Mapping the Seafloor of the Northern Gulf of Mexico

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Seismic Surveys are Crucial to Mapping Geology

Seismic surveys are a method of exploration geophysics which uses reflected sound waves to create 2-D lines and 3-D cubes of the Earth’s upper crust.

- Offshore - airgun arrays are used as the acoustic source
- Onshore - explosives and vibroseis trucks are typical
- Signals recorded with hydrophones or geophones
BOEM’s Gulf 3-D Seismic Survey Coverage

Database contains over 2,000 3-D surveys.
340,000 km² total offshore coverage.
Surveys Incorporated into the New Map

117 surveys used to compile the BOEM seafloor grid. 240,000 km² in deep water mapped.
Map can be downloaded from our BOEM website:
https://www.boem.gov/Gulf-of-Mexico-Deepwater-Bathymetry/
BOEM’s Deepwater GOM Bathymetry Map

• Created by splicing together seafloor maps originally created for identifying potential natural hydrocarbon seeps
• 1.4 billion defined cells; 40x40 ft (12.2x12.2 m)
• Water depth 130-11,000 ft (40-3,350 m)
• Depth error ≈1.5 % of water depth when measured at 300 oil & gas wells
• Will provide exceptional value in scientific and academic communities because of its high resolution:
  – Marine biologists and ecologists (deepwater biota habitat modeling, dive planning)
  – Geoscientists (geomorphology and sedimentology)
  – Oceanographers (ocean-bottom current modeling, oil spill modeling)
Main Gulf of Mexico Geological Provinces

- Salt Mini-basin
- Mississippi Fan
- Outer Continental Shelf
- Florida Shelf & Escarpment
Publications of Bathymetry Map to Date

• Originally published in AGU’s Eos online magazine
• Within days, covered by online National Geographic, Smithsonian, Forbes, Gizmodo, ESRI, Daily Mail, Hydro International among others
• Eos Magazine, August print version, lead article
• Oil and Gas Journal, upcoming September print version, lead article
• National Geographic, TV episode of “Drain the Ocean”, production in October, to be aired mid 2018
BOEM Mapping of Natural Seeps

• Since 1998, BOEM has used 3D seismic data to map seafloor amplitude anomalies that are indicators of natural hydrocarbon seepage and other geologic features

• After numerous manned submersible dives, unmanned ROV and AUV deployments, and camera sled tows, it was apparent that these sites were indeed seep sites

Photos courtesy of Ian MacDonald
Groundtruthing Natural Seep Sites

Camera Sled

“Sentry” AUV

“Alvin” Submersible

“Jason” ROV
Three types of seep-related anomalies:

**High Positive**
- interpreted to be from authigenic carbonates formed at slow to moderate seeps by bacteria in the sediment

**Low Positive/Negative**
- interpreted to be high-flux vent sites and mud volcanoes, oil and gas expulsion accompanied by sediment and brine

**Pockmarks**
- circular to oval depressions on the seafloor interpreted to be rapid, one-time expulsion of gas only

Image from BOEM website
≈3,000 non-seep-related anomalies:

- sediment flows out of high flux vent sites
- exposures of salt
- turbidite fans and channels
- slumps at the base of over-steepened salt flanks
- Cretaceous carbonate outcrops on the face of the Florida Escarpment

Downloadable shapefiles of all anomalies at BOEM website: https://www.boem.gov/Seismic-Water-Bottom-Anomalies-Map-Gallery/
Seismic Amplitude Anomaly Distribution

35,000 amplitude anomalies as of January 2017.
20 different classifications.
Note that most seeps are located over and along flanks of the bathymetric highs, which are supported by the underlying salt.
High Positive and Low Positive Amplitude Anomalies

This area visited several times and all features are confirmed
Seismic Traverse A - A’

High and Low Positive Amplitude Anomalies

- High Positive Anomalies
- Low Positive Anomalies
- Mud Volcano

Image from BOEM website
Diverse, High Density Chemosynthetic Community

Tubeworms, clams, gas hydrate, sea anemones, pogonoferans, all found on authigenic carbonate (high positive anomalies)

Photo courtesy of Ian MacDonald
“Fireworks Coral”

Corals require hard substrate as well and are also protected

Photo courtesy of Ian MacDonald
Bubble Plumes Emanating from Hydrate Mound

Surface mounds of gas hydrate are common in the GOM in association with carbonates and are always surrounded by abundant benthic organisms.

Photo courtesy of Greg Boland, BOEM
Overhanging Ledge of Carbonate with Hydrate and Numerous Mussels

Surface mounds of gas hydrate are common in the GOM in association with carbonates and are always surrounded by abundant benthic organisms

Photo courtesy of Okeanos Explorer, NOAA
Fish are Common at Deepwater Seep Sites

Photo courtesy of Ian MacDonald
Seafloor Amplitude Map
Pockmarks and High Positive Amplitude Anomalies

Image from BOEM website
Pockmarks probably form when gas is expelled forcefully, without accompanying fluidized sediments and/or brine.
Video: Seafloor Pockmarks

Island of Manhattan for scale reference
Depth Bathymetry Map with Acoustic Amplitude Underlay

Natural Seeps in the Vicinity of Deepwater Horizon

Seismic Seafloor Seep Anomalies

DWH Well

Oil Slicks

C

C'

20 m contours

3 miles

Modified from ERMA website
Seismic Traverse C - C’
Oil & Gas Migration Pathways Along Flank of Salt

Seismic line showing relationship between probable seep sites and underlying salt bodies controlling migration pathways

Modified from ERMA website
Natural Oil Seep Above a Salt Canopy
Mud Volcanoes in Mississippi Canyon 345

Modified from Gordon Research Conference
Mud volcanoes form when sediment and brine accompany gas and oil.
Crater of a Mud Volcano

Photo courtesy of NOAA
Thank you for your attention