Formation ages and volumes of smooth plain deposits in the Rembrandt and Caloris basins on Mercury

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MESSENGER's Mercury Dual Imaging System (MDIS) showed evidences of volcanism on Mercury, such as magma flows, pyroclastic materials, vents and volcanos. Smooth plains are also interpreted to be volcanic in origin: Smooth plains were formed by resurfacing by magma eruptions, so they have less craters than surrounding heavily cratered terrains. Most smooth plains are related to floors of impact basins and topographic lows. MDIS multiband images showed that smooth plains have brighter and redder spectra than that of surrounding heavily cratered terrains, suggesting its different compositions from crustal materials.

Smooth plains occupy ~10 times larger surface area on the northern hemisphere than on the southern hemisphere [Denevi et al., 2013; Ostrach et al., 2015; Byrne et al., 2016]. This hemispheric asymmetry may be contributed by differences in magma production rate in mantle and/or the crust thickness between the two hemispheres. The latter effect is supported by the fact that smooth plains are mainly located within impact basins where impactors excavated crusts and so crusts are thinner than surrounding terrains.

In this study, in order to evaluate the difference in magma production between the northern and southern hemispheres, we focused on smooth plains within two impact basins, the Rembrandt basin (D = 716 km) in the southern hemisphere and the Caloris basin (D = 1,550 km) in the northern hemisphere, which have thinner crusts than surrounding terrains. Using MDIS image data, we performed crater size-frequency measurements in the smooth plains and on ejecta deposits of the basins. Based on the observed crater size distributions, we estimated the volumes of lavas and the ages of basin formations and magma eruptions using Mercury's cratering chronology model [Le Feuvre and Wieczorek, 2011].

The formation ages of the Rembrandt and Caloris basins were estimated to be 3.91 and 3.88 Ga, respectively, consistent with previous estimates [Whitten and Head, 2015a; Hynek et al., 2017; Jozwiak et al., 2018]. We found deflections in the size distributions of both smooth plains, suggesting the formation by multi-episodic eruptions. The eruptions periods were estimated to be 3.81 to 3.75 Ga within the Rembrandt basin and 3.78 to 3.72 Ga within the Caloris basin.

The estimated magma eruption flux per area in the Caloris basin is 1 to 3.5 times of that in the Rembrandt basin, which is much smaller than the area ratio of smooth plains of ~10 times. This result suggests that the difference of crust thickness between the northern and southern hemispheres is main cause for the hemispheric asymmetry of smooth plain areas.

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