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Interpretation of groundwater age tracers (CFC-12, 14C, 4He) in a mining-influenced stream-aquifer system with transient recharge dynamics.

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Interpretation of groundwater age tracers often requires consideration of the mixing of groundwater with varying residence times. Quantification of mixing can be approached through measurement of multiple groundwater age indicators with varying ranges of temporal sensitivity, and their interpretation using lumped parameter models. However, in systems altered by mining, where recharge mechanisms are highly transient in space and time, lumped parameter models do not adequately represent the complexity of the system.

In the Pilbara region of Western Australia, water abstracted during dewatering of ore-body aquifers is disposed of by discharging it into ephemeral streams and allowing it to recharge the aquifer. Because this water is essentially being recycled, stable isotopes and chloride are not useful tracers of the impact of this dewatering discharge. In contrast, gas tracers that respond rapidly to exposure to the atmosphere are more useful tracers for constraining the influence of dewatering discharge on the aquifer water balance. In this study we measured CFC-12, 14C and noble gases in production wells and transects of piezometers perpendicular to the stream. Even in samples from wells screened over intervals of 1 m, we observe combinations of tracer concentrations that indicate mixing of groundwater with contrasting residence times. For example, all samples contained measureable CFC-12 concentrations, including those with appreciable terrigenic 4He.

Interpretation of these data requires consideration of the history of mining activity in the area. Stream 14C activities, which now range from 50 to 75 pMC, are a function of the dewatering discharge, and are no longer in equilibrium with the atmosphere. As a result, groundwater that recharged prior to mining operations can have higher 14C activities than groundwater that recharged through the stream in the last 10 years. The dewatering discharge has caused the stream to transition from a disconnected ephemeral system, to a connected perennial stream system, which may result in lower, or negligible, excess air amounts in recently recharged waters. We calculate ternary mixing ratios from the CFC-12 and 14C data to estimate the fractions of regional groundwater, pre-mining stream recharge and during-mining dewatering recharge in each water sample. These results are cross-checked against the calculated excess air and terrigenic 4He amounts. These data suggest that the influence of dewatering discharge extends at most 500 m, and in some places less than 50 m laterally from the stream. This implies that the majority of the dewatering discharge is being recycled locally or flows along the alluvial channel aquifer associated with the stream.