ON BIOGEOCHEMICAL CONSEQUENCES OF COASTAL PROCESSES IN THE EURASIAN ARCTIC SEAS

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PREFACE

Any attempt to understand the effect of the Arctic Ocean on global change or the effects of global change on the Arctic Ocean requires thorough knowledge of the coastal processes as a linkage between land and ocean processes in the Arctic. Clearly, any attempt to understand the effect of on-shore permafrost degradation on change in geomorphology, geochemistry and biology onto the arctic shelf requires a through knowledge of the coastal erosion and riverine inputs of water and dissolved and solid substances.

Present data indicate that rate of coastal erosion in the Arctic might be changed from a few meters up to tens of meters (Are, 1999; Grigoriev & Kunitsky, 2000; MacDonald & Thomas, 1991). Many small ice-permafrost islands were disappeared during the XX century, for example: Semenovsky I., Vasilievsky I. in the Laptev Sea. Increase in amplitudes of the Siberian Rivers discharge and temperature in their watersheds after North-Asian climatic shift of the 70s (Savelieva et al., in press) indicates that greenhouse effect causes not only Global Warming, but also increase in the atmospheric circulation that is recorded in change of the riverine amplitudes(Semiletov et al, 2000). It agrees with temporal change in the atmospheric CO_2 seasonal amplitudes (Conway et al., 1994) and results of simulations that indicates on increase in general atmospheric circulation, especially in cyclone frequency along the coastal line and over the inland Arctic(Chapman and Walsh, 1993; Shubert et al., 1998). Historical data indicates that atmospheric pressure gradient between centers of the Siberian High and Aleutian Low is increased significantly during the last 30 years that agrees with increase in the seasonal amplitudes of atmospheric ground temperature (Savelieva et al., in press).

Therefore rates of coastal retreat might be increased not only due to Global Warming but with enhance in hydrodynamics too. During glacial-interglacial transition and sea level rise (~100-120 m in the Arctic) a huge amount of buried terrestrial carbon should be involved in biogeochemical cycling through increased coastal degradation. It could be a significant factor for increase in atmospheric burden of the main greenhouse gases (CO_2 and CH_4). Note, that only the upper 100 m layer of permafrost contains about 10,000 Gt of organic carbon that could be involved in biogeochemical cycling in CH_4 and CO_2 forms due to increase of depth of summer thaw layer and thawing of permafrost beneath the northern lakes(Semiletov, 1999a). Therefore a positive feedback loop might work between strong efflux of the main greenhouse gases (CO_2, CH_4, N_2O) due to the degradation of inland and coastal permafrost, the drying of soils, the expansion of thaw lakes and change in the atmospheric circulation and land hydrology - shelf – basin environment.

CURRENT RESEARCH AND NEEDS

In frame of the land-shelf international projects (SPASIBA, LAPEX and other) it was assumed that the main modern process controlling organic carbon deposition of dominantly terrigenous organic matter is supplied by the rivers (Cauwet and Sidorov, 1996; Kassens et al., 1999; Guay et al.,1999; Stein et al., 1999). According Wheeler et al. (1996,1997) river run-off plays a second role (25 %) as a major source of DOC in the central Arctic, after in situ production (56 %), but it is more important source of DOC in comparison with Pacific waters (19 %). The transport of organics due to the coastal retreatment and their influence on shelf biogeochemistry might also be important, too, but this source of organic matter was not evaluated.

Our preliminary evaluation based on three-year research (1997-1999) in the Russian Arctic marginal seas indicates that an transport of organics (as a particulate matter) induced by coastal erosion is a value similar with DOC transport with the rivers; whereas a total income of terrestrial solid caused with coastal retreatment is about 7 times more in comparison with the riverine transport, because the most riverine particulate matter is settled in the mixing zone that is a geochemical barrier(Semiletov, 1999a,b,c). Our results indicate on a strong terrestrial signal in distribution of $\delta^{13}C_{org}$ in the coastal surface sediment in the eastern part of the Laptev Sea/Dm. Laptev Strait that agrees with the anomalous high pCO_2 values in the bottom water (up to 3000-4000 microatm) adjacent sites with high rates of the coastal retreatment. The results demonstrate high organic content (up to 10-12%w) and C/N ratio in the coastal sediment remote from the riverine input that is induced by the coastal erosion.

Many researchers found that the chemical composition of sea water deviates from the Redfield ratio, especially in the upper water column of the Nordic Seas (Brostrom, 1998) where DOC has high carbon content C:N ≈ 15. It was found also that DOC concentrations and C:N ratio of the dissolved organic pool in the Arctic Ocean is higher than those reported for lower or southern high-latitude systems (Daly et al., 1999). Because a lack of information about process that is responsible for this C:N increase, I suggest that it could be related with offshore efflux of DOC and C-N-P species with terrestrial signature.

In the coastal zone large quantities of organics are oxidizing into CO_2-form and supply shelf waters with new nutrients with a terrestrial signature. A crude evaluation (Semiletov, 1999b, 2000) shows an annual flux of organic carbon (in form of particulate matter) along the Yakutian sea coast only(from eastern Taymyr to Chukotka) is equal 3.5-7.0 TgC (for OC ground concentration 5-10 w%). Sedimentary denitrification in the shallow zone influenced with coastal erosion may be a key site of atmospheric evasion of greenhouse gases: CO_2, CH_4, and N_2 (N_2O) along the Arctic Rim. It could play a significant role in regional carbon cycling in past and future (Christensen, 1994).

Because of coastal permafrost along Siberia Rim is the most icy and sensitive for the Global Warming and the adjacent shelf is the most shallow and wide in the Arctic, it is important to evaluate a role of coastal processes and transport and fate of terrestrial material into the sea and biogeochemical consequences of them in the shelf-basin system.

INTERNATIONAL PARTNERSHIP

The proposed study integrates with current and future ACSYS research projects. These include particularly the biological work of the OAII study projects. The study will extend ongoing onshore permafrost research along the East-Siberian Transect onto the shelf (offshore permafrost)). The study will provide necessary input data for development and verification of permafrost degradation in the typical areas of the land-shelf system. The terrestrial signal onto the shelf induced by coastal erosion and riverine transport will be used as a bridge to link permafrost degradation and the shelf food web (Semiletov's projects funded by the International Science Foundation, CIFAR and the Russian Fund for Basic Research). The proposed project can be closely linked with ongoing RAISE projects (PIs: B. Peterson, J. Brown, A.Proshutinsky, H. Eicken), and ongoing and previous NSF projects (PIs: J. Grebmeier, J. Christensen, L. Codispoti, L. Cooper, A.Devol, J. Kelley, S. Naidu, P.Shlosser and others).

The proposed research will be an international effort of scientists from the USA and Russia and will integrate an ACSYS component (LAII/OAII; ATLAS/SBI) with non-ACSYS research programs examining the arctic system, namely the IGBP Northern Eurasia Study (IGBP-NES), IGBP-IGAC and the IGBP-JGOFS, the GAME project of the WCRP. This research will also interact with several other international programs including BESIS-IASC, ITEX, PICES, CREST and new initiatives under the umbrella of IARC.

Ongoing Russian research is carried with Laboratory of Geochemistry in the Polar Regions(LGPR), Pacific Oceanological Institute. The research is funded by Rusian Foundation for Basic Research, a former Ministry of Science and Technology of Russian Federation, and MacArthur Foundation. Transarctic Expedition-2000 headed by LGPR will be a good start for cooperative research between US NSF/SBI and Russian scientific communities.

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