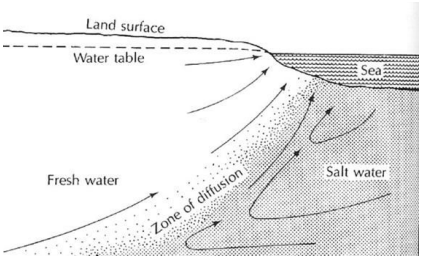
Under the Jungle - Geo Karst challenge - Sunday Aug 16
Flow in the saline water ?

DOES THE DEEP SALT WATER FLOW AT ALL? Has anyone observed currents in deeped haloclines? Last week, we learned that shallow salt water can flow inland in the caves, it makes sense that close to the ocean the tides would have an effect -- but what about these places in the middle of the Yucatan with 70-meter deep haloclines? **Is the deep water salt water just sitting there like a nice salty puddle?**



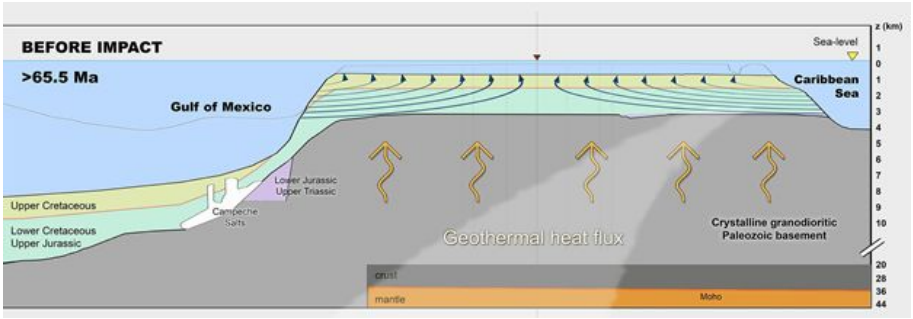
The deeper you go - the harder it is to get actual data..... But here are some powerful ideas with some actual data to support them...

Yes - there will always be some circulation in the deep salt water - Lava Lamp Effect !

Since the "very beginning", even when the platform was covered in ocean water.... There was saline circulation. The heating inside the platform by the geothermal gradient gently heats the deep saline water, making it a little bit lighter, and that makes it rise up and exit across the whole top of the platform - and of course you have to have inflows somewhere, with younger marine water being pulled in through the sides.

No caves required. No fresh water lens since there is no land.

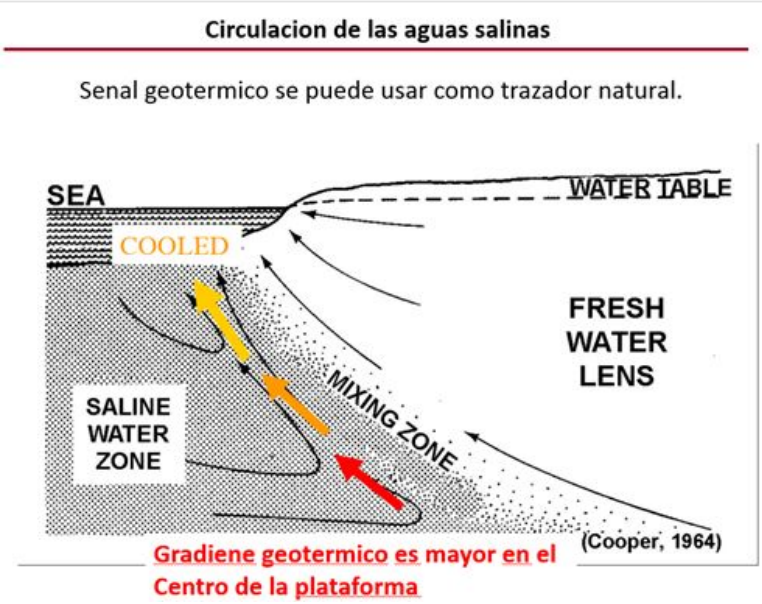
This happens in all sub-marine platforms.



Quite recently - global sea level dropped and there was some land on the Yucatan! Rain leads to formation of a fresh-water lens

The lava lamp effect driven by geothermal gradients will still be there and will still drive the saline water circulation.....

Which is in part why we have the "classic textbook" model (aka Kohout Circulation) of the saline circulation under the fresh water lens being driven by the extra heating in the deep saline water in the middle.



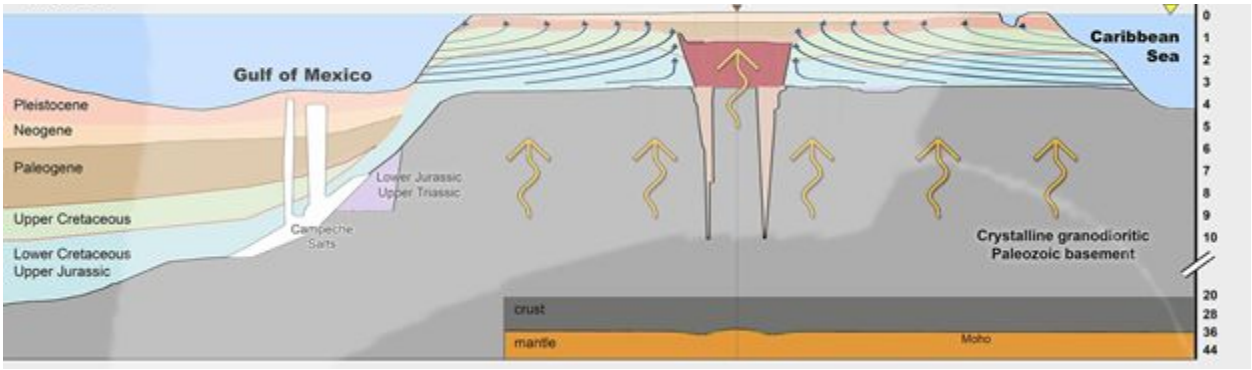
Boom - comes Chicxulub!

Yeah - not so simple in the Peninsula, but actually helpful!

The impact made a crater, which was then all covered and blanketed by massive layers of water saturated carbonates. [vertical scale on the figure below is km - and there is a 25x vertical exaggeration or stretch]

Deep below though, the impact also left a massive glassy, low permeability melt plug, which is still hot even today. [the red cone thing in the diagram]

Not only does the geothermal heating continue from the basement rock, but DAMN! The aliens had really good aim and hit the geographic center of the platform. The hot melt plug and heat of impact just complimented the pre-existing sub-marine platform circulation with warmed saline water going up and the young marine water being drawn in from the sides. Post impact - likely even more deep saline circulation and mostly in the same pattern as before.



Eventually global sea level dropped enough, that we had land, and rainfall, and then a fresh-water lens that can have caves forming along the halocline mixing zone and also at the water table.

Once you have a fresh water lens.... Then you can get all the great horizontal flow caves.

And with sea level going up and down.... The cave forming depth is also going up and down - mostly from present high down to 150 m current level.

All the evidence points to stacked levels of caves that relate to relatively recent past sea level.

Is geothermal (and chicxulub?) heat driving deep saline circulation even today?

Likely - at least some places....

With a collection of "deep" profiles of temperature and salinity from a number of sties ..... We have some sites with temperature increases that match up well enough to the geothermal gradient (black dashed line). Perfect!

Never so simple though - some sites have constant temperature in deep saline. Grrrr.

Interpretation - there are complex flow patterns in the Peninsula and different sites have different flow regimes.

We see this site variance also in the shallow fresh water passages - some flow really well and some may not be flowing much at all.

Sabak Ha - constant T with saline depth

Santa Maria - small step wise increases - but definitely not a geothermal gradient.

Aak Kimin - which is coastal in Akumal - I read the gentle curve in the saline temperature from ~10 to 55 m as being from warm Caribbean water going though, but aggressively flowing in at time at ~10 m with the T spike there.

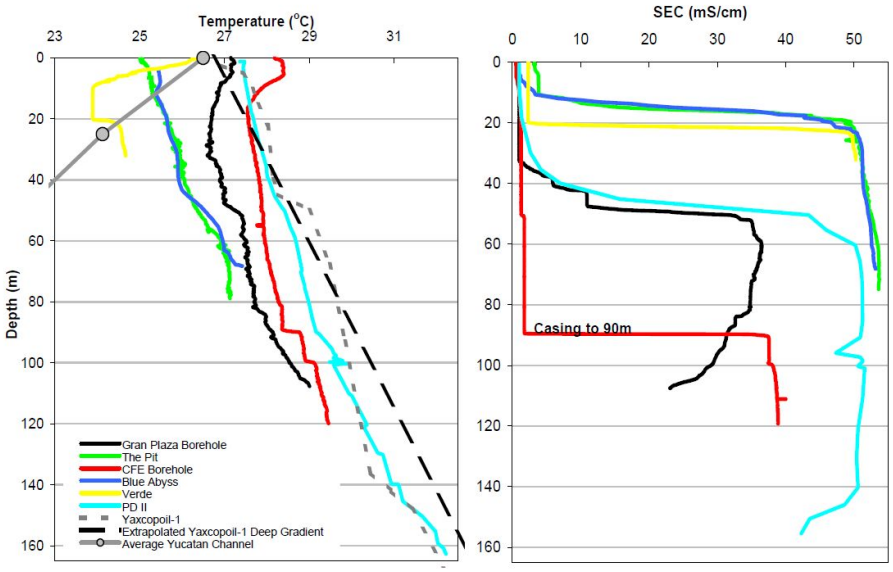


Figure 4.16 **Temperature and SEC profiles from cenotes and boreholes with geothermal gradients. The extrapolated Yaxcopoil-1 deep gradient is based on a gradient of 3.75°C per 100 m below 300 m depth (Wilhelm & Hiedinger, 2002). Average Caribbean sea temperatures as observed in 1984-1986 (Merino, 1997). PD II data from Socki (1984). Gran Plaza & "CFE" data from Buckley (2003) and SEC is uncalibrated with maximum values likely to be ~ 50 mS/cm. Refer to Figure 3.10 for site locations.**

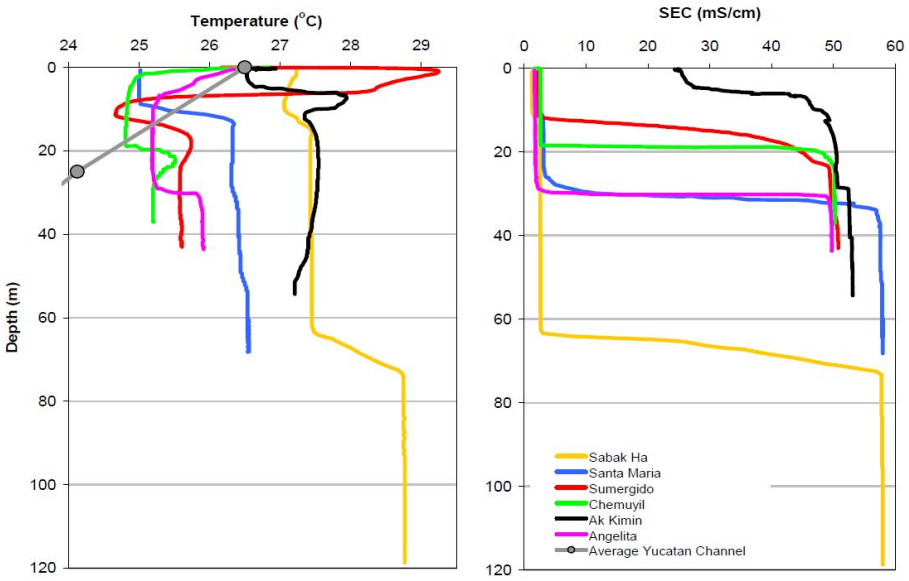


Figure 4.15 **Temperature and SEC profiles from cenotes and boreholes with isothermal SWZs. Caribbean temperatures as observed in 1984-86 (Merino, 1997). Sabak Ha & Santa Maria profiles from Iliffe (2003) for which SEC is uncalibrated with maximum values likely to be ~ 50 mS/cm. Refer to Figure 3.10 for site locations.**

Why yes - there is some pattern to the sites with geothermal or isothermal (mixed) profiles?

Per usual - it would be REALLY good to double the amount of data... but broadly:

The sites on top of the melt plug have geothermal gradients which should be low water flow... but heating from the bottom up. Makes sense - they are on top of that low permeability glass lump.

The sits ON the Ring of Cenotes - have isothermal gradients -which indicates some flow or some mixing. Hmmmmmm

The sites on the Caribbean Yucatan - mixed set.... Complicated.

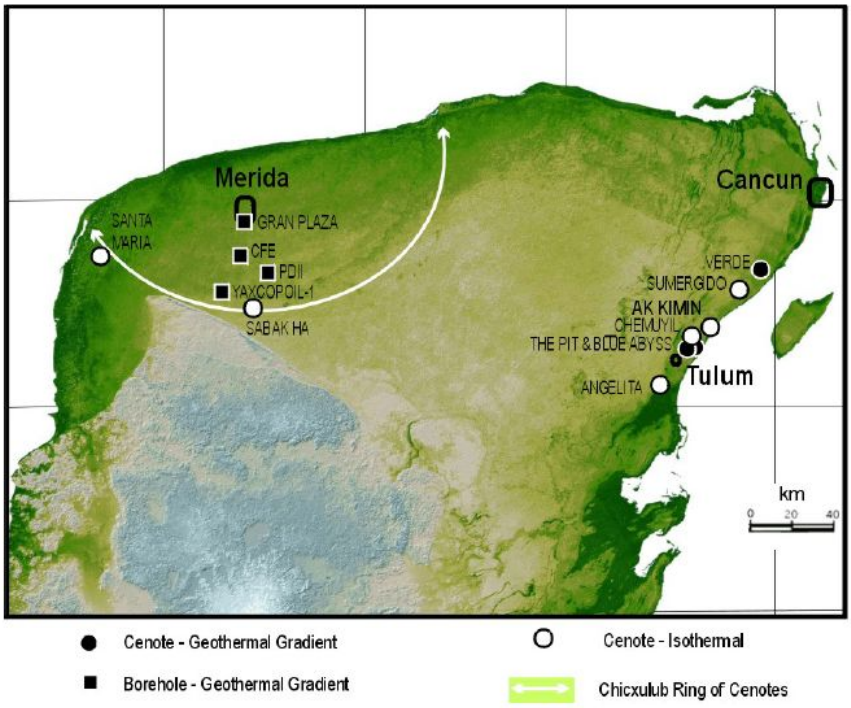


Figure 4.18 **Location of pit cenotes and boreholes profiled to more than 10 m below the MZ with isothermal and geothermal gradients in the SWZ. Base map is false colour shaded relief (no colour key available; NASA et al., 2000).**

NOW FOR SOME ACTUAL REAL FLOW DATA!!!!!

Shocking results actually

The Pit - 60 m - APRIL 2000.

THANK YOU STEVE, AND BIL, AND PIERRE, AND SAM SMITH AND EVERYONE ON THE TEAM

SIGNIFICANT FLOW APPROACHING 2 cm/s, and persistently INLAND..... That is surprisingly fast....

TIDAL - check!

However - not directly tied to the Caribbean ocean..... (see panel D) almost all sites all hydrogeo data show parallel pattern between flow velocity and Caribbean Sea Level.

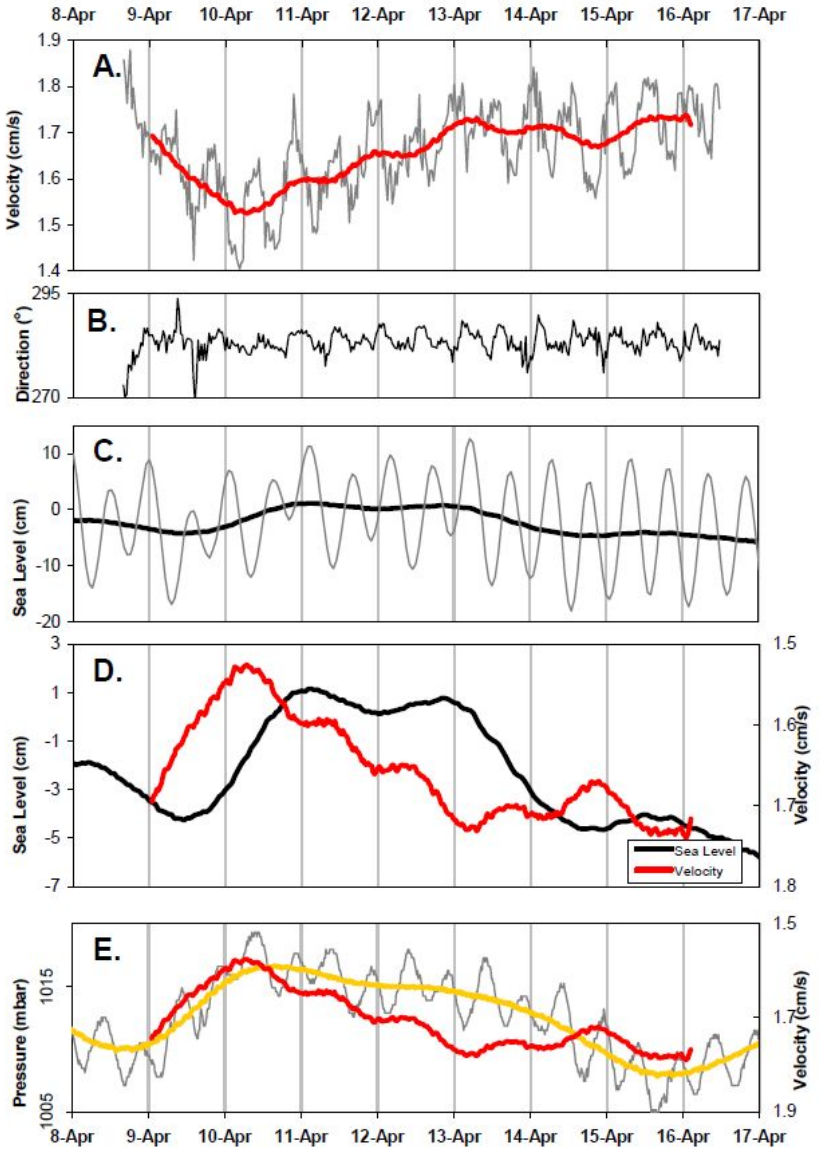
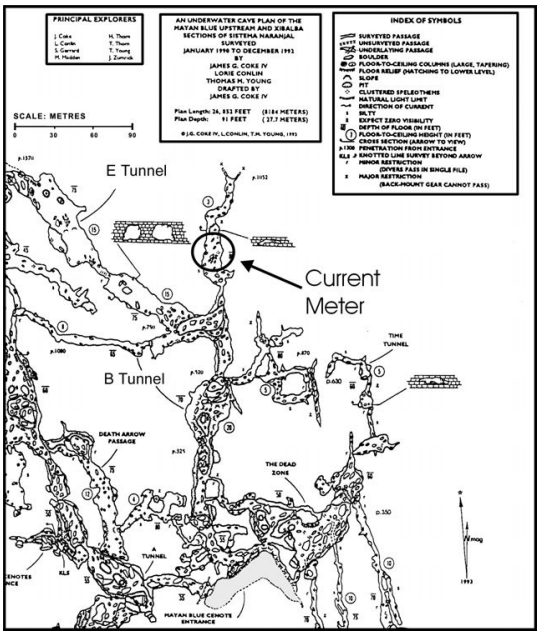


Figure 6.20 Saline groundwater velocity record at 60 m depth in the Cardea Passage in The Pit (Sistema Dos Ojos) from 8 to 16 April 2000.
A. Velocity (grey) with Pertsev filter (red)
B. Direction in which flow is to.
C. Puerto Calica sea level (grey; Badan, 2002a) with Pertsev filter (black).
D. Pertsev filter of velocity and sea level.
E. BP in Akumal (grey; CEA, unpublished data) with Pertsev filter (orange). Pertsev filter of velocity (red) plotted in reverse scale on Y2 axis.



What about others sites... how about a deep saline passage in Maya Blue?

In Maya Blue - 23 m

April 2000

Similar results

Surprisingly fast velocities - hitting 3 cm/s.

Tidal - check.

PERSISTENTLY FLOWING INLAND - AGAIN!!!!!! Whoa!!!

And similarly - panel D shows that the “average” pattern does not easily match the Caribbean Sea level.

[FYI - keep getting data fom a number of sites... but I don’t want to drown you in squiggle curves.]

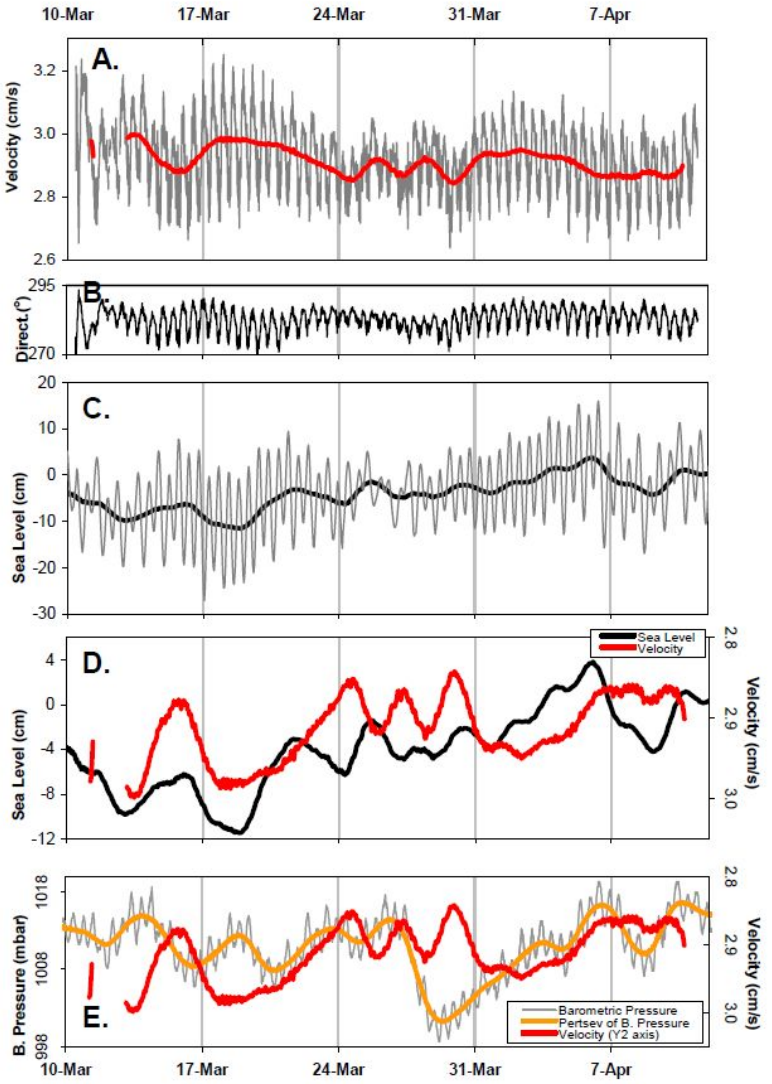


Figure 6.16 Saline groundwater velocity record from ~ 5.9 km inland near Cenote Maya Blue, Sistema Naranjal, at ~ 23 m depth, 10 March to 11 April 2000.
A. Velocity (grey) with Pertsev filter (red).
B. Flow direction.
C. Puerto Calica sea level (grey; Badan, 2002a) with Pertsev (black).
D. Pertsev filter for velocity and sea level.
E. BP for Akumal (grey; CEA, unpublished data) with Pertsev filter (orange).
Pertsev filter of velocity plotted on Y2 axis in reverse scale.

The deep aquifer is definitely flowing..... and significantly.

First of all - I think we have growing arguments for there being many different levels of aquifer, and that indeed the off-shore vents Isla Mujeres and others strongly argue for there being old fresh water deep down there that is still flowing out (see final diagram :-)).

Second - Every time I have put a decent flow meter in a deep saline passage - it shows tidal flows INLAND.

And as you know - what goes in - must come out.

If water is flowing INTO the DEEP saline passages at least some of them.... Then where is it going?

I think it is possible and even likely that we have SOME saline water flowing THROUGH the platform.

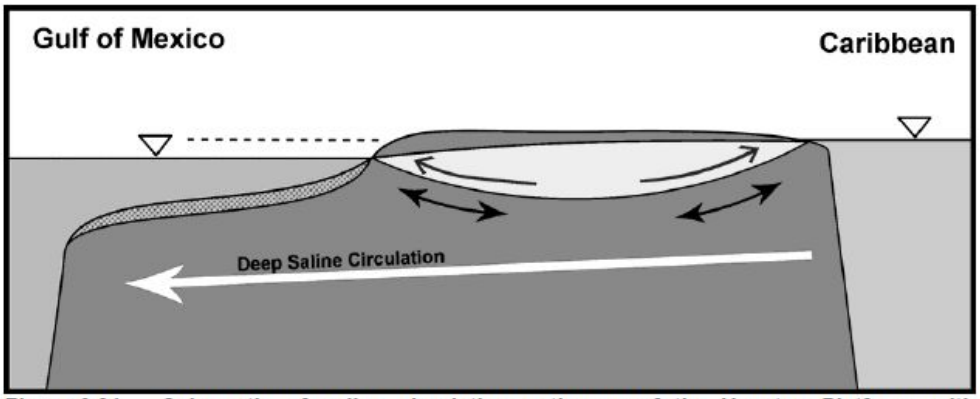


Figure 6.31 Schematic of saline circulation pathways of the Yucatan Platform, with representative velocities of the shallow saline shuttle and the deep cross-platform saline based on current meter and dye tracing data obtained in 2000 and 2001.

No - I am not bat-shit crazy.... Yet.... that I know of.

Consider that the Caribbean ocean is 40-60 cm HIGHER then the Gulf of Mexico. Shocking eh!

That is a very large gradient..... More than enough to drive flow through a platform.

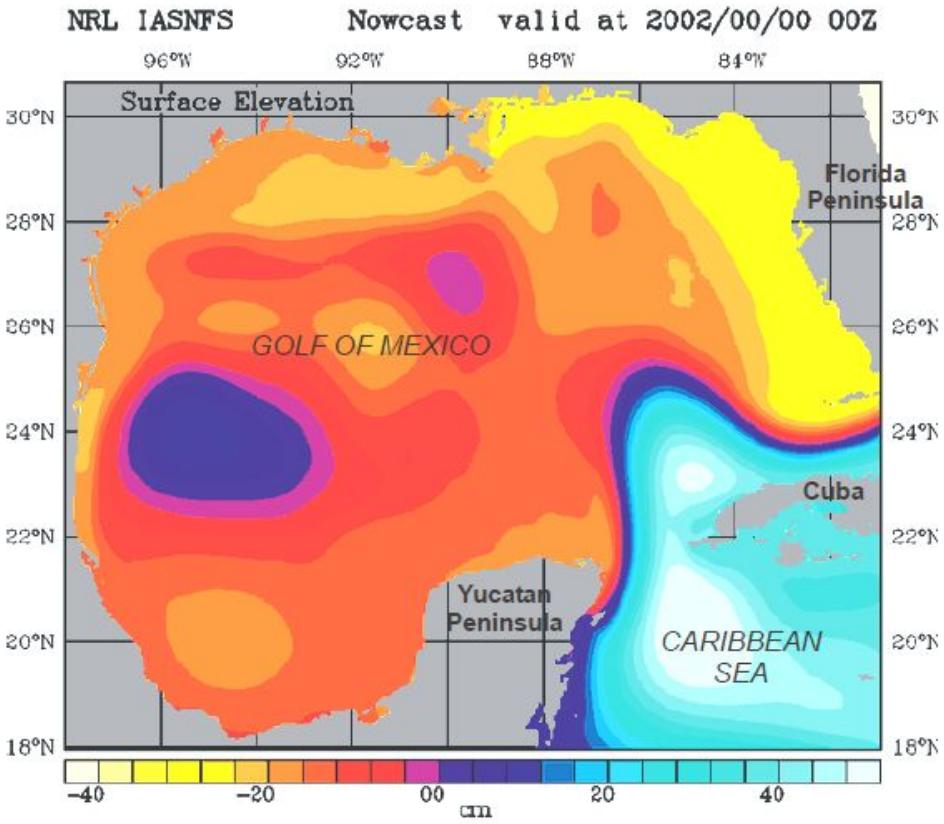


Figure 6.25Average 2002 SSH from the Experimental Real-Time Intra-Americans Sea Ocean Nowcast/Forecast System (www7320.nrlssc.navy.mil/IASNFS_WWW/)

And we know from the increasing deep exploration and from borehole data that we have deep karstification with turbulent flow tunnels - at least to the sea level low during glaciations.

Overall, I argue that we have #1 - Shallow saline shuttle directly under the mixing zone… decoupled from the fresh water flows. That was the discussion from last week.

#2 - below that - we have some deep saline sites that have persistent saline inflows…. Driven by head differences across the platform….

#3 - the door is open on there being even deeper fresh water aquifers…. Trapped down there - and that may be the source for the offshore discharges now formally documented off Isla Mujeres and some other sites (although the fishers knew about them a long time ago :-))

Like in Florida - AND common in other carbonate platforms blobally - there are likely confining layers downe there that need to be found and mapped. Between those confining layers, there are likely trapped waters…. And those will have their own circulations…. And they may still be largely fresh.

I argue that this is not only possible but increasingly likely given the actual field data and observation.