The Jovian Early Bombardment and the primordial evolution of Vesta and the asteroid belt. D. Turrini[1], A. Coradini[1], G. Magni[1], [1] Institute for Space Astrophysics and Planetology INAF-IAPS, via Fosso del Cavaliere 100, 00133 Rome, Italy (e-mail: diego.turrini@ifsi-roma.inaf.it).

Introduction: The Solar Nebula phase is assumed to start about 4568 Ma ago [1] with the condensation of the Ca-Al-rich inclusions and to end in less than 10 Ma [2] with the dispersal of the nebular gas. Across this timespan, planetary accretion was acting in the Solar Nebula to form the planetesimals, the planetary embryos and the giant planets (see [3] and references therein). The spectral connection between Vesta and the Howardite-Eucrite-Diogenite (HED) meteorites, recently confirmed by the Dawn mission [4], indicates that Vesta was among the planetary bodies which formed and differentiated in the Solar Nebula (see [5,6,7,8] and references therein). We report here the results of our study of the dynamical and collisional evolution of the asteroid belt and of Vesta in the Solar Nebula at the time of the formation of Jupiter.

The Jovian Early Bombardment in the asteroid belt: Our results [9,10] indicate that the formation of Jupiter caused a phase of primordial bombardment we named the Jovian Early Bombardment (JEB). The JEB results from the appearance of the mean motion resonances in the asteroid belt and from the scattering of planetesimals from the outer Solar System [9]. While the migration of Jupiter enhances the intensity of the JEB due to the sweeping resonances, the formation of the giant planet is necessary and sufficient condition for triggering the JEB [9,10]. The JEB is relatively short, its duration being of the order of 0.5-1 Ma [9]. Nevertheless, the greater population of planetesimals in the primordial asteroid belt implies that the JEB is extremely violent. In particular, we found that collisional erosion plays a more important role than destructive impacts across the JEB [9,10].

The survival of the primordial planetesimals to the JEB depends on the size distribution of the planetesimals, on their location respect to the orbital resonances and on the extent of Jupiter's migration [9,10]. If the disk of planetesimals was dominated by large bodies ($D > 100$ km), like in the case of planetesimals formed in turbulent circumstellar disks, the JEB would cause the ablation of bodies of 500 km or smaller [10]. Conversely, disks dominated by small planetesimals (i.e. $D < 20$ km), like those formed in quiescent circumstellar disks or produced by collisional evolution, represent more favorable environments for the survival of bodies of 200 km or bigger [10]. Planetesimals of 200 km, however, would survive only in the scenario where Jupiter's migration was limited [10]. In all other scenarios, they are generally disrupted if Jupiter migrated by 0.5 AU or more [10].

Vesta and the Jovian Early Bombardment: Vesta and Ceres [9,11] would undergo an intense cratering that would saturate their surfaces with craters as big as 150 km, with a tail of few bigger craters (200-300 km). Due to its lower gravity, Vesta would undergo a higher degree of surface erosion than Ceres due to the JEB [9,11]. Under the simplifying assumption of a uniform distribution of the craters, on Vesta the JEB could excavate up to a depth of about 10-20 km [11,12]. Moreover, assuming a conservative depth-to-diameter ratio of 1:7, the JEB could excavate the crust of Vesta either locally or regionally [9,11]. The geophysical history of Vesta. as inferred by HED meteorites, suggests that its differentiation ended in a few Ma [7,8]. Depending on the relative timing between the JEB and the differentiation of Vesta, the local or regional excavation of the primordial crust of the asteroid could cause large-scale effusive phenomena similar to the Lunar maria [9,11]. In all scenarios, moreover, the JEB saturates the surface of Vesta and likely covered the asteroid with a thick regolith layer [9,11]. The data that the Dawn mission is collecting on Vesta will thus allow us to investigate the Jovian Early Bombardment scenario and the early evolution of the Solar System [3].

References: [1] Bouvier A., Wadhwa M. (2010). Nature Geoscience. Vol. 3, 637; [2] Meyer M. R. (2008). Proc. Intern. Astron. Un., 4, 111; [3] Coradini A., et al. (2011a). SSR, 163, 25; [4] Coradini A., et al. (2011b). Abstract at EPSC-DPS 2011; [5] Keil K. (2002), in Asteroids III, University of Arizona Press; [6] Scott E. (2007), An. Rev. of Earth and Planet. Sci., 35, 577; [7] Bizzarro M. et al. (2005). ApJL, 632, L41; [8] Schiller M. et al. (2011). ApJL, 740, L22; [9] Turrini D., Magni G., Coradini A. (2011), MNRAS, 413, 2439; [10] Turrini D., Coradini A., Magni G. (2012). To appear on ApJ, Arxiv e-print arXiv:1202.4887; [11] Turrini D., et al. (2011). Abstract at the EPSC-DPS 2011; [12] Turrini D., et al. (2012). Abstract at Early Solar System Impact Bombardment II Workshop.

Additional Information: The authors wish to dedicate this work to their friend and colleague A.C., who passed away after a long illness on September 5th, 2011. This research has been supported by the Italian Space Agency (ASI) through the ASI-INAF contract I/015/07/0 and I/010/10/0. The computational resources used in this research have been supplied by INAF-IAPS through the project HPP - High Performance Planetology.