Characterization of groundwater flow at the depths by a geochemical method

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It is required for the geological disposal of high-level radioactive wastes that groundwater scarcely or very slowly flows in the depths (about 300 to 1000 m) around the buried wastes. In order to know the behavior of groundwater flow at the depths, we employed a geochemical method, which proved to be very useful for revealing very long-term behavior of groundwater.

The analyses were made at a site in Kanto Mts. where are distributed Jurassic olistostromes consisting mainly of sandstone, mudstone, and bedded chert. The water specimens were collected from rivers (4 points), meteoric water (2 points), and galleries (13 points) that were excavated at depths of 170 to 700 m from the earth surface. Dissolved constituents, isotopes of hydrogen and oxigen, and carbon 14 ages were measured. The hydraulic conductivities measured at boreholes in the site are very low, and range mostly between 10exp-7 and 10exp-9 m/sec. The densities of intact bedrocks are about 2.6 g/cm3, and groundwater flows through fractures including joints.

The water specimens are divided into four types on the trilinear diagram; type I [Ca, Mg -- HCO3], type III [Na, K -- Cl, SO4], type IV [Na, K -- HCO3], and intermediate type between type III and IV. The specimens collected from deeper (300-700 m) galleries belong to type III, and the other specimens collected from shallower (300 m) galleries or subaerial spots belong to type I, IV, or the intermediate with one exception.

Type III water has a high concentration of NaCl as dense as 1/4 - 1/5 of the present seawater. Type I and IV waters are plotted nearly on the meteoric water line (see ref.) defined by [2H/1H] and [18O/16O]. On the other hand, type III waters are plotted out of the line suggesting fossil seawater origin. In addition, type III water contains a larger amount of B (boron) than the average seawater, indicating fossil seawater origin. These lines of evidence indicate that type III water is probably diluted fossil seawater. Miocene shallow marine sediments had unconformably covered the bedrock in the study area until Early Pliocene and the area has been subjected to erosion since Early Pliocene. The fossil seawater is possibly of Late Miocene origin.

The carbon 14 ages range between 11,000 and 16,000 yBP for type I, IV, and the intermediate, and between 30,000 and 40,000 yBP (nearly saturated ages) for type III.

In conclusion, groundwater originated from fossil seawater is distributed at depths of 300-700 m in the study area although it has been diluted by 1/4 - 1/5 of the present seawater. The presence of fossil seawater at least older than several tens of thousand years indicates that the flow velocity of groundwater has been very slow at depths in the study area during a long period longer than several tens of thousand years. The geochemical method employed in this study proved to be quite useful for evaluating long-term groundwater behaviors.

Reference

Craig, H. (1961): Isotopic variation in meteoric waters, Science 133, p.1702