

## **Solfataric and hydrothermal activity of volcanoes of Kunashir Island (Southern Kuriles, Russia)**

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In Kunashir Island four active volcanoes are, three of which are on solfataric-hydrothermal stage of activity: volcanoes Golovnin (547 m), Mendeleev (889 m) and Ruruy (1485 m).

Modern solfataric-hydrothermal activity of Golovnina volcano (southern part of island) is shown as outputs solfataric gases and a hydroterm inside of caldera and on the foot of a volcano on the Okhotsk Sea coast. Inside caldera there are young extrusive andesite-dacite domes, six solfataric fields and two lakes, formed, basically, due to thermal waters. At coast, at northern foot of the volcano, hydrothermal outputs form Northern-Alekhinskiy and Southern-Alekhinskiy groups of thermal springs, the formation of these thermal waters is connected with Vneshniy extrusive dome (Zotov et al., 1988). For volcanoes-calderas to which Golovnin volcano concerns another features of distribution of hydroterm types are characteristic, than for stratovolcanoes. In the center of caldera of Golovnin volcano there are two extrusive domes, on their periphery as of hydrothermal-phreatic eruptions the lakes and solfataric fields formed. On solfataric fields there are outputs of gases with temperature up to 101 °C and outputs of acid, carbonic, sulphatic hydroterms with difficult cation structure. It is remarkable, that on coast of Kipyashchee Lake acid, carbonic, sulphatic thermal springs and subneutral, carbonic, sulphatic-hydrocarbonaceous calcite-sodium thermal springs adjoin. On periphery of the volcano, in the area of Vneshniy extrusive dome, mainly, acid, carbonic, sulphatic-chloride sodium-calcite Alekhinskiy thermal springs with temperature up to 55 °C discharge. The basic part of Southern-Alekhinskiy groups of thermal springs and outputs of steam with temperature up to 110 °C is located on the narrow beaches. Outside the Vneshniy dome subneutral, hydrocarbonaceous-sulphatic calcite-sodium terms with temperature up to 53 °C discharge. Isotope composition of hydrogen, oxygen, argon, helium and neon of thermal springs of Golovnin volcano (Baskov, Surikov, 1989; Cheshko, 1994; Chudaev, 2003) also corresponds to local meteoric waters.

Mendeleev volcano (the central part of island) is a stratovolcano, on the top of which extrusive dome of dacite composition is. Along annular fractures on periphery of extrusive dome the explosion funnels were formed, which now represent extinct and active solfataric fields (Abdurakhmanov et al., 2004). Outputs solfataric gases are concentrated on four active solfataric fields of a volcano: South-Eastern, Eastern, North-Eastern, North-Western. In valleys of the rivers and streams, originating from solfataric fields and from slopes of a volcano the groups of thermal springs of a various chemical composition are located. Thermal springs are located in the riverhead of Chetverikova Stream, Lechebnyy Stream, in the valley of Kislyy Stream, in the riverhead Lesnaya River, in the top and bottom current of Doktorskiy Stream, in the bottom current of Valentiny Stream, Tret'yakova Stream and Zmeinyy Stream, and also on the coast of Pacific Ocean in the area of cape Goryachiy. For hydrothermal systems of stratovolcanoes, such as Mendeleev volcano, are revealed the certain regularity of change of chemical and gas composition of thermal waters with height, depending on the distance from the center of a volcano to his periphery.

This regularity was allocated by many researchers (Markhinin, Stratula, 1977; Dunichev, 1983; Chudaev, Chudaeva, 2004 and many others), it proves by our data. On solfataric fields and in head of streams, besides the solfataric gases with temperature 100-108 °C, acid, carbonic, sulphatic sodium-calcite-magnesian hydroterms with raised maintenance  $Al^{3+}$ ,  $Fe^{2+}$ ,  $H^+$  and a mineralization up to 1 g/l are. Below, in the valleys of streams, acid hydroterms of chloride-sulphatic sodium structure with a mineralization 2-4 g/l (the thermal springs of Low group of Kislyy Stream and Doktorskiy Stream) is situated. At foot of the volcano the outputs of subneutral thermal springs mainly chloride sodium composition, with a mineralization from 0.6 g/l up to 15 g/l (Mouth group of Kislyy Stream, Stolbovskie springs, Tret'yakovskie thermal springs and hydrothermal outputs of the Goryachiy Plyazh) are located. Isotope composition of hydrogen, oxygen, argon, helium and neon in hydroterms of the

volcano Mendeleev (Baskov, Surikov, 1989; Cheshko, 1994; Chudaev, 2003; Chudaev, Chudaeva, 2004) corresponds to local meteoric waters that are explained by their prevailing participation in formation of hydroterms.

On Ruruy volcano (northern part of island) thermal and solfataric activity is concentrated on the western slope on the area about 1.5 km<sup>2</sup>, solfataric fields and thermal springs form Neskuchenskaya group of thermal springs. The temperature of waters of thermal springs of Neskuchenskaya group varies from 40 °C in valleys of streams up to 90-100 °C on solfataric fields and on sea coast. On a chemical composition the waters of thermal springs investigated by us can be divided into three groups having different anion structure: sulphatic, sulphatic-hydrocarbonaceous, hydrocarbonaceous-sulphatic. The group of sulphatic thermal waters includes acid thermal springs of solfataric fields, neutral and alkalescent sulphatic-hydrocarbonaceous thermal springs are located below on the slope and on a sea coast. On a first sea terrace hydrocarbonaceous-sulphatic thermal springs is situated. Cations structure of thermal springs, irrespective of values pH, temperatures and heights of an output is practically equal. The isotope structure of hydrogen and oxygen of thermal waters (Cheshko, 1994) is practically identical to meteoric waters. It shows that in a feed of thermal waters, mainly, participate waters of an atmospheric origin which are heated up on depth and then rise to a surface.

Thus, high solfataric-hydrothermal activity is characteristic for volcanoes of Kunashir Island. Here practically all types of thermal waters known in the region of active volcanism locate. On different morphogenetic types of volcanoes ("difficult" stratovolcanoes Ruruy and Mendeleev, Golovnina Caldera) special regularities of change of hydrochemical types of thermal waters from the center to periphery of volcanoes are observed.