

Application of Environmental Isotopes

-- A Case Study of A Spring

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Abstract

In this paper, the recharge of a spring in the study area is studied by means of hydrogen and oxygen stable isotopes and strontium isotopes, combined with hydro-geochemical methods and analysis of karst hydrogeological conditions. By using isotope hydro-geochemical method, the recharge amount and recharge path of spring water can be obtained.

Keywords

Isotope; Spring; Radioisotope; H; O; Sr.

1. Introduction

Isotopes refer to different nuclides of the same chemical element with the same proton number but different neutron number. Environmental isotopes refer to the widely existing isotopes H, C, N, O, S, Cl, and Sr in the environment. They are the basic elements in hydrological, geological and biological systems. Isotopes are divided into stable isotopes and radioisotopes. Stable isotopes include ^2H , ^{14}C , ^{34}S , ^{18}O , ^{37}Cl and ^{87}Sr , which can be used as tracers. Analyzing the sources of main ions in deep groundwater, clarifying the restrictive factors of groundwater evolution, providing a scientific basis for the rational development and utilization of groundwater resources and water quality evaluation, is of great significance to the study of groundwater chemical genesis and evolution law.

The structural geology in the concealed karst area is very developed, and the karst hydrogeological conditions are complex, and the mixing degree of various water bodies is high. By analyzing and summarizing the previous research results, it is found that the relationship between karst water at the dam site, a river and the spring is the focus of the research, and there are differences. Most researcher believe that the supply source of the spring water mainly comes from the leakage of the river, followed by the supply of atmospheric precipitation. Some experts questioned whether there is groundwater along the fault to replenish the spring, and there is no evidence to support this hypothesis. In this paper, the environmental isotope method is used to study the recharge source and path of the spring.

2. Isotope H and O

Hydrogen and oxygen are two main chemical elements in nature. They widely exist in the form of simple substances or compounds all over the earth. They have three isotopes: H, ^2H (D), ^3H (T) and ^{16}O , ^{17}O and ^{18}O . Among them, H, ^2H (D), ^{16}O , ^{17}O and ^{18}O are stable isotopes, and ^3H (T) is radioisotope.

Most groundwater comes from the recharge of atmospheric precipitation. In the process of hydrogeology and environmental geology research, by analyzing and studying the composition of H and O stable isotopes in atmospheric precipitation, surface water and groundwater, drawing corresponding curves, and comparing the global atmospheric precipitation line, we can analyze the relationship and process, so as to reveal the formation and migration process of local groundwater [1] The isotopic content in water will change slightly with the water cycle. In order to deeply analyze its change process, its ratio is usually used δ The expression of the research is as follows: $\delta = (R_{\text{sample}} - R_{\text{standard}}) / R_{\text{standard}} \times 1000\text{‰}$. Hydrogen and oxygen stable isotopes [2] have a strong indication of the mutual transformation between different water bodies. Craig analyzed 400 isotopic data collected all over the world and found that there was a linear relationship between the mass concentrations of D and ^{18}O in atmospheric precipitation. Through statistics, the global atmospheric drawdown line was obtained $\delta \text{D} = \delta ^{18}\text{O} + 10$. Liu Nannan [3] by studying the variation law of isotopes in the process of three water transformation, the effects of precipitation and temperature on surface water are obtained δD , $\delta ^{18}\text{O}$ content has a great influence. Wei Wen [4] etc. the groundwater recharge sources in the study area are well identified by analyzing H, O stable isotopes and radioisotope ^3H and combining regional hydrogeological conditions. According to the survey results of Shaanxi Geological Survey Institute in 2002, the atmospheric downline equation in the middle of Weibei, Shaanxi is $\delta \text{D} = 8.103 \delta ^{18}\text{O} + 10.16$. By analyzing the hydrogen and oxygen stable isotopes of river water and karst water δD and $\delta ^{18}\text{O}$ content and ^3H value, it is found that karst water is closely related to modern atmospheric precipitation. By analyzing the deuterium surplus contour map of karst water, it is found that the deuterium surplus value of karst water decreases from northwest and southwest to Southeast, showing the runoff path of karst water. When the mixed sample comes from three different paths, we can use the relationship between δD and $\delta ^{18}\text{O}$ to select the corresponding extreme sample point as the terminal element, then establishing a mixture model of three components to calculate mixing samples of mixed proportion of each terminal element. In order to calculate the mixing ratio of karst water in different directions, according to the detection data, we take the karst water at point C, point A and point B as three terminal elements respectively. The sample plotted in the triangle, indicating that the kind of karst water are main due to the mixed karst water of C, A, B. The results of isotope δD and $\delta ^{18}\text{O}$ ternary mixture show that the mixing ratio of spring water from three points C, A, B are 2.4%, 19.7% and 77.9%. It shows that they have a certain hydraulic connection.

3. Stable Sr Isotope

There are four natural stable isotopes of strontium. The residual time of Strontium in seawater is much longer than the mixing time of seawater. Therefore, the isotopic composition of Strontium in seawater around the world can be considered to be uniform [5]. Stable Sr isotopes do not fractionate in natural environment and respond to water rock interaction. Therefore, it is a reliable tool to evaluate groundwater mixing and trace the origin of water and water rock interaction. Considering Sr content and $^{87}\text{Sr} / ^{86}\text{Sr}$ ratio can effectively identify the source of groundwater Sr and water rock interaction in water medium, which is of great significance to

further understand the evolution and mechanism of groundwater and reveal the formation and circulation process of groundwater.

The relationship between the $^{87}\text{Sr} / ^{86}\text{Sr}$ ratios of different water bodies in the study area is that the atmospheric precipitation samples are higher than the precipitation samples in the study area, showing the strontium isotope characteristics of atmospheric precipitation in arid and semi-arid areas. The $^{87}\text{Sr} / ^{86}\text{Sr}$ ratio of river water sample is close to that of river, showing obvious evaporation concentration effect. The $^{87}\text{Sr} / ^{86}\text{Sr}$ ratio of karst water samples is high, showing the characteristics of buried karst water.

Sr isotopes are widely used to determine the mixing ratio of mixed samples. Both $^{87}\text{Sr} / ^{86}\text{Sr}$ ratio and Sr concentration are affected in the mixing process. In the $^{87}\text{Sr} / ^{86}\text{Sr}$ and $1 / \text{Sr}$ diagrams, the curves of two mixed solutions with different Sr concentrations and $^{87}\text{Sr} / ^{86}\text{Sr}$ ratios are straight lines. The mixing equation can be derived from the relevant parameters of a series of aqueous media formed by the mixed solution of two solutions. When the research object is considered to have three mixing sources, its samples should be distributed in the three terminal element region of the triangle, and the ternary mixing model needs to be used to calculate the relevant mixing ratio. The calculation of ternary mixing ratio is based on binary mixing because there is a linear relationship between each mixed sample. In other words, the ternary mixing result is determined by the quadratic linear superposition of binary mixtures.

4. Conclusion

Hydrogen and oxygen stable isotope is an important means to trace the water source of natural water body. By applying this means, we find that for the recharge of the spring area, the mixing ratio of spring water from three points C, A, B are 2.4%, 19.7% and 77.9%. Different sources have different $^{87}\text{Sr} / ^{86}\text{Sr}$ ratios, so strontium isotopes can be used as source tracing fingerprints. Strontium isotope content can be used to calculate the mixing ratio of mixed samples.

References

- [1] Shang Haimin, Li Guomin, Yu Jinqing. Applications of environmental isotope in groundwater studying[J]. Groundwater, 2008 (02): 18-22.
- [2] Zhang Lei, Qin Xiaoguang, Liu Jiaqi, Mu Yan, an Shikai, Lu Chunhui, Chen Yongchun. Characters of Hydrogen and oxygen stable isotope of different water bodies in Huainan coal mining area[J]. Journal of Jilin University: Earth Science Edition), 2015,45 (05): 1502-1514.
- [3] Liu Xiangnan. Application of environmental isotopes in the law of "Three-Water Conversion"[J]. Water science and engineering technology, 2019 (06): 12-15.
- [4] Wei Wen, Chen Zongyu. Identification of the origin groundwater recharge using environmental isotopes in the southwest Songnen Plain[J]. Journal of arid Land Resources and environment, 2017,31 (01): 173-177.
- [5] Guo yaogeng. Application of strontium isotopes formed by weathering of geological minerals in sedimentology [J]. World nonferrous metals, 2020 (22): 178-179.