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Debris Disk Ejected by Giant Impacts: Its Dynamical and Chemical Influences on the Terrestrial Planets

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During the last stage of terrestrial planet formation called the giant impact stage, Mars-sized protoplanets collide with each other. These collisions among protoplanets have a large influence on the various features such as the number of terrestrial planets formed, their mass, and spin state (Kokubo and Genda 2010). Giant impacts are highly energetic events and are responsible for the creation of large satellites, such as the Moon and planets with extremely large cores such as Mercury.

Genda et al. (2012) performed more than 1000 simulations of giant impacts to investigate the merging criteria for giant impacts. We made further analysis of the collision outcomes, and found that significant amount of colliding protoplanets is ejected during giant impacts. In the typical giant impact that occurs during the giant impact stage, several percents of protoplanets are ejected from protoplanets. We developed the hybrid code that includes both orbital evolution of protoplanets and impact process of protoplanets, and investigated the total amount of ejected material during the giant impact stage. We found that about 10% of the mass of the planetary system is ejected. We also found that such ejected materials contain metallic iron. In this study, we focus on the ejected materials by giant impacts, and investigate the dynamical and chemical influences of such ejected materials on the terrestrial planets.

Ejected materials have a dynamical influence on the orbits of the terrestrial planets through the gravitational interaction and reaccretion. Especially, gravitational interaction between ejected materials and terrestrial planets decreases the eccentricity of the terrestrial planets down to the present level (˜0.01). Using N-body simulation of such configuration, we confirmed that the eccentricity of the terrestrial planets decreases down to 0.01.

Ejected materials also have a chemical influence on the terrestrial planets. Especially, re-accretion of metallic iron would greatly increase the concentration of highly siderophile elements in the Earth's mantle, which would be source of supply of late veneer. Additionally, re-accretion of metallic iron changes redox state of the Earth's surface from oxidized state to reduced state. Reduced surface environment will be maintained for about 1 Gyr.

Keywords: giant impact, BARAMAKI, late veneer, redox state