Formation of Phobos and Deimos in a giant collision scenario facilitated by a large transient moon.

S. Charnoz[1] , P. Rosenblatt [2], K.M. Dunseath[3], M. Terao-Dunseath[3], A. Trinh2, R. Hyodo R.[1,4], H. Genda[5], S. Toupin[6] . [1]Université Paris Diderot / IPGP / Laboratoire AIM/CEA France charnoz@cea.fr, [2] Royal Observatory of Belgium, 1180 Brussels, Belgium, [3]Institut de Physique de Rennes, UMR6251 CNRS-Université de Rennes 1, Rennes, France, [4]Kobe University, Kobe 657-8501, Japan, [5]Earth-Life Science Institute, Tokyo Institute of Technology, 2-12-1 Ookayama, Meguro-ku, Tokyo, Japan, [6]Institut d'Astronomie et d'Astrophysique, Université libre de Bruxelles, CP 226, Boulevard du Triomphe, B-1050 Brussels, Belgium

Two scenarios for the origin of the Martian moons Phobos and Deimos have been proposed: either they are asteroids that have been captured[1,2,3,4], or they formed in orbit around Mars[2,3]. The capture scenario cannot explain the present orbit of the two moons[3]. In situ formation scenarios assume Phobos and Deimos accreted from a disc of debris blasted into orbit by a giant impact on Mars that has given the red planet its northern dichotomy and its spin[5]. Previous models however fail to form two moons of the mass of Phobos and Deimos in their current orbits around Mars[3,5]. Here we show that Phobos and Deimos can form in a disc extending up to the synchronous orbit, consistent with impact simulations. Our scenario implies Mars once possessed one or more large inner moons that formed from the inner part of the impact generated disc. By migrating outwards, the largest inner moons resonantly repelled smaller debris in the outer part of the disc (fig.1), facilitating their accretion into two small moons similar to Phobos and Deimos. As the disc eventually dispersed, the large inner moons crashed back onto Mars, leaving Phobos and Deimos to slowly evolve under tidal dissipation to their current orbits[7].

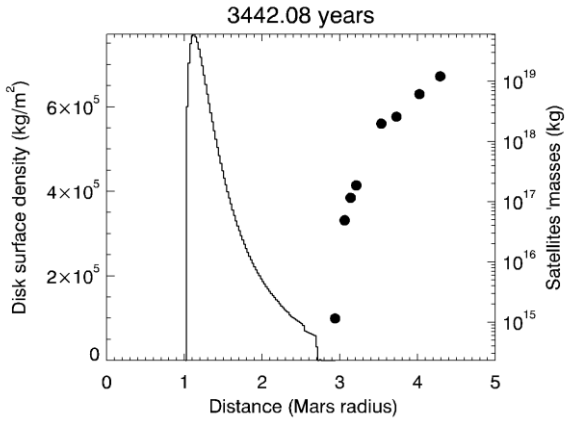

Figure 1: solid line : surface density of the impact generated disk (left scale), black circles: moons generated by the disk (mass on right scale) after ~3440 years evolution.

Our results clarify why the Martian system is so diffent from the Earth-Moon system: since the Roche Limit lies well within the synchronous orbit, any large inner moons remain in orbit only for a short time[7,8]. They may however have had a significant impact on the evolution of the outer disc, resulting in the formation of small moons instead of a single larger one. Our results also imply that Phobos and Deimos may be aggregates of material from both Mars and the giant impactor.

REFERENCES

[1]J. Burns, in H.H. Kieffer, B.M. Jakosky, C.W. Snyder, M.S. Matthews, Eds., *Mars* (Univ. Press of Arizona, Tucson, 1992), pp. 1283-1301.
[2] S.J. Peale, in G. Shubert, T. Spohn, Eds., *Treatise on Geophysics* vol. 10, pp. 465-508 (2007).
[3] P. Rosenblatt, *Astron. and Astrophys*. 19, 1 (2011).
[4] V.S. Safranov *et al.*, in J.A. Burns, M.S. Matthews, Eds., *Satellites* (Univ. Press of Arizona, 1986), pp. 89-116.
[5] R.I. Citron, H. Genda, S. Ida, *Icarus* 252, 334 (2015).
[6] R.A. Craddock, *Icarus* 211, 1150 (2011).
[7] P. Rosenblatt, S. Charnoz, *Icarus*, 221, 806 (2012)
[8**]** S. Charnoz, J. Salmon, A. Crida, *Nature* 465, 752 (2010).