The Paleogeography of the Lacustrine Rift System of the Pre-Salt in Santos Basin, Offshore Brazil*

Marcos Fetter[1], Henrique Penteado[1], Vanessa Madrucci[1], and Adali Spadini[1]

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[1]E&P, Petrobras, Rio de Janeiro, RJ, Brazil (fetter@petrobras.com.br)

Abstract

The Santos Basin, in Southeastern Brazil, comprises one of the most expressive lacustrine rift systems developed during the breakup of the Gondwana supercontinent in the Lower Cretaceous. The associated petroleum system is responsible for world-class discoveries during the last decades. In this work, we discuss some aspects related to the evolution of this lacustrine system.

At the Hauterivian/Barremian transition, the stretching phase of the rift formed deep depocenters associated with the main faults oriented to NNE and characterized by extensive volcanism. The half grabens produced by mechanical subsidence controlled the paleogeography of the lakes; the syn-rift sedimentation was characterized mostly by fine-grained siliciclastic rocks, including Mg-silicates.

By the end of the Barremian, mudstone facies with variable siliciclastic and carbonate content, including high TOC intervals, were deposited in brackish-saline water lakes at wider depocenters generated at the onset of the thinning phase of the rift, with growing influence of thermal subsidence. Porous bivalve coquinas were deposited at the crests of tilted fault blocks. In the Aptian, fault activity migrated towards the East, with the development of low-angle detachments. The full development of the thinning phase during the Aptian, with thermal subsidence at high rates and active detachments, produced the expansion of the lake system, in which volcanism was less intense.

An important regional unconformity is recognized in the Lower Aptian and above it, a carbonate sequence was deposited. Stromatolites and grainstones/rudstones are the most important reservoirs, deposited at structural highs controlled by the active normal faults and detachments, while fine-grained limestones with variable content of siliciclastics defined the background sedimentation in the sublittoral/profundal environments. Authigenic Mg-silicates, including kerolite, sepiolite and stevensite sometimes occur associated with carbonate facies and are indicative of alkaline conditions.

By the end of the Aptian at the exhumation phase, just before breakup, the carbonate sequence was covered by a thick salt layer. At that time, the connection between the lacustrine system and the South Atlantic Ocean had already been established.

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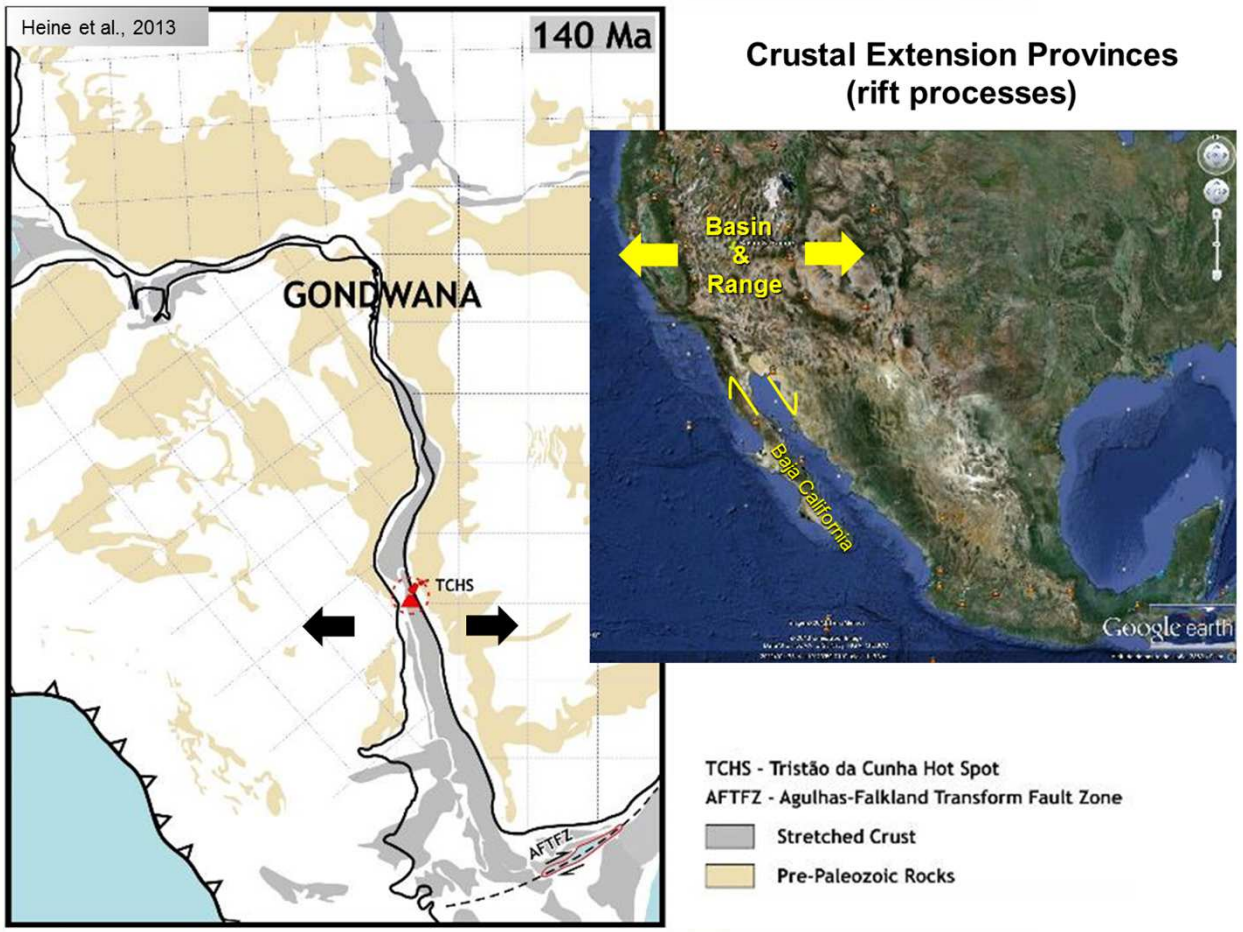
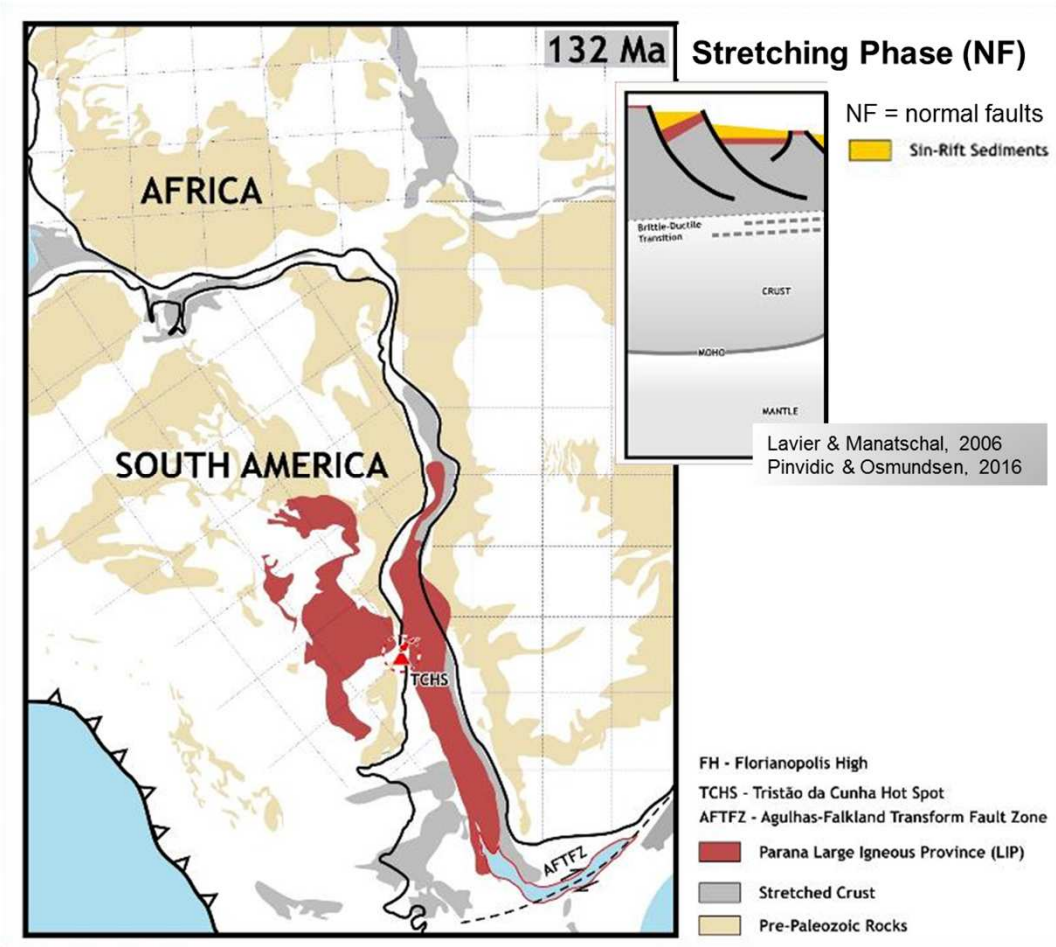
ACE 101: Bridging Fundamentals and Innovation

During the Lower Cretaceous transgression…

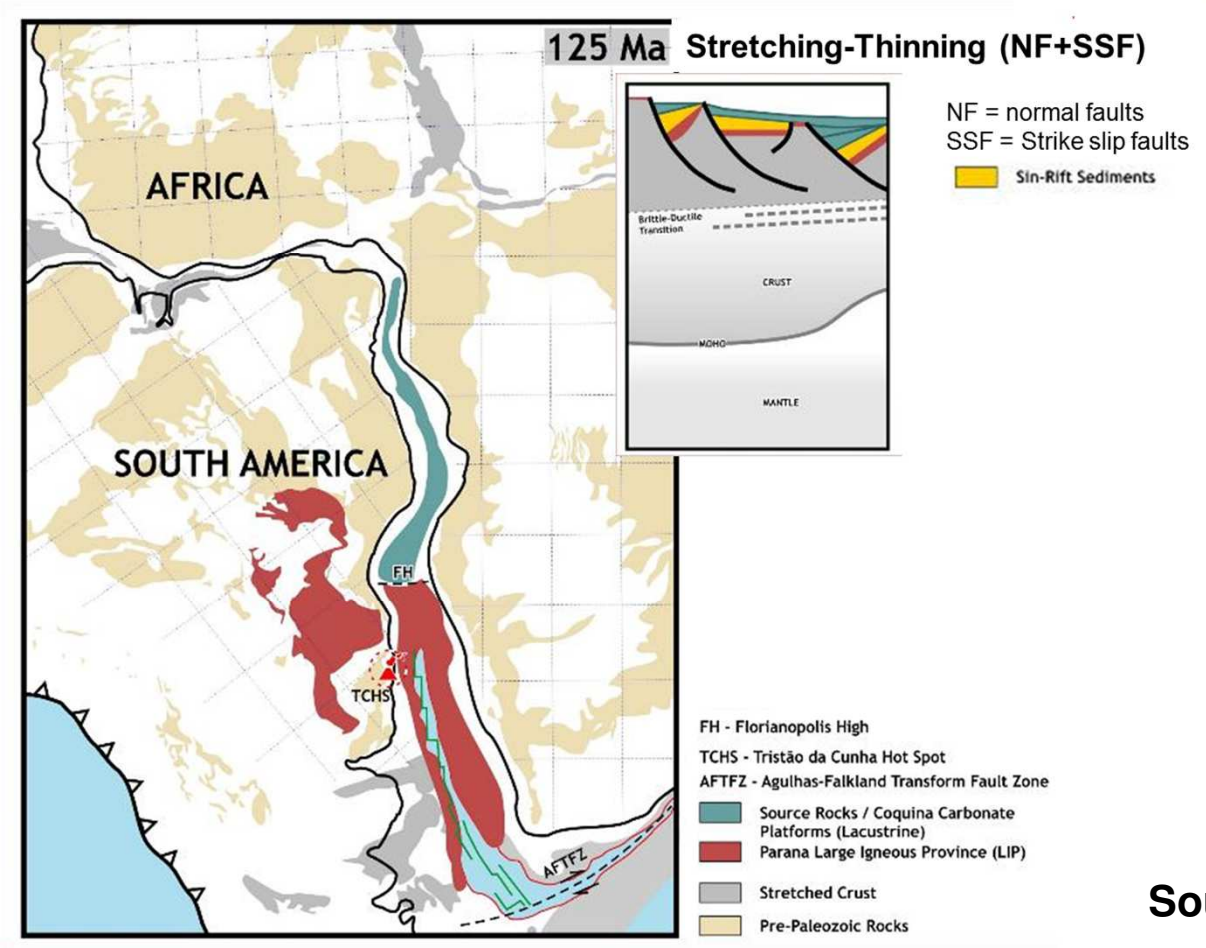


…the breakup of Gondwana…



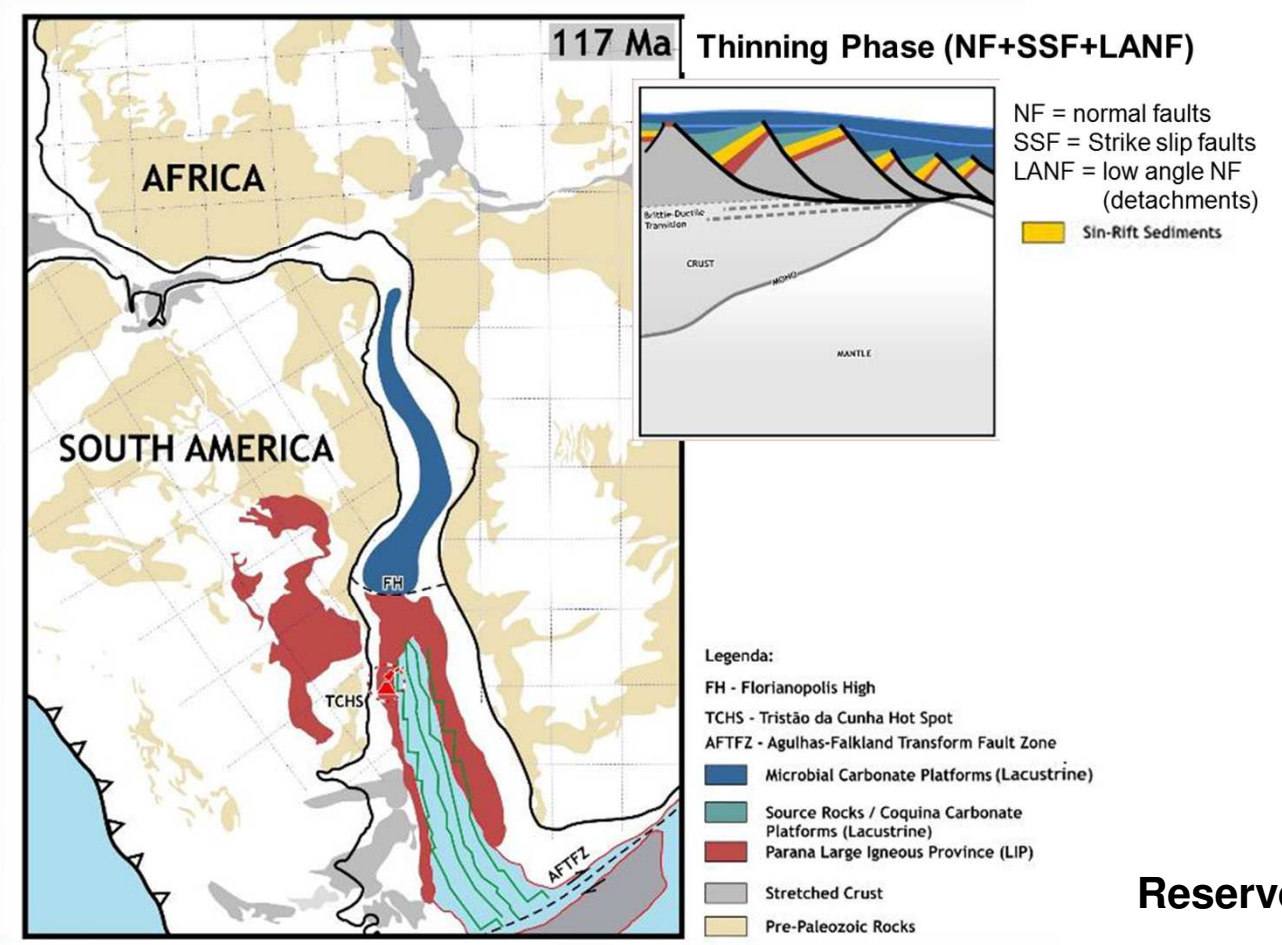
Basement Structure

…produced a rift lake system…



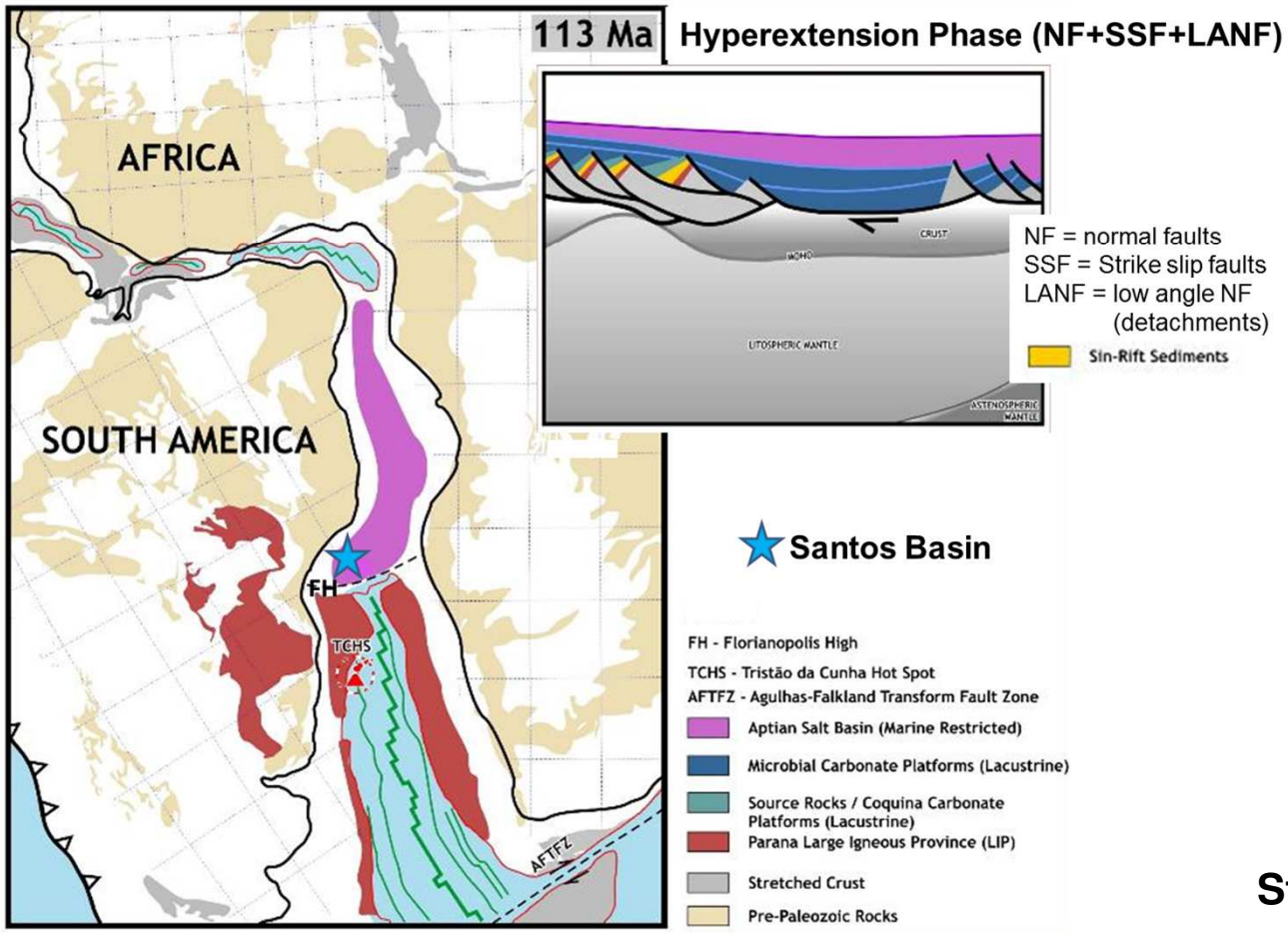
Source + Reservoir

…that widened to a continental scale…



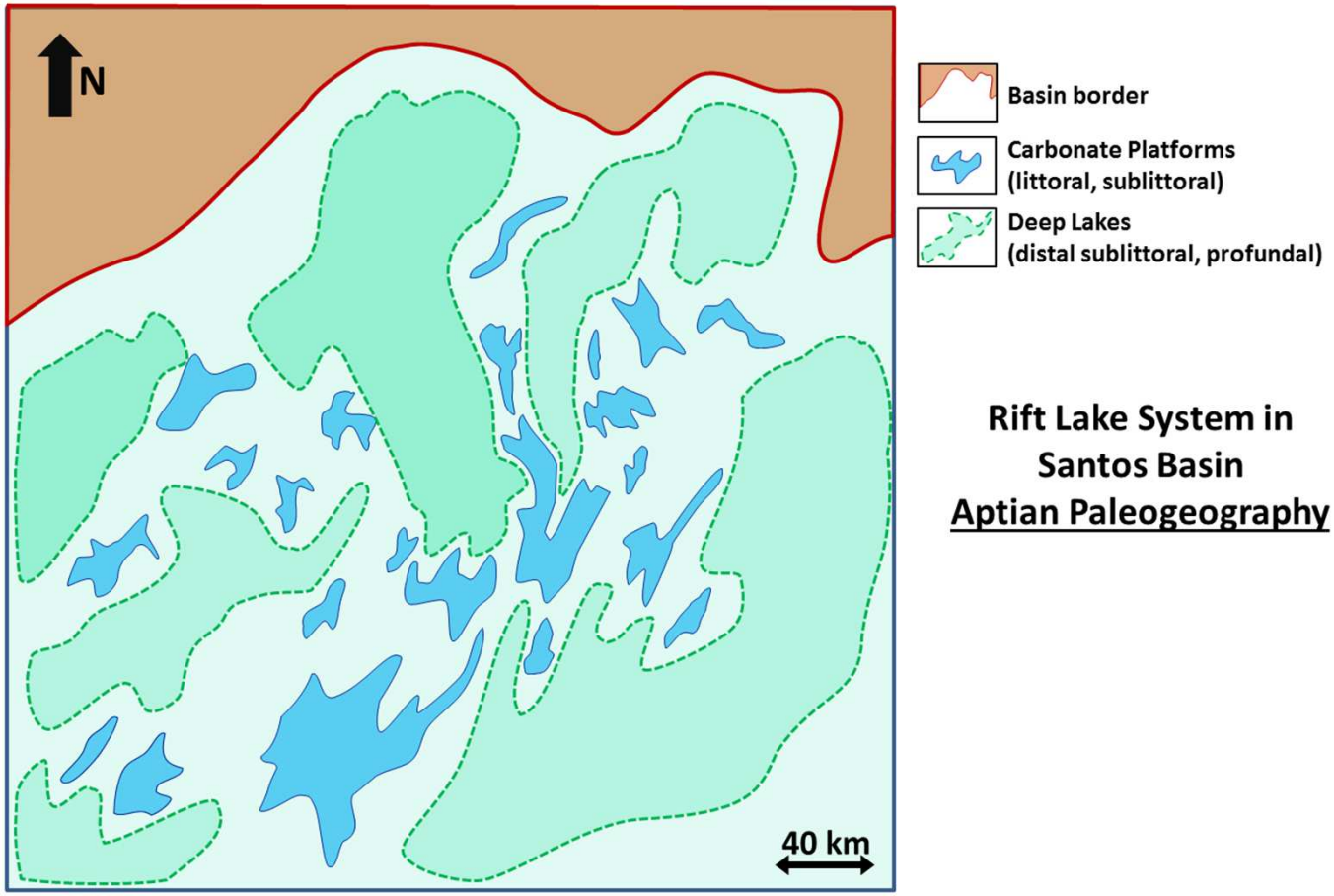
Reservoir + Structure

…and was drowned by the sea…



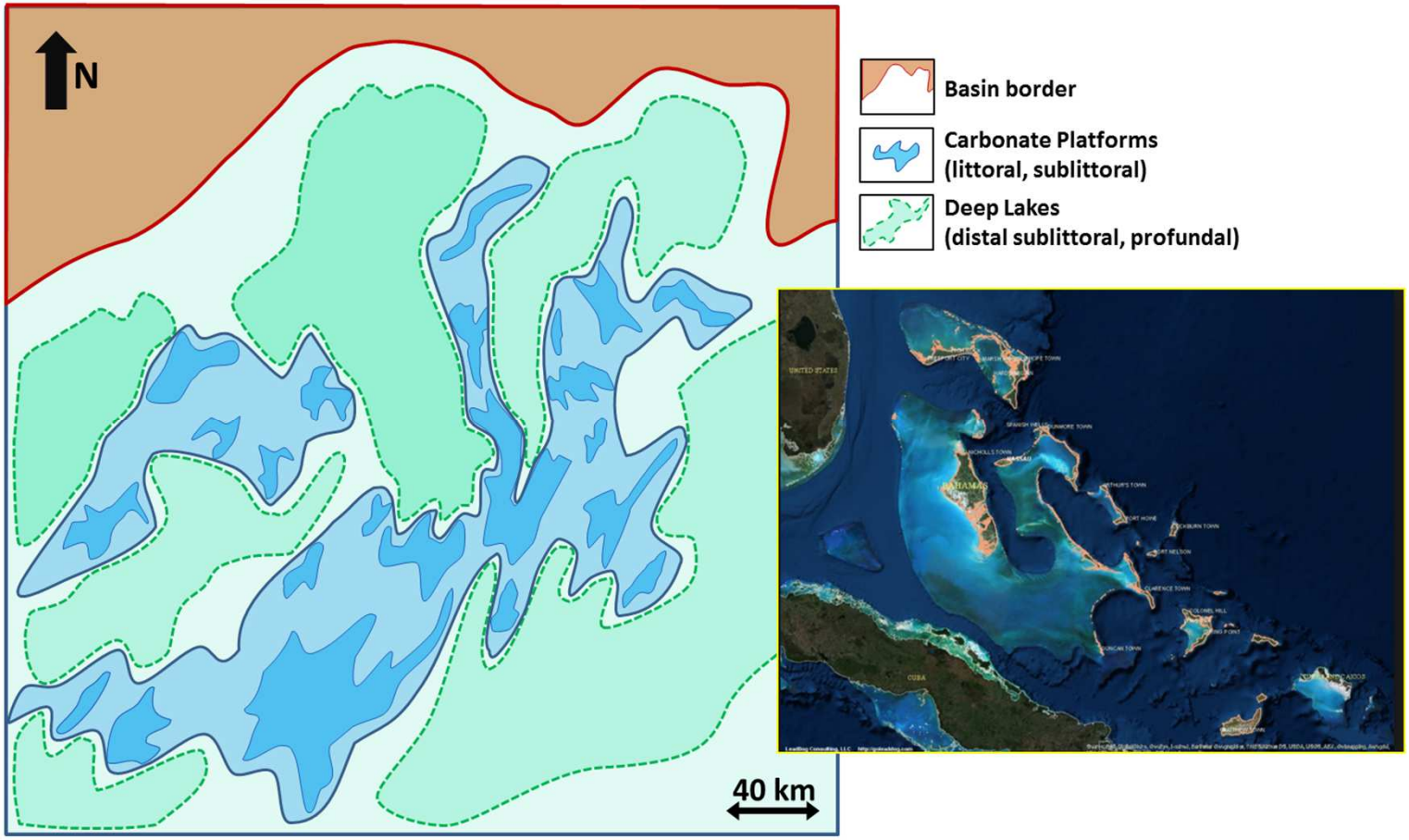
Structure + Seal

…zooming in Santos Basin just before the Aptian salt deposition…

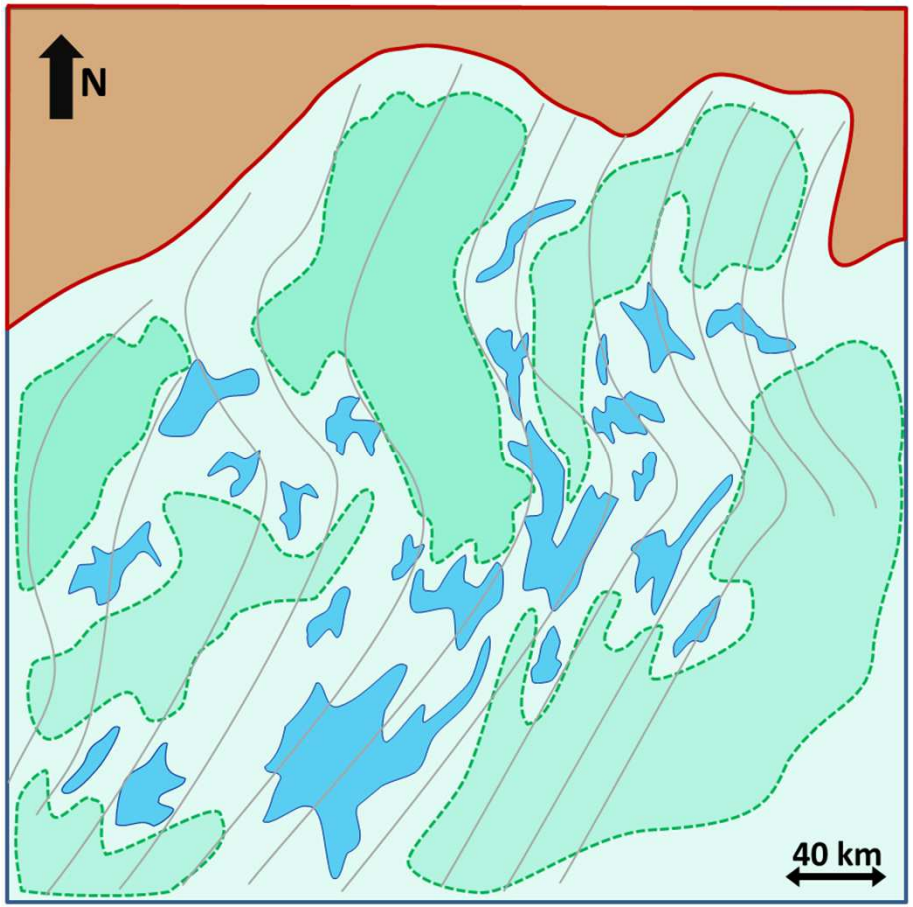


Rift Lake System in Santos Basin
Aptian Paleogeography

…a Bahamas-like lacustrine system…



…controlled by rift active structures…



Basin border

Carbonate Platforms
(littoral, sublittoral)

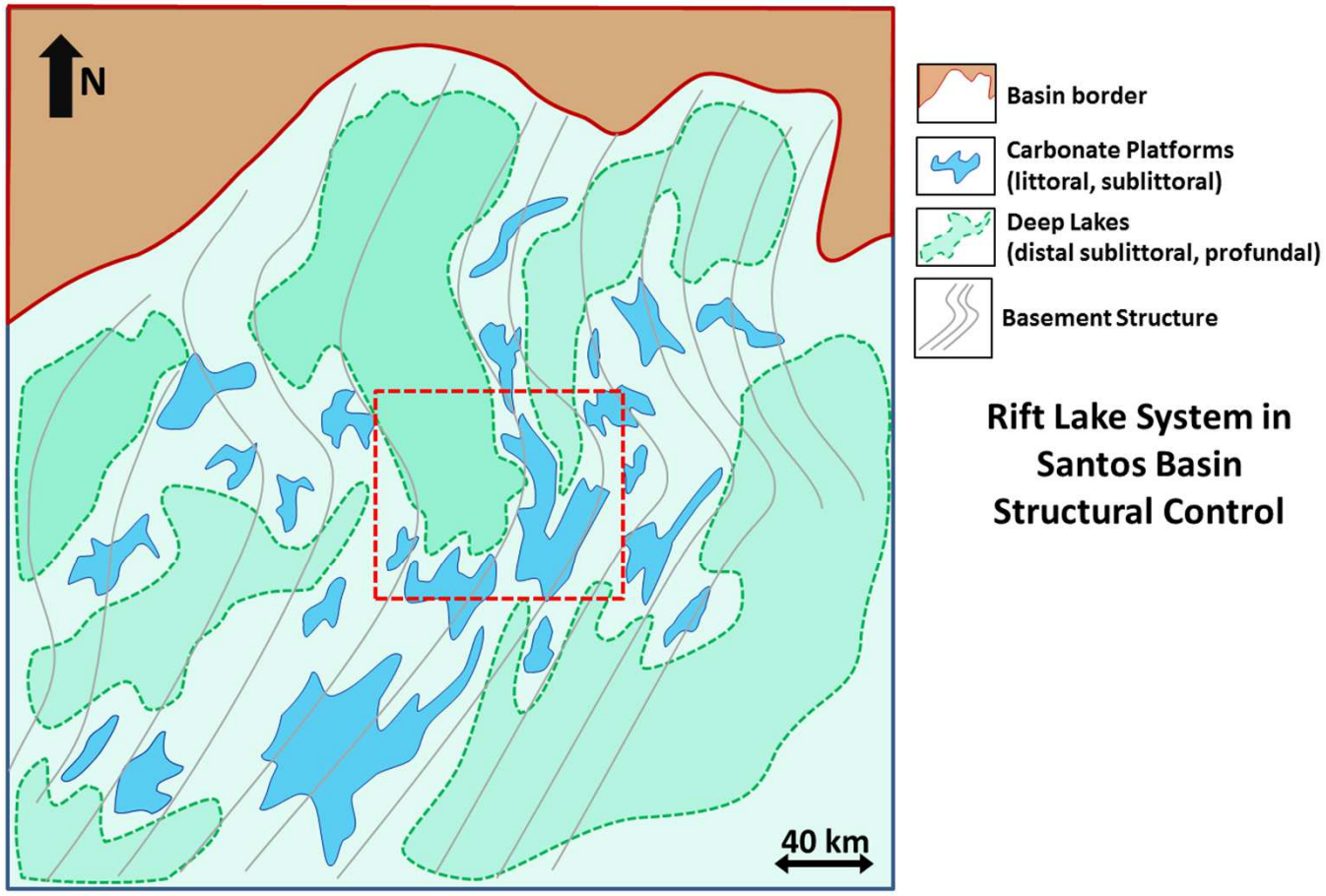
Deep Lakes
(distal sublittoral, profundal)

Basement Rift Structure

Rift Lake System in Santos Basin
Structural Control

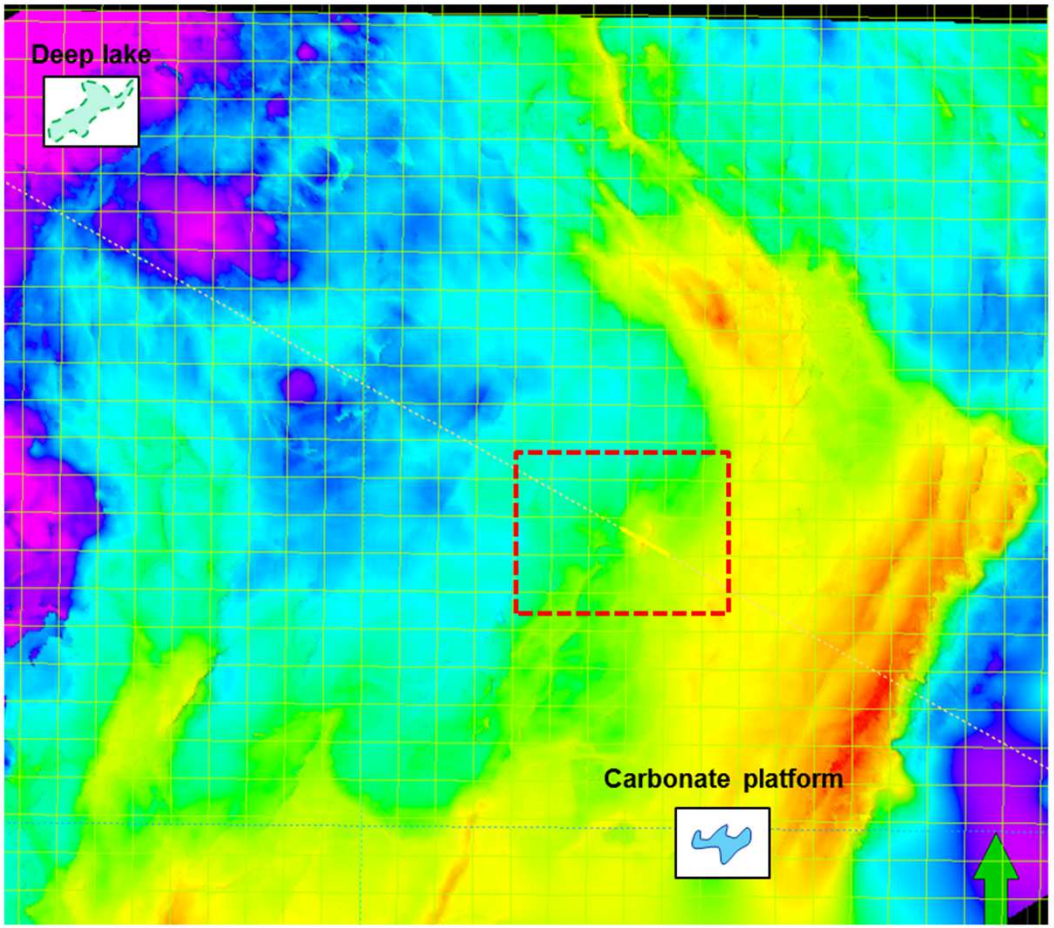
NF + SSF +LANF systems

…zooming in further…

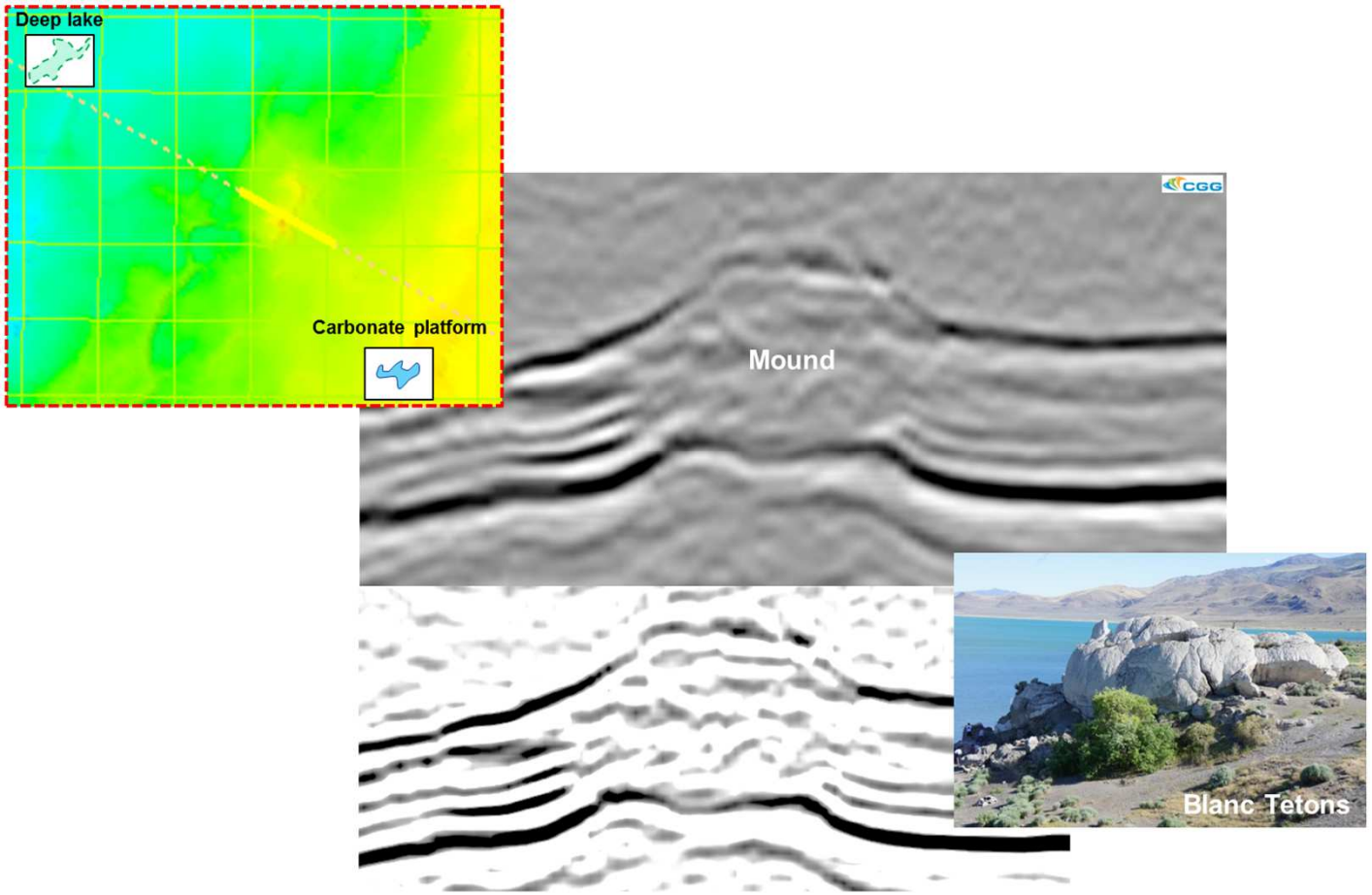


Rift Lake System in Santos Basin Structural Control

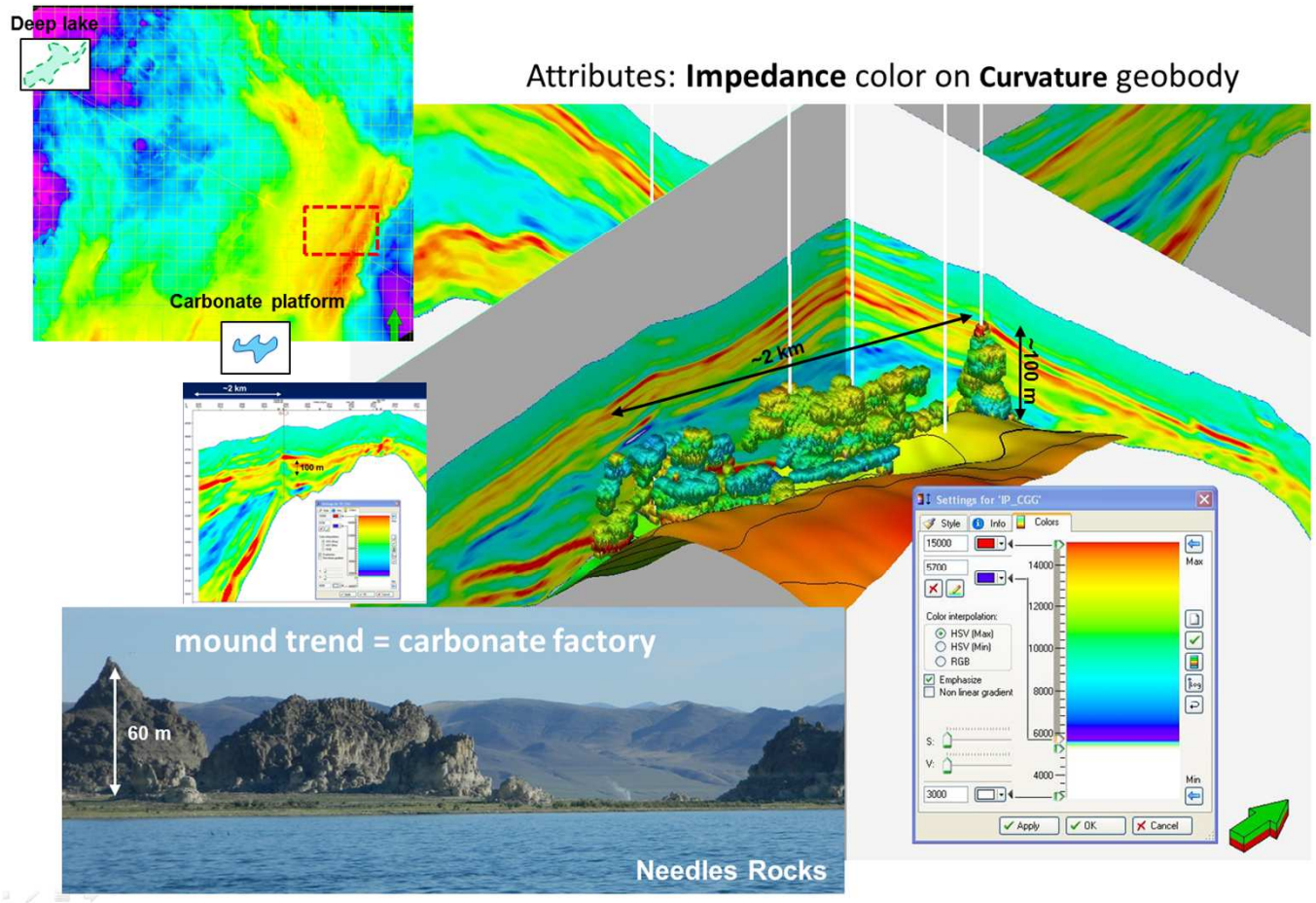
…zooming in further…



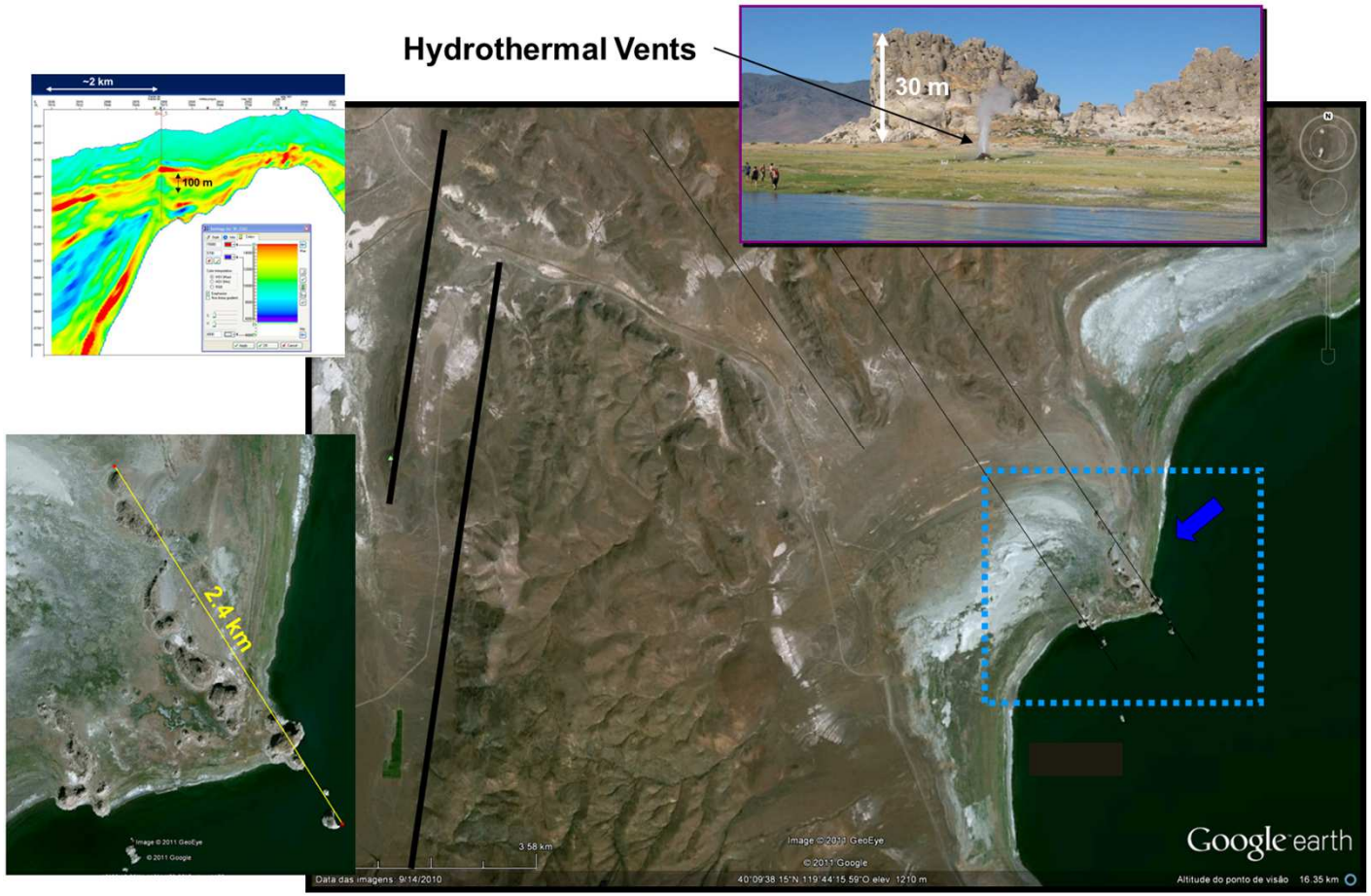
…isolated mounds at lake shore (Pyramid Lake - Blanc Tetons = carbonate factory)…



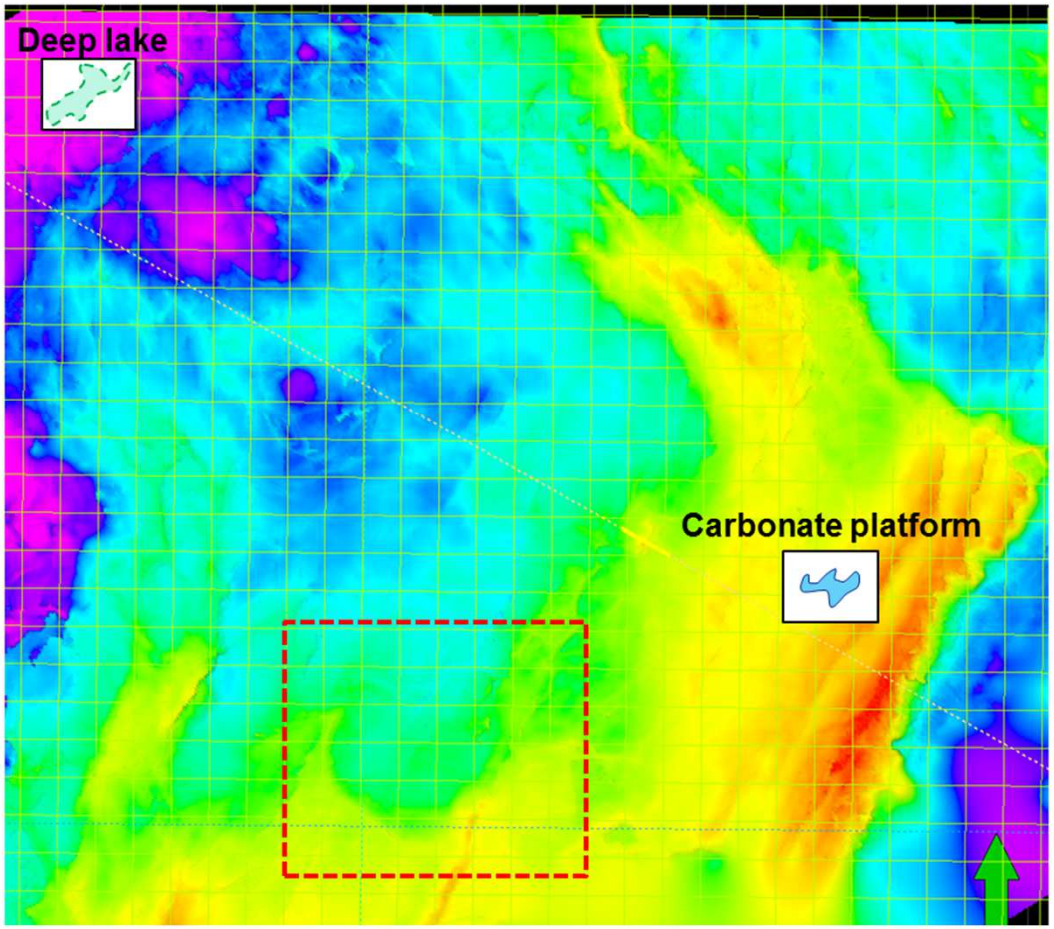
…and mound trends (Pyramid Lake - Needles Rocks)…



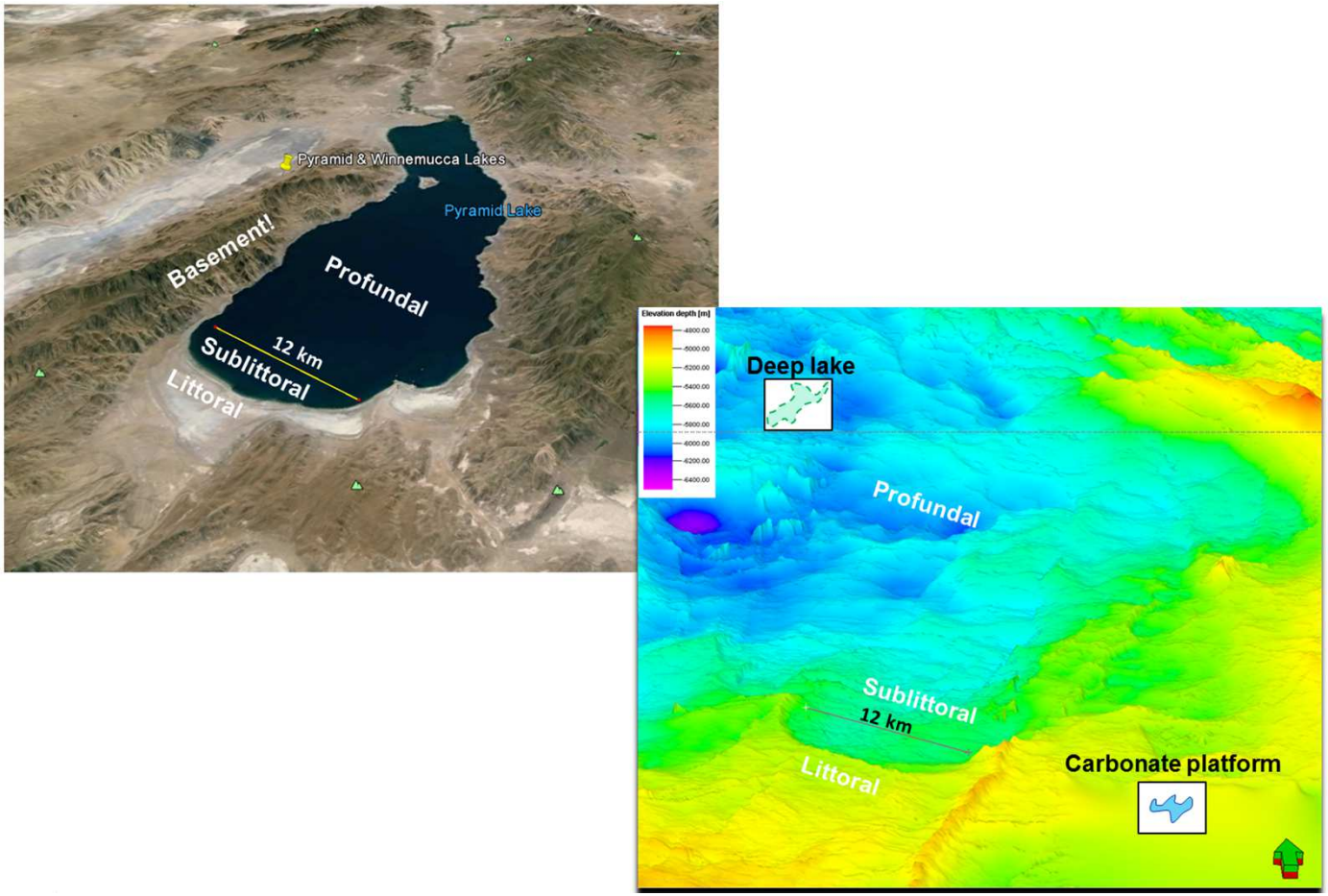
…mound trends controlled by faults (Needles Rocks)…



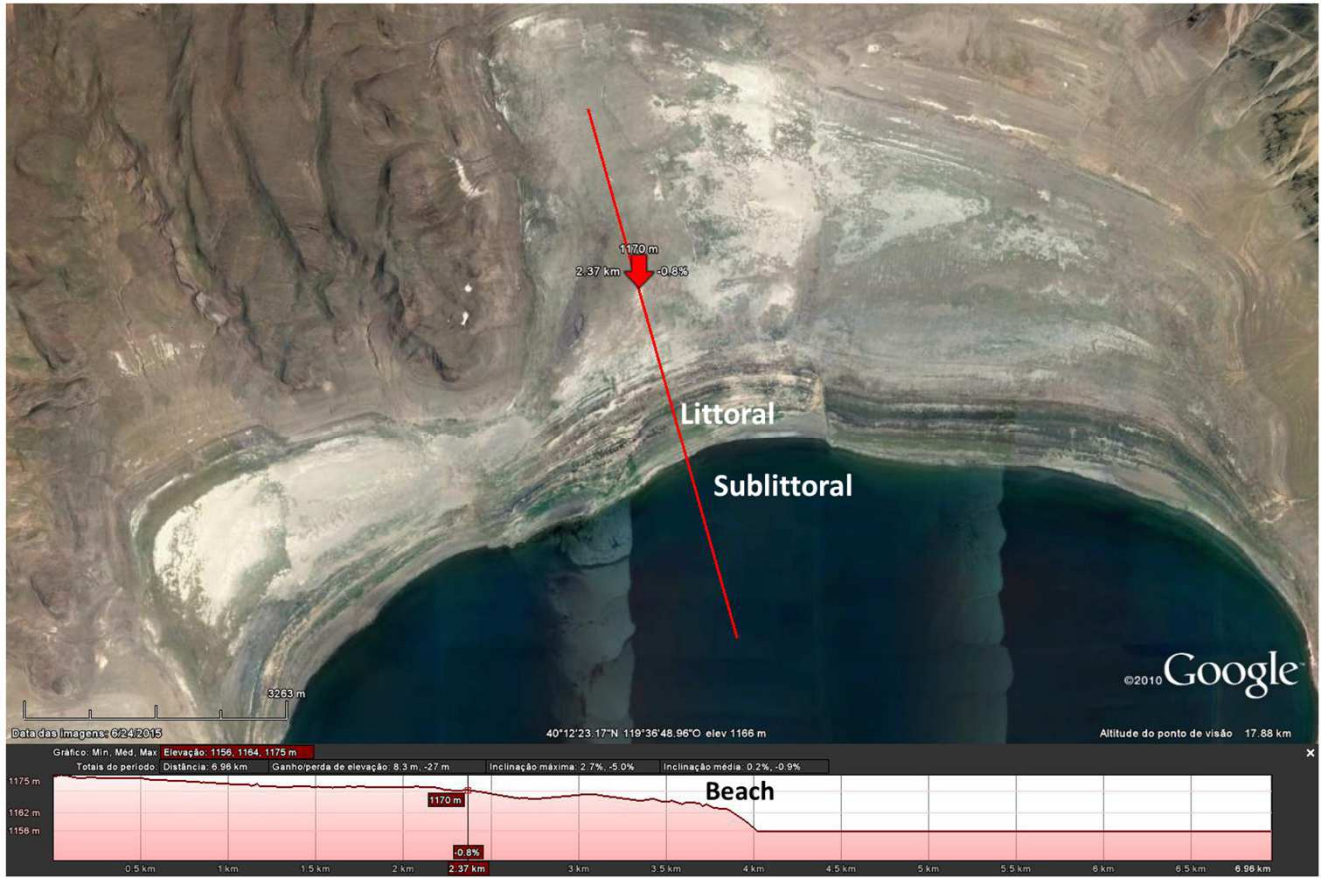
…reworking at lake beaches (littoral, sublittoral)…



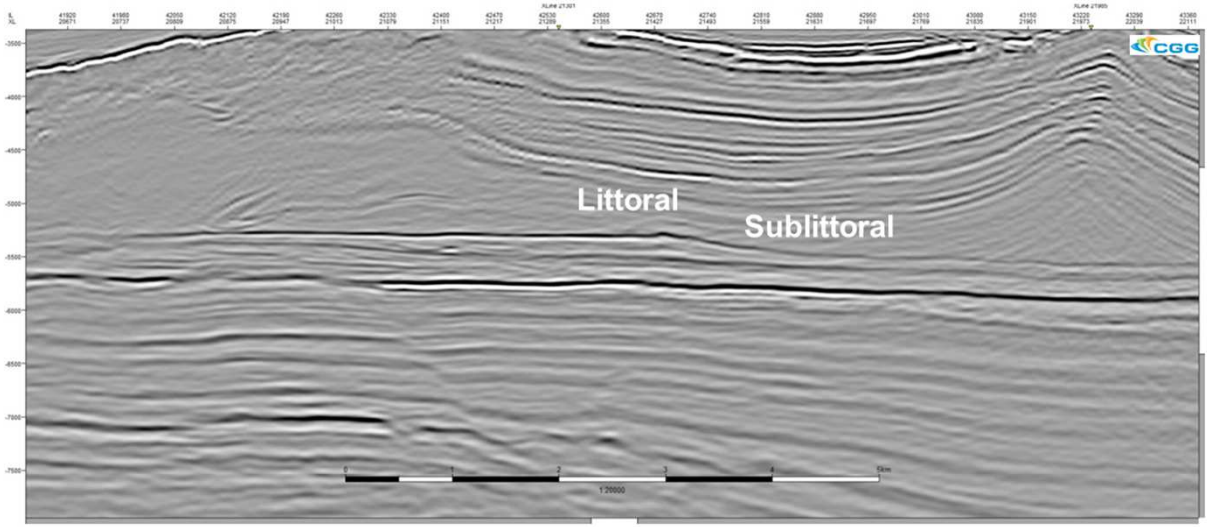
…Basin & Range again (lake processes = reworking)…

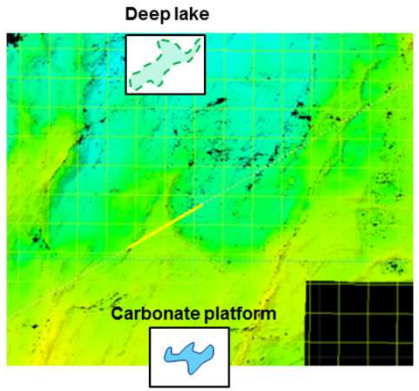


…lacustrine beaches (littoral and sublittoral environments)…

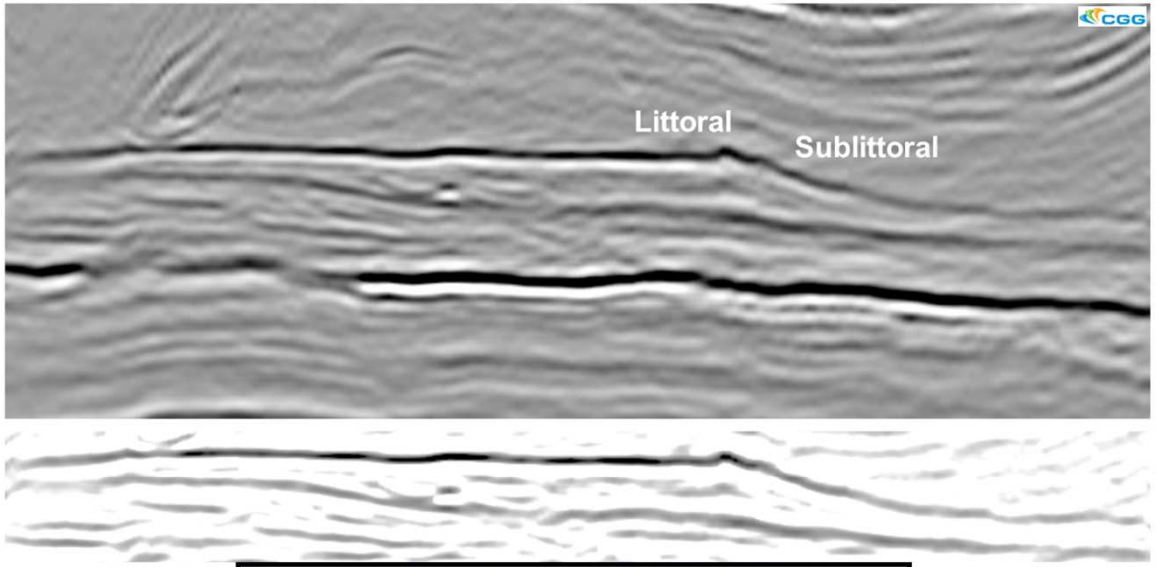


…littoral and sublittoral environments = reworking…



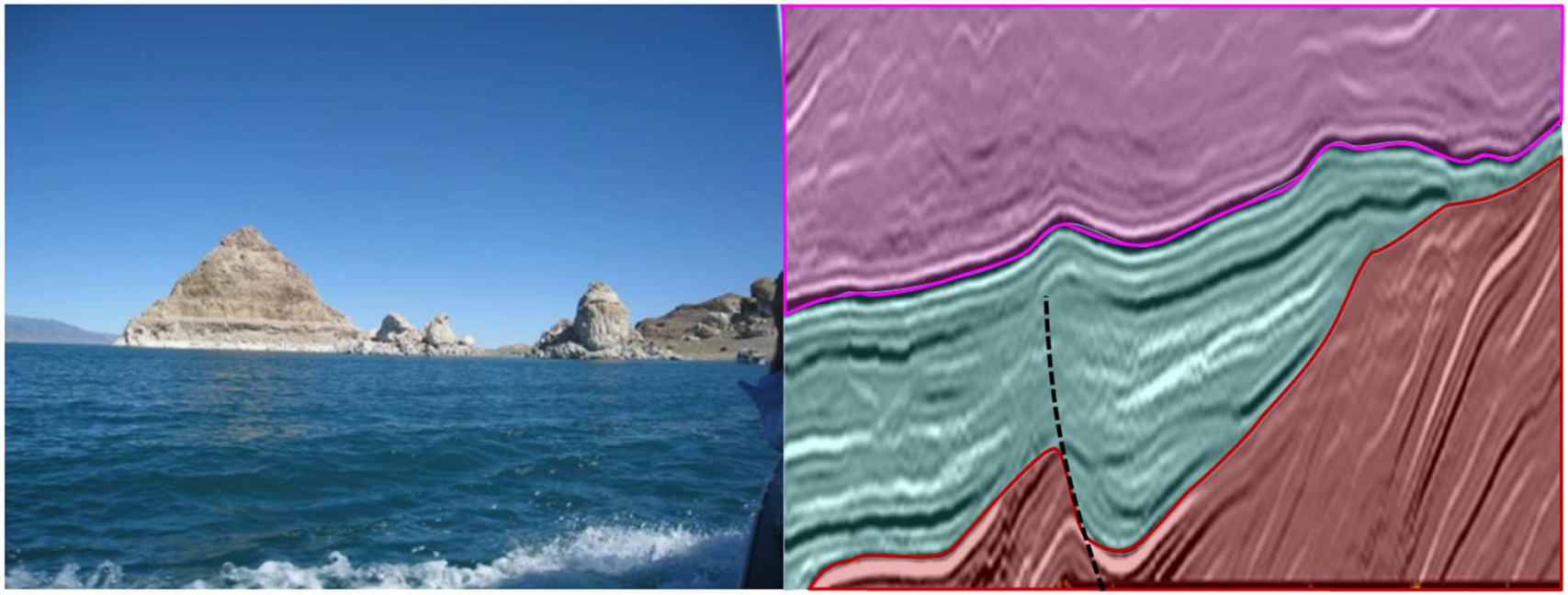


…lacustrine beaches at carbonate platform margins…

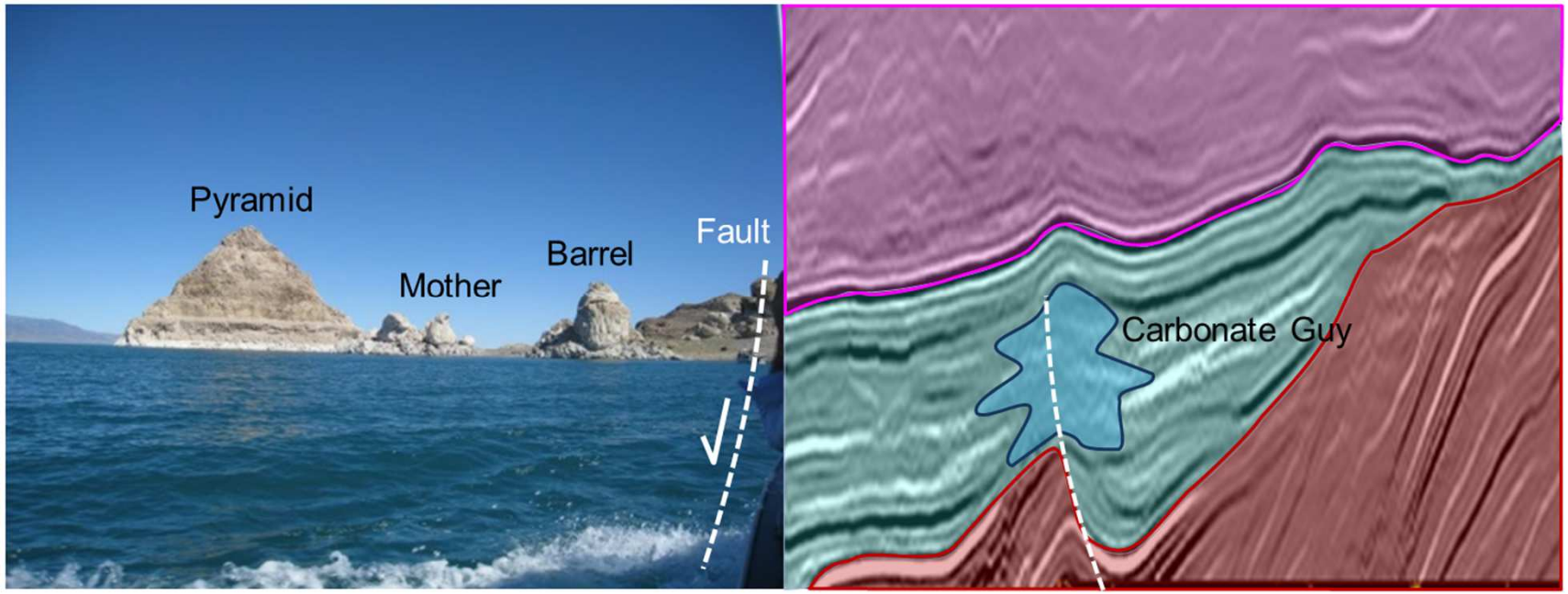


…alongshore currents (Pyramid Lake – spit beach)…

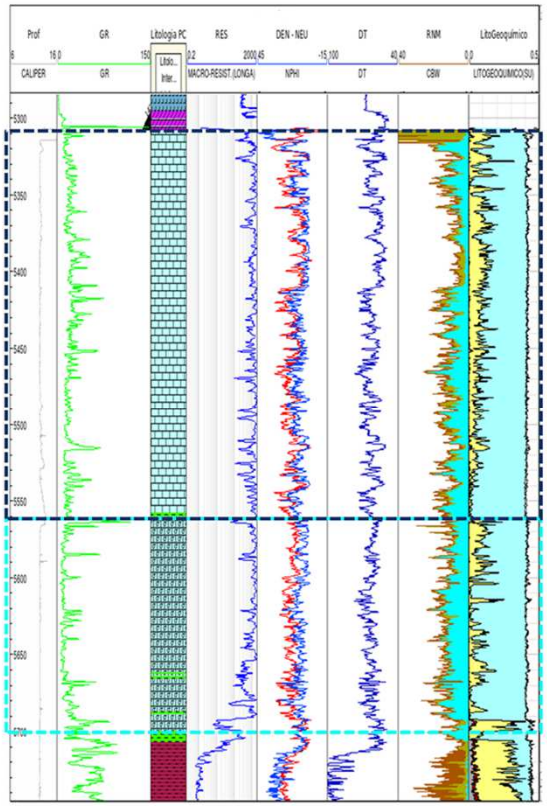
Stacked carbonate reservoirs (The Pyramid itself)…



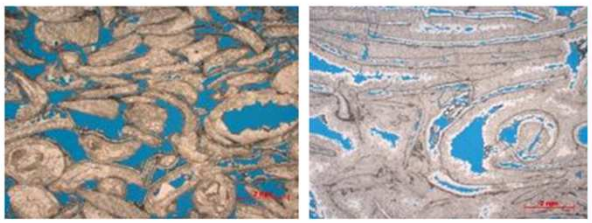
Stacked carbonate reservoirs (The Pyramid itself)…



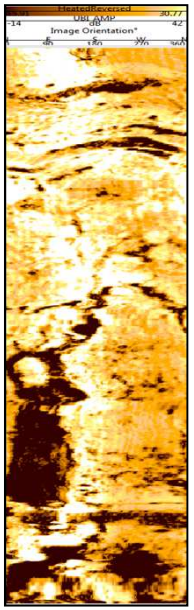
Stacked Carbonate Reservoirs



Microbial Carbonate Reservoirs

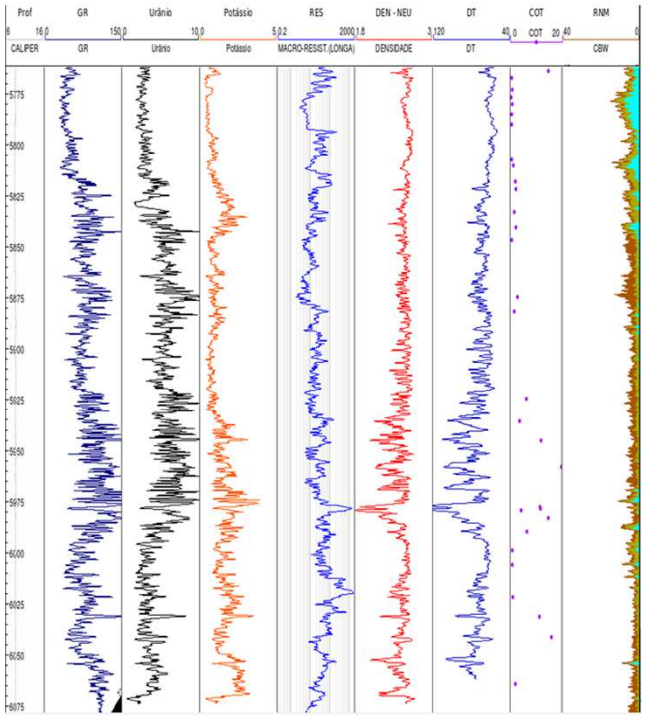


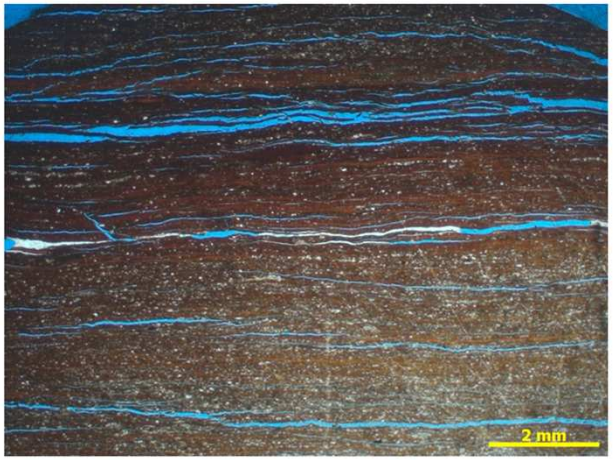
Coquina Reservoirs



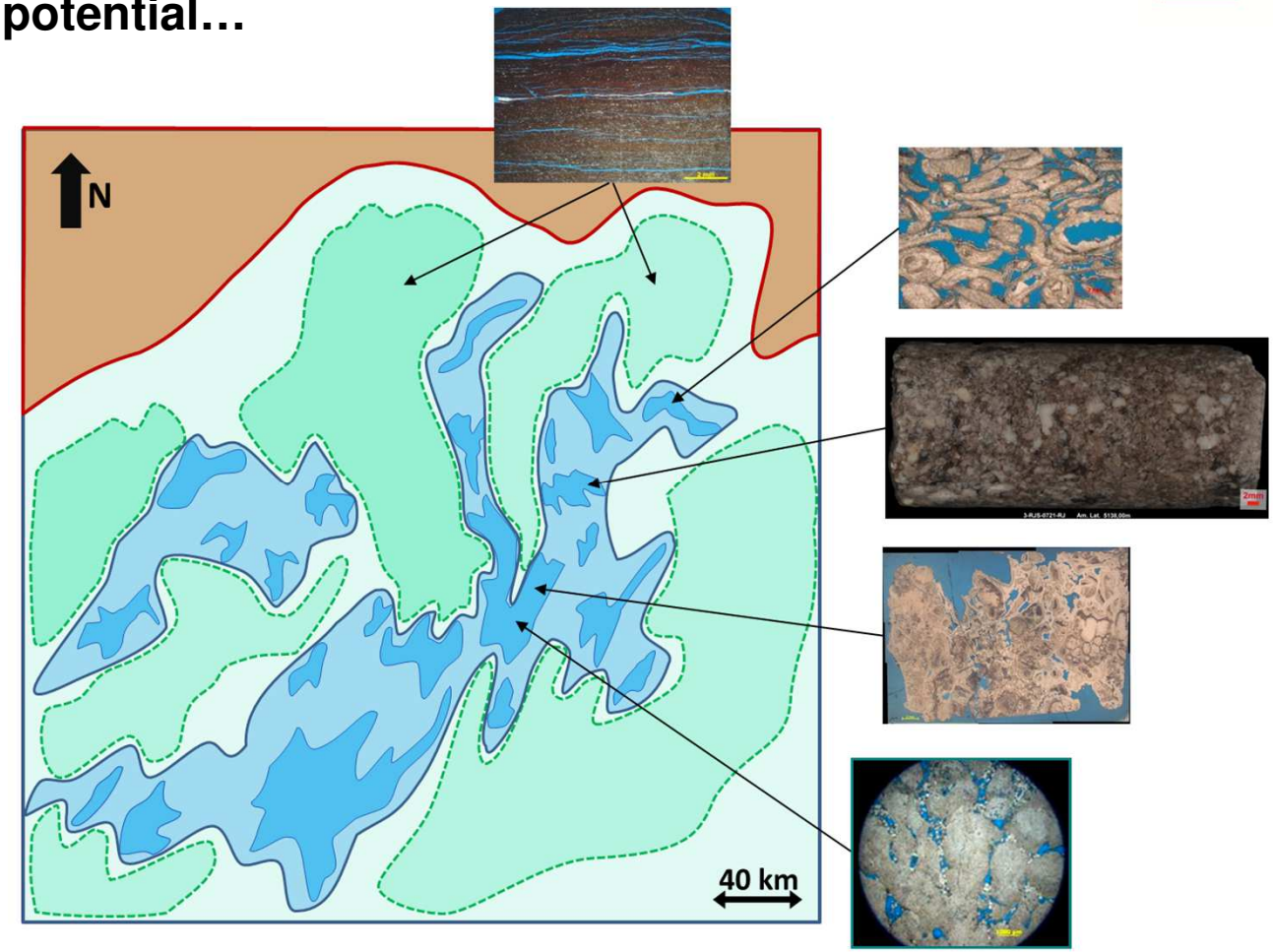
Hydrothermal Products

High TOC Source Rock





…paleogeography helps to predict reservoir quality and source rock potential…



Concluding remarks

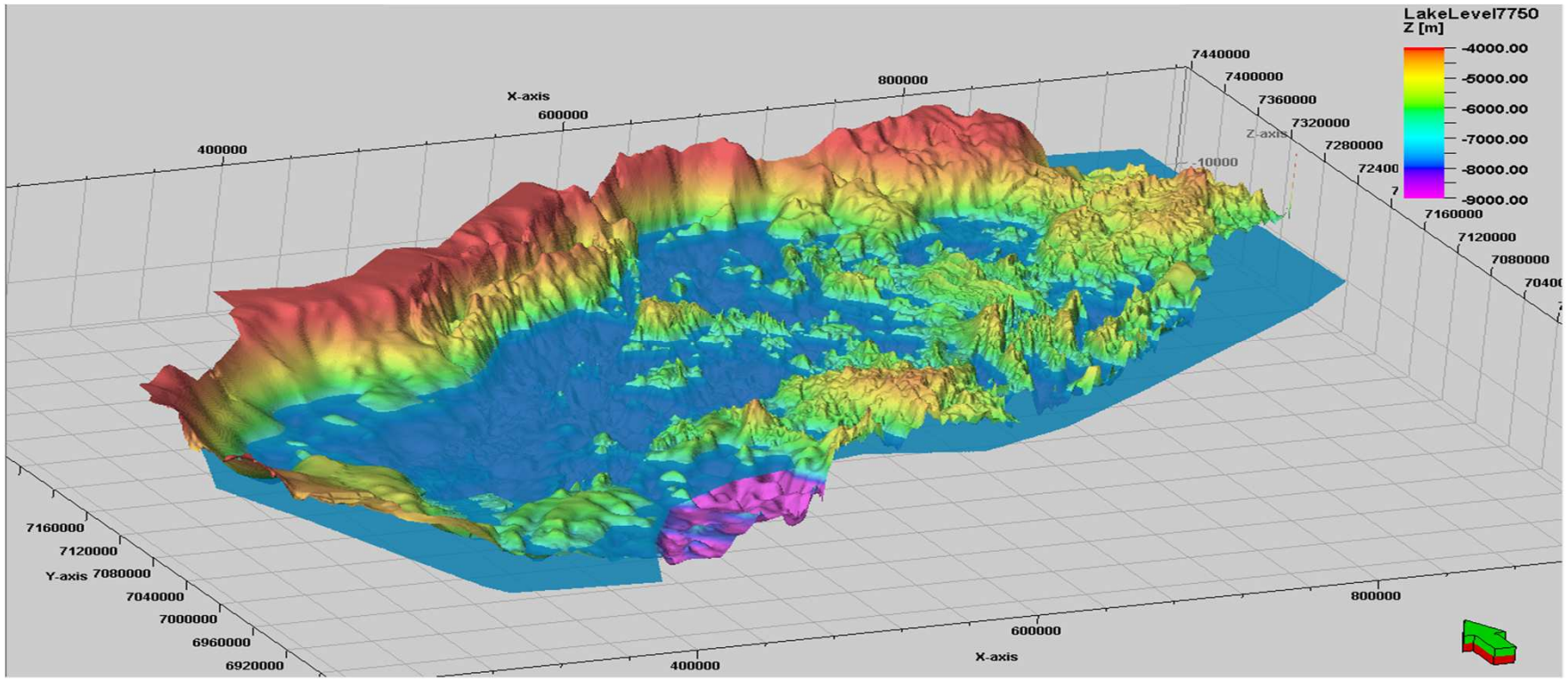
Processes

- Transgression + Rift Lake System
- Aggradation ('carbonate factory')
  - Uplift (structural control)
    - Footwall Uplift (NFs)
    - Transpression (SSFs)
    - Block Rotation (LANFs & Core Complexes)
- Hydrothermal Vents (structural control)
- Reworking (littoral, sublittoral)

Products

- Lacustrine Carbonate Platforms
  - Reservoirs
- Profundal Lake Enviroments
  - Source Rocks

Concluding remarks



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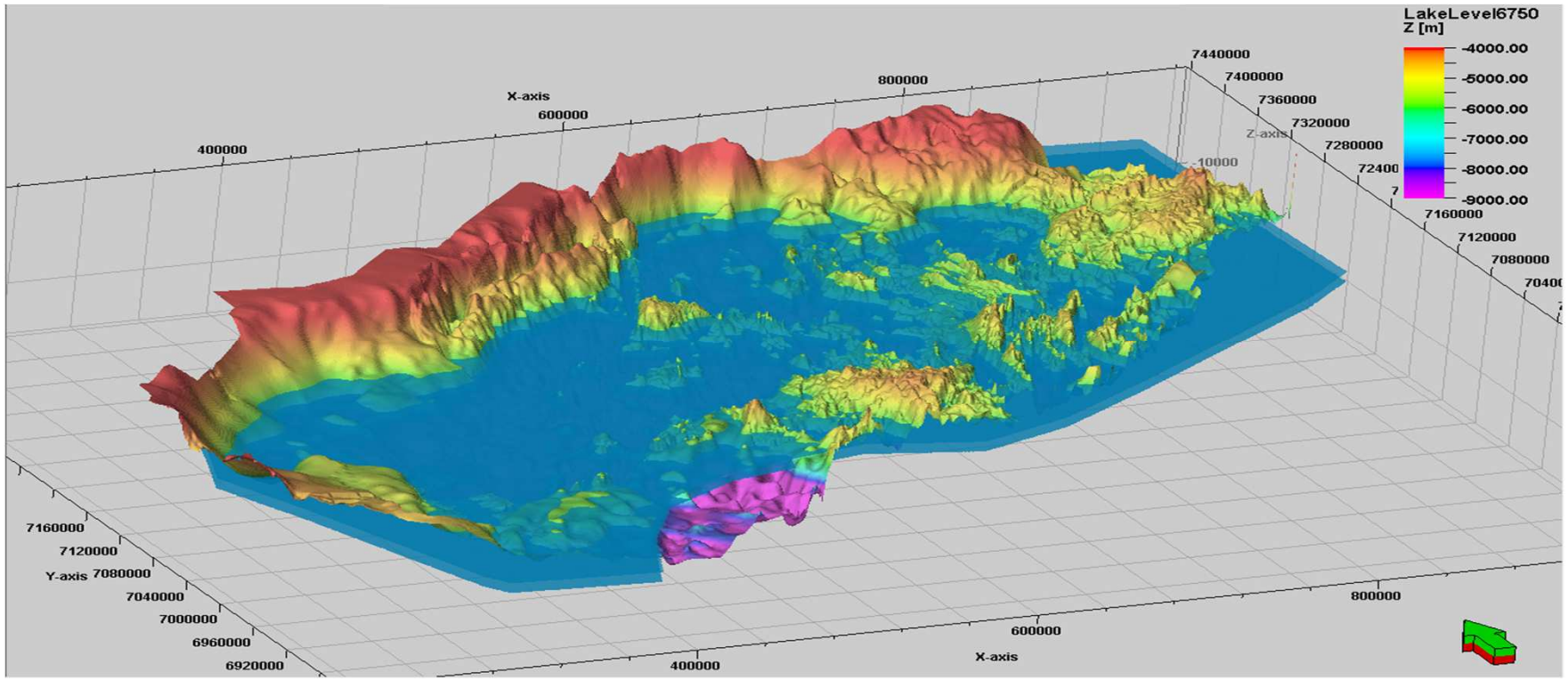

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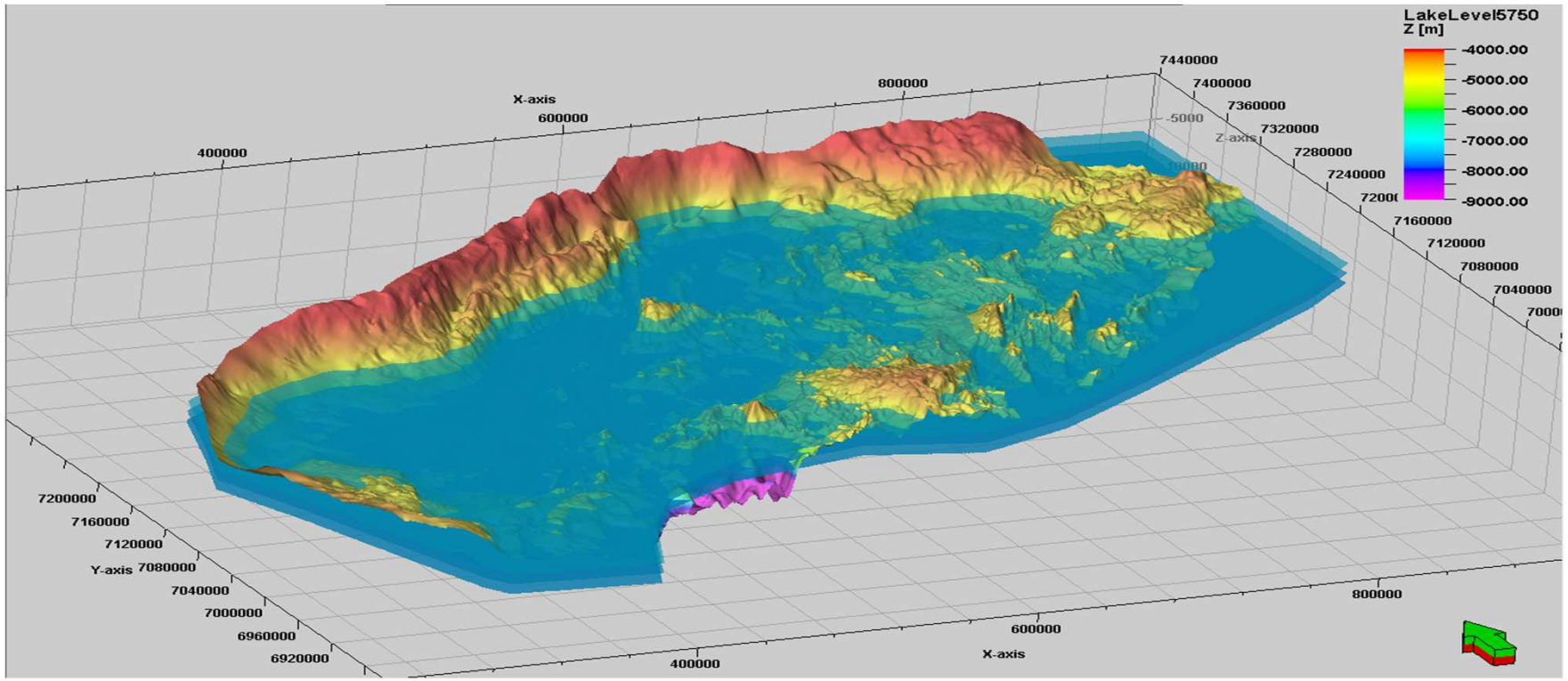

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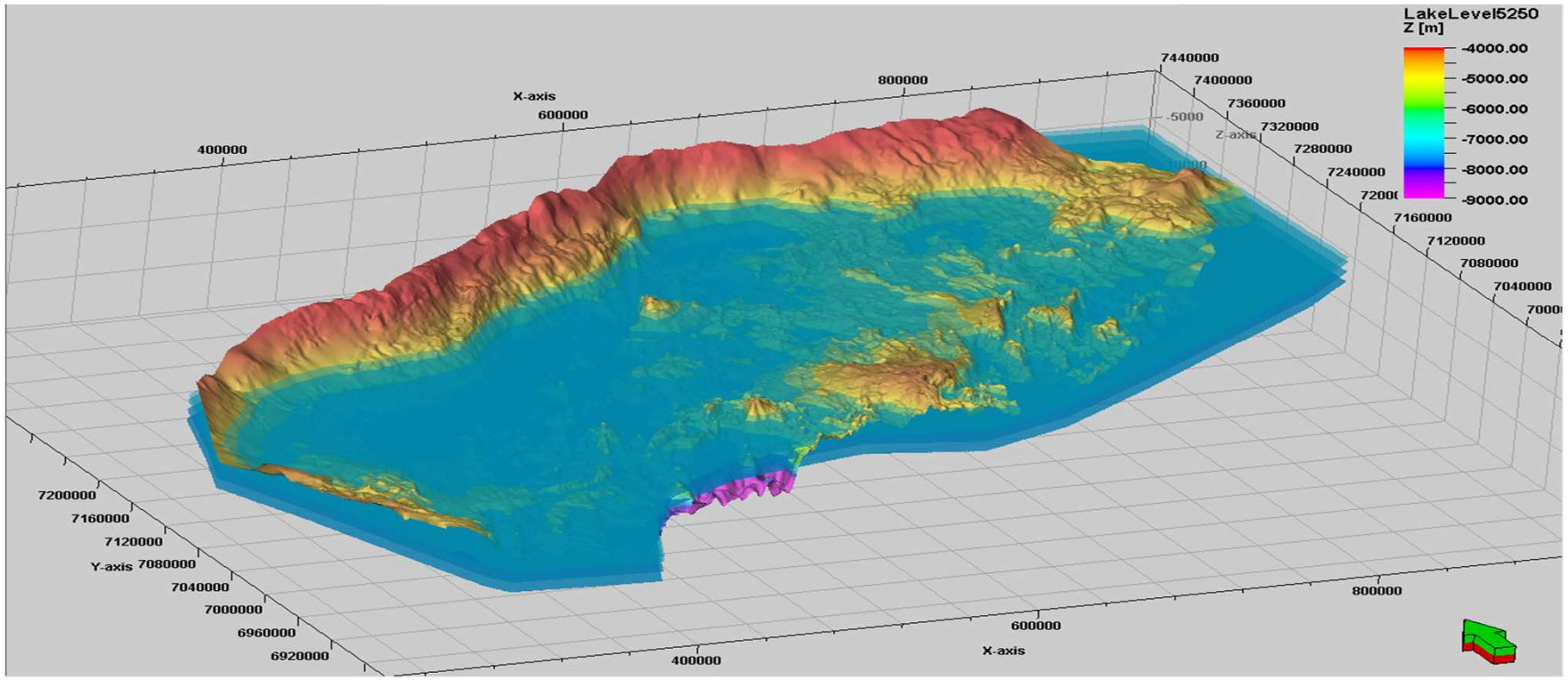

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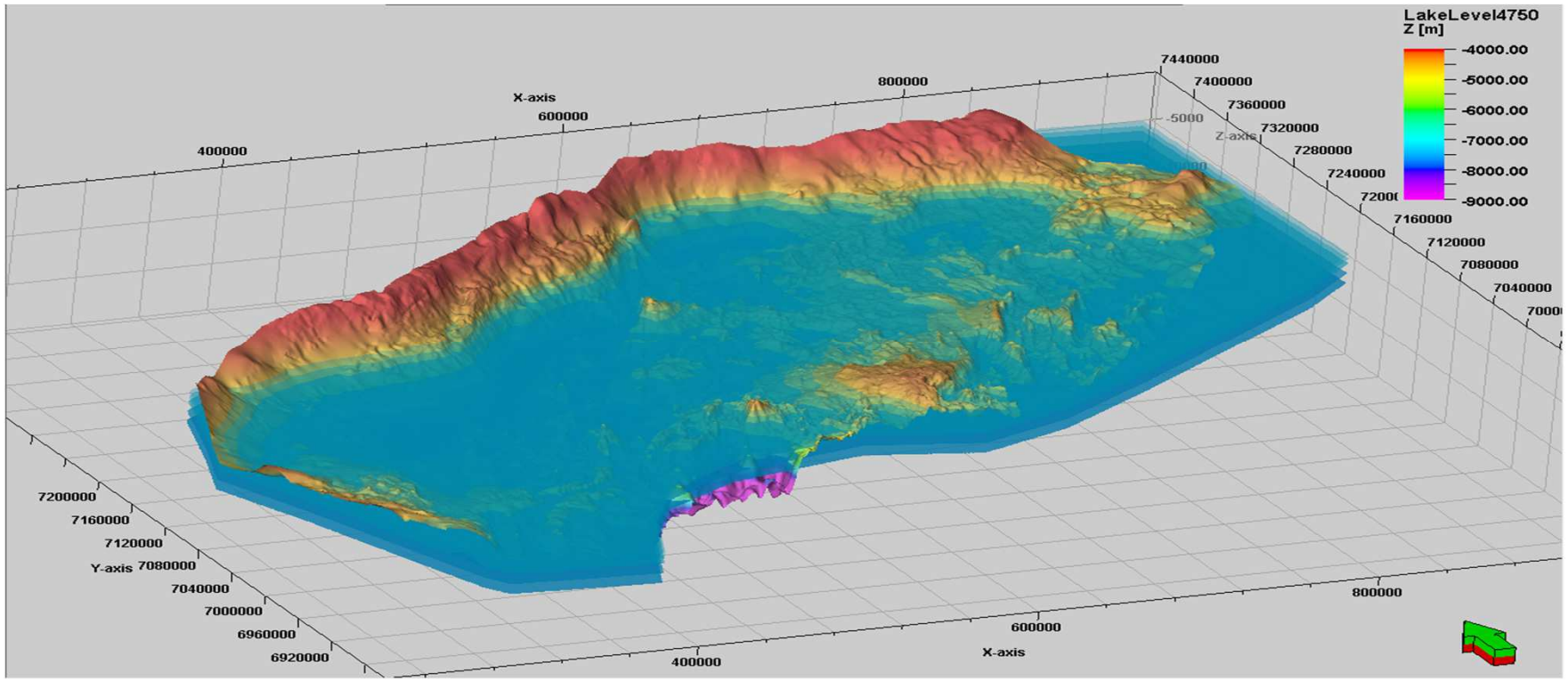

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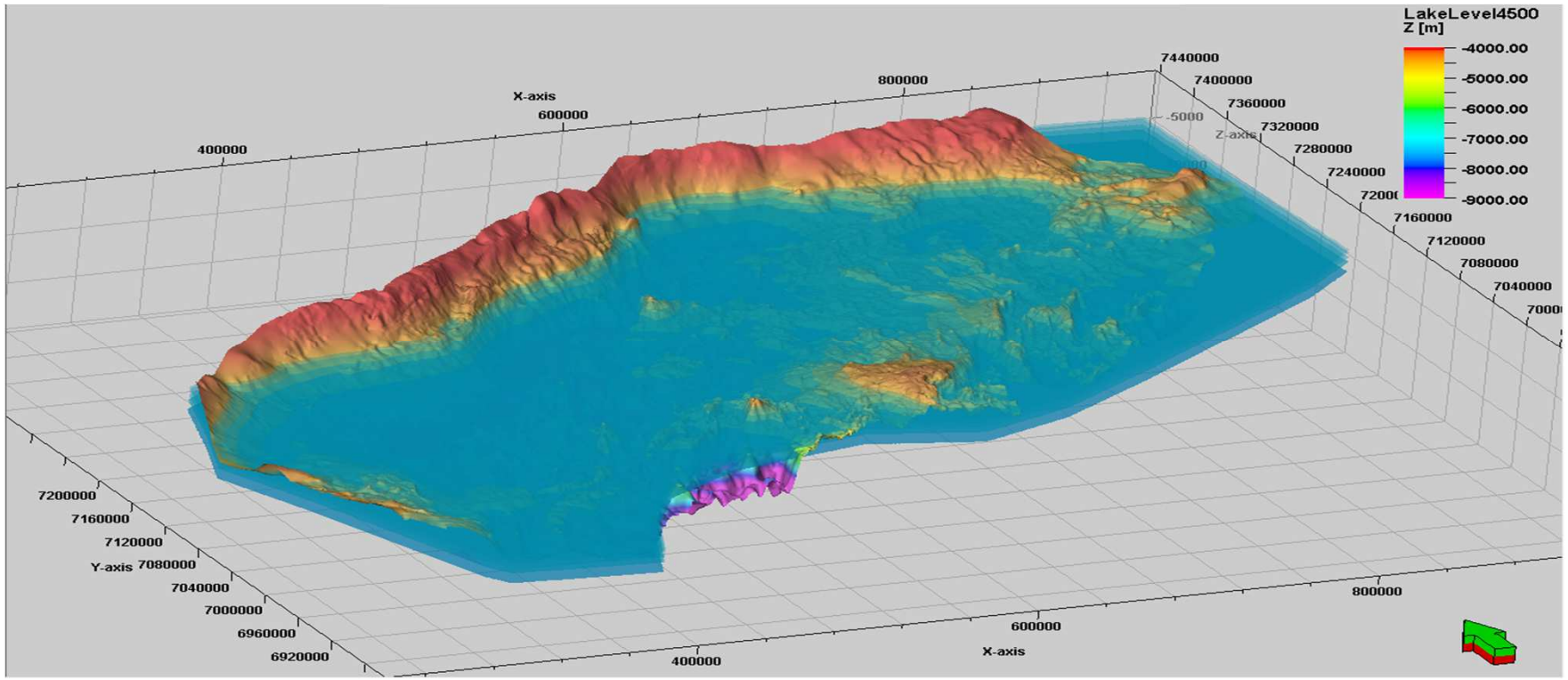
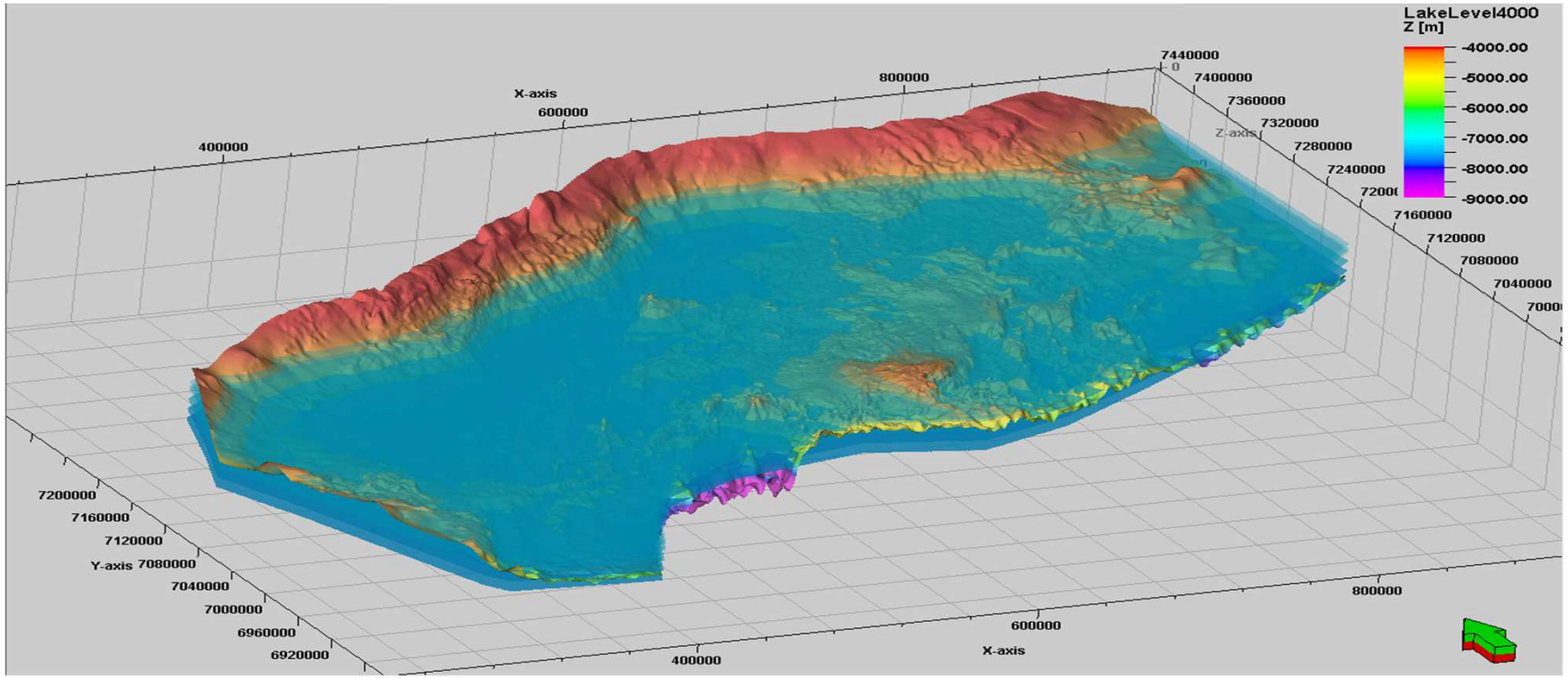
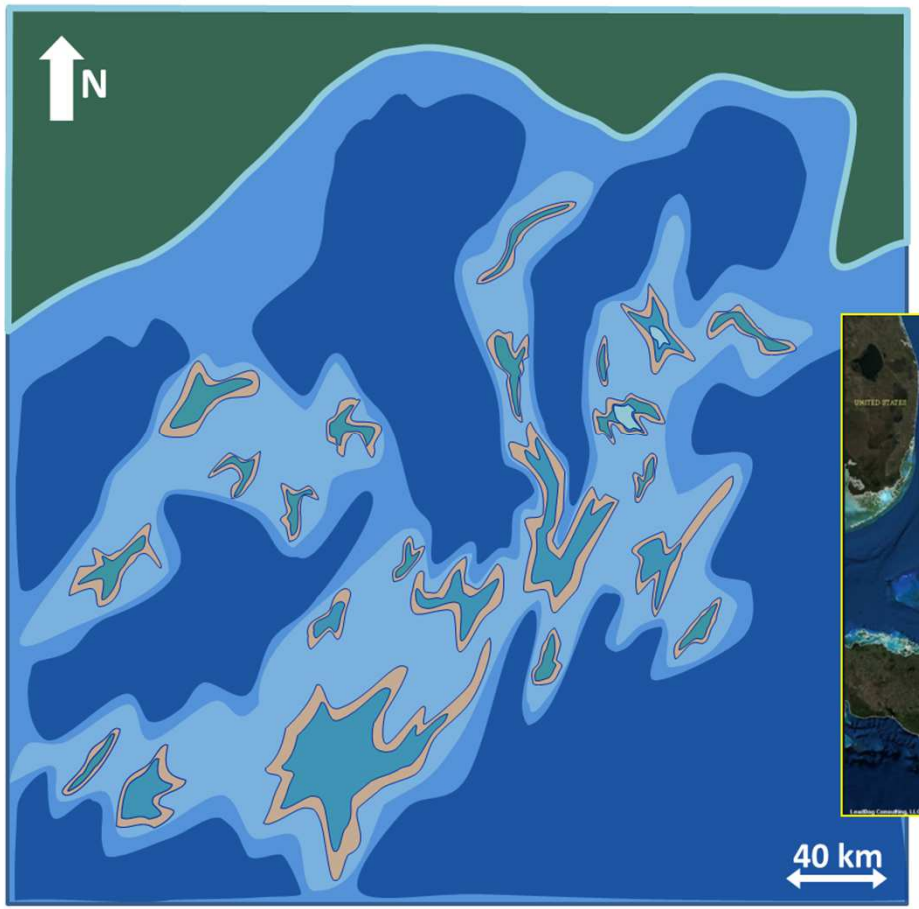


Concluding remarks

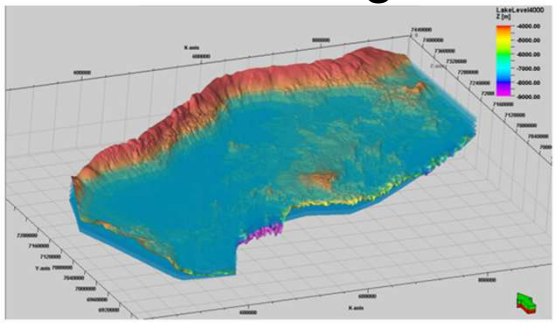


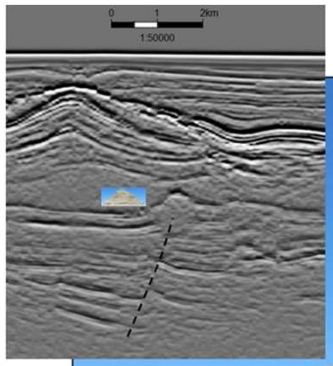
…a Bahamas-like lacustrine system…

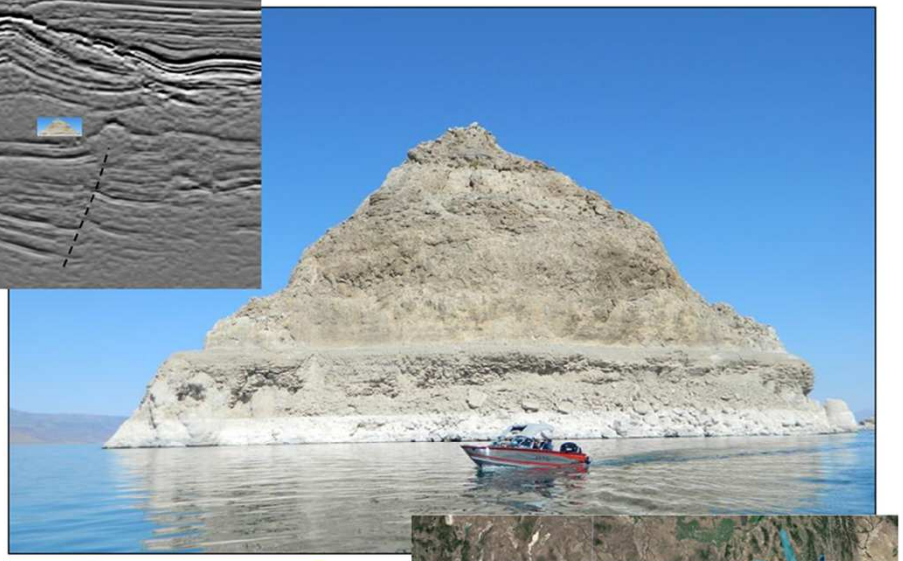


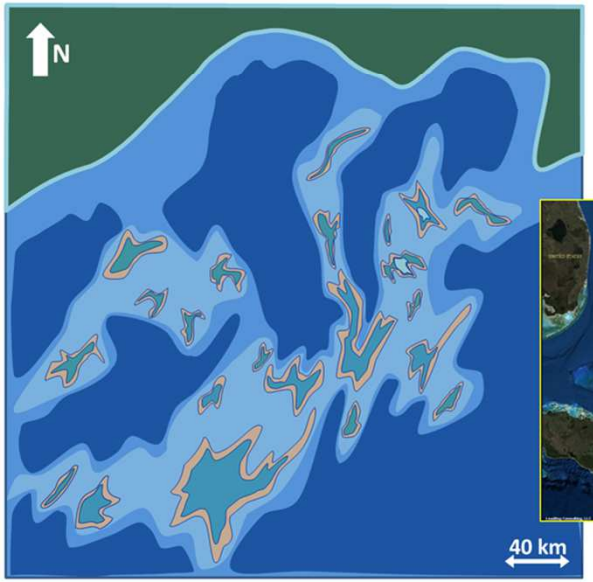
- ✓ Mounds (‘reef’)
- ✓ Lacustrine Beaches (´forereef’)
- ✓ Lacustrine Protected Pools (´backreef’)
- ✓ Travertines
- ✓ Karst Systems
- ? Slope Systems
- × ~~Rivers~~
- × ~~Valley Fill~~
- × ~~Deltas~~
- × ~~Fans~~

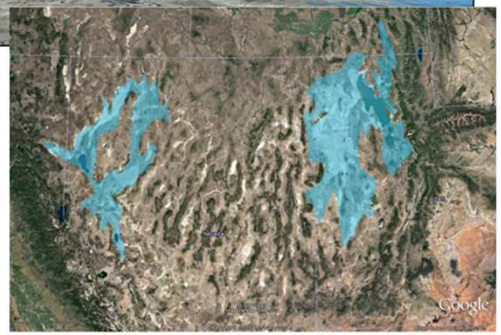
…into the Basin & Range…











Pleistocene Lakes
Lahontan & Bonneville

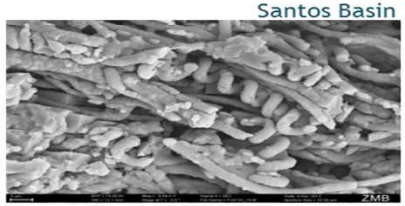
Acknowledgements

Pamukkale

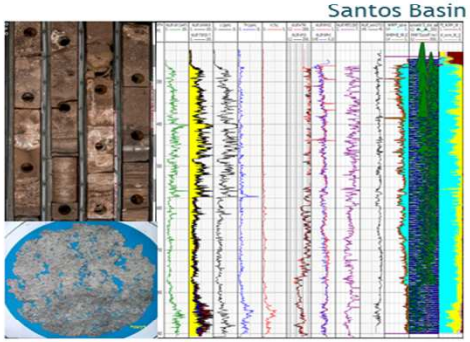
Salta

Sergipe-Alagoas Basin

Santos Basin



Santos Basin



Death Valley

Shark Bay

Coastal Lakes, Brazil

Namibia

Winnemucca Lake

Oman

Bridgeport Travertine

Mono Lake

Pyramid Lake

THANKS!

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