Geophysical Research Abstracts,
Vol. 11, EGU2009-11476, 2009
EGU General Assembly 2009

Contradicting climate versus vegetation history in NE-Siberia?

M. Zech (1) and R. Zech (2)

(1) Chair of Geomorphology and Department of Soil Physics, University of Bayreuth, Universitätsstr. 30, D-95440 Bayreuth, Germany, (2) Geographical Institute, University of Bern, Hallerstr. 12, CH-3012 Bern, Switzerland

Northern Siberia may play a key role for the climate on the entire Earth. The classical Milankovitch Theory suggests that changes in summer insolation due to the Earth' orbital parameters caused build-up of snow and ice over the extensive continental masses at high northern latitudes. Various positive feedback mechanisms, like surface albedo and sequestration/release of atmospheric carbon dioxide in/from frozen, organic-rich soils, could then be responsible for the onset of global glaciations. More recently, high northern latitudes have also gained a lot of attention due to the potential of their soils and peats to release large amounts of methane and carbon dioxide. The Siberian ecosystems may turn into significant greenhouse gas sources as global warming continues and causes melting of permafrost and mineralisation of soil organic material that has been built up and stored over thousands of years.

Quaternary scientists are therefore searching for long-term and continuous archives in order to reconstruct the Siberian climate and landscape history. A wide range of different analytical tools (e.g. different dating techniques, elemental composition, mineralogy, magnetic properties, grain size distribution, characterisation of organic matter and palynology) is used to infer palaeoclimatically and palaeoecologically relevant information. All of these methods have their advantages and their disadvantages. For instance, pollen analyses allow a high taxonomic differentiation, but variable pollination rates of different plant species, influx of long-distance transported pollen, and variable preservation of different pollen taxa have to be considered. Concerning the interpretation of pollen spectra in NE-Siberia, arboreal pollen, especially larch pollen, are traditionally considered to be 'warm plant taxa', hence the occurrence of these pollen in archives is interpreted as reflecting warm interglacial or interstadial conditions.

We have recently presented a multi-proxy analytical characterisation and palaeoclimatic interpretation of a loess-like permafrost palaeosol sequence (the Tumara Palaeosol Sequence, TPS) in NE-Siberia (Zech et al., 2008, Geoderma 143(3-4), pp. 281-295). Accordingly, the TPS developed on a Middle Pleistocene fluvio-glacial terrace, comprises a sequence of glacial and interglacial/-stadial palaeosols and represents the last ∼240,000 years. Palaeosols with higher contents of organic matter (Corg up to 2.5%) are correlated with glacial periods, whereas palaeosols with low contents of organic matter (Corg ∼0.5%) are correlated with interglacial periods. This Corg pattern is explained with a thinner active permafrost layer, water logging and reduced organic matter degradation during glacials.

However, the reconstructed vegetation history based on unpublished alkane biomarker and pollen analyses seems to be at odds with the climate history based on the pedologic features. Namely in the lower part of the TPS, we found evidence for forest vegetation and abundant Larix pollen in the stratigraphic unit correlated with the Late Saalian glaciation (130–160 ka BP) (Svendsen et al., 2004, Quaternary Science Reviews 23(11-13), pp. 1229-1271) and the Marine Oxygen Isotope Stage (MIS) 6. Trees, especially larch, are traditionally regarded as 'warm plant taxa' in NE-Siberia. Interestingly, similar severe discrepancies between the vegetation history and the geochemically derived chronostratigraphy have also been described for the sediments from Crater Lake El'gygytgyn (Lozhkin et al., 2007, Journal of Paleolimnology 37, pp. 135-153), the latter certainly being the most continuous and long-term archive in the study area.

In order to explain these discrepancies, we suggest that various palaeoclimatic parameters, like temperature, precipitation, and seasonality, differently affected (i) glaciations, (ii) pedogenetic conditions and (iii) vegetation history, respectively.

(i) Concerning glaciations, NE-Siberia is characterised by an extreme continental climate with very low winter temperatures causing several hundreds of meters of permafrost. Nevertheless, the Verkhoyansk Mountains in the study area are not glaciated today because precipitation is too low to support a positive glacial mass balance. Hence, NE-Siberian glaciations in the past have not been only driven by changes of temperature, but have been also very sensitive to changes of precipitation.
(ii) Similarly, pedogenetic conditions have not been only prone to temperature changes, especially summer temperature changes, but also depended largely from the degree of water logging of the topsoils and the thickness of the active permafrost layer. This is controlled by both temperature and precipitation. Hence, the correlation of palaeosol sequences like the TPS with the glacial history should be valid.
(iii) On the contrary, Siberian vegetation is generally assumed to depend mainly on July temperature and the annual sum of days with mean-temperatures above 5°C. Provided that the chronology of the TPS is correct, we therefore propose that trees grew in NE-Siberia during the 'humid' Late Saalian glaciation, reflecting relatively warm summer temperatures. The glaciation and the high Corg contents in the respective palaeosols indicate increased precipitation and water logged topsoils.

The discrepancies between the geochemically derived chronostratigraphies on the one hand and the biomarker and pollen based vegetations histories on the other hand can be considered to be complementary rather than contradicting results. They might have huge potential to increase our understanding of climate and environmental changes in NE-Siberia.