# The maar-diatremee volcanism in the Paramushir Island (the Kuril islands)

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Maar-diatreme (hydrothermal) eruptions are common processes in hydrothermal systems such as the North-Paramushir hydrothermal system, located in the Vernadsky and Karpinsky volcanic ranges (Paramushir Island, Kuril volcanic arc). Many eruptions have taken place in this area during the History. The prehistoric hydrothermal eruptions of this system were identified because of above the diorites intrusion, (the intrusion was revealed by drilling a well (2500m)) eruption breccias were found. The comparative analysis of the characteristics of hydrothermal systems of the andesite island arcs and the North-Paramushir hydrothermal-magmatic system shows that they are analogues. The hydrothermal-magmatic structure of the northern part of the Paramushir Island was formed during the Pliocene-Holocene period. The axial part of Vernadsky and Karpinsky ranges consists of few andesite and dacite volcanoes. Structure and texture of these volcanoes show that they were formed as a result of underwater or subaerial eruptions. Hydrothermal activity is concentrated along the axis of the ranges.

Apart from surface and subsurface activities of heated acid waters, which form the upper caprock, inside of the vadose zone (the axial part of Vernadsky and Karpinsky ranges) phreatic and phreato-magmatic eruptions and lavas effusions took place frequently. The trogs and moraines show that the glacier covered the axis of mountain ranges and slip down along the Vernadsky and Karpinsky rivers valleys. In this conditions, magmatic melts, gases, and deep hydrothermal solution with complex composition flow up to the surface. It has led the formation of an ascending thermal stream zone in the Ebeko and Bogdanovicha volcanoes areas (the axial part of Vernadsky and Karpinsky ranges), and also the formation of the horizontal streams of bicarbonated thermal waters. These streams were revealed by drilling a well and they discharge to the sea (Fig.1).

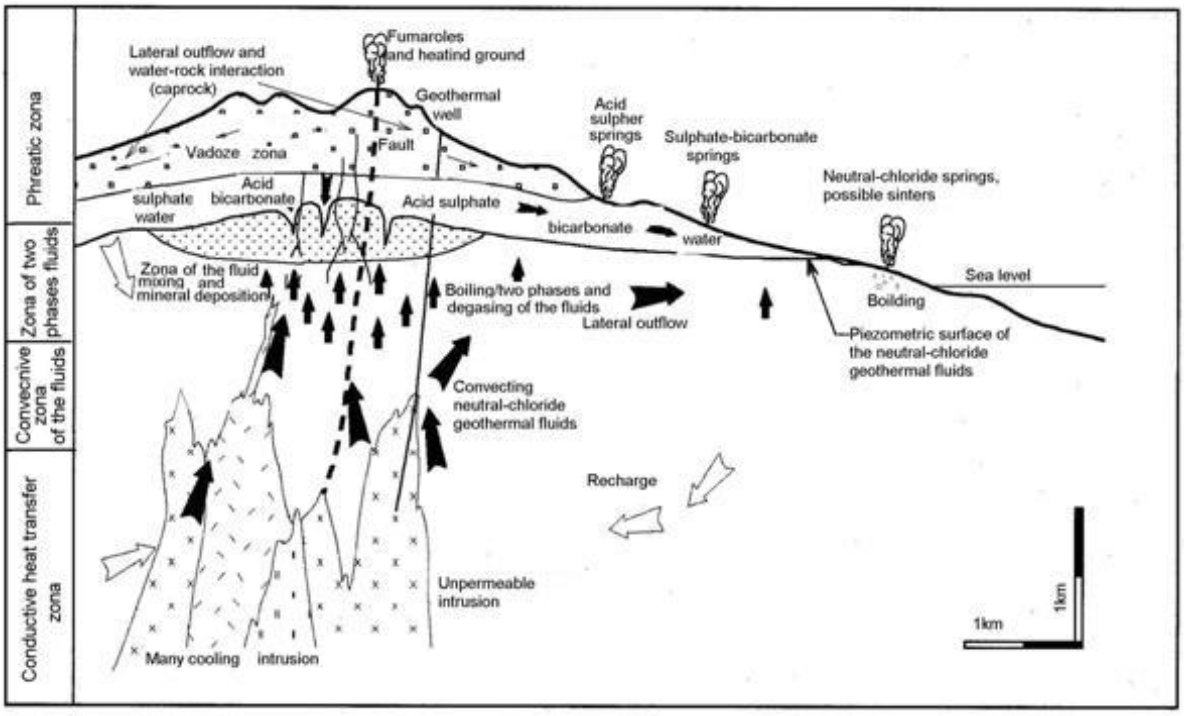


Fig.1. The conceptual model of the hydrothermal-magmatic system (Bogie et al., 1987).

During the History, in the areas mentioned above, most of the phreatic eruptions occurred in Ebeco volcano. On August 8th, 1965 in the crater-lake of Ebeco volcano, a phreatic eruption took place with high steam-gas emission and dark silts with rock fragments. The emission in the North-East, North- West and West parts of lake reached 6-8 m high (Scripco et al. 1966).

During the Prehistory occurred also phreato-magmatics eruptions in Vernadsky and Karpinsky ranges. It proves the presence of lavas flows, extrusive domes, dikes and pyroclastic material. The materials of the historic eruptions from Ebeco volcano consists of ash and big rock fragments, which were formed after destruction of the volcano. In the structure of the fragments are present a lot of hydrothermal altered rocks. Geological-hydrogeological structure of the North-Paramushir hydrothermal-magmatic system can be shown as a conceptual model (Fig. 1). In this model of hydrothermal-magmatic systems related with andesitic island arcs, the phreatic zone is marked. This zone spatially coincides with horizon of bicarbonated thermal waters, which is formed under the influence of $CO_2$ diffused flux (Allard, 1992). Martin et al. (2007) consider, that maar-diatremee volcanoes are commonly regarded as the phreatomagmatic equivalent of scoria cones. Maars occur in volcanic fields, on ring plains surrounding composite cones and inside the calderas of polygenetic volcanoes. Maars are usually formed when magma rises within a fissure and interacts with groundwater. If groundwater ceases to interact with magma at times during the eruption, continued magma ascent to the surface gives rise to a wide range of volcanic forms and products associated closely with maar-diatremee volcanoes. Maar-diatremee volcanoes are considered to be the second most common volcanic landforms in subaerial environments in many different geological settings. The records of maar eruptions commonly indicate switching between magmatic and phreatomagmatic processes in the conduit, varied transport processes in vertical plumes and lateral currents, and diverse depositional processes. Diatremees are the substructures of maar volcanoes, and consist of inverted-cone-shaped volcanic structures, up to 2.5 km deep and up to 2 km in upper diameters, that are cut into pre-eruptive rocks. In the opinion of the authors, phreatic and phreatomagmatic eruptions in Paramushir Island are caused by the interaction of several factors, which are characteristics of hydrothermal-magmatic systems connected with andesite island arcs. The upper caprock plays an important role in the formation of subsurface horizon of bicarbonated thermal waters. This caprock dissolved the $CO_2$ diffused flux; when supersaturation of $CO_2$ is reached, the gas phase $CO_2$ is formed. The gas bubbles rise upward along the bottom border of caprock to the axial part of Vernadsky and Karpinsky ranges. $CO_2$ gas stimulates the boiling of high-temperature waters at 2,0-2,5 km deep from axial ranges, where is localized the gas upflow of hydrothermal-magmatic system (Fig. 2). This gas upflow includes gases that can cause an explosion ($H_2$, $CH_4$, CO, etc.) and chemically active gases (HCl, HF, $SO_2$, etc), which

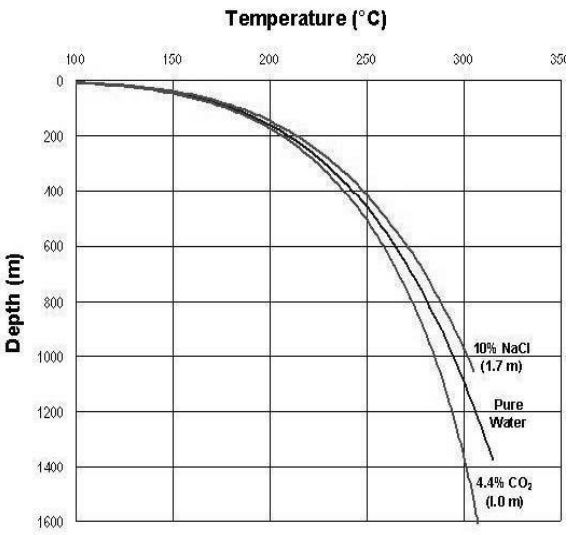


Fig.2. Hydrostatic boiling point - depth relations, showing contrasting effects of salinity and gas content (Henley 1985).

acidify watersheated by steam that yield the formation of local horizons of impermeable rocks. Under the impermeable rocks there is an accumulation of explosion gases, which explode when mixing with atmospheric air injected to diatreme during the discharge of phreatic flux.

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