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Anomalies of methane in the atmosphere over the East Siberian shelf: Is there any sign of methane leakage from shallow shelf hydrates?

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Methane release from continental margins is widespread and contributes methane to the biosphere, hydrosphere, and atmosphere, thus making up an important part of the global carbon cycle. The contribution of arctic shallow seabed sediments to the global carbon budget and, particularly, to the marine methane budget, has received little attention because the area of these sediments is small in extent and because, due to low temperatures that characterize these sediments, they are not considered conducive to methanogenesis. In addition, 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 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.

Extremely high concentrations of methane (up to 8 ppm) in the atmospheric layer above the sea surface along with anomalously high concentrations of dissolved methane in the water column (up to 560 nM, or 12000% of super saturation), registered during a summertime cruise over the ESS in September 2005, were analyzed together with available data obtained during previous and subsequent expeditions to distinguish between possible methane sources of different origin, potential, and mobility. Using indirect evidence it was shown that one such source may be highly poten-

tial and extremely mobile shallow methane hydrates, whose stability zone is seabed permafrost-related and could be disturbed upon permafrost development, degradation, and thawing. Further immobilization of stored methane could cause abrupt methane release and unpredictable climatic consequences.

The total area of submarine permafrost within the Siberian Arctic shelf is estimated to be more than one and half million square kilometers. Amount of methane hydrate deposited beneath and/or within submarine relic permafrost is estimated to be at least 540 Gt. Amount of free gas, accumulated beneath the hydrate deposits, is expected to be about 2/3 of the amount of hydrates or 360 Gt. Additionally as much as 500 Gt of carbon could be stored within as minimum as a 25 m-thick permafrost body of this type. The total value of ESS carbon pool is, thus, not less than 1,400 Gt of carbon. Since the area of geological disjunctives (fault zones, tectonically and seismically active areas) within the Siberian Arctic shelf composes not less than 1-2% of the total area and area of open taliks (area of melt through permafrost), acting as a pathway for methane escape within the Siberian Arctic shelf reaches up to 5-10% of the total area, we consider release of up to 50 Gt of predicted amount of hydrate storage as highly possible for abrupt release at any time. That may cause $\sim$12-times increase of modern atmospheric methane burden with consequent catastrophic greenhouse warming.