

Krypton-81 sampling of geothermal water in Xianyang city, NW China

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Groundwater age is one of the most important parameters in water resources, nuclear waste disposal, carbon sequestration, paleoclimate studies and so on. Guanzhong Basin is a major groundwater drainage basin with >5000m of Cenozoic sediments in the middle reaches of Yellow River, suitable for deep and old groundwater studies. Previous studies showed that ^{14}C contents in most geothermal waters were about 3pmc, which is beyond the dating range of ^{14}C method [1]. ^{36}Cl method showed that the age could reach 1124ka [2]. However, this method is complicated by variations of the initial ^{36}Cl activity and subsurface Cl input. Therefore, a new isotopic method for dating old groundwater is needed in this area.

The advent of ATTA (Atom Trap Trace Analysis) [3] enables routine measurements of rare noble gas isotopes, and ^{81}Kr ($t_{1/2} = 229,000$ years) is a desirable tracer for old groundwater dating. Large quantities of Kr are required for determining the isotopic abundances of noble gas radionuclide, so gas extraction should be finished in the field. In fact, very little field work has been conducted so far in the geothermal water due to the temperature limitation ($5-40^{\circ}\text{C}$) of the previous membrane contactors. The deep groundwater (the Tertiary aquifers located at 1000–3000m) of Guanzhong Basin has a higher temperature ($>70^{\circ}\text{C}$), which is exploited intensely for space heating and other purposes at a rate of $1.4 \times 10^7 \text{ m}^3/\text{a}$.

In our work, a cooling coil wrapped with moving cool water was equipped before water was transferred from the well into the membrane contactors, lowering the temperature to about 30°C . Eight gas samples were extracted from 100L~160L water in the heating season of 2015 successfully. This can be considered as a first successful attempt for ^{81}Kr sampling in the geothermal system in China. What's more, there are still some problems found in the sampling processes. 1) The membrane contactors are not available if the geothermal water is mining discontinuously. In this case, gas-water separator must be used. 2) The membrane contactors do not work without water or electricity. Ice and the inverter with an accumulator should be added in the future where water or electricity is infeasible. In a word, an optimal gas extraction method needs to be adjusted according to above.

[1] Qin et al. (2005), *Geothermics* 37,471-494

[2] Ma et al. (2016), *Hydrogeology&Engineering Geology* 43, 1000-3665 (in Chinese)

[3] Lu et al. (2014), *Earth-Science Reviews* 138,196-214