Extreme acidic environments associated with carbonate Mound Springs: the western Great Artesian Basin

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Introduction

The carbonate mound springs of the western Great Artesian Basin (GAB) are natural discharges for artesian groundwater, forming distinct geomorphological features. They are generally located along fault lines which may extend to great depths in the lithosphere. The isolated nature of many GAB springs has resulted in the preservation of a number of endemic, rare and relict species of great ecological, evolutionary and biogeographical significance to the nation and are of worldwide importance. Any change in artesian pressure or flow may have significant impacts on these species. This study highlights another hazard associated with the discharge environments: extreme acidification from acid sulfate soils.

Sample locations

Soil regolith samples were collected from a number of springs west and north-west of Lake Eyre. For most springs, a shallow soil sample or surface mineral efflorescence was collected where field observations suggested that ASS may be present. More detailed sampling was undertaken at selected springs where sulfidic soils were suspected (low pH, yellow/green surface efflorescences) or where strongly sulfuric materials were identified in the field.

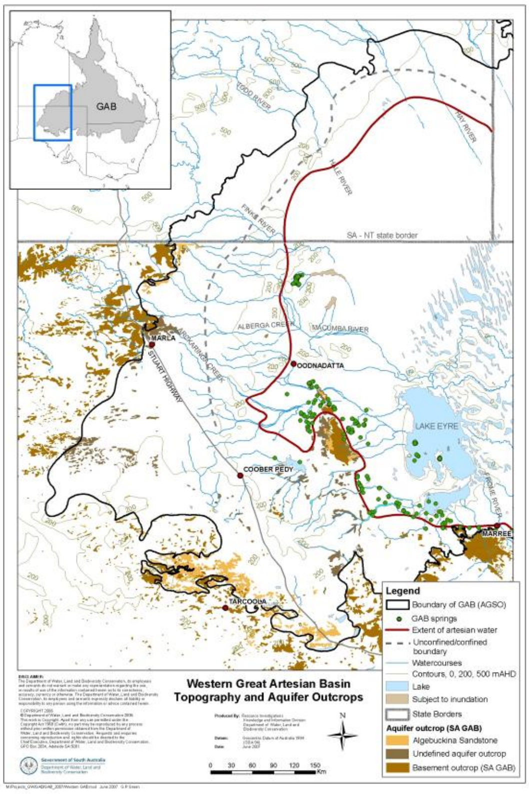

Figure 1: The occurrence of mound springs in the western GAB.

The pH of the soils was measured upon return to the laboratory, and allowed to incubate in chip trays to determine their potential to oxidise over time (Shand *et al*. 2008; Fitzpatrick and Shand

2008). Acid base accounting analyses were also completed to calculate Net Acidity and the hazard from actual and stored acidity.

Field data

One of the ubiquitous features of discharge zones in the arid environment of Mound Springs tails is the presence of surface mineral efflorescences (salts) due to very high evaporation rates. At a number of springs, bright yellow, yellow-green and white mineral efflorescences were noted, along with a strong smell of sulfur-gasses (similar to that at acid mine drainage sites). Field pH measurements at a number of these springs were very low (pH < 1-4) suggesting the presence of strongly sulfuric materials. Although the soils were very acidic, the impacts on surface water quality were limited, as the soils appear to have only recently started to dry. At Brinkley Spring, however, small pools of very acidic water were present (Figure 2).

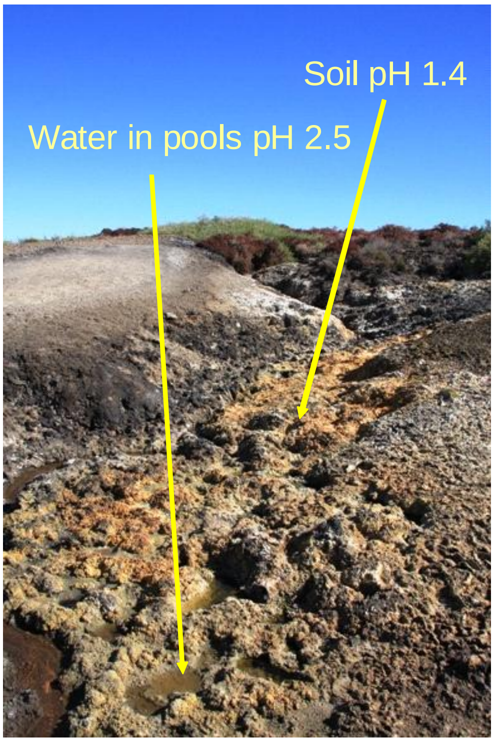

Figure 2: Acid surface water pools at Brinkley Spring adjacent to acidic surface soils and acidic mineral efflorescences.

The surface waters around other springs remained high, although adjacent to the springs acidic soils and mineral efflorescences were present (Figure 3). Water levels in spring pools appear to be decreasing as evidenced by recent oxidation of shallow soils. Historical evidence was also gathered from pipes and other infrastructure which are now well above current pool levels.

Laboratory data

The pH of soils varied widely from pH < 1 to pH 10. In the most extreme soils, sulfuric materials were present to depths of at least 80 cm. The change in pH during incubation experiments also varied, with many circumneutral pH soils showing a small decrease due to high buffering capacity by ANC (high contents of calcium carbonate), whilst others showed very large decreases where sulfide concentrations were high and ANC was low. The lowest recorded pH was pH 0.12.

The concentrations of sulfide (measured as Cr-reducible S: S_{CR}) varied from <0.01 % to the highest yet recorded for ASS (> 40 % SCR). Net acidities showed an extremely wide range from -10,852 to +26,680 mol H+/tonne (Figure 4), the latter being the highest recorded net acidity ever recorded in ASS. Although trigger values have not been explicitly defined for inland ASS, those for coastal ASS vary from +19 mol H^+/tonne for coarse-grained materials to +62 mol H^+/tonne for fine-grained materials. The highest values recorded for GAB springs, therefore, indicate severe acidification hazards from these soils.

Figure 3: Acidic mineral efflorescences noted at a number of different springs in the GAB.

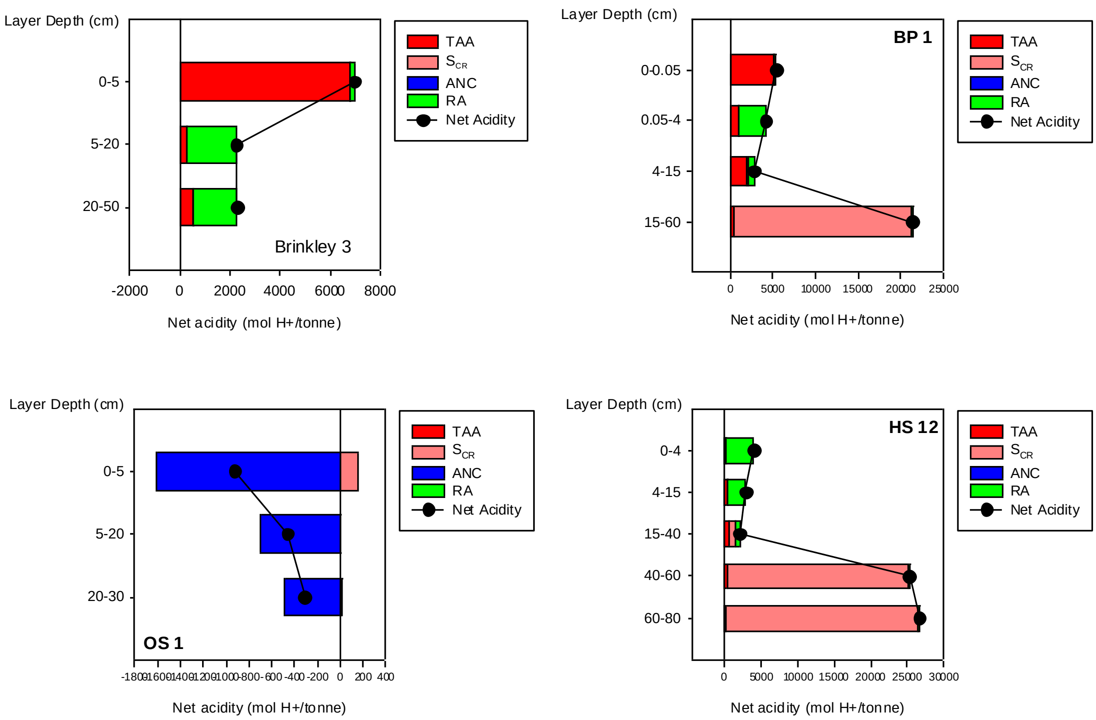

Figure 4: Acid-Base accounting data for selected soil profiles.

Discussion

The development of groundwater resources and climate variability/change has led to a decrease in piezometric levels in some areas causing a decrease in spring flows. A number of springs are now acidifying with the development of strongly sulfuric surface materials (pH<1). As well as impacting surface water quality in mound spring tails, oxidation reactions have had a significant impact on the geomorphology of the tufa (calcium carbonate) deposits which form the structure of the mounds. Dissolution features are considered to be a major control on the structure and preservation of tufa mounds and a conceptual model has been developed which describes changes related to oxidation episodes. Mound forms suggest that such processes may have occurred in the past. A range of Al- and Fe-bearing efflorescence minerals are forming above sulfuric materials in the worst affected areas, many of which are extremely rare (e.g. ferrinatrite, Jurbanite, metavoltine, sideronatrite) and some represent the first known occurrences in Australia. These contrast with other springs in the eastern GAB where pH may be extremely high (> pH 10) and mineral efflorescences such as trona and thermonatrite occur.

The hazards associated with the acidic springs include soil and water acidification and metal release, and these pose a significant risk to the isolated and often rare ecosystems around the springs. Management options are constrained by the dominant control of artesian pressure in the underlying aquifer from where the waters are sourced. Practical solutions to ameliorate existing impacts need to be based on minimising decrease of the local and regional piezometric surface. However, there remains limited understanding of the source of spring waters and spatial connectivity of underlying aquifer units of the GAB. The presence of acid sulfate soils also needs to be taken into account for local management options such as e.g. phragmites and date palm management as well as disturbance of soils by livestock.

References

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