WHAT DO ORIGIN MODELS TELL US ABOUT LUNAR VOLATILE DEPLETION? D. J. Stevenson, Caltech 150-21, Pasadena, CA 91125, djs@gps.caltech.edu.

Introduction: The giant impact model is a well established semi-quantitative description of the formation of Earth's moon. It is only partially quantitative because the full dynamical evolution of the impact generated disk has not yet been carried out (published models are deficient in one or more respects) and is not readily amenable to numerical simulation. The physics and physical chemistry are complex and the total evolution time (tens to thousands of years) is enormous compared to the orbital timescale. (By contrast, most of the immediate consequences of the giant impact are over in of order 24 hours.) Even the state of the disk immedatiely after the giant impact (the intial condition for orbital evolution) is not fully understood. In this presentation, emphasis will be placed on the uncertainties and how these translate into a range of possible "predictions", esepcially for the intial water of the moon. Unfortunately these range all the way from very dry to Earthlike (wet).

Limiting Cases: Pahlevan and Stevenson [1] proposed that the remarkable isotopic similarity of Earth and Moon (specifically for oxygen) may be explained by efficient mixing between Earth and Moon reservoirs, so that the Moon "looks like" Earth even if the projectile did not. It is not known whether this model is correct but it does have a variety of implications for isotopic relationships between Earth and Moon that are not violated by (and are perhaps even supported by) recent observations. This model is not as prescriptive (or as testable) as some workers have supposed because there is no simple connection between the turburlent diffusion of a tracer (oxygen or water) and the mechanism of angular momentum transport. In other words, diffusivity and kinematic viscosity need not be equal and are in general very non-equal. Current models for terrestrial planet formation suggest that Earth's water was delivered early rather than much later. Accordingly there is an identifiable limiting case in which the Moon would be initially as wet as Earth . This would be true *provided hydrodynamic escape has a longer characteristic timescale than diffusive re-equilibration.* In this limit, the region of lunar formation would be continuously replenished in water from the effectively infinite reservoir of Earth's magma ocean by outward transport (turbulent diffusion) in the disk. This limiting case cannot be excluded with certainty but seems unlikely since hydrodynamic escape rates are significant (cf [2], although the model they describe does not have a self-consistent density ansd temparature structure for the outflow region). The opposite limiting case is one in which the lunar forming region is effectively isolated from the terrestrial water reservoir, perhaps through rapid viscous evolution of the disk. Hydrodynamic escape from the outer periphery of the disk is favored by the lower gravitational energy requirement and this then dries out this isolated reservoir, leading to strong volatile depletion of the newly forming moon. There is not yet a detailed model that describes this but an outline of such a model will be provided in this presentation.

Challenges: The Moon is heterogeneous and even if the modeling strategy outlined above can be carried through, the connection to the observables requires a good understanding of the later evolution (the magma ocean phase of early lunar evolution.)

References:

[1] Pahlevan, K and Stevenson, D. EPSL, 262, 438 (2007). [2] Desch, S ad Taylor, G. J. LPSC 42 (2011).