Self-organization of Ionian paterae into uniform distribution by obliteration

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Io, one of the Galilean satellite around Jupiter, is strongly heated by tidal dissipation, which induces many volcanic activities and resurfacing (the age of Io’ s surface is only a few million years). These global volcanic activities produce unique morphologies on Ionian volcanoes not only in the scale of one volcano but also in group of volcanoes.

One of such a unique behavior is self-organization of paterae. Patera is caldera-like volcano with collapsed crater. On Ionian surface, paterae are globally distributed. Hamilton et al. (2013) performed mean nearest neighbor distance analysis for the distribution of volcanoes, and revealed that the paterae on Io are distributed uniformly (mean nearest neighbor distance among paterae are larger than the case of random distribution). Hamilton et al. (2013) indicated that the reason of the uniform organization of paterae is the magma collection from surrounding area by magma chamber, which results in separation of each chamber. However, they also found that another type of volcanos such as hot spot is distributed randomly rather than uniformly.

Here, we suggest that the organization of Ionian paterae into uniform distribution was caused by the unique shape and obliteration process of paterae. Paterae have depressed crater. Thus, if an active patera erupts near inactive paterae, they are obliterated by lava and disappear. When inactive paterae are clusterd, many paterae are obliterated by the same new patera. On the other hand, if active patera erupt at sparse area, obliteration does not occur. Due to this process, each patera is separated automatically, which results in the uniform distribution.

Using the simple gauss type obliteration probability and Monte Carlo simulations, we calculated the uniformity of paterae organized by obliteration. If the obliteration radius is approximately 80 km and the generation rate of new paterae is ~5.0×10^{-6} km^{-2} Ma^{-1}, number density of paterae is consistent with the observed value and their distribution is evolved into uniform distribution sufficiently even though paterae are generated randomly.

Keywords: Io, Paterae, Uniform distribution

