EVERYONE WINS: A MARS-IMPACT ORIGIN FOR CARBONACEOUS PHOBOS AND DEIMOS. M. Fries[1], Welzenbach L.[2] and A. Steele[3], [1]NASA Johnson Space Center, Mail Code XI2, Houston, TX 77058 marc.d.fries@nasa.gov, [2]Planetary Science Insitute, Tucson, AZ 85719 [3]Geophysical Laboratory of the Carnegie Institution for Science, Washington DC 20015.

Introduction. Discussions of Phobos' and Deimos' origin(s) tend to feature an orthogonally opposed pair of observations: dynamical studies which favor coalescence of the moons from an orbital debris ring arising from a large impact on Mars [1,2], and reflectance spectroscopy of the moons that indicate a carbonaceous composition that is not consistent with martian surface materials [3-5]. One way to reconcile this discrepancy is to consider the option of a Mars-impact origin for Phobos and Deimos, followed by surficial decoration of carbon-rich materials by interplanetary dust particle (IDP). The moons experience a high IDP flux because of their location in Mars' gravity well. Calculations show that accreted carbon is sufficient to produce a surface with reflectance spectra resembling carbonaceous chondrites.

Mars Impact Origin. An impact on Mars has been proposed as the origin for Phobos and Deimos [1,2]. Models show that this scenario may explain the high angular momentum of the Martian system just as formation of the Moon by giant impact provides a similar explanation for the Earth-Moon system. Impact formation also provides a mechanism to explain Phobos and Deimos' highly circular, equatorial orbits and the moons' irregular shapes. Reflectance spectra of Phobos and Deimos indicate abundant carbon, which has been taken to imply that the bulk mineralogy of the moons is similar to carbonaceous chondrites [3-5].

An Infall-Derived Carbonaceous Rind. We propose a different interpretation of the reflectance spectra of Phobos and Deimos. The moons lie within Mars' gravity well, and so are subjected to much higher interplanetary dust particle (IDP) flux than that seen for asteroidal bodies. This flux is sufficient to have added a significant amount of carbon-rich IDP material to Phobos' and Deimos' surfaces since their formation, such that the moons' reflectance spectra now strongly resemble carbonaceous asteroid spectra.

Flynn [6], noting that IDP infall onto Mars is almost three times that of Earth, calculates an influx of $12e^6$ kg/year, of which ~10% is carbon by mass [6]. We assume that the flux is the same for Phobos and Deimos as the moons lie within Mars' gravity well and essentially get in the way of IDP flux onto the planet. Using the surface areas of Phobos, Deimos, and Mars as factors to calculate the portion of this infall that lands on the moons, we find that Phobos accretes IDP material at a rate of 128 kg/year and Deimos at 41 kg/year. If Phobos and Deimos formed 4 Ga ago [7] then Phobos has accrued $5.1e^{11}$ kg of IDP material and Deimos $1.6e^{11}$ kg of IDP material, ~10% of which is carbonaceous. If this material is retained within the top meter of regolith, then the total mass of accreted IDP material amounts to ~180x the original mass of the top meter of the moons' regolith. Note that this value accounts for steady IDP flux only, and does not include periodic meteor shower flux. Additional work is also needed to ascertain the extent of mobilization and loss of carbonaceous material over time, but the calculations presented here indicate that there is a high likelihood that the moons should retain sufficient carbonaceous material to contribute to their reflectance spectra. Assumptions for this calculation include a constant IDP flux over 4 Ga, no loss of IDP mass after infall, and even distribution of infall mass over the surfaces of Phobos and Deimos. Given the total IDP mass calculated here, changes to these assumptions would have to be quite dramatic in order to render the accreted mass insignificant from a spectral standpoint.

Conclusions. For the martian moons, this finding indicates that carbonaceous material should constitute a significant component in reflectance spectra, even if the bulk composition of the moons' interiors is carbon-poor. Also, the moons' reflectance spectra should be an amalgam of the asteroid and cometary classes, as opposed to matching a single reflectance class, since the IDP flux arises from many different bodies. Rivkin [5] finds significant differences between the leading and trailing faces of Phobos, which may indicate mobilization or ablation from Phobos' leading face to expose underlying, relatively carbon-depleted material.

For Mars, Phobos' and Deimos' surfaces are roughly analogous to Mars' regolith composition in the absence of the strongly oxidizing martian surface chemistry. As such, the moons preserve a record of carbonaceous infall onto Mars throughout its history. This record has probably been lost on the planet itself due to the strongly oxidizing surface environment.

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