Hydrochemical approach to identification of groundwater flow paths in Matsumoto Basin, Nagano, Japan

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The Matsumoto basin, which located in a high land with altitude of 550 m to 750 m, depends considerably on groundwater for domestic, agricultural, industrial and urban use. An understanding of the flow path of the groundwater provides important strategy into the resource management and prevention of groundwater contamination.

We investigated stable isotope of oxygen and hydrogen and water quality of groundwater in order to identify flow paths in the Matsumoto basin and estimate recharge zones. The first purpose of this study is to show applicability of stable isotope data to identification of groundwater flow paths. The second is to evaluate a role of faults in groundwater system.

Sample and analysis

In the study, the 99 groundwater samples and 24 river samples were collected from 99 wells for domestic, agricultural, industrial and urban use and from 10 rivers, respectively, in July to November, 2000. Alkalinity, pH, electrical conductivity (EC) and temperature were measured at the time of field sampling. The major and minor ion analyses and the oxygen and hydrogen isotope analyses were performed in laboratory. All samples had ionic balance error below 5 % and had errors of isotope analyses within -0.1 per mil to +0.1 per mil and -1 per mil to + 1 per mil for d18O and dD values, respectively, where d=((R sample/R standard)-1)x1000 and R is stable isotopic ratio. Additional meteoric water sample were collected from 8 locations around the Matsumoto basin in November, 2001 and the oxygen and hydrogen isotope analyses were performed for obtaining altitude effect in order to estimate the recharge zone.

Results and discussion

All stable isotope data fell on a meteoric line widely in a plot of d18O (-9.9 to -12.7 per mil) against dD (-70.5 to -87 per mil), which has a relation between dD = 8 d18O +10 [Craig, 1961] and dD = 8 d18O +17. The main process influencing the stable isotopic ratio is precipitation at a different altitude, namely altitude effect, in the study region, because a good correlation between altitude and d18O content appeared for additional 8 samples distributed on the meteoric line. The plot of altitude against d18O content for the study region is correspond with that of central Japan [Waseda and Nakai, 1983]. The spatial distributions of the oxygen and hydrogen stable isotopic ratios indicate that flow systems of shallow groundwater and deep groundwater and seven flow paths are distinguishable in the study region. Based on the major cation and anion, Ca-HCO3 and Na- HCO3 water types are found in shallow groundwater system and 4 water types are found in deep groundwater system in the study region. These are: Ca-HCO3, Na-(Cl)-HCO3, Na-SO4 and Ca-HCO3-SO4 types. The four flow paths through shallow and deep aquifers are along river flows. The two flow paths through each of two inferred faults, which are covered by the alluvial thin layer, are estimated by lower d18O and dD values. A flow path through an inferred fault into the deeper aquifer is estimated by the comparison of the stable isotope data of the deep groundwater with that of the shallow groundwater. Consequently, some faults play a role of flow path and then, they induce mixing of different groundwater types. The ionic composition data support the identification of flow paths and mixing of different groundwater types. This study shows applicability of stable isotope data to identification of groundwater flow paths. Based on the stable isotope data of 7 flow paths, the altitude and location of recharge zones can be estimated roughly. By Shinji Nakaya, 2002, Feb. 27.