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**Water Rock Interaction [WRI 14]**

# Geochemical study of groundwater in the Sho River fan, Toyama Prefecture for heat usage by a geothermal heat pump

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**Abstract**

Chemical and isotopic (D, O) compositions of 56 water samples from the Sho River fan, Toyama, northern part of central Japan, were analyzed to examine their water quality, origins, and water flow for geothermal heat extraction used for air-conditioning and melting of road snow by a geothermal heat pump (Geo-HP). Groundwaters are a mixture of two big river waters (Sho and Oyabe) and precipitation. Deep groundwaters from observation wells are characterized to be high in pH and enriched in $HCO_3$ compared to the shallow groundwaters. These features may indicate that the shallow groundwater originated from a mixture of river water and precipitation moving to the north and becoming confined due to the presence of an impermeable layer. Groundwaters attain high pH due to ion exchange reactions with rocks containing clay minerals, where $HCO_3$ concentration also increases.


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*Keywords:* groundwater, heat usage, hydrogen isotope, oxygen isotope, Toyama

## 1. Introduction

In central areas along the Japan Sea such as Toyama Prefecture, northern Central Japan, the averaged air temperature is 0 ℃ in winter and extends to 35 ℃ in summer. The water temperature of groundwater in Toyama is constant to be 15 ℃ throughout year and can be used for heat source of air conditioning of houses and industry by using the temperature difference between air and groundwater. The use of the

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geothermal heat pump (Geo-HP) is now spreading worldwide [1-2]. In this Geo-HP system, groundwater is pumped to the surface, undergoes heat exchange and returned through a reinjection well to the aquifer. In this treatment, the quality and water movement mode are important parameters for the use of groundwater.

In this study, groundwater and river water in Sho River fan were geochemically analyzed to examine the water movement and quality of groundwater for usage of heat energy by geothermal heat pumps. These data will be applied for estimation of water level variation, flux and movement of groundwater in the Sho River fan by 3D-simulation reported by Tomiyama et al. [3]. In the Sho River fan, groundwater has been abstracted for industry, melting of road snow and drinking. Land subsidence has occurred in the northern part of the fan due to excessive extraction of groundwater in the past and creates permanent damage to the land surface.

## 2. Samples and analytical procedures

The studied area and water sampling sites are provided in Fig. 1. In this study, 3 types of water samples are indicated; shallow groundwater in the fan, groundwater in observation well, and river water, were collected and analyzed for their chemical and isotopic compositions. Shallow groundwaters were obtained in three days; on 12th (samples No. 1 to 14) and 27th August (samples No. 15 to 32) and 9th September (samples No. 33 to 43) in 2011 (Fig. 1). Water samples were collected in plastic bottles (100 ml and 250 ml volume). At the sampling site, water temperature, pH, EC, and Eh were measured by a thermometer, a pH meter (Shindengen, KS-701), EC meter (Horiba, B-173), and Eh meter (TOA, RM-12P), respectively. Dissolved ion concentrations were measured using conventional methods. The major anions Cl and $SO_4$ in filtered water samples were analyzed with a Dionex DX-120 ion chromatograph using an IonPac As14 column. Alkalinity was determined using standard titration with HCl. Cations were analyzed with ICP-MS and ICP-AES at the geochemical laboratory, University of Toyama.

The H- and O-isotopic measurements were performed at the geochemical laboratory, University of Toyama. Both hydrogen and oxygen isotope ratios were determined by the stable isotope analyzer for $H_2O$ by use of diode laser (LA-RIMS; Ablation assisted resonance ionization mass spectrometry) and reported relative to V-SMOW with an analytical precision of 1 ‰ and 0.1 ‰, respectively.

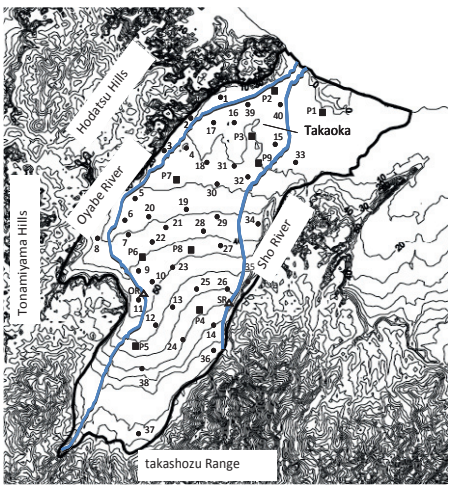


Fig. 1. Sample localities of shallow groundwaters and river water in the Sho River fan area.
●: Shallow groundwater, ■: Groundwater in observation well, △: River water