Meteoroid transfer to Europa and Titan. B. Gladman[1],L. Dones[2], H. Levison[2], J. Burns[3], J. Gallant[1]
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Introduction: The existence of lunar and martian meteorites show that intact rocks that have been subjected to low peak shock levels can be delivered to other planetary bodies by impacts that launch fragments at faster than the target body's escape speed. This raises the possibility that if the ejected rocks hosted bacteria that can survive the rigors of launch, transport, and landing, natural panspermia is possible.

Background: Previous work [1] indicates that bacteria are hardy enough to survive all components of the transfer process, especially if the orbital transfer is neither too long (not more than millions of years) and if the trajectory spends little time closer to the Sun that 1 astronomical unit (for if the interior of the fragment warms above freezing DNA degeneration is rapid in the presence of liquid water).

Previous discussions of panspermia from Mars to Earth are in the context of whether early Mars may have had bacterial life. But there IS one source in the Solar System of rocks teeming with bacterial life: the Earth itself. In the scenario in which a large asteroidal or cometary impactor strikes the Earth and liberates near-surface rocks into heliocentric orbit, the ejecta will be dispersed throughout the inner Solar System and into Jupiter-crossing and Saturn-crossing orbits.

Numerical Setup: We numerically simulated the orbital evolution of suites of about 18,000 particles ejected from Earth. A spherically symmetric and radially-expanding shell of a fixed geocentric speed was constructed, leaving the Earth with speeds such that once escaping from the Earth's gravity a desired 'velocity at infinity' would be achieved [2]. We then evolved these heliocentric orbits for 5 million years, monitoring and recording flybys of all the planets.

Numerical Results and Discussion: We then used the flyby logs to calculate the collision probability and thus expected number of impacts onto a desired target satellite. The figure shows the case of Triton for three different launch speeds; within 5 million years of the impact, a few to 20 pieces of terrestrial impact ejecta are delivered to Titan. Our calculations show that these terrene meteoroids strike Titan's upper atmosphere at 10-15 km/sec, in which case atmospheric deceleration to sub-sonic speeds is viable. For Europa there are 30-100 deliveries, but they strike Europa's surface in the uncomfortable speed range of 20-30 km/s.

Conclusions: If the Earth's atmosphere is not a major impediment to the escape of terrestrial impact ejecta in extremely large impacts (KT-event level or larger), then delivery of terrestrial meteorites to the major satellites of the giant planets is plausible. The survivability during and after the delivery is debatable.

References: [1] Mileikowsky, C., et al. (2000) Icarus 45, 391-427. [2] Gladman, B. et al. (2005) Astrobiology 5, 483-496.

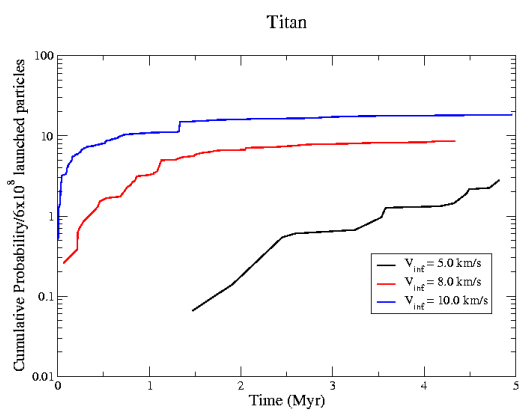

FIGURE: The cumulative number of particles that have struck Titan as a function of time since an impact on Earth that launches a suite of particles with a given launch speed. The upper, middle, and lower curves correspond to impacts giving escaping geocentric speeds (after escaping Earth's gravity well) of 10, 8, and 5 km/sec. The deliveries have been normalized assuming that 600 million fragments escape from a terrestrial impact [1]; different launch yields would simply scale linearly with the number of particles escaping Earth into solar orbit.