The Formation of Conduit Caves in The Bahamas

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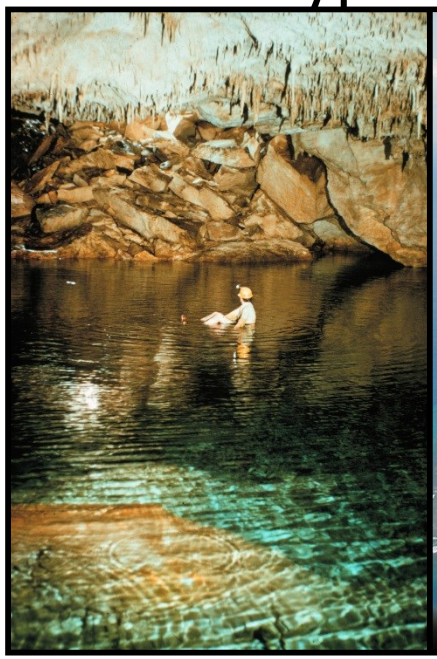
Carbonate Island Karst Model

- Mixing of fresh and saltwater
- Sea-level changes
- Eogenetic rock
- Four types of carbonate islands



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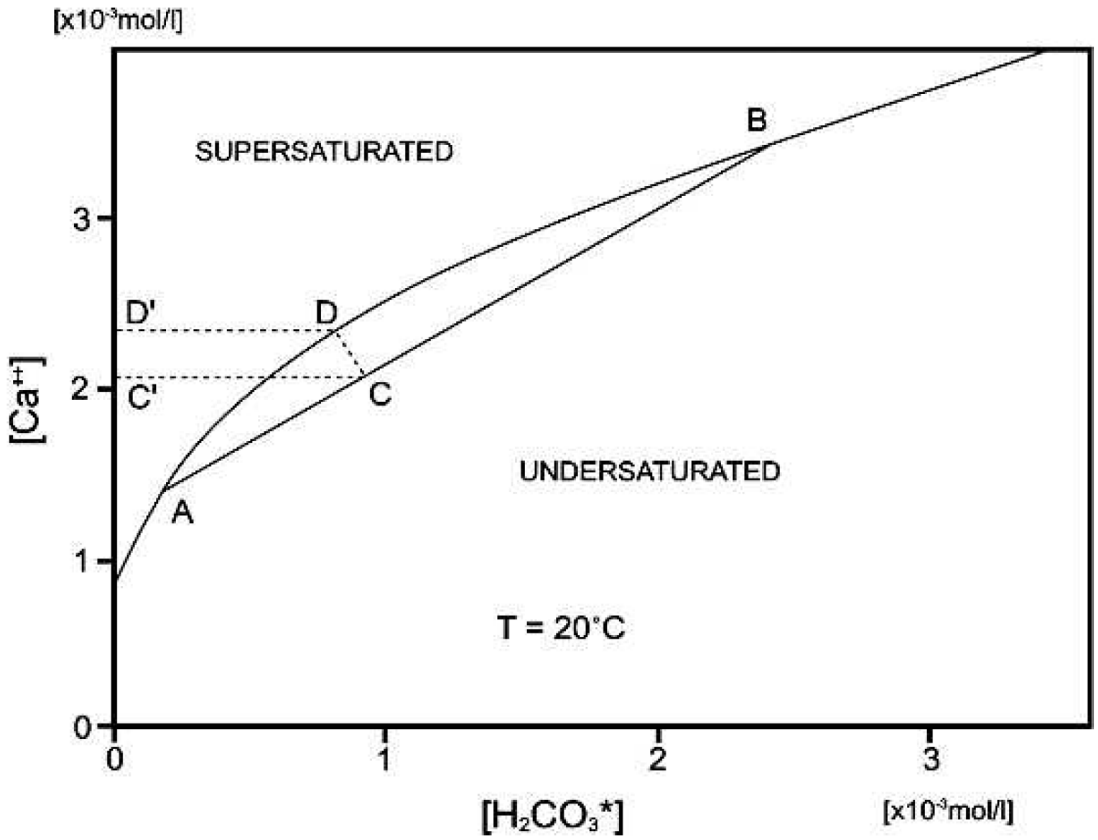
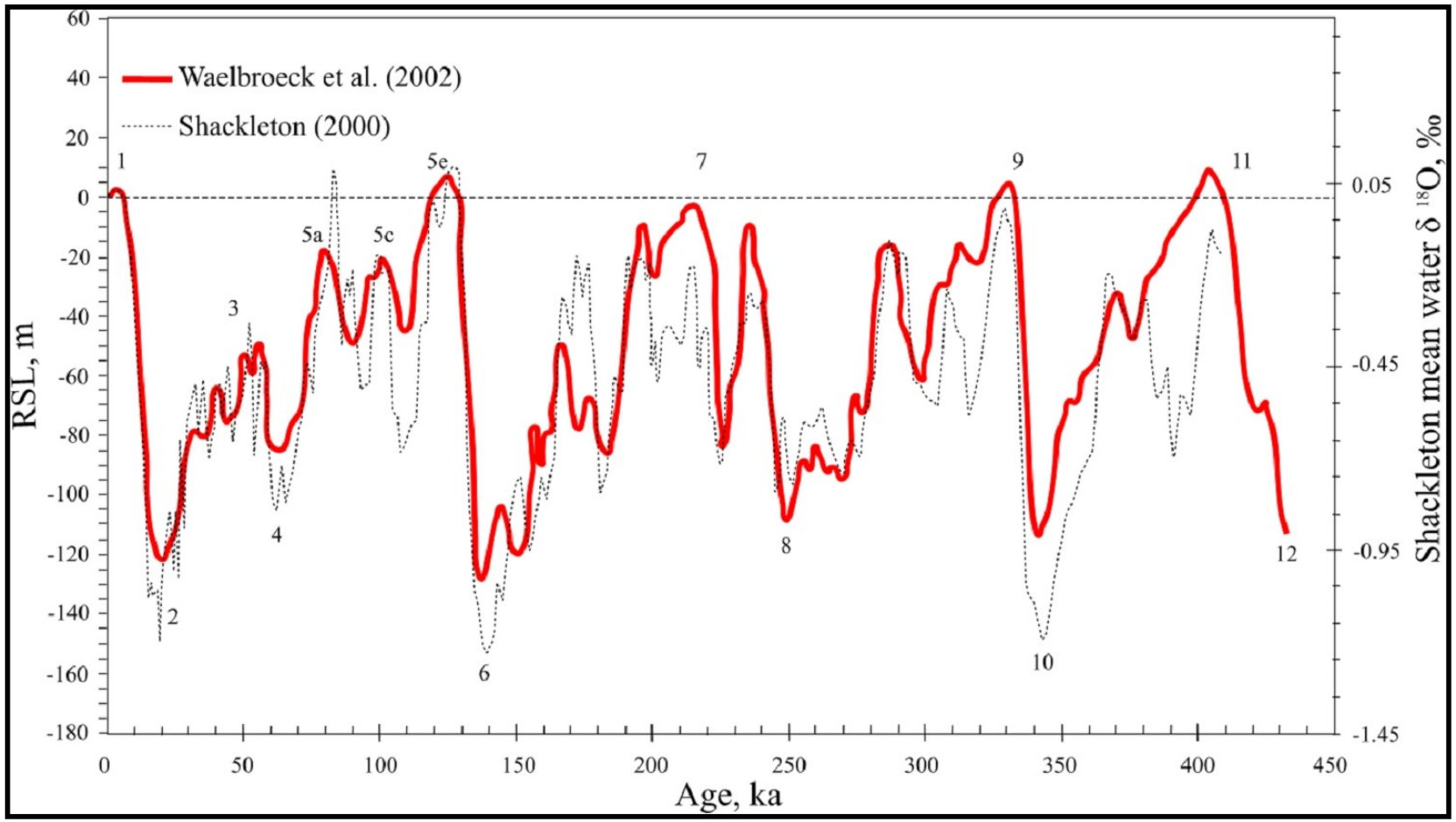


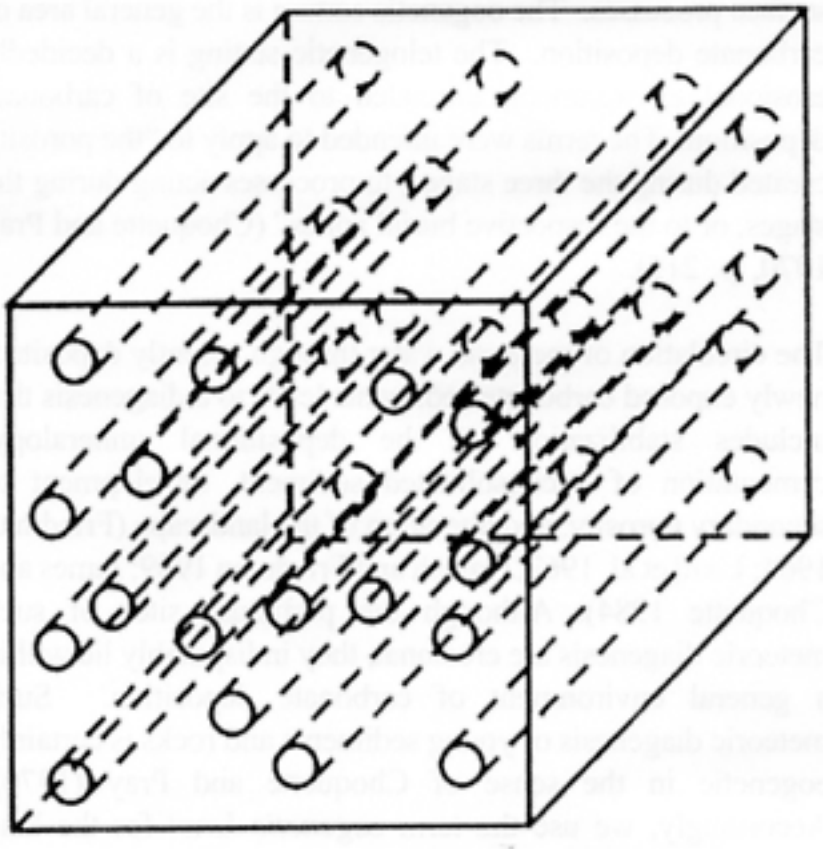
Dreybrodt, 2000

Carbonate Island Karst Model



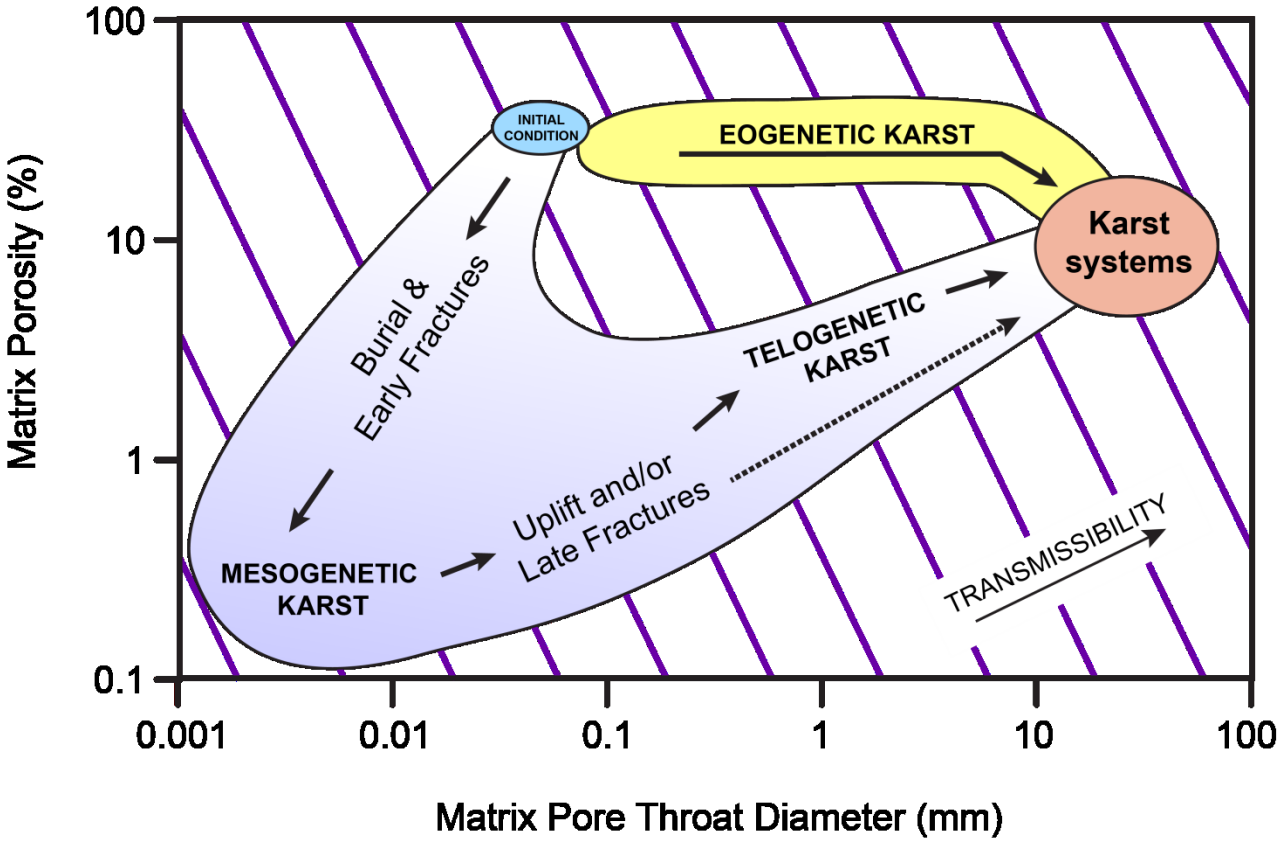
Lascu, 2005

Carbonate Island Karst Model



Vacher and Mylroie, 2002

Carbonate Island Karst Model



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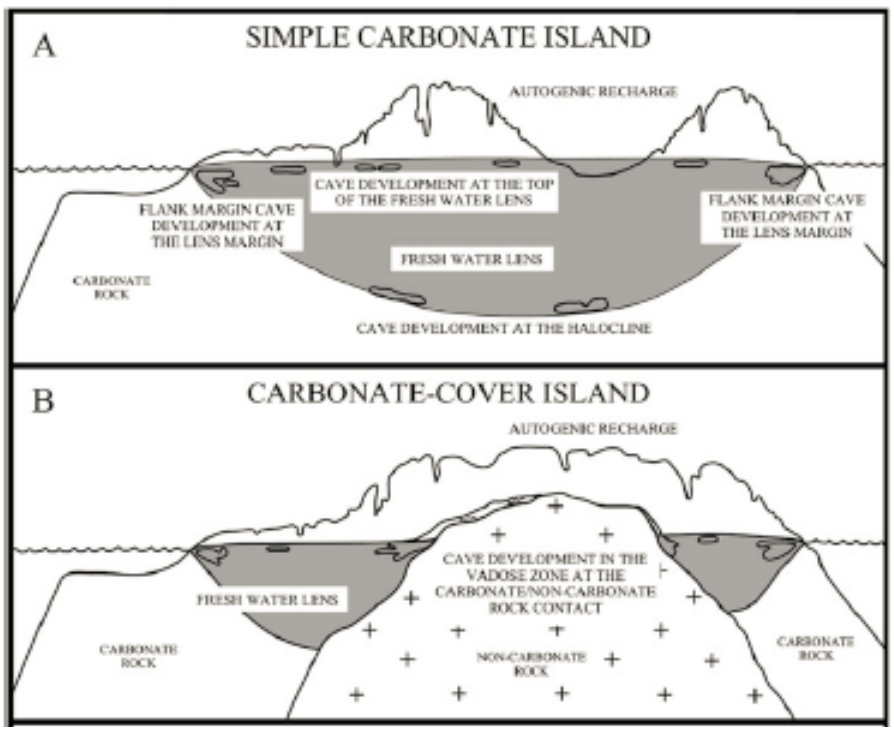
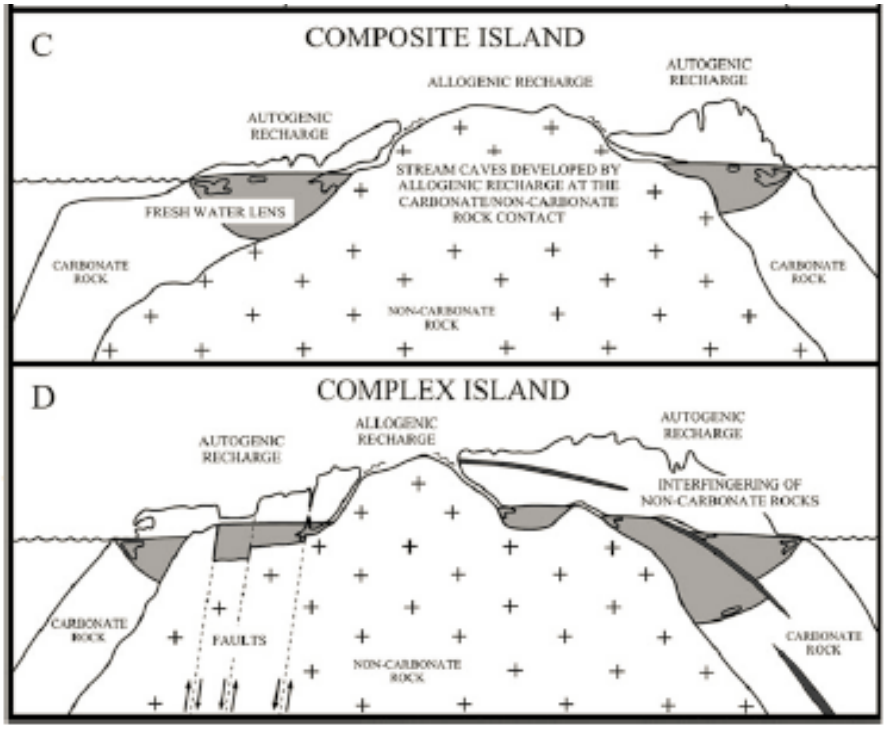
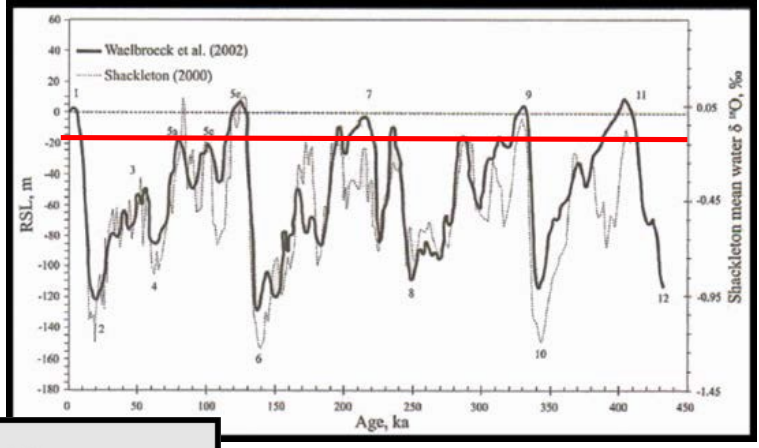
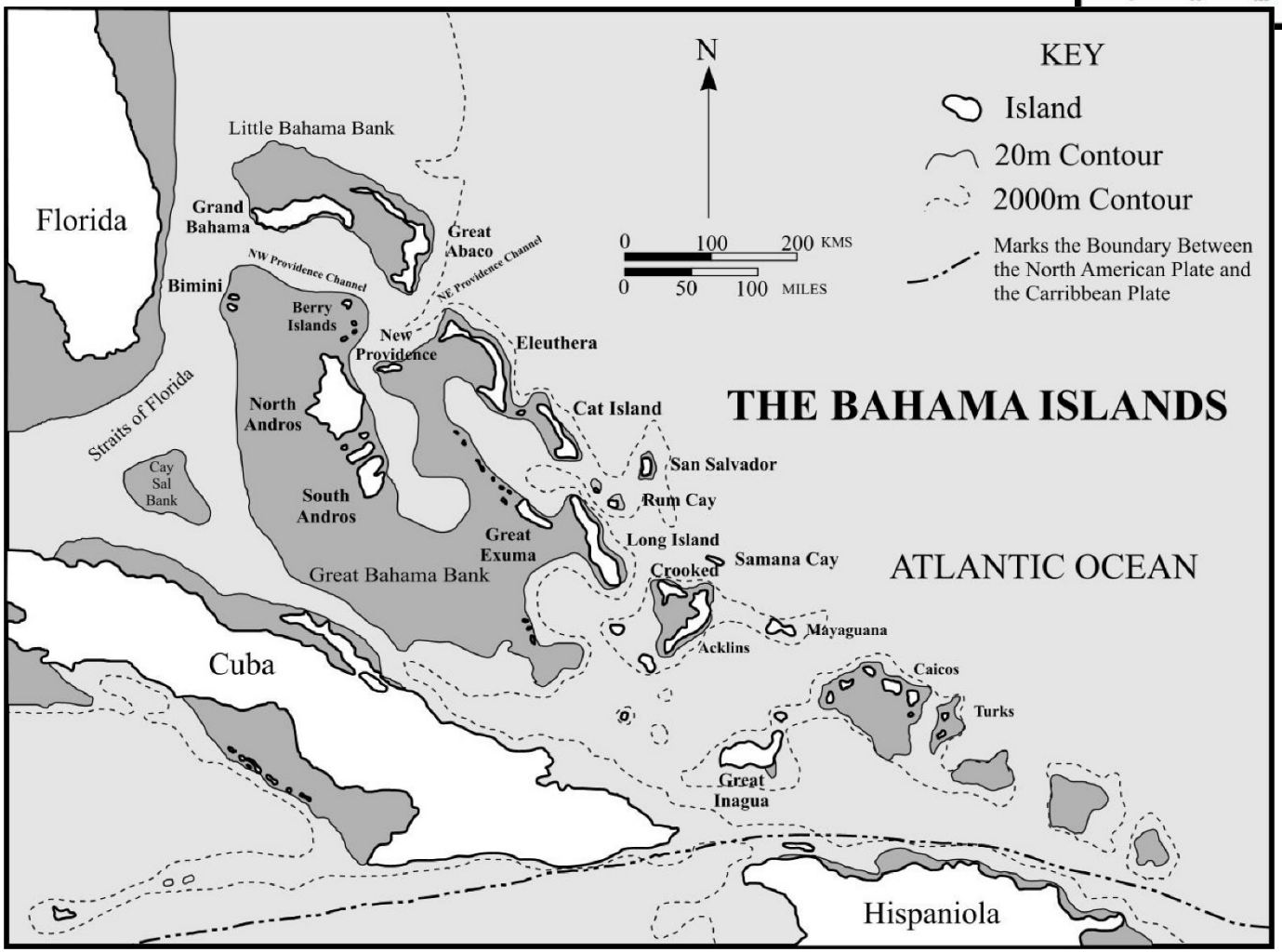




Jensen et al., 2006

Sea-level Change





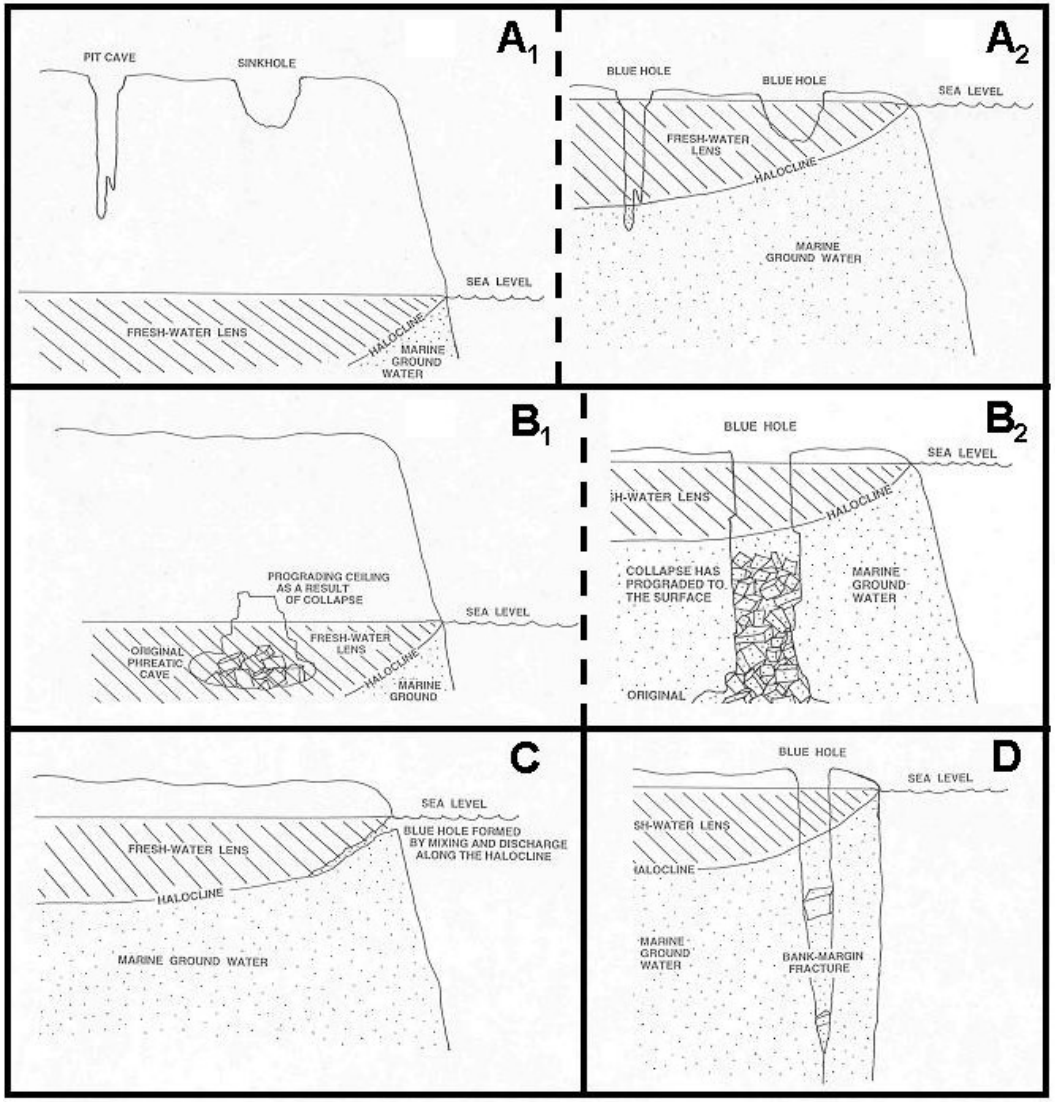
Lascu, 2005

Carew & Mylroie, 1997

Conduits

- Known because of blue holes

Blue Holes



Mylroie et al., 1995

Blue Hole Expression

Inland Blue Hole – Protected from sediment infilling

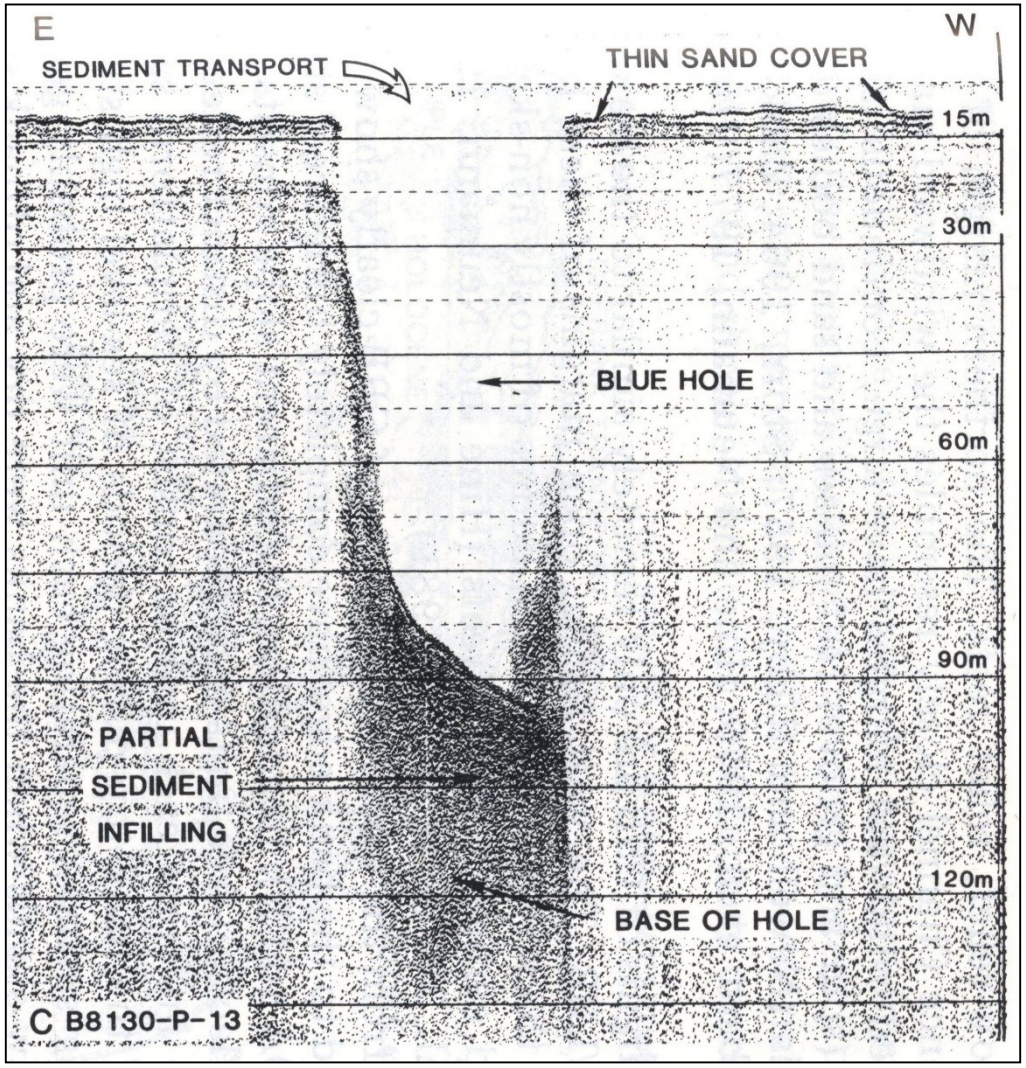
North Andros Island

Blue Hole Expression

Ocean Blue Hole – Partly protected from sediment infilling

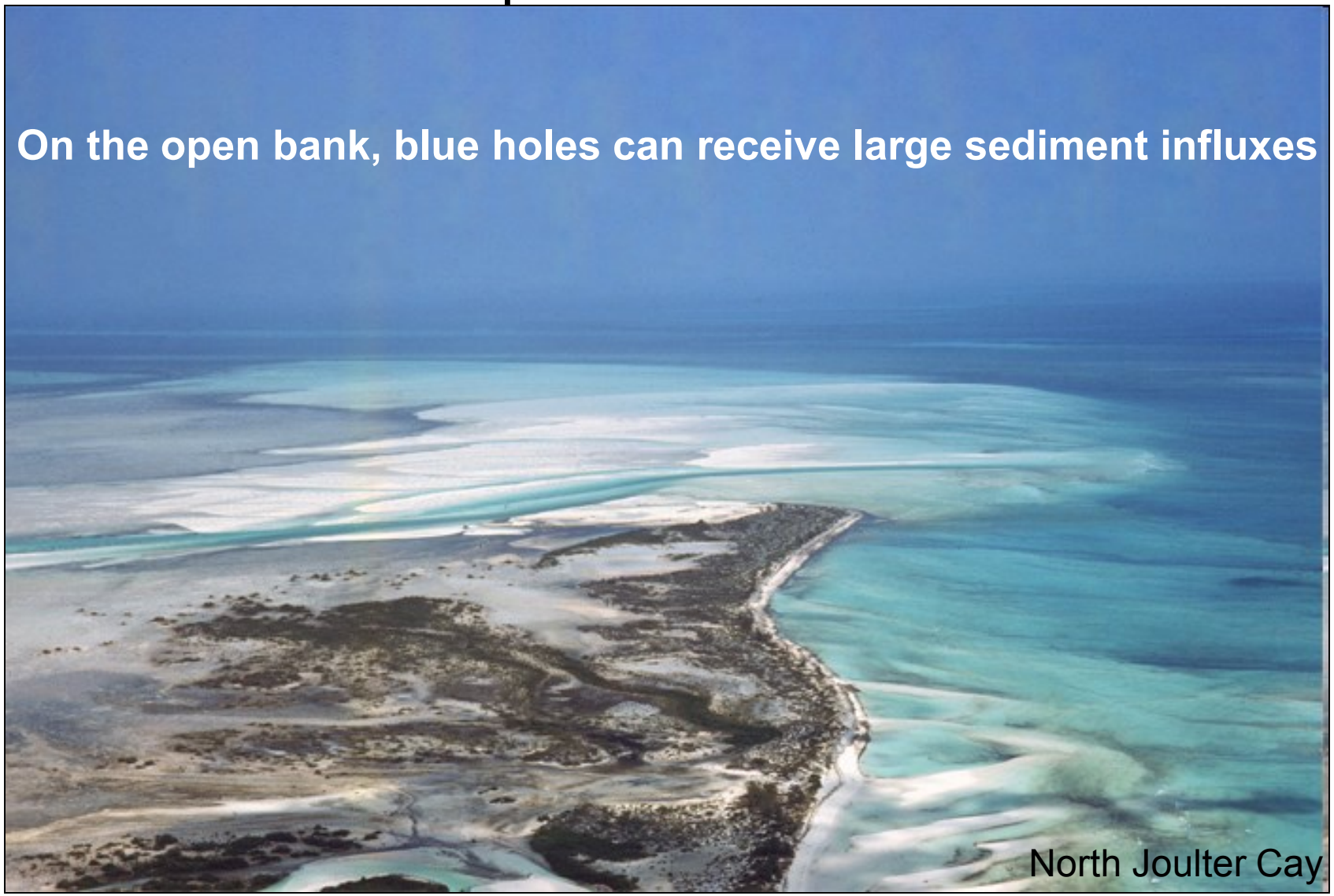
Deans Blue Hole, Long Island

Blue Hole Expression



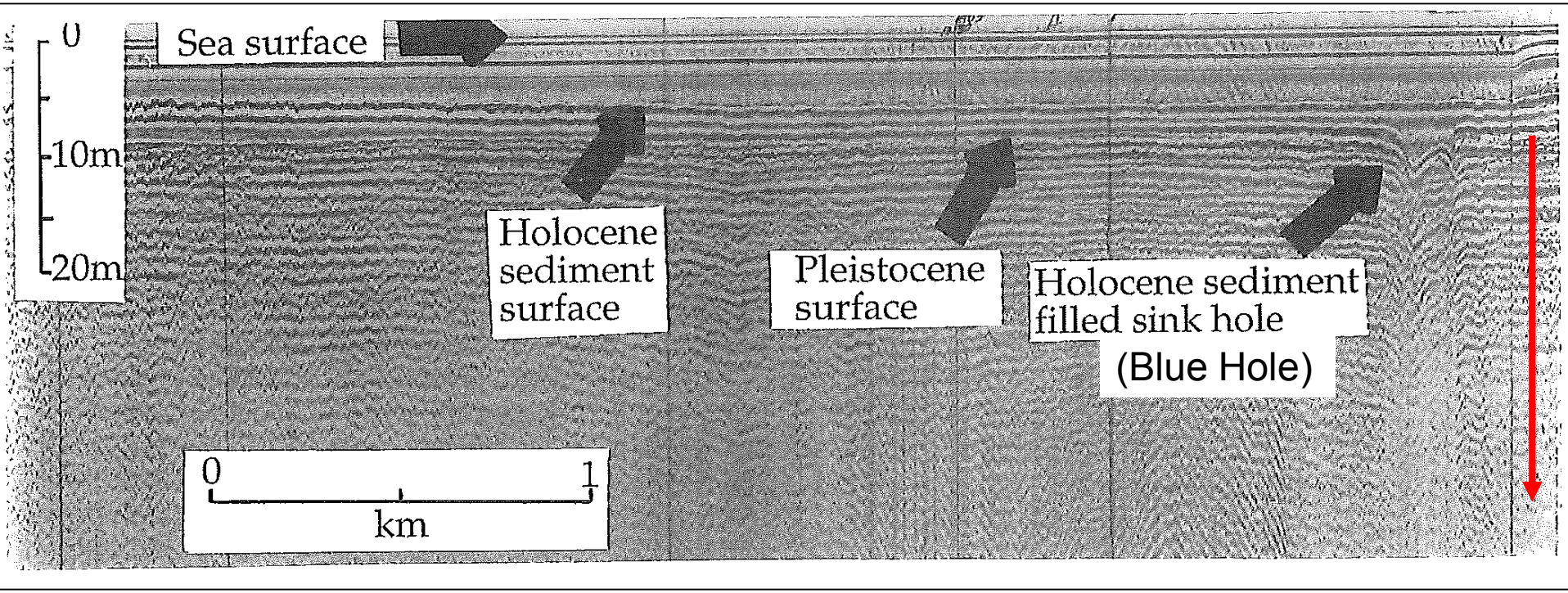
Hine & Steinmetz, 1984

Blue Hole Expression



http://www.sepmstrata.org/CarbonateParticles/images/006-Ooid-Shoals-N-Joutlers-Cay-Bahamas.jpg

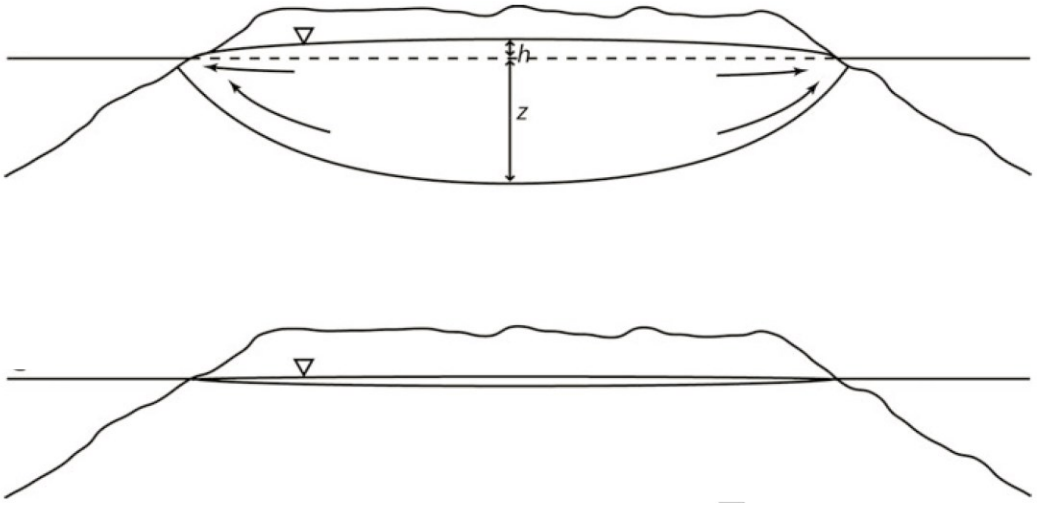
Blue Hole Expression



Beach, 1995

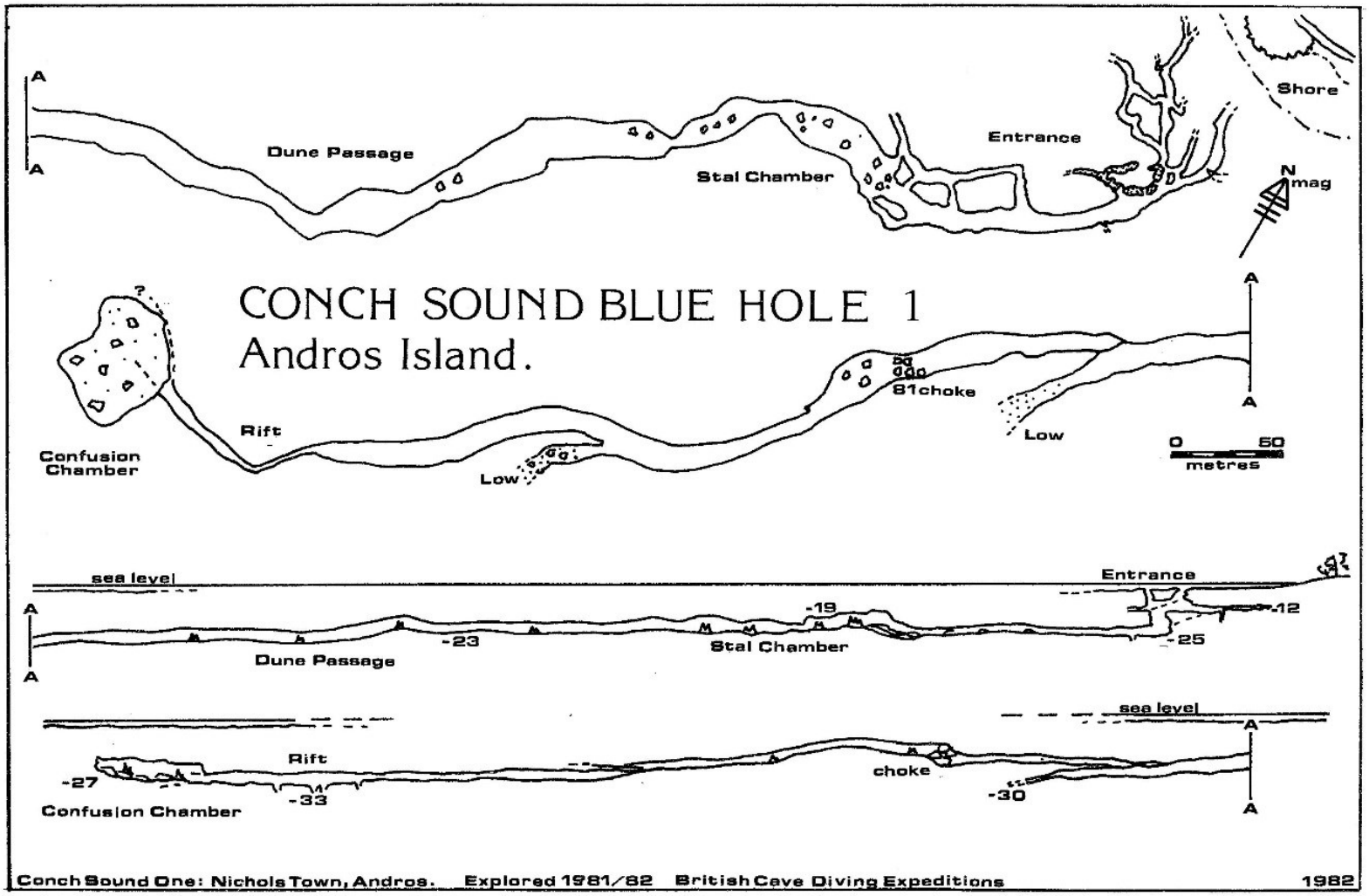
Freshwater Lens

- Self organizing aquifer
- Diffuse flow → Conduit flow (?)
  - Area/Perimeter
    - Mylroie & Vacher, 1999; Vacher & Mylroie, 2002



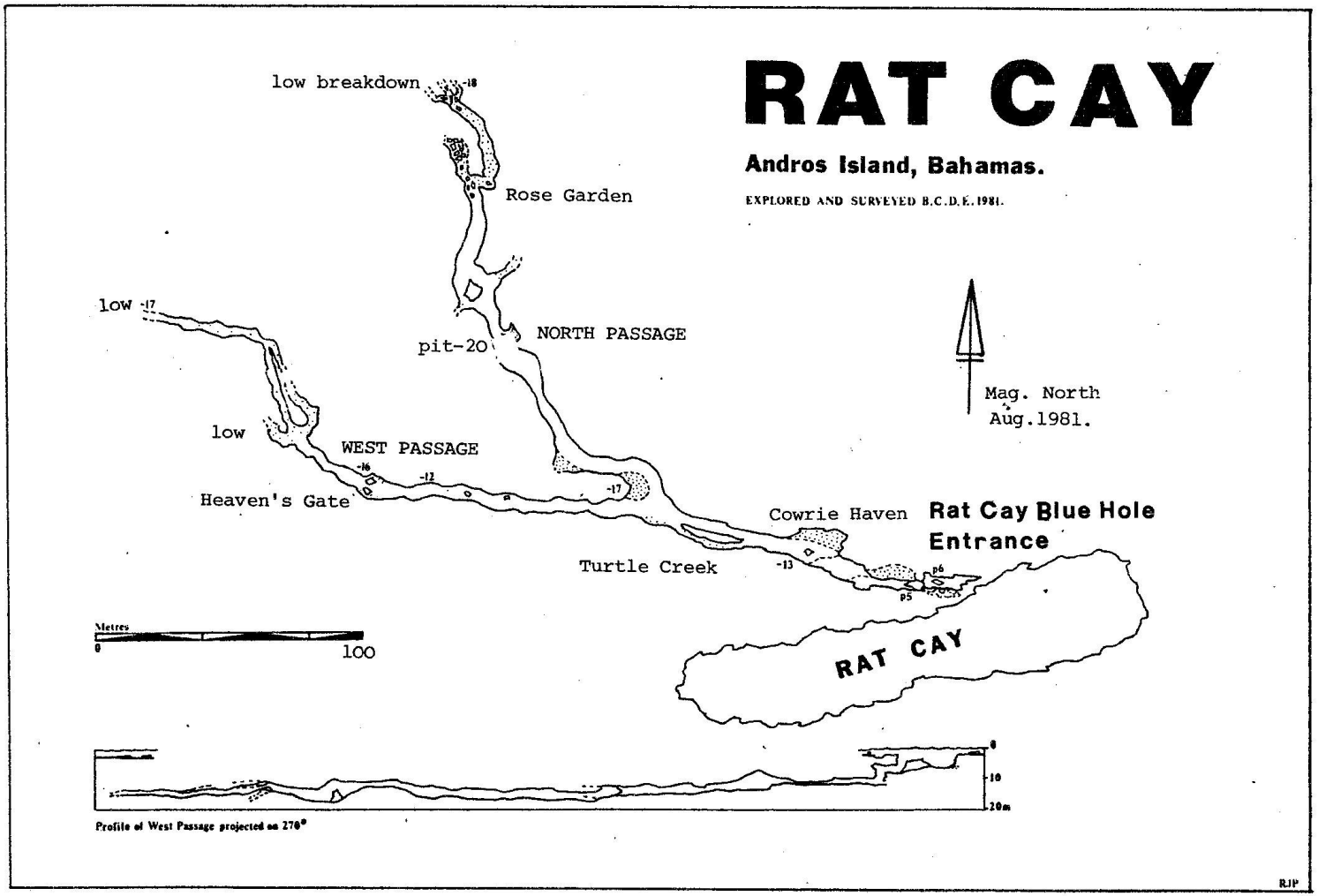
Fratesi, 2013

Conduits



Farr and Palmer, 1984

Conduits



Farr and Palmer, 1984

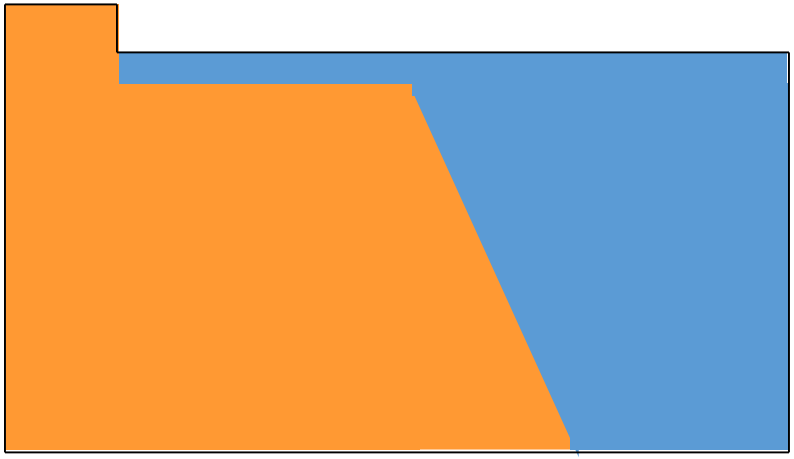
Conduits

Dan’s Cave Abaco Island

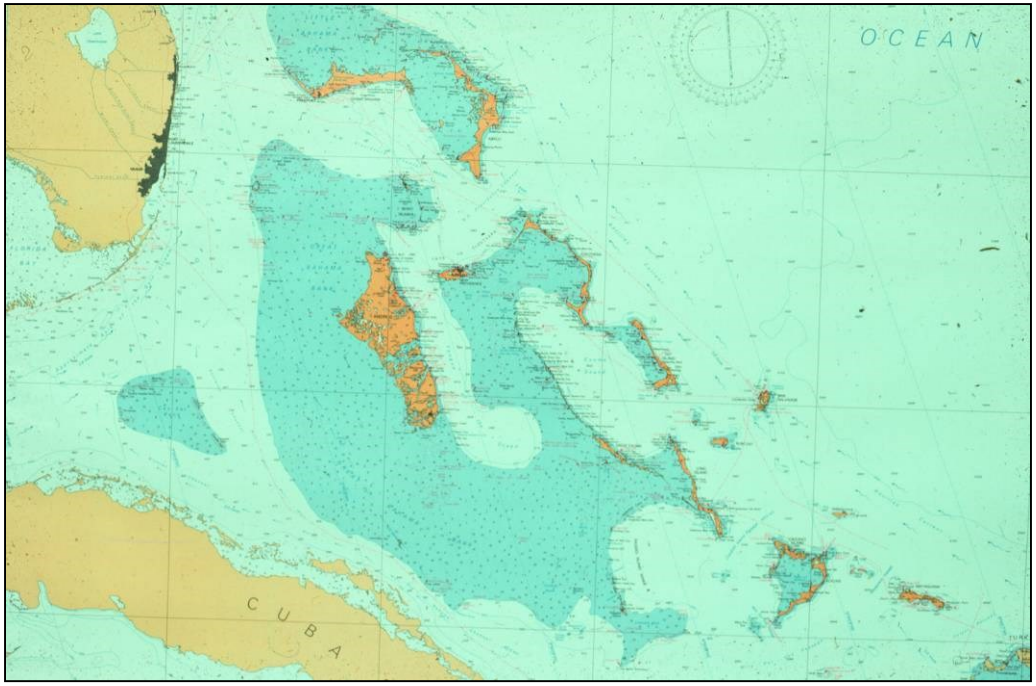
Conduits

- Known because of blue holes
- >15 m depth

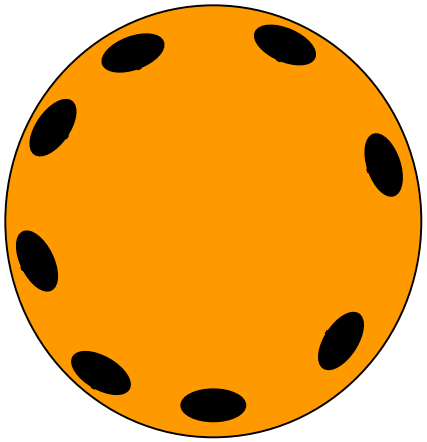
Progradational Blue Hole Collapse Formation



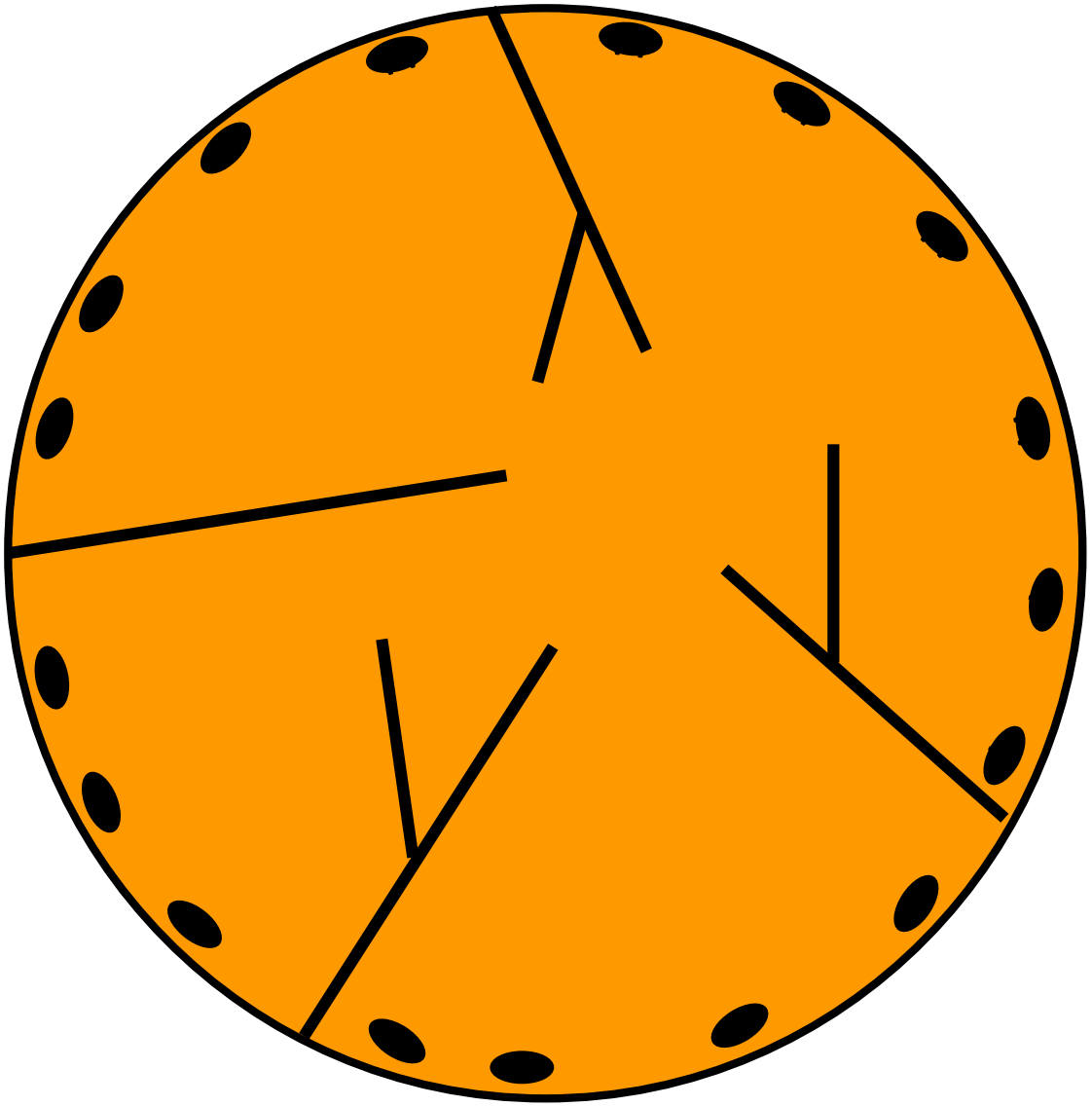
10m drop in sea level subaerially exposes Bahamian banks



Sea-level Highstand
(e.g. Present)



Sea-level Lowstand
(e.g. LGM)

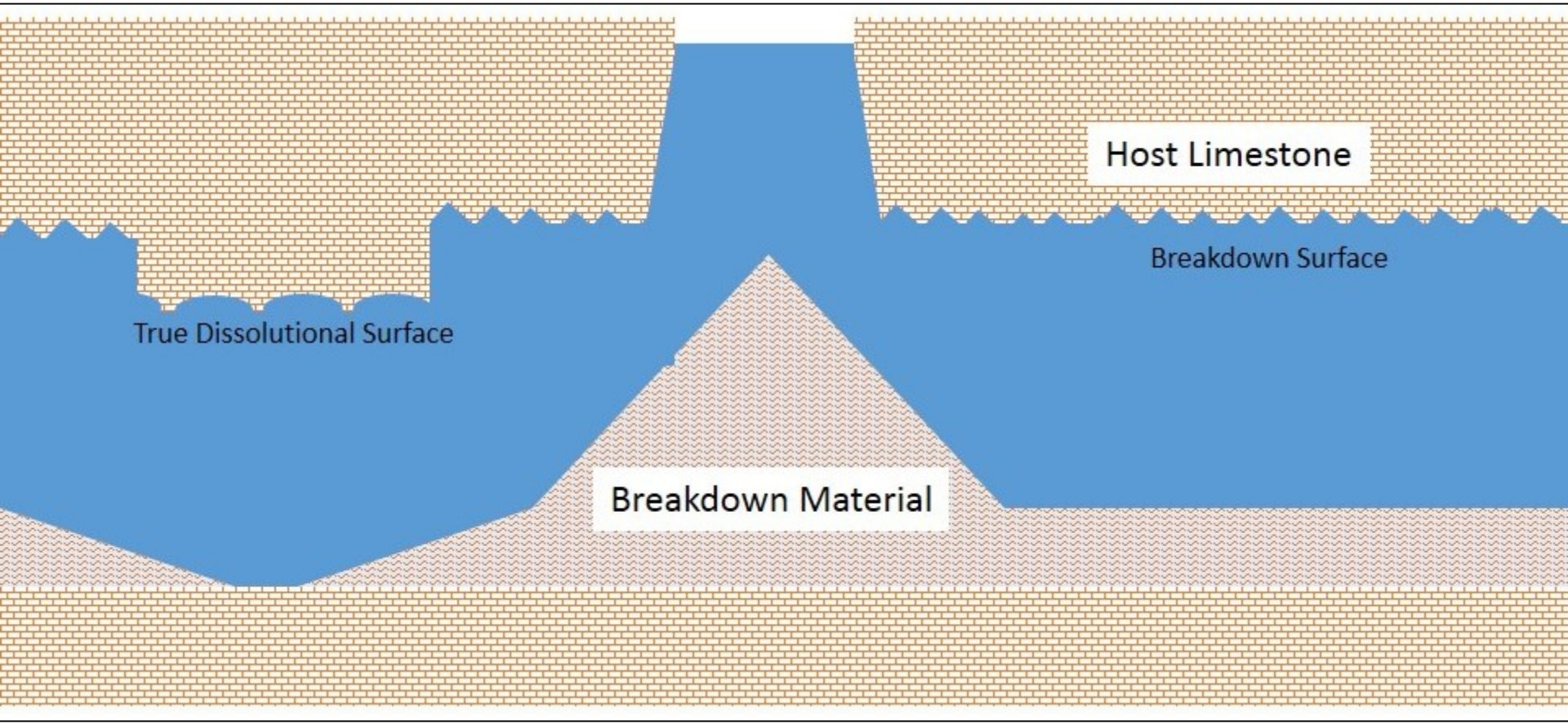


During sea-level lowering, land area increases by the square and island perimeter increases linearly

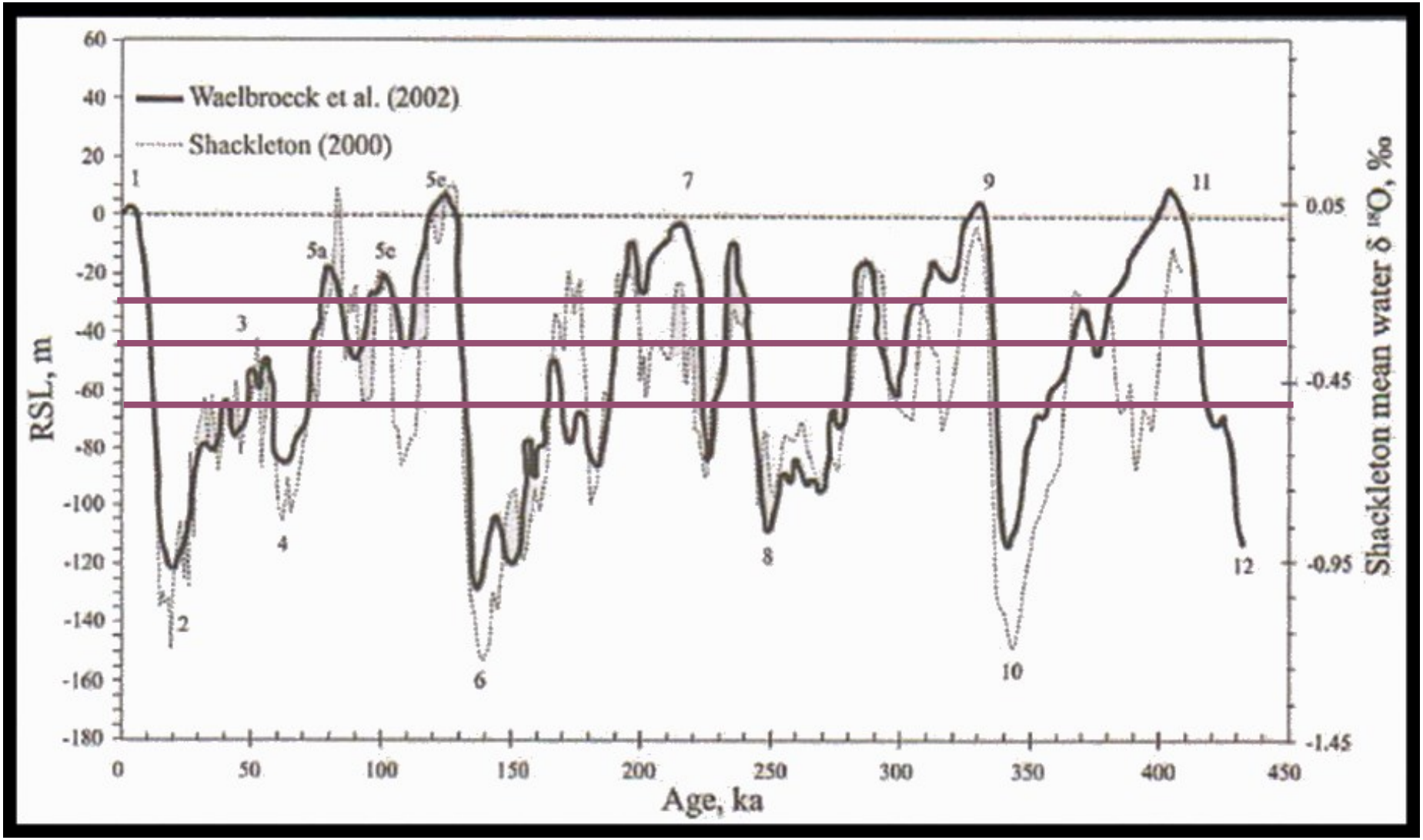
Flank Margin Cave

Conduit Cave

Collapse


Host Limestone
Breakdown Surface
True Dissolutional Surface
Breakdown Material

Blue Hole Bottom Depths



sensu Larson et al., in review

Time of Expression

- Overlying lithology indicates time of expression

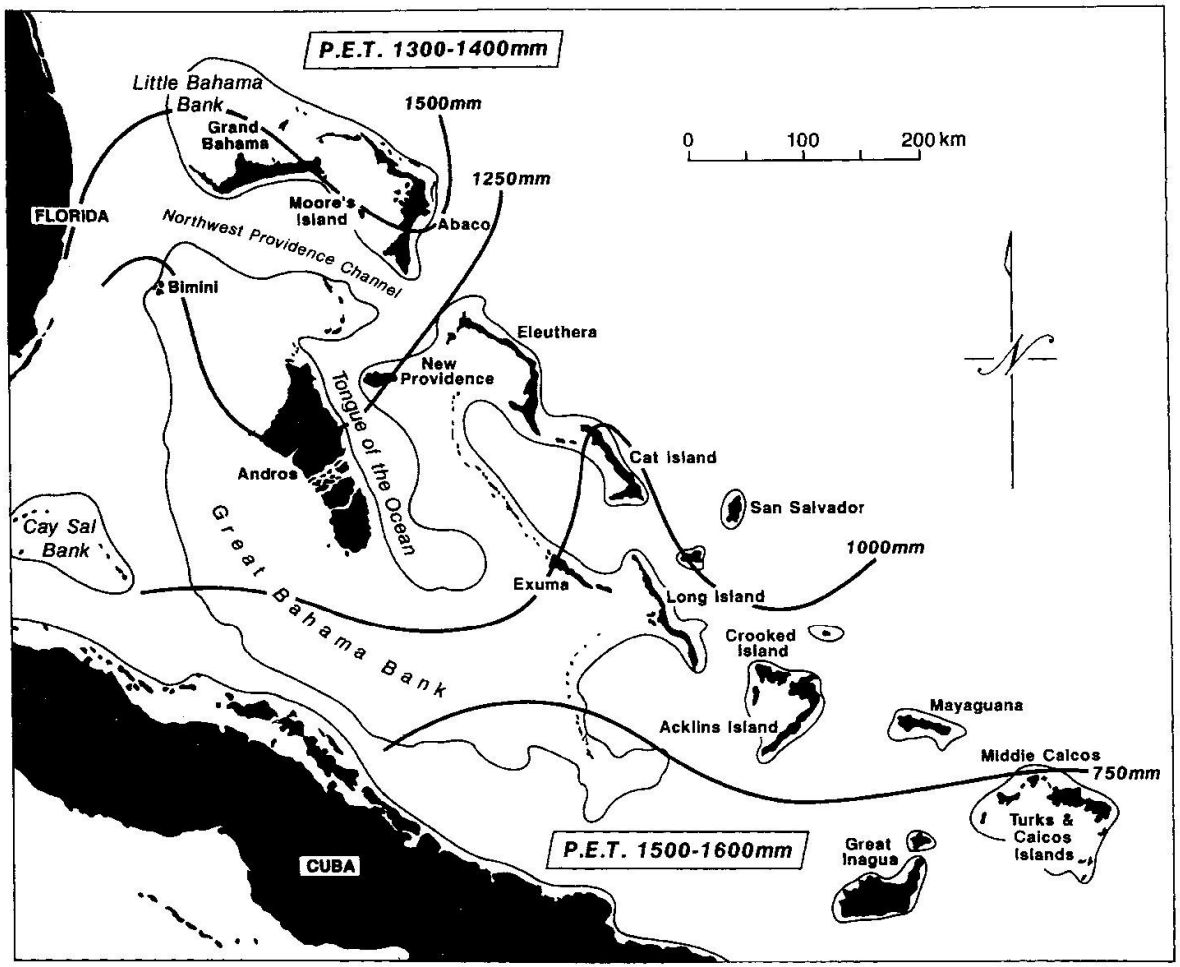
Methods – Blue Holes

- Conduit Formation
  - Model flow out of islands:
    - Island sizes
    - Recharge rates
      - Whitaker and Smart (1997)
    - Time
    - Enlargement Rate
      - Moore et al. (2010)

	Years	Porosity (%)	Tube Radius (m)	Hydraulic Conductivity (m / day)
Time 1	0	25	0.0005	5
Time 2	12	20	0.035	500
Time 3	3000	15	0.75	5000

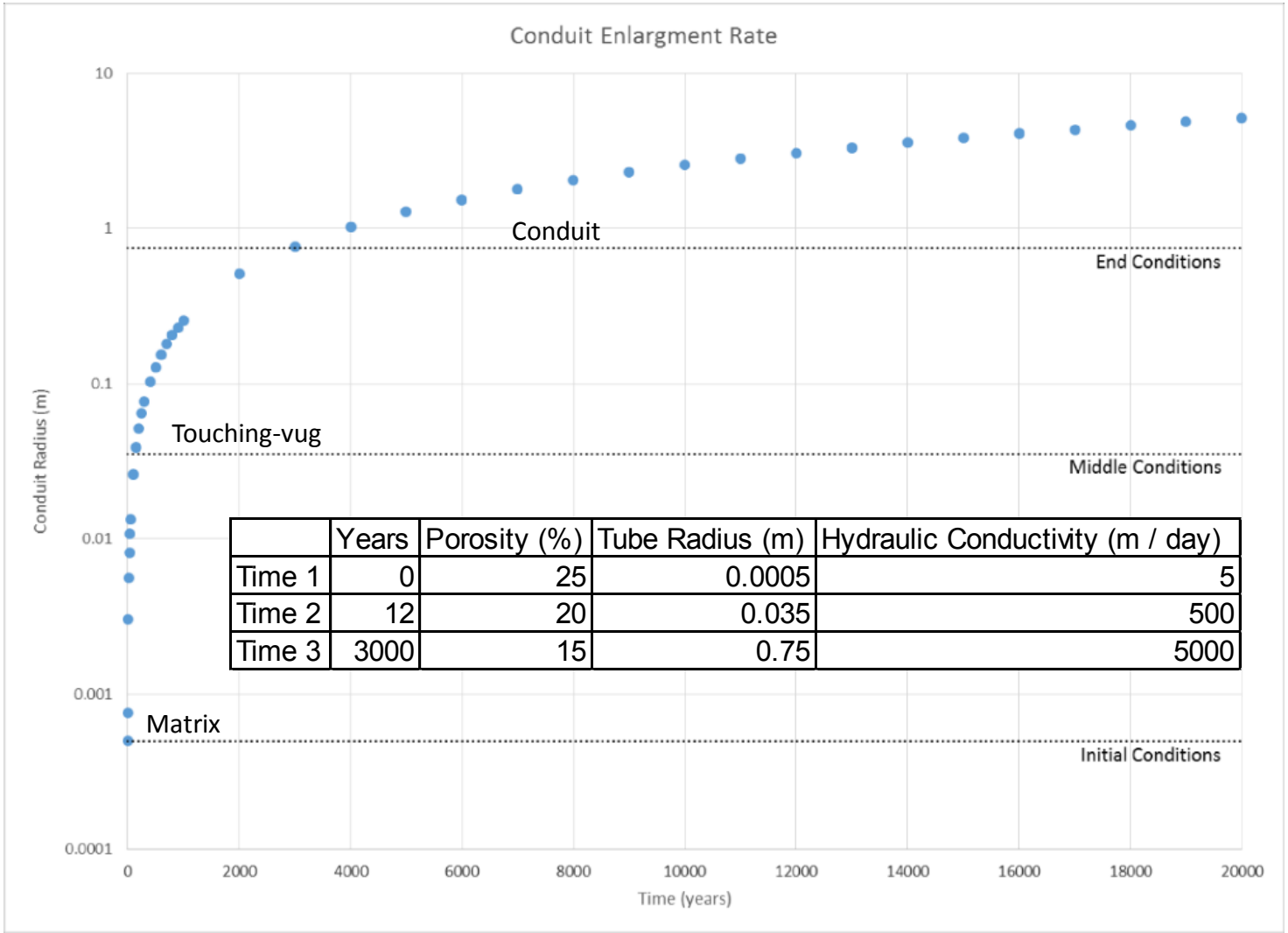
Vacher and Mylroie, 2002

Recharge Rates



Whitaker and Smart, 1997

Results – Conduits



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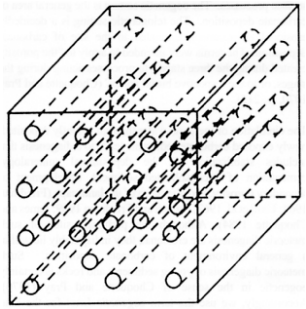
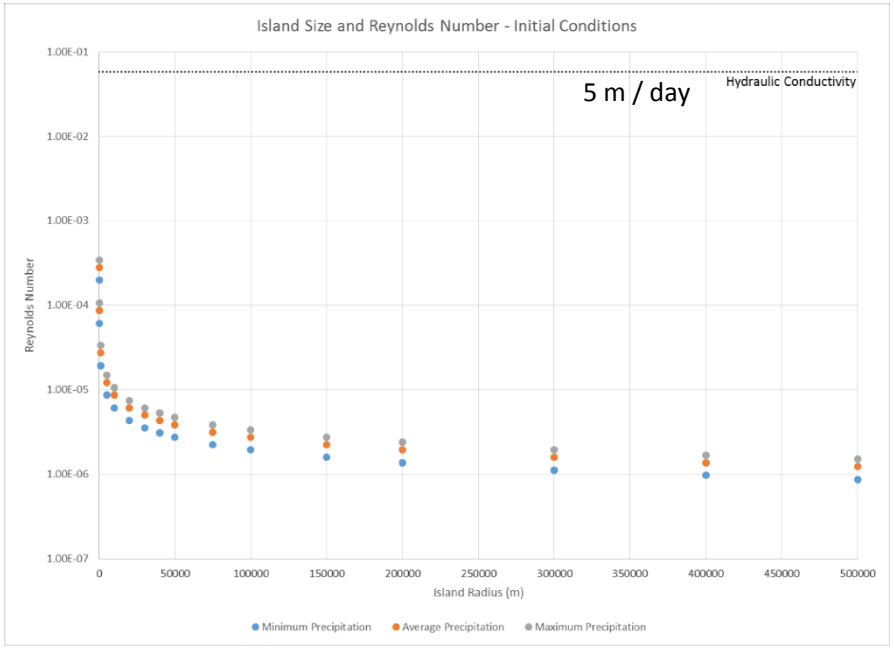
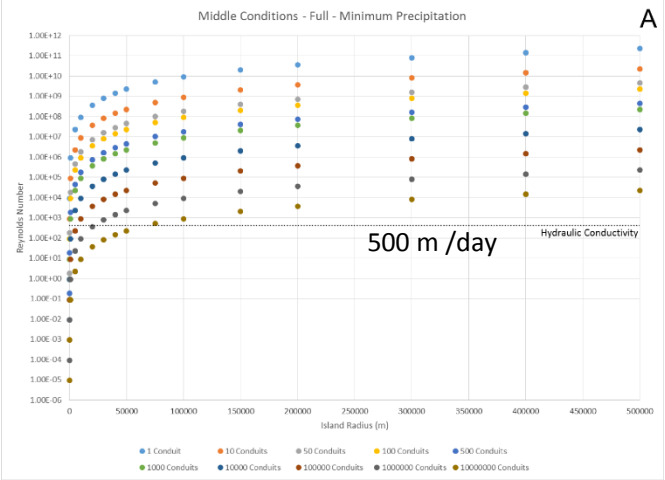
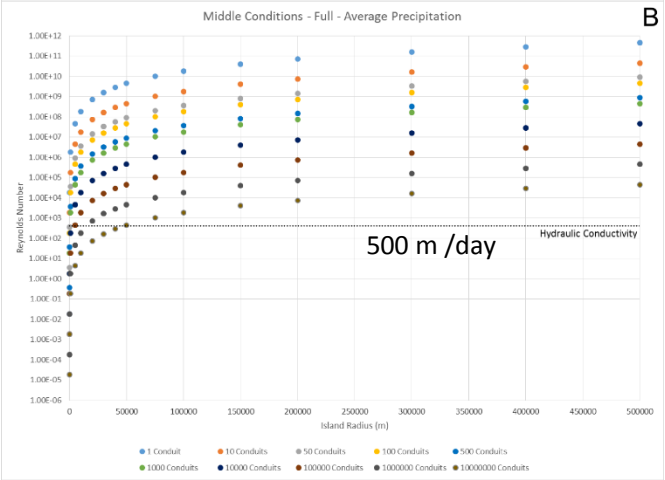
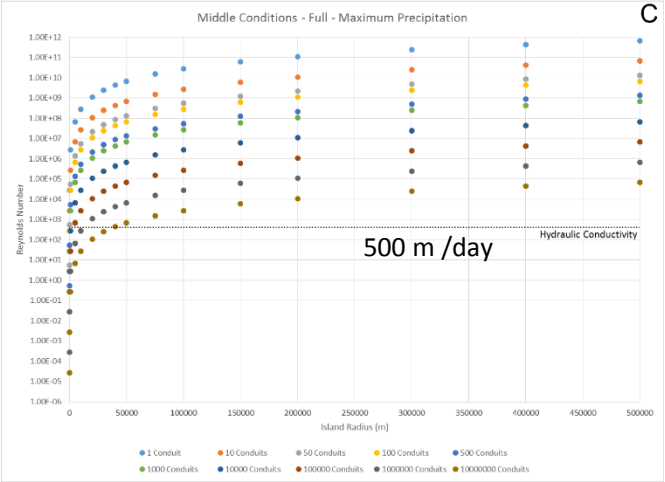


- Assuming an isotropic aquifer that does not dissolve (quartz sand)
- However, limestones do self modify and dissolve over time
- < K = able to drain effectively
- > K = unable to drain effectively – encouraging additional conduit growth

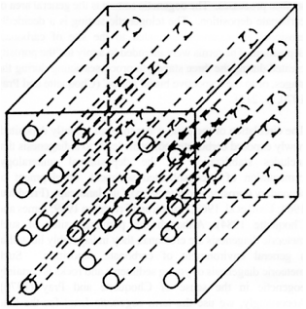




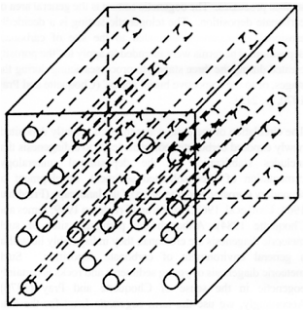




Vuggy-permeability

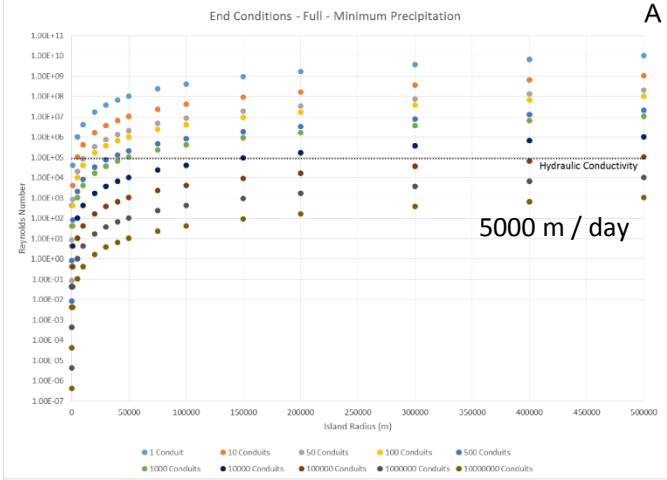


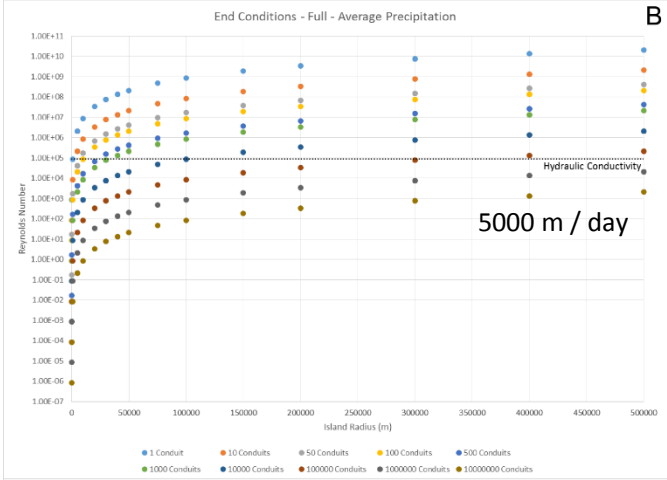
- 12 Years
- 1 – 10,000,000 tubes
  - 0.035 m radius
- More tubes, easier to drain
- Encourage conduit development and competition

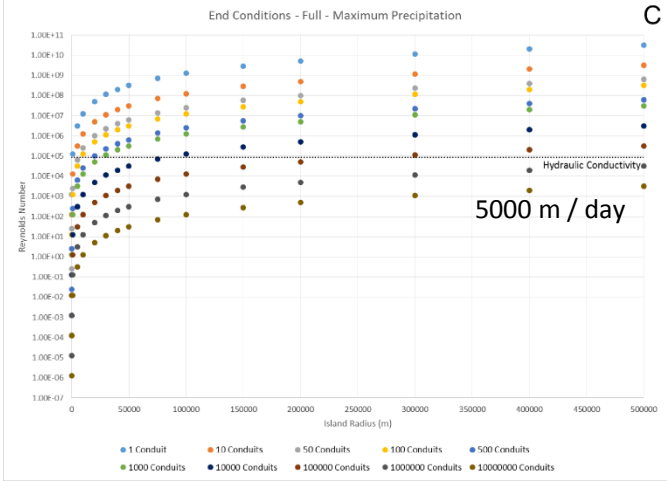


- 3000 years
- 1 – 10,000,000 tubes
  - 0.75 m radius
- More tubes, easier to drain
- Encourage conduit development and competition

Conduit







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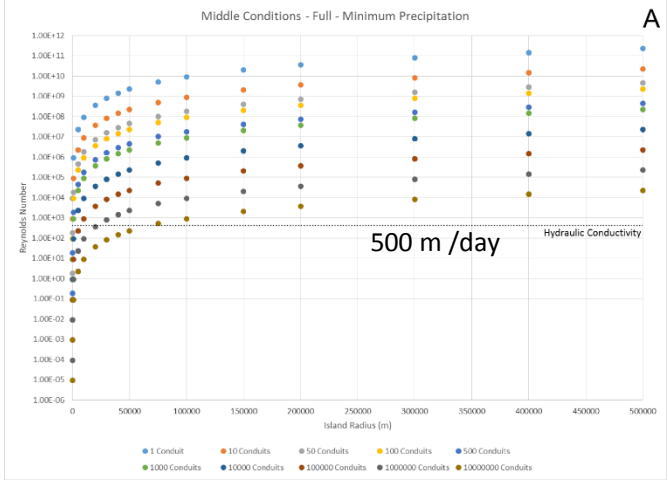
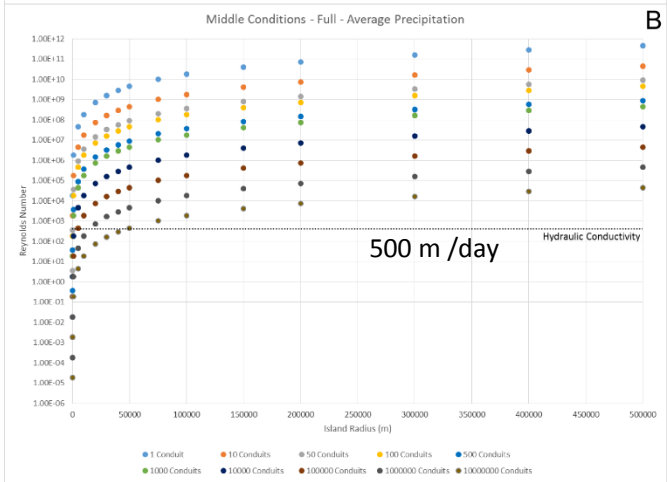
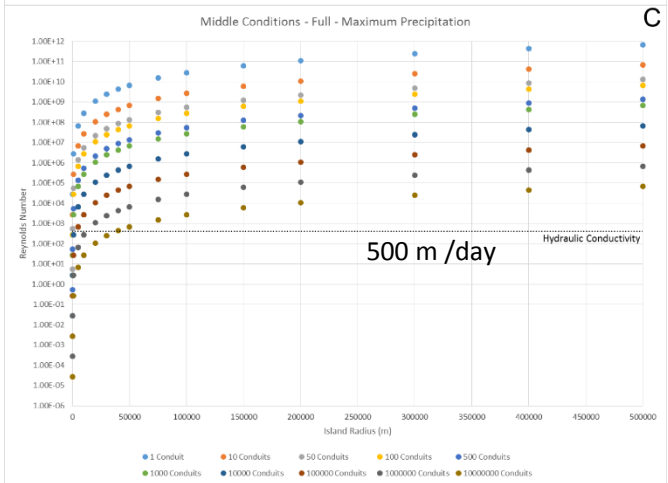
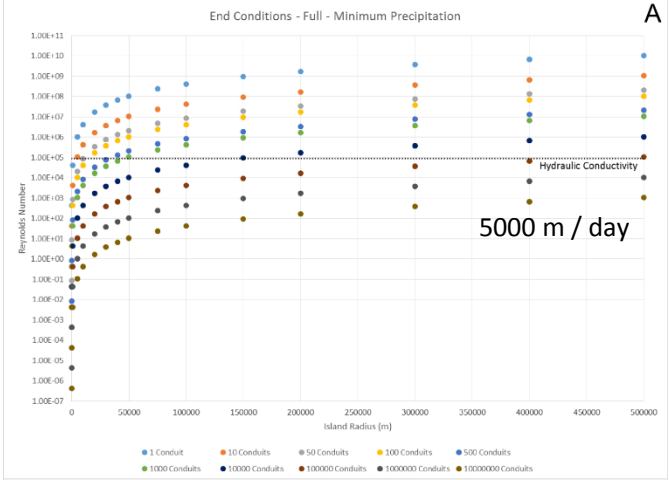
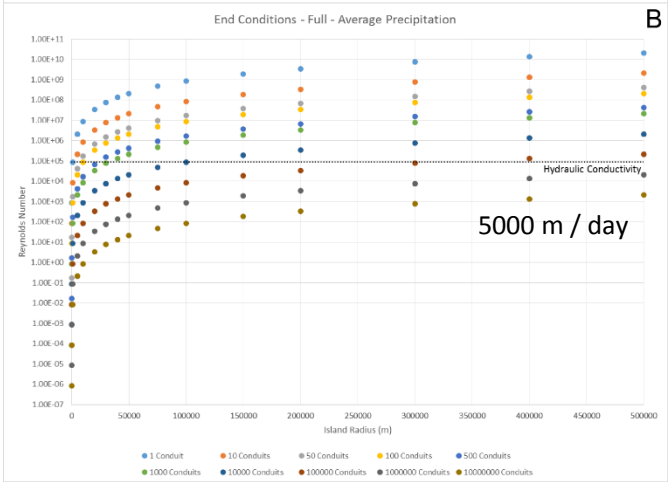
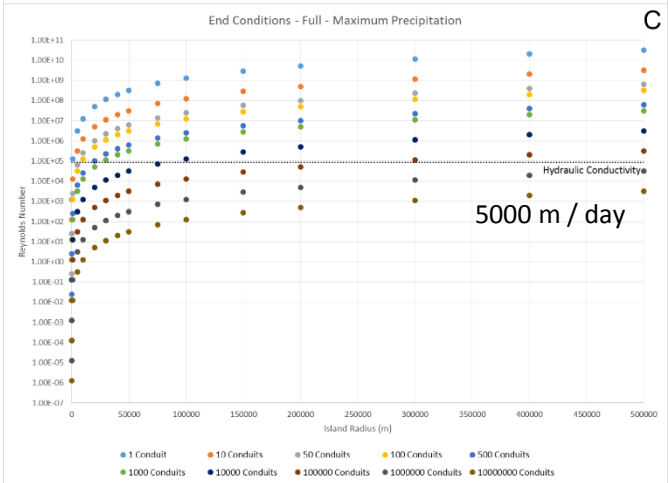


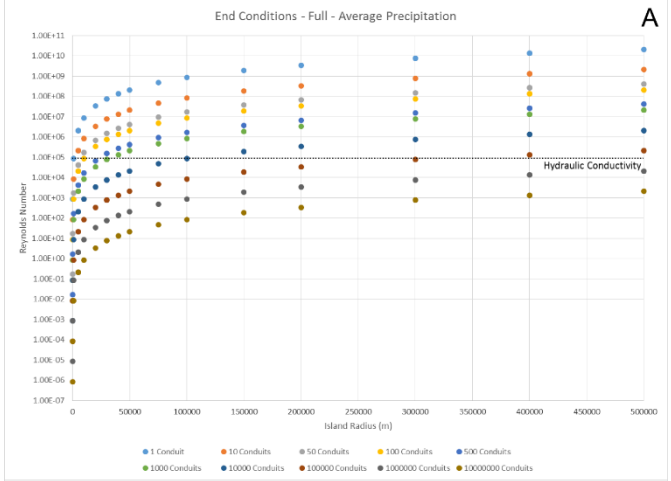


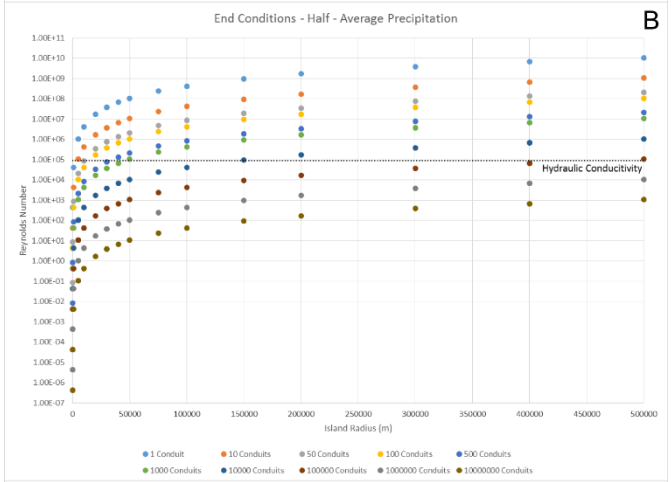


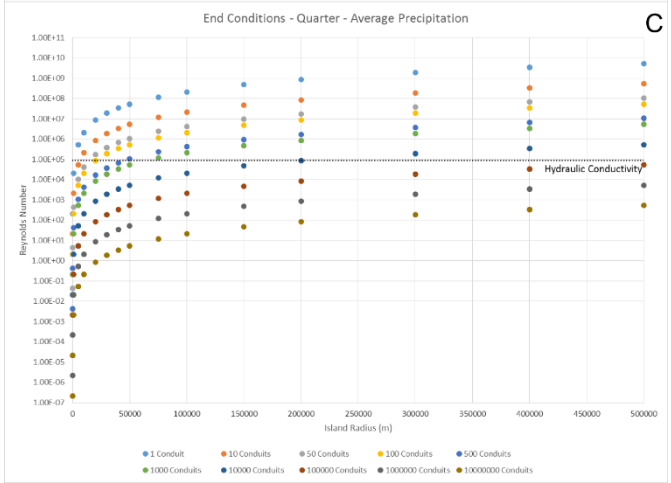


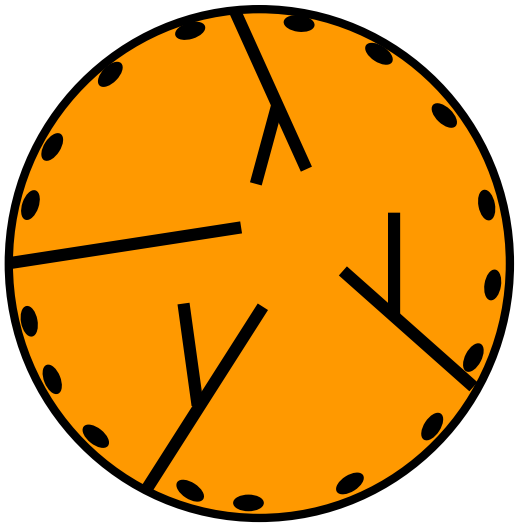






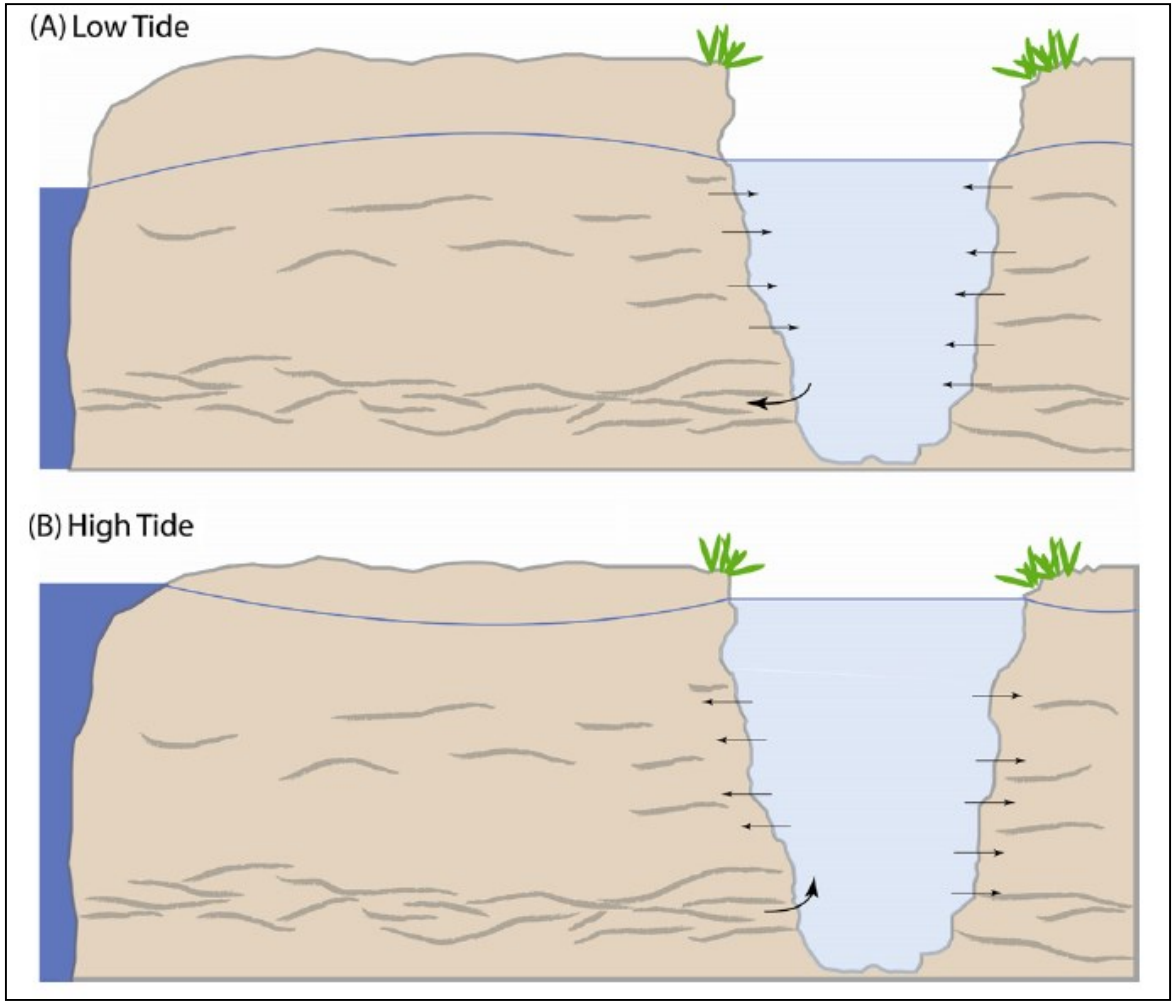






- Only allow some of the water to drain through the conduits
  - 100%
  - 50%
  - 25%
- Expect about 90% drains through the conduits
  - Beddows, 2004

Implications – Whiting Formation



Martin et al., 2012

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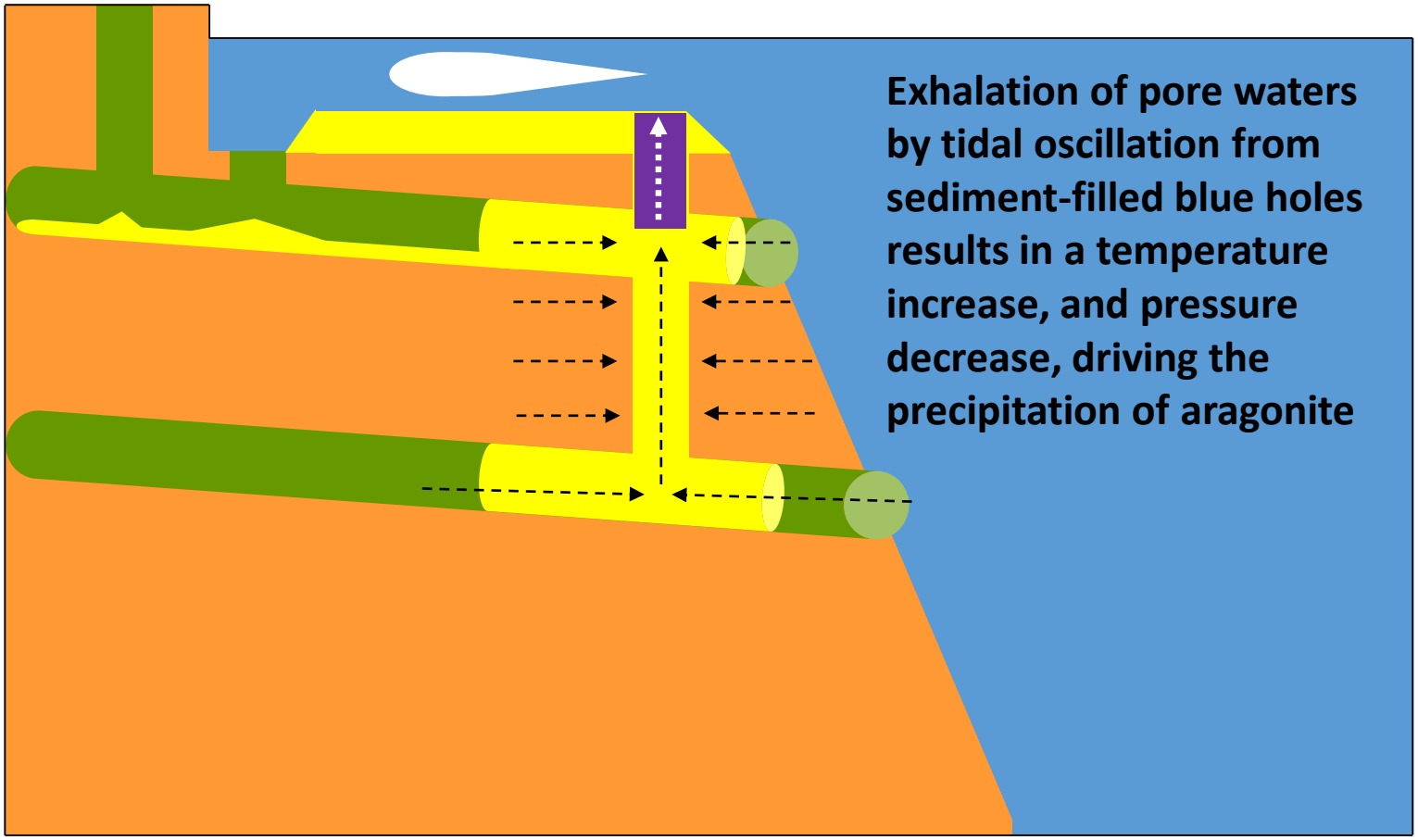

Discussion

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  - Northern banks are the largest
  - Northern banks receive the highest amounts of recharge

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- Overlying lithology indicates time of expression
- Area/Perimeter ratio does not control conduit formation, but rather by the water budget as a function of recharge and island area
  - Northern banks are the largest
  - Northern banks receive the highest amounts of recharge
- Islands with a radius of 5-10km will continue to drain under diffuse flow, larger islands develop conduits

Questions / Comments

The Lusca

http://pirates.hegewisch.net/lusca.gif