, however, lunar and Martian surface geology indicates that anorthosite was likely more universal on the Earth as primordial continent during the first 600 million years after its formation.Difference in the presence of an anorthositic continent is due to the size of planet. The reason why the primordial continent of the Earth disappeared is explained by the strength and duration of mantle convection. On Mars, due to its size and relatively rapid heat loss, a proposed early phase (~>3.93 Ga) of plate tectonism shut down [7] before the primordial crust could be destroyed.The presence of a primordial continent is the essential and most significant factor as it determines the fate of the planet to be habitable or not. The key is to have limited amount of an initial ocean to emerge a significant extent of primordial continent at the surface, as well as to operate plate tectonics on the planet [8].When this logic is applied to a super-Earth, it suggests that a primordial continent forms on the surface but that the continent is transported into the deep mantle due to strong mantle convection immediately following its formation. After the primordial continent disappears from the surface of the planet, the supply of nutrients necessary for life terminates. Even if a primordial ocean existed on the surface of a super-Earth, the ocean would disappear before life emerges. Therefore, there is very little chance for life to emerge on a super-Earth. Mars, on the other hand, may hold significant environmental information not only about extremely ancient Mars and the solar system, but also possible early life. References: [1] Carter, J., Poulet, F. (2013) Nature Geoscience 6, 1008-1012. [2] Bandfield, J.L. et al. (2000) Science 287, 1626–1630. [3] Wray, J.J. et al. (2013) Nature Geoscience 6, 1013-1017, doi:10.1038/ngeo1994. [4] Sautter, V. et al. (2015) Nature Geoscience, doi:10.1038/ngeo2474. [5] Anderson, R.C. et al. (2015) GSA Annual Meeting in Baltimore, Paper No. 203-11. [6] Dohm, J.M. et al., 2013. In "Mars Evolution, Geology, and Exploration", Nova Science Publishers, Inc., pgs. 1-34. [7] Baker, V.R. et al. (2007) In “Super-plumes: Beyond plate tectonics”, Springer, p. 507–523. [8] Maruyama, S. et al., 2013. Geoscience Frontiers 4, 141-165.

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