

Helium-4 characteristics of groundwaters from Central Australia: Comparative chronology with Chlorine-36 and Carbon- 14 dating techniques

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Helium isotope and concentration characteristics were determined for a suite of ground-water samples from the Alice Springs, Dune Plains, and Mututjulu aquifers in Central Australia. Measurements of ⁴He, ³⁶Cl/Cl and ¹⁴C on the same samples enable us to assess the relative accuracies of the three water chronometers over a range of anticipated ground-water residence times, and to investigate discordant 'ages' derived from the different ground-water dating techniques.

Preliminary results from the analyses of fifteen ground-water samples from the Amadeus Basin aquifers show helium concentrations ranging from 1.86×10^{-7} to 3.49×10^{-6} ccSTPg⁻¹H₂O. Restricting our comparison to samples with ³He/⁴He ratios less than 0.1R_A (R_A = air ³He/⁴He ratio) to avoid potential difficulties with air corrections, the range of helium concentrations yield uncorrected ground-water 'ages' (i.e. time since recharge) of 13,700 to 513,000 yr on the basis of measured uranium and thorium contents of 2.4 and 7.9 ppm respectively and assuming effective porosity variations between 10 and 20%. ³⁶Cl/Cl ratios on the same samples range from 90×10^{-15} to 169×10^{-15} , representing ground-water ages from 22,300 to 301,000 yr. This assumes an initial ³⁶Cl/Cl ratio of 160×10^{-15} . Radio-carbon levels on the same samples ranged from 41.5% to <2% MC corresponding to ground-water ages between 7,060 and >30,000 years.

In general, the ⁴He method calculates longer ground-water residence times compared to ³⁶Cl/Cl and ¹⁴C techniques, and this implies the presence of an extraneous helium component. To reconcile ⁴He ages with ³⁶Cl ages, it is necessary to adopt an average crustal helium flux component of 1.58×10^{-7} ccSTPcm⁻²yr⁻¹ that supplements in-situ produced helium in the aquifer. Adoption of an average crustal helium flux of $\sim 2 \times 10^{-6}$ ccSTPcm⁻²yr⁻¹ (similar to the value estimated for the Great Artesian Basin [1]) lowers ⁴He ages relative to ³⁶Cl but produces good agreement between ⁴He and ¹⁴C ground-water ages.

[1] Bethke, C.M., Zhao, X., and Tøgersen, T. (1999) *JGR* (104) 12999-13011.