The geochemistry of submarine grounwater discharge in volcanic and alluvial fan area

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Introduction

The flux of fresh water to the ocean through a costal aquifer is known as submarine groundwater discharge (SGD). SGD has recently been recognized as a source of nutrients that can strongly influence the composition of coastal-water and geochemical budget of the ocean. Coastal marine ecosystems are incidentally affected by the dissolved nutrients inputs from circulating offshore water, river runoff, and groundwater seepage.

Rishiri is a highly dissected andesitic stratovolcano that forms a 20 km wide island off the northern tip of Hokkaido. The volcanic edifice is composed mainly of alkali basalt and calc-alkaline andesite. The SGD system there is complicated, because the island consists of various geological unit (alluvial fan, volcanic rocks) and geo-hydrological components (clay, sand and gravel). Thus, groundwater flows with different mechanisms and variable time scales. Surface flow is absent between 600-1721m, and this situation facilitates high discharge of SGD.

Previous studies have indicated that residence time of groundwater varies from 15-30 years. Geochemical investigation of SGD is limited. Due to the lack of geochemical characterization including isotopic composition of SGD.and no records of isotopic composition of SGD. Due to absent of geochemical characterization of the SGD. This study therefore aims to; firstly, identify and chemically characterize all water types that occur in and discharge from the volcano. Secondly, to constraint the submarine groundwater flow regime using chemical and isotopic compositions. Rishiri SGD is faster than SGD in Toyama bay where the previous study have been reported (Zhang and Satake, 2003, Zhang, et al., 2005, Koyama et al., 2005 Hatta et al., 2005)

Method of study

Samplings of precipitations were carried out from January 2008 to November 2008 and, for groundwater October 2007 to July2008 three times. During this period 84 samples of water springs from groundwater, rivers, and submarine groundwater were collected from the study area. The pH, temperature, conductivity, DO, Major ions, silica, and heavy isotope of oxygen and hydrogen were analyzed in the samplers by standard methods. Relative standard deviation (RSD) for major ions is less than 3% and for isotope $\delta18O$ and δD was ±0.1 and ± 1.5‰

Results and discussion:

Piper diagram showed that subsurface water is dominated by Ca^{2+}—Mg^{2+}—Na^{+}— HCO_3^-, which along side precipitation is affected by sea salt spray. The molar ratio plot of Cl^- vs SO_4^{2-} and Na^+ plotted above the seawater line indicate other sources of Na^+ and SO_4^{2-}. The plot of cation value in the subsurface water against HCO_3^- showed an increasing trend indicating same source. A plot of all the cation against silica indicates that the possible source of ions in the groundwater is the dissolution of basaltic rocks. In upland area, groundwater and SGD show the high concentration 0.015-0.031meq/l of NO_3^- than in the terrestrial spring with lower concentration range of 0.008-0.02meq/l indicate either by denitrification or assimilation by plant.

Oxygen ($\delta^{18}O$) and hydrogen (δD) isotope composition in the precipitation ranged from -12.7 to -6.48‰ and -78.7 to -45.5‰ respectively and high in summer while low in winter. The d-excess value had shown in Table-1. Th air mass movement over Rishiri using backward trajectories shows different direction. Groundwater range of $\delta^{18}O$ and δD from -11.88 to -10.05‰ and -79.8 to -65.41‰ and SGD range from -11.81 to -11.5‰ and -78.0 to -75.0‰ respectively.

Table1 d-excess value

water sample	d-excess Value
Summer rainfall	10‰
Winter snow	23‰
Terrestrial spring	16‰
SGD	19‰

Table2 Estimation of mixing ratio using d-excess value

d-sample= d-summer*X + d-winter

	mixing percentage
Terrestrial spring:	Summer 54%, Winter 46%
Submarine spring:	Summer 30%, Winter 70%

The average d-excess value of subsurface water is 16‰ indicate subsurface is recharge by both season of water and plotted between two season of precipitation. The mixing ratio of terrestrial spring and SGD had shown in Table-2. The changes of $\delta^{18}O$ and δD contents with altitude are -0.12 and -0.38‰ per 100m respectively. The recharge elevation of terrestrial spring varies from 200 to 800m and groundwater varies from 800 to 1200m whereas SGD varies from 1000 to 1200m.

Conclusion:

1) Submarine groundwater discharge originate from groundwater.
2) SGD recharge by mixture of two season of water
3) Groundwater show altitude effect
4) SGD recharge higher elevation than terrestrial spring
5) Backward trajectories show different direction of air mass movement over Rishiri
6) NO_3^- is assimilation by plant.