Using Tritium Concentrations to Age Date Groundwater in the Palouse Basin

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What is Tritium?

Hydrogen exists in several forms: ordinary hydrogen (hydrogen-1 or ***protium***), hydrogen-2 (^{2}H or ***deuterium***), and hydrogen-3 (^{3}H or ***tritium***). Ordinary hydrogen comprises over 99.9% of all naturally occurring hydrogen. Deuterium comprises about 0.02%, and tritium comprises about a billionth of a billionth of natural hydrogen.

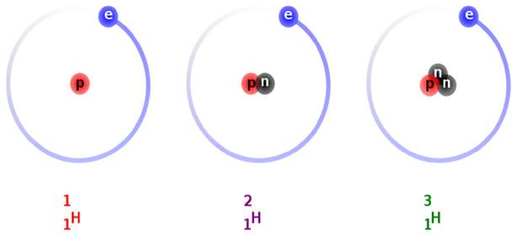

Figure 1– Nuclei Schematic of the three types of hydrogen. From left to right: protium, deuterium, tritium

Each form of hydrogen has a single proton in its nucleus, but the number of neutrons vary (Fig. 1). Tritium has two neutrons in its nucleus which makes it unstable and it is therefore a radioactive isotope of hydrogen. This instability causes tritium to decay spontaneously to helium-3 (^{3}He) through beta decay. During this decay process, a beta particle (or high-energy electron) is released. Tritium has a half life of 12.32 years, which corresponds to a decay rate of 5.6% per year.

The most common forms of tritium are tritium gas and tritium oxide, also called "tritiated water." In tritiated water, a tritium atom replaces one of the hydrogen atoms so the chemical formula is HTO rather than H_2O.

How is Tritium Measured?

Tritium concentrations are measured by a scintillation counter, which measures the ionizing radiation in a sample, and are reported in tritium units (*TU*) where one TU is the equivalent of one tritium atom in 10^{18} atoms of hydrogen.

In SI units, one TU is about 0.118 bequerels per liter (Bq/L) where one Bq is equal to one decay per second. One TU also equates to about 3.19 pinocuries per liter (pCi/L).

Where does Tritium Come From?

Tritium is produced by both natural and artificial processes. It is naturally present in small percentages in the upper atmosphere where it is produced as a result of the interaction of cosmic radiation with atmospheric gases. The testing of thermonuclear weapons in the atmosphere between about 1952 and 1963 (Fig. 2) caused the average concentrations of tritium to go up considerably. Naturally occurring tritium exists in concentrations of about 1 to 5 TU. The nuclear weapons tests added an additional 1.13 x 10^9 TU to the Northern Hemisphere, making the concentrations jump to 12 to 15 TU.

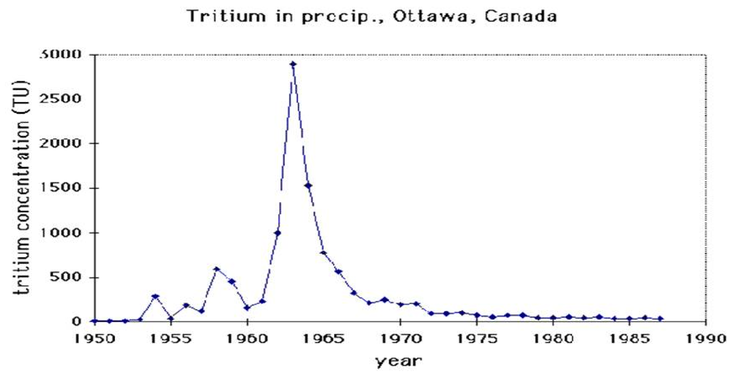

Figure 2– Tritium concentrations in precipitation in Otlawa, Canada

How does Tritium get in the Groundwater?

Since the number of protons and not neutrons determines the bonding nature of an atom, tritium behaves like normal hydrogen and can therefore replace hydrogen in a water molecule and make its way into the hydrologic cycle as precipitation.

Tritium as an Age Dater

Groundwater tritium concentrations reflect atmospheric tritium levels when the water was last in contact with the atmosphere. These concentrations can therefore be used to provide relative dates for the age of the groundwater (primarily whether the groundwater was recharged before or after 1953, when bomb tritium was introduced to the atmosphere). This relative dating is not very quantitative, but nevertheless, the presence of tritium in groundwater is a good indicator that recharge has occurred in the order of years to decades.

Tritium Sampling in the Palouse Basin

The Grande Ronde aquifer system of the Palouse Basin has a groundwater level that has been declining regionally at a rate of about 0.5 to 1.5 feet per year since the 1960's. Tritium concentrations will be collected from wells and springs around the basin and evaluated for the presence of young water in order to help confirm or refute the previous conceptions that modern recharge may not be making it down to this deeper aquifer. The knowledge obtained from these tritium concentrations will then lend insight for groundwater resource managers.

Acknowledgements

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References

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