Seismic Evidence for *Subsurface* Gas Hydrate in the Northern Gulf of Mexico

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The Dilemma

Photo: I. Macdonald, TAMU

Well known surficial hydrate mounds

Well known leaky petroleum system

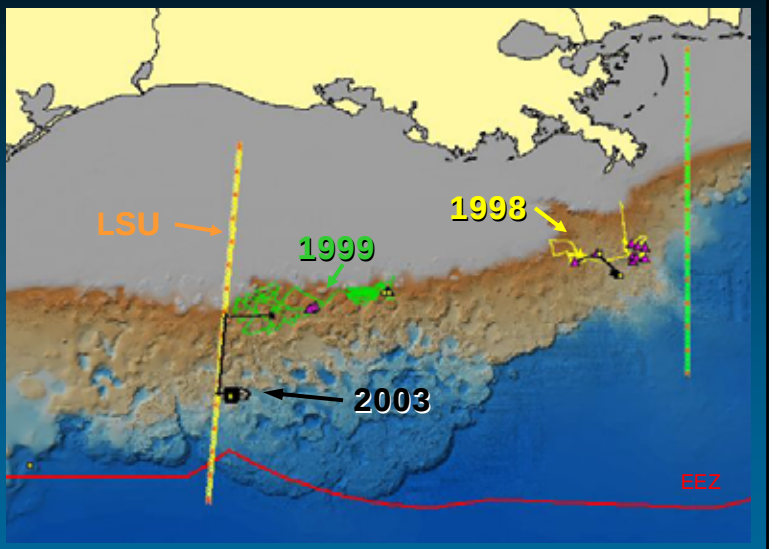
Where are the subsurface hydrates?

USGS

USGS Gas Hydrate Studies

Field
+
Subsurface

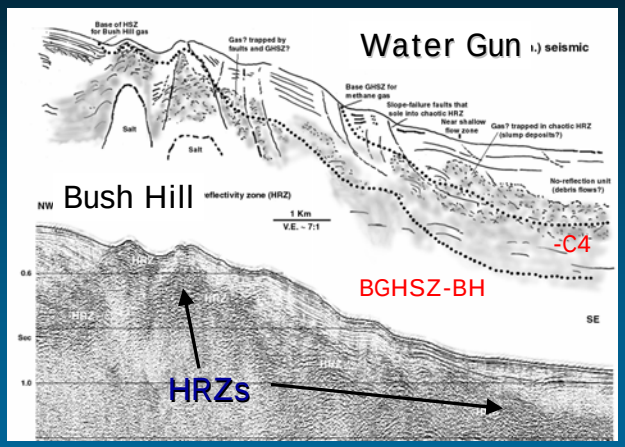
Seismics
+
Coring



USGS

The Elusive BSR in the Gulf of Mexico

1998 and 1999 cruises:
HRZ's
Free Gas?



Cooper and Hart, 2002

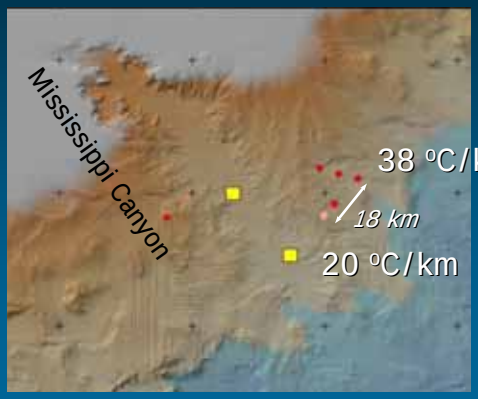
USGS

Insight into Complexity

Results from 2002 Giant Piston Coring in the Gulf of Mexico

USGS

(1) Heat Flow
Geothermal Gradients are elevated and variable.



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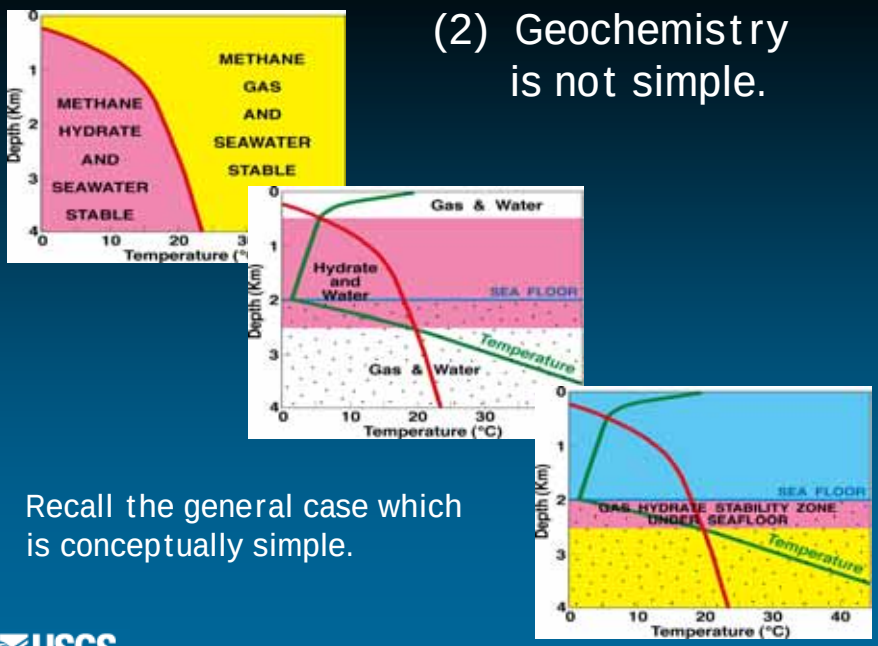
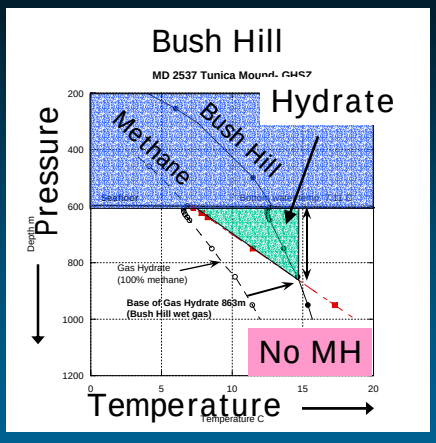
(2) Geochemistry is not simple.

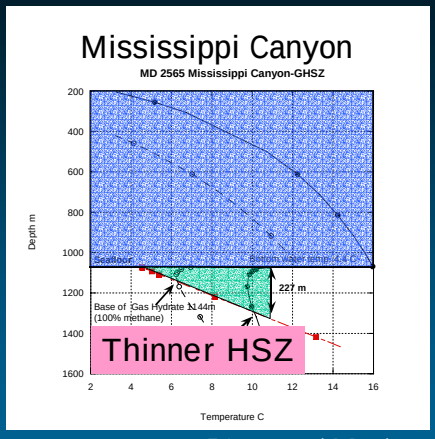


Recall the general case which is conceptually simple.

USGS

Examples from the MD Cores





T. Lorenson and J. Dougherty

The phase diagram boundaries are not simple.

USGS

Understanding Gas Hydrate Occurrence in the Northern Gulf of Mexico

Requires at a minimum:

- Seismics – to understand the geology
- Heat Flow – to understand the thermal regime
- Geochemistry – to understand the chemical complexities

And to integrate the results

To understand the fluxes

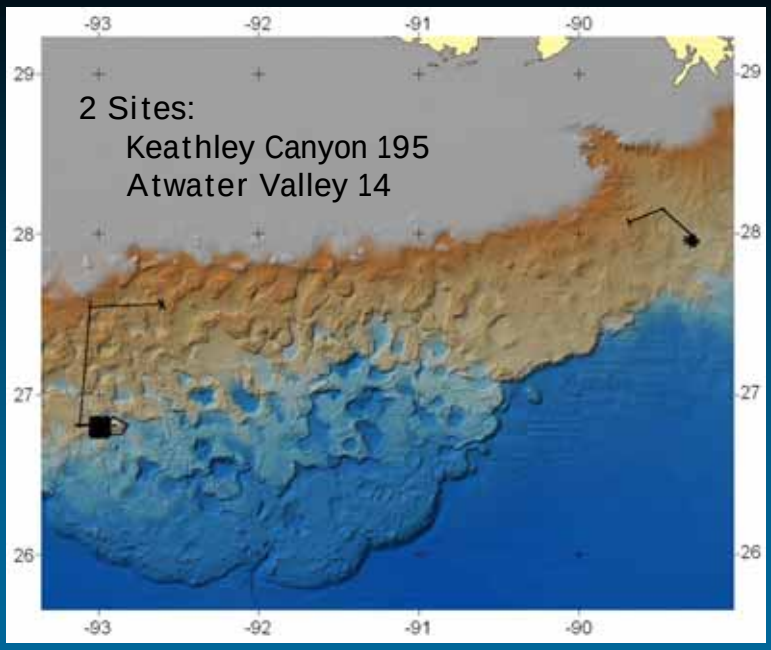
USGS

USGS High-Resolution Multichannel Seismics Site Survey

From TAMU web page

1-14 May, 2003
R/V Gyre

USGS



USGS

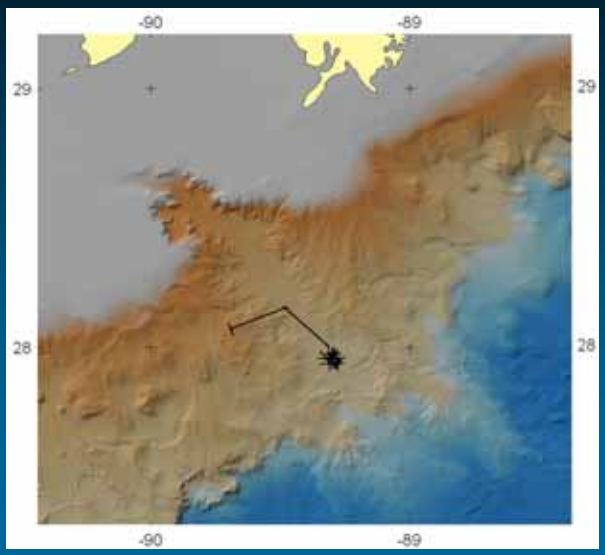
Acquisition

240-m Streamer, 24 channels, 10-m groups
13/13 GI Gun, 20-m shots, 3000 psi
1/2 ms sampling rate

USGS

Atwater Valley – Preliminary Results

Floor of the Mississippi Canyon



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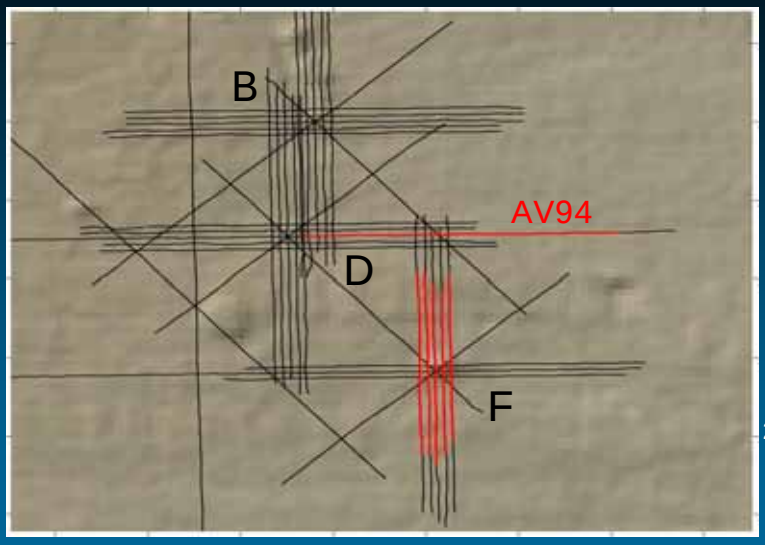
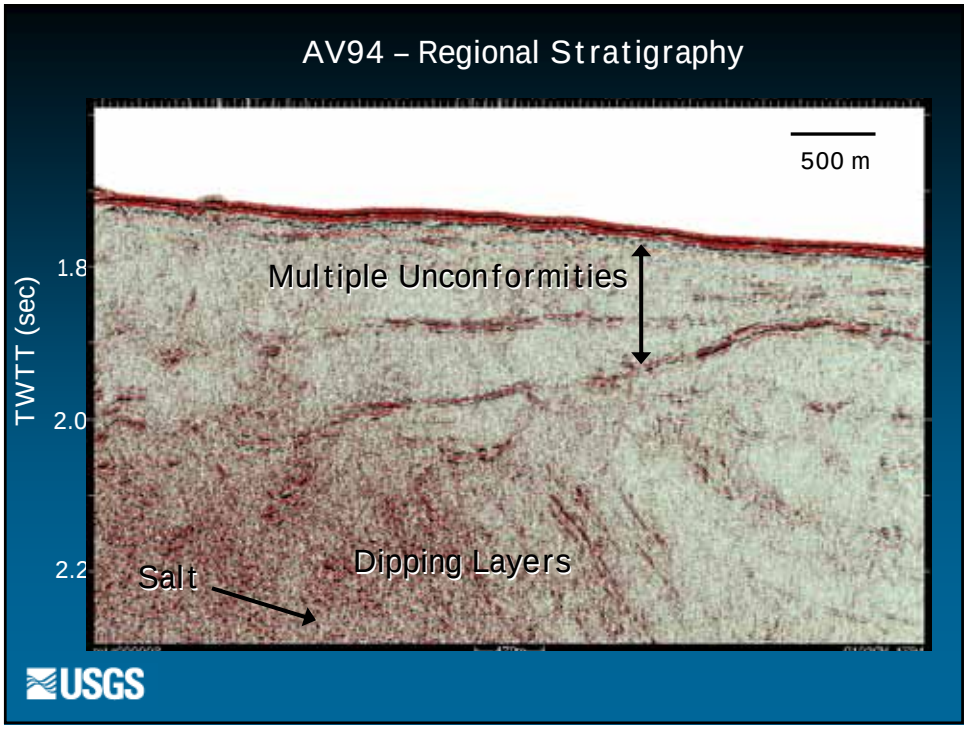
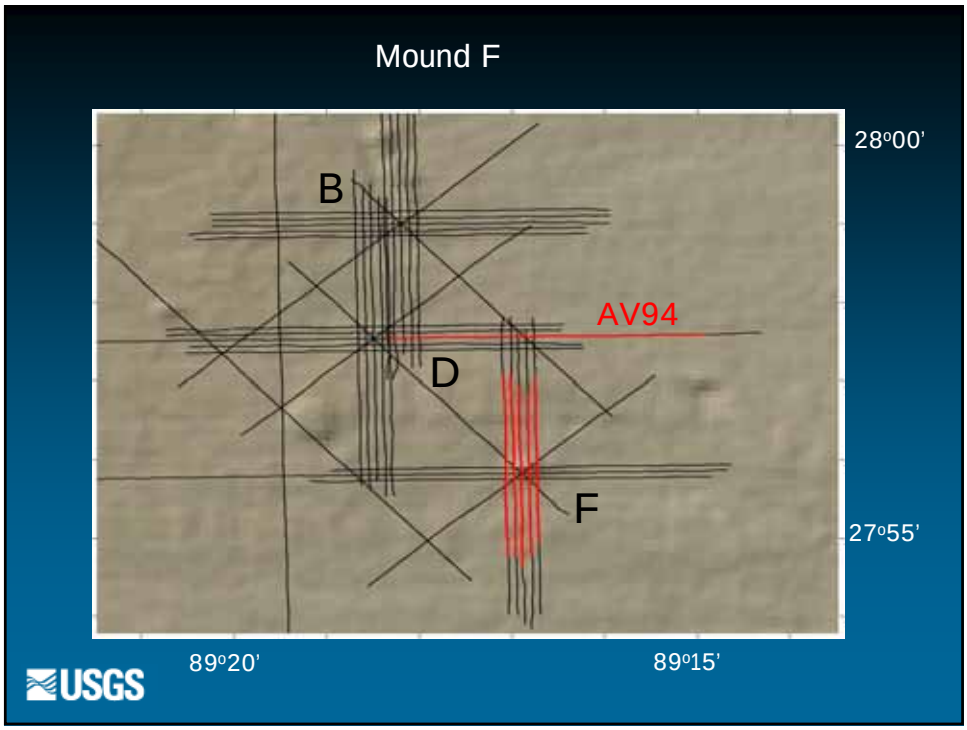
General Morphology - Mounds



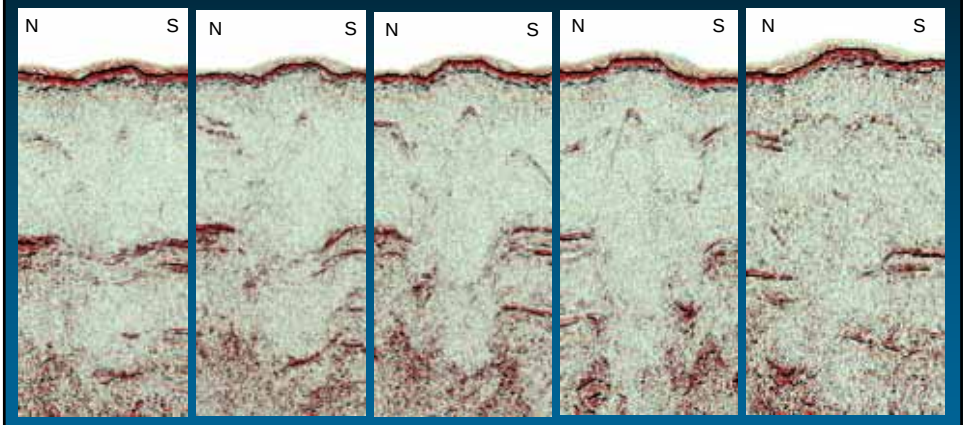
USGS


AV94 – Regional Stratigraphy
500 m
TWTT (sec)
1.8
2.0
2.2
Multiple Unconformities
Salt
Dipping Layers
USGS


Mound F
B
AV94
D
F
28°00'
27°55'
89°20'
89°15'
USGS

Mound F

AV69 AV71 AV68 AV70 AV67



West

500-600 m across
6-20 m high

East

USGS

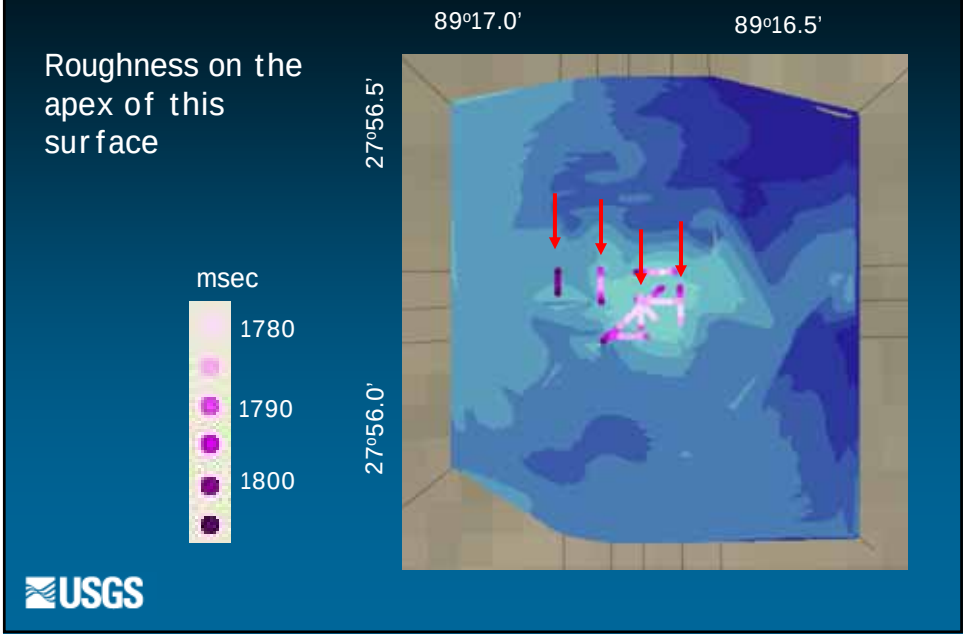
AV68

Note how shape is not of a diffraction

Is this a BSR upwarped by warm fluid flux?

USGS

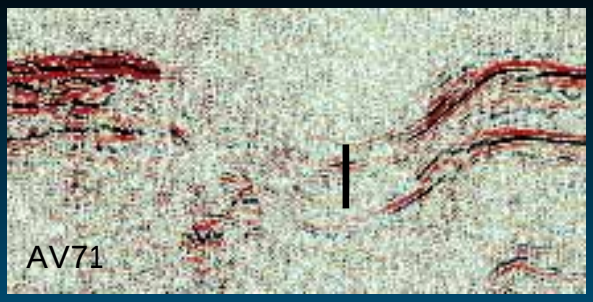
Roughness on the apex of this surface



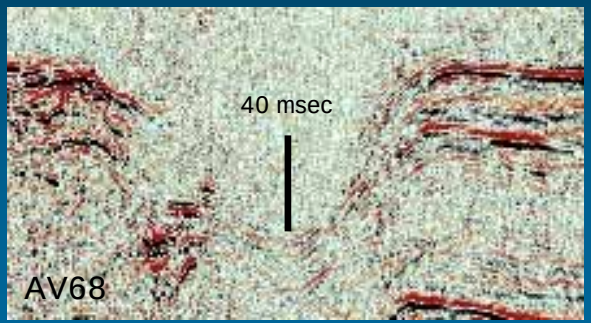
USGS

Pulldown Effect

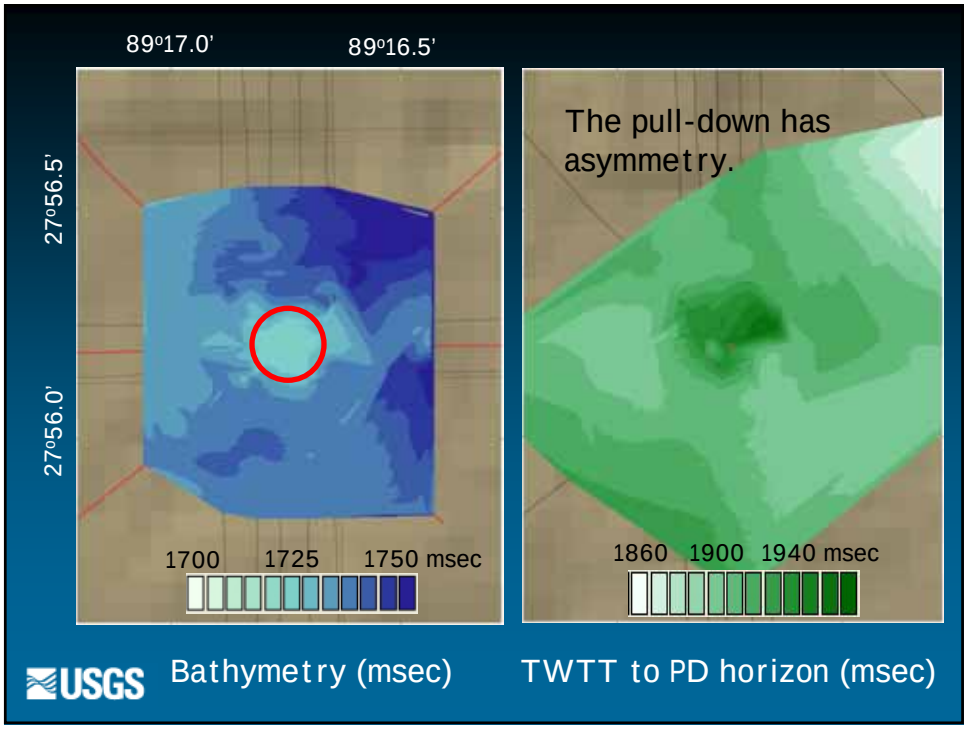
Differential Velocity Pulldown

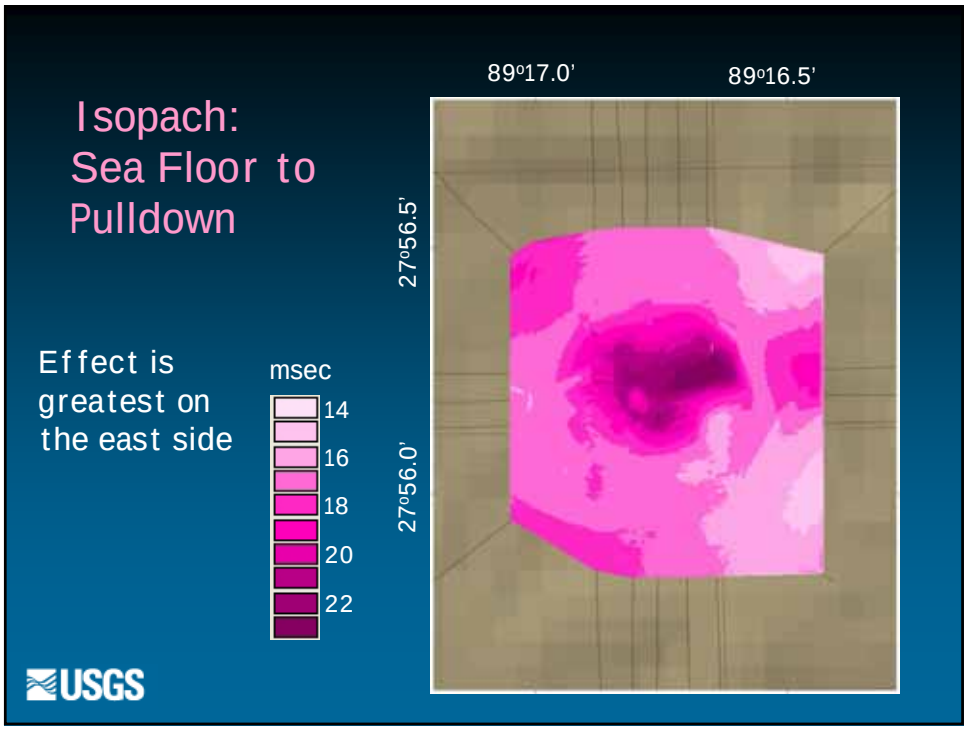


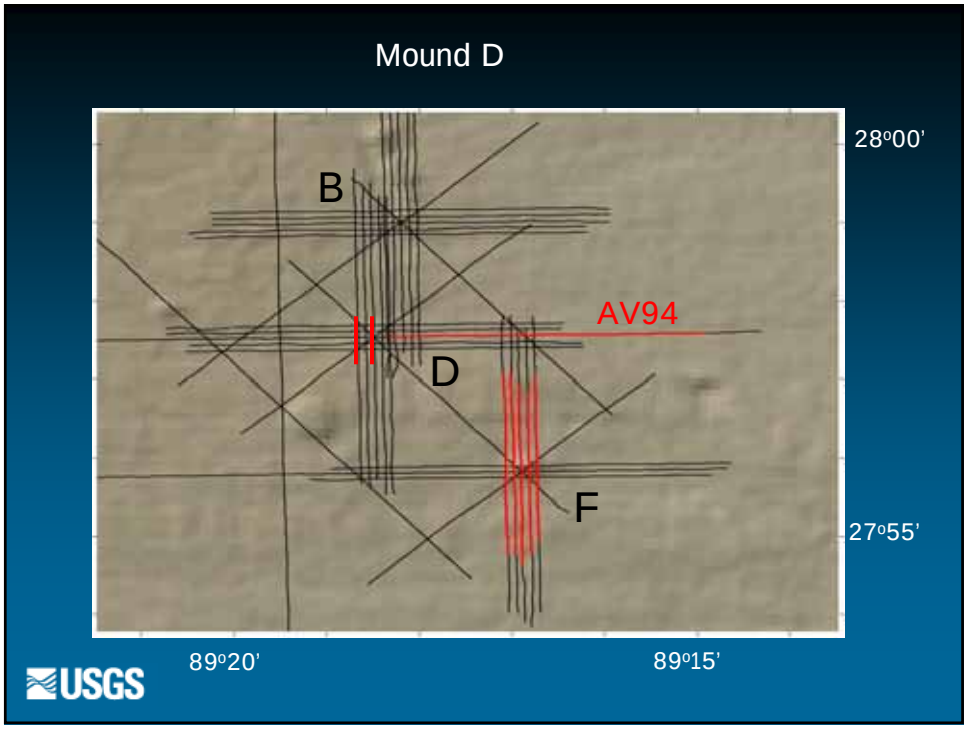
Is this evidence of free gas?

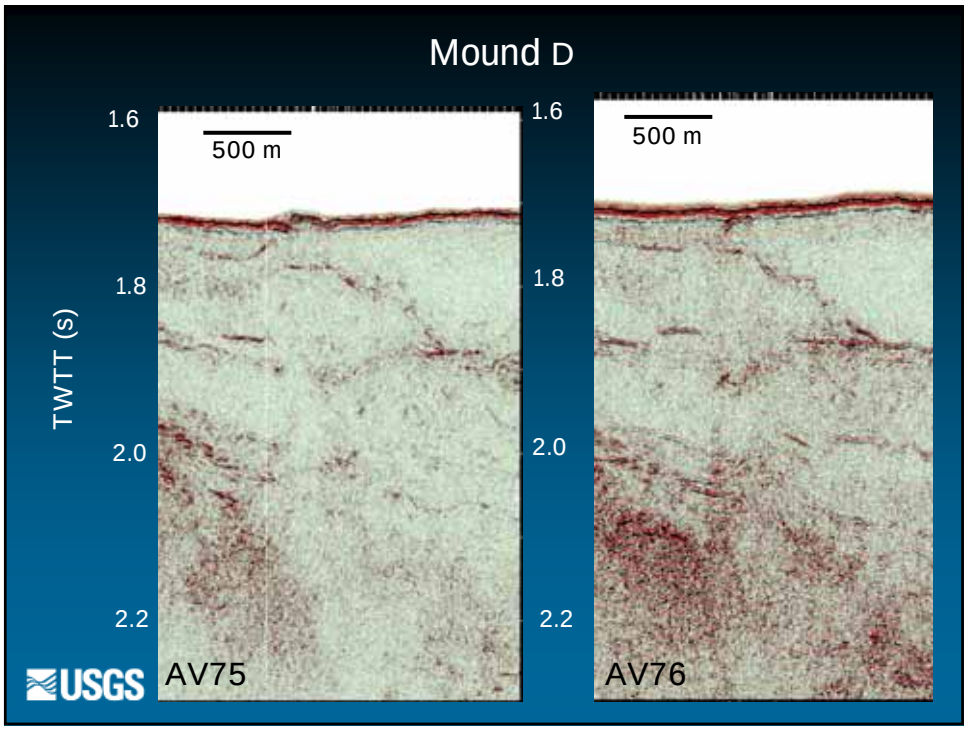


USGS

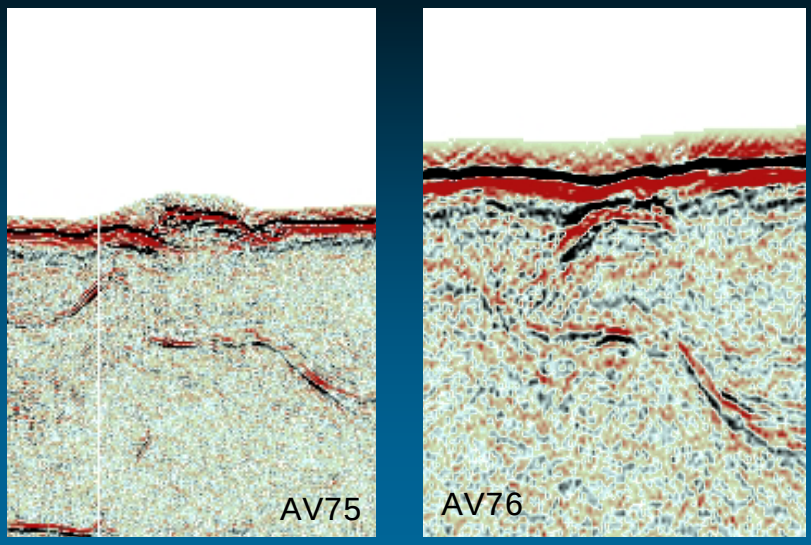

89°17.0'
89°16.5'
27°56.5'
27°56.0'
1700 1725 1750 msec
The pull-down has asymmetry.
1860 1900 1940 msec
USGS
Bathymetry (msec)
TWTT to PD horizon (msec)


Isopach:
Sea Floor to Pulldown
Effect is greatest on the east side
msec
14
16
18
20
22
89°17.0'
89°16.5'
27°56.5'
27°56.0'
USGS


Mound D
B
AV94
D
F
28°00'
27°55'
89°20'
89°15'
USGS

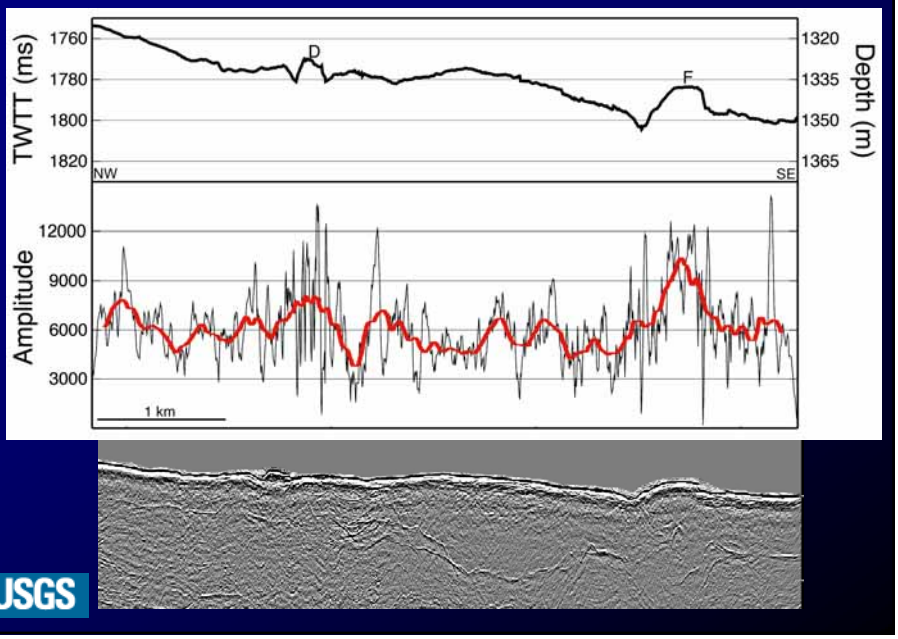

Mound D
1.6
1.8
2.0
2.2
TWTT (s)
500 m
AV75
AV76
USGS

Shallow structure on edge of mound d



USGS

AV65



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Atwater Valley Summary

Mounds

BSR??

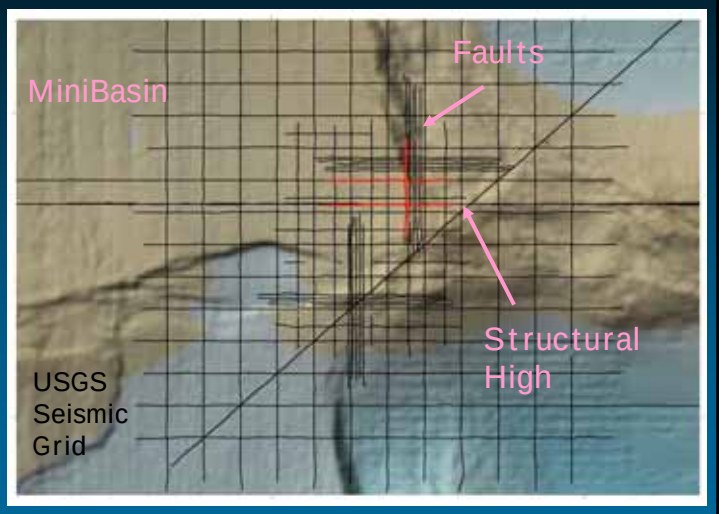
Free Gas ??

Different sizes and seismic character

USGS

Keathley Canyon Preliminary Results

700 km data
BSR
Mounds
Geologic Framework



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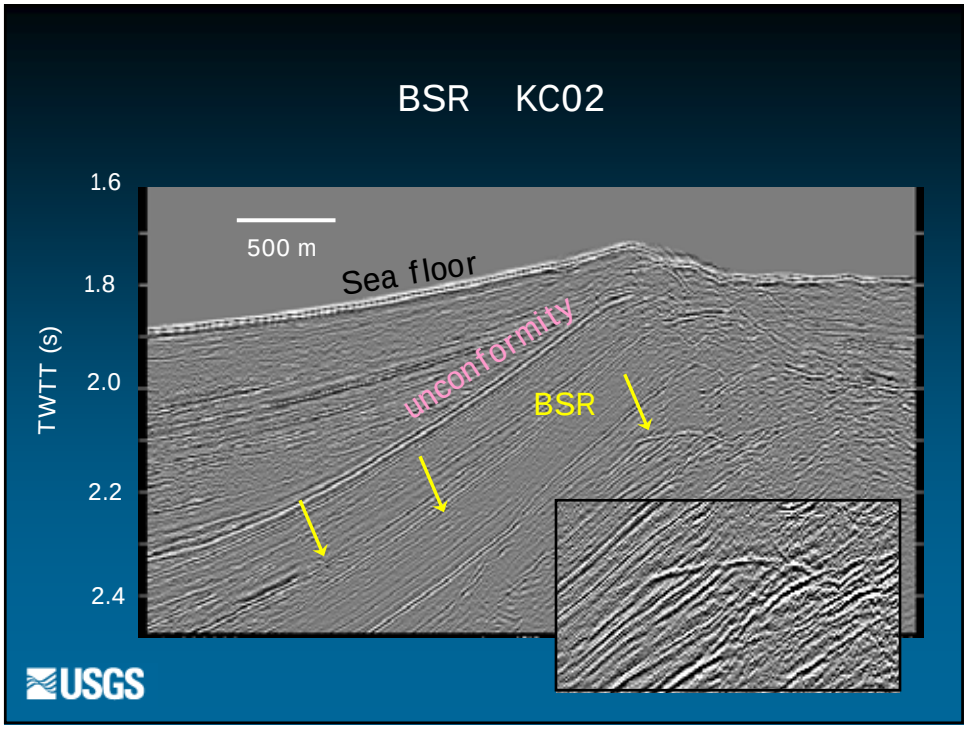
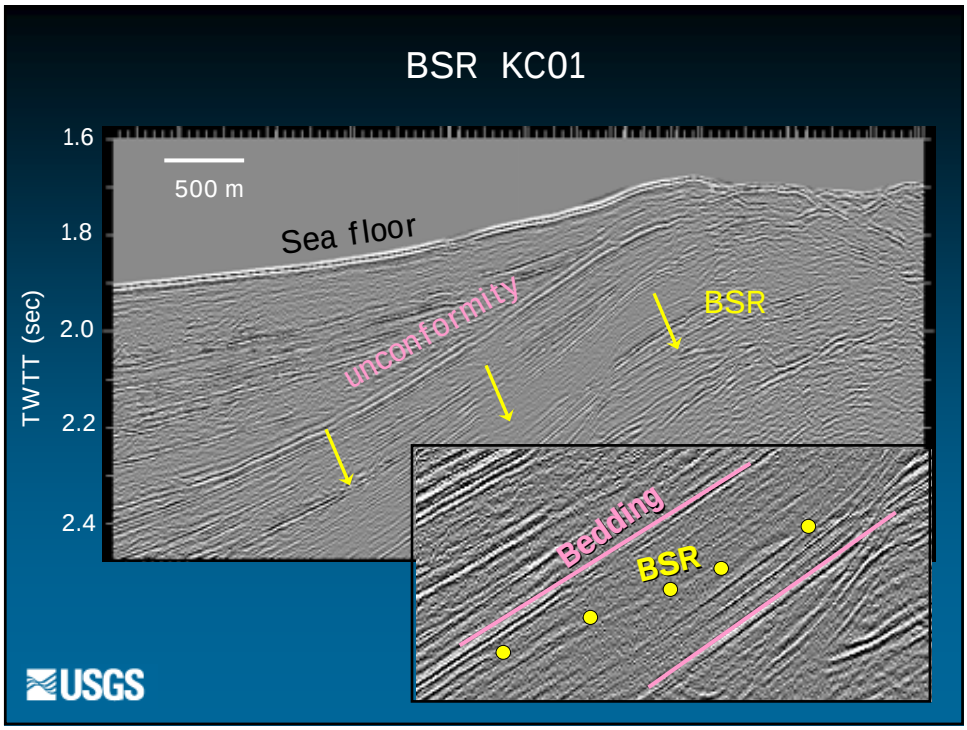
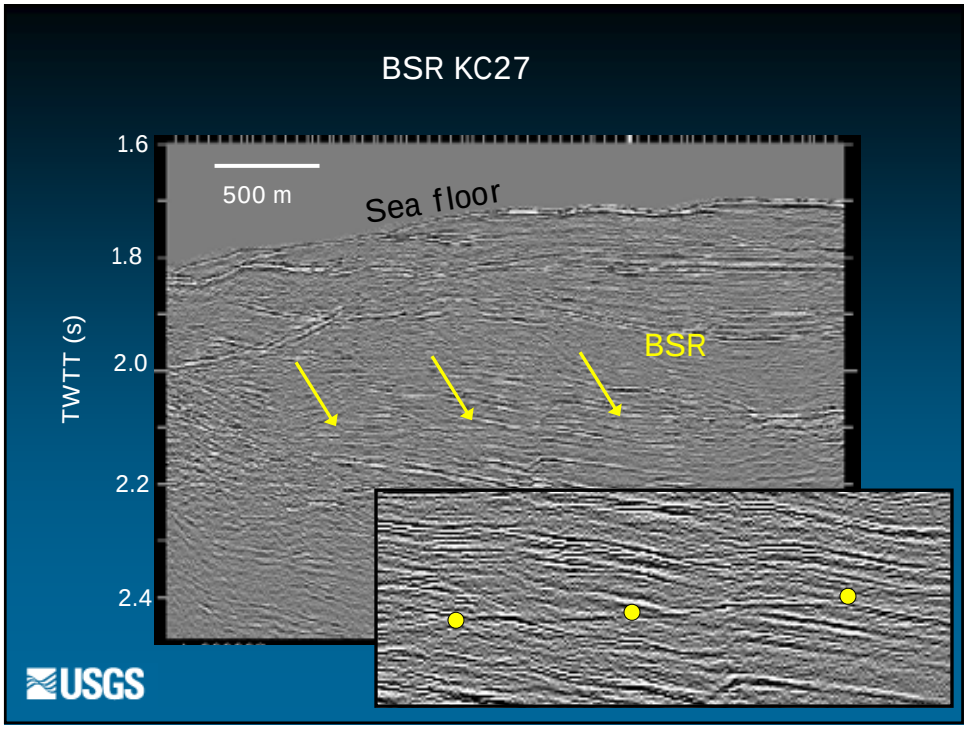
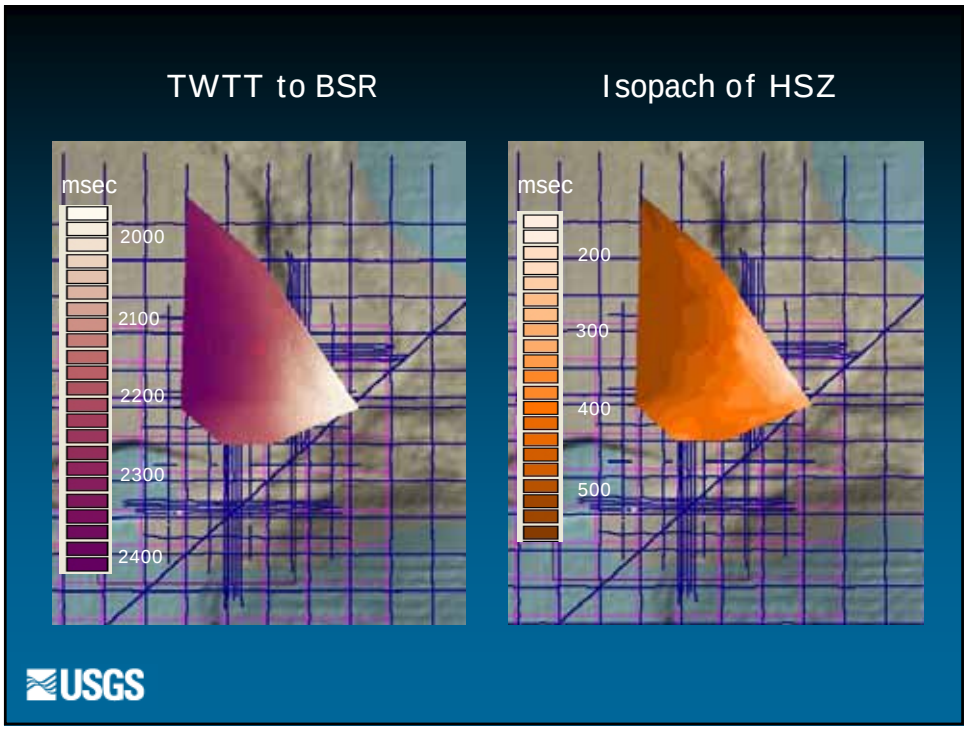
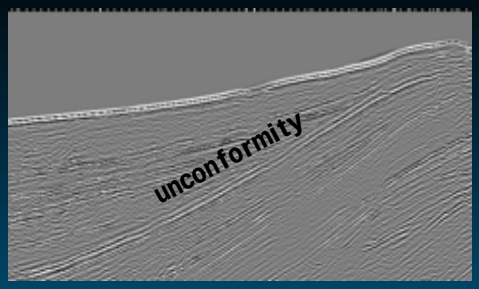
Very Different from Atwater Valley


BSR KC02
1.6
1.8
2.0
2.2
2.4
TWTT (s)
500 m
Sea floor
unconformity
BSR
USGS

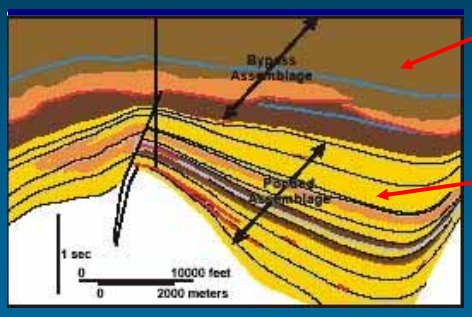

BSR KC01
1.6
1.8
2.0
2.2
2.4
TWTT (sec)
500 m
Sea floor
unconformity
BSR
Bedding
BSR
USGS


BSR KC27
1.6
1.8
2.0
2.2
2.4
TWTT (s)
500 m
Sea floor
BSR
USGS


TWTT to BSR
msec
2000
2100
2200
2300
2400
Isopach of HSZ
msec
200
300
400
500
USGS



BSR is beneath a major unconformity that may represent a change to coarser material.



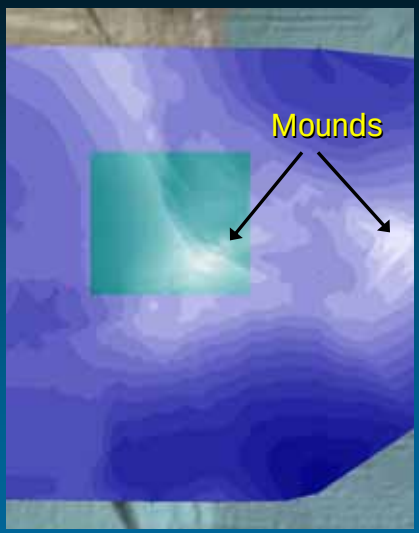
Younger Bypass Assemblage is siltier, disrupted, and more choatic.

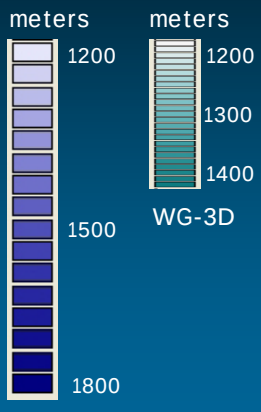
Older Ponded Assemblage is more sand rich and layered; i.e., a better lithology for concentrating hydrate.

USGS

Winker and Booth, 2000

Bathymetry





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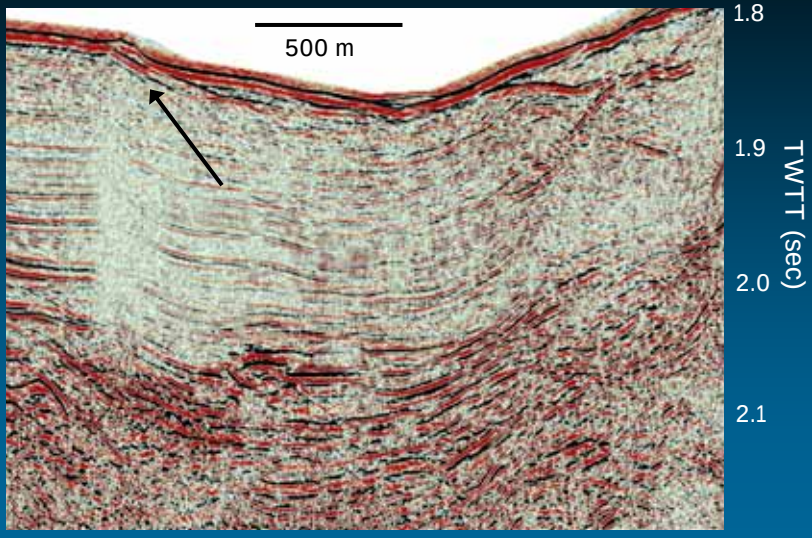
WG-3D bathy courtesy of Western Geco

KC01 – Mound (Vent??)



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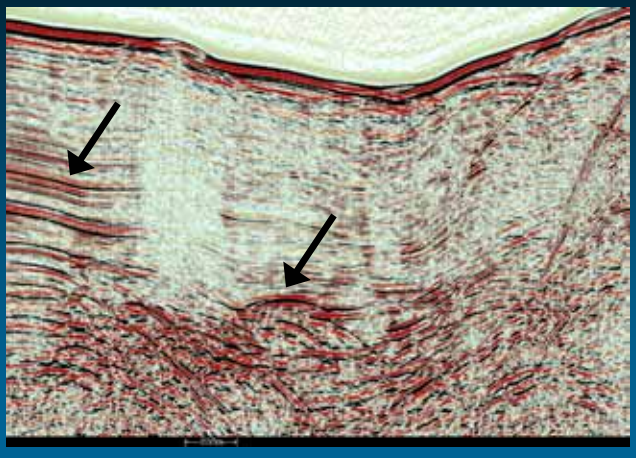
High-amplitude anomalies – free gas??



USGS

Summary

The evidence for subsurface gas hydrate is subtle.

Some of the indicators are:
(1) A “normal” BSR at KC 195
(2) Possible free gas to the east of a large fault.
(3) A mound/vent system in AV14 that may indicate the presence of a BSR perturbed upwards by warm fluids.
(4) In AV14, velocity pulldown indicating deeper free gas that might be feeding shallower hydrate.

Understanding hydrate formation in the Gulf of Mexico requires knowledge of the geologic framework, the heat flow, and the geochemistry.

USGS

Where to from here?

Integrate seismics with heat flow and geochemistry.

Refine proposed drill-sites

Develop better understanding of the geologic framework.

Develop a conceptual model for the interactions between surface hydrate and deeper petroleum system that is likely to be feeding it.

USGS