PHOBOS: CURIOUS ALTERNATIVES OF ORIGIN RECONSIDERED; P. Jakeš, Lunar and Planetary Institute, 3303 NASA Rd. 1, Houston TX 77058, and Department of Geosciences, University of Houston, Houston TX 77204.

Missions to Phobos were launched to study small bodies of the solar system with the assumption that Phobos represents a captured C-type asteroid [1,2] of carbonaceous chondrite composition. The low albedo, the relatively low density of Phobos (2.2 + 0.5 g.cm-3), and its irregular shape were used as arguments.

Pang et al.[3] have shown, however, that reflectance spectra of Phobos do not fit exactly to spectra of carbonaceous chondrites, and later Britt and Pieters [4] examining reflectance - compositional relations presented a model in which carbonaceous chondrites, Mars ejecta, Deimos ejecta, and "black" chondrites could contribute to the formation of Phobos. Jakeš and Ceplecha [5] showed that physical constants determined for Phobos are poorly defined, and the variety of materials on its surface could fit the data on density (thick regolith, porous material), and reflectance (size of particles, carbon coating, basaltic glass). Analysis of meteor trajectories tangentially approaching the Earth [6] showed that non - disintegrative capture is an unlikely process. An "ad hoc" hypothesis relating the origin of Phobos to SNC-type meteorites was formulated [4,5] in which an event similar to the event that have sent the SNC meteorites on trajectories toward the Earth could be responsible for the formation of Phobos. Collisional ejection of already fractionated material (and its later assembly in martian orbit) instead of the non-disintegrative capture of primitive unfractionated body was advocated. Such a scenario would imply that Phobos formed late in the history of Mars, though the nearly crater-saturated surface indicates an old age of the moon.

The pre-failure Phobos-2 data of IMS [7], KRFM [8], TV images [9], and thermal imaging [10] provide additional constraints on Phobos' composition (and hence origin), and make the idea that Phobos represents a primitive carbonaceous chondrite body less likely than in the pre-mission era. Using the same data and constraints, the opposite view (i.e., Phobos is carbonaceous chondrite) was presented by Sasaki [11].

New data [3] show lower mass (1.08 +/- 0.01 x 1017 kg), unchanged volume, and consequently lower density (1.95 +/- 0.1 gm.cm-3). The densities of carbonacoues chondrites that have suitable reflectance spectra are high (3.4g.cm-3) and difficult to interpret. The densities of other silicate meteorites (some chondrites and achondrites - SNC) are lower but not as low as required. The near-infrared imaging spectrometer (IMS)[7] indicates a very low hydration level (OH content) of the surface layer of Phobos. The contents of OH are comparable to those of highly evolved C4 carbonaceous chondrites and are substantially lower than OH contents in surface rocks of martian plateaus. If the water content of the surface layer is representative of bulk Phobos contents, then the moon is formed of dry assembled rock blocks and the voids, not the presence of volatile phases, could account for low density. IMS data thus confirm the prediction of Fanale and Salvail [19] that water-bearing components have been lost at least in the surface layer). IMS data the absence of unchanged CI and CM components in surface layer. Thick regolith [12,15], if it is of low density is not negligible for the resulting density of the whole body, since in a body of Phobos' size, regolith may account for up to 15 % of the total volume.

The reflectance properties of carbonaceous chondrites do not fit satisfactorily to the reflectance features of the "optical surface" of

Phobos [4]. Albedo and reflectance spectra of other meteorites (e.g., suggested SNC) differ, and numerous experiments show that different proportions of silicate, metal (sulphide) and carbon components, and different particle sizes could be "mixed" to fit the measured values for C-type asteroids or Phobos [16,17]. Phobos-2 data indicate, however, the difference between the optical surface layer and that of deeper parts of Phobos. The presence of widespread bright rims (subtle reddish regions) on craters of large (several hundred meters) diameter and those smaller craters that are classified as fresh or only partly degraded [9,13] is most distinct. The bright material may represent sub-regolith compositions. The unusually thick regolith of Phobos, its optical surface layer, and deep "substantial parts" of this body differ.

Observed heterogeneity in the distribution of bright material and in color variation in the craters [9,13] is complemented by the heterogeneity of thermal and spectral properties [7,8,] and km-scale heterogeneities are suggested.

Whereas large (atmosphereless) bodies do have regolith formed predominantly of "indigeneous material" Phobos' unique gravity field [14] makes the body compositionally exceptional and complex. Components contributing to the upper layer of the regolith may include black chondrites, Brownlee particles, martian material, Deimos material, and dehydrated (impact altered) carbonaceous chondrites[4]. Extremely thick regolith probably results from the above effect and probably from some process similar to those adocated by Hartmann [18] i.e., "scattering" of C-asteroids. The timing of this scattering, however, could be different than suggested. The unique gravity field of Phobos could also serve as a "center" to condense a small fraction of volatiles or their components escaping the martian atmosphere.

Phobos remains enigmatic. It is vertically as well as horizontally inhomogeneous (whatever that means in a potato shaped body). The concept of a heterogeneous Phobos rather than simple non - fractionated carbonaceous chondrite fits better to observations though it poses numerous questions into the nature of S-type asteroids: Are they compositionally homogeneous and the same as carbonaceous chondrites or is it only the trend - convergence of optical surface features that leads to S-type reflectance ?

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