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Groundwater tracing with nucleogenic ^{36}Cl in West Canning Basin, Western Australia

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Chlorine-36 has been used over the past 20-30 years as a groundwater tracer in many hydrological studies and is a well-established dating technique. Given the half-life of 301 kyr it is well suited for dating of 'old' groundwater between 50 kyr - 1 Myr. A challenge associated with utilising ^{36}Cl as a tracer is that it can be produced via three different pathways that will influence the result based on the unique hydrogeological setting of a study area. Typically the dominant source of ^{36}Cl in groundwater is atmospheric ^{36}Cl that is produced at troposphere and stratosphere via interaction of cosmic-ray protons and secondary neutrons with Ar. However, the secondary cosmic-ray neutrons can similarly produce ^{36}Cl in surface rocks particularly at high elevations. Also nucleogenic production of ^{36}Cl at subsurface environments can become significant, especially if U and/or Th concentrations are high. Delineating and quantifying these processes is essential when using ^{36}Cl as a groundwater dating tool.

In contrast to a conservative situation where atmospheric ^{36}Cl dominates, we present a study in the West Canning Basin located in the Pilbara region of Western Australia, where the ^{36}Cl/Cl ratio increases from $\sim 30 \times 10^{-15}$ near the recharge zone to 100×10^{-15} over a 60 km of flow path within a confined aquifer. Additional isotopic evidence (^{14}C and ^{87}Sr/^{86}Sr) in groundwater, mineralogy (X-Ray diffraction) and elemental analysis (Neutron Activation) of whole-rock powder samples from the aquifer and overlying geological units, is used to establish an interpretation that nucleogenic ^{36}Cl production is effectively the only potential process to explain the data.

Nucleogenic production can influence the groundwater ^{36}Cl content in two different ways: (1) as an additional input of Cl with a ^{36}Cl/Cl ratio that reflects the neutron flux within the particular mineralogy; or (2) via "in-situ" production of ^{36}Cl directly in the groundwater from the dissolved ^{35}Cl where the rate is dictated by the neutron flux in the aquifer and the residence time. For this study, the whole-rock elemental composition is used to calculate the nucleogenic production within the aquifer and confining units of the groundwater system. This effectively ruled out both the Wallal sandstone aquifer and the overlying confining unit of the Jarlemai clay aquitard as the sources of ^{36}Cl. Here we explore the idea that the underlying granite is the most likely source of ^{36}Cl.