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Water Rock Interaction [WRI 14]

Geochemical evolution of groundwaters of the far-east Russian volcanic belts: Kamchatka & Kuril Islands and Sikhote-Alin Mountains

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Abstract

This article examines the composition and geochemical evolution of groundwaters developed in volcanic areas: the first region characterized by modern volcanic activity (eastern Kamchatka and Kuril Islands), and the second in eastern Sikhote-Alin where volcanism terminated in the upper Cretaceous–Paleocene. Despite the meteoric source of these groundwaters, its geochemical features in volcanic areas are heavily affected by the impact from external sources, as well as the duration of the water-rock interaction and the water/rock ratio.

Keywords: hydrogeochemistry; Kamchatka; Kuril Islands; Sikhote-Alin.

1. Introduction

Hydrogeological characteristics of volcanic areas in the Far East Russia were examined by [1], but chemical composition of groundwaters and their diversity from the perspective of water-rock interactions were never studied in detail. Therefore here geochemical data collected in period 1995-2010 were used for the purpose of this study [2,3]. Among the various groups of groundwaters found in volcanic areas this article looks specifically into the following two: the first group is closely related to modern volcanic activities induced by subduction of Pacific plate (Eastern Kamchatka: Mutnovsky and Uzon geothermal areas) as well as volcanoes of Kuril Islands (Mendeleev, Baransky, Ebeko). For this first group of groundwaters heat sources and fluid are related to shallow magmatic system where as the second group of groundwaters is not related to modern volcanic activity, but host rocks for most of them are volcanic. This latter group of thermal springs includes sodium-bicarbonate water of Sikhote-Alin (from south to

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north: Chistovodnoe, Amgy, Tumnin, and Annesky warm springs) as well as cold calcium-sodium bicarbonate water (Gornovodnoe springs), figure 1.

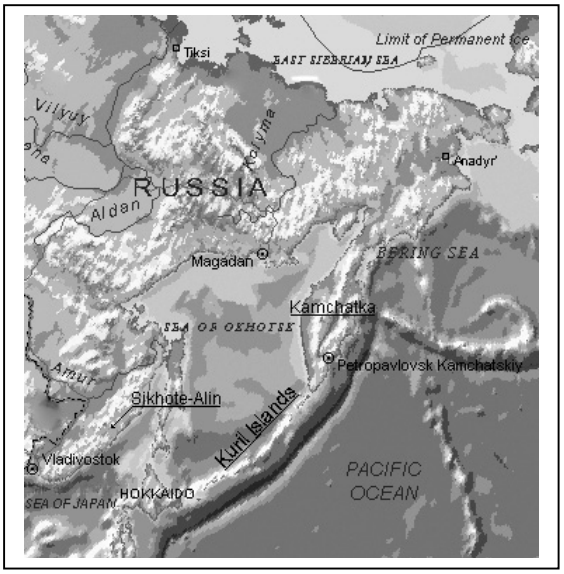

Fig. 1. Area of study

2. Results and discussion

The waters here examined for this paper are characterized by a wide range of major and minor components that allow to the recognition of two distinct groups of ground waters. All thermal waters can be characterized by high sodium content. In case of the cold mineral waters, calcium appears to be the dominant element (figure. 2). Analogous evidences are reflected by the distribution of anionic constituents.

In high-temperature springs from Kamchatka and Kuril Islands bicarbonate contents are not significant chlorine- and sulphate - ions are predominant, whereas in low-temperature springs and peripheral volcanic waters (Vulichinsky and Voinovsky springs), HCO_3 contents are higher, prevalent in springs from Sikhote-Alin. Here HCO_3^- contents are significantly higher with respect to Cl^- and SO_4^{2-} concentrations.

These features suggest that the Na^+ source may be identified in the rainwater component Sikhote-Alin and Kamchatka-Kuril regions (figure 2), whereas Ca^{2+} is mainly delivered from shallow freshwaters system where is accumulated [2, 3]. As these waters are involved in groundwater systems two different scenarios can be depicted.

If CO_2 is added as occurs in mineral waters from Sikhote-Alin waters progressively become weakly acidic and a continuous Ca^{2+} accumulation occurs until to the attainment of the saturation in carbonates. Otherwise Ca^{2+} enriched groundwaters progressively increase their temperature during infiltration due to the occurring thermal gradient. Following interaction between these waters and host rocks involve a progressive Na^+ removal from host rocks whereas Ca^{2+} is partially removed allowing to a Ca-Na replacement. The latter scenario is mainly suggested for warm springs of Sikhote-Alin where increasing TDS of thermal waters is traced northward and related to the increasing concentrations of sodium and silicates.