Water on Phobos and Deimos: Implications of Water in Tektites for the Giant Impact Origin Hypothesis for the Moons of Mars

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Abstract. For both science and human exploration planning, determining the water content of Phobos and Deimos is important. The expected water content on the two martian moons depends on their origin and evolution through time, which still remain unknown. One intriguing hypothesis is that they are reaccreted debris resulting from one or more giant impacts on Mars[1]. This hypothesis is commonly thought to imply that those moons would be depleted in volatiles, in particular water, as often assumed in the Giant Impact Origin hypothesis for the Earth's Moon[2]. However, large impacts into wet targets may produce wet ejecta. Insights into the survival of target water in large impact events may be gained from the study of the water content of terrestrial *tektites*, natural glasses derived from the hypervelocity impact melting, ejection, atmospheric transit, quenching, and fallback of upper crustal materials[3]. Although tektites resemble volcanic glass in form, they are compositionally similar to sedimentary rocks minus most of the water[4]. Among tektites, Australasian tektites have the higher water content, typically ~ 0.02 to 0.04 wt%[4,5]. If their source impact took place on emerged land, the impact target was likely a wet site, allowing those tektites to be buffered by water in the ejected cloud. Alternatively, the mole fraction of water in melting fluid is estimated to be at least 0.3 to explain the dissolved water content of Australasian tektites by using the model of water solubility in rhyolitic melts at low pressure[6], suggesting a submerged offshore impact site. Although the water content in Australasian tektites generally decreases as the distance increases away from Indochina, Australasian tektites recovered in Australia, which must have exited and reentered Earth's atmosphere, contain significant water (~0.02 wt%)[5]. The survival of target water even in distal tektites suggests that large impacts do not necessarily produce water-depleted high-energy ejecta, if the original target materials were water-rich. This opens the possibility that for the hypothesis in which Phobos and/or Deimos are reaccreted Mars impact ejecta, not all target water was necessarily lost in the giant impact debris. This possibility is further supported by the recent realization that significant amounts of water are present in lunar crustal rocks[7,8,9]. Our study suggests that Phobos and Deimos might have had an original water content of up to ~10^{-2} wt%, even in the Giant Impact hypothesis for their origin, if the target Mars crustal materials were water-rich.

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