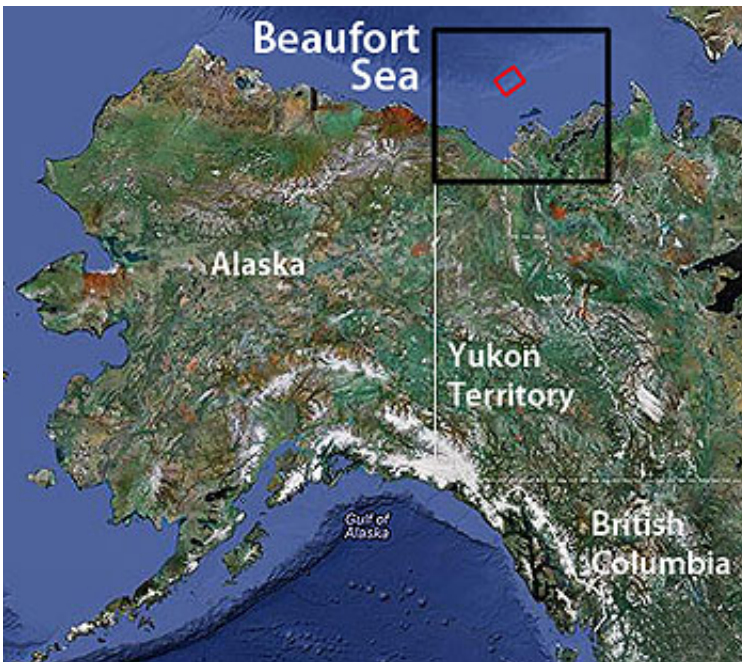


Expedition to study methane gas bubbling out of the Arctic seafloor

September 24 2012



The black rectangle on this map shows the general region where Paull and his collaborators have been studying methane releases in the Beaufort Sea. The smaller red rectangle indicates the edge of the continental shelf and continental slope where they will conduct research during their current expedition. These areas are shown in greater detail in the maps below. Credit: Google Maps

(Phys.org)—In the remote, ice-shrouded Beaufort Sea, methane (the main component of natural gas) has been bubbling out of the seafloor for thousands of years. MBARI geologist Charlie Paull and his colleagues at the Geological Survey of Canada are trying to figure out where this gas

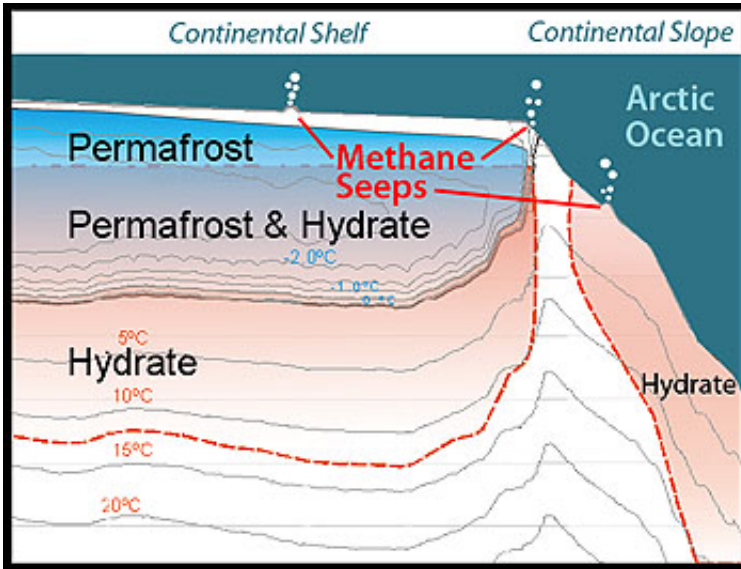
is coming from, how fast it is bubbling out of the sediments, and how it affects the shape and stability of the seafloor. Although Paull has been studying this phenomenon for a decade, his research has taken on new urgency in recent years, as the area is being eyed for oil and gas exploration.

In late September 2012, Paull and his fellow researchers will spend two weeks in the Beaufort Sea on board the Canadian Coast Guard ship Sir Wilfred Laurier, collecting seafloor sediment, mapping the seafloor using sonar, installing an instrument that will "listen" for undersea gas releases, and using a brand new undersea robot to observe seafloor features and collect gas samples.

This will be Paull's third Beaufort Sea expedition. As in previous expeditions, he will be working closely with Scott Dallimore of Natural Resources Canada's Geological Survey of Canada and Humfrey Melling of Fisheries and Oceans Canada's Institute of Ocean Sciences.

Paull's work in the Arctic started in 2003, with an investigation into the [enigmatic underwater hills called "pingo-like features"](#) (PLFs) that rise out of the continental shelf of the Beaufort Sea. (Pingos are isolated conical hills found on land in some parts of the Arctic and subarctic.)

Over time, the focus of the team's research has moved farther offshore, into deeper water. Their second expedition in 2010 looked at [diffuse gas venting](#) along the seaward edge of the continental shelf. The 2012 expedition will focus on three large gas-venting structures on the continental slope, at depths of 290 to 790 meters (950 to 2,600 feet).



This idealized cross section of the continental shelf and continental slope in the Beaufort Sea shows zones in the seafloor where permafrost and methane hydrate are likely to exist, as well as hypothetical locations of methane seeps on the seafloor. Ocean depths not shown to scale. Credit: 2012 MBARI

Frozen gas—a relict of previous ice ages

The Beaufort Sea, north of Canada's Yukon and Northwest Territories, is a hostile environment by any definition of the term. It is covered with ice for much of the year. Historically, only from mid-July to October has a narrow strip of open water appeared within about 50 to 100 kilometers (30 to 60 miles) of the coast. Even at this time of year, winds often howl at 40 knots and temperatures can drop well below freezing at night. Researchers must allow extra time for contingencies such as dodging pack ice and having to shovel snow off the deck of the research vessel.

Average annual air temperatures along the coast of the Beaufort Sea are well below freezing. Thus deeper soils remain permanently frozen throughout the year, forming what is called permafrost. Around the

Beaufort Sea, permafrost extends more than 600 meters (about 2,000 feet) below the ground.

Permafrost also exists in the sediments underlying the continental shelf of Beaufort Sea. This permafrost is a relict of the last ice age, when sea level was as much as 120 meters lower than today. At that time, areas that are now covered with seawater were exposed to the frigid Arctic air.

As sea-level rose over the last 10,000 years, it flooded the continental shelf with seawater. Although the water in the Beaufort Sea is cold—about minus 1.5 degrees Centigrade—it is still much warmer than the air, which averages minus 15 degrees C. Thus, as the ocean rose, it is gradually warmed up the permafrost beneath the continental shelf, causing it to melt.

Quite a bit of methane, the main component of "natural gas," is trapped within the permafrost. As the permafrost melts, it releases this methane, which may seep up through the sediments and into the overlying ocean water.

The deeper sediments of the Beaufort Sea also contain abundant layers of methane hydrate—an ice-like mixture of water and natural gas. As the seafloor has warmed, these hydrates have also begun to decompose, releasing additional methane gas into the surrounding sediment.

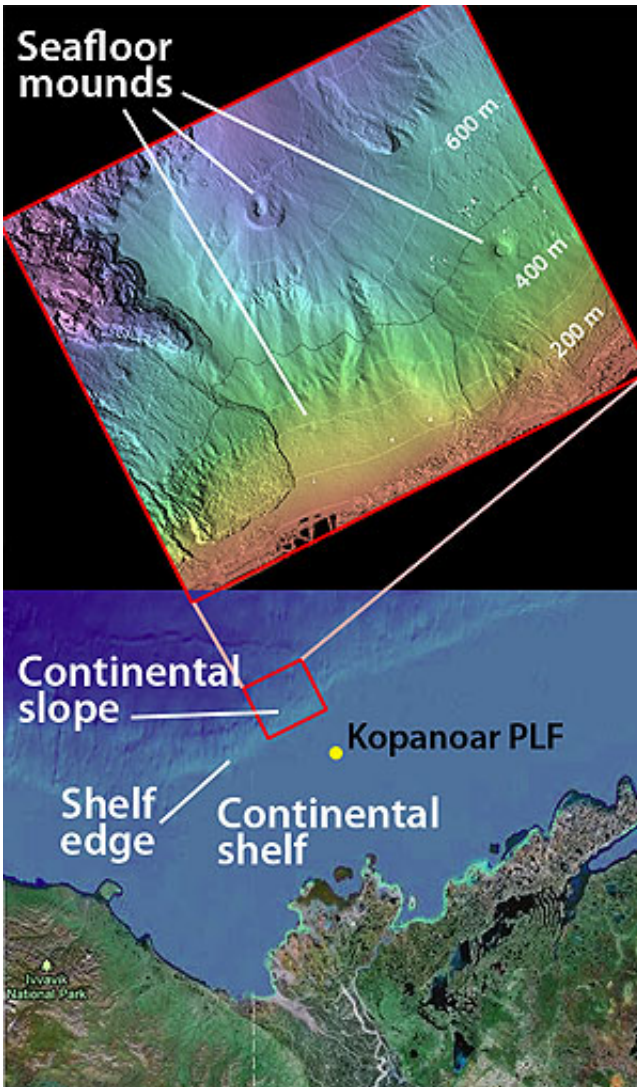
A tantalizing glimpse

A 2010 expedition by Paull and his colleagues provided a tantalizing glimpse of how much methane is present on the continental shelf of the Beaufort Sea. Using a remotely operated vehicle (ROV) with video camera to explore the shelf edge, they found white mats of methane-loving bacteria almost everywhere. They also videotaped what turned to be methane bubbles emerging from many of these mats. Based on these

observations, as well as the contents of sediment cores collected by the Geological Survey of Canada, the researchers concluded that the shelf edge is an area of "widespread diffuse venting" and that "methane permeates the shelf edge sediments in this region."

During 2010, the research team also conducted ROV dives on a shallow underwater mound called Kopanoar PLF. At the top of this mound they discovered "vigorous and continuous gas venting" that released clouds of bubbles and sediment into the water. In one ROV dive, the researchers saw something no one had ever seen before—a plume of gas bubbles that moved rapidly along the sea floor, apparently following a crack in the sediment that was in the process of being forced open by the pressure of the gas coming up from below.

The researchers also studied several deeper PLFs during the 2010 expedition. They dropped core tubes into the tops of these mounds. When the cores were lifted back onto the ship, the sediments inside fizzed and bubbled for up to an hour. The sediment was chock full of methane hydrates. Paull said, "We knew that there was a lot of gas venting going on down there, and now we have good reasons to believe that methane hydrates are present within the surface sediments. But our ROV couldn't dive deep enough, so we weren't able to go down and see what these areas actually looked like." That's one reason the team is heading back to the Arctic in 2012.



These maps show the area to be studied during the current expedition. The lower map shows the continental shelf and continental slope of the Beaufort Sea. The upper image shows detailed seafloor bathymetry of a portion of the continental slope that will be studied during the current cruise, as well as the three seafloor mounds that the researchers will explore using their new ROV. Credit: (lower image) modified from Google Maps; Credit (upper image): Natural Resources Canada

Heading back for more

For the 2012 expedition, the team will continue its strategy of following the topography to study areas of gas venting in the Beaufort Sea. They plan to focus on three circular, flat-topped mounds on the continental slope. The researchers believe that these pingo-like features form at the tops of "chimneys" or conduits where methane is seeping up from sediments hundreds of meters below the seafloor.

During his previous cruises, Paull used a small ROV that could dive only about 120 meters below the surface. However, the mounds on the continental slope are in about 300 to 800 meters of water. So MBARI engineers Dale Graves and Alana Sherman designed and built an entirely new ROV just for this expedition. The new ROV is small, portable, agile, relatively inexpensive, and can dive to 1,000 meters. It can also be launched and operated by just two people (for the 2012 expedition, those two people will be Graves and Sherman).

Amazingly, the new mini-ROV went from initial design to final field tests in only 15 months. But the vehicle's simple yet elegant design reflects Graves' decades of experience designing ROVs and underwater control systems. "It was a fun project for me," Graves said. "A dream come true. We designed it from scratch with a budget of just \$75,000, not including labor. We mostly reused parts from MBARI's older ROVs, and built the rest in house. MBARI's electrical and mechanical technicians and machinists worked on it in between their other projects."

In addition to a state-of-the-art high-definition video camera, the ROV carries a special system for collecting methane gas bubbles. This is not as easy as it sounds, because the methane gas has a tendency to turn back into solid methane hydrate, which blocks the flow of any additional methane gas into the system. The new ROV's gas collection system includes a built-in heater to melt the hydrates and keep the gas flowing.

In addition to collecting samples of gas, the ROV will be used to look for

communities of tubeworms or clams that typically grow around seafloor methane seeps. Paull said, "Nobody has ever found a living chemosynthetic biological community in the Arctic proper. But I think we have a good chance of finding them at the tops of these structures."



MBARI researchers tested this new mini-ROV in the institute's test tank before sending it out to face the challenges of the Arctic Ocean. Credit: Todd Walsh © 2012 MBARI

Addressing the big questions

Although the researchers have begun to understand where the gas in the Beaufort Sea is coming from, many other questions remain. One of the big questions the researchers are trying to answer is whether the three gas chimney structures on the continental slope are related to the gas

venting systems in shallower water, on the [continental shelf](#). As Paull put it, "Are they independent gas-venting structures that just happen to be together, or are they all part of the same system?"

Another important question is how all this methane gas affects the stability of the seafloor. When methane hydrates warm up and release [methane gas](#), the gas takes up much more space than the solid hydrate, putting pressure on the surrounding sediments. Similarly, the decomposition of either methane hydrate or permafrost can reduce the mechanical strength of the surrounding sediment. Either process could make the seafloor more susceptible to submarine landslides.

Undersea landslides are common along the continental slope of the Beaufort Sea, but researchers do not yet know when or how they form. However, decomposing methane hydrates are believed to have triggered major landslides in other deep-sea areas. Such landslides could potentially destabilize oil platforms, pipelines, or other equipment on the seafloor, and have the potential to generate tsunamis.

If there is time during the 2012 cruise, the researchers hope to perform ROV dives on one or more underwater-landslides. In Fall 2013, when the team returns to the Beaufort Sea for a fourth time, these features will become the primary focus. During that expedition, the team also hopes to use one of MBARI's autonomous underwater vehicles (AUVs) to make very detailed maps of the shelf edge, the underwater landslides, and areas where [methane](#) is bubbling out of the seafloor.

Oil and gas companies have known for decades that deep oil and natural gas deposits exist in the sediments below the continental slope of the Beaufort Sea. With the warming of the Arctic and the retreat of sea ice, these hydrocarbons have become more accessible. However, it remains to be seen whether they can be extracted safely, economically, and without excessive environmental damage. Thus, the team's research will

not only provide new insights into previously unknown geological processes, but will also provide important information for decision-makers involved in oil and [gas](#) permitting.

Provided by Monterey Bay Aquarium Research Institute

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