Detailed Geomorphology of Cold Seeps Associated with a Buried Salt Diapir, Offshore Nova Scotia, Canada

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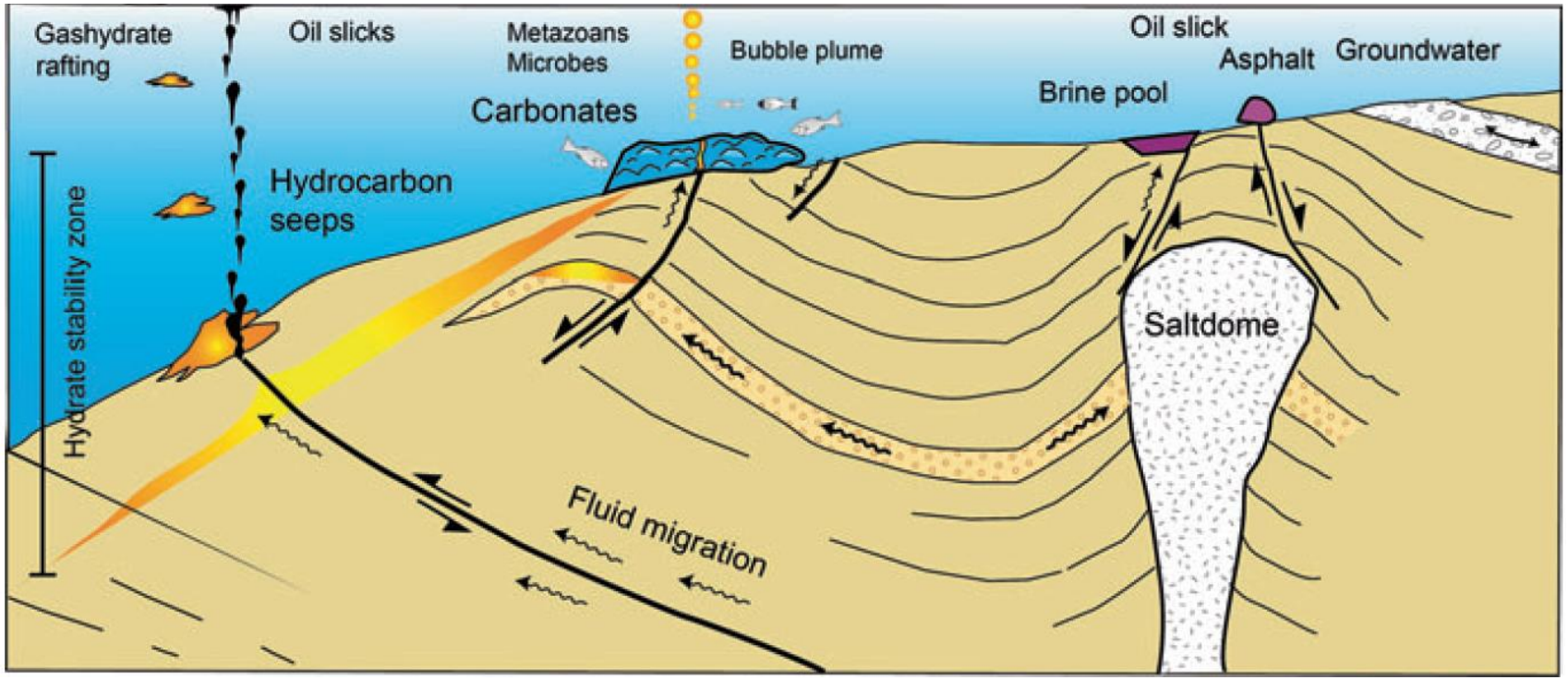
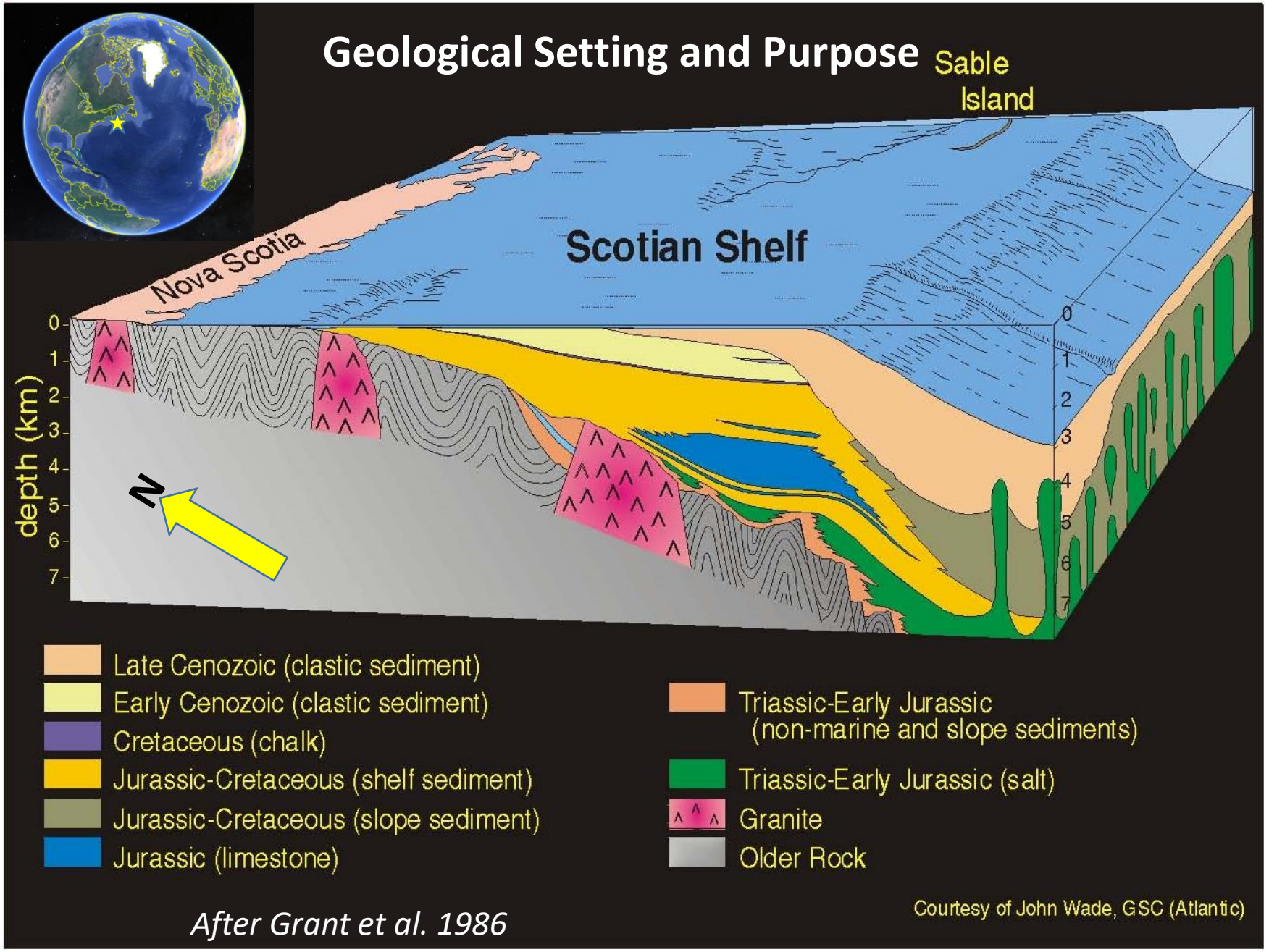
Cold Seeps



Suess 2018

- Occur where fluids, such as hydrocarbons, migrate from depth and escape at the seabed.
- Relatively common features in petroleum basins around the world.
- Often host unique biological communities.
- A potential geological hazard as indicate excess pore fluid pressures in shallow sediments.
- Provide critical information about fluid migration pathways and fluid source.
- Are notoriously difficult to sample because of their ephemeral nature.

Geological Setting and Purpose



After Grant et al. 1986

- Western North Atlantic passive continental margin offshore Nova Scotia.
- Thick clastic deposits bury evaporites formed early in the rift history leading to diapirism.
- Objective is to understand the geology, geochemistry and geomicrobiology of cold seeps linked to salt diapirism.
- Target tops of salt diapirs where fluids might be migrating from depth.
- Challenging environment- 2500-3000 m water depth.

Data and Methods

3D Seismic Survey Area

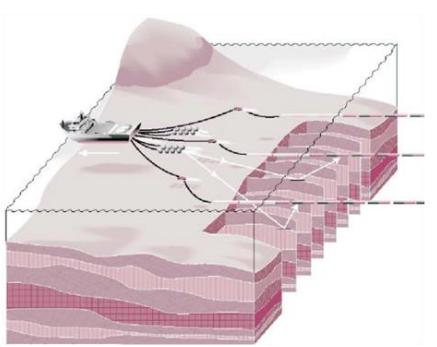
Study Area

D

Water Depth
Metres
High : -200
Low : -4000

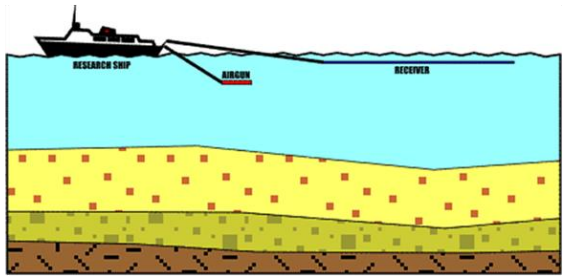
20,000
Metres

D- salt diapir with seafloor expression
white circles- core locations



Extensive Industry 2D and 3D seismic reflection data

Spatial resolution 25 m
Vertical resolution 6 m

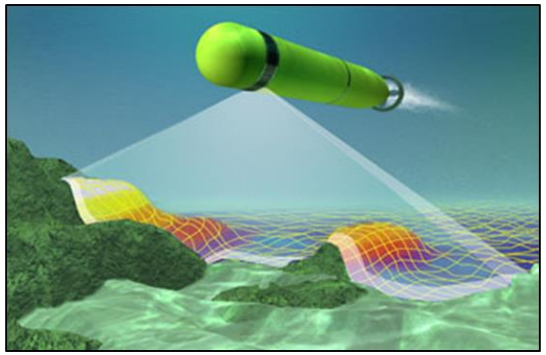


Site survey single channel 2D research seismic reflection data (GI Gun and Sparker)

Vertical resolution 0.3-2 m

Conventional surface-acquired multibeam bathymetry

Spatial resolution 75 m



Autonomous Underwater Vehicle (AUV)

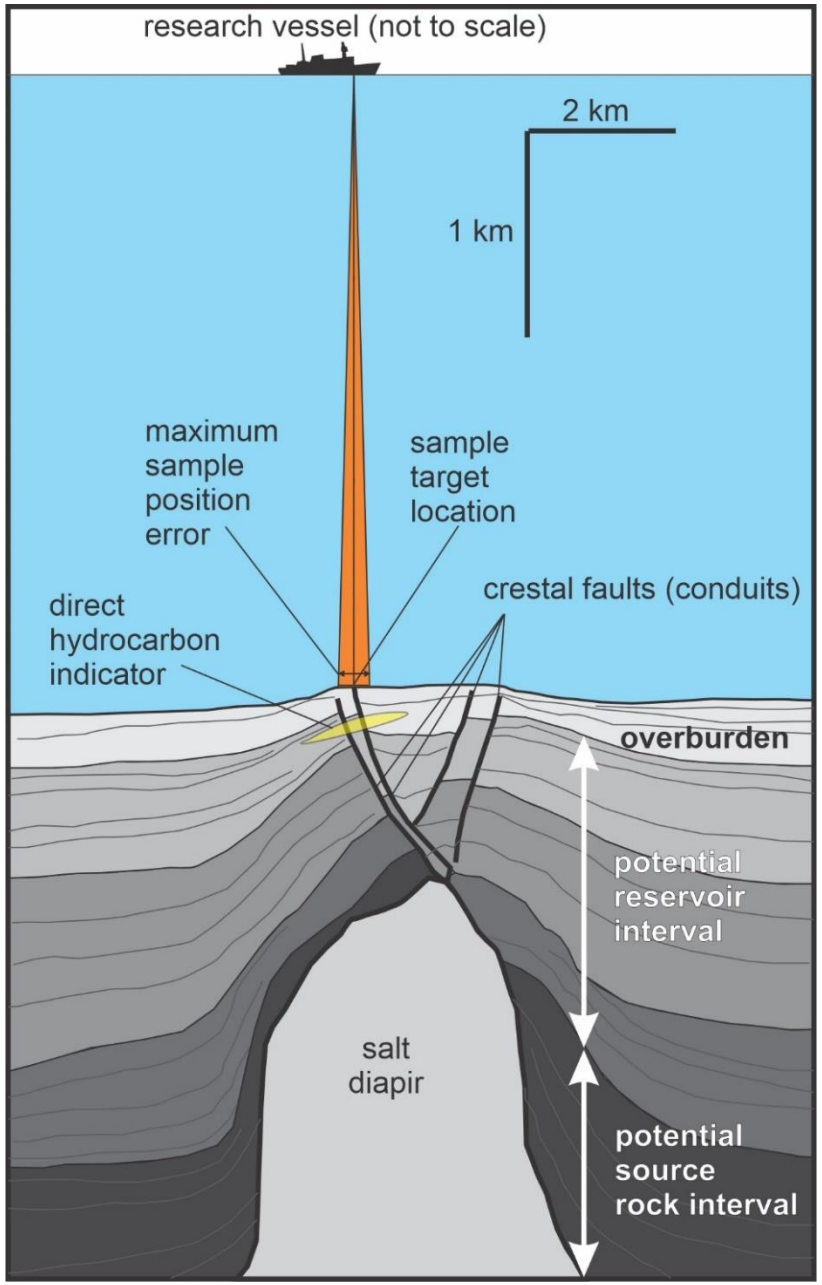
Sidescan, swath bathymetry, and sub-bottom profiler data

Spatial resolution 0.15-0.5 m
Vertical resolution 0.2 m

2020-05-02

Results

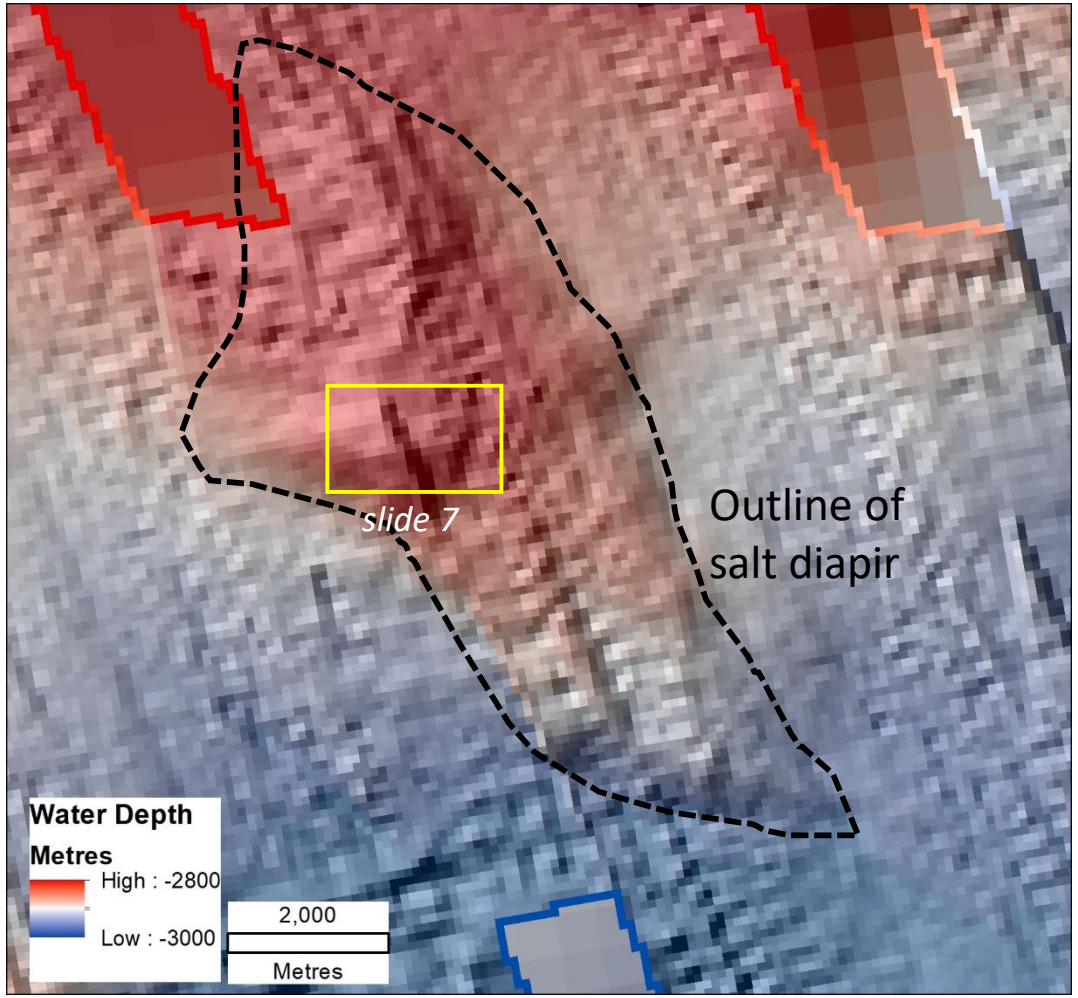
- Many high-quality coring targets based on analysis of seismic reflection data.
- Despite collecting more than 100 core samples in 2015 and 2016, indication of seep activity in sediment cores was limited (<5% of core samples).
- Clear challenges in detecting seeps at the seabed using sea surface methods and accurately locating core samples in such water depths.
- Returned in 2018 with AUV to survey a site that showed positive indication of hydrocarbons and gas hydrates.



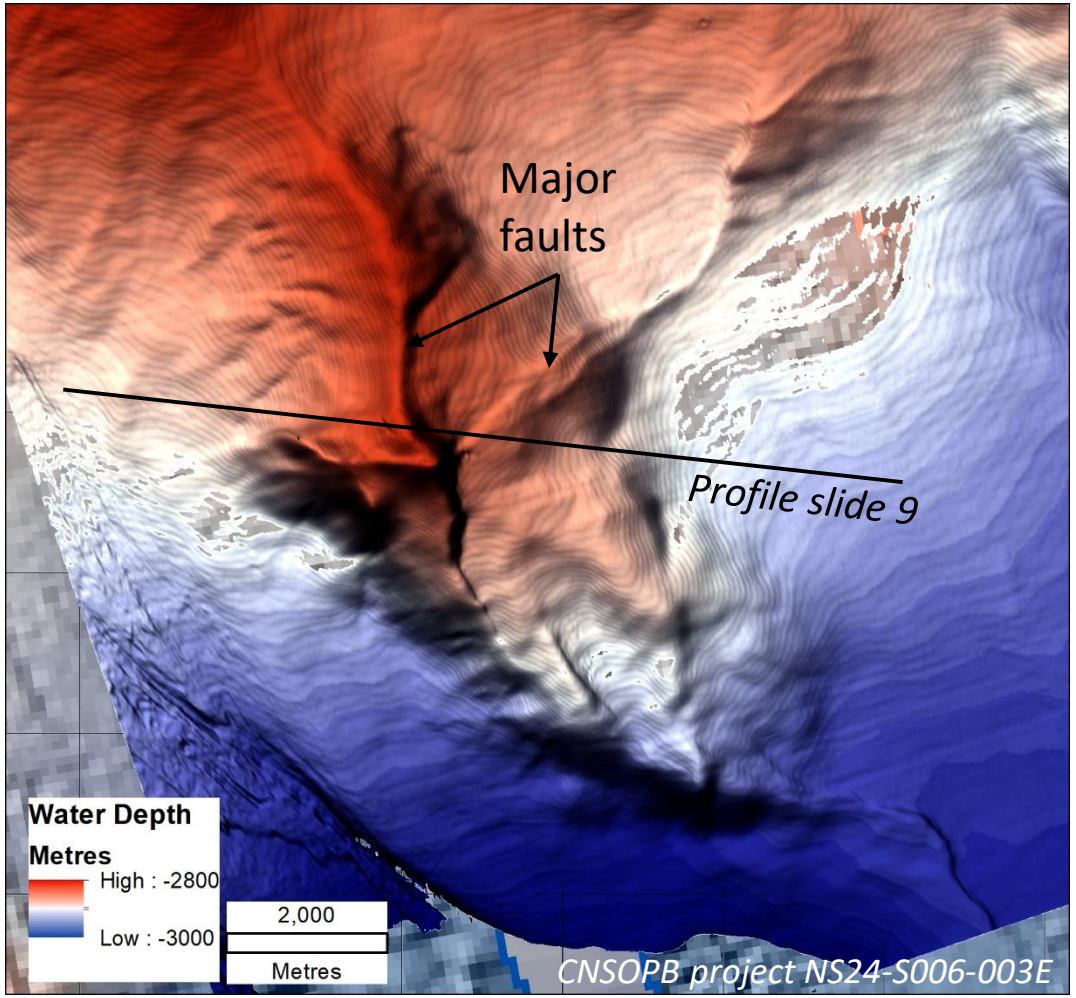
Typical cold seep target scenario for this study

Intercalated hydrate in core samples

Multibeam bathymetry over salt diapir

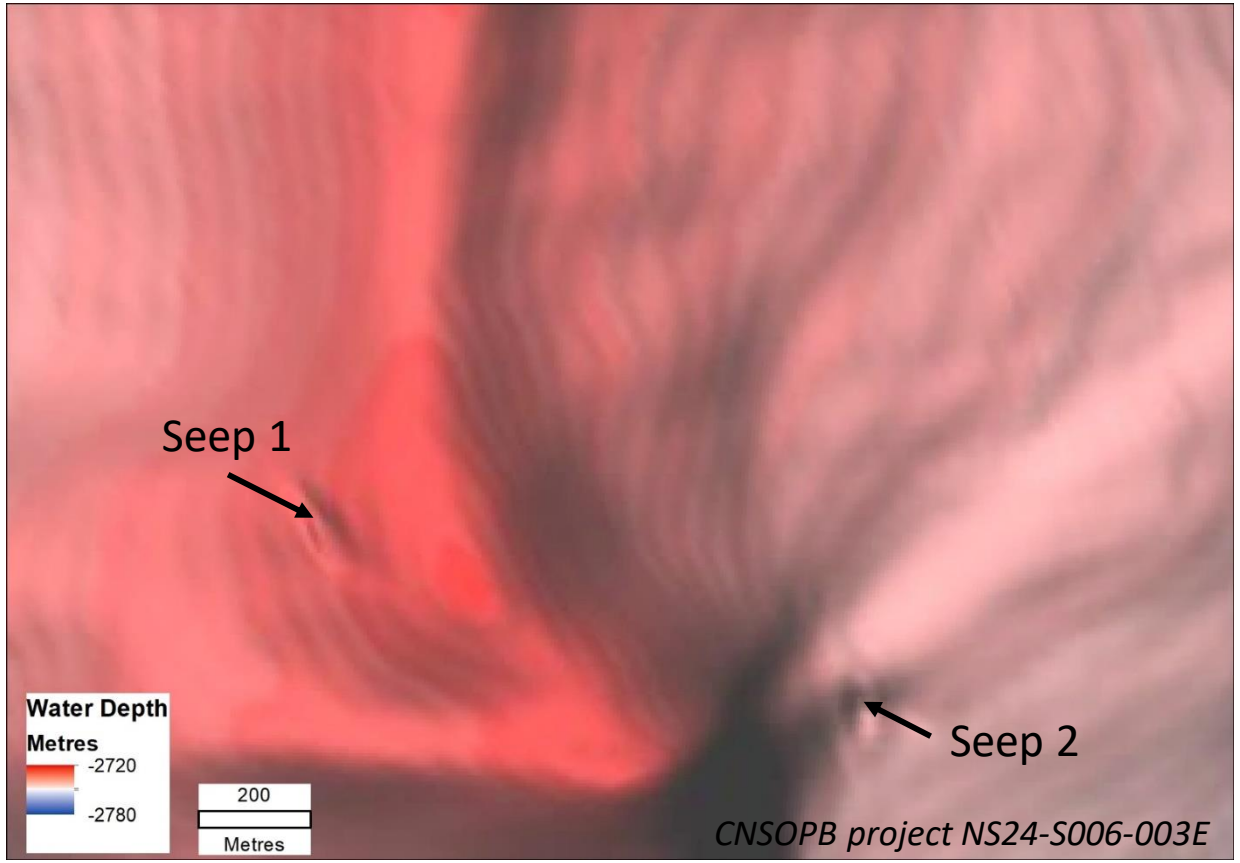


3D seismic seabed morphology

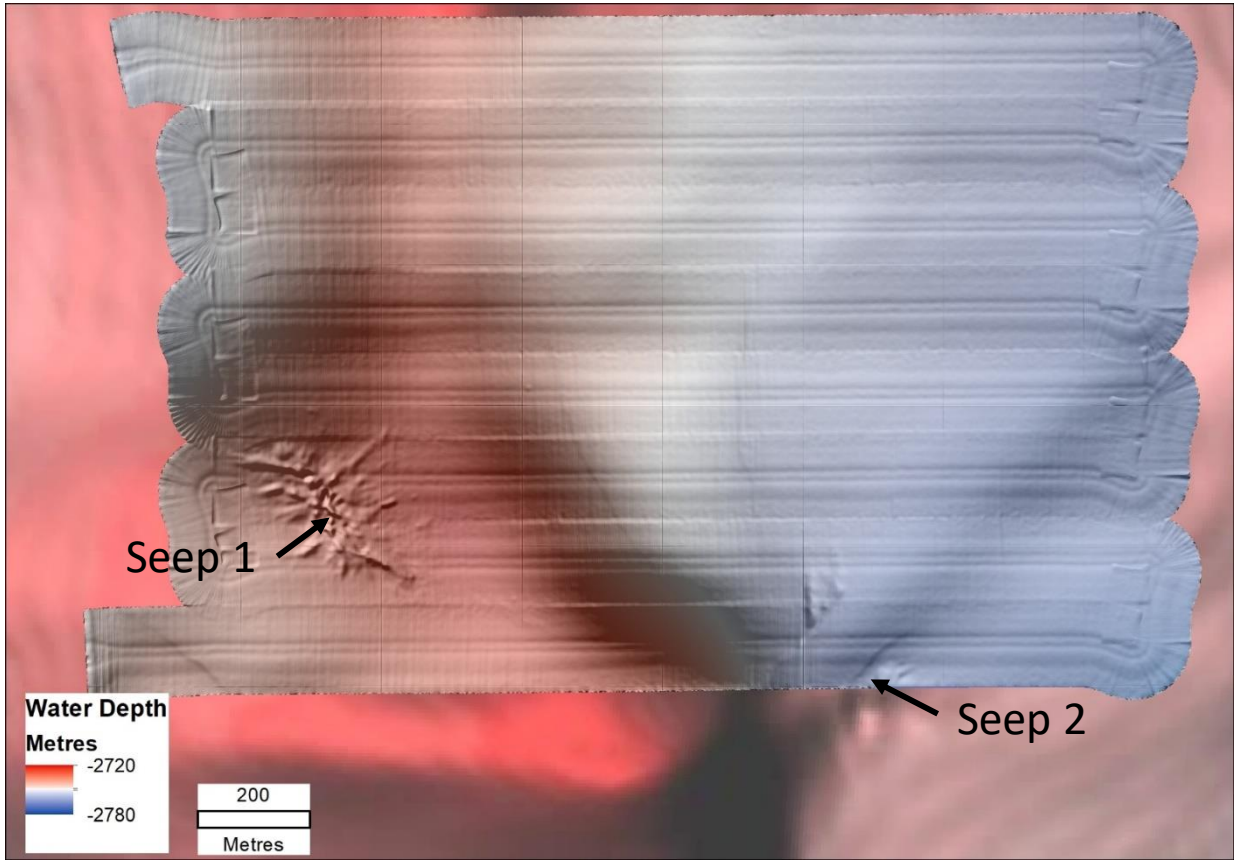


The diapir forms an oblong mound barely discernible on conventional multibeam bathymetry. It rises 200 m above the surrounding seabed. Two major orthogonal faults are apparent on the seabed that cut the mound along its major and minor axes. See slide 4 for location.

3D seismic seabed morphology

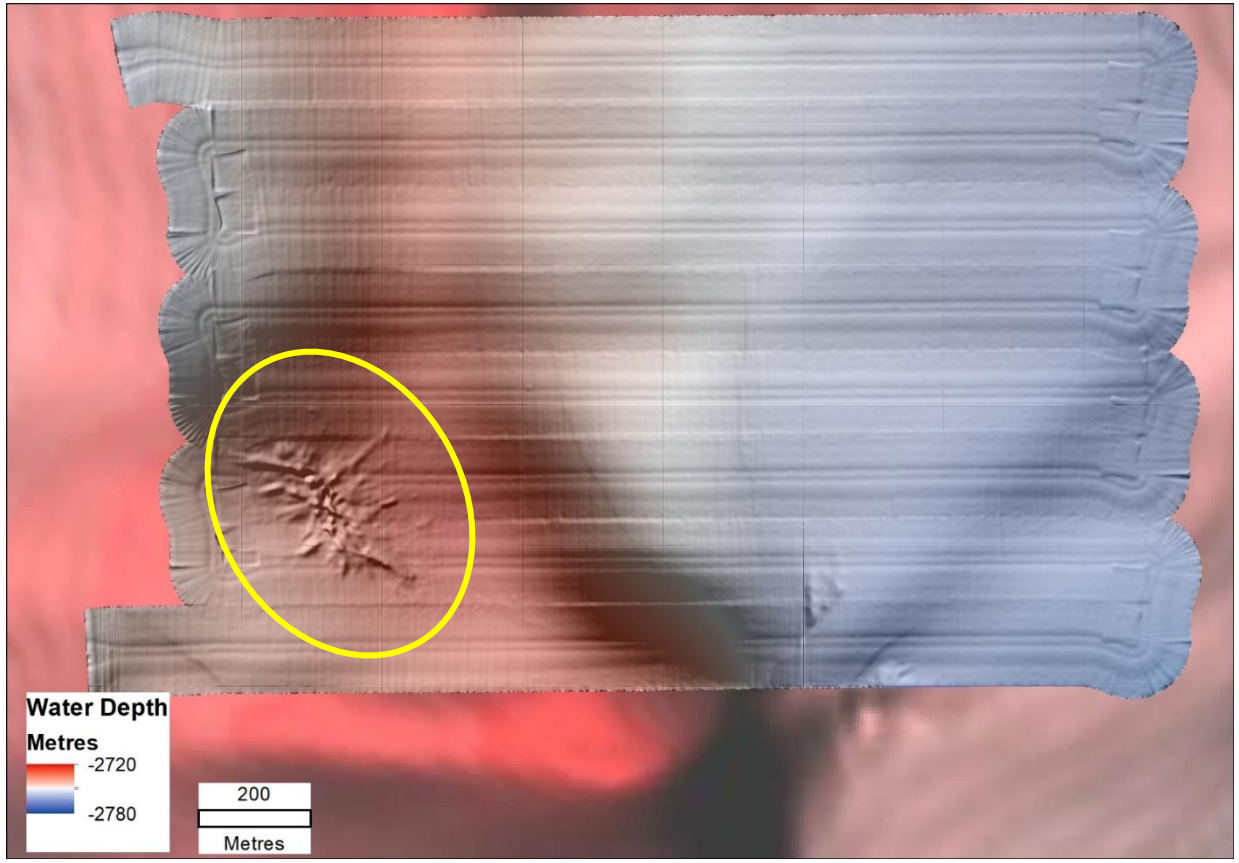


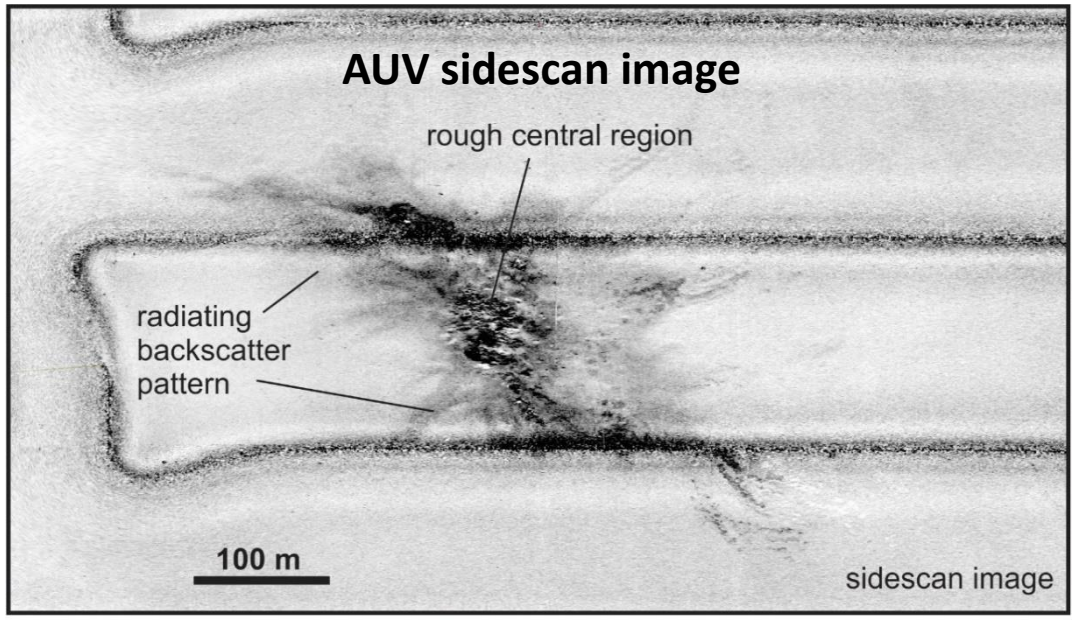
AUV seabed morphology

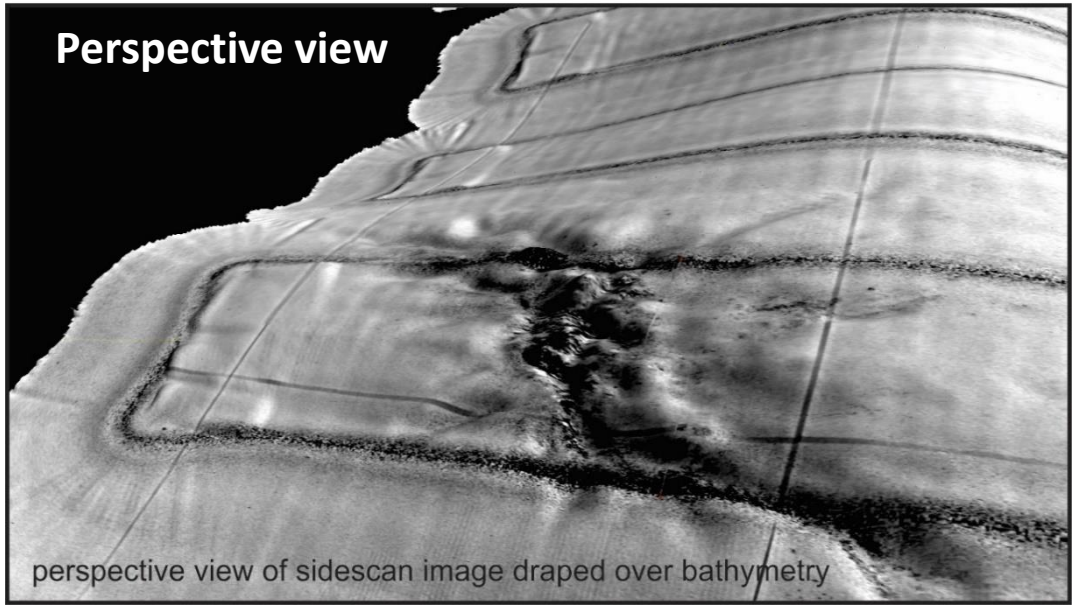


The seep morphology presents as subtle depressions on the 3D seismic data seabed morphology. In contrast, AUV data acquired over the crest of the diapir reveal a 500 m by 200 m fissure on the western flank of the diaper, off axis from a major fault. Another seep occurs on the eastern flank of the diapir crest and coincides with a crestal fault.

AUV seabed morphology

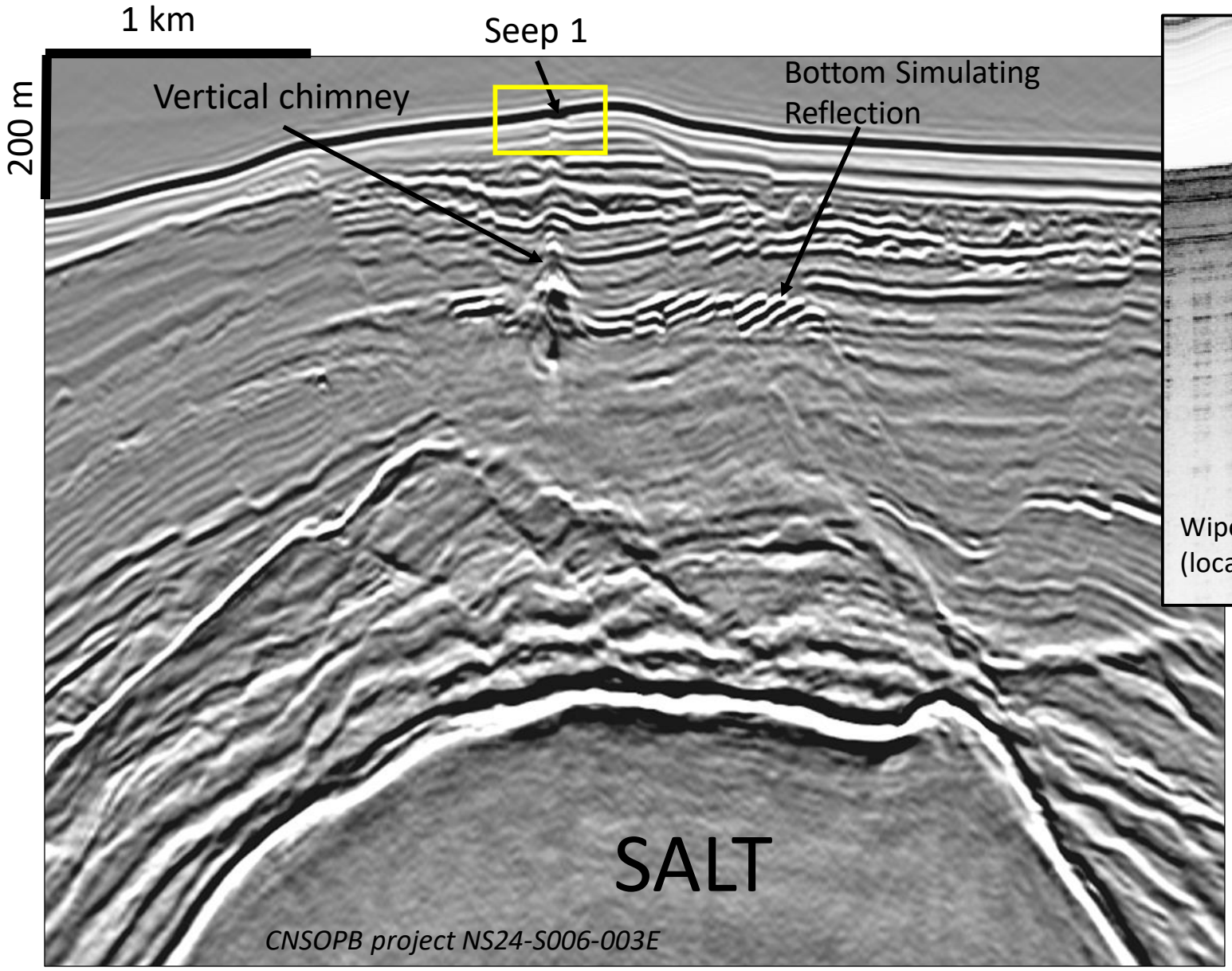




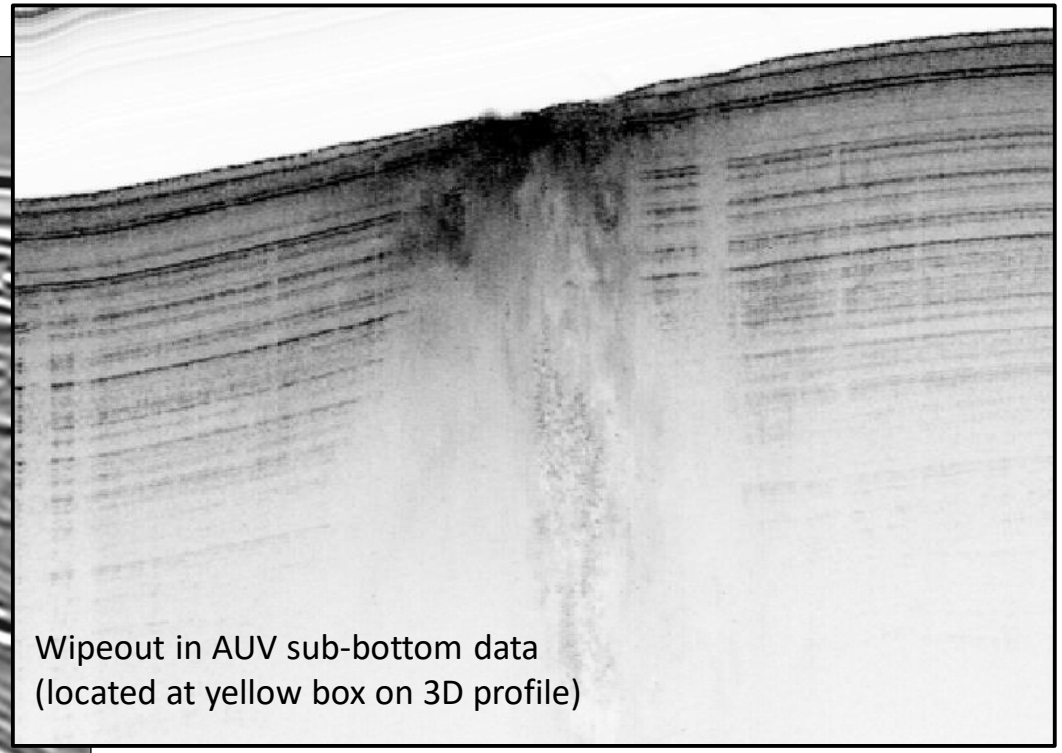


The AUV sidescan data show that the fissure of Seep 1 is composed of a blocky central zone along its axis, and radiating “cracks” that show backscatter variation, possibly indicating recent fluid expulsion.

3D Seismic Profile



AUV Sub-bottom Profile



Wipeout in AUV sub-bottom data
(located at yellow box on 3D profile)

Integration of the AUV data with the 3D seismic data show that the fissure in Seep 1 is fed by a vertical chimney that intersects a bottom simulating reflection above the diapir. Remarkably, the chimney does not appear to be related to any of the sub-vertical crestal faults.

SUMMARY:

- A wide range of geophysical datasets were used to investigate the geomorphology of a cold seep at the crest of a salt diapir in 2700 m water depth offshore Nova Scotia, Canada.
- AUV data reveal a 500 m by 200 m fissure on the western flank of the diapir.
- Integration of the AUV and 3D seismic data show that the fissure is fed by a vertical chimney and does not coincide with one of the sub-vertical crestal faults.
- The cold seeps present as very subtle features on the 3D seismic reflection data and are only positively identified in the AUV datasets.
- This study shows that conventional surface-acquired acoustic data are potentially insufficient for detecting cold seep morphologies in deep-water settings.

Acknowledgments-
Science staff and crew of CCGS Hudson expeditions associated with project. Natural Resources Canada, Nova Scotia Department of Energy and Mines and Canada-Nova Scotia Offshore Petroleum Board.

References

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Suess, E., 2018. Marine cold seeps: background and recent advances. Hydrocarbons, Oils and Lipids: Diversity, Origin, Chemistry and Fate. Handbook of Hydrocarbon and Lipid Microbiology, pp.1-21.