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Formation of the Hydrothermal Plume at the Base of Europan Internal Ocean : Implications for the formation of Chaos Terrain

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High resolution images by Galileo showed some curious features named as chaotic terrain which is composed of fragmented and dislocated polygonal blocks with pre-existing structures and matrix of finer hummocky materials. Chaotic terrain has been interpreted as strong geological evidence for the liquid water ocean (internal ocean) under the icy shell in Europa. The most probable origin of the chaotic terrain is proposed as localized melting of the icy lithosphere. Thermal plume generated by heating from the rock core is supposed to be one of the most significant heat source for the localized melting. It is also possible that dark materials observed on the chaotic terrain, including salts and/or sulfuric acid, are supplied from the seafloor due to this thermal plume.

However, there is a quite few studies about the formation and propagation of thermal plume at the internal ocean. Therefore, it is impotant to investigate the thermal anomaly, and the spatial distribution and the time variation of the hydrothermal plume caused by heating from rock core. In a point of biological view, hydrothermal system under the extraterrestrial environment is very stimulating. To relate localized melted surface features with the thermal plume activities in the internal ocean two basic problems should be clarified; 1) how such localized thermal anomaly both in space and time is generated?, 2) how such plumes can reach the surface without modifications by diffusion/entrainment in low viscosity water?. Here we will present numerical simulations focussing on the thermal situation at the bottom of the ocean in view of the plume formation.

The surface of rock core is assumed as the permeable layer unless the core surface is covered by the magmatic flow or smoothed by erosion. In this work, we performed the numerical simulations on the convection in porous media in a two dimensional rectangular box, and discuss the resultant thermal anomaly as well as its spatial and temporal variations. Our results show that in case of relatively low Rayleigh number, corresponding to the low permeability, the convection in the porous media exhibits an oscillatory behavior, emerging thermal plumes with high thermal anomaly (up to 25K compared with mean temperature of an ambient ocean water) from the upper boundary. In this situation, the internal ocean is supplied hot plumes from the bottom layer at average interval of several thousands years to several hundreds of thousands years. This interval time is comparable to estimated time scale required for the resurfacing.