Confirming the Presence of a Working Petroleum System in the Eastern Black Sea Basin, Offshore Georgia Using SAR Imaging, Sea Surface Slick Sampling, and Geophysical Seafloor Characterization*

Harry Dembicki, Jr.[1]

Search and Discovery Article #10610 (2014)**
Posted July 7, 2014

*Adapted from oral presentation at AAPG Annual Convention and Exhibition, Houston, Texas, April 6-9, 2014

[1]Anadarko Petroleum Corporation, Houston, Texas (harry.dembicki@anadarko.com)

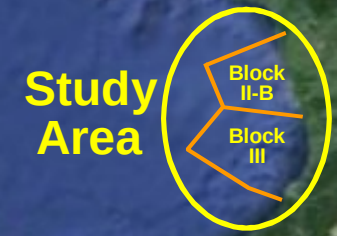
Abstract

As new plays emerge in deepwater settings, one of the more difficult tasks facing the explorationist is to find evidence confirming the presence of a working petroleum system. In the Eastern Black Sea Basin, the elements of a petroleum system are likely present. Source rocks of Oligo-Miocene age in the Maykop Formation should be charging middle Miocene deepwater channel-levee sands in fold and thrust system traps. Yet to reduce the exploration risk in this frontier area, direct evidence of hydrocarbon generation and migration is needed. To provide confirmation of charge, a collection of diverse data was used. First, synthetic aperture radar satellite images revealed the presence of large recurring sea surface slicks over prospective structures. These slicks were then sampled during 3-D seismic data acquisition. Geochemical analysis showed that the compositional characteristics of the slicks' hydrocarbons were similar to known Maykop-sourced oils in the region. To verify that the slicks were related to the subsurface, a seafloor extraction from the 3-D seismic data was used to identify bathymetric features consistent with seafloor hydrocarbon seepage. The features identified included pockmarks, near-seafloor sediments with high impedance contrast, suggesting authigenic carbonates, and mud volcanoes. The apparent origins of the slicks on the sea surface were found to be coincident with the locations of these seafloor features. Finally, the 3-D seismic imaging was used to demonstrate there are potential migration pathways from the suspected charged traps to these seafloor features. This combination of data provides a high level of confidence that the seismically imaged traps in the Eastern Black Sea Basin in offshore Georgia are charged. What it cannot tell us is how much petroleum may be in these structures. This question can only be answered by the drill bit.

AAPG 2014 Annual
Convention And Exhibition
Houston - April 8, 2014

Confirming the Presence of a Working Petroleum System in the Eastern Black Sea Basin, Offshore Georgia Using SAR Imaging, Sea Surface Slick Sampling, and Geophysical Seafloor Characterization

"Exploring the unknown requires
tolerating uncertainty."
– Brian Greene



Harry Dembicki, Jr.
Geological Technology Group
Anadarko Petroleum Corporation

Slicks, Seafloor Seeps And Offshore Exploration

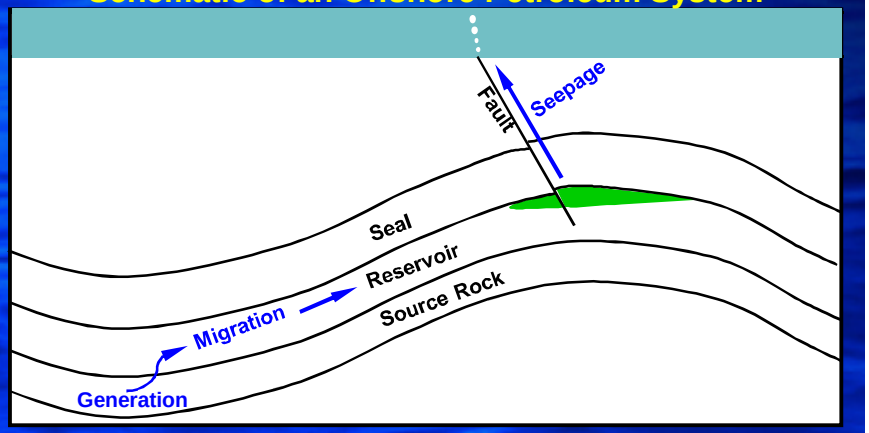
- Most sea surface slicks are episodic and ephemeral.
- They need to be sampled to confirm the presence of thermogenic hydrocarbon.
- There also needs to be evidence that the hydrocarbons originated from the seafloor, such as…

  …observing surfacing oil,

  …identifying seafloor features that are consistent with seepage, and

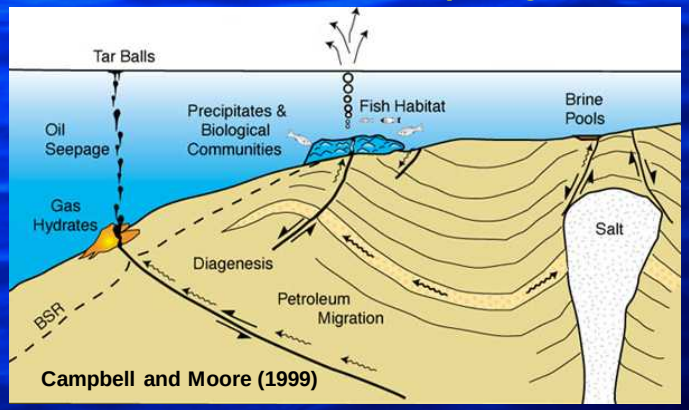
  …correlating the slick's hydrocarbons to oils in the area.
- The potential seafloor seep features need to be linked to subsurface reservoirs by potential migration pathways to the surface.
- And, the seafloor seep features should eventually be sampled for confirmation.

Schematic of an Offshore Petroleum System



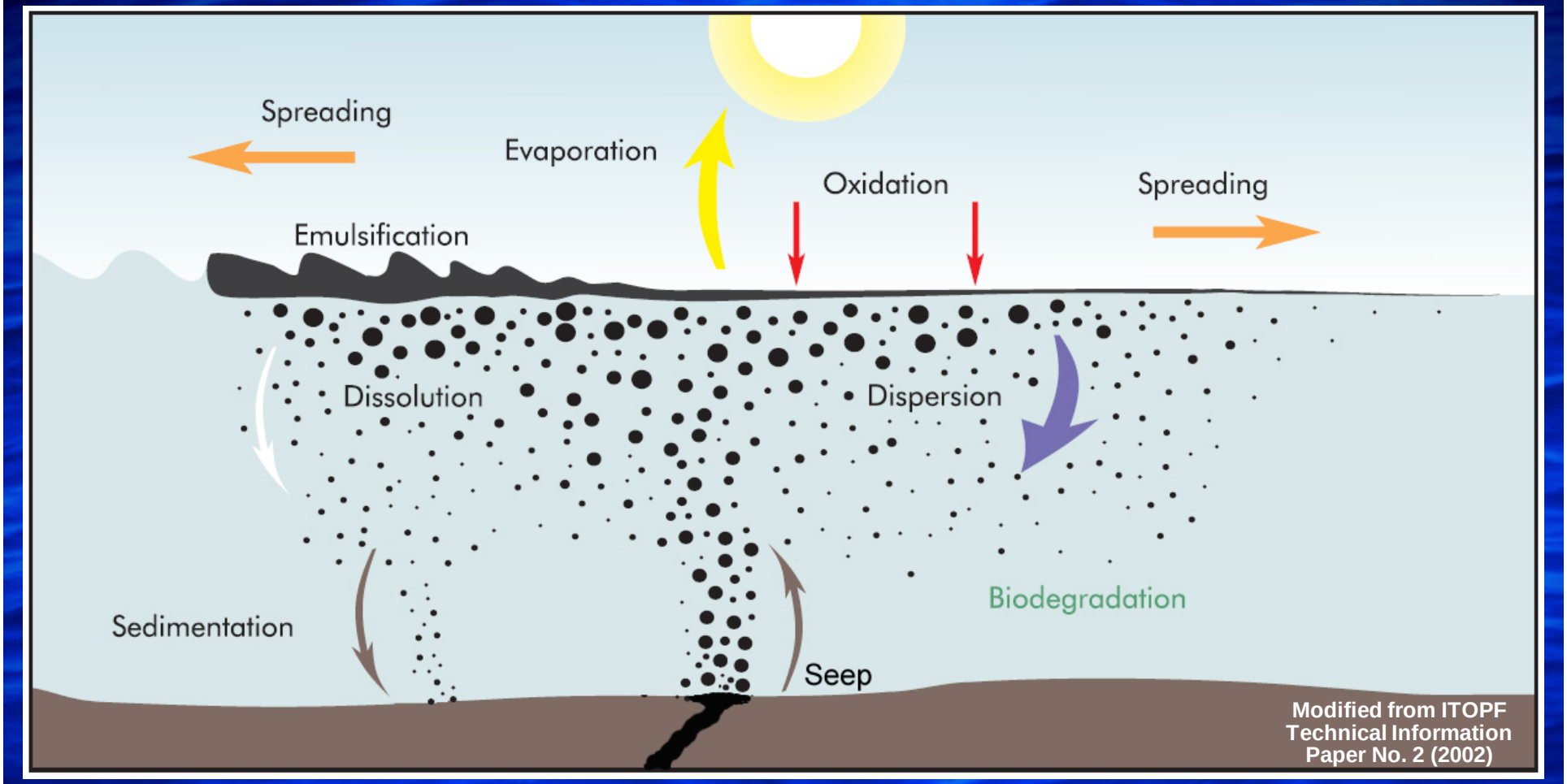
Classic "Pancake" of Surfacing Oil

Potential Seafloor Seep Targets



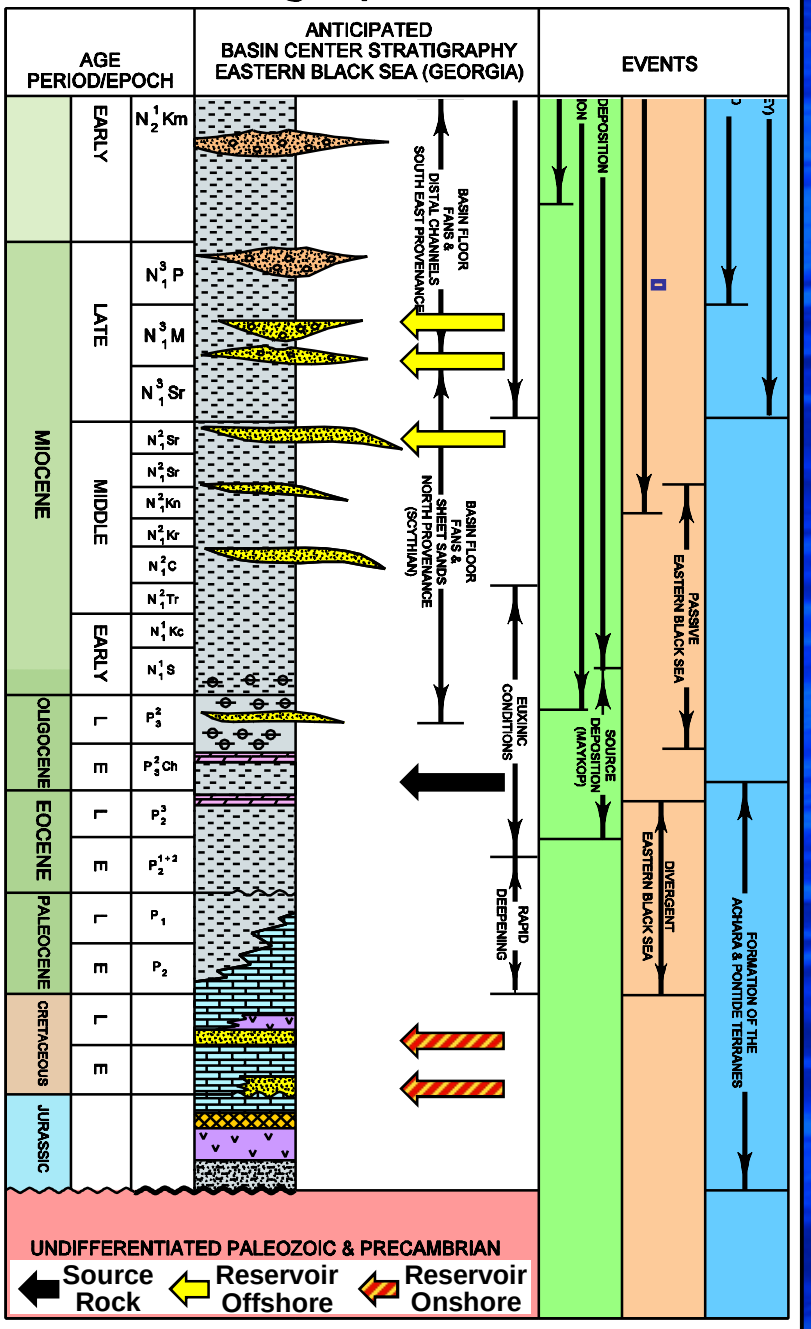
Campbell and Moore (1999)

Possible Fates For Sea Surface Slicks

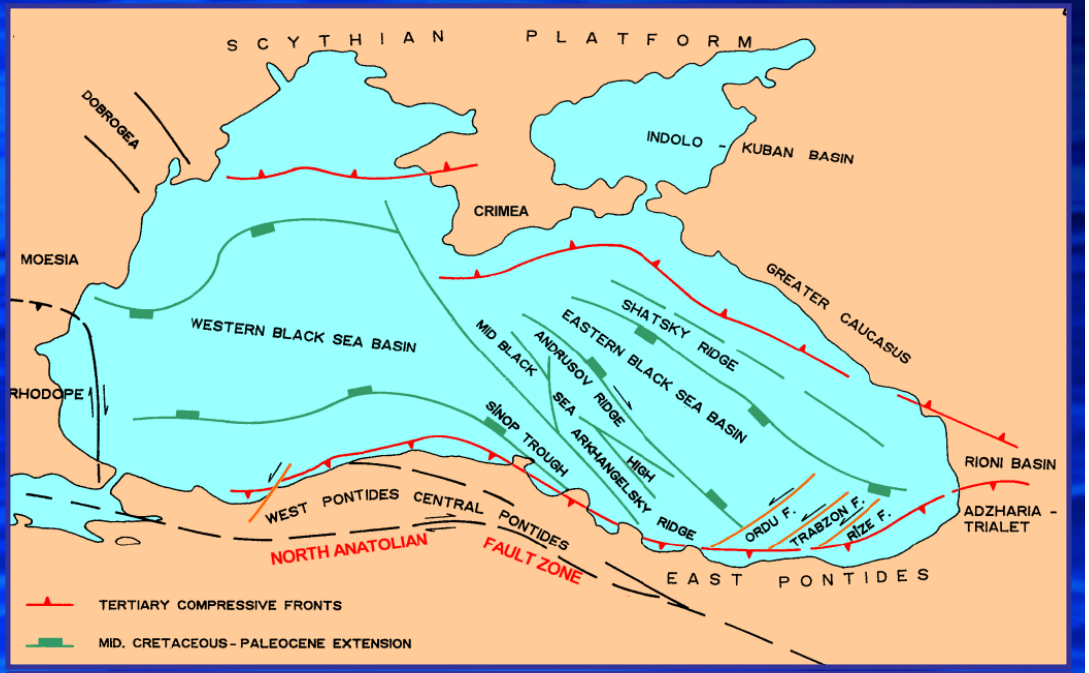


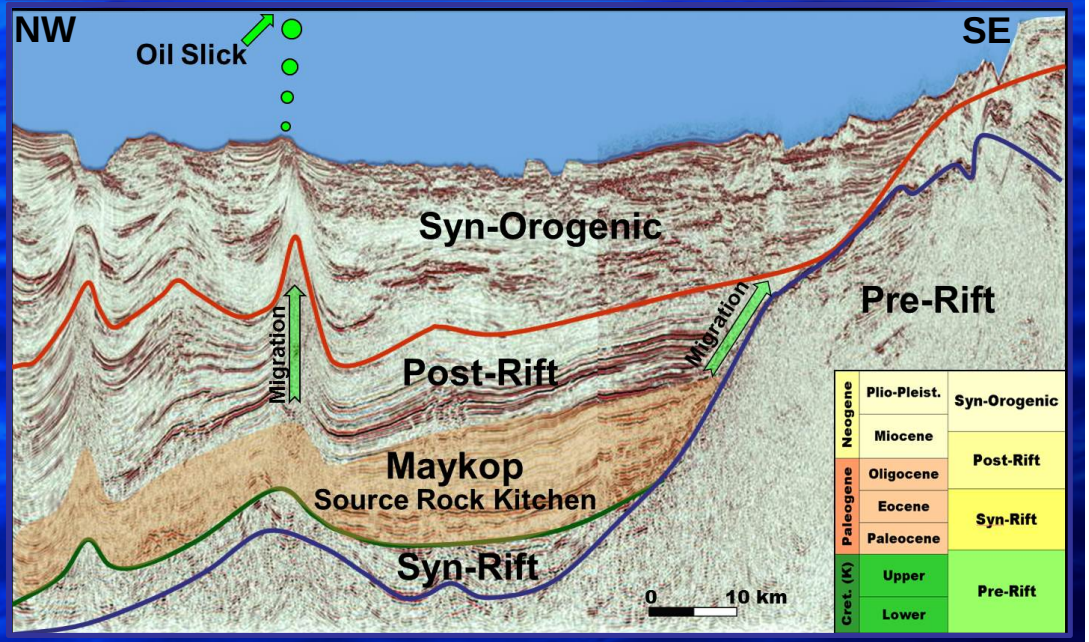
Sea surface slicks can have numerous biological, chemical, and physical processes can act on the seeping oil at the sea floor, in the water column and at the sea surface to alter its composition and physical state.

Stratigraphic Column

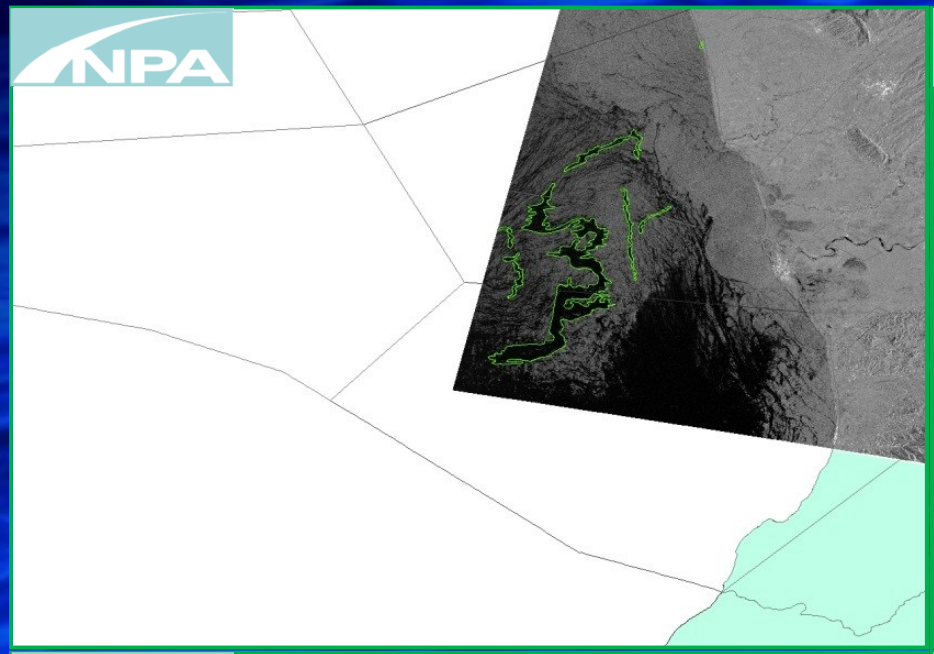


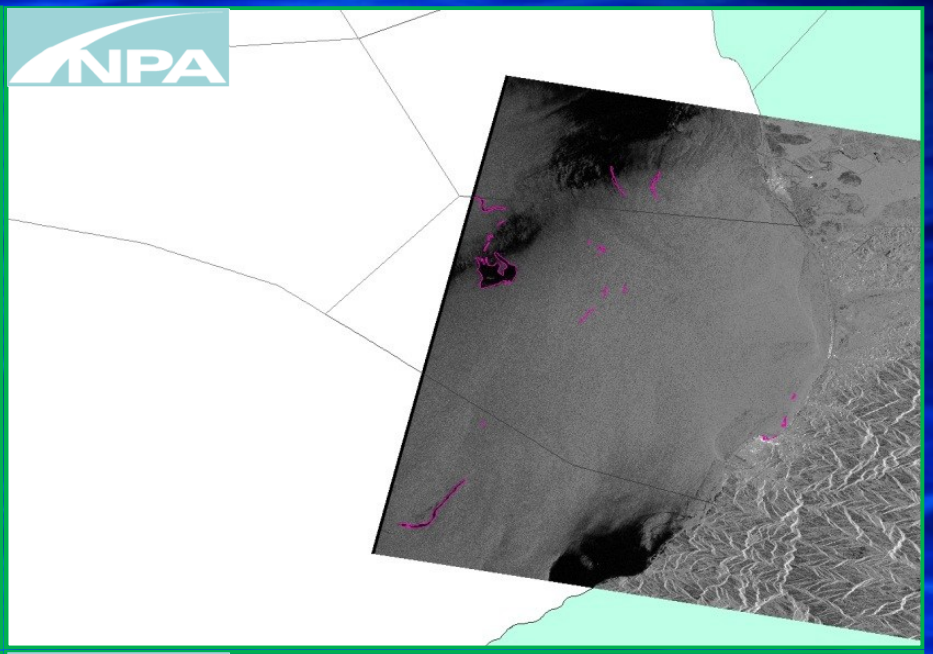
Geologic Setting

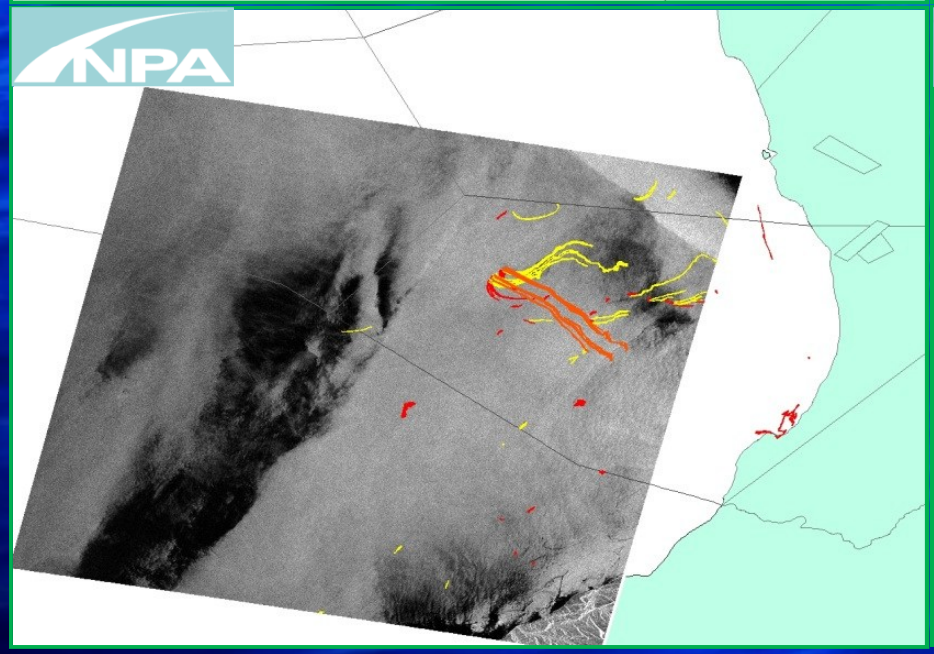


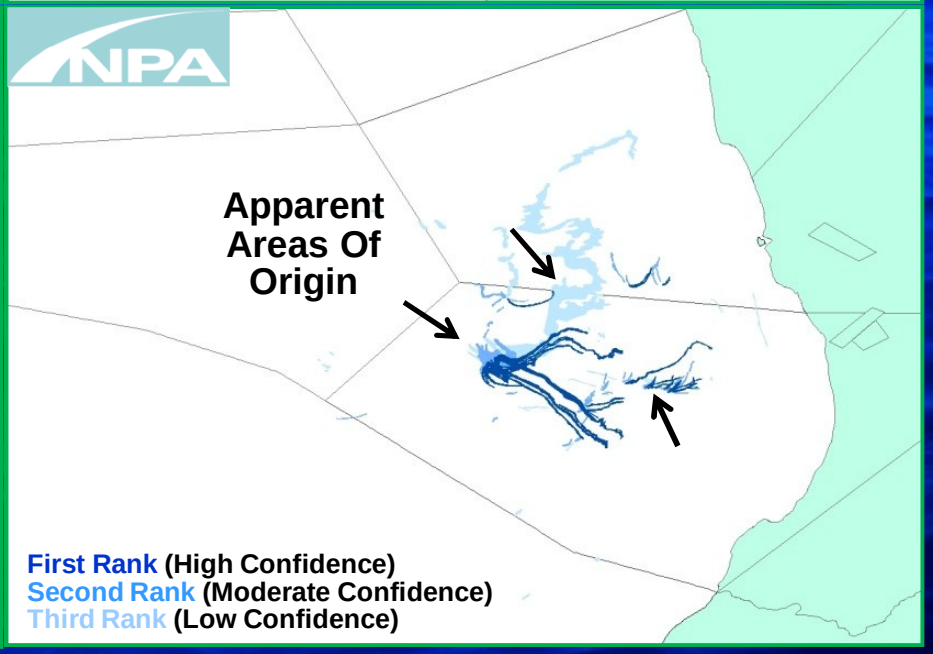


Slick Detected With Synthetic Aperture Radar









SRA data courtesy of CGG NPA Satellite Mapping Limited

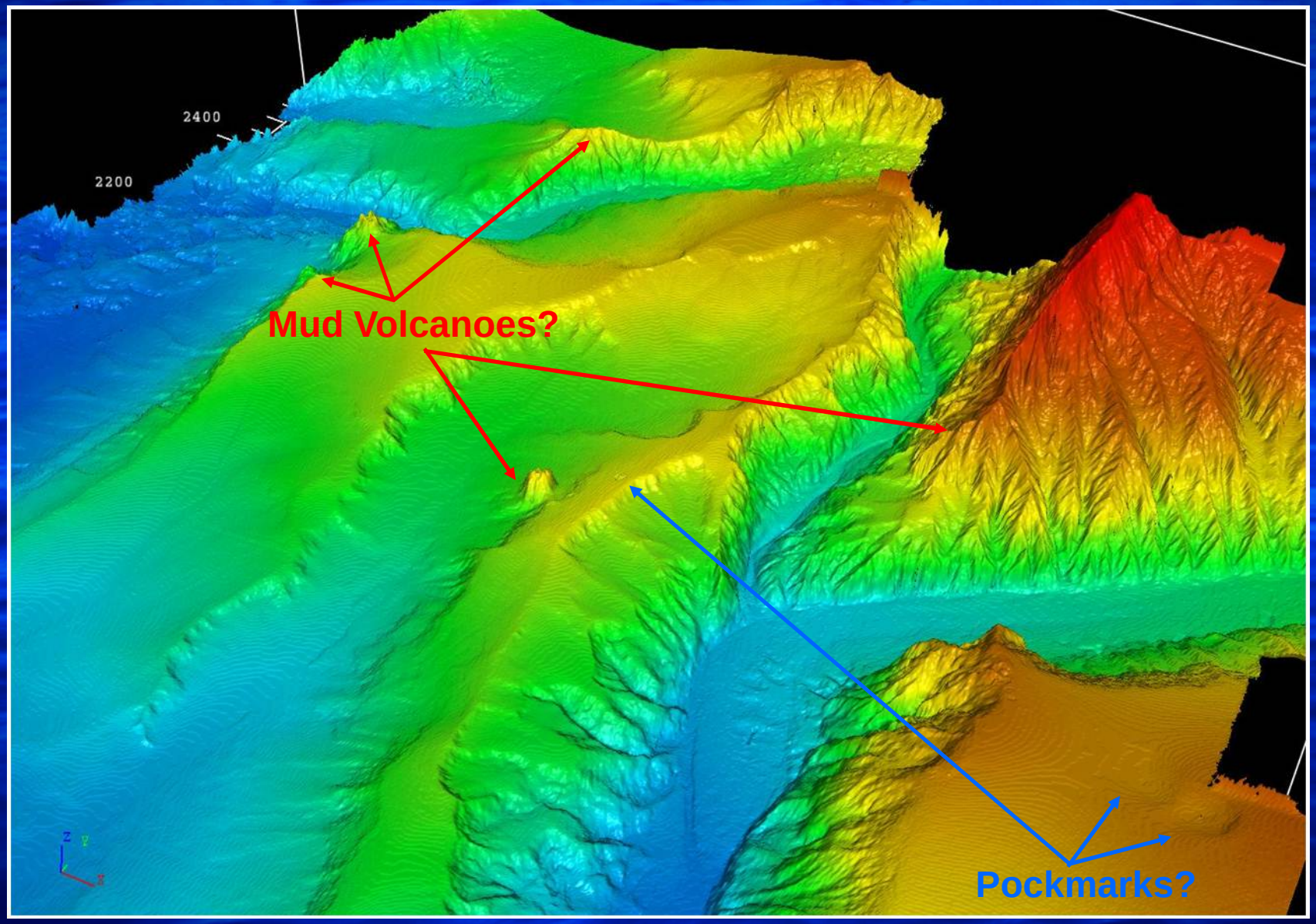
Shipboard Observations Of Sea Surface Slicks

When observed from a distance, the slicks were often described as "marks on the water" or "flatter sea surface" on the seismic vessel's log.

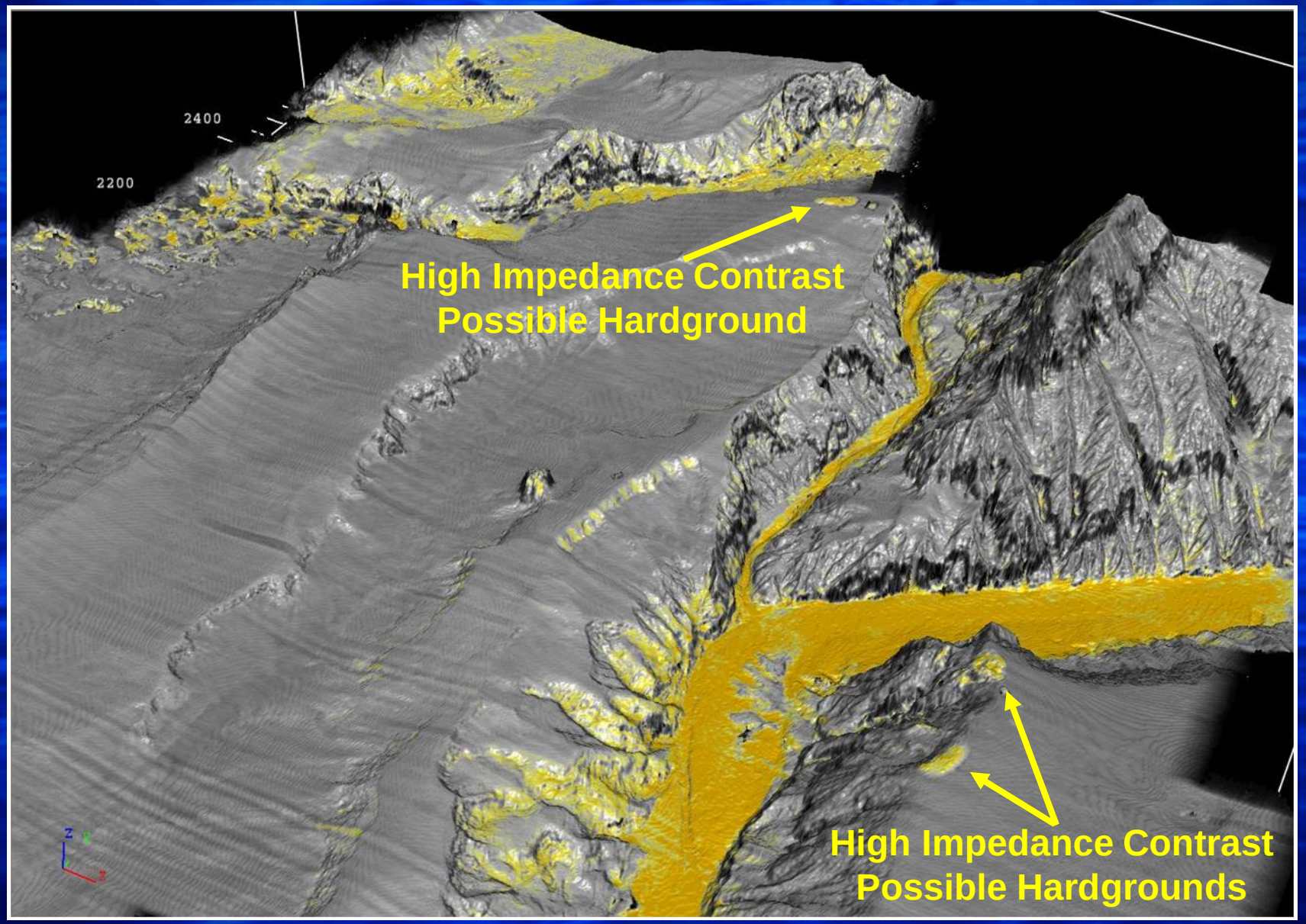
Shipboard Observations Of Sea Surface Slicks

When closely observed, the slicks appear as iridescence surface films, having a fuel-like smell.

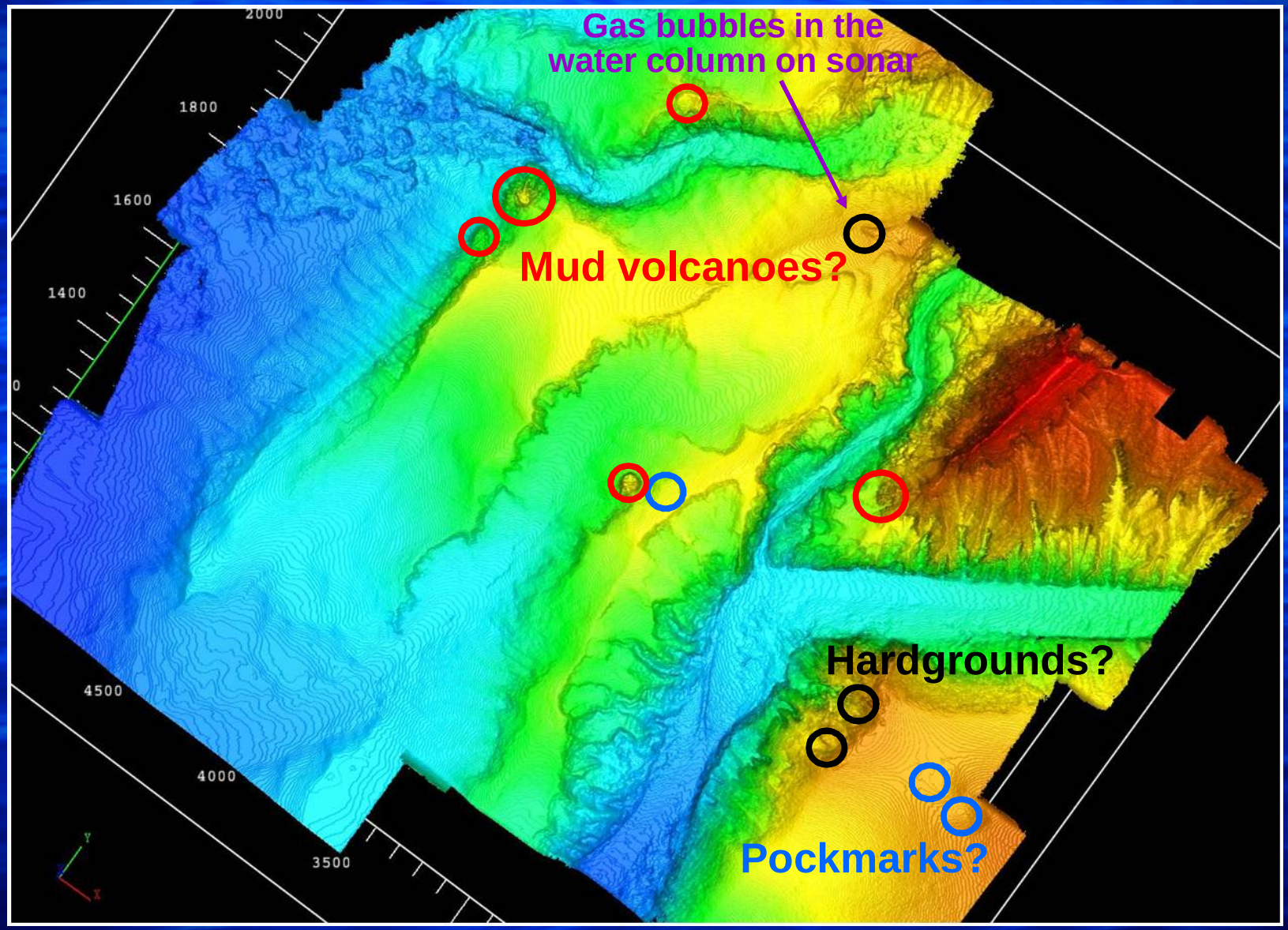
Potential Seep Features Recognized From The Bathymetry Extracted From The 3-D Seismic



Potential Seep Features Recognized From Near Surface Amplitudes Extracted From The 3-D Seismic

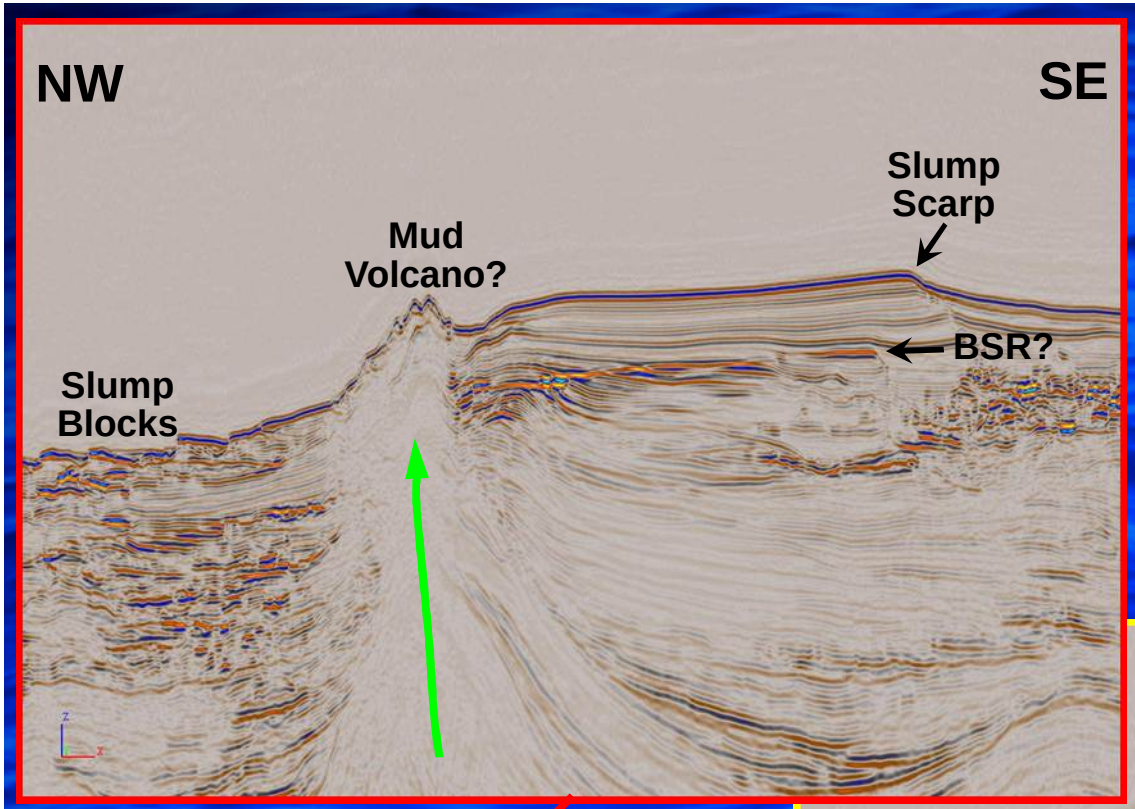


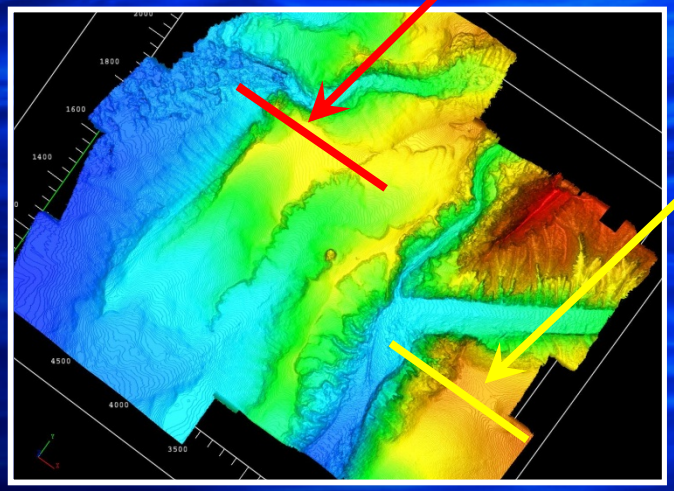
Summary Of Potential Seep Related Features

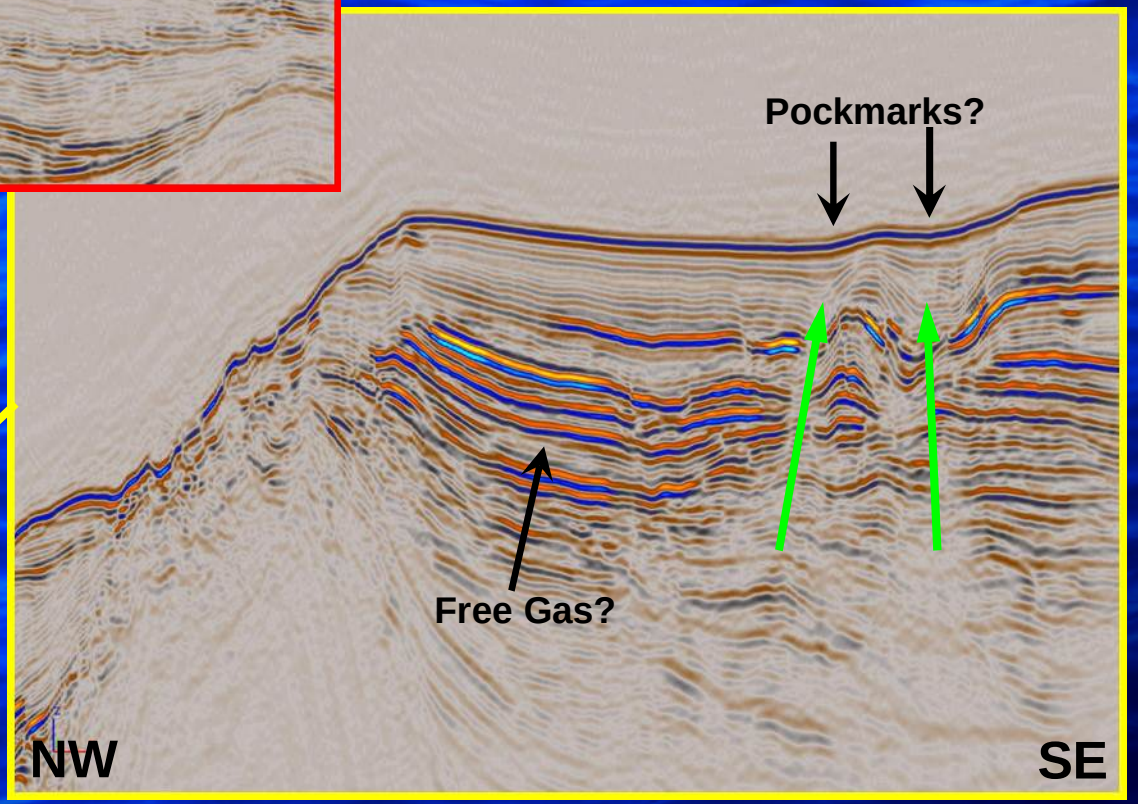


Deep Looking Seismic

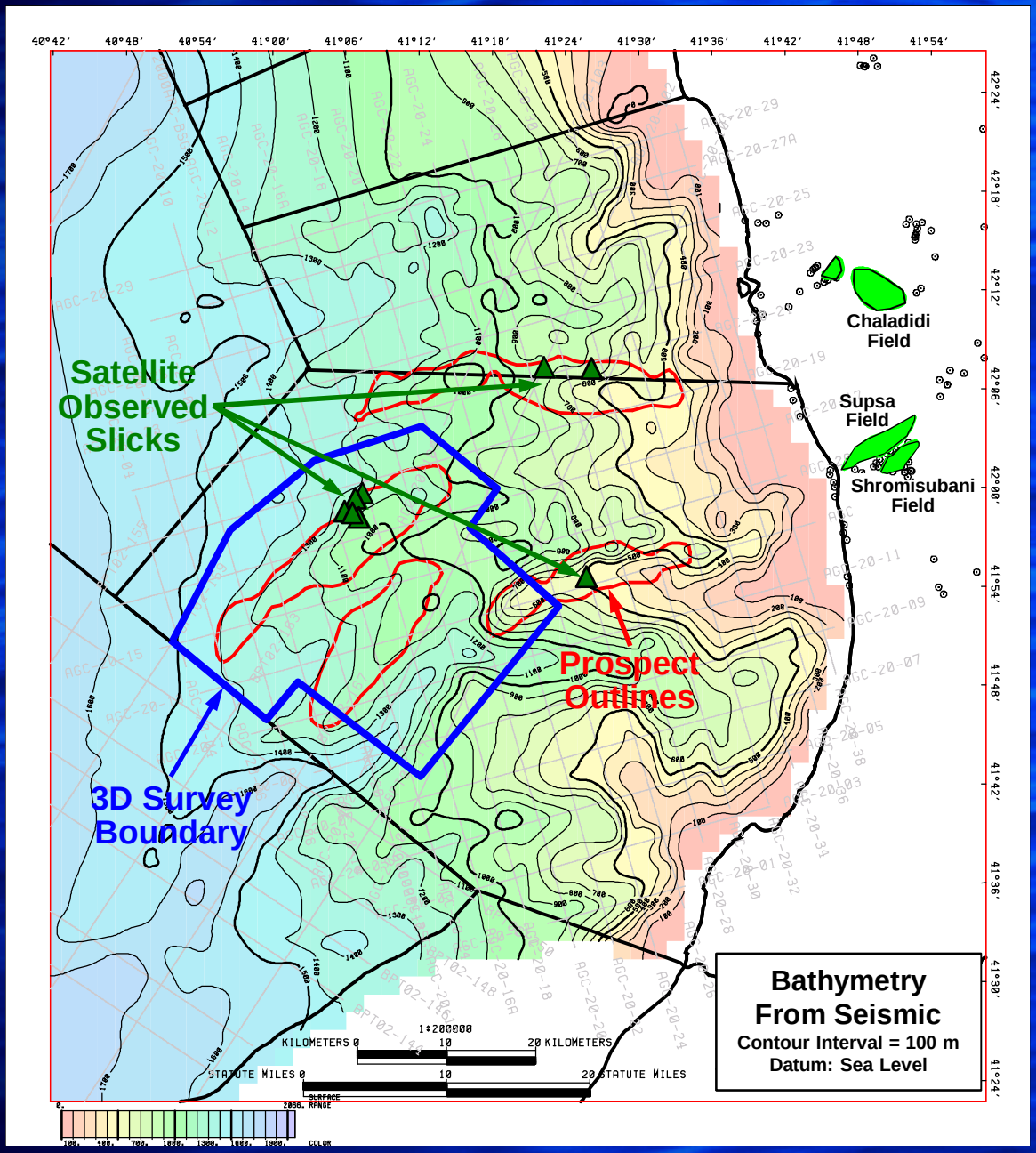
These seismic lines show potential migration pathways from depth that could direct seeping hydrocarbon to the seafloor.



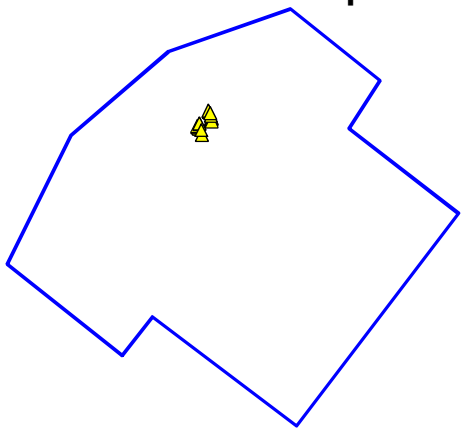




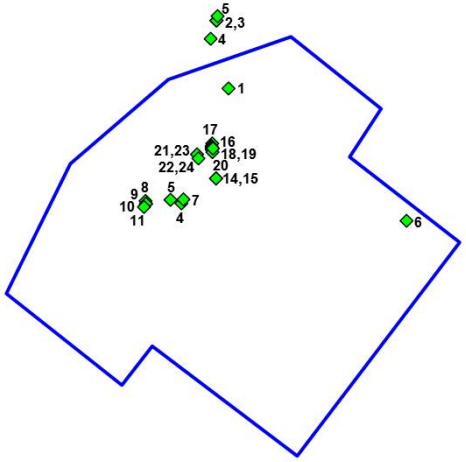
Slick Observation And Sample Locations



Surfacing Oil Observed During the 3D Seismic Acquisition



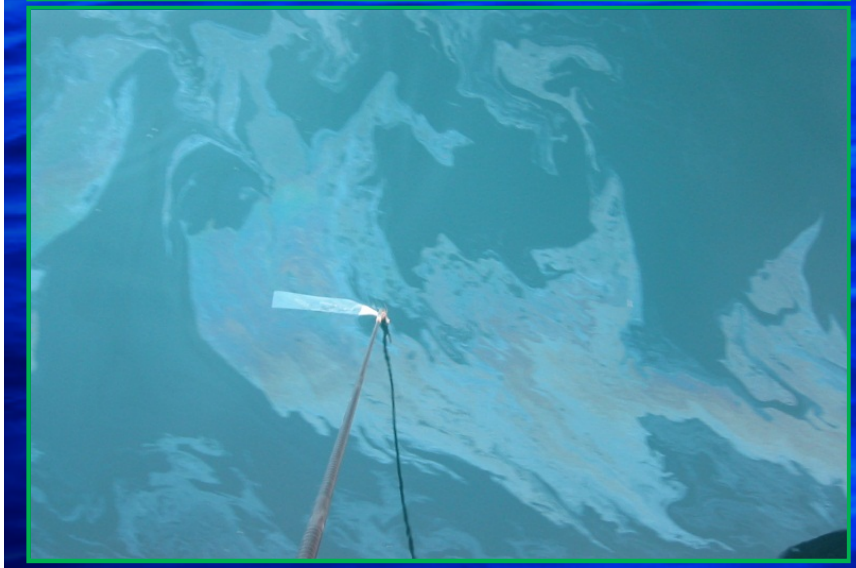
Slick Sampling Locations



Slick samples 1, 3, 5, 6, 7, 9, 11, 14, 16, 18, 20, 22, and 24 recovered adequate oil for analysis.

Slick Sampling And Analysis

A member of the crew "fishing" for hydrocarbons in a surface slick.



Extended exposure of the Nybolt increased the amount of hydrocarbon recovered.

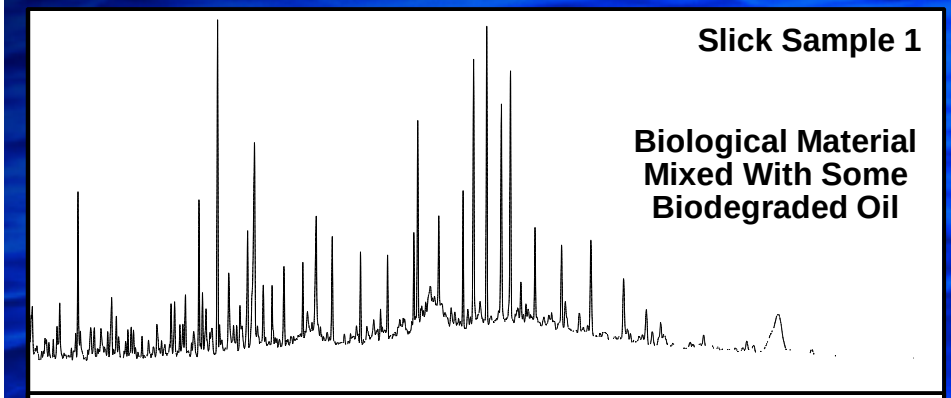
Sample Collection

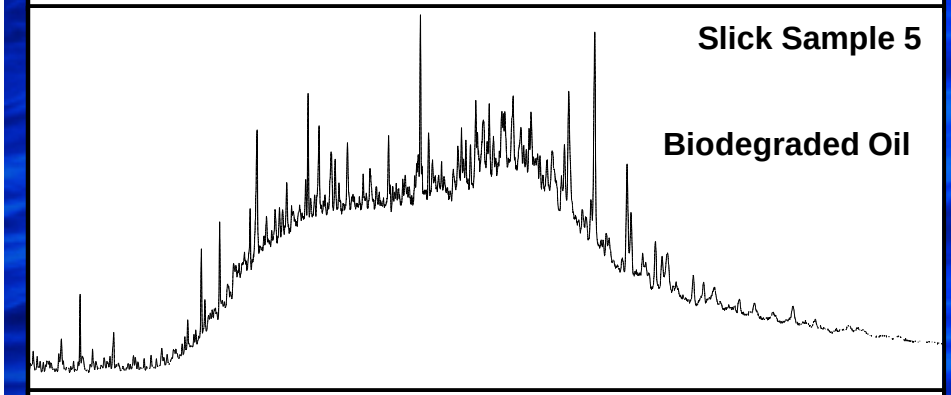
- The hydrocarbons in the slicks were sampled by repeatedly dragging strips of Nybolt (a polyamide bolting cloth) through the organic film at the sea surface.
- The strips of Nybolt were then placed in glass jars with Teflon lined cap for storage and transport.

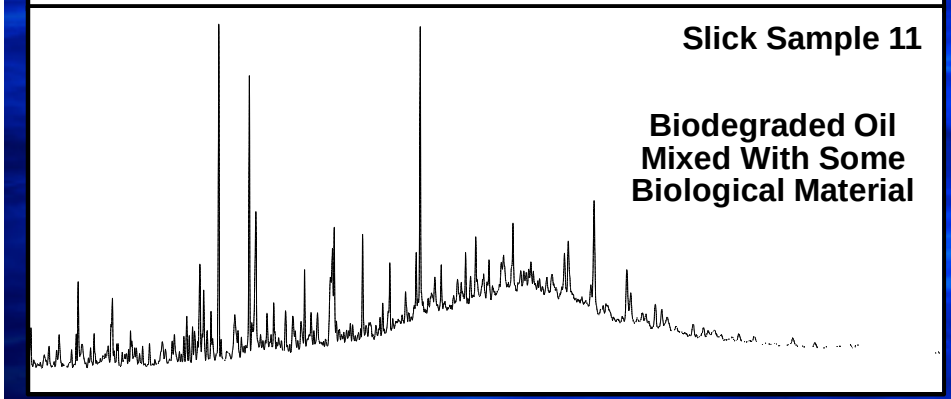
Sample Analysis

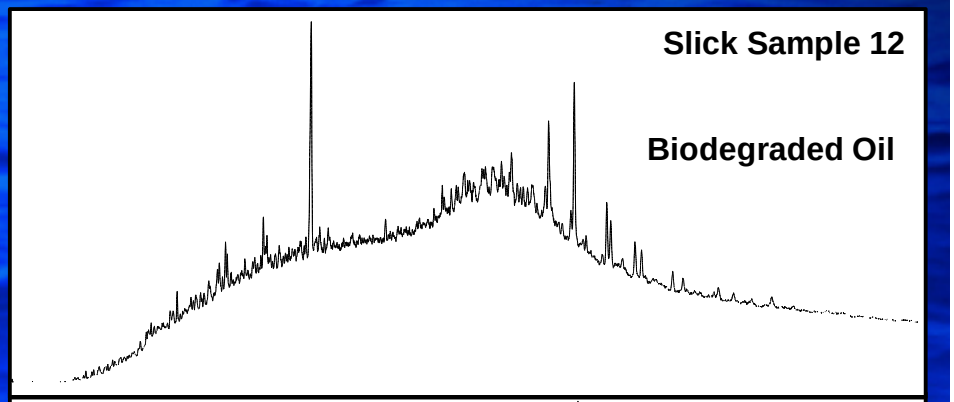
- Once in the lab, the Nybolt strips were extracted with dichloromethane.
- Only 13 of the 24 samples collected yielded enough extract for analysis.
- All 13 samples were analyzed by gas chromatography of the total solvent extracts followed by high resolution GC-MS for biomarkers analysis.
- Samples of onshore Maykop sourced oils were also obtained and analyzed for comparison.

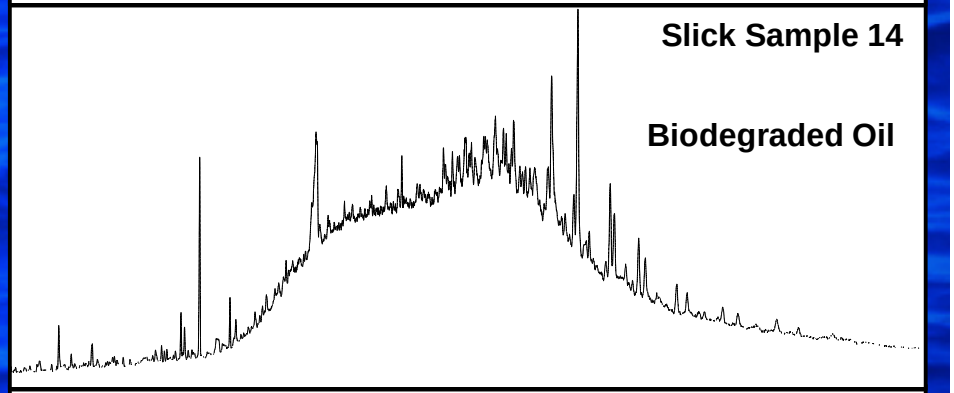
Whole Extract Gas Chromatograms From n-C_{14} – n-C_{40}

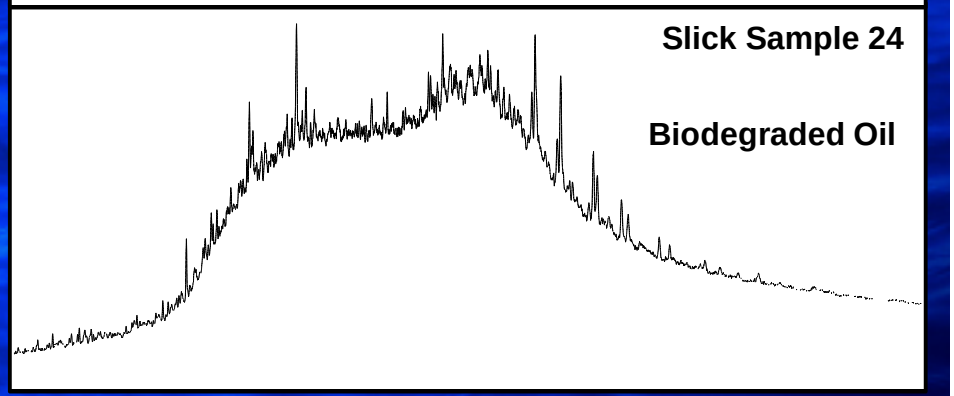




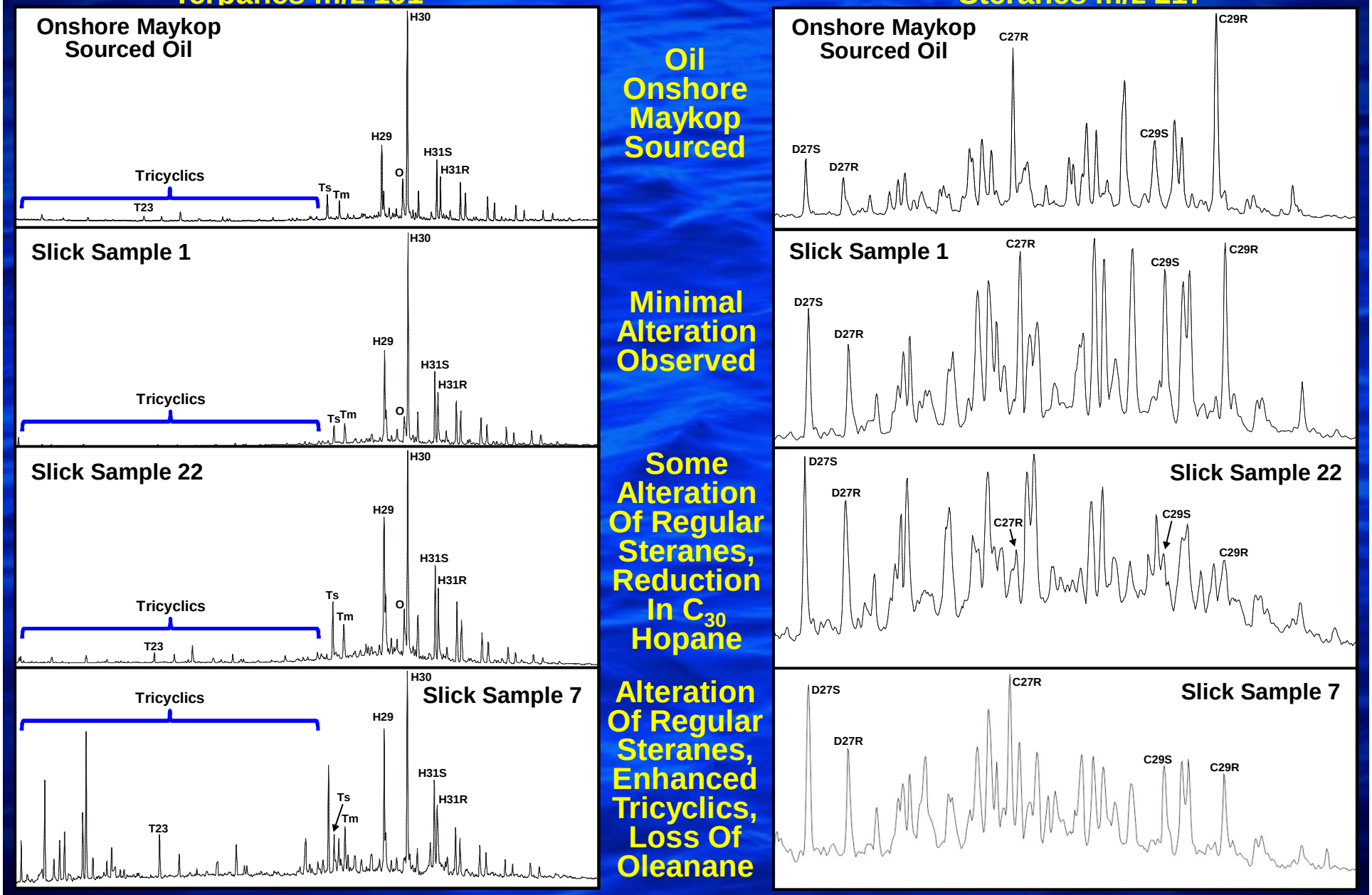






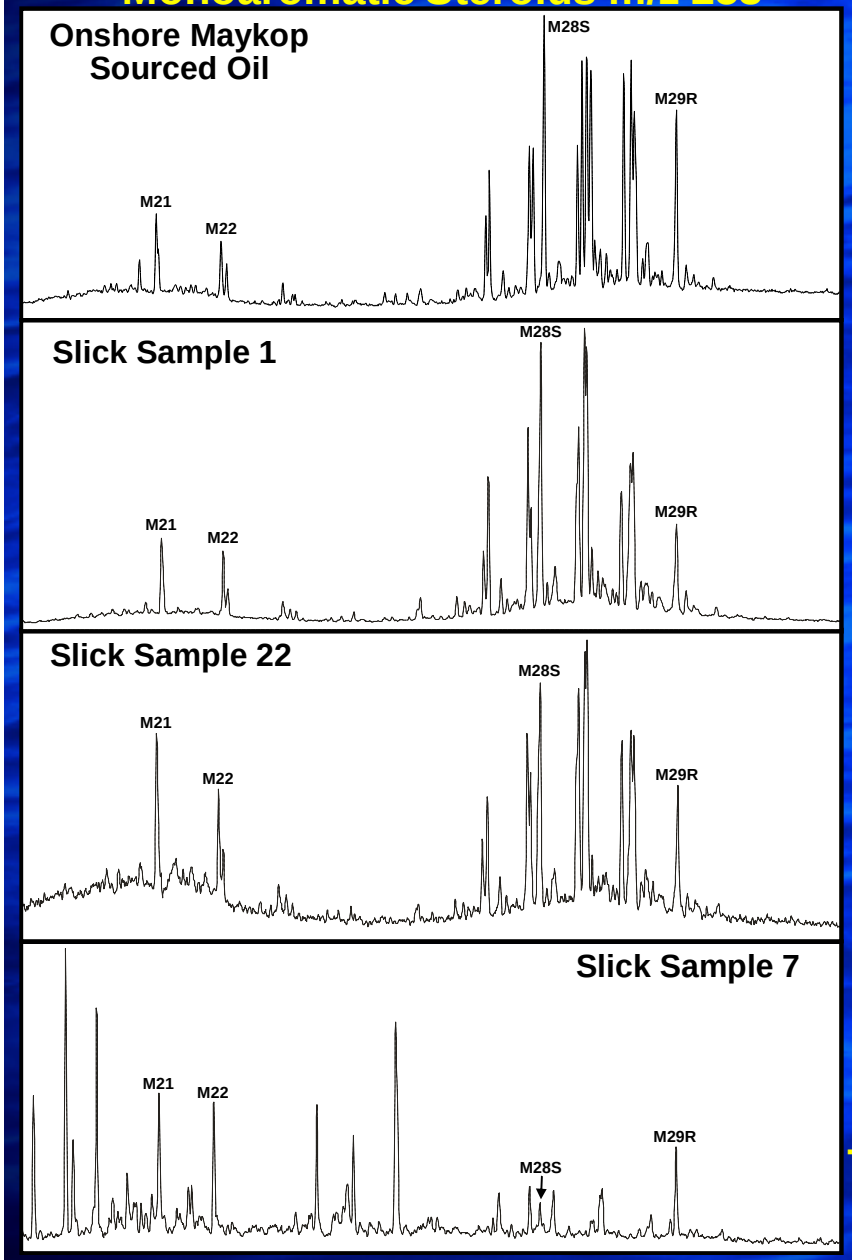


Saturate Fraction Biomarkers



Aromatic Fraction Biomarkers

Monoaromatic Steroids m/z 253



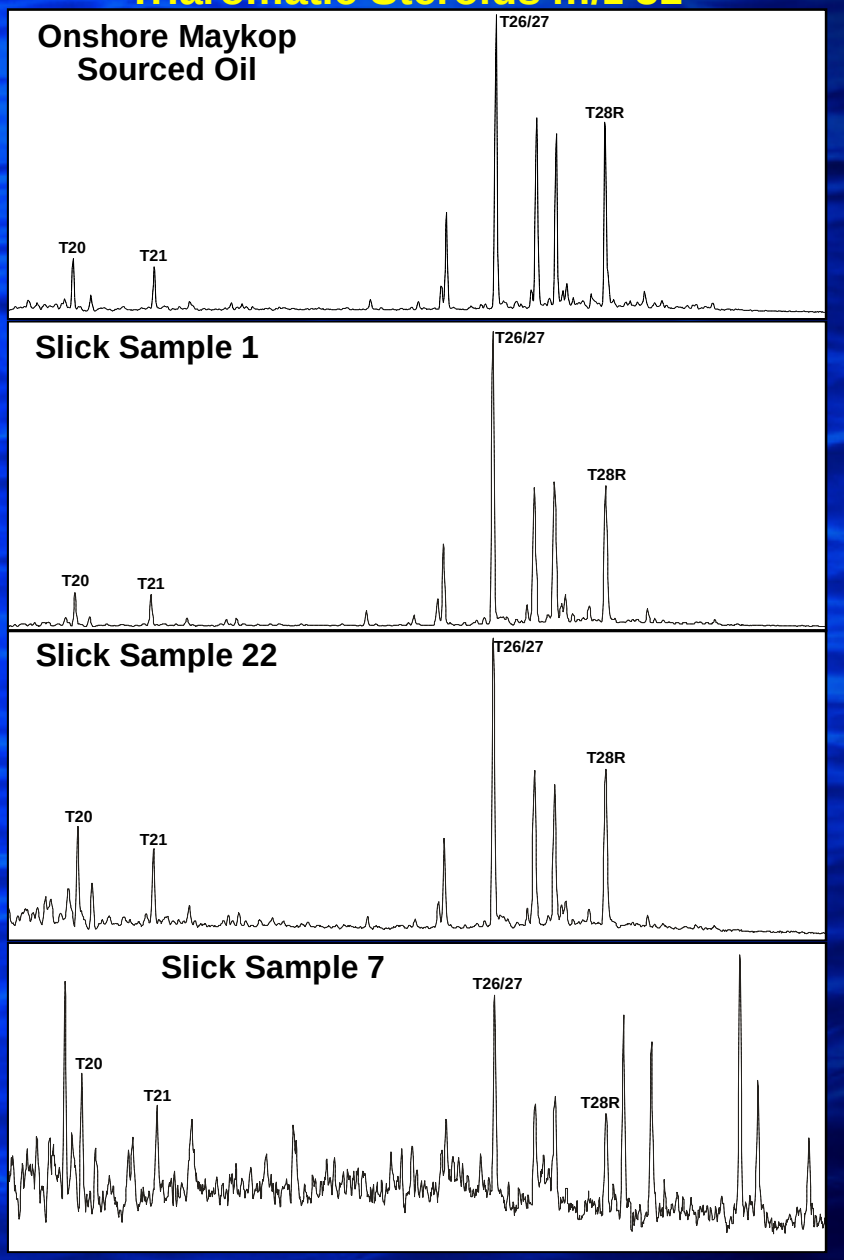
Oil Onshore Maykop Sourced

Minimal Alteration Observed

Slightly More Alteration Observed

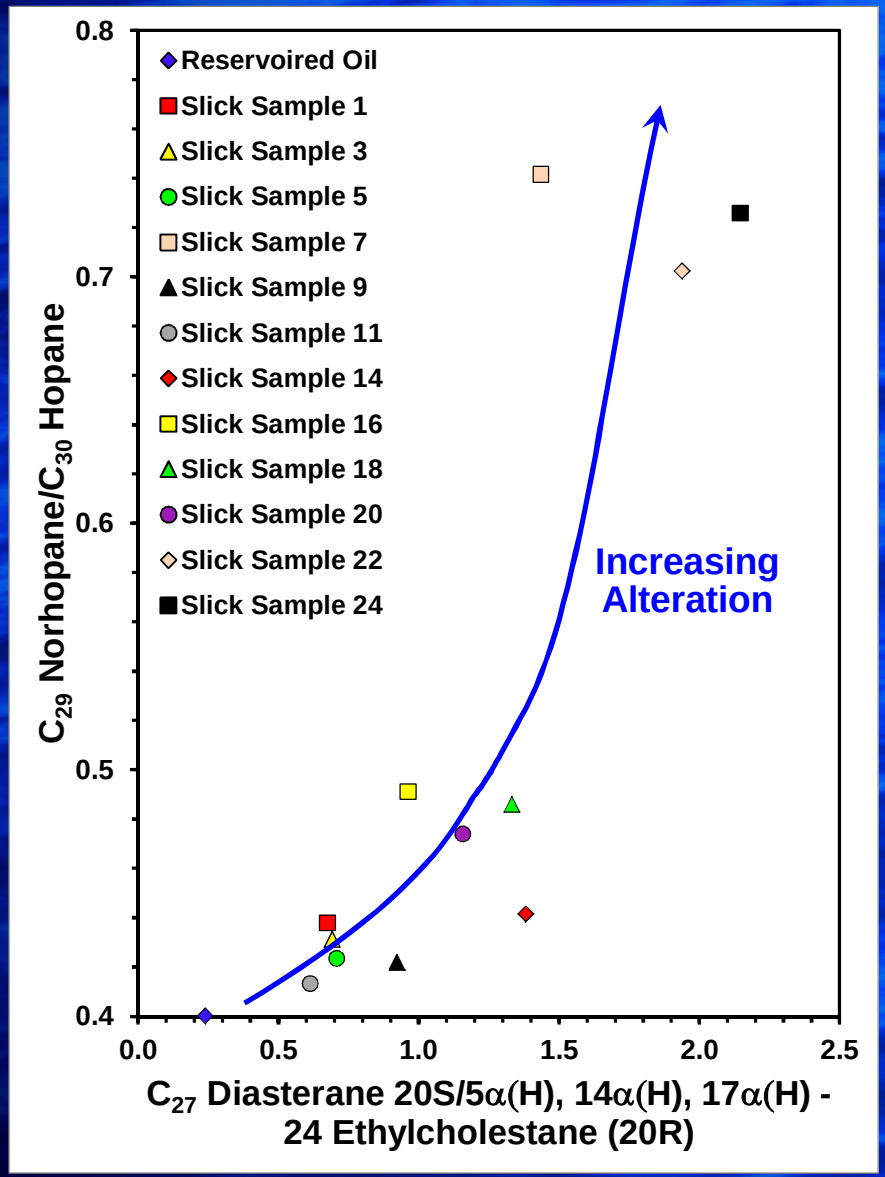
Significant Alteration Of Both Mono- And Triaromatic Steroids

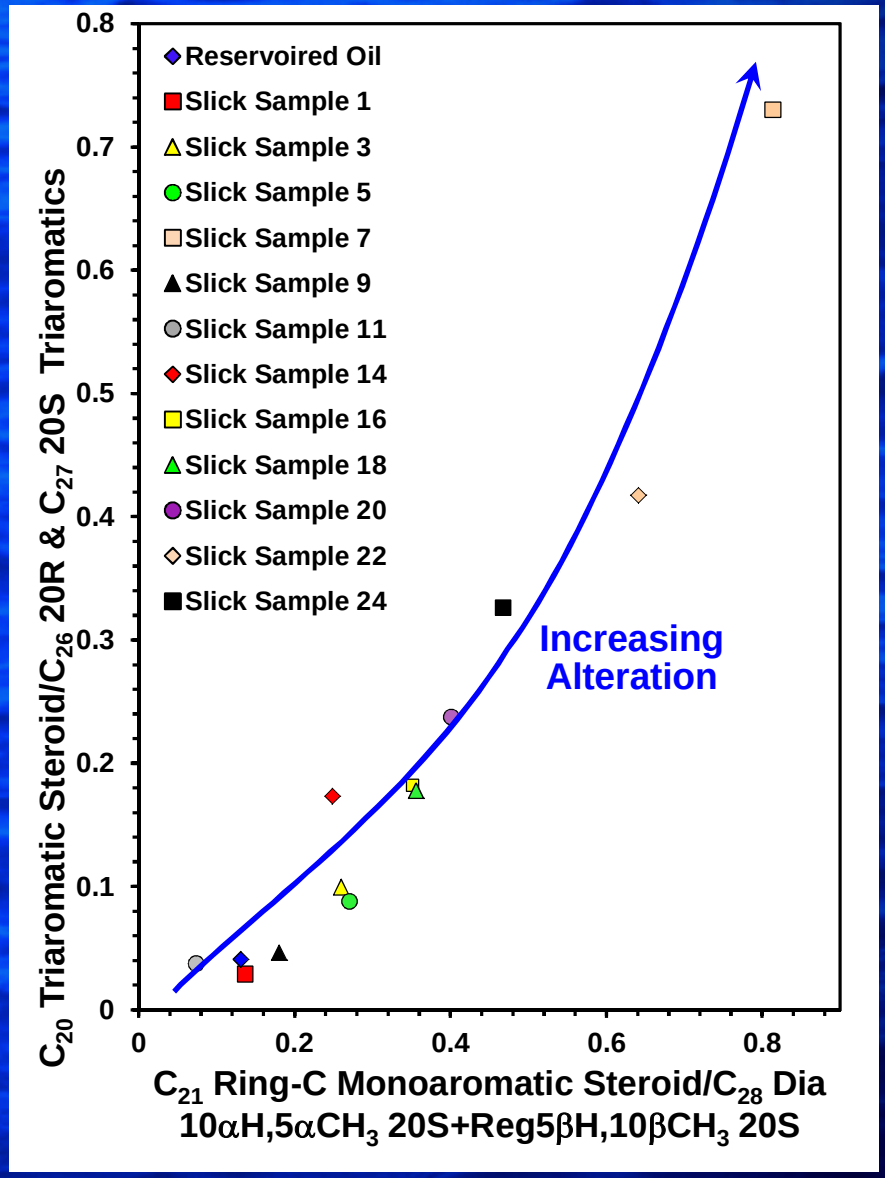
Triaromatic Steroids m/z 31



Assessing Alteration In The Slick Samples

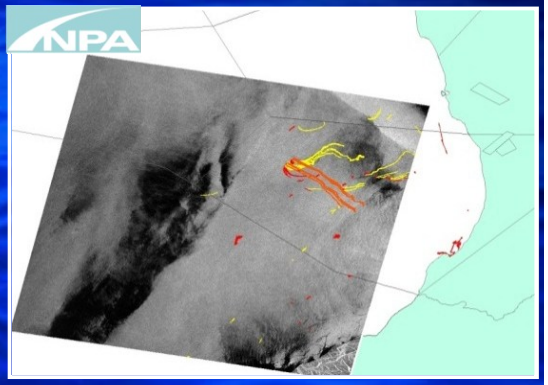
By observing the changes in ratios of key biomarker peaks, the relative alteration experienced by the slick oils can be assessed.

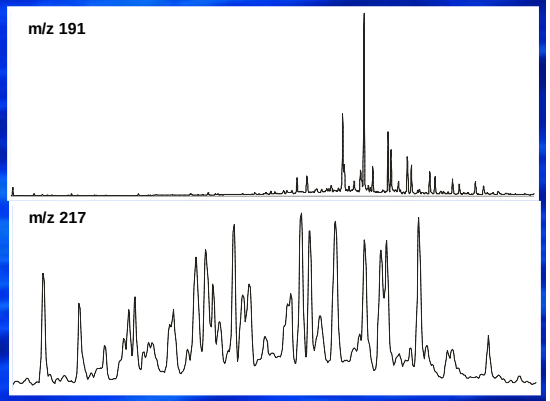


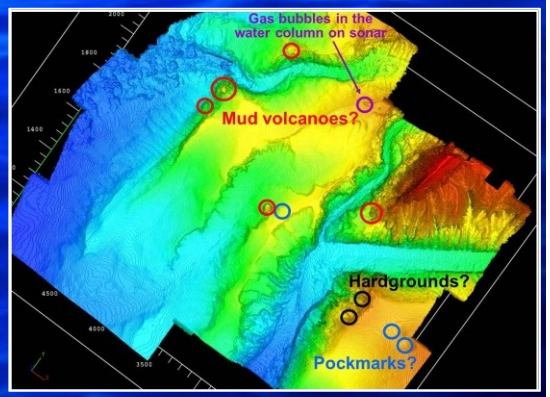


Observations And Conclusions, Part 1

- Sea surface slicks were encountered in the same areas where slicks were observed in the SAR satellite images.
- These slicks were sampled and confirmed to be composed of naturally occurring thermogenic hydrocarbons.
- The biomarkers from the thermogenic hydrocarbons are consistent with nearby onshore Maykop sourced oils, the same source that is expected to be contributing to the offshore traps.
- Bathymetric and amplitude data extracted from the 3D seismic survey revealed a series of seafloor features including mud volcanoes, pockmarks, and hardgrounds suggestive of hydrocarbon seepage.

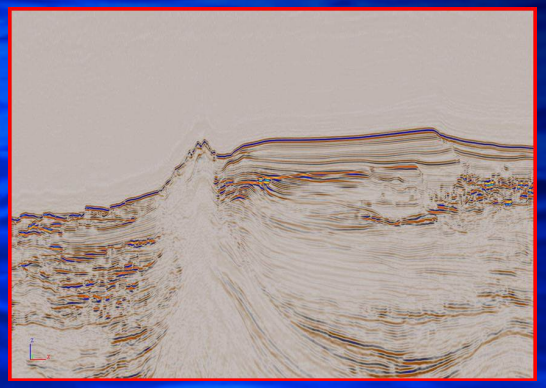


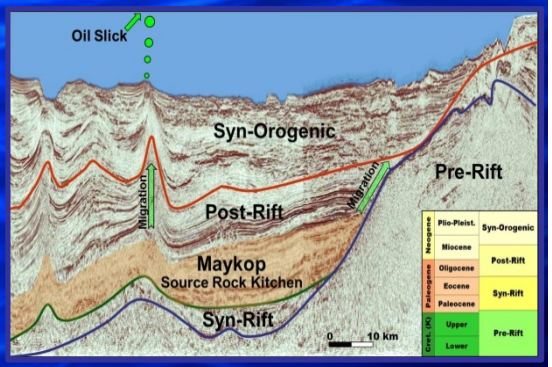




Observations And Conclusions, Part 2

- Deep-looking seismic data tied these seafloor features to subsurface prospects and migration pathways.
- Hydrocarbons were witnessed to be surfacing at locations nearly directly above some of the seafloor features suggestive of hydrocarbon seepage.
- From these observations, we concluded there was a working petroleum system present, thereby reducing the charge risk to this exploration play.
- The seep features were sampled in 2005 and 2007 by UNESCO Training Through Research cruises. Geochemical analyses were reported in a MS Thesis by Dmitriy Nadezhkin at Moscow State University.





Thank You For Your Attention. Questions?

Confirming the Presence of a Working Petroleum System in the Eastern Black Sea Basin, Offshore Georgia Using SAR Imaging, Sea Surface Slick Sampling, and Geophysical Seafloor Characterization

Harry Dembicki, Jr.
Geoscience Technology Group
Anadarko Petroleum Corporation
email: harry.dembicki@anadarko.com

Thanks to Anadarko Petroleum Corporation for permission to present this paper, CGG NPA Satellite Mapping Limited for permission to show the SAR images and the selection committee for the opportunity to share these ideas.

"Exploring the unknown requires tolerating uncertainty." – *Brian Greene*