OBLIQUITY EVOLUTION OF MARS DURING THE NOACHIAN PERIOD. R. Deitrick[1], R. Barnes[1], J.C. Armstrong[2], C. Scharf[3], S.D. Domagal-Goldman[4], A.D. Del Genio[5], [1]University of Washington, Astronomy Dept., Box 951580, Seattle, WA, 98195 (contact: deitrr@uw.edu), [2]NExSS ROCKE-3D Team, [2]Weber State University, Dept. of Physics, 1415 Edvalson St., Dept. 2508, Ogden, UT, 84408, [3]Columbia University, Dept. of Astronomy, Mail Code 5246, 550 W 120th St., New York, NY, 10027, [4]NASA Goddard Space Flight Center, Planetary Environments Laboratory, 8800 Greenbelt Rd., Greenbelt, MD, 20771, [5]NASA Goddard Institute for Space Studies, 2880 Broadway, New York, NY, 10025.

Introduction: During Mars' Noachian period (4.1—3.7 Gyr ago), the orbits of the giant planets were probably more compact [1]. Gravitational perturbations from other planets dictate the rotational and orbital evolution of modern Mars [2], so their evolution during the Noachian could be markedly different than today [3]. Moreover, since properties like eccentricity and obliquity are fundamental drivers of climate, our understanding of water on ancient Mars requires a careful and thorough understanding of the orbital and rotational evolution of Mars at a time when the solar system was more compact.

Geological features on the surface of Mars provide evidence of liquid water [4] during the Noachian. Studies of exoplanets with large orbital and rotational forcing have shown that planets at the outer edge of the habitable zone (like Mars) could be more likely to host liquid surface water [5]. Another possibility is that episodic glaciation and melting events, triggered by obliquity evolution, could have formed the observed features without the persistence of liquid oceans. In either case, it is important to understand the role of Mars' obliquity during this era.

Methods: We have run 10,000 simulations of the orbital evolution of the early solar system to determine the resulting obliquity evolution of Mars. The orbital elements of the outer planets were randomly selected to match pre-Nice model-like conditions [1]. These were integrated forward for 1 Myr using Mars' current rotation rate and dynamical ellipticity.

Results: Mars' obliquity evolution is strongly dependent on its initial obliquity. Figure 1 shows the amplitude of the obliquity oscillations experienced over a 1 Myr time frame as a function of the initial obliquity. We see that obliquity evolution is strongest in the region from ~0º-70º, and reaches a minimum at ~140º. The maximum change in obliquity over this time frame is ~30º, significantly smaller than the obliquity oscillations of modern day Mars [2]. This evolution may not be strong enough to provide the warming necessary to allow persistent water on the surface during the Noachian, however, further work using climate models should be done to determine the significance in driving episodic glaciation and melting.

Modern Mars' large obliquity oscillations are thought to be a consequence of one or more secular resonances [6]. In our simulations, Mars lies tantalizingly close to several secular orbital frequencies during the Noachian, suggesting that if Mars' orbital and rotational properties are slightly different from what we initially assumed, this type of resonance may have occurred.

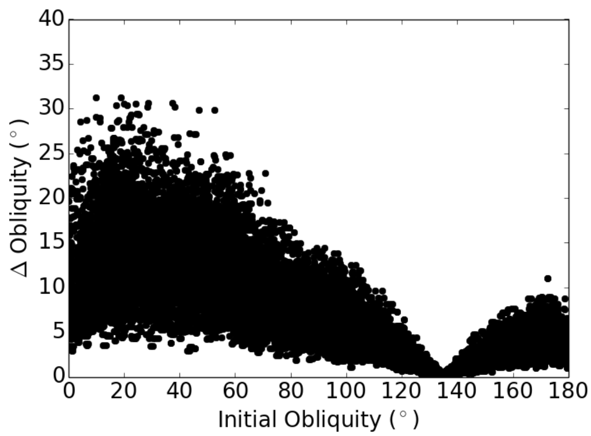

Figure 1: Amplitude of Mars' obliquity oscillation as a function of initial obliquity during the Noachian. A peak amplitude of ~30º occurs around 20º initial obliquity. At ~140º, the obliquity becomes almost stationary.

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