Impact of Volcanic Fluids on Water Quality, Baransky Volcano, Southern Kuriles

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***Abstract*-To determine the impact from volcanic fluid on river water quality, we sampled all visible water streams in the Baransky watershed. Using discharge data from Kipyaschiy Creek and the Sernaya River in conjuction with the concentration of components, we calculated the impact of volcanic fluid onto environmental waters. Total washout of components in tons per year: sulfate: 24371, chlorine: 12147, sodium: 4510, calcium: 4181, magnesium: 1773m and potassium: 628. Total washout for trace metals in kilos per year is as follows: lithium: 5969, vanadium: 1799, barium: 2758, rubidium: 4070, nickel: 3295, chromium: 921, copper: 1167, zinc: 6159.**

Keywords- Volcanic Water Chemistry; Water Quality; Kuriles; Baransky Volcano

I. INTRODUCTION

Today, the problem of potable water is well researched in many regions of the Earth. The main factors that influence water quality are human activity causing pollution, climate change and overpopulation causing draughts, and volcanic activity. This paper will show how the influence of a volcano on groundwater and surface water quality. The Baransky Volcano is a part of the Ivan Grozniy volcanic belt in the central part of Iturup Island, in the southern Kuril Islands (Fig. 1).

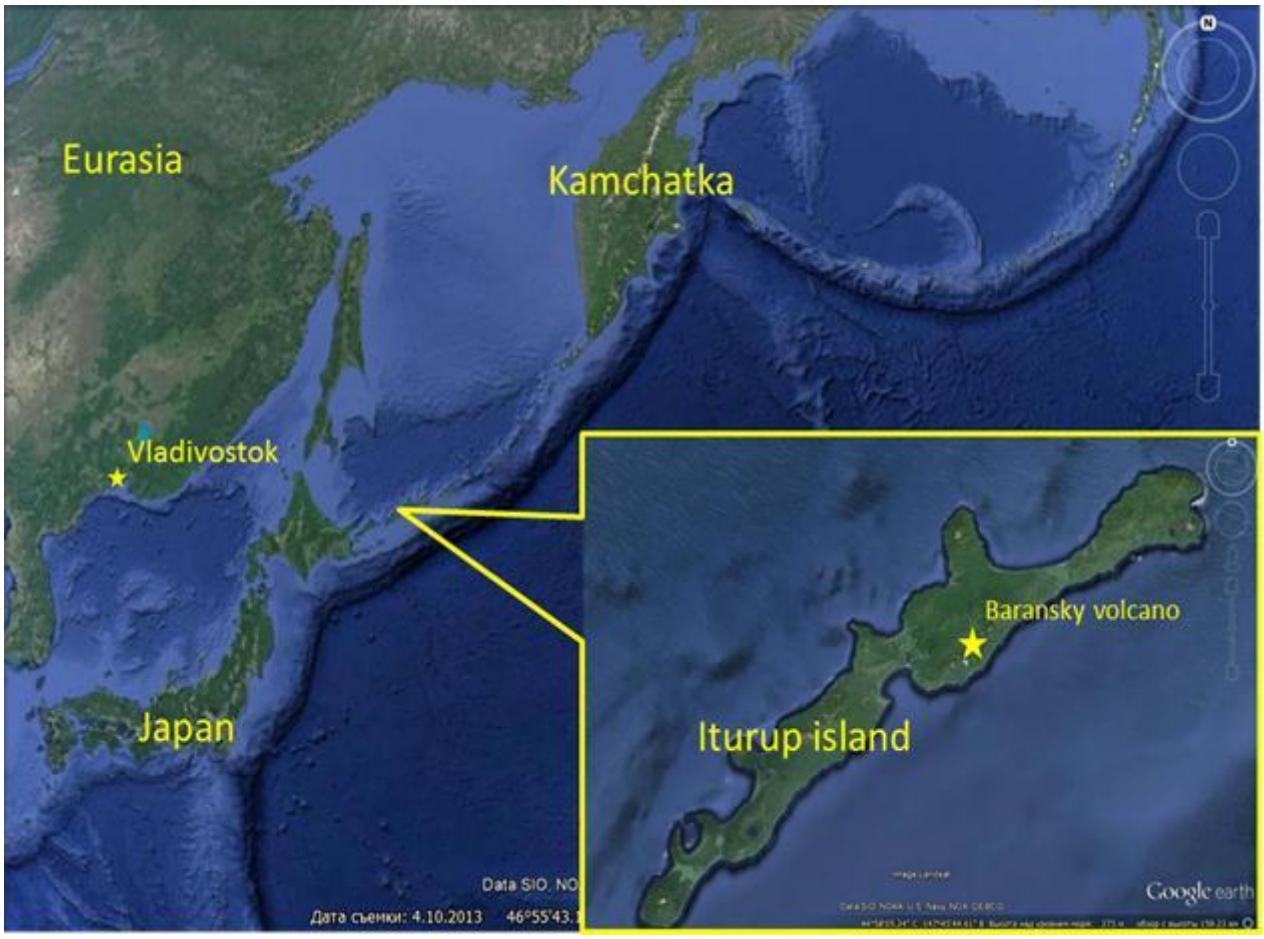

Fig. 1 Location of studied objects [1]

The Kuril Islands are the result of the subduction of the Pacific Ocean under the Eurasian plate. This means that many territories in this region (i.e., Kamchatka, Kuril Islands, Japan) face similar problems in regard to the impact of volcanic

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activity on the quality of potable water. The Baransky hydrothermal system is confined to the southwestern slope of a young andesitic volcano, located in the center of medium-Pleistocene caldera Kipyaschiy, which is characterized by maximum heat removal to the surface [2]. Fault zones are composed of intensely fractured rocks and various breccias. In the depths of horst is an active process of volcanic rebirth, as well as volcano-sedimentary subvolcanic rocks of influenced high-temperature (300-350℃), fractured porous hydrogen sulfide-carbonate-sulphate and sodium chloride, and carbon-nitrogen treatment [3]. Kipyaschiy Creek is 2.5 km long and originates on the slopes of the Baransky Volcano, and flows into the Sernaya River. These are the only water routes which drain all water into the Baransky area.

II. MATERIAL AND METHODS

We sampled all visible springs and seeps on the watershed of Kipyaschiy Creek. Samples were collected into acid-washed, high-density polyethylene sampling bottles. Before sampling, all water samples were filtered through cellulose filters (0.45μm) and then acidified to pH<2 with an ultrapure nitric acid, excluding samples intended for anion analysis. Water temperature, conductivity and pH were measured directly in the field (in situ) to avoid variation of parameters [4]. Major elements (Na, K, Ca, Mg and NH_4, NO_3, F, Cl, SO_4) were analyzed by liquid chromatography, with analytical error of less than 5%. HCO_3 was determined by titration with a 0.01N HCl solution of 10 ml of a non-filtered non-acidified sample aliquot. Silica concentrations were analyzed by colorimetric photo spectrometric methods, performed on diluted samples. Microelements were measured by mass spectrometer with inductive coupled plasma Agilent 7500c; if necessary, samples were pre-acidified to pH<2 to prevent fractionation.

III. RESULTS AND DISCUSSION

The main hydrochemical parameters of Kipyaschiy Creek and Sernaya River are presented in Table 1.

TABLE 1 HYDROCHEMISTRY OF MAIN FLUIDS OF BARANSKY VOLCANO

Sample Location	TDS	Discharge	pH	Temp	Na^+	K^+	Ca^{2+}	Mg^{2+}	SO_4^{2-}	Cl^-
	mg/l	l/s		C	mg/l					
KipyaschiyCreek (estuary)	11100	200	1.26	30.6	93.1	22.7	94.7	21.1	1750	844
SernayaRiver before mixing with Kipyaschiy	105	12000	6.62	14.5	10.7	1.25	9.45	2.28	25.6	12.6
SernayaRiver after mixing with Kipyaschiy	150	12000	2.78	15.3	11.92	1.66	11.05	3.1	64.4	32.1

We can see that the main ions in the volcano-fed Kipyaschiv Creek are chlorine and sulfate, resulting in the degassing of the magmatic chamber of Baransky. This flux also flows into the Sernaya River and increases concentrations of all main ions while decreasing pH to 2.78, which is significantly acidic. After this kind of impact the river becomes dead, because no organism can live in such acidic conditions.

Another important factor with great impact on water quality is groundwater flow. Groundwater is fed from low horizons by volcanic fluid and from the surface by subsurface Kipyaschiy Creek. The total sum of these two flows can be calculated as the difference between the sum of Kipyaschiy Creek and the Sernaya River volumes before mixing with Kipyaschiy, and the volume of the Sernaya River after mixing with Kipyaschiy Creek (Table 2).

TABLE 2 ANNUAL IMPACT OF BARANSKY VOLCANO ON SURROUNDING WATER OBJECTS

Object	Macro weathering,(tons per year)								
	Na	NH_4	K	Ca	Mg	Cl	Br	NO_3	SO_4
Kipyaschiy Creek (1)	587.2	8.8	143.2	597.3	133.1	5323.3	5.2	2.3	11037.6
Sernaya River before mixing with Kipyaschiy Creek (2)	4049.2	121.1	473.0	3576.2	862.8	4768.2	7.6	189.2	9687.9
Sernaya River after mixing with Kipyaschiy Creek(3)	4510.9	68.1	628.2	4181.7	1173.1	12147.7	7.6	196.8	24371.0
Groundwater of Kipyaschiy Creek (4)	-125.5	-61.8	12.0	8.2	177.2	2056.1	-5.2	5.3	3645.6

	Micro weathering (kg per year)											
	Li	V	Cr	Co	Ni	Cu	Zn	Ga	Rb	Ag	Cd	Ba
(1)	2019.6	865.9	113.1	5.7	101.3	26.6	451.0	68.1	41.1	8.1	0.4	379.2
(2)	5291.7	414.9	1816.6	51.7	3341.0	985.4	5097.3	6.4	1559.7	10.6	66.1	2234.3
(3)	5969.6	1799.9	921.9	46.0	3295.3	1167.9	6159.2	13.4	4070.0	26.3	66.1	2758.1
(4)	-1341.7	519.1	-1007.8	-11.4	-147.0	155.9	610.9	-61.1	2469.1	7.6	-0.4	144.6

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We determined some negative values in the 4th row. These are caused by precipitation of these components under changing conditions after mixing of the Semaya River and Kipvaschiv Creek [5].Basing on this data, with both the total discharge of a creek and a river we can calculate total impact of macro components (Fig. 2) and microelements (Fig. 3) on the environment from a volcano [6].

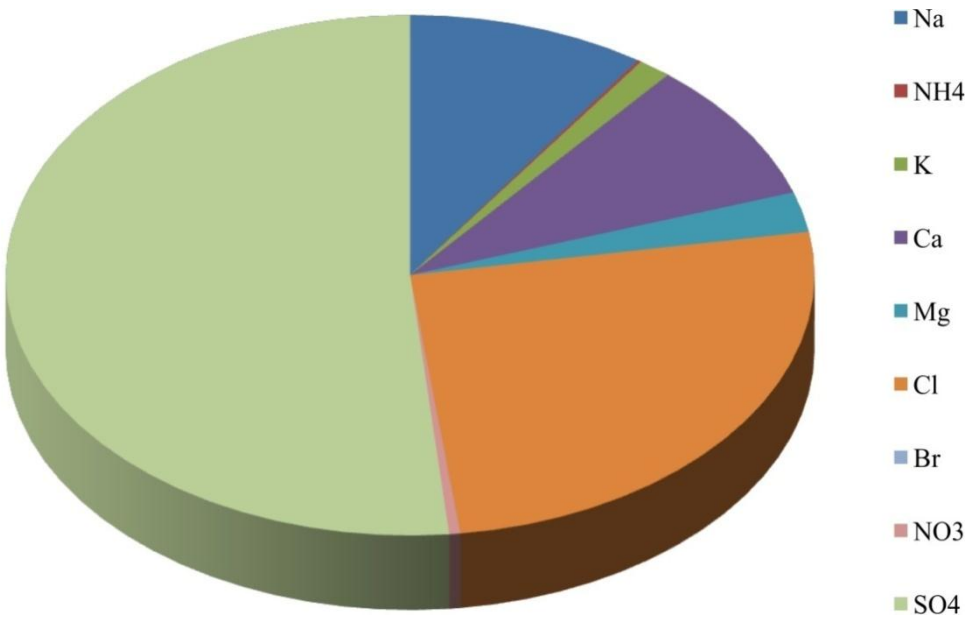

Fig. 2 Contribution of macro components onto annual impact from Baransky Volcano into surrounding groundwaters

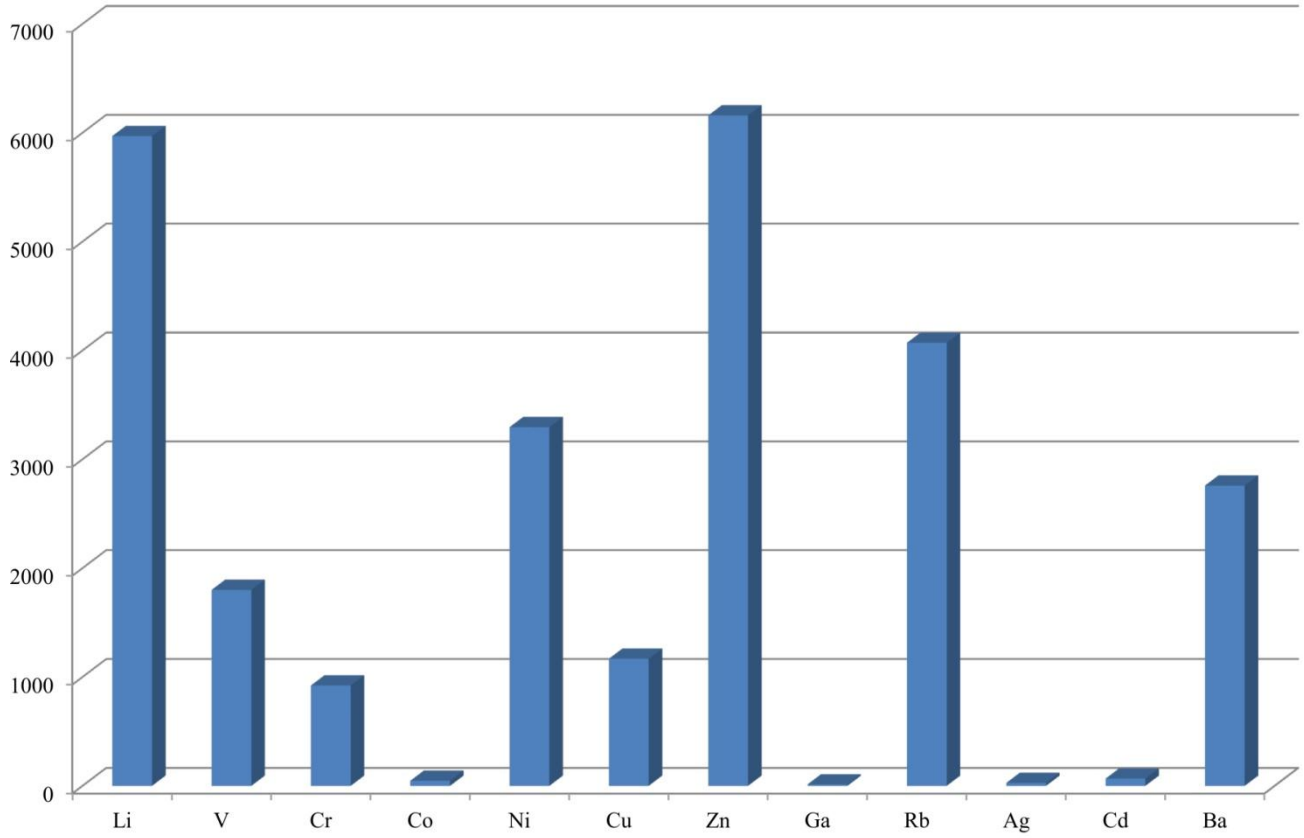

Fig. 3 Annual impact of microelements from Baransky Volcano (kg)

We determined that main marcro component contributors to environmental impact are sulphate and chlorine, and the main microelement contributors are zinc, lithium, rubidium, barium, nickel, vanadium, copper and chromium.

IV. CONCLUSIONS

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Using discharge data of Kipyaschiy Creek and the Sernaya River in conjunction with concentrations of components, we calculated the impact of volcanic fluid onto environmental waters. Total washout of macro components, in tons per year: sulfate: 24371, chlorine: 12147, sodium: 4510, calcium: 4181, magnesium: 1773 and potassium: 628. Total washout for trace metals in kilos per year is as follows: lithium: 5969, vanadium: 1799, barium: 2758, rubidium: 4070, nickel: 3295, chromium: 921, copper: 1167, zinc: 6159. This flux exists in Kipyaschiy Creek and flows the into Sernaya River, increasing concentrations of all main ions and decreasing pH to 2.78, which is significantly acidic. After this kind of impact the river becomes "dead," because no organism can live in such acidic conditions.

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