# Modelling initial carbonate platform formation in groundwater upwelling zones, Kati Thanda (Lake Eyre) South region, South Australia

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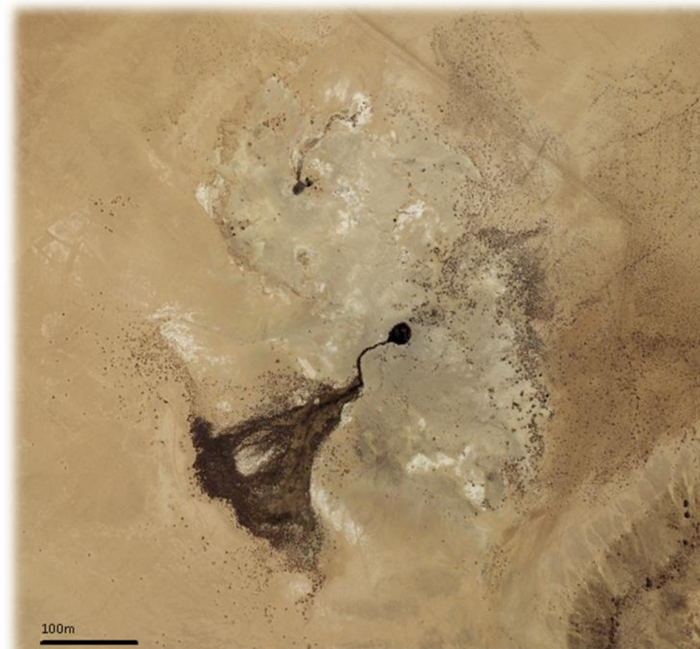
# Definition

- Mound springs are dome-shaped structures built from calcareous spring deposits (limestone) from discharging groundwater


*Billa Kalina Spring*

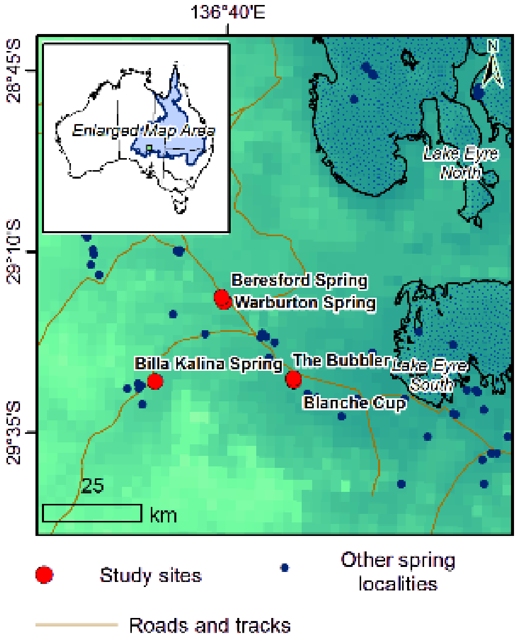



*Warburton Spring*

# Introduction

*Determine the hydrochemical and environmental factors important to mound spring formation and maintenance.*

*Warburton Spring*




Improve conservation management

Relevant to palaeoclimatic, palaeohydrologic and neotectonics studies .

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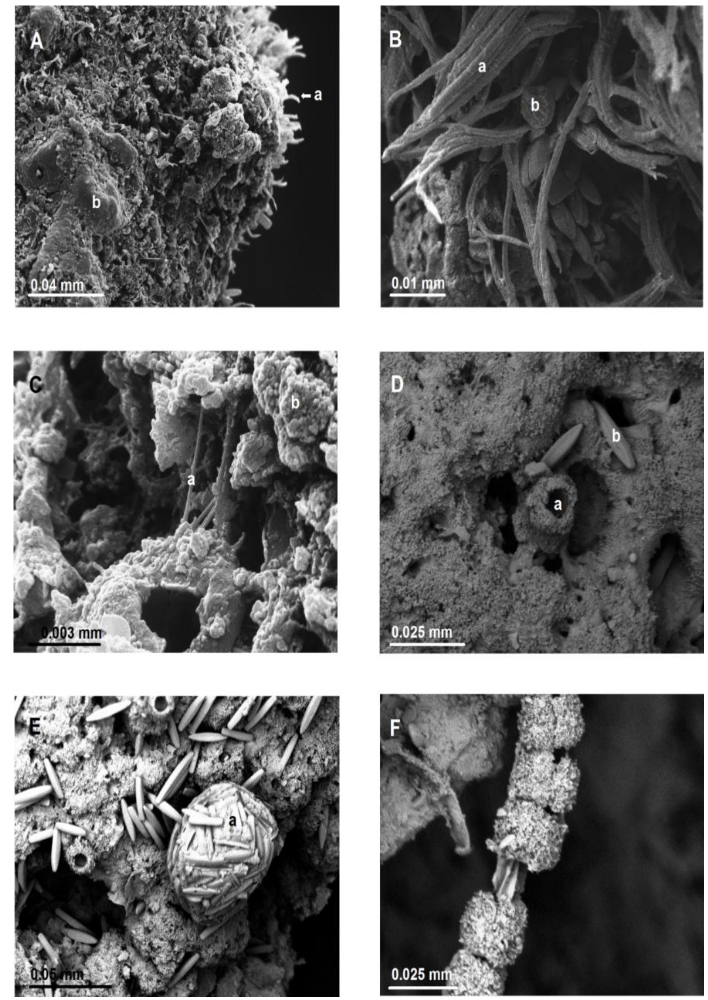
# Pertinent background information

- Sediment predominantly limestone (tufa).

- Strong association between vegetation, microbial activity and the deposition of carbonates (swamp or shallow stream)



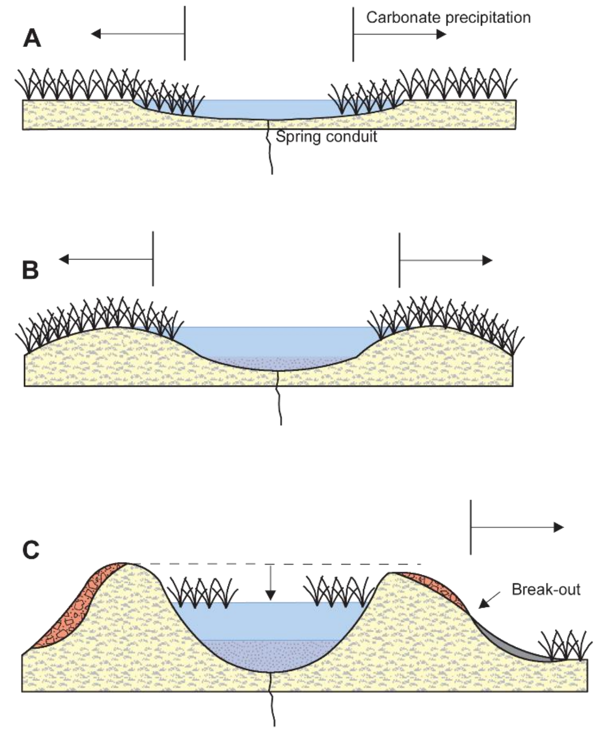
# Pertinent background information

- Deposition of calcium carbonate controlled by rate-limited $PCO_2$ degassing ($Ca^{2+}$ (aq) + $2HCO_3^-$ (aq) ↔ $CaCO_3$(s) + $CO_2$(g) + $H_2O$(l).)

*The Little Bubbler*

*Callabonna Springs*

*The Bubbler*




- Rate of degassing changes as mound structure changes – Can lead to mound spring flow stability.

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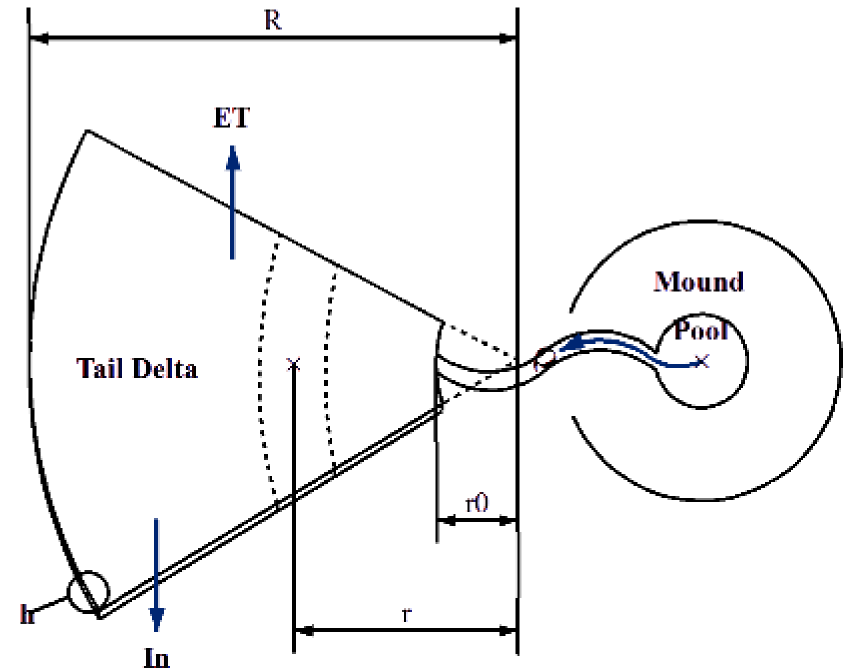
*Tail Gutter, Billa Kalina Springs*

# Modeling wetland hydrochemistry

- The model calculates the changing chemical composition of the water as it flows away from the spring vent (PHREEQC2).
- Rates of evapotranspiration determined from chloride and stable isotope mass balance calculations.
- $CO_2$ exchange rate determined iteratively:
  - $CO_2$ degassing.
  - Soil respiration.
- Geometry of early mound wetland was conceptualised as a sixth of a circle.

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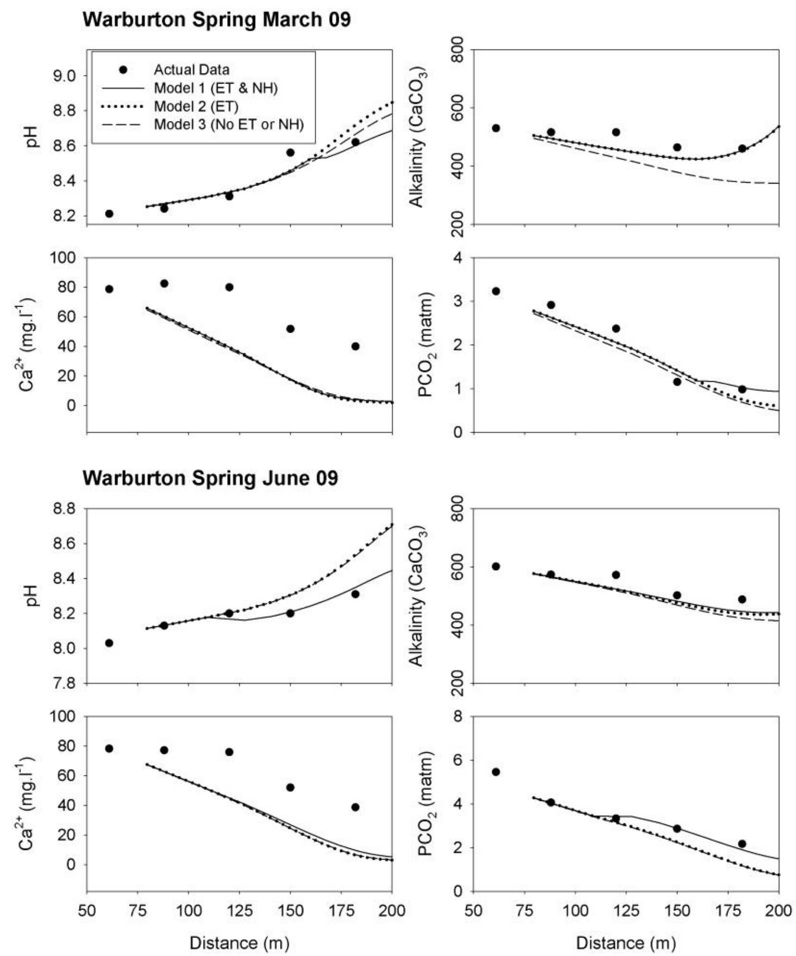
# Modeling wetland hydrochemistry

- The developed reactive transport model adequately simulates the field data.
- Degassing largely driven by a pressure differential
- $CO_2$ invasion into wetland waters in the lower tail as a consequence of interpreted net heterotrophy.
- Water loss via evapotranspiration has a negligible impact on carbonate precipitation.





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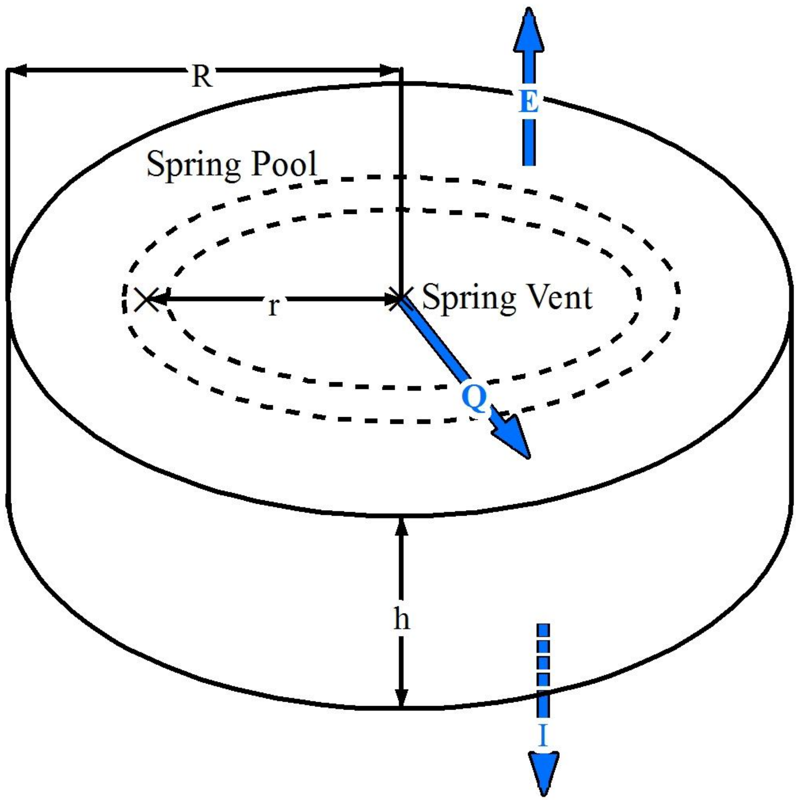
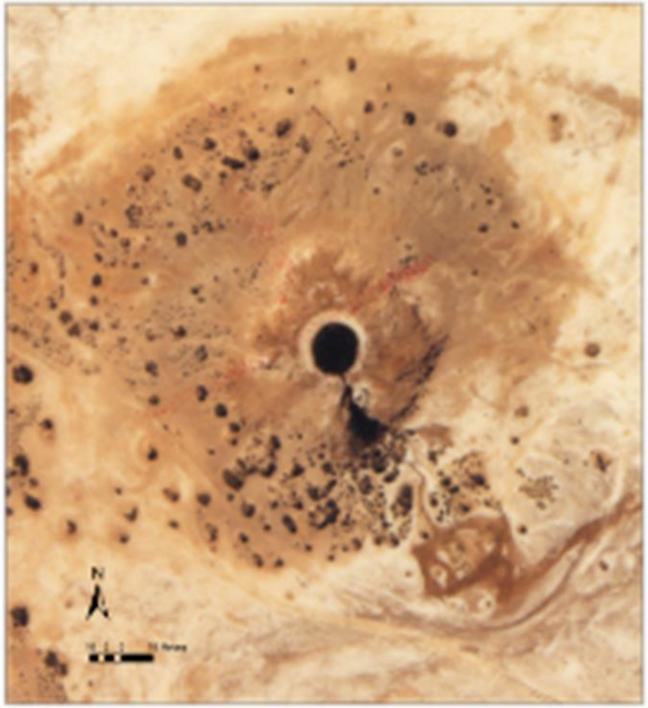
# Extrapolating the hydrochemistry model




Wetland extent based on flow (Q), modelled average evapotranspiration (*ET*) and infiltration (*In*) rates. ($Q = ET + In$).

Relationship used to determine fixed transport time steps for use in PHREEQC-2.



*Blanche Cup*

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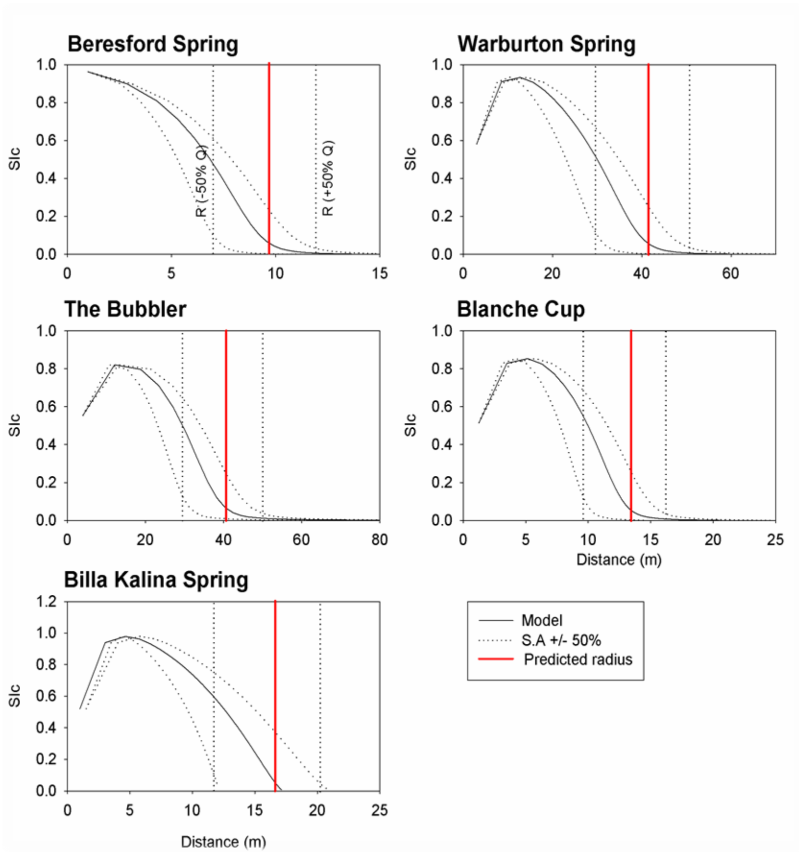
# Extrapolating the hydrochemistry model




- The predicted radius is equal to the distance at which point the calculated SIc falls below 0.05.

- The initial mound footprint of these structures can be described as mostly controlled by carbonate precipitation.

*Blanche Cup*

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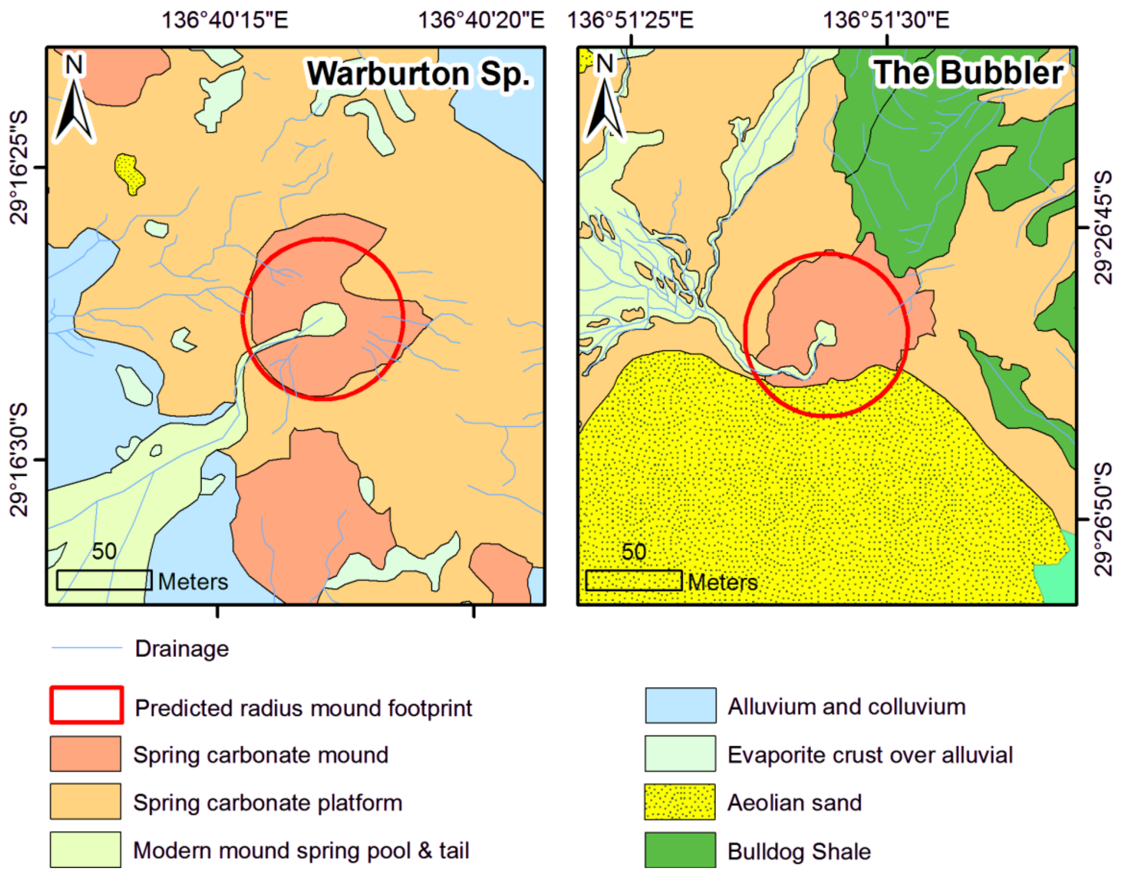
# Extrapolating the hydrochemistry model

- The size of the predicted mound footprints generally compare well to the mapped outline of the mounds.

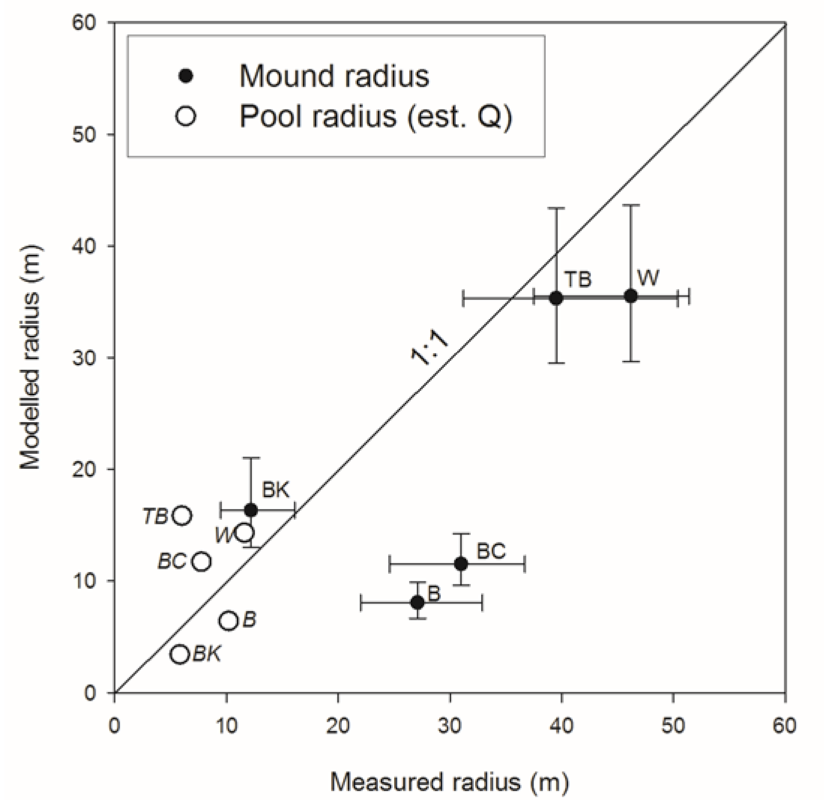


# Extrapolating the hydrochemistry model

- Large differences in the predicted and actual radius of mound structures could be used as an indication of changes in discharge rate.

- Model was found to be most sensitive to changes in flow and water column height.

- Model was least sensitive to changes in evapotranspiration.



# Summary

Can reactive transport model be used to describe how these limestone mounds initially form?
Yes, it can give you an idea

*Blanche Cup*

Does chemistry control the magnitude of a mound?
Yes. It is the most important factor in most cases

How important is discharge?
It is important with respect to controlling the water depth in the wetland.

Can a subsequent model be used to estimate changes in spring flow over time?
You can use it, but please respect the uncertainty!

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# Thank-you

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*Warburton Spring*

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# Extrapolating the hydrochemistry model

- The flow mechanics of such a spring-fed wetland environment are theorised to reflect laminar, gravity-driven flow through a doubly porous medium

$$q = vh_c = K_w h^b \left(\frac{dh}{dr}\right)^a$$ Kadlec (1990)

*Warburton Spring*

*South Well Spring*