THE GEOLOGY AND HYDROCHEMISTRY OF CALCAREOUS MOUND SPRING WETLAND ENVIRONMENTS IN THE LAKE EYRE SOUTH REGION, GREAT ARTESIAN BASIN, SOUTH AUSTRALIA

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(BSc. Hons.)

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School of the Environment

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For Tanya, Edith and Maggie

Oncoids at Blanche Cup, Wabma Kadarbu National Park, South Australia

On Monday, when the sun is hot
I wonder to myself a lot:
Now is it true, or is it not,
That what is which and which is what?

On Tuesday, when it hails and snows
The feeling on me grows and grows
That hardly anybody knows
If those are these or these are those?

On Wednesday, when the sky is blue,
And I have nothing else to do,
I sometimes wonder if it’s true
That who is what and what is who?

On Thursday, when it starts to freeze
And hoar-frost twinkles on the trees,
How very readily one sees
That these are whose- but whose are these?

On Friday-

Sadly, this was never finished, due to an untimely interruption from Kanga

A. A. Milne. "The House at Pooh-corner"

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SUMMARY

Mound springs of the Lake Eyre South region of South Australia (SA) are dome-shaped accumulations of largely calcareous precipitates associated with artesian springs sourced by groundwater from the Great Artesian Basin (GAB). These springs and associated wetlands provide unique habitats for a number of endemic flora and fauna species and hold great cultural and societal importance to indigenous and non-indigenous Australians.

Few intensive studies of mound spring structures exist despite similar formations being found worldwide. Specifically, there has been little work with respect to either determining or verifying the hydrochemical and environmental factors important with respect to mound spring formation, or how spring flow is maintained once a mound structure has been built. Consequently, existing descriptions for the formation of mound structures described in the literature are inadequate with respect to the Lake Eyre South mound springs.

Consequently, geological and hydrochemical investigations were undertaken to develop a conceptual model for the initial formation and evolution of mound spring environments. A reactive transport model was developed to provide a generic, quantitatively constrained framework for the analysis of spring hydrochemistry. This model was also adapted to afford insight into the hydrochemical conditions within the initial spring wetland from which mound structures develop (the maximum spatial extent of the mound base or mound "footprint").

This study found that mound spring-related calcareous deposits were largely composed of tufa, defined here as a terrestrial limestone precipitated from sub-

ambient to ambient temperature springwater, with sedimentary textures synonymous with microbial activity and encrustation around hydrophytes. Evidence from experimental data obtained during this study highlighted the important role cyanobacteria have in mediating tufa precipitation.

Carbon dioxide (CO_2) degassing from calcium carbonate ($CaCO_3$) laden water is the primary cause for $CaCO_3$ precipitation. Degassing is caused by either physio-chemical processes, particularly in subterranean and near vent environments, or biomediation. CO_2 degassing and $CaCO_3$ precipitation were found to be time-dependent, with this dependence controlled by the rate at which CO_2 is able to degas. The CO_2 degassing rate was in turn dependent on flow turbulence and the surface area exposure of water to substrate and the atmosphere. Such rate-limited $CaCO_3$ precipitation in mound spring environments is reasoned to have a critical stabilising effect on mound growth and spring flow; consequently rate-limited $CaCO_3$ precipitation is central to a new conceptual model for mound spring formation and evolution.

Reactive transport modelling was used to infer the previously unrecognised roles infiltration and heterotrophy have in controlling wetland hydrology and water chemistry respectively. Conversely, evapotranspiration was not found to significantly affect the rate of $CaCO_3$ precipitation. The mound footprint predicted by the model provided a reasonable approximation of the measured mound, with the prediction being primarily a product of the carbonate precipitation rate.

The location of mound springs are correlated with a tectonically active shear zone related to the Adelaide Fold Belt. Seismicity is evidenced through the propagation of deformation structures within spring-related sediments that are concordant with these regional structures and may have an important role in influencing the development of mounds.

This study has demonstrated that a unique interplay between hydraulics, hydrochemistry and the environment is responsible for mound structure formation and the maintenance of spring flow after a mound structure has formed, while the developed reactive transport modelling methodology is novel with respect to terrestrial calcareous deposits and resultant morphotype development.

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DECLARATION

I certify that this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any university and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text.

Mark Nicholas Keppel, Bachelor of Science (Hons).

CO-AUTHORSHIP

Mark Keppel is the primary author of this thesis and all the enclosed documents. Chapters 3 to 5 were written as independent manuscripts in which the co-authors provided intellectual supervision and editorial comment. Chapter 2 as well as parts of Chapter 6 and Appendix 1 were written to be incorporated into independent manuscripts in which the co-authors provided intellectual supervision and editorial comment.

Additionally, Dr Vincent Post suggested a modelling approach as a means of quantifying the processes interpreted from hydrochemistry data and played an important role in the development of the modelling protocol used in Chapter 4. Dr Karl Karlstrom suggested including U-series dating data collected by Ms Stacey Priestley in Appendix 1. Dr Karl Karlstrom and Ms Stacey Priestley contributed supporting field data to those already collected by the author, U-series dating data presented in Appendix 1 and some text pertaining to the U-series dating data. Finally Dr Todd Halihan provided discharge measurement data used in Chapters 4 and 5.