SECARB Offshore

# Woolsey Mound, Carbon Storage and Risk Assessment

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# Acknowledgements


- Southern States Energy Board (SSEB)
- U.S. Department of Energy (NETL)
- Gulf of Mexico Gas Hydrate Research Consortium
- Geophysical Exploration/ Tectonics and Geophysics Labs
- TGS-Nopec; WesternGeco
- Bureau of Ocean Energy Management (BOEM)
- Seismic Micro-Technology, Landmark Graphics, Veritas Hampson-Russell, Schlumberger- Petrel

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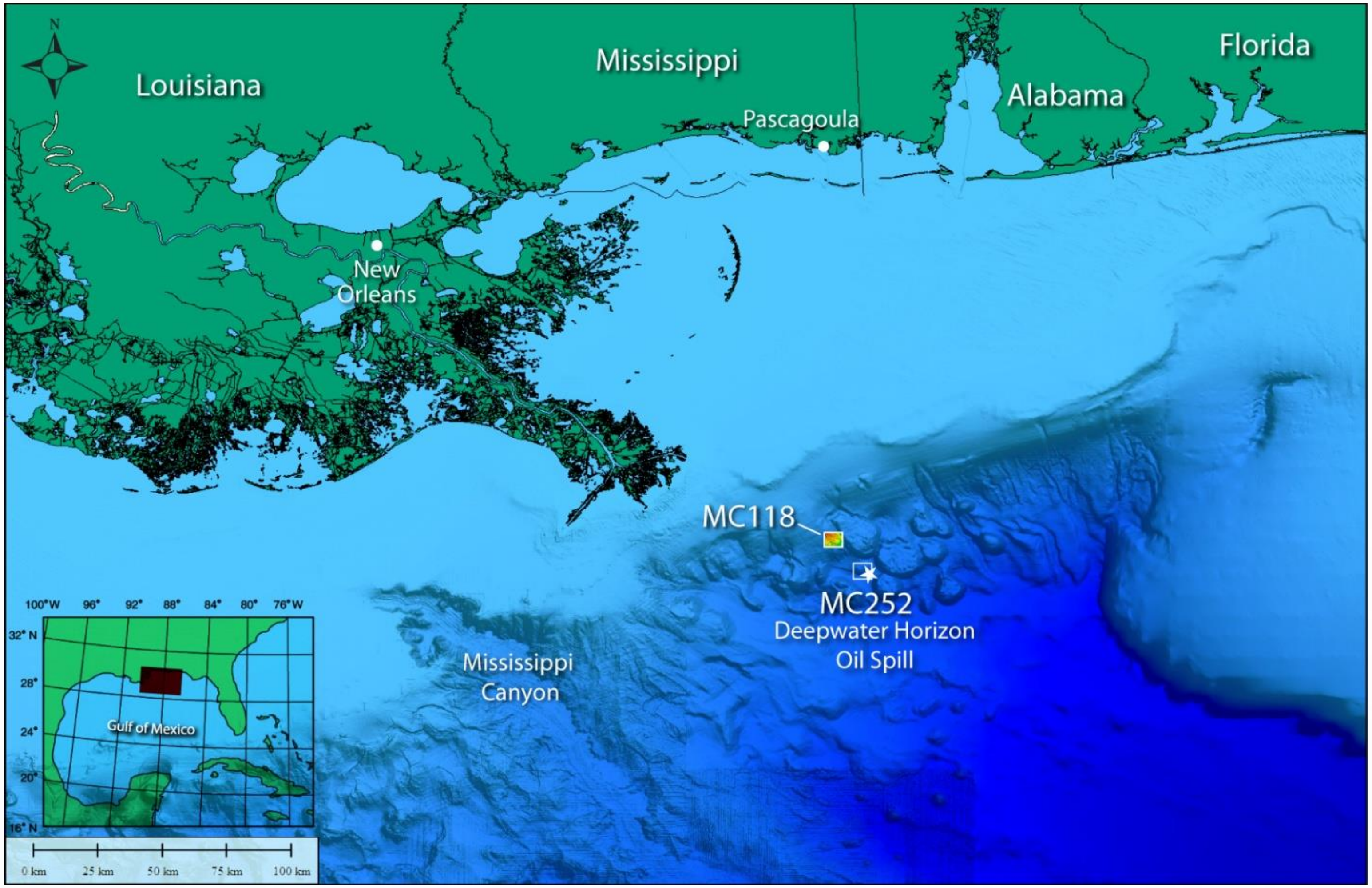
# Woolsey Mound - CSHS

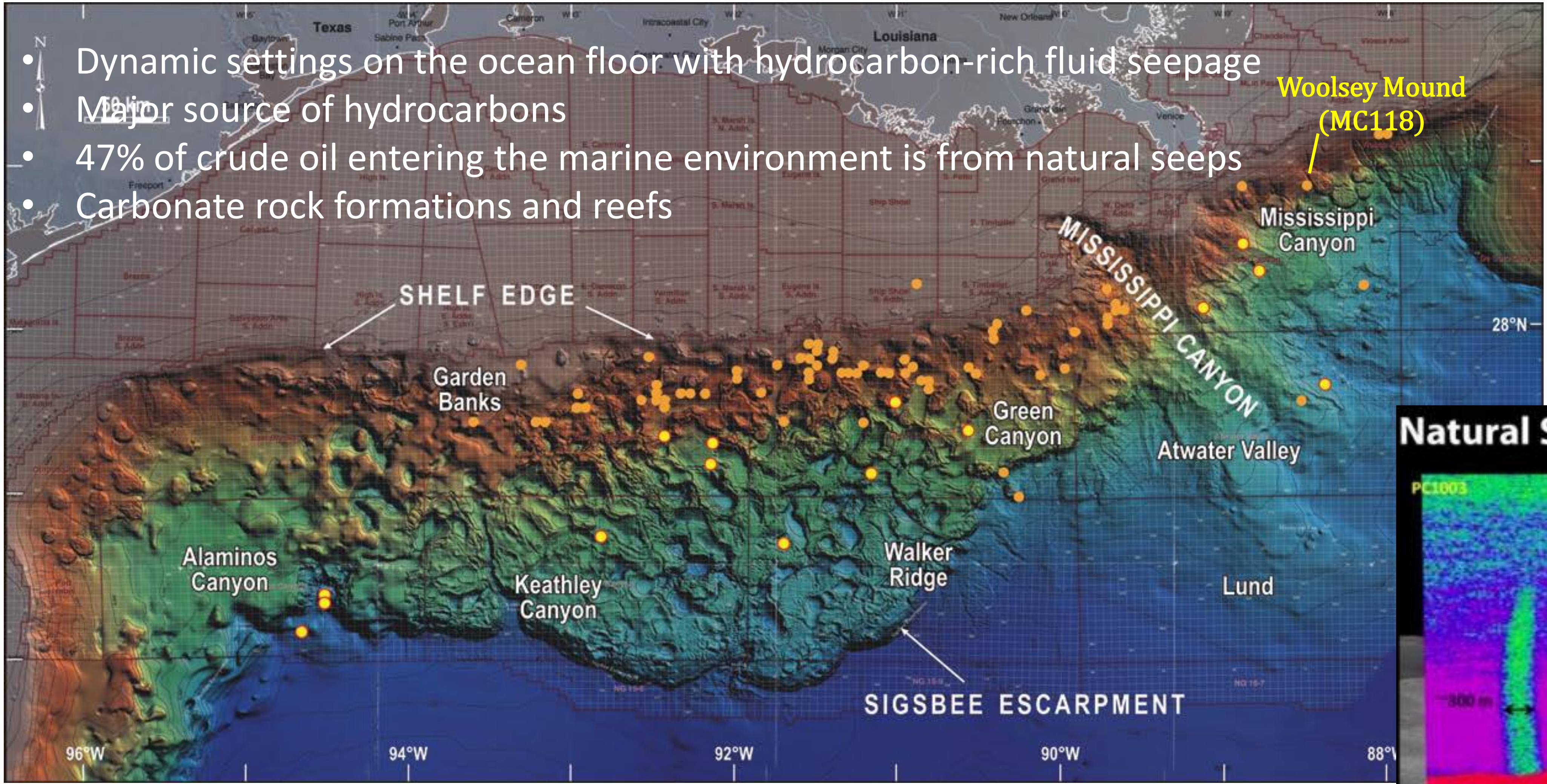


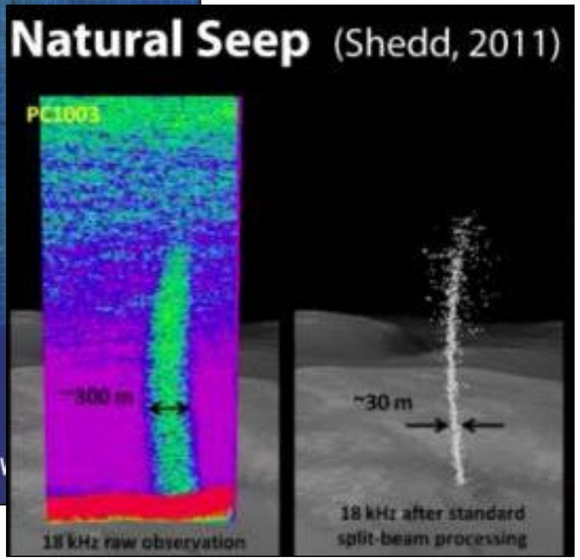

*McGee et al. 2009*

- 900 m WD on the N continental slope of the GOM.
- Slope highly discontinuous, intersected by slumping, folding and faulting mainly driven by salt tectonics and sediment load delivered by the Mississippi River.
- Deepwater Horizon rig, Mississippi Canyon 252, April 22, 2010.

# Cold Seeps in the Gulf of Mexico

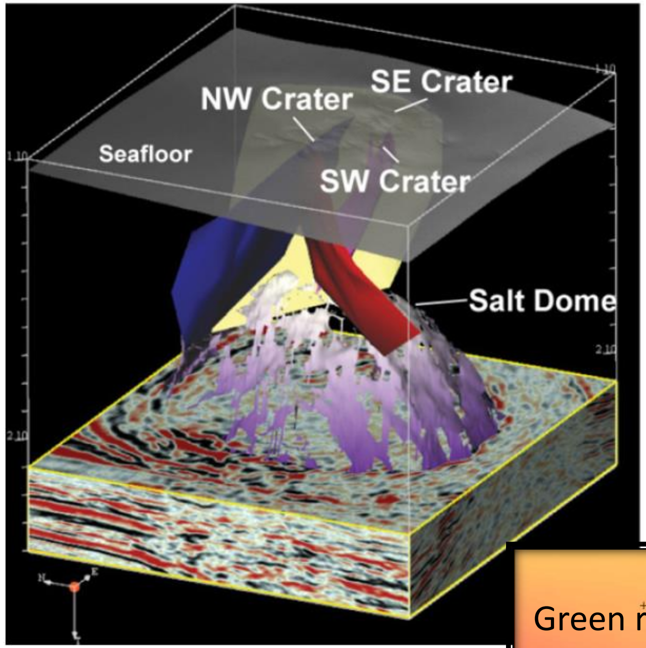
- Dynamic settings on the ocean floor with hydrocarbon-rich fluid seepage
- Major source of hydrocarbons
- 47% of crude oil entering the marine environment is from natural seeps
- Carbonate rock formations and reefs

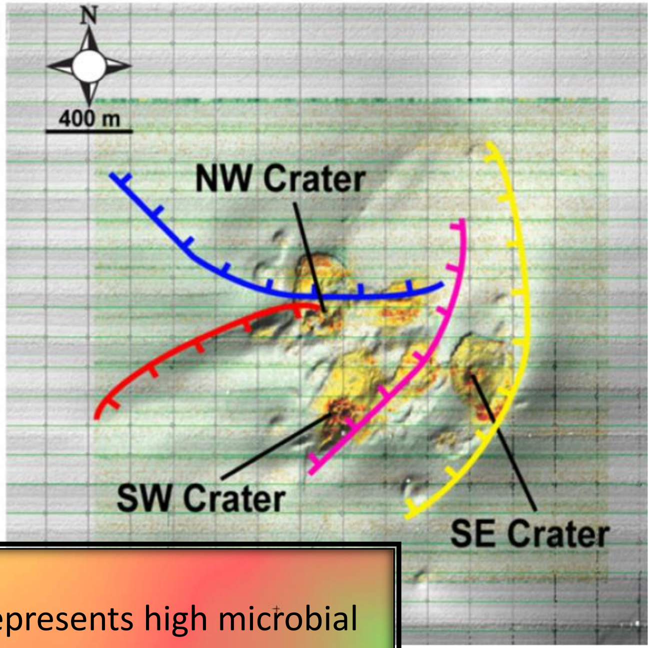


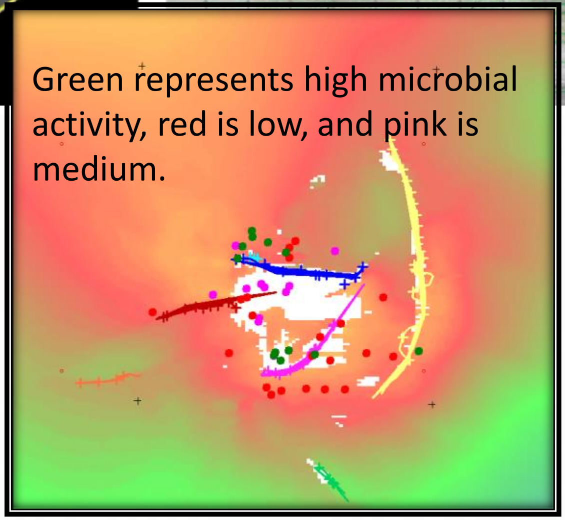




*(Fisher et al., 2007)*

# WM Salt Dome and Major Faults



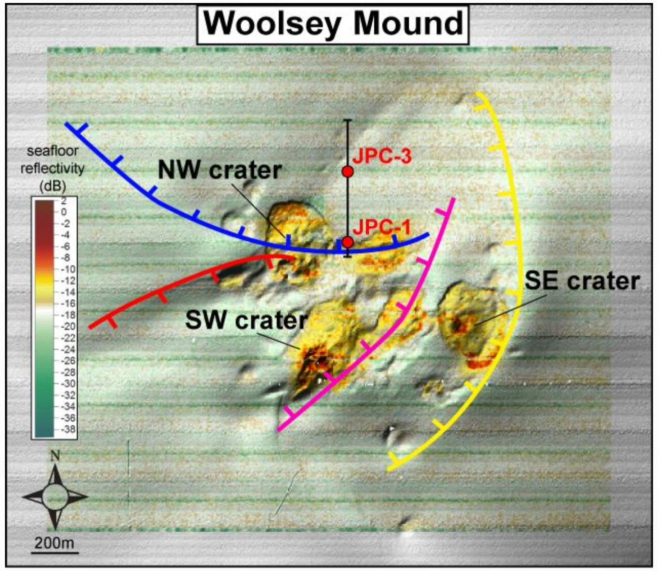




*Macelloni et al. 2012*
*Knapp et al., 2010*

- Fluid flow and gas hydrates formation are segmented laterally along faults.
- Hydrate formation and dissociation vary temporally in the vicinity of active faults and can seal them as conduits for thermogenic fluids.
- Periodic migrations of gases may perturb the GHSZ in terms of temperature and pressure, producing the observed lack of classical BSRs.
- Fluid expulsion events are suspected to occur episodically in the NW and SW complexes to form seafloor craters and pockmarks.
- Vent and microbial activity show temporal evolution from SE to SW to NW mounds

# Woolsey Mound Hydrates

- GH are genetically related to the salt system through active normal faults, conduits for thermogenic gas
- GH formation and dissociation vary temporally in the vicinity of active faults, and can temporarily seal them as conduits for thermogenic fluids.
- GH at WM are controlled by a highly heterogeneous stability field leading to the general paucity of BSRs.
- AVO analysis is a good indicator of hydrates in the absence of well defined BSRs.
- Apparent temporal changes in seismic amplitudes of the subsurface are correlated with periodic fluid expulsion and hydrate dissociation.



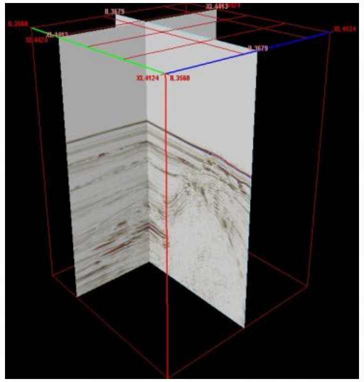

*Simonetti et al., 2013*



MC 118, (Lutken et al., 2011)

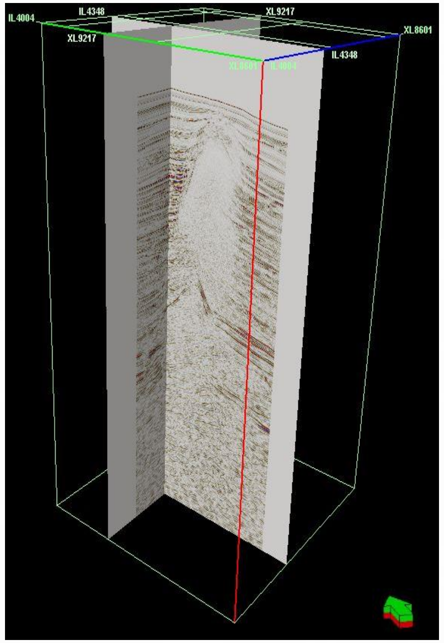
# Available Seismic Data

3 sec TWTT

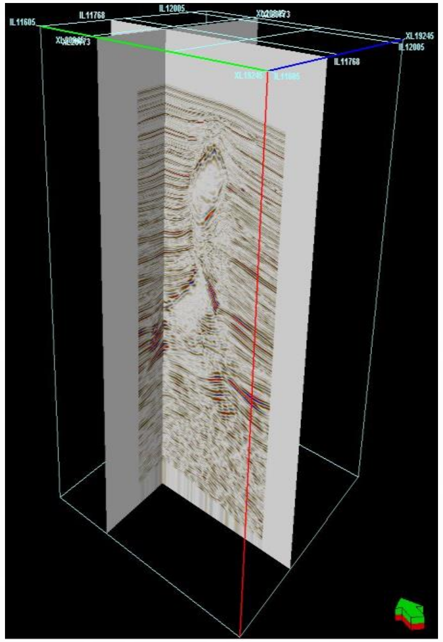


TGS 2000

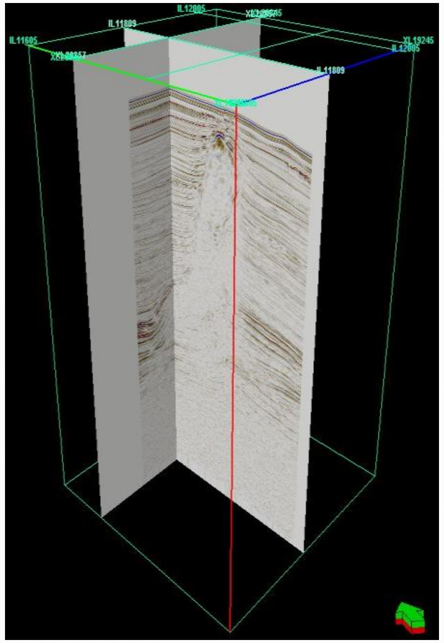
10 sec TWTT



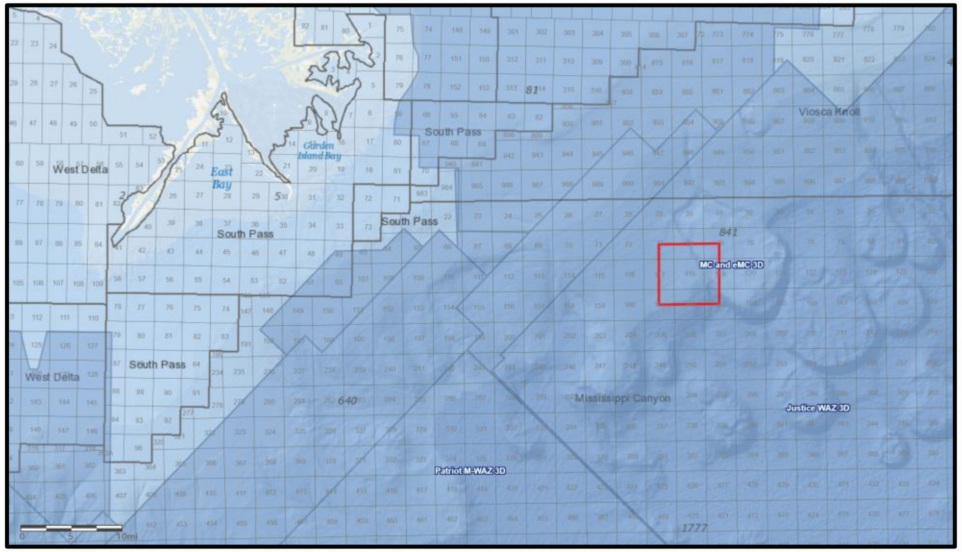
**WesternGeco 2003**



**Justice 2010**



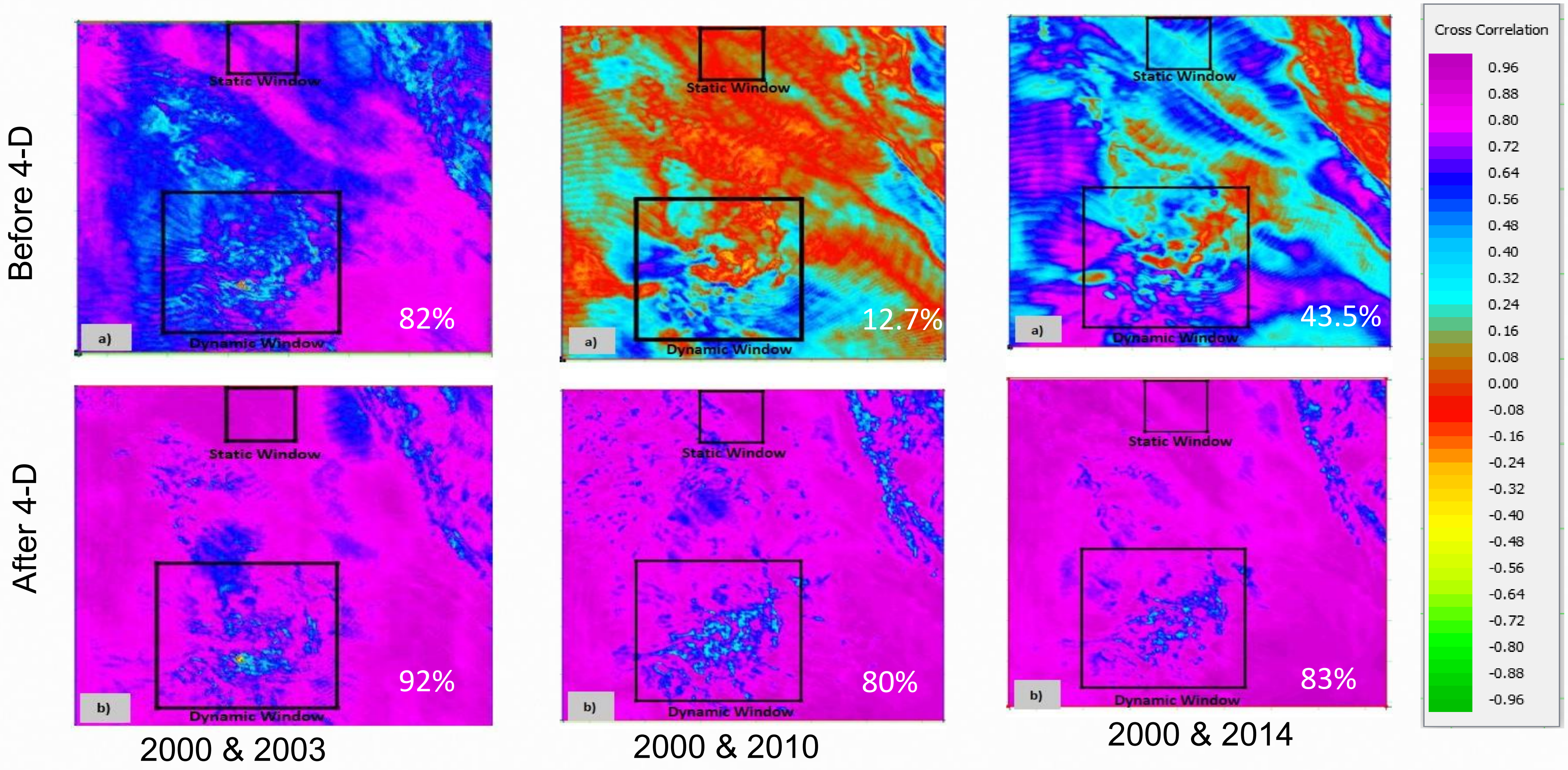
**Declaration 2014**




Four sets of collocated post-stack 3-D seismic data used in this study. The TGS 2000 is used as the base in the time-lapse study. All the other datasets are processed to minimize the differences from the variation in acquisition parameters.

Resampling → 3D geometry re-binning → Time shifting and phase matching → Designing shaping filter → Amplitude balancing

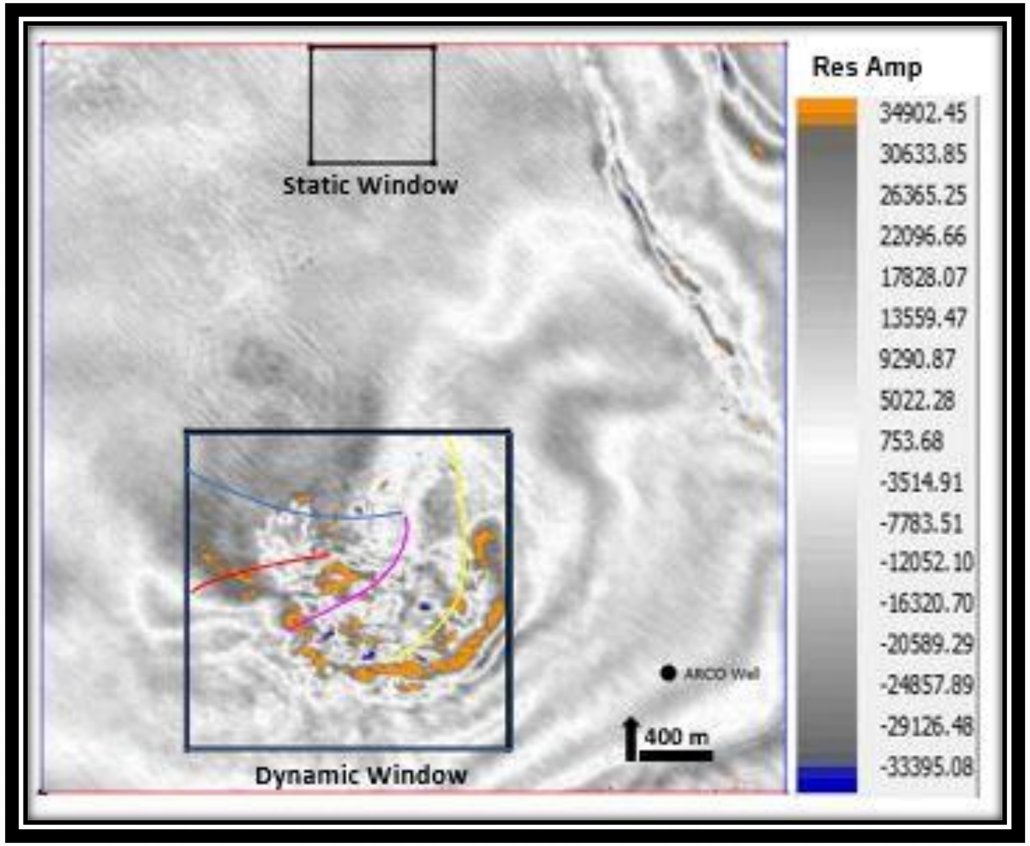
# Results of 4-D Processing




*Alam and Knapp (in progress)*

# Amplitude Changes at the BSR

- A time slice is extracted at 1295 ms from each 4D processed residual amplitude volume to observe the residual amplitude anomalies that persisted after 4D processing. This time range is close to the hypothesized base of the hydrate stability zone (BHSZ). These time slices are transparently overlaid on the variance time slice to observe the spatial evolution of gas hydrates.
- **Change in 3 years**




*Alam and Knapp (in progress)*

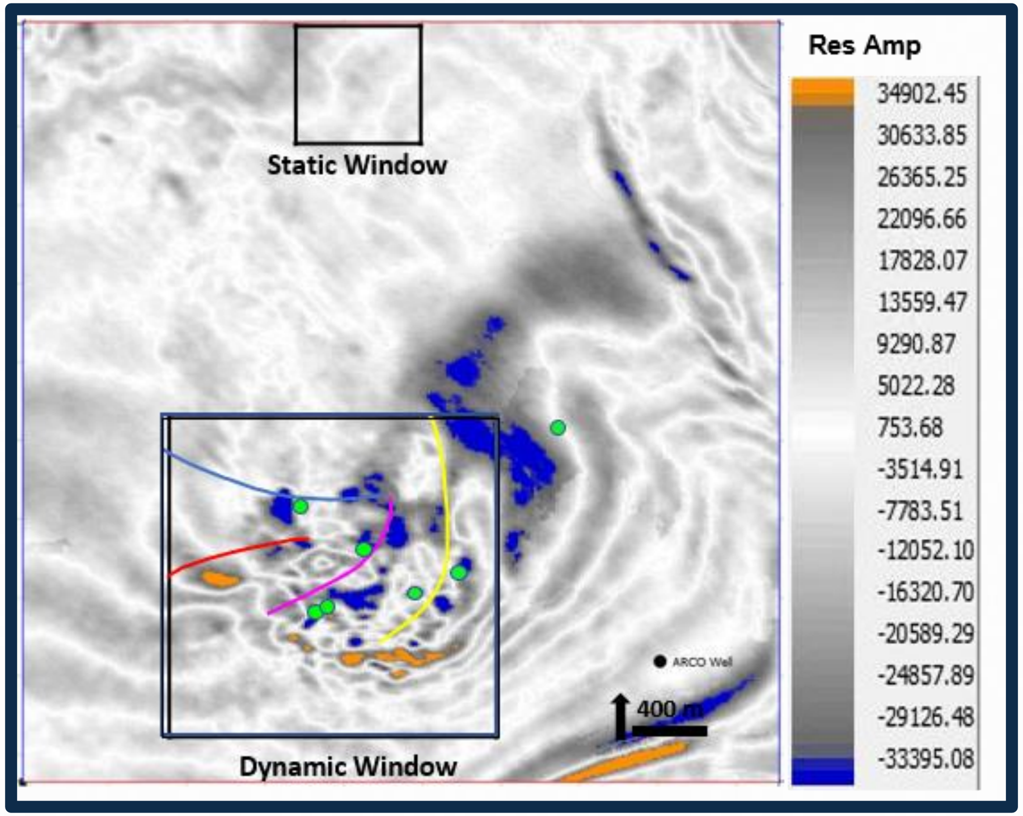
Transparent overlay of the residual amplitude slice (from the residual amplitude volume of 2003 data) on the variance slice extracted at 1.295 s TWTT.

Positive amplitude anomalies imply hydrate dissociation.

Hydrate dissociation is dominant along the SE and SW crater bounding faults.

# Amplitude Changes at the BSR

- **Change in 10 years**




*Alam and Knapp (in progress)*

Transparent overlay of the residual amplitude slice (from the residual amplitude volume of 2010 data) on the variance slice extracted at 1.295 s TWTT.

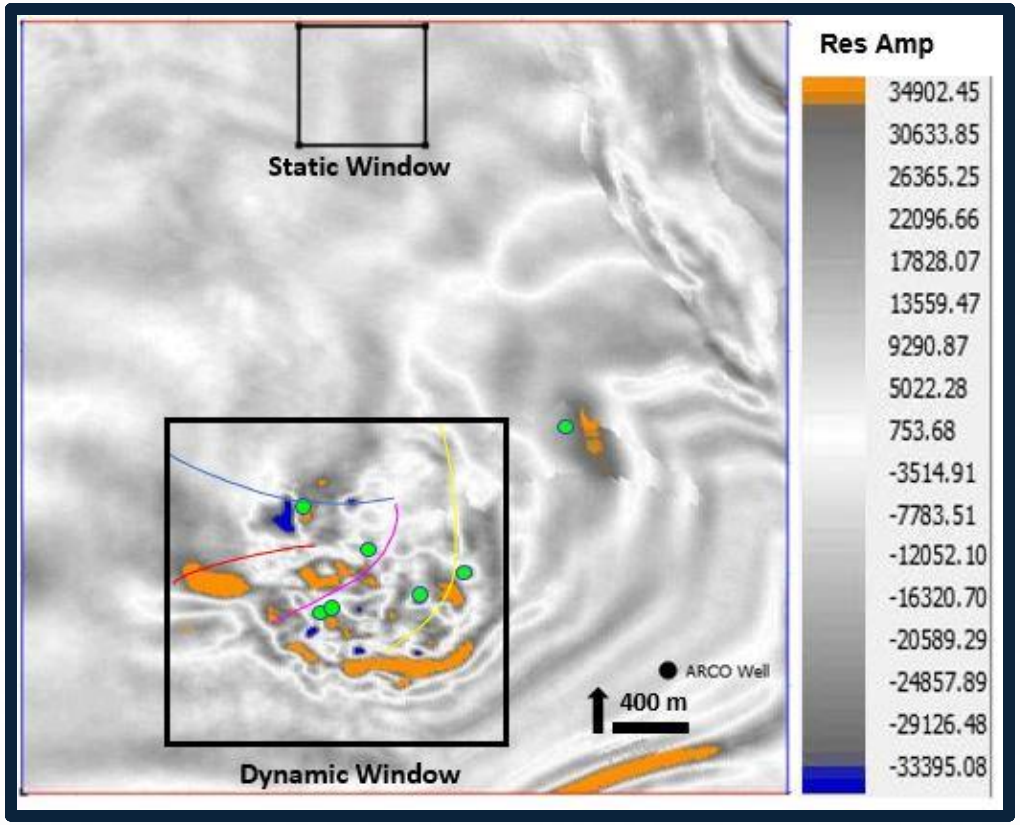
Hydrate dissociation is more prominent than in 2003. The dissociation occurred mostly along the master faults.

Hydrate formation moves toward the NW crater along the blue fault.

The seafloor methane seeps recorded in 2011 are shown in green circles.

# Amplitude Changes at the BSR

- **Change in 14 years**



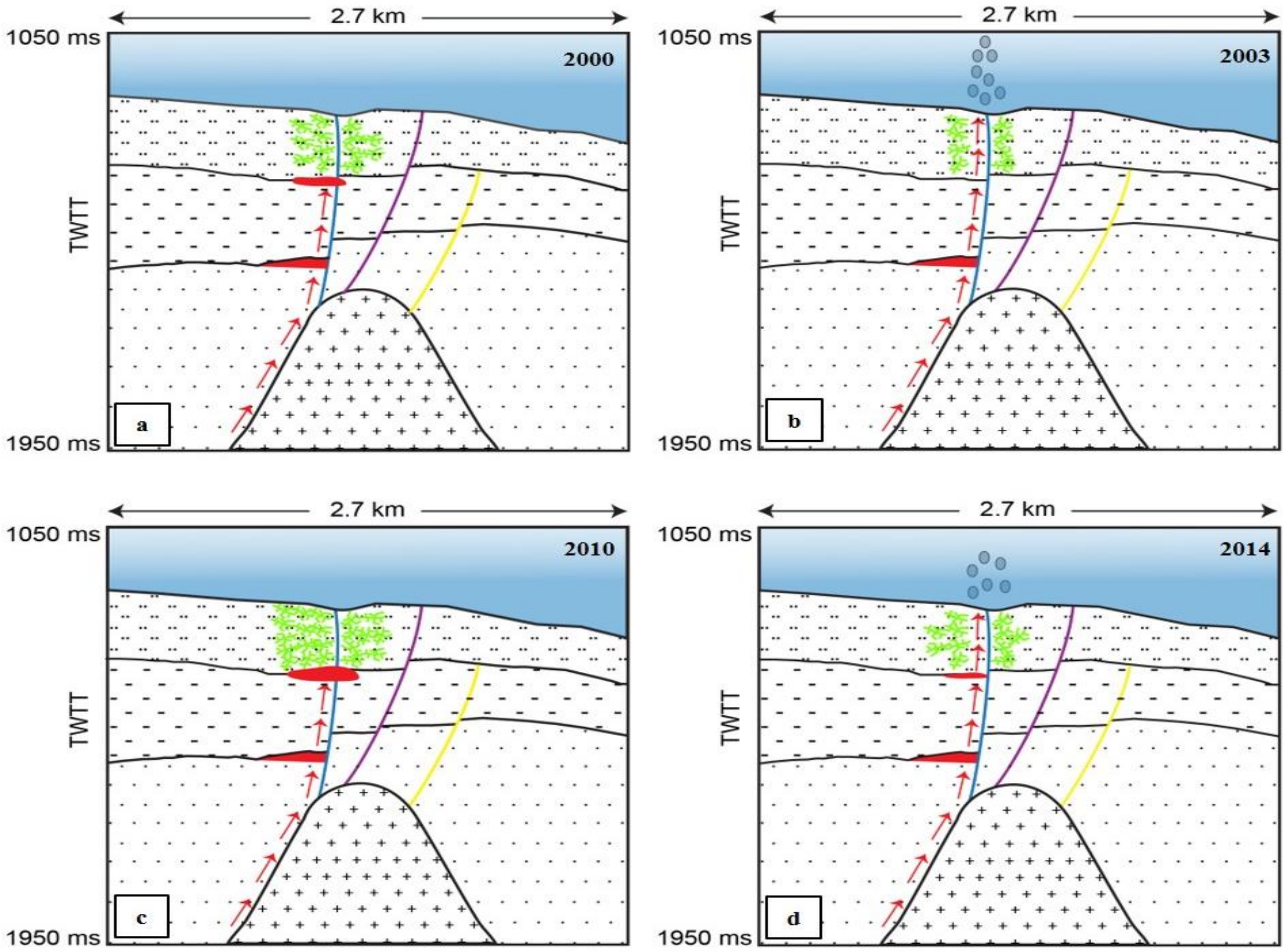

*Alam and Knapp (in progress)*

Transparent overlay of the residual amplitude slice (from the residual amplitude volume of 2014 data) on the variance slice extracted at 1.295 s TWTT.

Hydrate dissociation has weakened significantly since 2010.

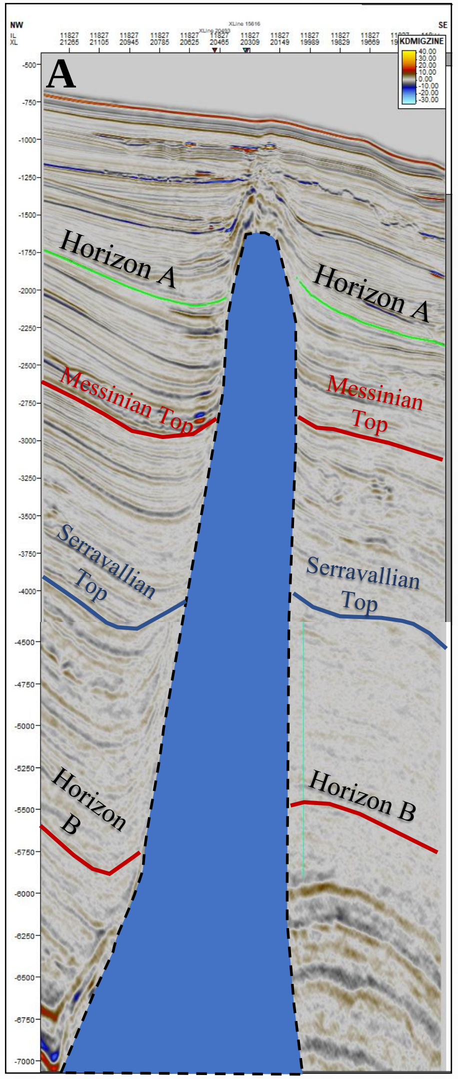
The seafloor methane seeps recorded in 2011 are shown in green circles.

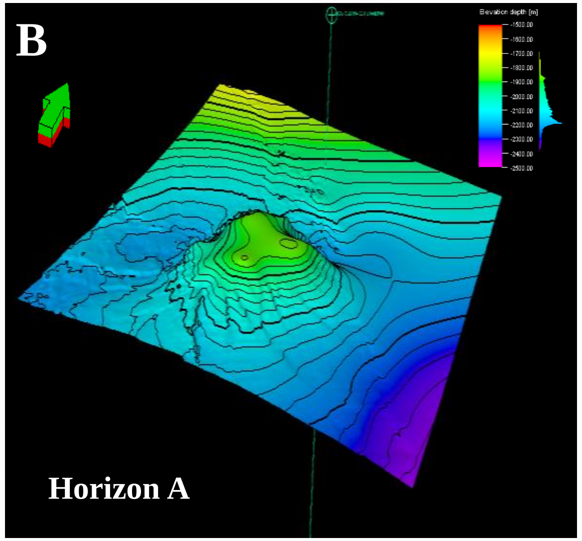
# Hydrate Evolution Model

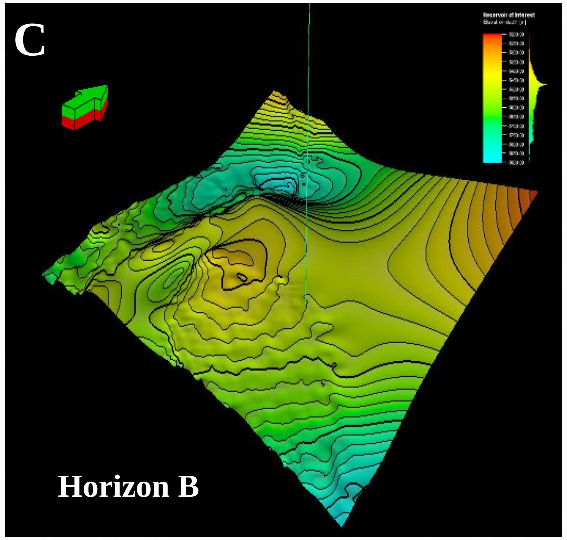


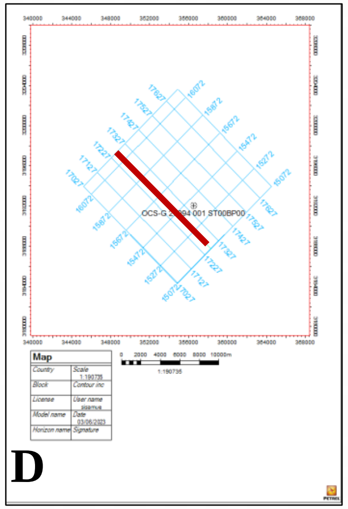

*Alam and Knapp (in progress)*

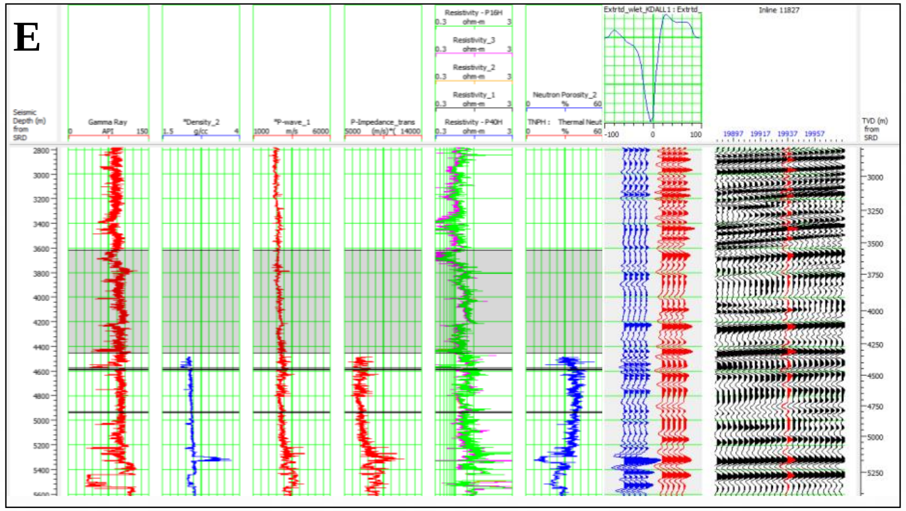
# Results from Seismic Data and Well Logs



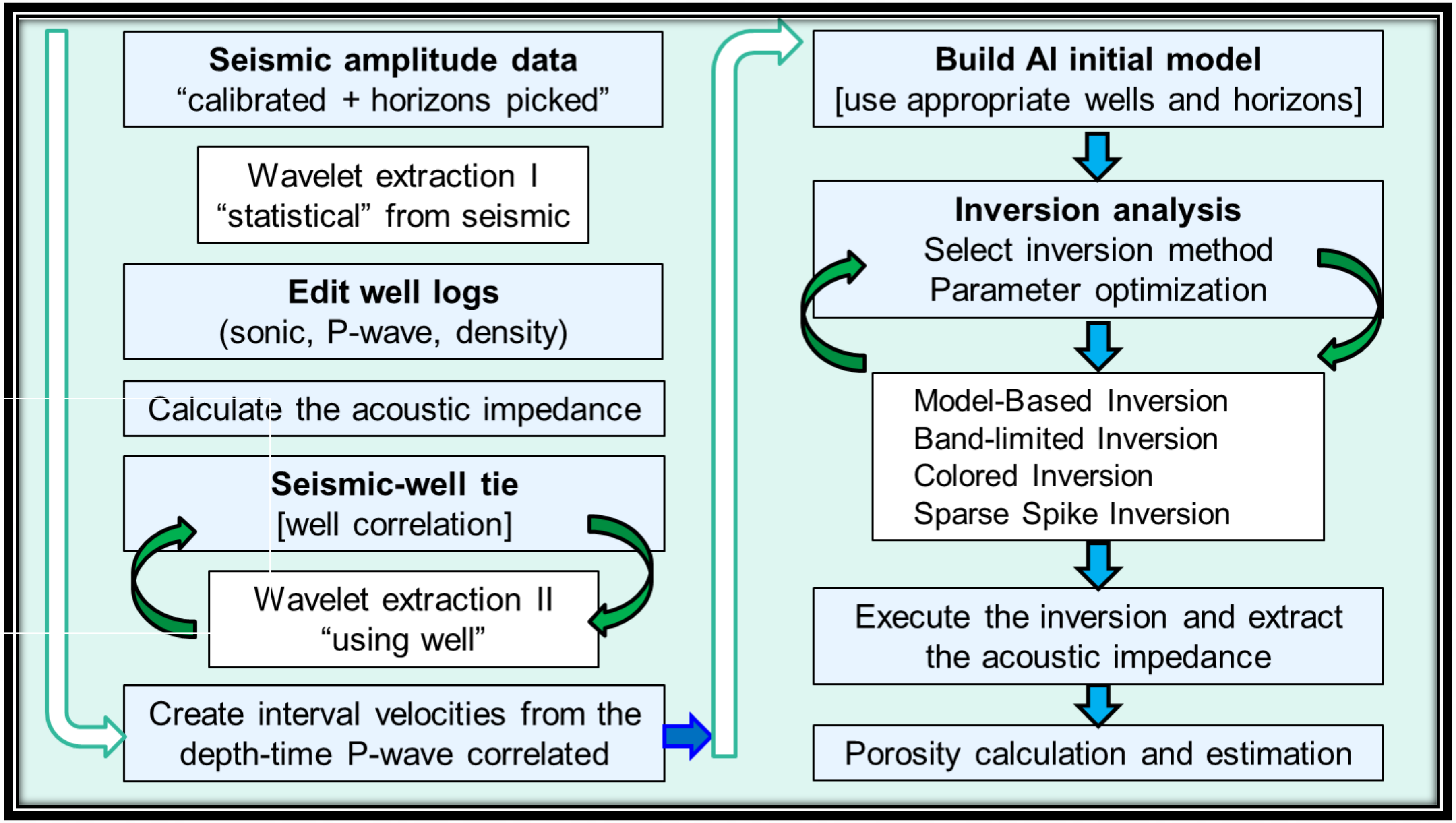



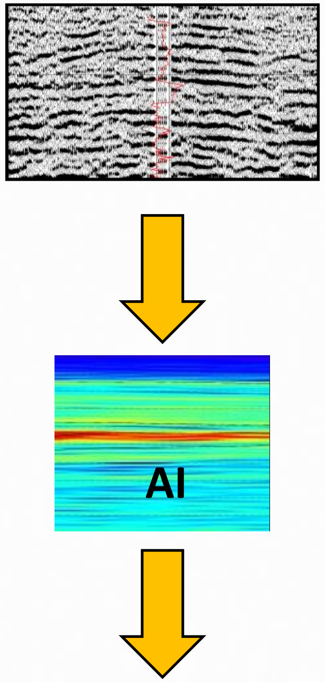



# Seismic Inversion Workflow




*Almutairi et al., 2022*




- **Porosity**
- **Lithology**

**"indicator"**

# Conclusions

- Salt, thermogenic hydrocarbons, faults and fractures play a significant role in the gas hydrate system evolution at Woolsey Mound.
- The residual amplitude changes that persisted following 4D processing are spatially correlated with higher permeability faults and fractures.
- 4-D seismic analysis suggests that CSHSs may  release considerable volume of methane over relatively short periods of time (2000 – 2014).
- Gas hydrate dissociation is prevalent in 2003 and 2014 data.
- Gas hydrate formation is prevalent in 2010 data in the SE crater.
- Hydraulic fracturing triggered by overpressure gases at the base of GHSZ may be the primary mechanism for hydrate dissociation at Woolsey Mound.
- Preliminary results show that deeper reservoirs seem to be suitable for long-term carbon storage.

# Thank You!

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