HYDROISOTOP gmbh
Laboratorium zur Bestimmung von Isotopen in Umwelt und Hydrologie

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Isotope of the month – ^{85}Kr

The noble gas krypton has six stable isotopes (^{75}Kr, ^{80}kr, ^{82}KR, ^{83}Kr, ^{84}Kr, ^{86}Kr) and two radionuclides (^{81}Kr, ^{85}Kr). While ^{81}Kr has a half-life of 210,000 years, ^{85}Kr is relatively short-lived with a half-life of 10.76 years.

Krypton only occurs in trace amounts in the atmosphere ($1.14*10^{-6}$ ppmv). There is hardly any cosmogenic production. Hence, the majority of krypton has entered and enters the atmosphere by nuclear explosions and the reprocessing of fuel elements in nuclear facilities. ^{85}Kr is primarily released in the northern hemisphere. Therefore, in the southern hemisphere around 20% lower ^{85}Kr levels are measured. This can be explained by constrained mixing across the intertropical convergence zone and the decay rate (Rozanski 1989, Salvamoser 1982).

The content of krypton is measured in dpm/mL$_{Kr}$ (decays per minute per mL krypton), at that the following applies: 60 dpm ≙ 1 Bq. To determine the ^{85}Kr content of groundwater, about 4 m³ of water are degassed during sampling. The gained gas is collected and further processed by cryogenic separation in the laboratory.

The natural ratio of ^{85}Kr/Kr is estimated to $3*10^{-18}$, but through nuclear industry the ratio has been reduced to $1.5*10^{-11}$. The level of krypton in the atmosphere rises continuously due to the use of nuclear energy. In 1990, 1 Bq/mL was measured in the air (Figure 1), which corresponds to a maximum of 0.07 Bq/m³ in water.

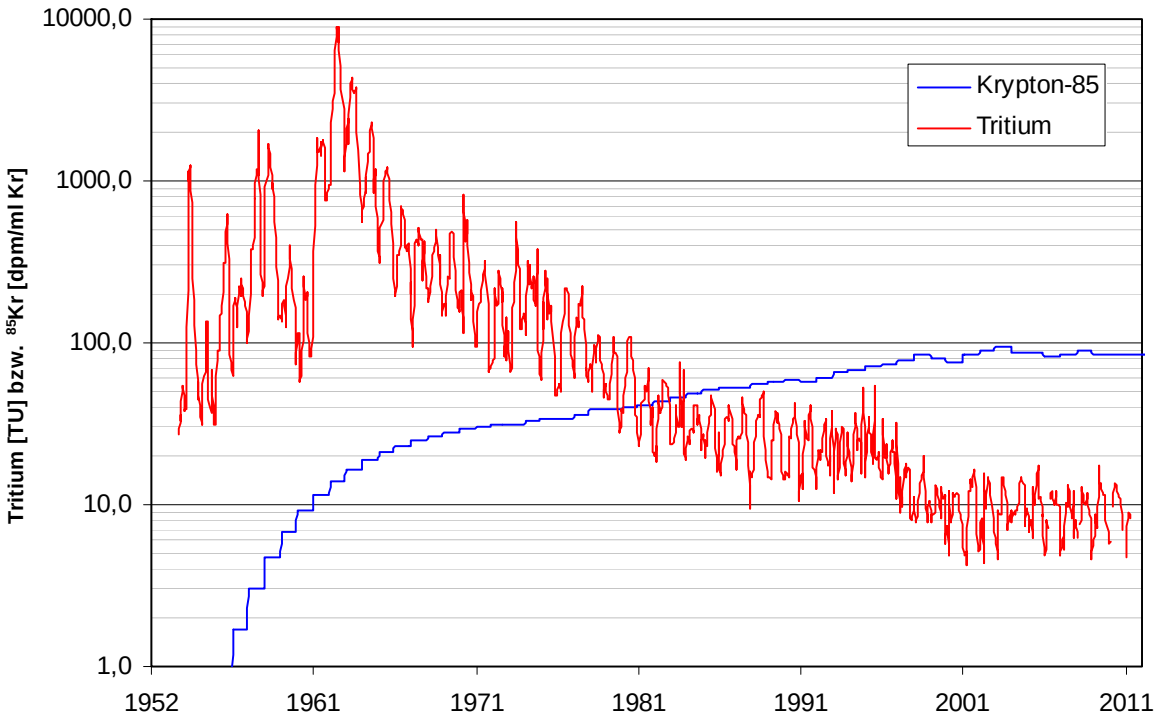

Figure 1: Input curve of Tritium and Krypton-85

Atmospheric krypton dissolves in rainwater and enters the groundwater. Unlike tritium, which starting point of dating is defined by the time entering the unsaturated zone, in soil water dissolved ^{85}Kr still exchanges with the soil gas and dating does not begin until the soil water has reached the groundwater.
Apart from the differences between northern and southern hemispheres, no significant regional differences occur. Hence, the input of ^{85}Kr to the atmosphere is well known and the activity of ^{85}Kr in groundwater allows a clear indication of age, or a statement about the residence time of the sampled groundwater, respectively (Figure 2).

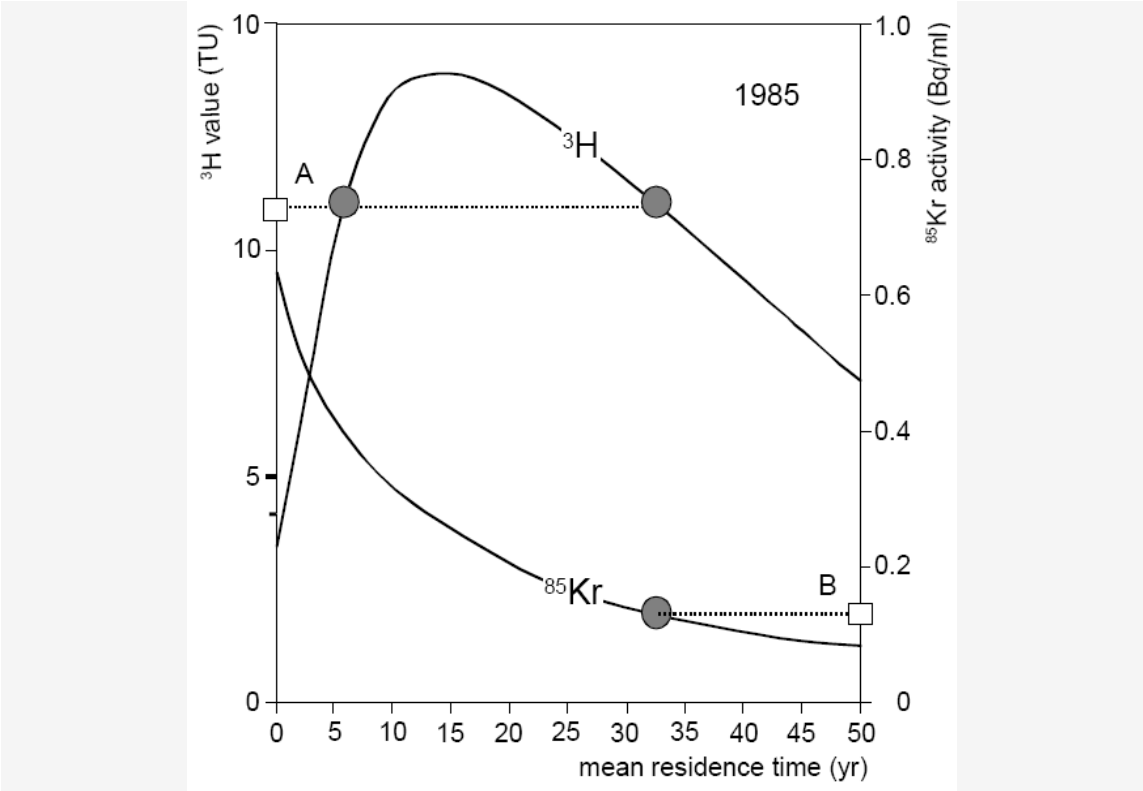

Figure 2: Theoretical relationship between the mean residence times (MRT) of ^{3}H and ^{85}Kr calculated with the exponential groundwater model for 1985 (Fig.3.5) and southern Germany. The ^{3}H value A yield two MRT values of 6 and 32 yr, the ^{85}Kr value B yields an even more precise MRT of 33 yr (taken from Mook 2000 after Salvamoser 1986).

In more complex groundwater systems, e.g. composed of different groundwater components of very different age, the determination of the ^{85}Kr content provides accurate information on the residence time of the groundwater because its unique input curve.
This is especially important for analysing mixed water systems, in which not only young, ^{3}H-containing groundwaters, but also old, ^{3}H-free groundwaters are involved. Moreover, the simultaneous determination of the ^{3}H and ^{85}Kr content is a validation of the used conceptual hydraulic model. It also offers the quantification and qualification of the proportion of young groundwater.