Abundance, Geophysical Character, and Distribution of “BSRs” (Bottom Simulating Reflectors) in the Gulf of Mexico and the Atlantic Basins

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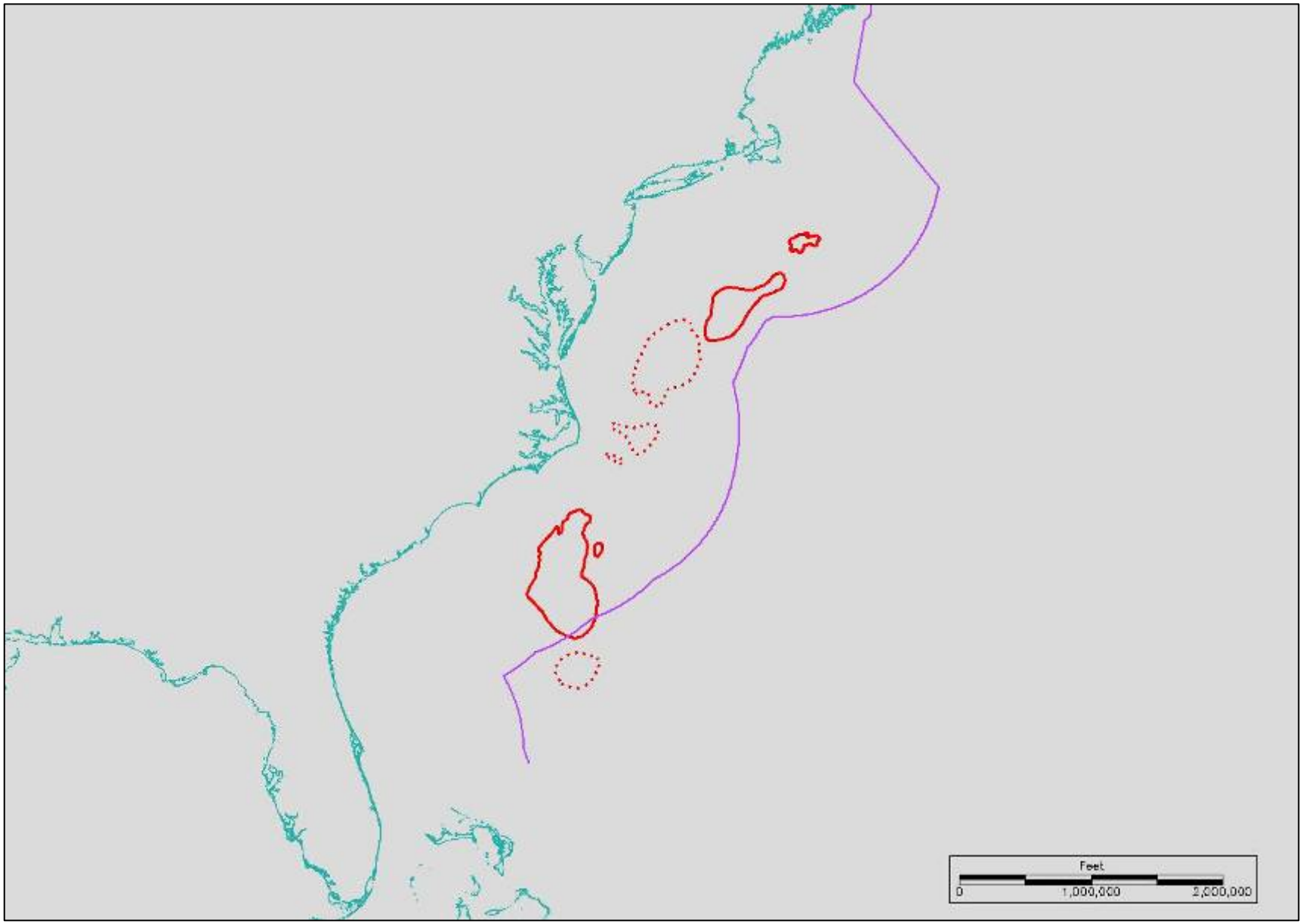
Natural gas hydrate is a solid, ice-like lattice of a natural gas molecule surrounded by water molecules that forms under low temperature and high pressure in the deep ocean margins worldwide and in the polar regions onshore.

“BSRs,” or bottom simulating reflectors, are generated at the base of hydrate saturated sediments (acoustically fast) when underlain by free gas saturated sediments (acoustically slow).

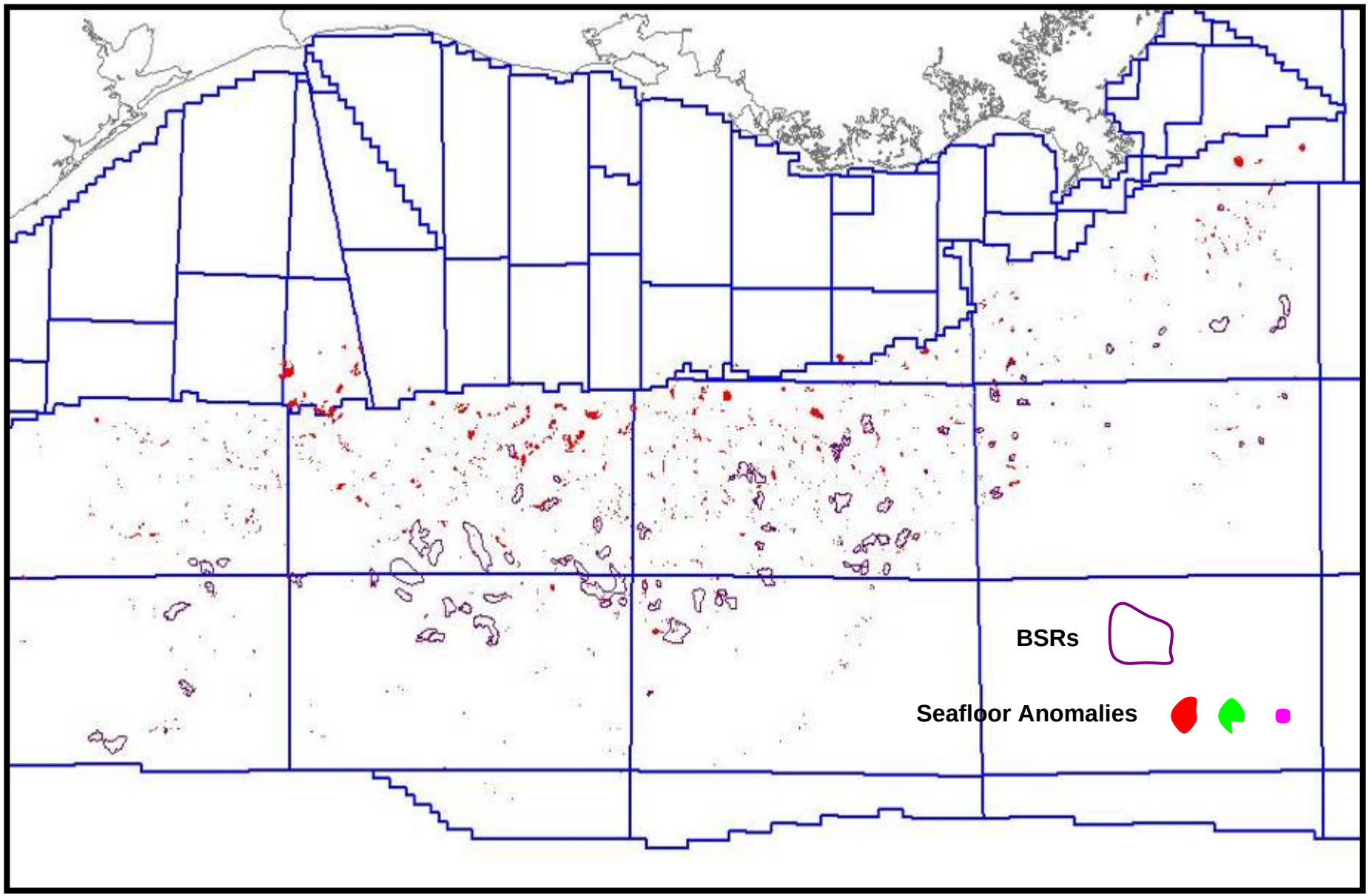
The MMS has an ongoing effort to identify and map BSRs in the GOM and the Atlantic in support of its assessment of hydrates as a resource and the site selection process for the Department of Energy's Joint Industry Project (JIP) to drill and sample hydrates in the GOM.

To date, over 100 BSRs have been mapped in the GOM, eight in the Atlantic.

BSRs in the Atlantic



BSRs and Seafloor Anomalies in the GOM

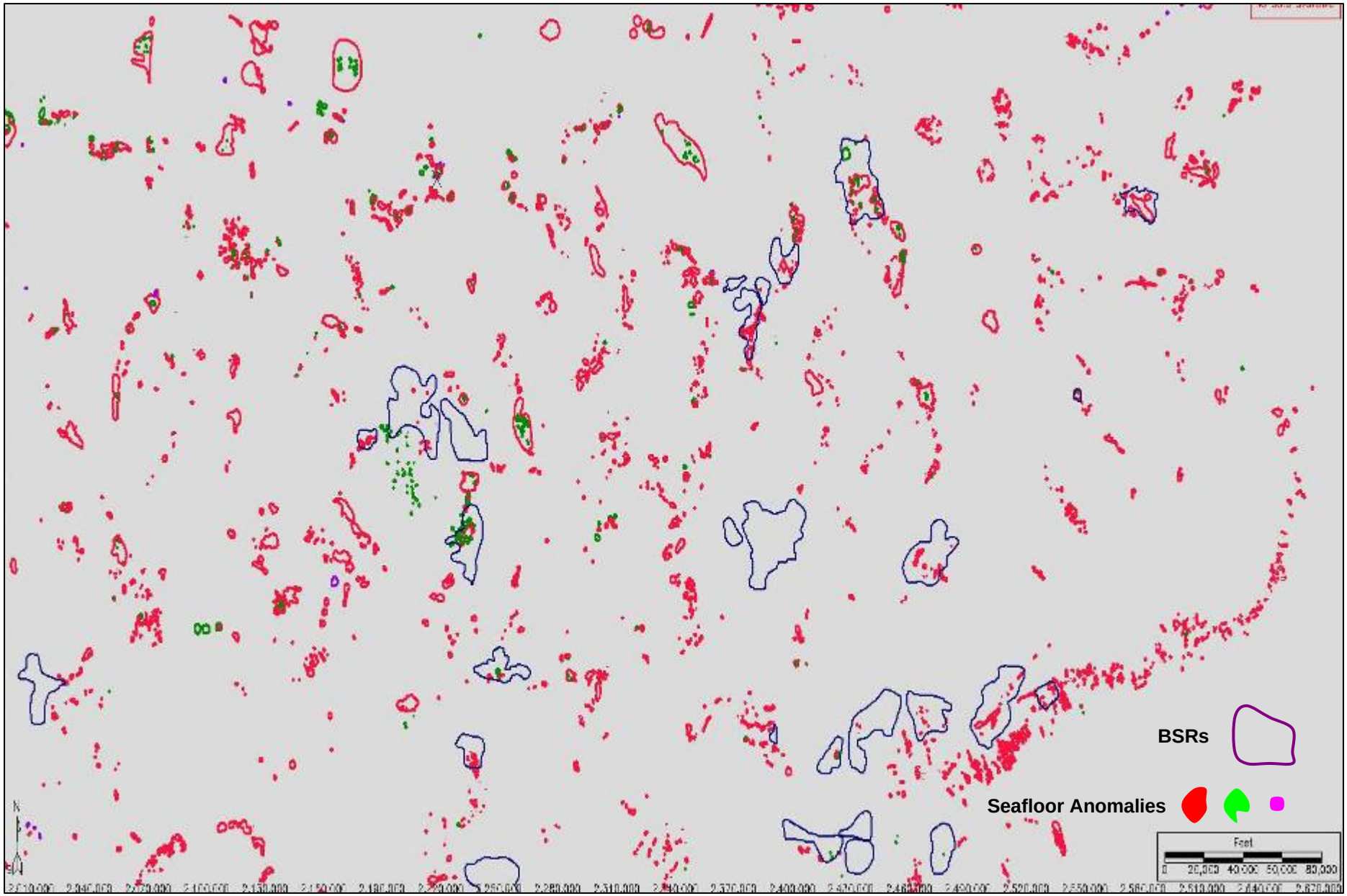


There is a strong correlation between the presence of BSRs and seafloor amplitude anomalies interpreted to be hydrocarbon seeps—hydrocarbons seeping at the seafloor have apparently charged the hydrate stability zone.

81% of all BSRs in the GOM are directly associated with seafloor amplitude anomalies;19% are not.

Note this relationship in the Green Canyon protraction area in the next slide.

Green Canyon BSRs and Seafloor Amplitude Anomalies



In areas of laterally and vertically consistent geothermal heat flow, the base of hydrate stability simulates the seafloor, as in the Atlantic.

In areas where heat flow is uneven, as in the Gulf of Mexico due to salt, BSRs do not simulate the seafloor and can “plume” upwards to or near the seafloor.

3 types of BSRs:

1) Continuous

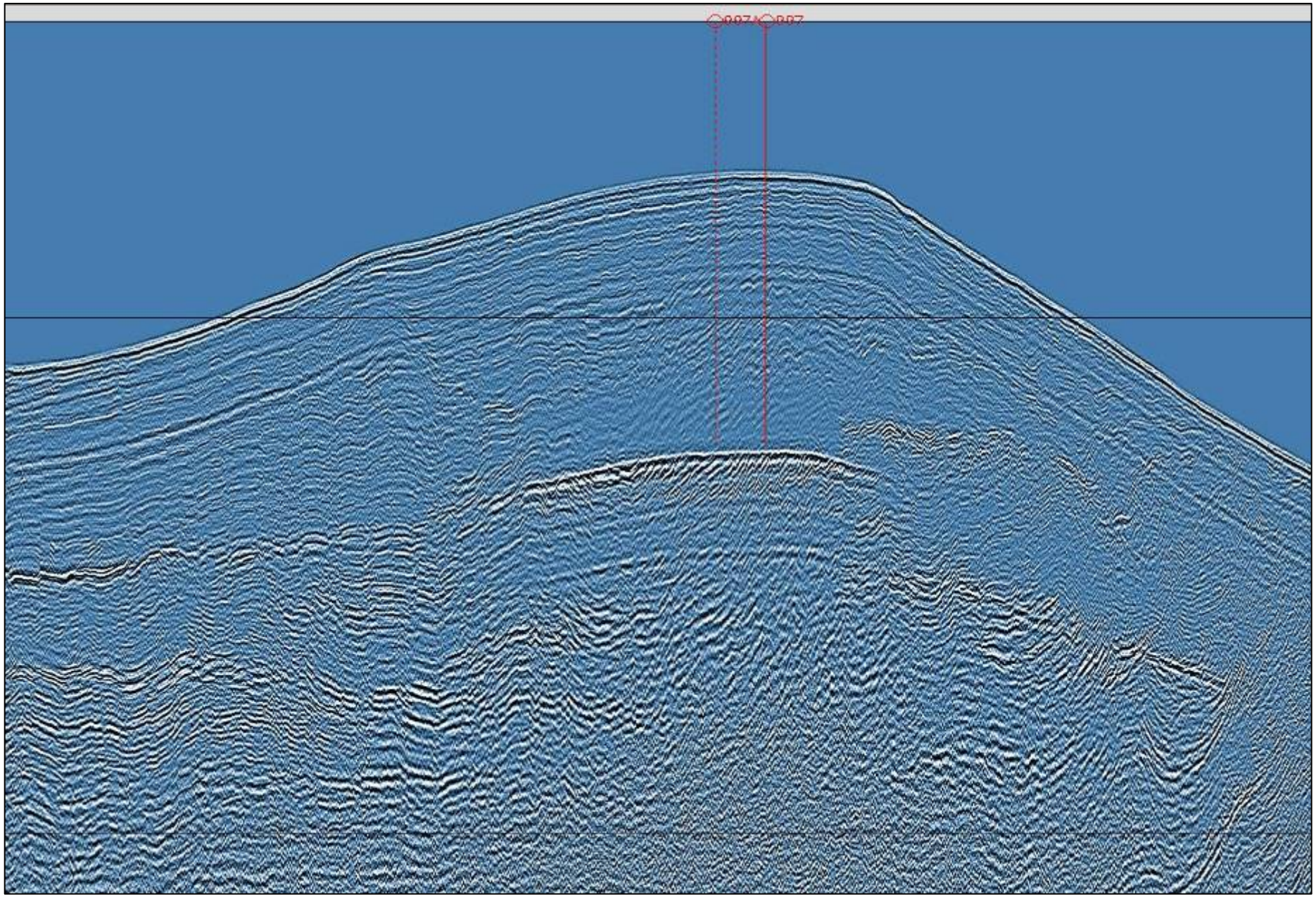
2) Segmented (discontinuous)

3) High-relief (pluming)

Continuous BSR

- **Occurs in homogenous stratigraphic settings, typically in fine-grained sedimentary sections**
- **Type section – Blake Ridge in Atlantic**
- **Not the most common type in the GOM – 12%**

Continuous BSR – Blake Ridge, Atlantic



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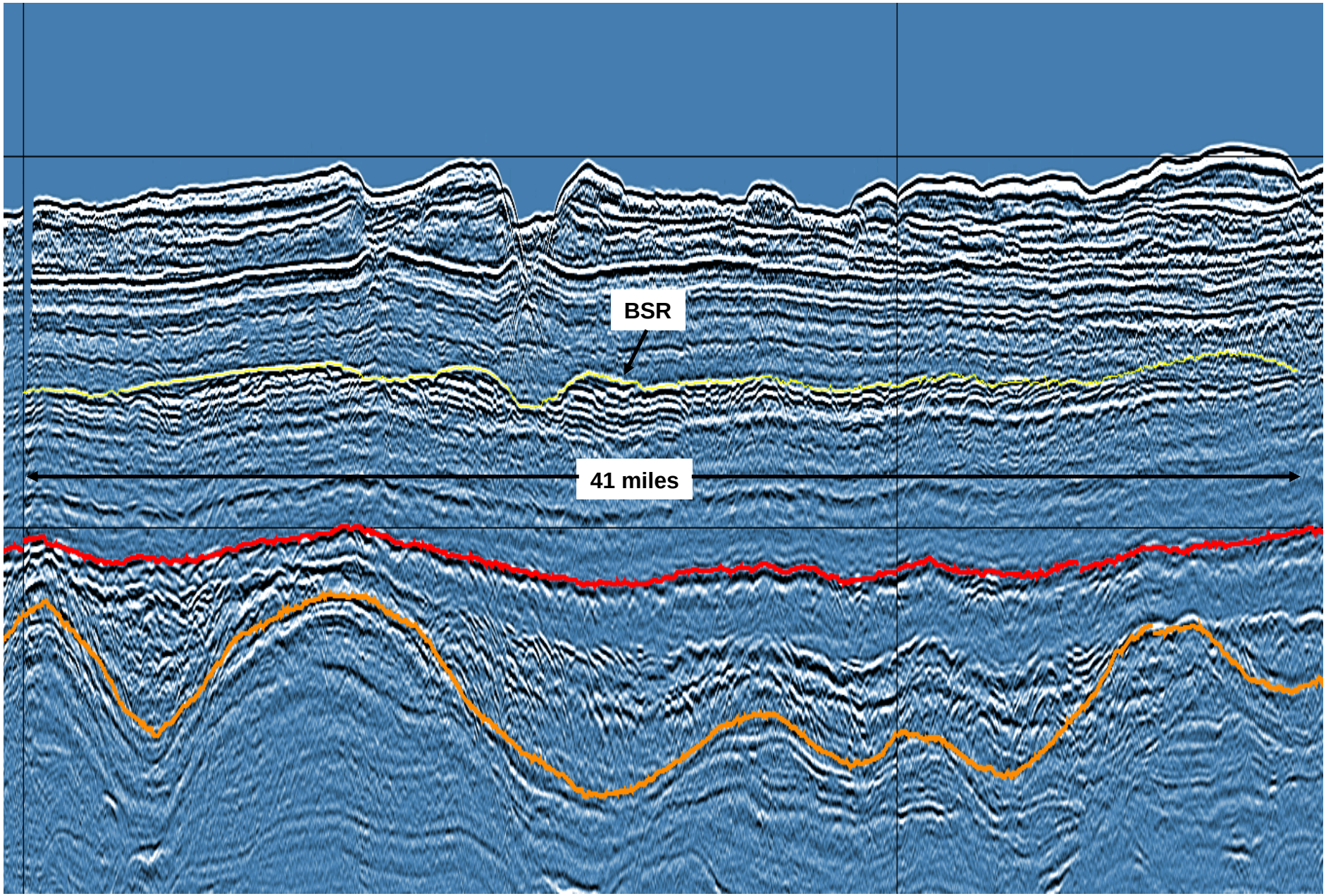
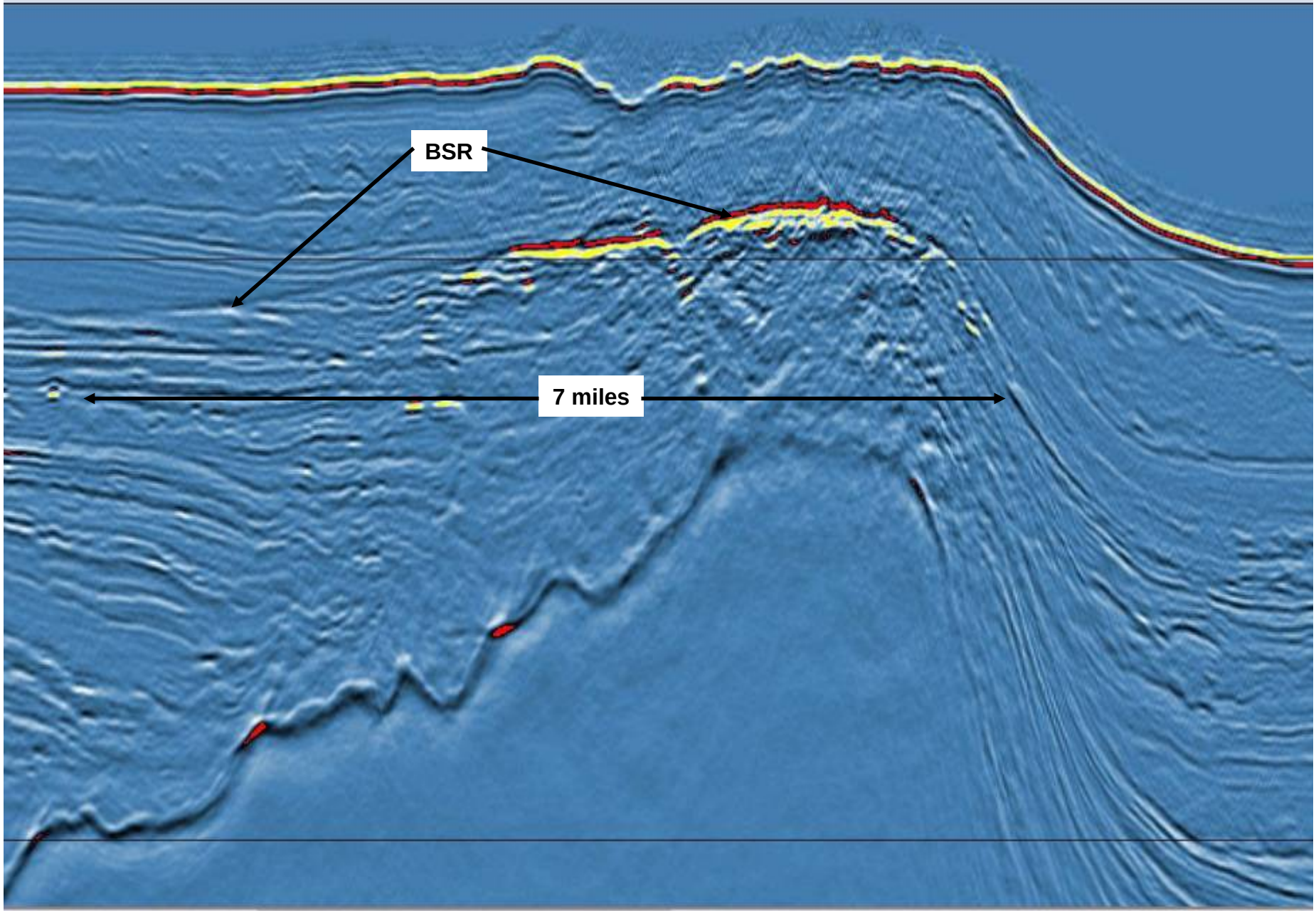
Continuous BSR – Atlantic



Continuous BSR – Gulf of Mexico



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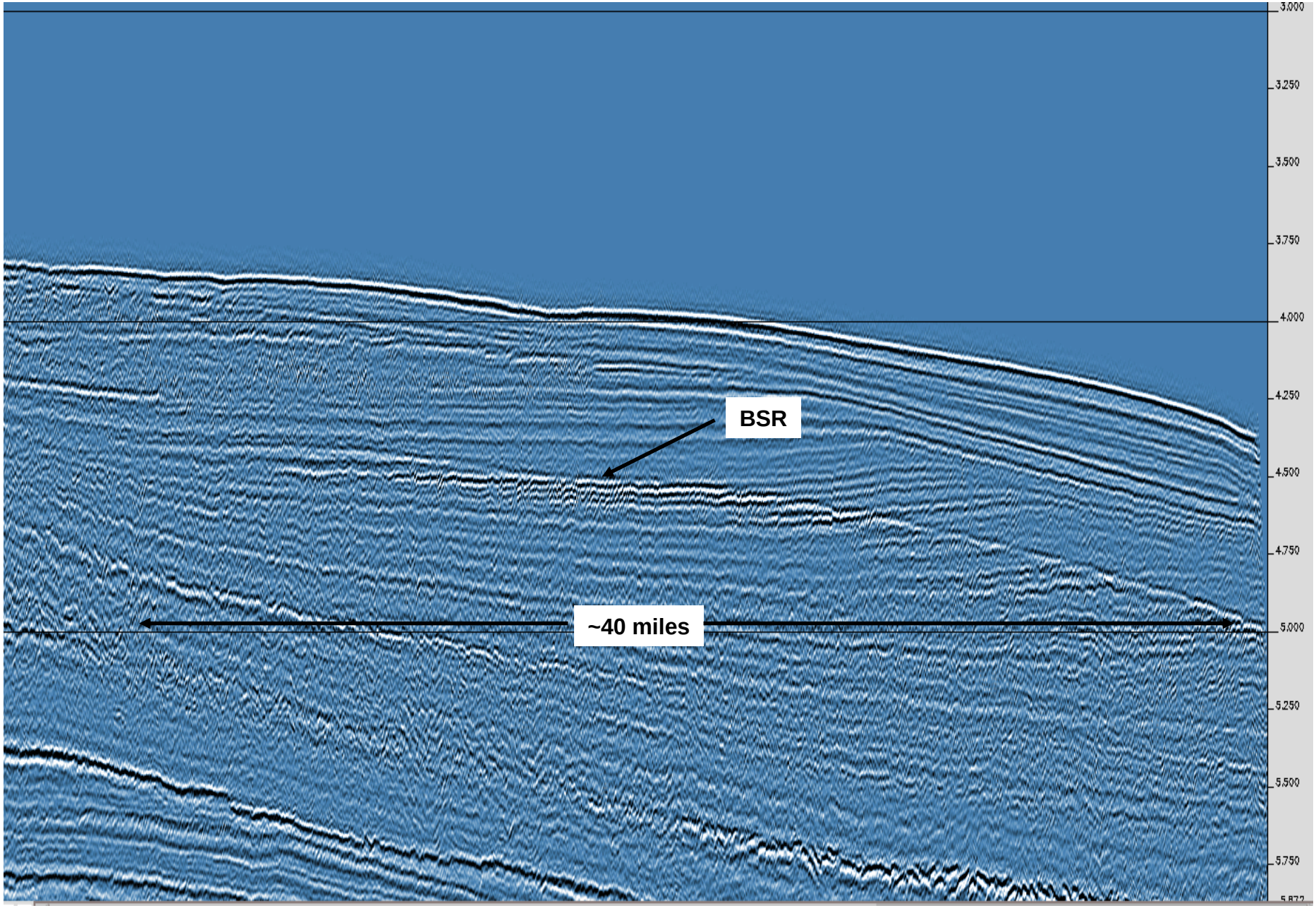
Segmented BSR

- Occurs in stratified stratigraphic sections
- Alternating sands and shales
- BSR is apparent where gas sands underlie hydrate saturated sands
- BSR is absent or weak in intervening shales
- Most common type in the GOM and the Mid and North Atlantic – 58%

Segmented BSR – Atlantic



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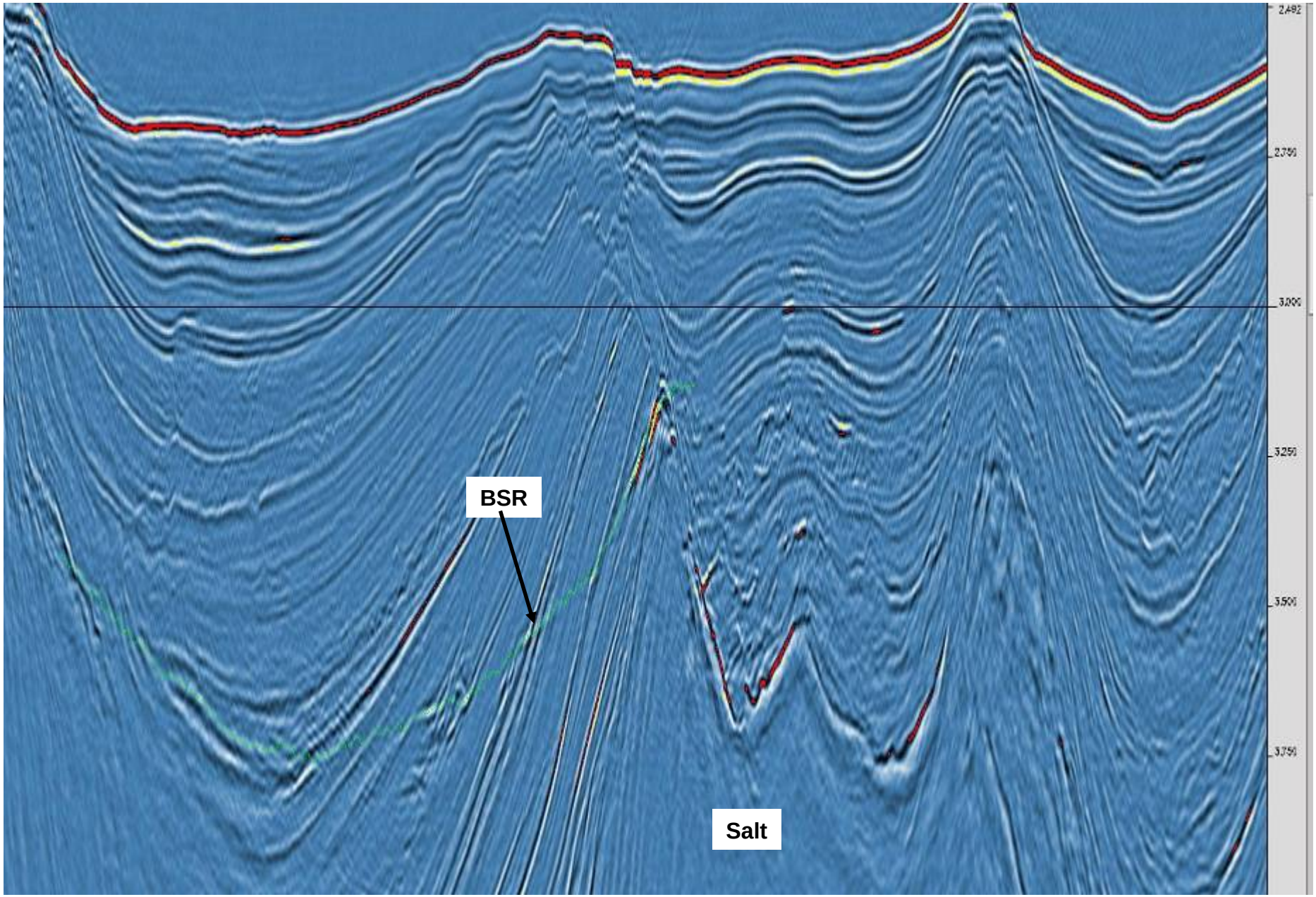
Segmented BSR – GOM



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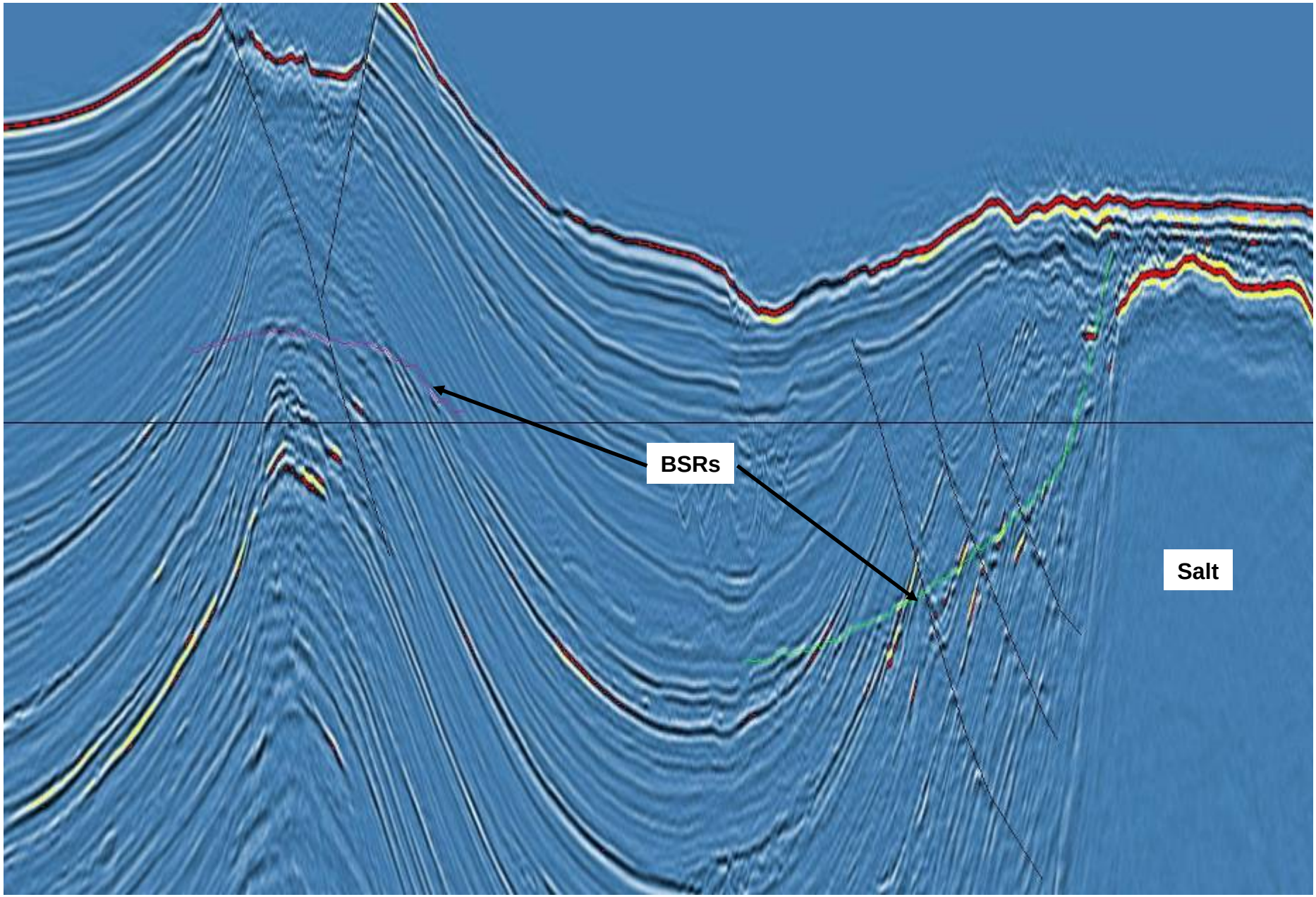
Segmented BSR – GOM



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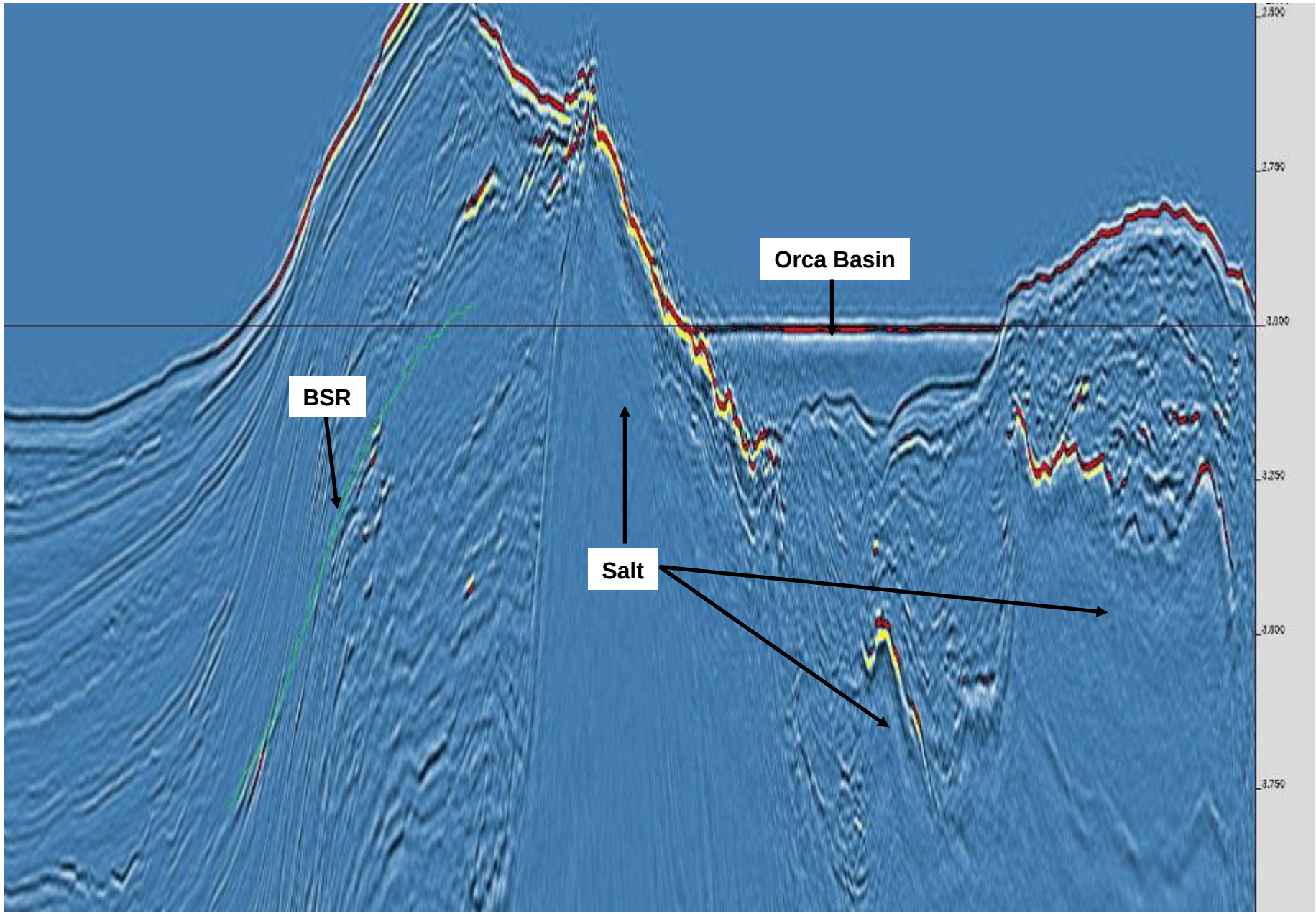
Segmented BSR – GOM



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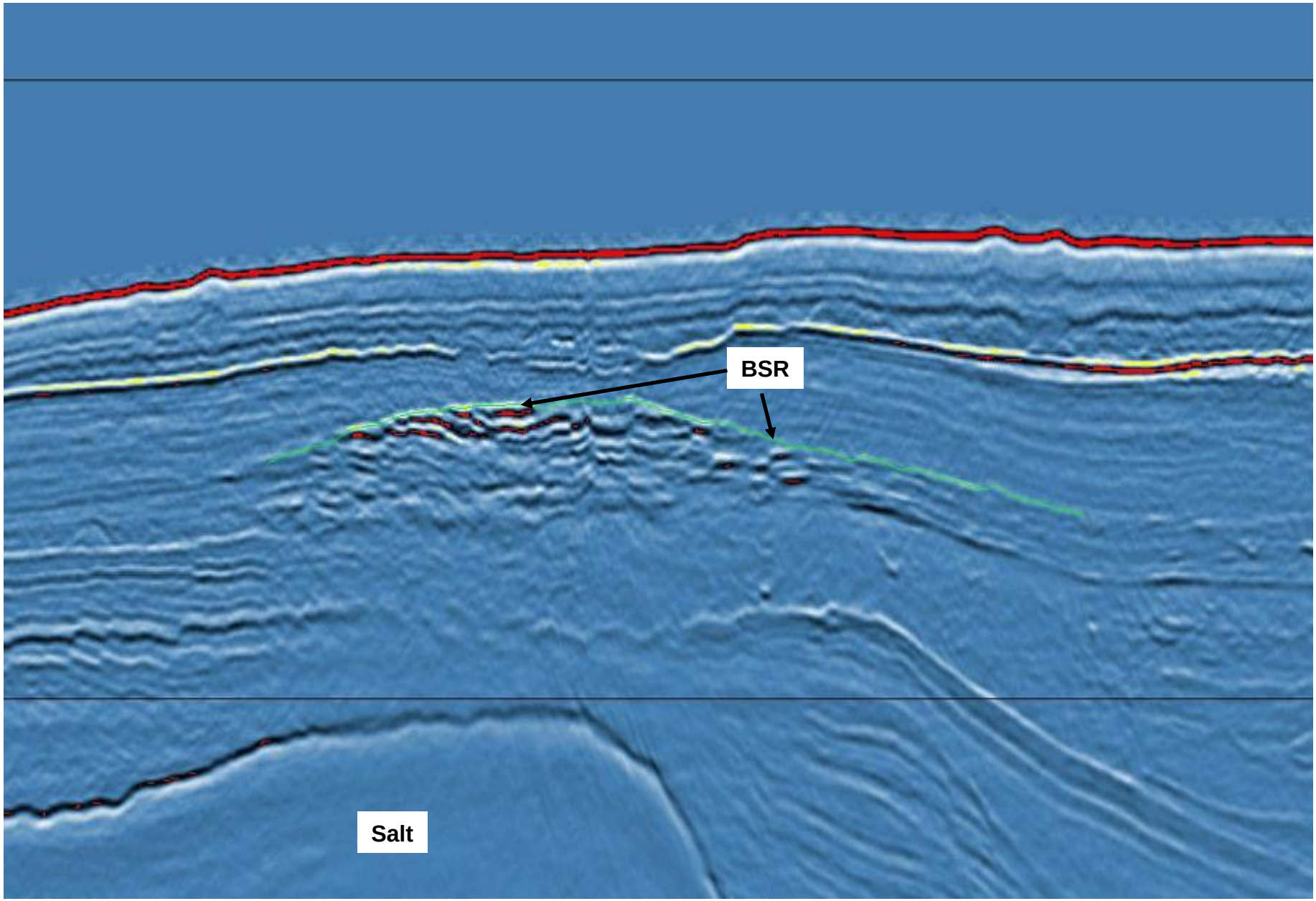
Segmented BSR – GOM



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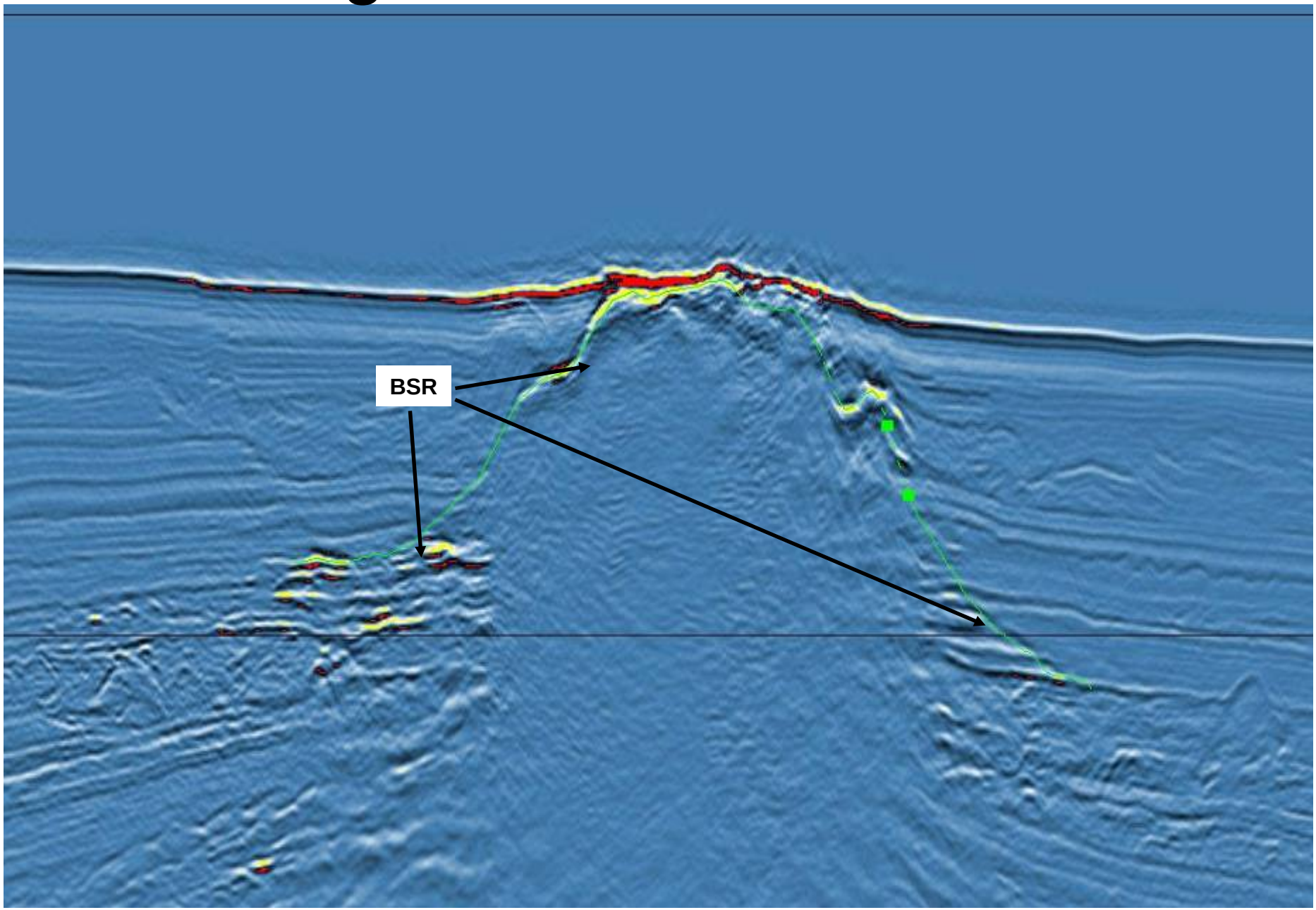
High-Relief BSRs

- **Occurs where plumes of gas, oil, and warm brine rise close to the seafloor, dramatically thinning the hydrate stability zone (HSZ)**
- **Most commonly found on the middle slope of the GOM**
- **5% are purely high relief**

High-Relief BSR – GOM



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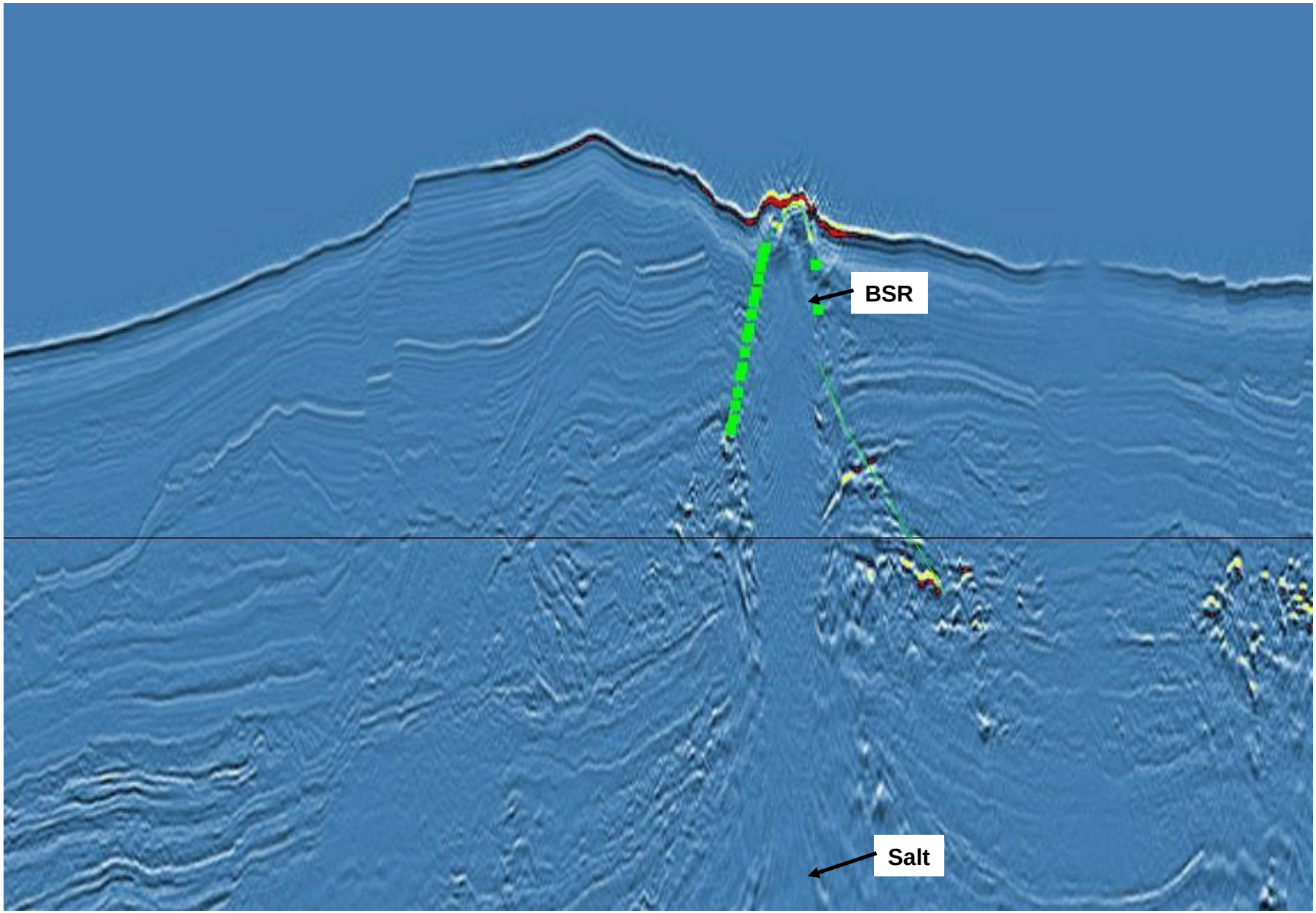
High-Relief BSR – GOM



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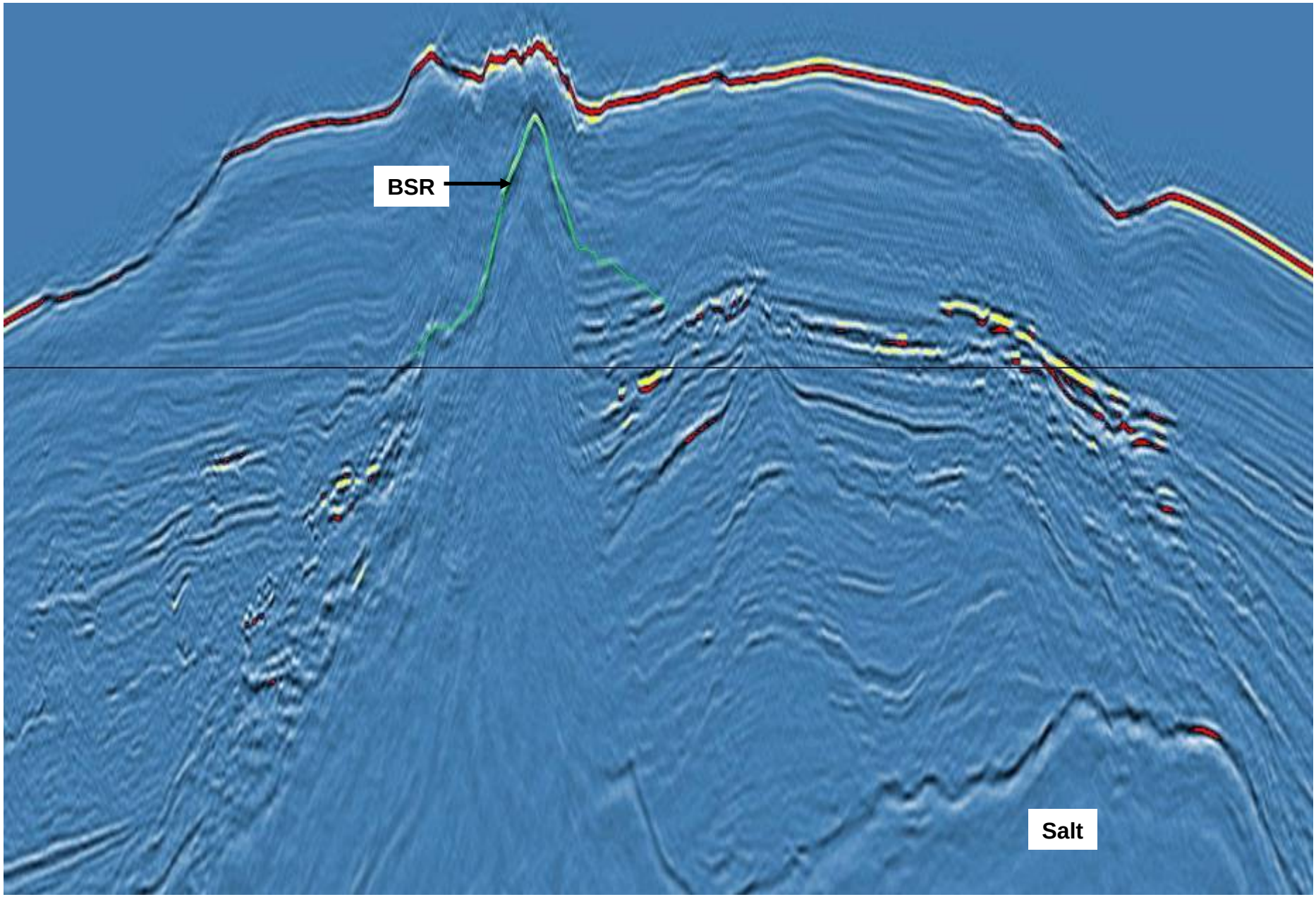
High-Relief BSR – GOM



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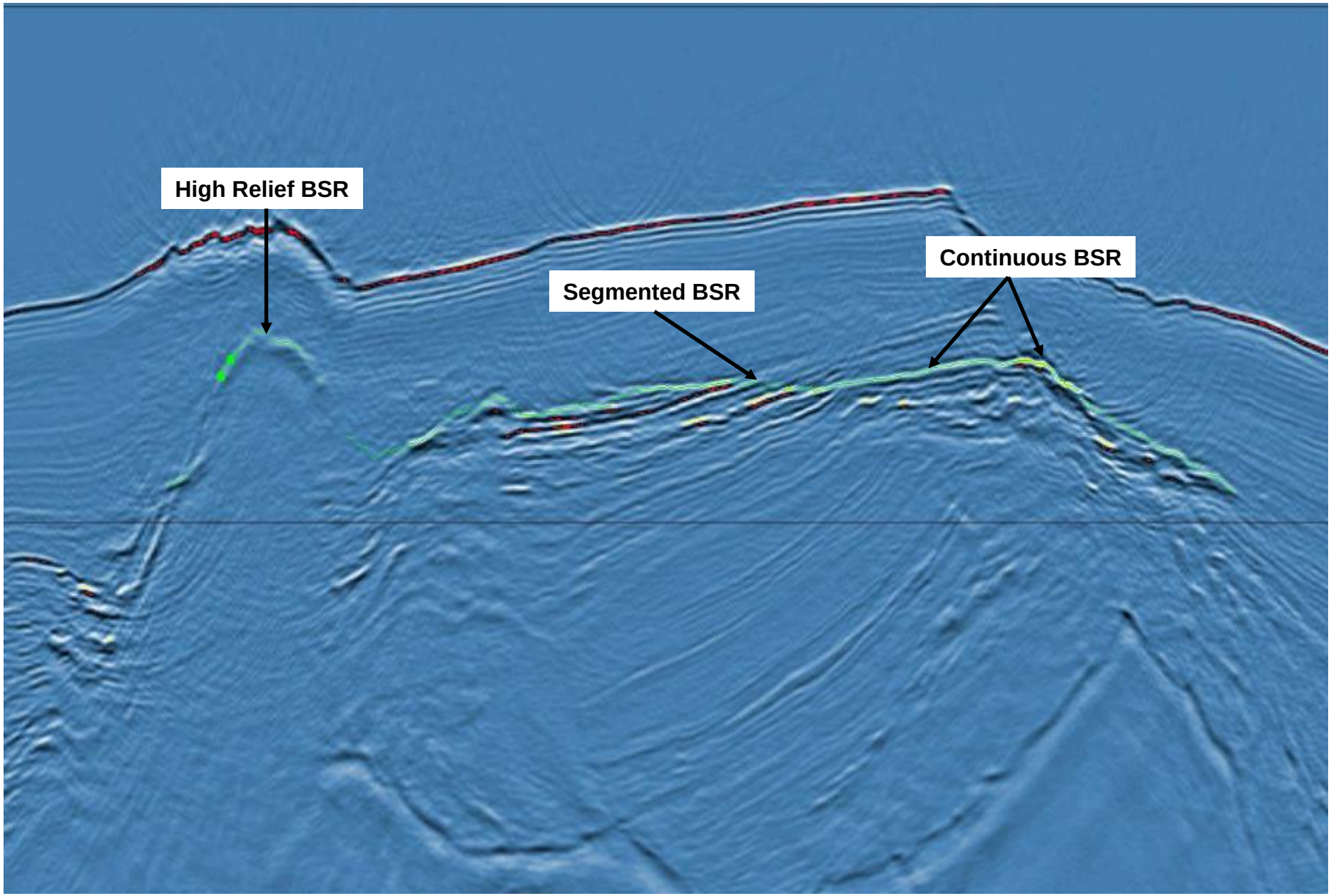
Combinations of these 3 types are a common occurrence in the GOM

~25% are combinations of 2 or all 3 of these types

Combination BSR – GOM



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The average size of BSRs in the Atlantic are much larger than in the GOM

Atlantic – 2.34 million acres range from 114,000 acres to 7.3 million acres (estimated from coarse 2-D seismic grid)

GOM – 6,800 acres range from 110 acres to 42,555 acres (estimated from 3-D data)