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A reappraisal of the hydrogeology of the Western margin of the Great Artesian Basin: chemistry, isotopes and groundwater flow

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Abstract

The combination of hydrochemistry with other environmental tracers such as noble gases and uranium series dating of travertine deposits are providing new insights into the hydrogeology of the western margin of the GAB. Previous conceptual models of simple geology and geochemical evolution along flow paths have been re-examined. Our results show that a far more complex model is evolving involving complex hydrogeology, faulting and sub-basins as well as a significant vertical flow component.

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1. Introduction

The Great Artesian Basin (GAB) represents the largest water resource in Australia, it underlies 22% of the Australian continent including considerable areas of Queensland, New South Wales, Northern Territory and South Australia. This manuscript summarizes some of the key results from a large 4 year project studying the hydrogeology and hydrochemistry of the western margin of the GAB (Fig 1). Our study site is home to the world

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famous GAB carbonate Mount Springs. Simple conceptual models of the GAB first began to emerge at the turn of the 20th century. Despite some minor modifications, this model has largely remained intact and has not been seriously challenged until now. This model used for water resource management of the GAB is based on the following: simple flow paths form recharge areas in eastern Australia to discharge in South Australia, simple groundwater aging along flow paths, recharge is equal to discharge and limited interactions with overlying basins. However, our study[1,2] has raised serious question about these assumptions. In the following, we present results from a selection of data dealing with hydrochemistry and noble gases and the implications for groundwater mixing and neotectonics.

2. Results and discussion

2.1. Hydrochemistry

The hydrochemical variations of groundwater and spring water provide important clues to the geochemical processes responsible for water quality and evolution of the main Jurassic aquifer of the GAB. The dissolved species also act as natural traces which can provide important information on the origin of springs and provide constraints on groundwater flow systems and recharge areas within the Western margin of the GAB. A Piper diagram (Figure 2) is very instructive, as it shows a wide range of hydro chemical groups for both springs and bore waters. In general terms, both spring and groundwaters cover the same range of hydrochemical facies from $Na^{-}Cl$ towards $Na^{-}HCO_3$, $Ca^{-}HCO_3$ and $Ca^{-}SO_4$. This wide range represents a myriad of different water rock interactions and different recharge areas and flow pathways.

2.2. Geochemistry and Neotectonics

The geochemistry of water and gas in mound springs provides a window into groundwater mixing in the GAB. Elevated 3He/4He gas values provide unequivocal evidence for small volume mantle-derived fluid sources that have been introduced into the groundwater system and hence document an active mantle-to-groundwater fluid linkage. Uranium -series dates indicate persistent deposition of travertine mound springs at discrete vent sites for at least hundreds of thousands of years. Travertine-depositing springs are windows into active and heterogeneous groundwater mixing processes. Major element chemistry suggests different and highly variable water chemistry at a regional scale in the spring discharge area, different end member endogenic fluids, and variable mixing proportions in different sub-basins. The travertine mound and platform rock record suggests the observed distinction between groundwater hydro-facies has been in place for at least about 650 ka, thus providing a link between the present and paleohydrologic systems of the GAB. Hence new models for the GAB require interactions between mantle and deep crustal fluid inputs, neotectonic pathways, and groundwater mixing and segmentation within this continental scale artesian basin.

3. Conclusions

A new model is emerging for the GAB that involves multiple scales of groundwater flow from different recharge windows.

Noble gas data indicate a linkage between the mantle and the mound springs.

Dating of the travertine deposits representing the first successful U-series dating effort on GAB spring deposits indicates that spring discharge has been long lived with springs having been active in the same general locations for at least the last 700 ka.

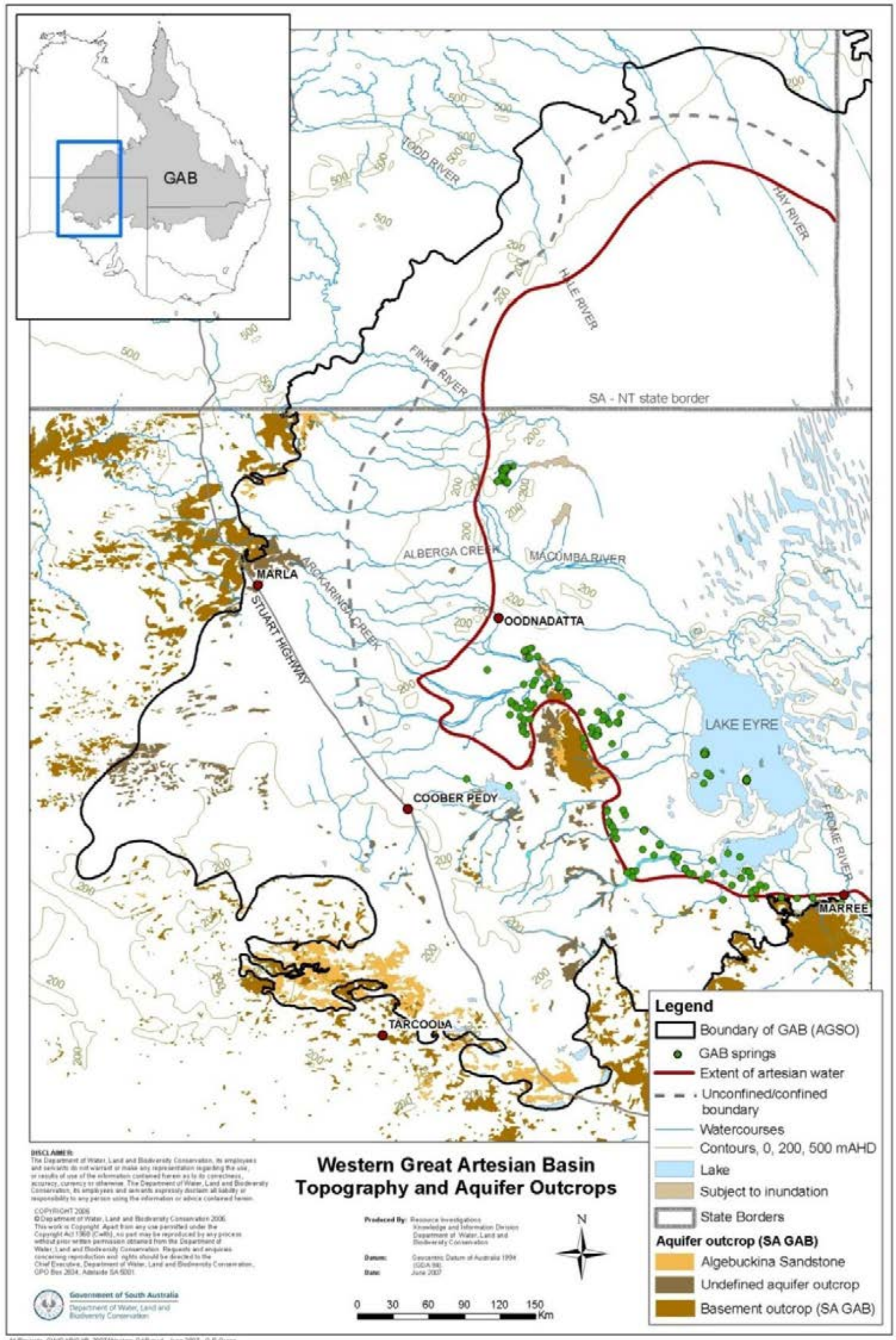

Fig. 1. Location of the Western margin of the GAB

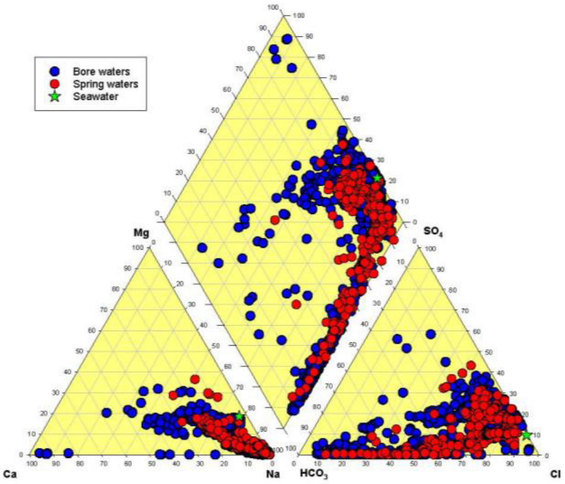

Fig. 2. Piper diagram

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