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A multi-tracer study in the Hutton Sandstone aquifer, Australia: How "wrong ages" give us deeper insights into aquifer structure and effective deep recharge to a double porosity system

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Depressurisation of coal seams in the Walloon Coal Measures in Queensland, Australia, may influence aquifers both over- and underlying the formation. The Gubberamunda Sandstone aquifer, which overlies the Walloon Coal Measures, is the starting point of the Great Artesian Basin (GAB) flow system and has been the focus of numerous recharge studies. In comparison, the Hutton Sandstone aquifer, which underlies the Walloon Coal Measures, has received much less attention. This aquifer however, is the main supply of stock water for the beef industry in the area.

A multi-environmental tracer study of the Hutton Sandstone aquifer was undertaken at the Mimosa Syncline and was complemented by a few samples taken from the underlying Precipice Sandstone aquifer. This multi-tracer study (comprising ^{18}O, ^{2}H, ^{3}H, CFCs, SF_6, ^{14}C, ^{36}Cl, and ^{4}He) demonstrated that the Hutton Sandstone aquifer behaves as a double porosity system. At the regional scale, the system features a relatively small fraction of conductive rock within a fairly large fraction of low permeability rock. Tracer migration therefore occurs mainly by advection in the conductive fraction and mainly by diffusion in the low-permeability fraction of the aquifer. Groundwater flow velocities, derived from exponential decrease of ^{14}C and ^{36}Cl concentrations with distance, differ by a factor of ten and therefore do not indicate the real groundwater flow velocity. However, accounting for a double porosity interpretation of the tracer data leads to a single groundwater flow velocity that is consistent with all observed data. Advective velocity in this double porosity model differs from face value flow velocities derived from ^{14}C and ^{36}Cl by a factor of 4 and 40 respectively.

As a consequence of this interpretation, the deeper groundwater flow system of the Hutton Sandstone aquifer is estimated to receive only ~3% of the recharge previously estimated using the Chloride Mass Balance approach at the intake beds. The other ~97% is assumed to be rejected recharge which discharges through spring complexes in the Surat Basin and contributes to base flow of the Dawson River. This interpretation also suggests: 1) that the Hutton Sandstone aquifer is potentially more vulnerable to impacts from groundwater abstraction, including from stock and domestic water supply and coal seam gas production, than previously anticipated; 2) that other "groundwater age records" around the world likely observe similar double porosity effects and their apparent ages may be similarly distorted; and 3) that the multi-tracer approach used here is a suitable method for identifying other previously unknown double porosity aquifer systems and can potentially quantify deep effective recharge where important water resources are subject of economic development.