AAPG Datapages/Search and Discovery Article #90234 © 2015 AAPG Asia Pacific Region, Geoscience Technology Workshop, Opportunities and Advancements in Coal Bed Methane in the Asia Pacific, February 12-13, 2015, Brisbane Australia

Hydrochemical Evolution of Coal Seam Gas Groundwaters and Implications for Inter-Aquifer Connectivity: Examples from the Clarence-Moreton and Surat Basins

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Abstract

The Australian Government's Bioregional Assessment Programme aims to assess the impacts of coal seam gas (CSG) and large coal mining on water-dependent assets. Since CSG extraction involves aquifer depressurisation at large depths, while most of the water-dependent assets are contained within shallow aquifers, understanding inter-aquifer connectivity is required to underpin such assessment. Due to the complex nature of the multi-level aquifer/aquitard systems, the assessment of aquifer inter-connectivity requires a holistic approach that integrates knowledge of geology, hydrogeology, and hydrochemistry with numerical modelling. We assessed the hydrochemical evolution of the groundwater contained within the Walloon Coal Measures (WCM), which are considered the primary target of CSG activities in the Clarence-Moreton and Surat basins (Figure 1). We then compared it to the hydrochemical patterns in adjacent aquifers to better understand how shallow and deeper aquifers are inter-connected.

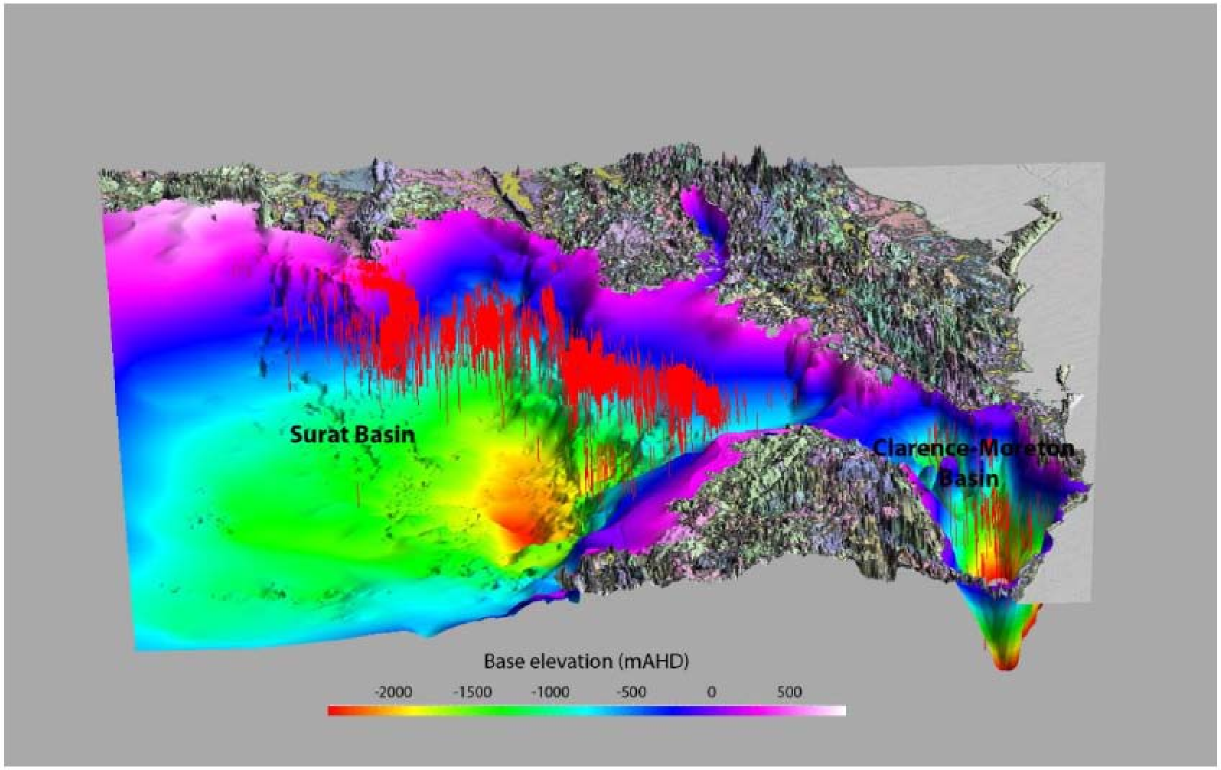

Figure 1. Base elevation of Surat and Clarence-Moreton basins and coal seam gas wells.

The hydrochemical evolution of CSG groundwaters can be influenced by a number of factors. Some of the typical major ion relationships observed in CSG groundwaters include high bicarbonate and sodium concentrations along with low sulphate, magnesium, and calcium concentrations. Those relationships are recognised as universal characteristics of CSG-groundwaters (e.g. Van Voast, 2003), hence, they suggest that they are controlled by similar hydrochemical processes. Other factors such as variable chloride and total dissolved solid concentrations ranging from brackish to saline appear to be controlled by basin-specific processes, thus requiring a detailed understanding of the regional characteristics of each sedimentary basin. Regional hydrological processes that influence the hydrochemical evolution of groundwater within coal-bearing units in sedimentary basins include (for example): groundwater recharge, mixing between groundwater originating from, and flowing along, different flow lines, or vertical connectivity between aquifers, which can be controlled by geological structures and affected by pumping.

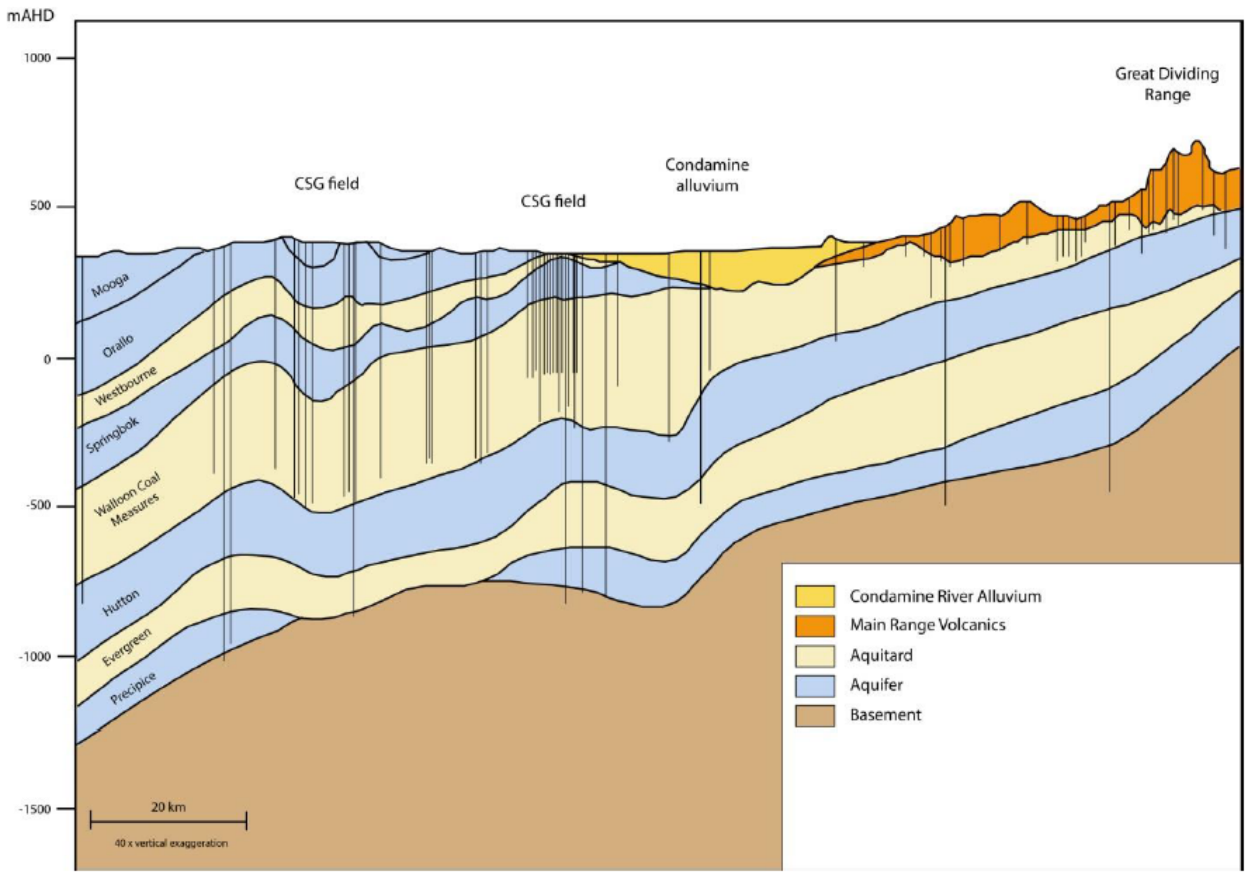

Figure 2. Cross-section through eastern part of Clarence-Moreton and Surat basins, highlighting geometric relationships between alluvial, volcanic and sedimentary basin aquifers and aquitards.

In this presentation, we will provide several examples from the linked parts of the Clarence-Moreton and Surat basins that highlight how the evolution of CSG groundwaters contained within the WCM is influenced by recharge processes, regional flow paths and connectivity of the WCM with adjacent aquifers. We will use a combined 3D geological model of the two linked basins developed in SKUA/GoCAD (Paradigm®) to demonstrate how groundwater hydrochemically evolves from the recharge areas to the deeper parts of the basins. The 3D geological model allows us to assess where the aquifer geometry and spatial relationships between aquifers suggest a likely connection. In the eastern part of the Surat Basin/western part of the Clarence-Moreton basins, for example, the large interface between the Walloon Coal Measures and the Main Range Volcanics (Figure 2) suggests that there is likely to be connectivity between these aquifers. The integration of hydrochemistry into the 3D geological model provides an independent line of evidence that allows the identification of how and where the WCM are hydraulically connected to, or separated from, adjacent aquifers along the flow paths.

The approach presented in this study demonstrates how the integration of geological, hydrogeological, and hydrochemical information can provide valuable insights into how aquifer geometry and geological structure influence groundwater flow, recharge processes, and aquifer inter-connectivity in complex multi-aquifer systems. This improved understanding enhances the confidence in conceptual models that underpin numerical models developed to assess the potential impacts of CSG activities on groundwater-dependent assets.

Reference Cited

Van Voast, W.A., 2003. Geochemical signature of formation waters associated with coal bed methane. American Association of Petroleum Geologists Bulletin 87, pp. 667–676.