A Review of Natalia Shakhova's Research on Methane Release from Arctic Methane Hydrates

Natalia E. Shakhova is a Russian scientist and Assistant Research Professor at the International Arctic Research Center (IARC) at University of Alaska Fairbanks (UAF) in Fairbanks Alaska, USA. Along with her colleagues, she has been active in monitoring atmospheric methane concentrations in the East Siberian Arctic Shelf and other high latitude regions, such as Alaska. Natalia Shakhova has carried out investigations concerning the contribution of terrestrial and sub-sea sources to the global methane budget and she is also examining the role of methane as a climate forcing agent.

"Semiletov's work during the 1990s showed, among other things, that the amount of methane being emitted from terrestrial sources decreased at higher latitudes. But those studies stopped at the coast. Starting in the fall of 2003, Shakhova, Semiletov and the rest of their team took the studies offshore. From 2003 through 2008, they took annual research cruises throughout the shelf and sampled seawater at various depths and the air 10 meters above the ocean. In September 2006, they flew a helicopter over the same area, taking air samples at up to 2,000 meters in the atmosphere. In April 2007, they conducted a winter expedition on the sea ice[1]." Findings relevant to methane hydrates are summarized by Shakhova and Semiletov in a WWF publication entitled "Climate Feedbacks: Global Implications":

- Large amounts of methane are frozen in arctic methane hydrates
- Continental shelves hold most of this hydrate
- Thawing sub-sea permafrost is already releasing methane
- Hydrates increase in volume when destabilized
- The most vulnerable hydrates are on the East Siberian She

They proceed to explain why sub-sea permafrost is more vulnerable than terrestrial permafrost:

[1] http://climatechangepsychology.blogspot.com/2010/03/natalia-shakhova-igor-semiletov-arctic.html

“The Arctic is warming more quickly than the rest of the world, and this warming is most pronounced in the arctic shelf. The main reason for this is that arctic rivers bring to the arctic shelf continental-scale signals of the terrestrial ecosystems’ response to global warming. That is, the degradation of terrestrial permafrost leads to increasing river runoff, which warms the shelf water, which, in turn, transports heat down to shelf sediments and sub-sea permafrost[2].”

The saline environment of sub-sea permafrost, they write, causes it to thaw even in temperatures slightly below $0^{o}C$. “When it thaws, sub-sea permafrost loses its ability to seal off the seabed deposits of methane, including hydrates[3]”.

Finally, this is what they write when commenting on recent field observations:

“Recent observational data obtained from the largest and shallowest arctic shelf — the East Siberian Arctic Shelf — indicate that methane is already being released from seabed deposits. This is a worrisome indication that methane emissions from arctic seabed deposits of methane, including methane hydrates, will increase with the warming that has been predicted for the Arctic during this century, with unpredictable consequences for the future climate[4].”

Shakhova and her team have published a series of papers based on observations from expeditions to the East Siberian Arctic Shelf between 2003 and 2008. Data that was collected over the late summer period of 2003 and 2004 were presented in Shakhova’s and Semiletov’s paper “Methane release and coastal environment in the East Siberian Arctic Shelf” published in 2007. Quoting from this study:

“According to our data, the surface layer of shelf water was supersaturated up to 2500% relative to the present average atmospheric methane content of 1.85 ppm, pointing to the rivers as a strong source of dissolved methane which comes from watersheds which are

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[2] “Climate Feedbacks: Global Implications”, WWF, Published August 2009
[3] “Climate Feedbacks: Global Implications”, WWF, Published August 2009
[4] “Climate Feedbacks: Global Implications”, WWF, Published August 2009

underlain with permafrost. Anomalously high concentrations (up to 154 nM or 4400% supersaturation) of dissolved methane in the bottom layer of shelf water at a few sites suggest that the bottom layer is somehow affected by near-bottom sources. The net flux of methane from this area of the East Siberian Arctic shelf can reach up to 13.7×104 g CH4 km−2 from plume areas during the period of ice free water, and thus is in the upper range of the estimated global marine methane release. Ongoing environmental change might affect the methane marine cycle since significant changes in the thermal regime of bottom sediments within a few sites were registered[5].”

“Degradation of underlying permafrost, retreat of coastal and submerged ice complexes, an increase in the discharge of East Siberian Rivers, and possible disturbance of gas hydrates deposits (either deep or relic) are all factors which together may lead to an unprecedented abrupt increase in air–sea methane transmission[6]”

“In comparison to other global sources of methane the Arctic Ocean is thought to be a small source to the global atmosphere, but due to our results we can assume a larger contribution, which will tend to increase under warming conditions[7].”

In another paper published in 2008, Shakhova et al write:

“In the case of the East Siberian Shelf (ESS), shallow sediments have not been considered a methane source to the hydrosphere or atmosphere because seabed permafrost (defined as sediments with a 2-year mean temperature below 0°C), which is considered to underlay most

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[5] “Methane release and coastal environment in the East Siberian Arctic shelf”, N.Shakhova and I. Semiletov, Journal of Marine Systems, 66 (1-4), 227-243.

[6] “Methane release and coastal environment in the East Siberian Arctic shelf”, N.Shakhova and I. Semiletov, Journal of Marine Systems, 66 (1-4), 227-243.

[7] “Methane release and coastal environment in the East Siberian Arctic shelf”, N.Shakhova and I. Semiletov, Journal of Marine Systems, 66 (1-4), 227-243.

of the ESS, acts as an impermeable lid, preventing methane escape. However, our recent data showed extreme methane supersaturation of surface water, implying high sea-to-air fluxes[8]."

The same study proceeds to give an estimation of the total amount of carbon available in the ESS. This is estimated to "not less than 1,400 Gt" and up to 50 Gt of hydrate storage is characterized "as highly possible for abrupt release at any time[9]."

This can be interpreted as an event of very high probability. Such an abrupt release is expected to cause a "12-times increase of modern atmospheric methane burden with consequent catastrophic greenhouse warming[10]." This, in turn can be interpreted as a consequence of great magnitude.

These conclusions are stated again in a more recent study published in 2010 by Shakhova et al:

"Remobilization to the atmosphere of only a small fraction of the methane held in East Siberian Arctic Shelf (ESAS) sediments **could trigger abrupt climate warming**, yet it is believed that sub-sea permafrost acts as a lid to keep this shallow methane reservoir in place. Here, we show that more than 5000 at-sea observations of dissolved methane demonstrates that greater than 80% of ESAS bottom waters and greater than 50% of surface waters are supersaturated with methane regarding to the atmosphere. The current atmospheric venting flux, which is composed of a diffusive component and a gradual ebullition component, is on par with previous estimates of methane venting from the entire World Ocean. Leakage of methane through shallow ESAS waters needs to be considered in interactions between the biogeosphere and a warming Arctic climate[11]."

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[8] "Anomalies of methane in the atmosphere over the East Siberian shelf: Is there any sign of methane leakage from shallow shelf hydrates?", Shakhova, Semiletov, Salyuk, Kosmach, 2008

[9] "Anomalies of methane in the atmosphere over the East Siberian shelf: Is there any sign of methane leakage from shallow shelf hydrates?", Shakhova, Semiletov, Salyuk, Kosmach, 2008

[10] "Anomalies of methane in the atmosphere over the East Siberian shelf: Is there any sign of methane leakage from shallow shelf hydrates?", Shakhova, Semiletov, Salyuk, Kosmach, 2008

[11] Extensive Methane Venting to the Atmosphere from Sediments of the East Siberian Arctic Shelf, Shakhova N., Semiletov I., Salyuk A., Joussupov V., Kosmach D., and O. Gustafsson, 2010, Science 327, 1246-1250

The results of Shakvova's research based on years of investigation and field observations indicate that methane release from sub-sea permafrost in Siberia shows there is a risk of methane emitting into the atmosphere from Arctic methane hydrates- occurring with a magnitude that may very well have catastrophic consequences.