Environmental isotopic and hydrochemical studies on geothermal groundwater circulation in Heyuan Fault Zone, Southern China

Xiaolin Qiu 1,2, Ya Wang 1, Zhongzheng Wang 2, Klaus Regenauer-Lieb 3
(1) Sun Yat-sen University, (2) The Hong Kong University of Science and Technology, (3) University of New South Wales

*xuil06@mail2.sysu.edu.cn

1 Motivation

With numerous hot springs and active neotectonic movements, Heyuan Fault Zone is a typical medium-low temperature geothermal system in Southern China. However, these geothermal resources are only used for bath. Compared with using for geothermal power generation, that results in some energy waste. For a better exploitation of these resources, multiple isotopic and hydrochemical techniques were used to study the circulation of geothermal groundwater in Heyuan Fault Zone, Southern China.

2 Study Area

Outcrop bedrock mainly are Jurassic biotite granite and Cretaceous “red layer” deposits. Heyuan main fault is a NE striking normal fault. The tectonic movement in the study area is relatively active and there were a lot small earthquakes happened after 1960s. These earth quakes are believed to be induced by the Xinfengjiang reservoir.

3 Recharge Source

Some thermal groundwater are formed in deep ground, and contain mantle materials. To constrain the recharge sources of the geothermal groundwater in Heyuan, we analyzed the helium and neon isotopes of gas in the hot spring. Because the He/Hel is quite different between the crust (8Ra) and the mantle (0.1Ra), and the He/Ne could distinguish the air and underground. So we could use the three end-member mixing equation to find out that the hot spring helium is primarily from crustal source, as shown in figure 2.

4 Groundwater Age

Groundwater age was estimated using radio-active 14C dating technique. The dissolution of inactive carbon in geothermal water is inevitable, and this may significantly increase the calculated groundwater ages. In this study, we use an isotope hybrid model and a geochemical model respectively to correct the dead carbon. Comparing the corrected results of the two models (Figure 6), the ages are similar, indicating the dating results are reasonable. Taking the average age of the two models, we conclude that the ages of the geothermal groundwater from 9.9 to 12.3 kyr.

5 Circulation Depth

To calculate the circulation depth of the geothermal groundwater, firstly, we need to calculate the reservoir temperature in the deep underground. Due to the hot spring water are immature, we apply the SiO2 geothermometers to estimate the temperature. But the results are quite different, varying from 83 °C to 157 °C.

There are obvious correlations between the exposed temperature and SiO2 concentration, as well as the exposed temperature and δD in the Heyuan Fault Zone. Assumed that the springs are derived from the same geothermal field and have experienced the same conductive cooling process, it could be concluded that the temperature differences are caused by different mixing ratio of cold non-geothermal water. And using the two end-member mixing equation, setting the highest temperature spring as geothermal groundwater end member, we calculate the cold water mixing fractions range from 17% to 48%.

Finally, using the local geothermal gradient, the circulation depth is estimated to about 6.5 km.

6 Conclusions

1. The main recharge source of Heyuan geothermal groundwater is local meteoric water. And the recharge area is granite zone, with the elevation of 440-670 m.

2. The hot springs were recharged by the rainfall 9.9-12.3 thousand years ago. It suggests that the recharge rate is quite slow, and the springs are not suitable for large-scale exploitation.

3. The mixing of cold water have significantly cooled down the geothermal groundwater. The reservoir temperature could up to 157 °C, with a depth of 6.5km.