Characterization of Groundwater Chemistry Using $^{3}H/^{3}He$ Age- Dating

Jeonghoon Lee · Byeongju Jung · Jun- Mo Kim · Ho- Wan Chang[1)]

1. Introduction

This paper depicts tritium (^{3}H) and noble gases, especially He were used as environmental tracers in combination with hydrochemical data to gain more detailed insights into the mechanisms controlling the hydrology of underground storage facility containing LPG. Groundwater chemistry around underground storage facility shows different patterns from that of shallow aquifer because of the caverns excavated in hard rock for the storage.

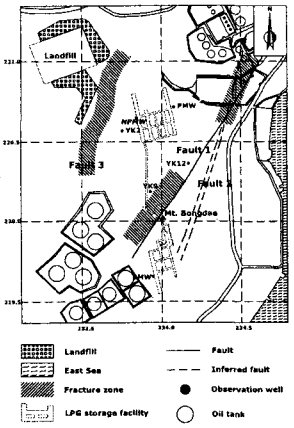

Figure 1. Study area

2. Site description

2.1 Study area

The study area is located in Yongjam-Dong, Ulsan, on the southeastern coast of Korea. The site is part of a small peninsula made up of hills of moderate height and narrow alluvial plains. Mesozoic sedimentary formations as intruding andesite sedimentary formations are distributed in this area. Hornfels, formed by contact metamorphism along the boundary between the sedimentary formations and the andesite, is occasionally observed.

2.2 LPG storage facility

The principle of LPG storage in unlined rock caverns is based on the constraining effect of groundwater in rock fractures that surround the cavern (Figure 2). The cavern or tunnel acts as sink or source of groundwater system and the seepage into the cavern or tunnel represents composition of surrounding fractured crystalline rock.

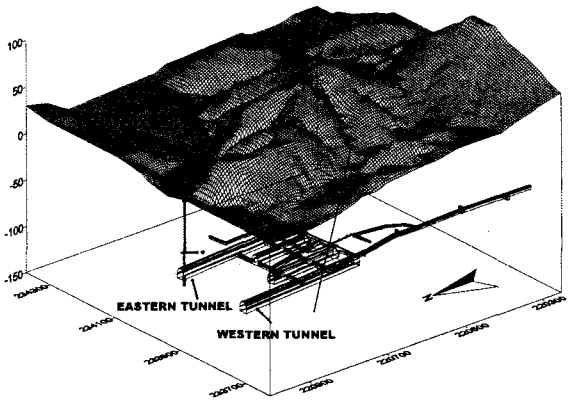

Figure 2. Distribution of well location

3. $^3H/^3He$ groundwater residence time

The $^3H/^3He$ age is defined since the gas exchange of a water parcel has stopped,which is the time since the water entered the saturated zone and is given by:

$$t_{^3H/^3He} = \frac{1}{\lambda} \ln\left(\frac{[^3He^*]}{[^3H]} + 1\right)$$

4. Results

4.1 Groundwater chemistry

Hydrochemistry of the study area has been severely affected by disinfection activities. Agent of disinfection activities, sodium hypochlorite (NaOCl), had high pH, sodium and chloride concentrations, so the wells in the vicinity of water curtain were inclined to show similar ion composition. As shown in Figure 3, chemical composition defines a continuous trend from Ca/Na-HCO_3 ground waters (YK9L/ 9U and YK2L) to Na- [(HCO_3+ CO_3)/Cl] (YK2U, NPMW/ PMW and PSP) type according to the input of sodium hypochlorite (NaOCl). The disinfectant agent transport from the water curtain to these wells (Na- [(HCO_3+ CO_3)/Cl]) indicate that the close connectivity between them. In YK12L, the transport of disinfection solution, of which diagnostic feature is high pH, sodium and chloride concentration, is observed and it means heterogeneous behavior of solute transport such as "channeling or preferential flow".

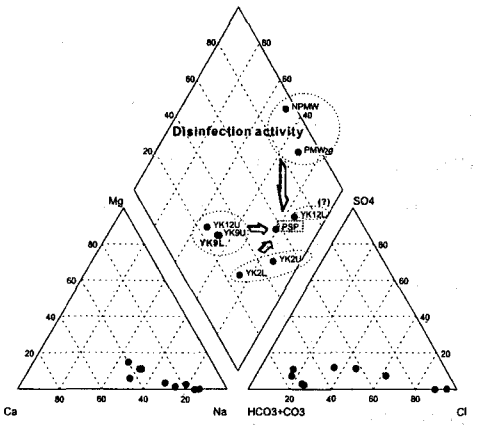

Figure 3. Trilinear diagram of chemic composition of the study area

4.2. Relationship between groundwater age and the chemistry of groundwater

The chemical changes as well as isotopic variations in groundwater may be used to identify evolution and provide information on groundwater flow paths. The analysis and comprehensive interpretation of helium isotope and additional use of a geochemical maturity indicator can significantly improve the quality of $^3H/^3He$ groundwater age determination, particularly if the sources of contaminants are obscure. In this case, YK12L shows dramatic increase of pH, using classical hydrochemical point of view. In this research, groundwater movement, which is crucial factor to operating LPG storage caverns, was investigated by helium isotope adding reviewing previous investigation.

4.3. Groundwater velocities and recharge rate

Vertical $^{3}H/^{3}He$ age profile can be used estimate vertical groundwater velocities and recharge rates. An attempt has been made to estimate groundwater velocities and recharge rates using calculated depths from the samples wells (YK9L/ 9U). The measurement point in a well was taken as the midpoint between the bottom of the plain casing and the total depth of the well.

5. Summary and Conclusions

Based on information obtained from groundwater chemistry and helium isotope data, we suggest the following conceptual model describing the hydrological system of the LPG storage caverns.

Key words: groundwater age dating, underground storage facility

1) School of Earth and Environmental Sciences, Seoul National University (goblok@geochem.snu.ac.kr)