PSSecondary Basins and Sediment Pathways in Green Canyon, Deepwater Gulf of Mexico*

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Abstract

Regional WAZ RTM seismic calibrated to well data has been interpreted to investigate the distribution and depositional history of secondary basins across the Green Canyon protraction area, deepwater Gulf of Mexico. Where well control is limited, relative ages were interpreted based on proximity to seafloor, structural style, and relationships in the growth stratigraphy. A variety of structural styles are observed in the secondary basins: 1) basins welded on top of the primary basin section; 2) basins that have subsided into a salt feeder, some extending down to the autochthonous salt level (aka "bucket weld" basins); 3) basins encased in salt; 4) stacked basins separated by a weld or salt; 5) expulsion roll-over basins; and 6) basins with highly asymmetric growth stratigraphy. Top and base of salt, salt welds, and the top primary basin surface were utilized to generate accurate gross isochore maps in complex areas near salt feeders, significant salt overhangs, multiple salt welds, and stacked basins. Isochore maps indicate that secondary basin deposition began in the early Middle Miocene, forming a NE-SW trending arc across the Green Canyon protraction area. This trend was further in-filled with new basins during the Late Miocene. In general, Miocene basins are relatively symmetrical and were prone to becoming partially or fully encased by salt. During the Pliocene, the existing basins aggraded while new basins were deposited by in-filling both up-slope and down-slope of the earlier Miocene basin trend. In the Pleistocene, deposition of new basins occurred down-slope of the Plio-Miocene basins, resulting in the inflation of the salt canopy towards the southeast. It is common for the Plio-Pleistocene basins to be highly asymmetric, to prograde to form expulsion roll-overs, or form "bucket weld" basins over 25,000 feet thick. Sediment pathways evolve from broad corridors in the primary basins between salt feeders and walls during the Early Miocene to narrower pathways between both primary and secondary basins during the Miocene, and finally to secondary basin-to-secondary basin routes during the Plio-Pleistocene.

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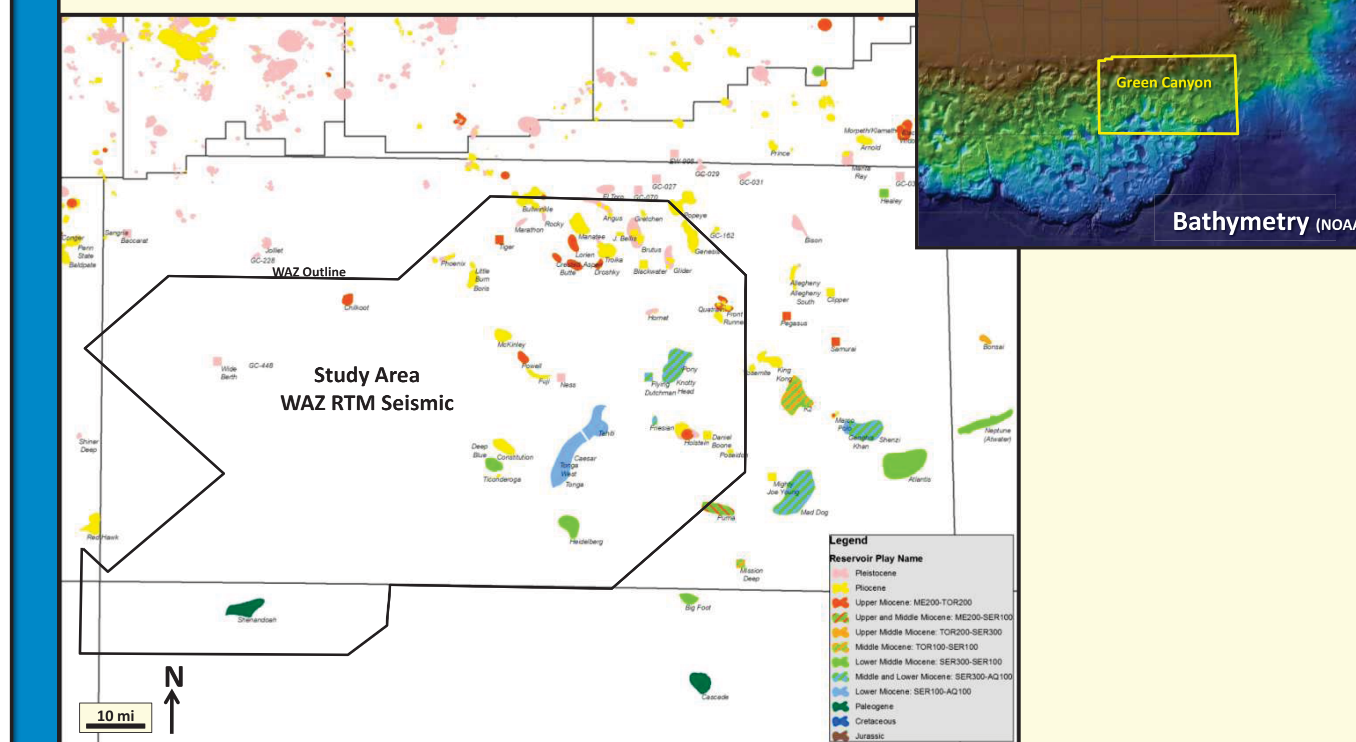
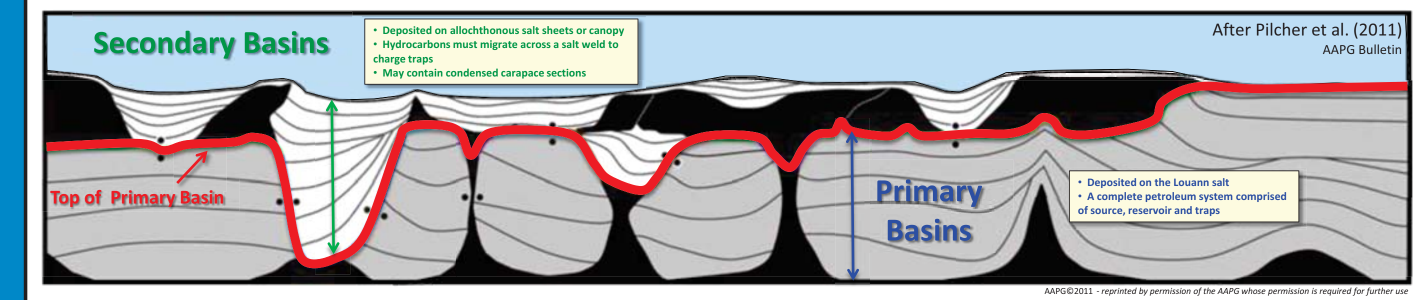
Regional WAZ RTM seismic calibrated to well data has been interpreted to investigate the distribution and depositional history of secondary basins across the Green Canyon protraction area, deepwater Gulf of Mexico. Where well control is limited, relative ages were interpreted based on proximity to seafloor, structural style, and relationships in the growth stratigraphy. A variety of structural styles are observed in the secondary basins: 1) basins welded on top of the primary basin section; 2) basins that have subsided into a salt feeder, some extending down to the autochthonous salt level (aka "bucket weld" basins); 3) basins encased in salt; 4) stacked basins separated by a weld or salt; 5) expulsion roll-over basins; 6) relatively symmetric basins with stacked depocenters; and 7) basins with highly asymmetric growth stratigraphy. Top and base of salt, salt welds, and the top primary basin surface were utilized to generate accurate gross isochore maps in complex areas near salt feeders, significant salt overhangs, multiple salt welds, and stacked basins. Isochore maps indicate that secondary basin deposition began in the early Middle Miocene, forming a NE-SW trending arc across the Green Canyon protraction area. This trend was further in-filled with new basins during the Late Miocene. In general, Miocene basins are relatively symmetrical and were prone to becoming partially or fully encased by salt. During the Pliocene, the existing basins aggraded while new basins were deposited by in-filling both up-slope and down-slope of the earlier Miocene basin trend. In the Pleistocene, deposition of new basins occurred down-slope of the Plio-Miocene basins, resulting in the inflation of the salt canopy towards the southeast. It is common for the Plio-Pleistocene basins to be highly asymmetric, to prograde to form expulsion roll-overs, or form "bucket weld" basins over 25,000' thick. Sediment pathways evolve from broad corridors in the primary basins between salt feeders and walls during the Early Miocene to narrower pathways between both primary and secondary basins during the Mid-to-Late Miocene, and finally to secondary basin-to-secondary basin routes during the Plio-Pleistocene.

Study Area: Green Canyon Protraction Area

Fields & Discoveries by Reservoir Age

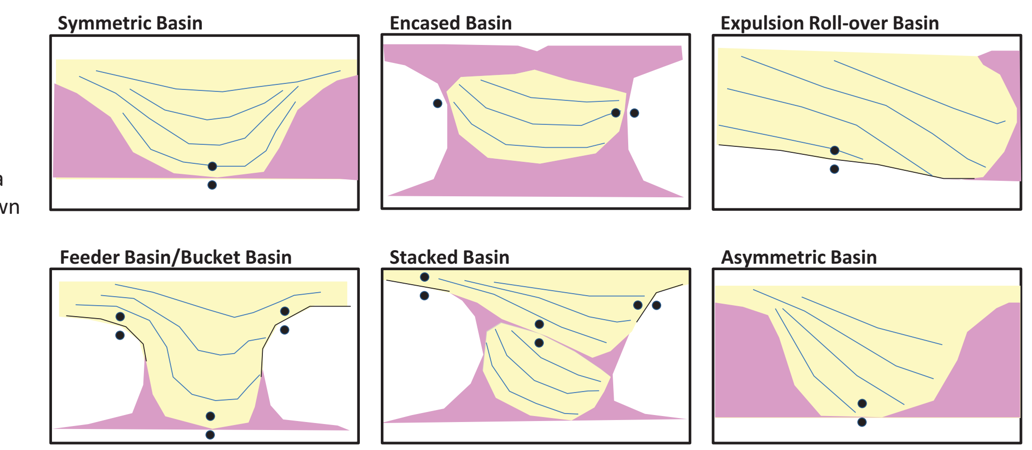
(Field Outlines modified from IHS Energy source data)

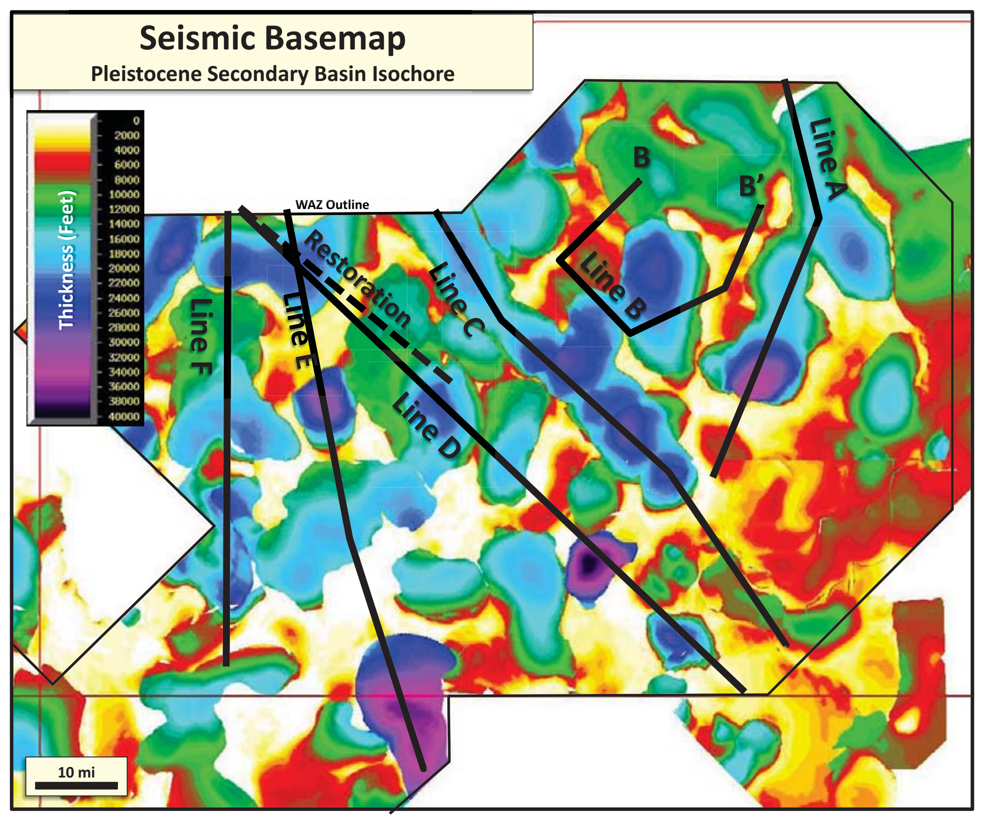


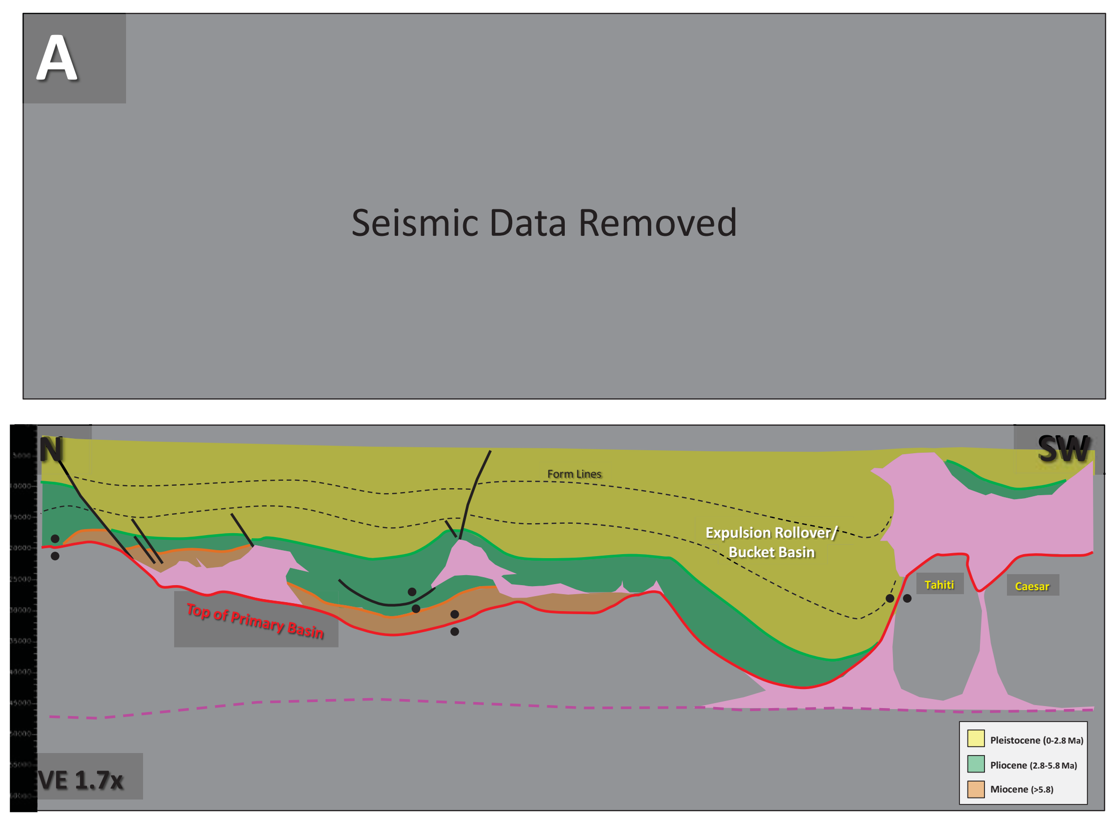


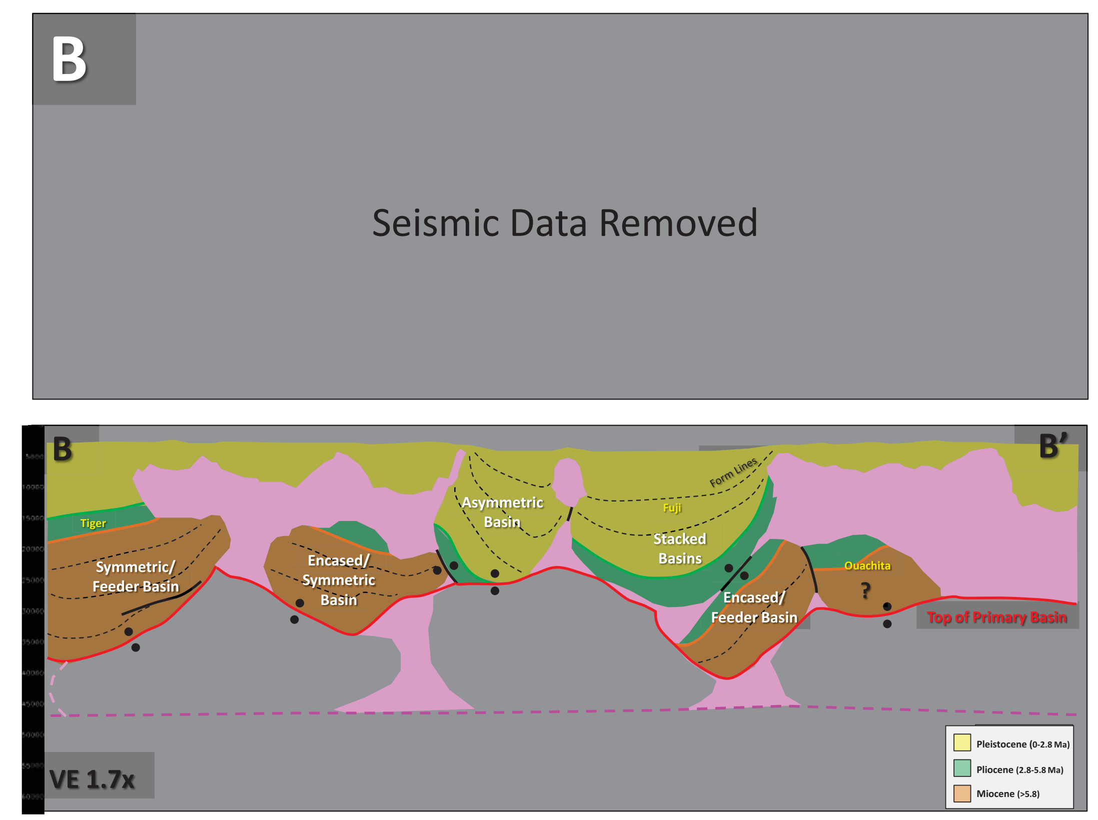
Observed Structural Styles of Secondary Basins

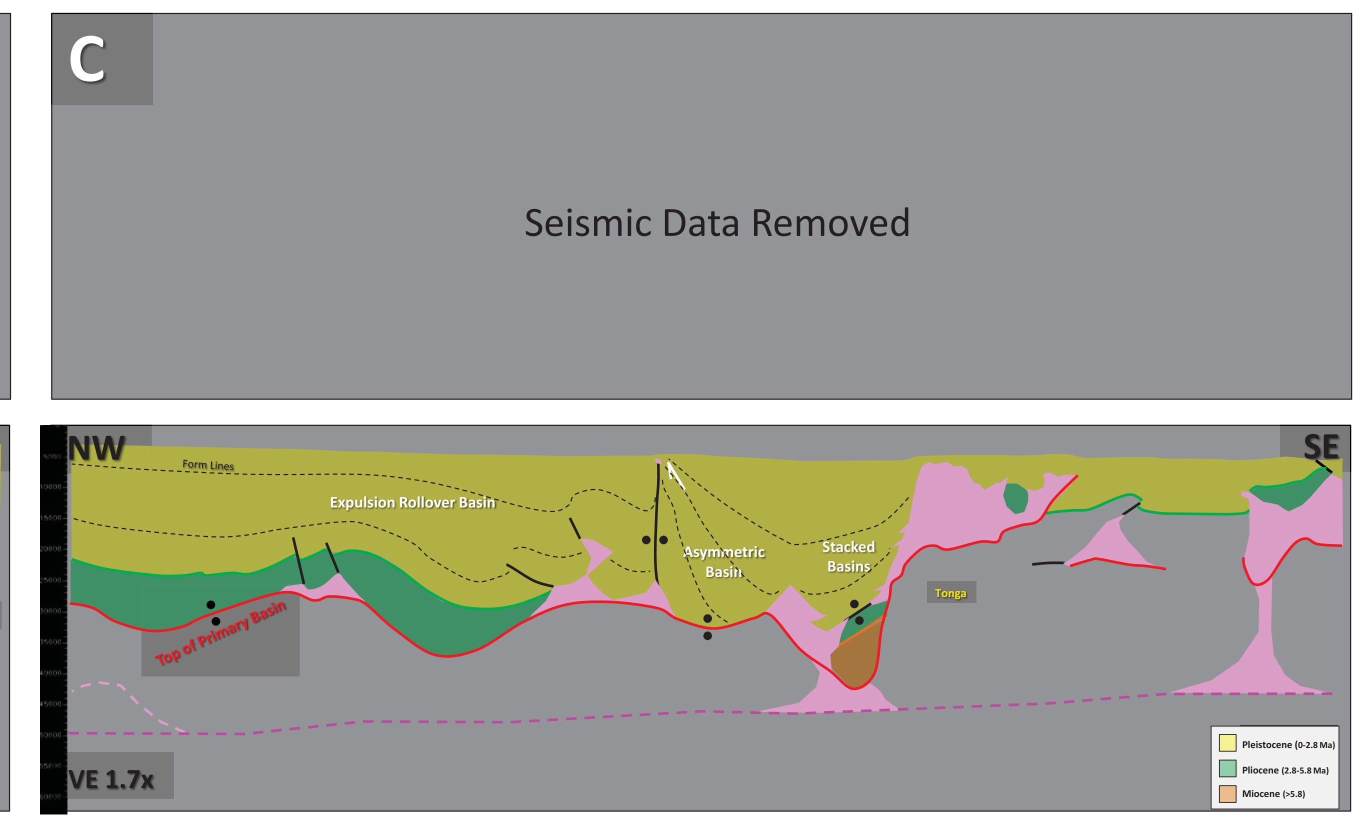
- Symmetric basins with stacked depocenters
- Basins welded on top of the primary basin section
- Basins that have subsided into a salt feeder, some extending down to the autochthonous salt level (aka "bucket weld" basins)
- Basins encased in salt
- Stacked basins separated by a weld or salt
- Expulsion roll-over basins
- Basins with highly asymmetric growth stratigraphy



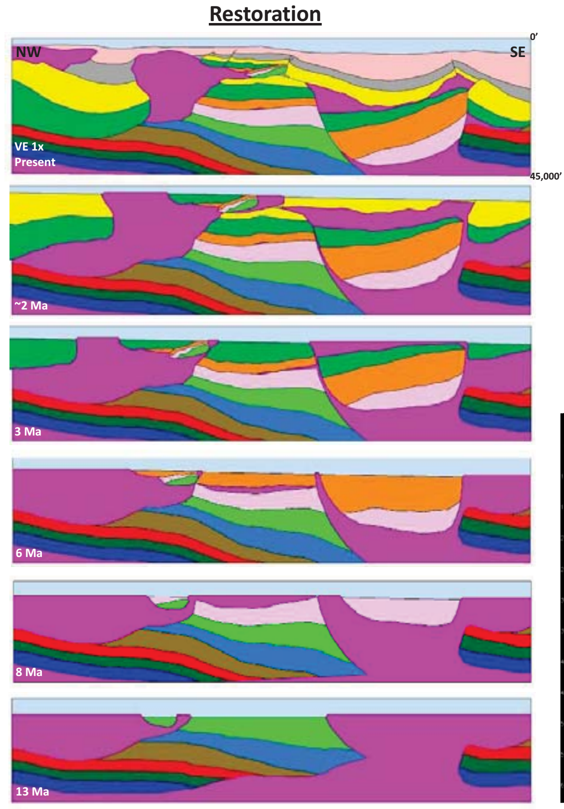


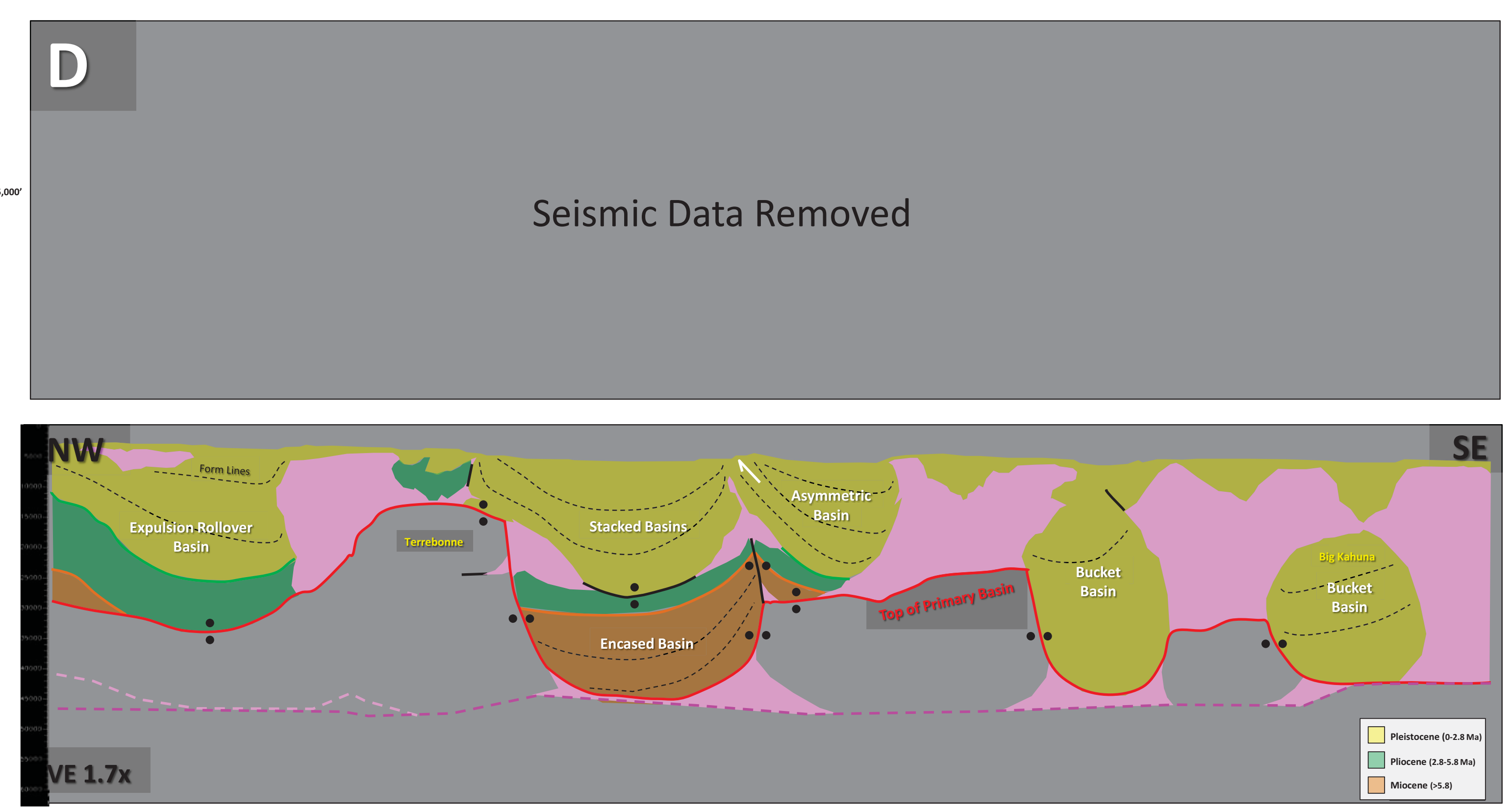


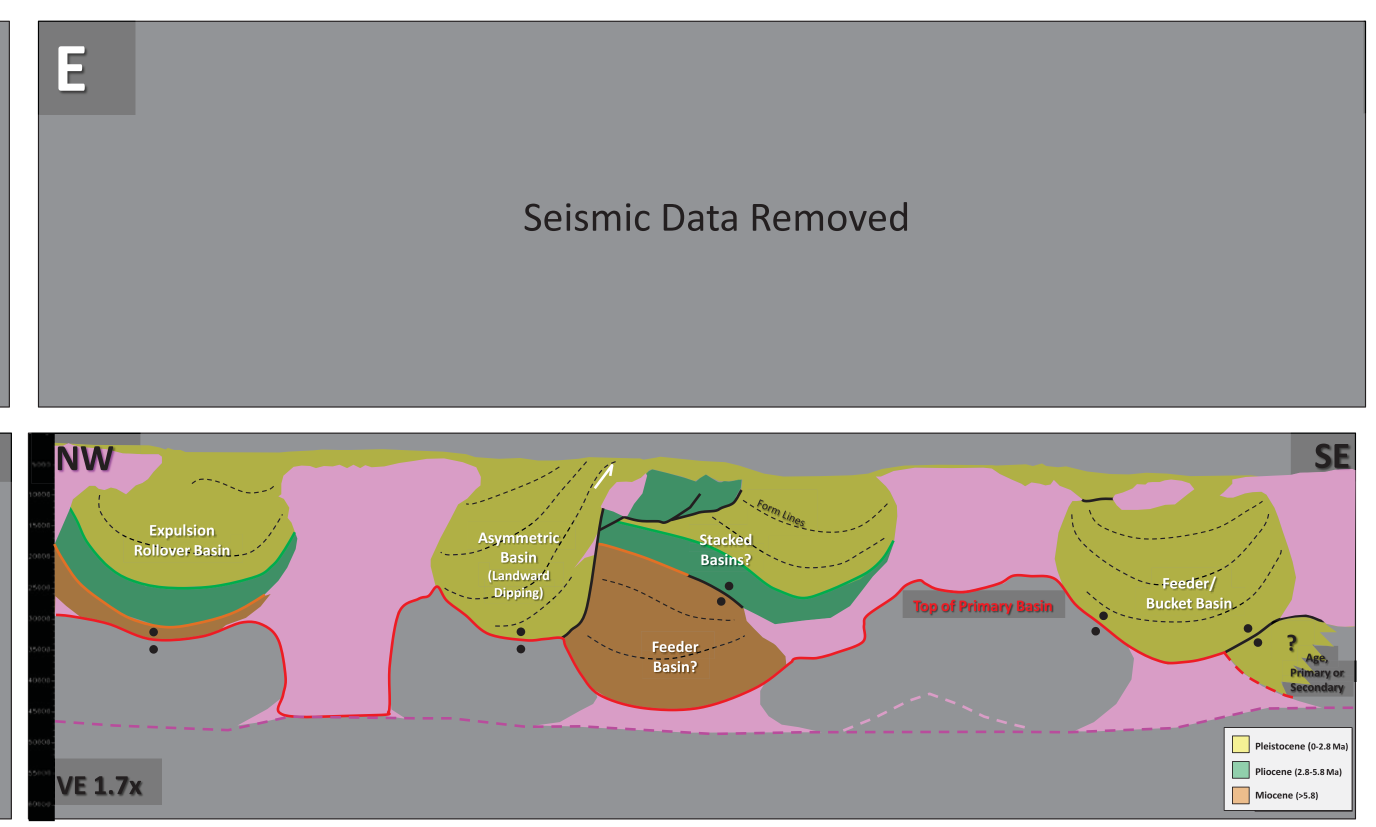


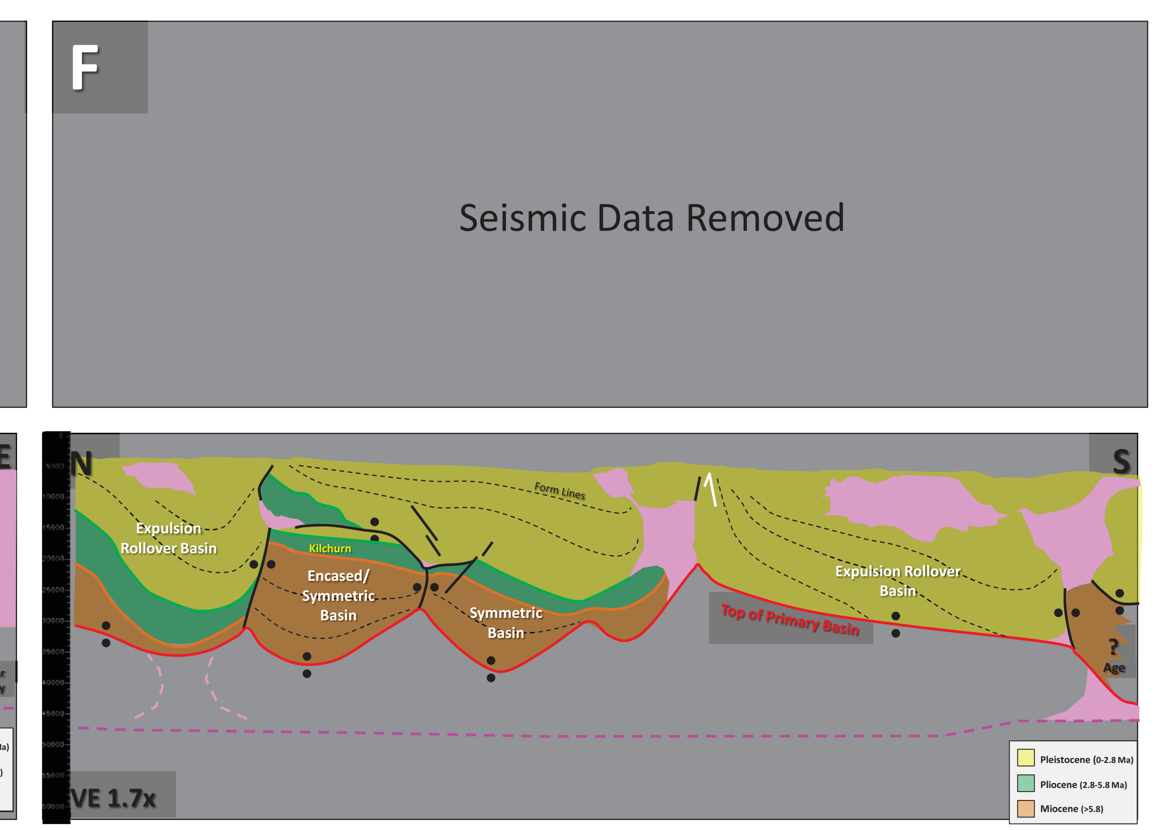


Restoration









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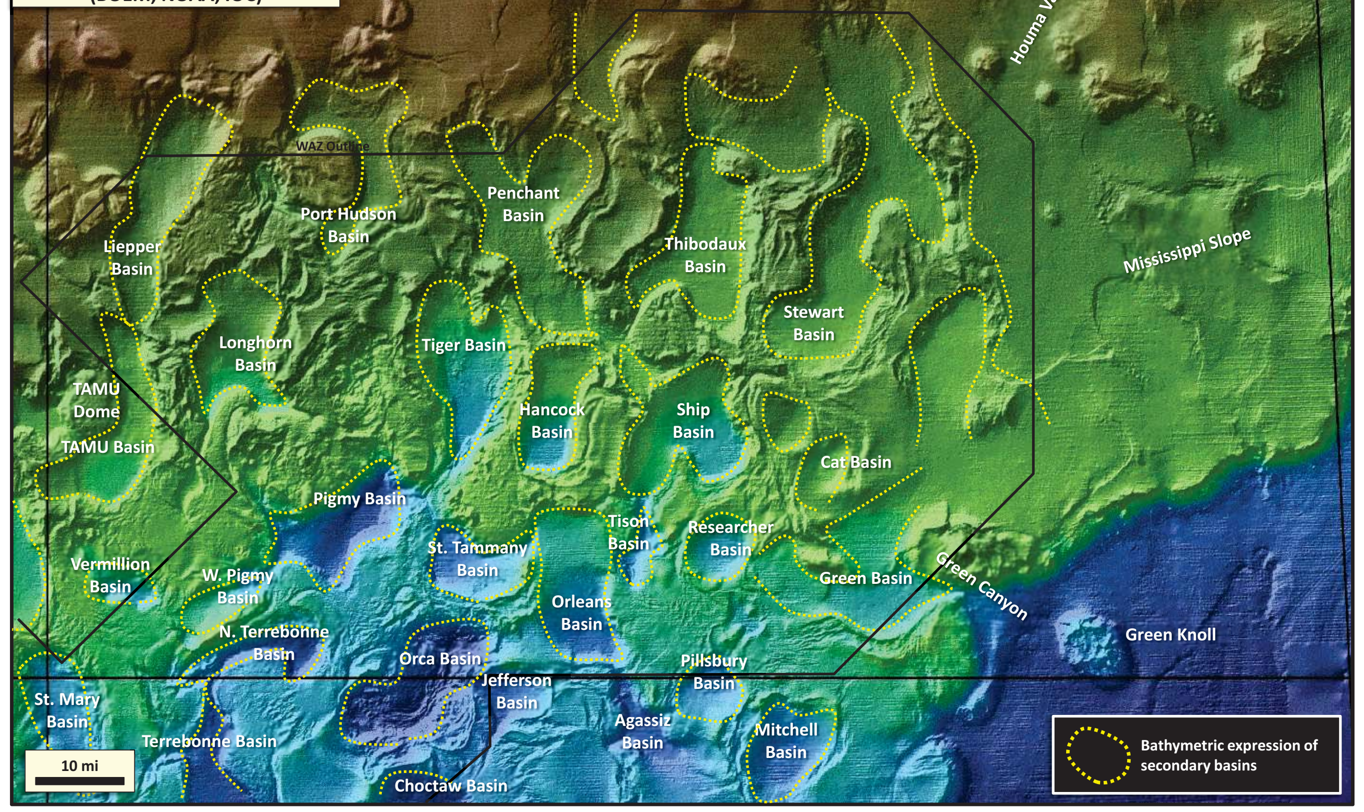
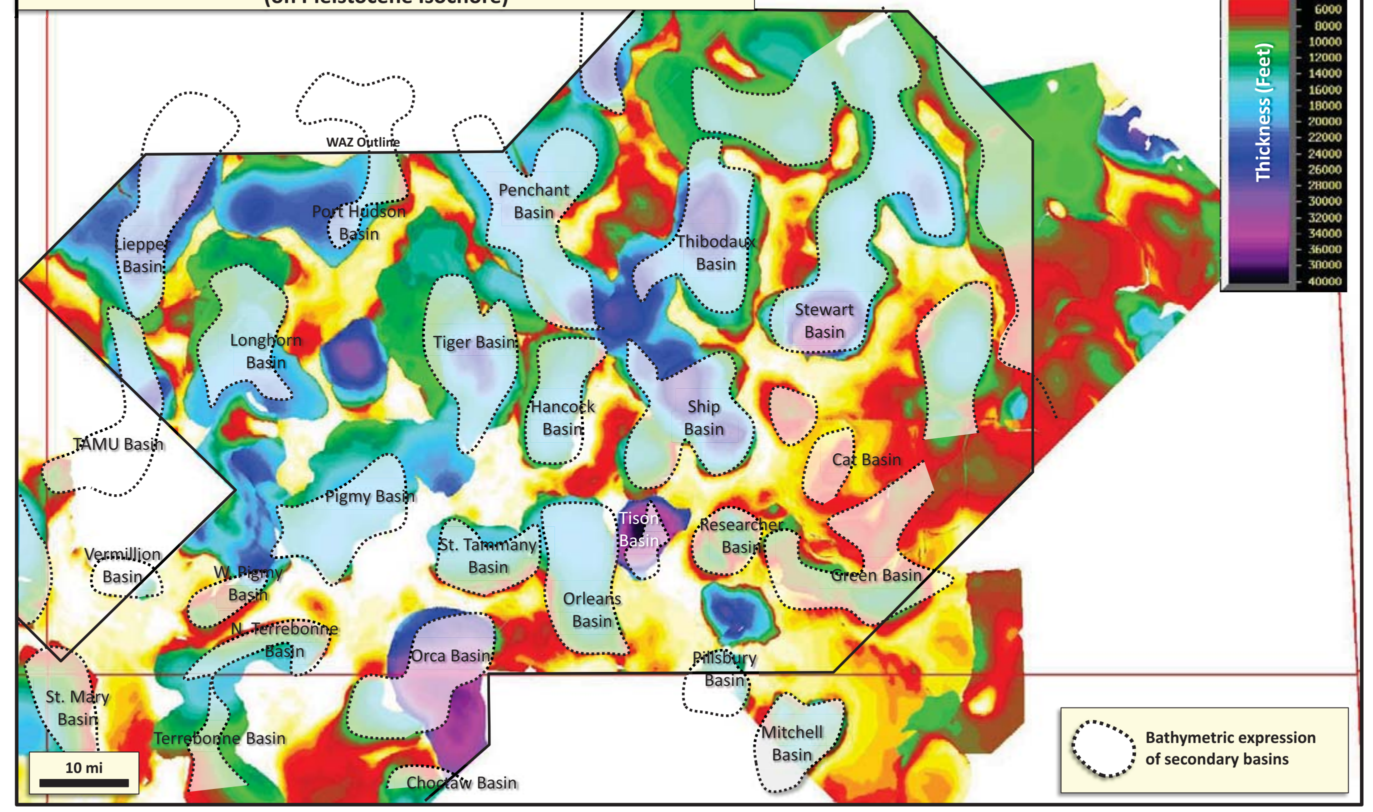
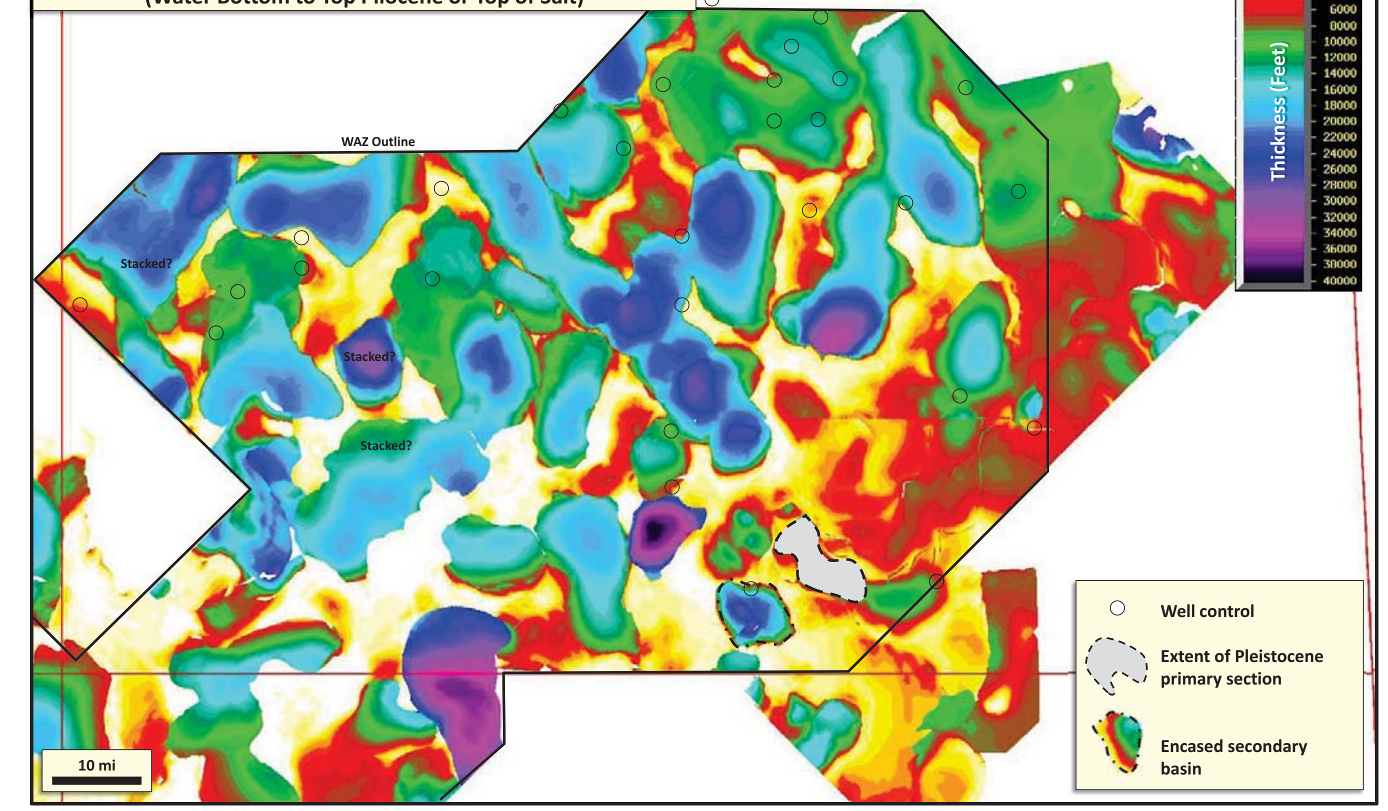
Bathymetry
(BOEM, NOAA, IOC)



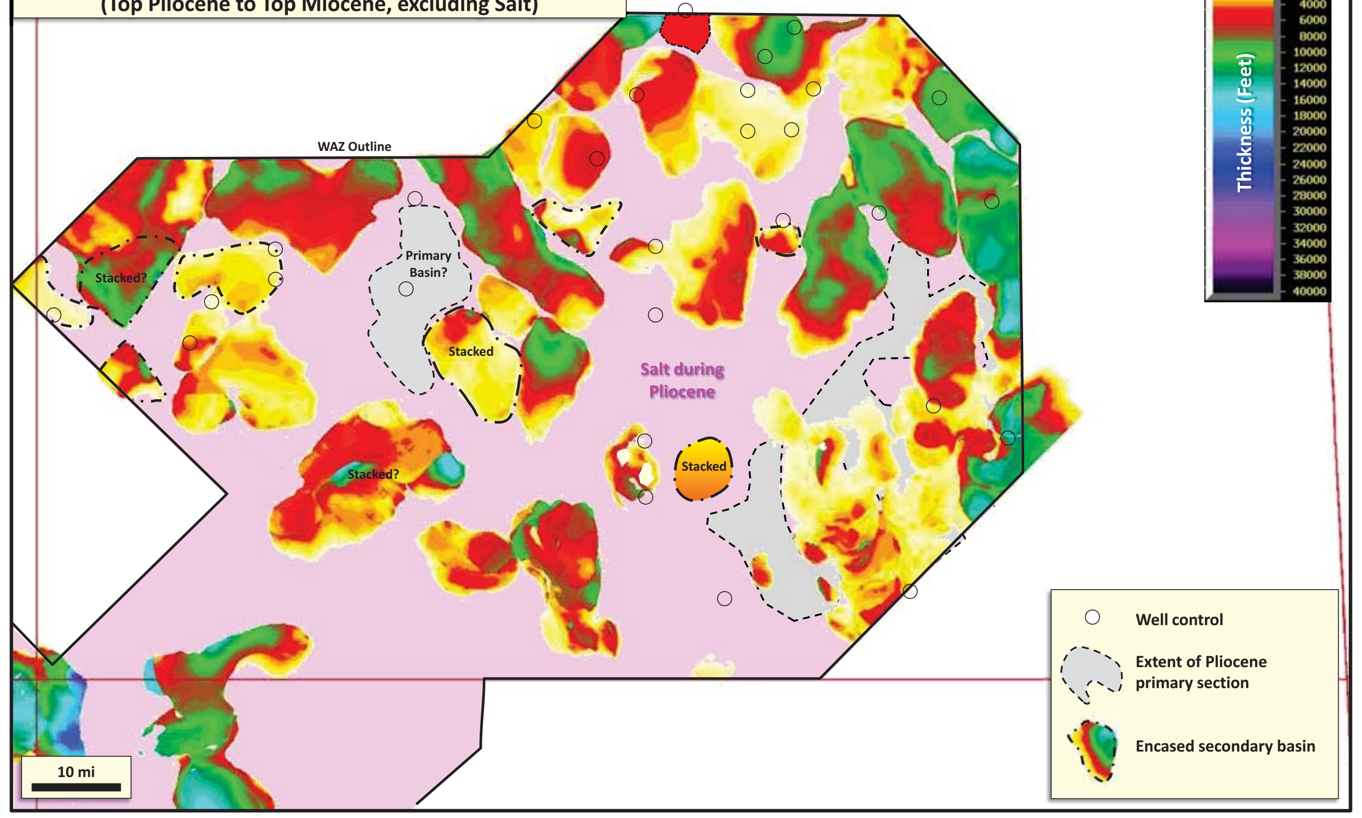
Bathymetric Expression of Secondary Basins
(on Pleistocene Isochore)



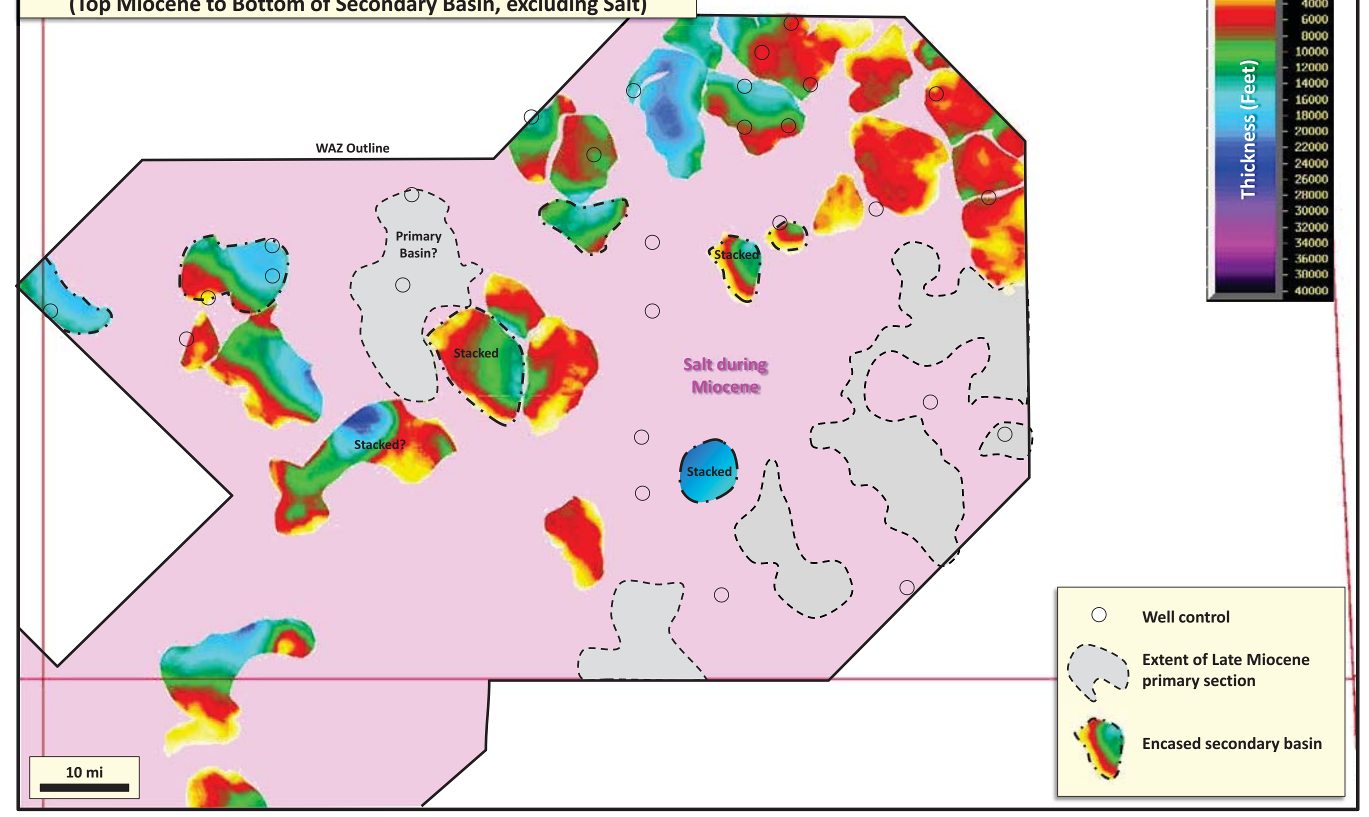
Pleistocene Secondary Basin Isochore
(Water Bottom to Top Pliocene or Top of Salt)



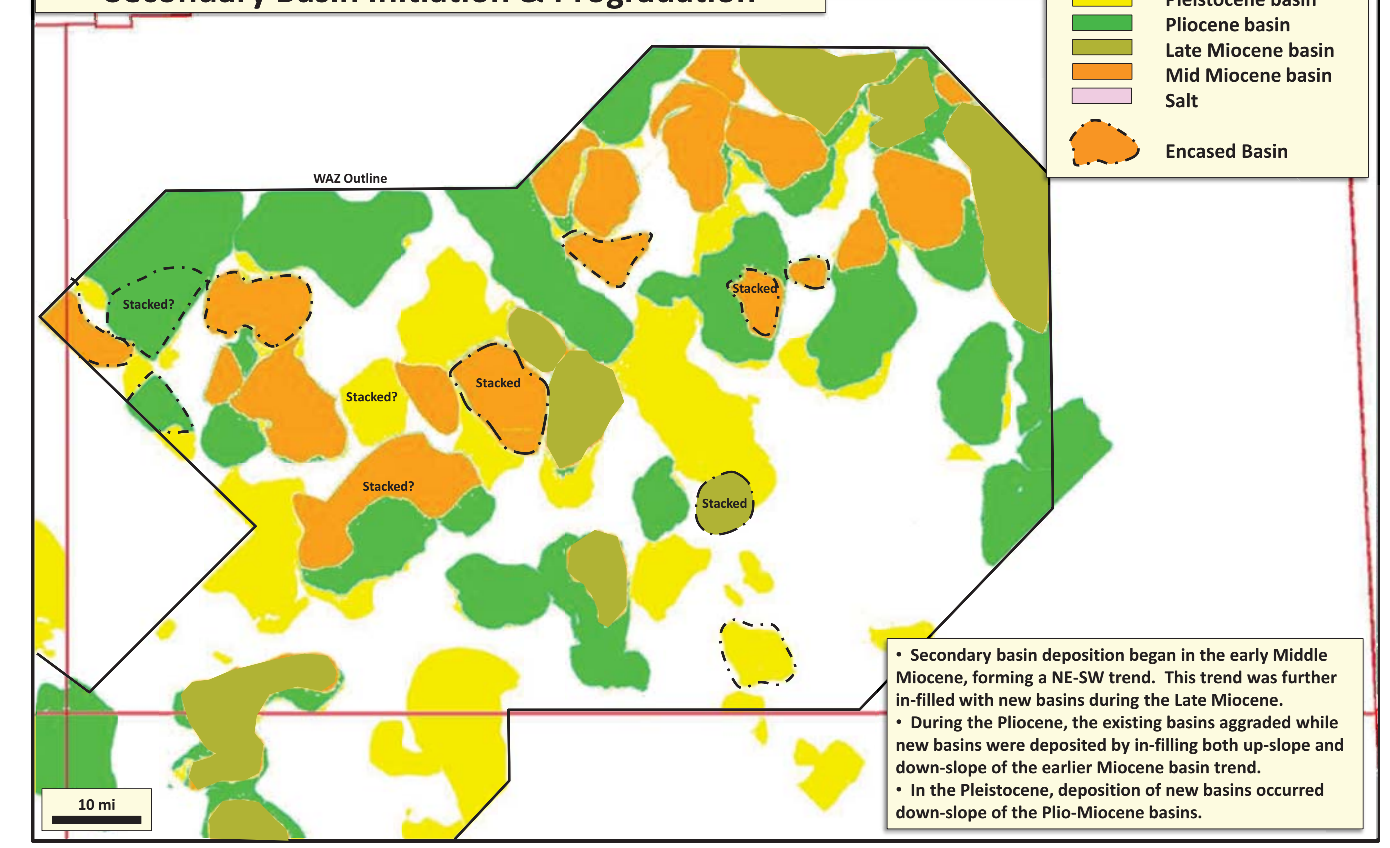
Pliocene Secondary Basin Isochore
(Top Pliocene to Top Miocene, excluding Salt)



Miocene Secondary Basin Isochore
(Top Miocene to Bottom of Secondary Basin, excluding Salt)



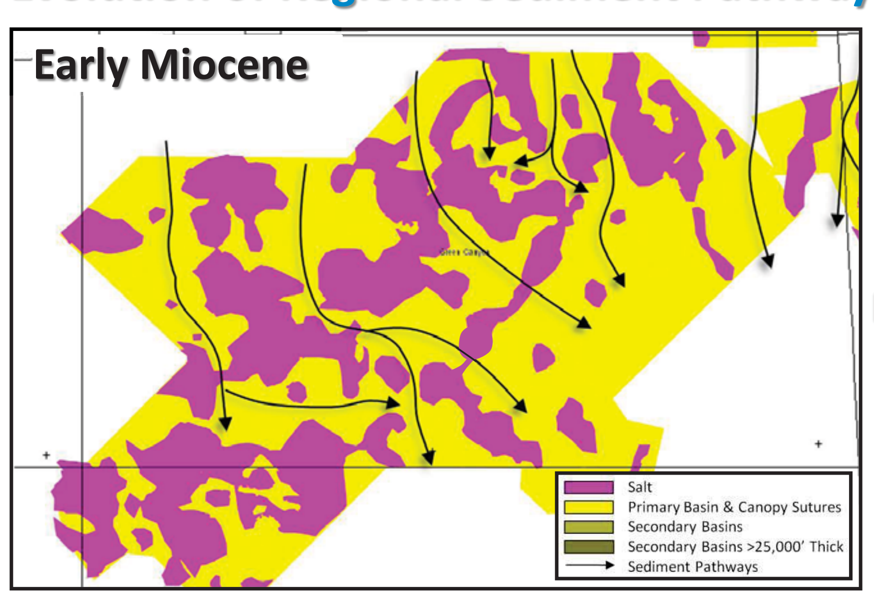
Secondary Basin Initiation & Progradation



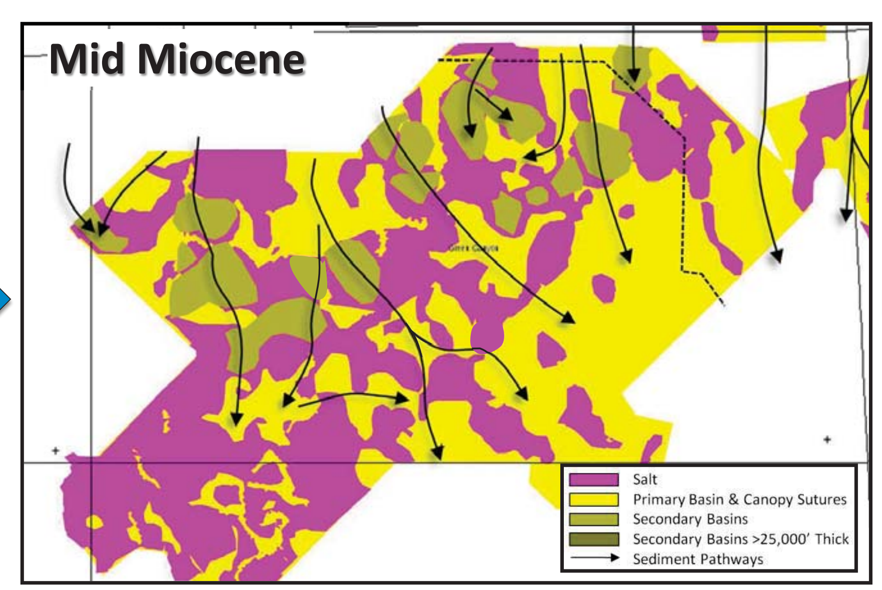
- Secondary basin deposition began in the early Middle Miocene, forming a NE-SW trend. This trend was further in-filled with new basins during the Late Miocene.
- During the Pliocene, the existing basins aggraded while new basins were deposited by in-filling both up-slope and down-slope of the earlier Miocene basin trend.
- In the Pleistocene, deposition of new basins occurred down-slope of the Plio-Miocene basins.

Evolution of Regional Sediment Pathways

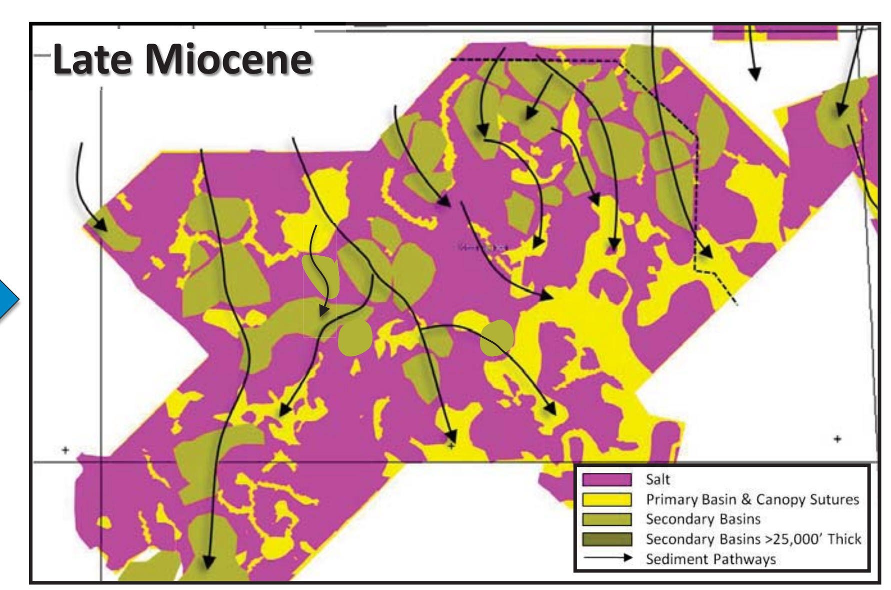
Early Miocene



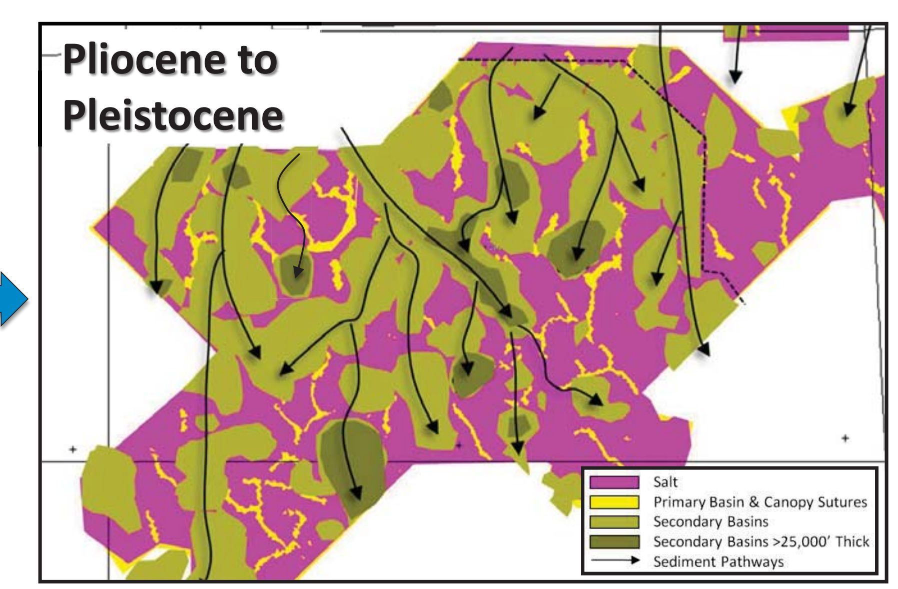
Mid Miocene



Late Miocene



Pliocene to Pleistocene



Sediment pathways evolve from broad corridors in the primary basins between salt feeders and walls during the Early Miocene to narrower pathways between both primary and secondary basins during the Miocene, and finally to secondary basin-to-secondary basin routes during the Plio-Pleistocene.

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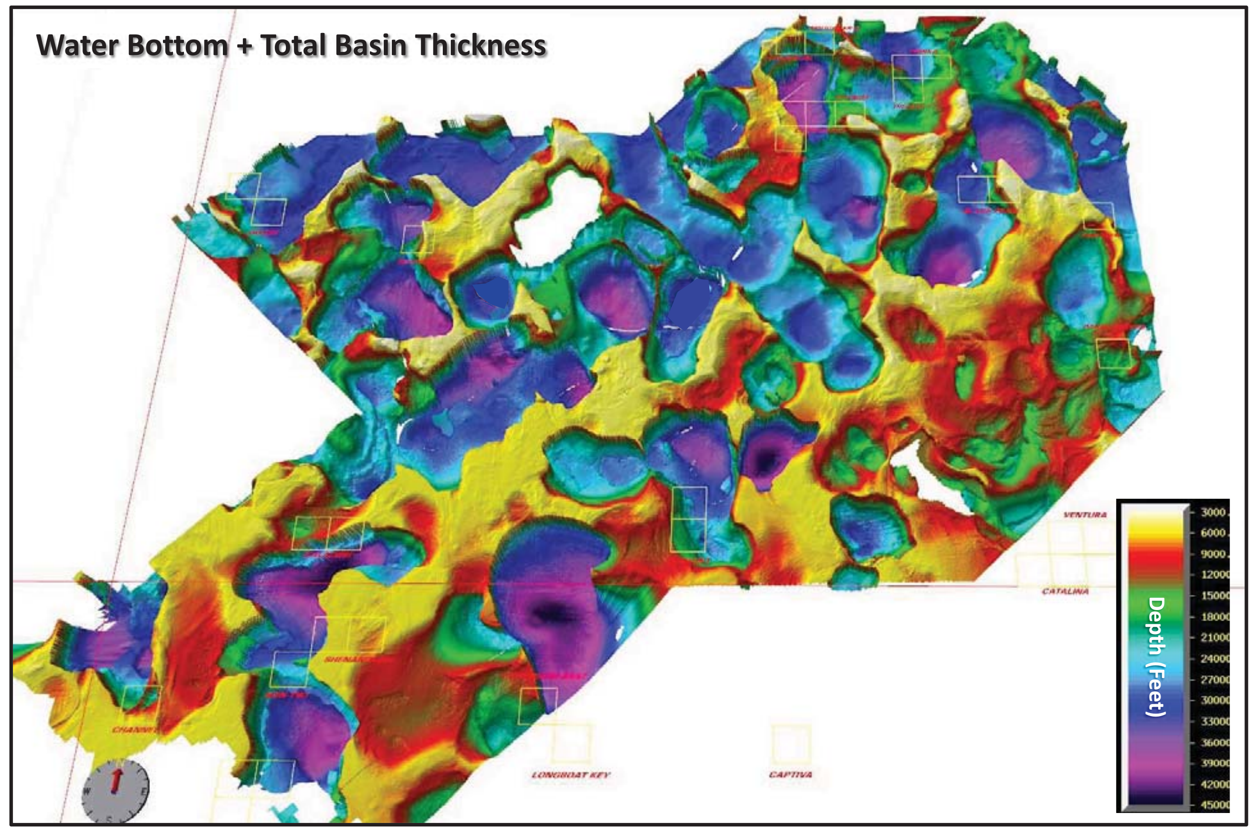
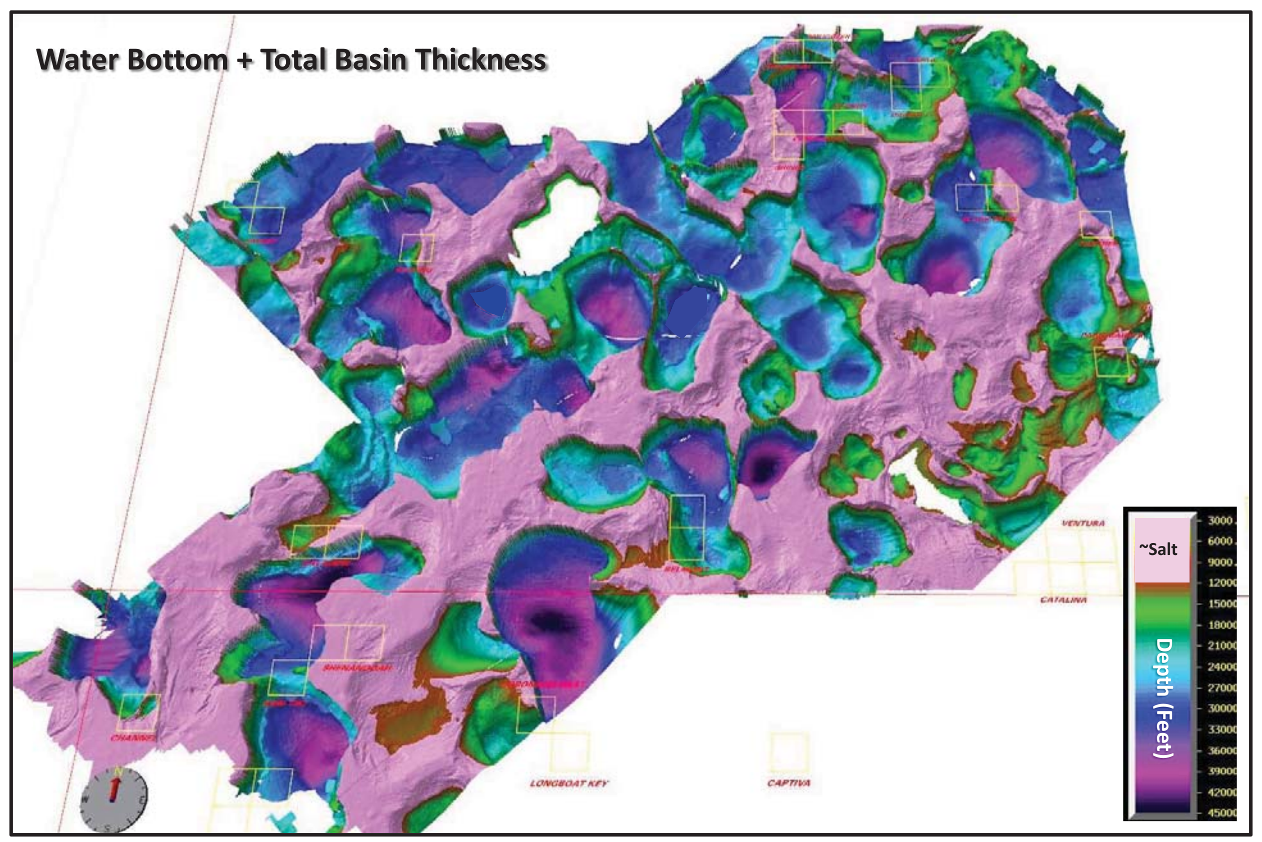
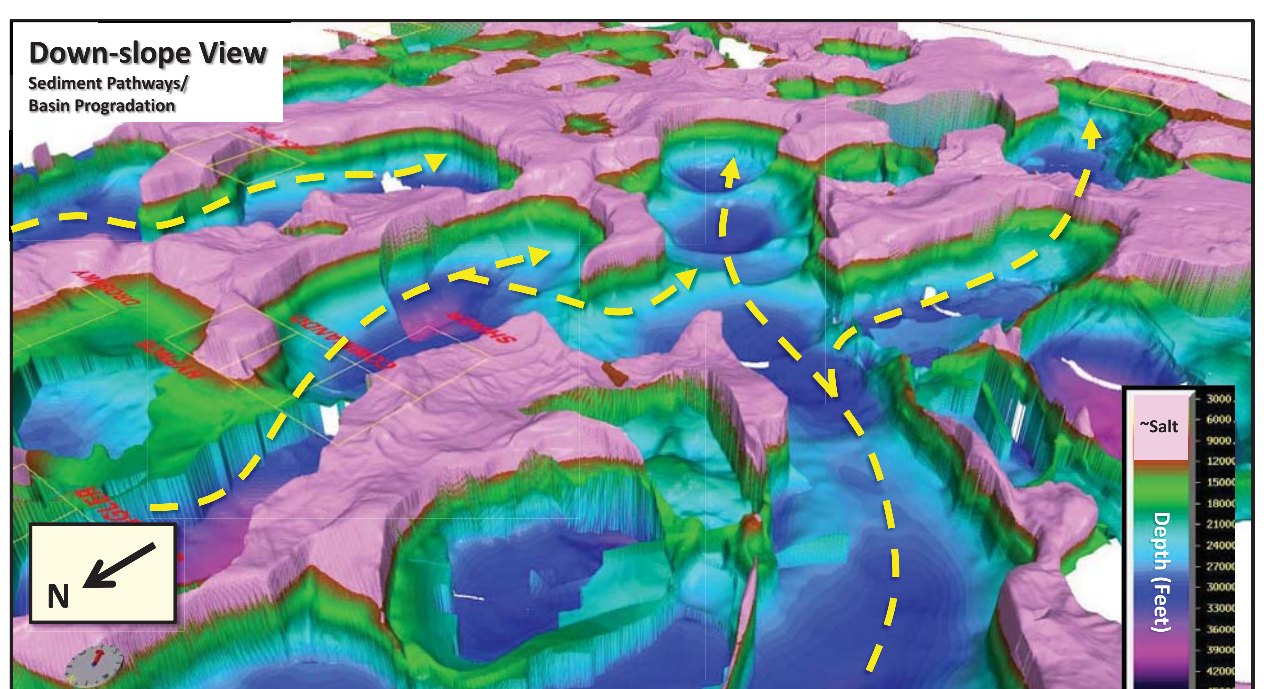
Visualization of Secondary Basins



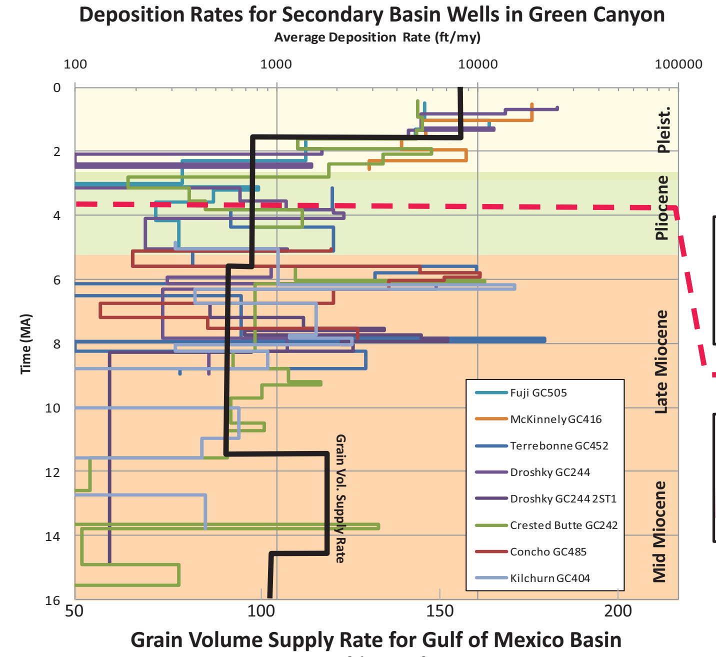




Conclusions & Discussion

- Miocene basins tend to be relatively symmetric and commonly partially-to-fully encased by salt.
  - Miocene basins were deposited onto an extensive salt canopy system sparsely populated by other basins.
  - Moderate-to-low deposition was favorable to basin aggradation and depocenter stacking.
  - Salt flowed out from underneath the basins in a simple fashion that favored the formation of symmetrical basins by density-driven subsidence, decay of salt topography, or other mechanisms of Hudec et al. (2008).
- Plio-Pleistocene basins tend to form either asymmetric basins, extremely thick feeder basins (bucket basins), or expulsion roll-over basins.
  - Pleistocene deposition was greater than in the Miocene, resulting in seaward stepping depocenters in most asymmetric basins (e.g., Hudec et al., 2008) , progradation of the expulsion roll-over basins, and down-building of the thick Pleistocene feeder basins (bucket weld basins).
  - With increased deposition, accommodation due to salt canopy evacuation became limited in existing basins in the Mid Pliocene, leading to fairway avulsion and a new wave of basin initiation. New basins forming during the Plio-Pleistocene were deposited in the areas between the adjacent Miocene basins.
  - Juxtaposition of new and old basins of varying shapes and thickness created complex pathways for salt flow, resulting in asymmetric withdrawal and deposition in some basins. The occurrence of both sea- and land-ward stepping asymmetric basins suggests that basin asymmetry is not controlled solely by depositional processes.
  - The adjacent Miocene basins were partially or fully encased by salt in response to canopy evacuation from beneath the adjacent thickening and/or prograding Plio-Pleistocene basins.

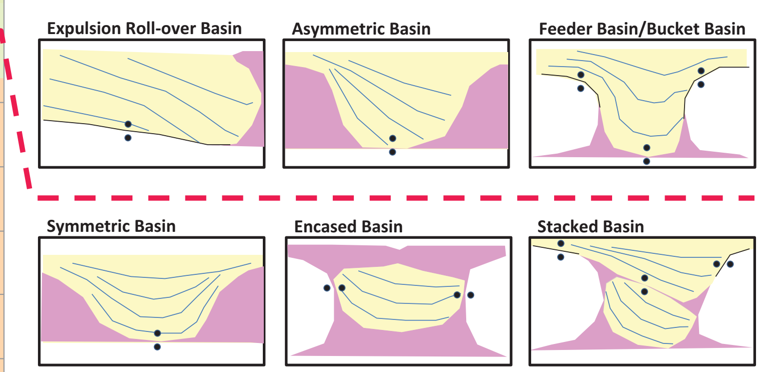
Deposition Rates for Secondary Basin Wells in Green Canyon



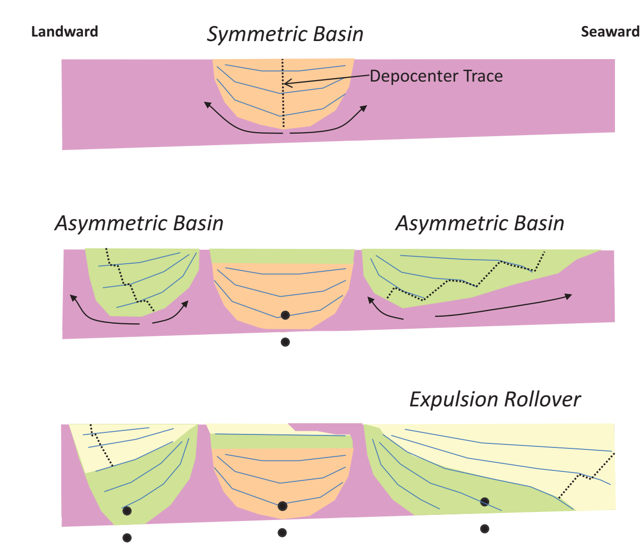
Grain Volume Supply Rate for Gulf of Mexico Basin (km^3 / Ma x 10^3)

Galloway et al. (2011)

Observed Structural Styles of Secondary Basins



Cross-section Model



Miocene
- Basins developed in an extensive salt canopy
- Salt flowed out from under the basins in a simple fashion favoring the formation of symmetric basins

Pliocene
- New basins developed between the aggrading older basins
- Juxtaposition of younger and older basins of varying shapes and thickness created complex pathways for salt flow, resulting in asymmetric withdrawal and deposition.

Pleistocene
- Increased deposition
- Progradation of expulsion roll-over basins and aggradation of the thick feeder basins (bucket weld basins)

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