Impact-Chronology Model as Mass-Estimate Method for Impacted Masses on Planetary Surfaces

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Introduction: The solar system has undergone a bombardment by small bodies, documented by cratering records on planetary surfaces as seen in image-investigations since the early 1960's. The well investigated lunar cratering record reveals a typical size-frequency distribution (SFD) leading to the well known impact-chronology model proposed by [1],[2]. Comparisons of size-frequency distributions of the cratering-record on surfaces of planetary bodies of the inner solar system with the observed Near-Earth-Asteroid (NEA) population of the the asteroid belt [2], [3], [4] has led to the conclusion that the asteroid belt acts as the major contributor of the impactor population for the planetary bodies of the inner solar system. This is, however, still in discussion for the outer solar system, especially for the Jovian and Saturnian system. Recent measurements of the impact crater-size frequency distribution on surfaces of moons in the Saturnian system and comparisons with the lunar-like crater size-frequency distribution also lead to the conclusion, that the asteroid belt is also a major contributor of impactors to the Jovian and Saturnian system [5].

Methods: In order to support the conclusion that the asteroid belt acts as the major contributing source for impactors for both the planetary bodies of the inner solar system and the planetary bodies of the Jovian and Saturnian system, the total mass impacted on the surfaces of planetary bodies is estimated with impact-chronology models derived from measurements of the size-frequency distribution of the lunar-cratering record as proposed by [1]. An estimate of the total impacted mass on the surface of planetary bodies is performed under the assumption of a common time-invariant size-frequency distributed population of impactors and the application of a suitable scaling law, by mapping crater size-frequency into impactor size-frequency distributions, as proposed by [6], [7], [8]. With the assumption of an average impactor density, an average impact angle and an average impact velocity, the diameter of the impactor can be approximated from the impact-crater diameter. Furthermore, its mass can be estimated by the assumption of a spherical shape.

Body	SFD	CHR	M [1.0E20 kg]	R [1.0E-03]
Mercury	[6]	[6]	0.51	0.696
Venus	$(*)_1$	$(*)_1$	1.98	2.70
Earth	$(*)_2$	[1]	3.55	4.83
Moon	[1]	[1]	2.01	2.74
Mars	[6]	[6]	3.35	4.56
Total			11.4	15.5

Table 1: Preliminary results of estimated mass accumulation on planetary bodies of the inner solar system due to impact processes. SFD: size-frequency distribution model, CHR: Chronology model, M: total impacted mass [kg], R: Ratio Moon mass ($R := M/M_{Moon}$, $M_{Moon} = 7.35E22$ kg). SFD and CHR models marked $(*)_1$ are taken from an unpublished work of Neukum and Horedt, 1986, those marked with $(*)_2$ are from Horedt, 1986.

Preliminary results: Integrating the impact-chronology model for each planetary body of the inner solar system over the past 4.5 Ga with proper coefficient-sets for each specific body gives the total accumulated mass estimate (column designated by M, in kg), as shown in table 1. The mapping of crater-diameter sizes into projectile-diameter sizes is performed by assuming one average projectile density, average impact angle and average impact velocity for the this first approach. The result for each planetary body is then compared to the lunar mass (column designated by R) as shown in table 1.

The estimate of impacted masses accumulated on the surfaces of planetary bodies in the solar system by application of recent well-investigated lunar-like impact-chronology models will lead to the mass-depletion and time-constraints of the major impactor's source which we consider to be the asteroid belt. However, the situation in the outer solar system is different from the inner solar system. In upcoming work, we will compare the impacted mass-estimates of both the inner and outer solar system with recent mass-estimates of the asteroid belt, and the time and dynamical constraints of its depletion.

Acknowledgement: The author was partly supported by the German Space Agency (DLR) with support of the Federal Ministry of Economics and Technology, grants 50QH0305

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