Quaternary Environment of the Eurasian North (QUEEN)

More about the Programme

The Arctic is more sensitive than any other part of the world to changes in global climate, such as those caused by the Greenhouse Effect. Melting ice from the Greenland ice cap in particular would make a major contribution to rising sea levels around the world. It is vital therefore to achieve a better understanding of the processes involved in environmental changes in the whole Arctic region. This can only be done by studying past environmental changes during the Late Cenozoic period.

Recent political changes have made it possible for the first time for Russian scientists to exchange information freely with their colleagues in the west. The ESF programme, Quaternary Environment of the Eurasian North (QUEEN), aims to exploit these more favourable political conditions by creating links between the various existing and planned future projects to build a solid understanding of environmental changes along the northern Eurasian coastal margin during the last 250,000 years. It will then be possible to establish a complete picture of environmental changes across the whole Arctic region, by combining information obtained from Eurasian studies with the results of projects covering Europe and North America.

Partly because the region has been less extensively studied than elsewhere, there is more controversy over the history of glaciation and corresponding environmental changes during the last 250,000 years in Siberia than in any other Arctic region. A primary objective of QUEEN therefore will be to resolve the controversy, and make sure that the environmental record is as complete for Eurasia as elsewhere.

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Introduction

It has become clear in recent years that the Arctic region as a whole has had a profound influence on the development of the global environment, and as a result scientific interest in the region has grown enormously. Until recently however the Eurasian Arctic has not been widely accessible, so studies of environmental changes have concentrated on land and sea areas elsewhere, such as the European continental shelf. The ESF programme, Quaternary Environment of the Eurasian North (QUEEN), therefore addresses the Eurasian Arctic area that has not been widely studied so far, focusing on Late Cenozoic environmental changes.

Its main objectives are to:

1. focus on environmental changes in the Eurasian Arctic over the past 250,000 years, i.e., the last two climatic cycles;
2. establish a detailed record of palaeoenvironmental changes during this period on land, on continental shelves, and in the deep sea of the Arctic Ocean along the Eurasian continental margin. Levels of glaciation have varied considerably along the length of the northern Eurasian margin;
3. correlate these terrestrial, shelf and deep ocean records using a variety of stratigraphic tools and dating methods;
4. reconstruct ice-sheet growth and decay over this period from geological and palaeontological evidence;
5. build numerical models that predict how sensitively ice sheets respond to climate change through the glacial-interglacial cycles;
6. study relative changes in sea level during the period to build a map of corresponding vertical movements of the underlying earth surface;
7. investigate how the depth of permafrost has responded to climatic and environmental change;
8. pay particular attention to the high resolution radiocarbon-dated environmental record of

the last glacial maximum and deglaciation (<30,000 yr BP).

The programme QUEEN proposes to establish links with other ongoing and planned activities, and exchange as much information as possible with them. The eventual aim is to develop a comprehensive understanding of the role played by the whole Arctic region in the global climate system.

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Background

Global climate models have shown clearly that the Arctic Ocean and surrounding continental areas are highly sensitive to the Greenhouse Effect. The temperature increase predicted by such climate models would lead to a reduction in Arctic sea ice cover and the release of further Greenhouse gases from Arctic soils. This in turn would have a major impact on the European climate.

Associated changes in surface albedo and ocean-atmosphere heat and gas exchange will accelerate global warming, having a positive feedback effect. Increased temperatures of Arctic surface waters will seriously affect the deep water renewal in the Nordic Seas and the effectiveness of the global Conveyor Belt, which regulates the European climate through the Nordic Heat Pump. Partial melting of the Greenland ice sheet from warming in the Arctic will induce a global sea level rise, increasing the danger of flooding in low lying regions close to coasts all over the world.

The models predicting future climate change are tested and validated mainly against historical climate data when the actual changes that subsequently occurred are known. To do this accurately obviously requires detailed knowledge of what these past changes were. Although the Arctic is known to have a key role in climate change, comparatively little is known about extent and rates of Late Quaternary changes of climatically and oceanographically important parameters in the Arctic.

Political changes in recent years have made it possible to exchange information freely between Russian scientists and their colleagues from Western countries. All scientists now have access to the Russian Arctic, which comprises about half of the circum-Arctic land mass. As a result, many projects looking at climatic and environmental changes during the recent geological past are now focusing on the Arctic as a whole. Yet many of the projects are still conducted in isolation, with little exchange of information between the institutions involved.

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The ESF programme

The new programme aims to combine information obtained by Russian and western projects to provide a common picture of present and past environmental changes across the whole Arctic. Only modest resources will be required to establishing the necessary flow of information between ongoing activities. Several bi-lateral projects between Russian and European scientific institutions have already been launched.

Regions of particular importance for understanding the Arctic's role global climate change are the vast areas of shallow water above the Eurasian shelves, and the large land masses to the south of these, including the permafrost areas of the Siberian tundra.

The ice sheets in these regions during Quaternary glacial cycles are key elements in palaeoclimatic models and also play a vital role in attempts to reconstruct a continuous record of changes in sea level. However there is still debate over the extent of individual ice sheets, and the history of growth and decay is still poorly understood. Yet the significant differences between the present morphology of the Barents, Kara and Laptev seas and surrounding continental slopes give vital clues to the complicated history of Quaternary glaciation.

At present, huge amounts of freshwater and sediments are discharged by the big Siberian river systems across the shelves, contributing to the surface waters and sedimentary processes in the deep Arctic Ocean. Sea ice is formed from the low saline surface water and transported to the Arctic Ocean and via the Fram Strait to the Greenland Sea. Lowland soils along the Siberian Arctic coastline are assumed to contain large, but as yet unknown, volumes of Greenhouse gases, which would be released into the atmosphere with thawing of the permafrost layer.

Given the new opportunities for international cooperation between Eurasian research institutions, and the urgent need for a better understanding of the Arctic climate system of the

past, present, and future, European environmental research activities in the Eurasian Arctic must be increased and co-ordinated better. Under the auspices of the European Science Foundation, QUEEN will improve data and knowledge exchange, increase cooperation between current programmes, and establish new collaborative projects.

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Aims and objectives

It is known that during the last 250,000 years ice sheets have formed on the continental shelf to the north of Eurasia on several occasions. These calved into the Arctic Ocean to the north and terminated on land to the south. However, there is less knowledge and more controversy over the extent and timing of these ice sheets than over any others on Earth. For example:

There is still debate over whether ice sheets ever existed in eastern Siberia.

While researchers agree that there was a large ice sheet in western Siberia during the last glaciation (Weichselian, Valdaian), there are strongly conflicting interpretations of whether its age is about 20,000 yr BP or >40,000 yr BP.

In the Barents Sea the existence of a large Late Weichselian ice sheet is generally accepted, but its timing and volume are hotly debated.

We will address especially the following issues:

1. The last glacial maximum. This is one of the periods most frequently used for testing and validating climatic models of general circulation. Yet it is still not known for certain how thick the ice sheets were across the entire Eurasian margin, and how far they spread. The goal is to reconstruct these ice sheets.
2. Mapping and dating changes in relative sea levels during pre-Eemian glaciation. It is known that ice sheets were much larger and more extensive than during more recent ice ages, but more needs be discovered about the precise pattern and the causes.These large glaciations caused a significant drop in global sea levels. However the weight of the ice caused glacial-isostatic depression of the land under it, causing an offsetting gain in relative sea levels along the coast.
3. Identification and dating of changes to the drainage of the Eurasian continent caused by the glaciation. Rivers that now flow into the Arctic ocean were dammed by the ice sheets, so that the drainage of an enormous part of the Eurasian continent was diverted from the Arctic Ocean towards the Kara, Caspian and Black seas.
4. Geological and palaeobotanical data obtained from the field research will be used to model ice sheet dimensions and dynamics through time. By combining these models with basic physical laws of ice flow and mass continuity, it will be possible to simulate how sensitively different ice sheet configurations are affected by variations in palaeoenvironmental factors.
5. The variation in extent and depth of permafrost both onshore and offshore in Arctic Eurasia have played a vital role in evolution of the whole Arctic environment. However the spreading and degradation of offshore permafrost and the geothermal conditions of sea floor sediments are poorly understood. Therefore, we intend to investigate past permafrost processes, including:
6. The history of Late Pleistocene regression (to 18-22,000 yr BP), with the sub-aerial exposure of continental shelves and consequent freezing of bottom sediments, the accumulation of ice complexes and gases and/or gas hydrates, and the formation of a zone of gas hydrate stability.
7. The succeeding marine transgression and flooding of the shelf, and the formation and degradation of offshore permafrost resulting in the thermo-abrasion of ice-rich scarps and sub-sea thawing of ice-rich sediments.
8. Recent processes of spreading of offshore ice-rich permafrost and taliks within Arctic continental shelves.

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International linkages

Japanese and US research projects are either being carried out or planned in the area of interest. Exchange of data and partial cooperation with other countries involved in Arctic research will be undertaken. Of special interest are links with investigations sponsored by the US National Science Foundation including current projects such as PALE (Palaeoclimate of Arctic Lakes and Estuaries), AMAP (Arctic Monitoring and Assessment Programme) and future American efforts in the Russian Arctic as defined by the preliminary meeting at Byrd Polar

Institute, Ohio State University, in Jan. 1995.

In addition to empirical studies of palaeoclimate from lake- and shallow marine archives, PALE also includes palaeoclimate modelling. This American programme is an umbrella project focused on past, present and future land-sea interactions with particular emphasis on environmental changes caused by an incessant retreat of the Siberian coastline during the Flandrian transgression. The objectives of AMAP, supported by the eight Arctic rim nations, can be summarised as:

Variations over time of levels, distribution and transport mechanisms of pollutants in the Arctic water, air and terrestrial environments.

Furthermore, the research programmes described above are in accordance with major Arctic Ocean research initiatives recommended by the Arctic Ocean Science Board (AOSB), the International Arctic Science Committee (IASC), and ICARP (International Conference for Arctic Research Planning). The work carried out through QUEEN is relevant to other international organisations and programmes in the Arctic Ocean such as IGBP-PAGES (International Geosphere-Biosphere Programme, Past Global Changes), ARCSS (Arctic Systems Science), NAD (Nansen Arctic Drilling), and AMAP. Appropriate steps are being taken to ensure that this new activity be linked closely to these organisations, but that duplication of efforts is avoided.

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Work schedule of QUEEN

The new programme will last for 5 years (1996 - 2000). Its main activities will be conducted during major annual 3-5 day workshops and smaller workshops as necessary, either in Russia or in one of the involved northern and western European countries. The main objective of the annual workshops is to provide effective links between the ongoing research programmes, while special efforts will be devoted to the correlation of palaeoenvironmental records across the Eurasian Arctic margins.

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Countries involved in QUEEN

So far seven countries are involved in QUEEN activities (Denmark, Finland, Germany, Norway, Russia, Sweden, Switzerland, United Kingdom). A preliminary survey of ongoing activities shows that there is a high level of existing research along the Eurasian Arctic continental margin devoted to the exploration of the Late Cenozoic palaeoenvironment.

These projects comprise activities in Russia and a number of European countries, on a national, bilateral and multilateral level, but many of them are carried out in isolation from each other with little exchange of information between areas, subjects, institutions etc. Therefore, much could be gained from an effective programme to link all of these projects.

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News / Current Status

This programme was approved by the ESF Executive Council in November 1995 to start operations in January 1996 for a duration of five years. It is supported by Member Organisations from Denmark, Finland, Germany, Norway, Sweden, Switzerland and the United Kingdom. Its 2000 coordination budget amounts to 500 kFF. In 2000 a proposal for a 2-year extension was submitted to ESF and approved by LESC.

QUEEN organised its fourth workshop on 8-11 April 2000 in Lund, Sweden. The meeting was attended by over 80 scientists from Europe and Russia. The programme was subdivided into several sessions, each of them giving credit to the marine-, shelf-, and land-based scientific background of the various activities within QUEEN. In conjunction with the Workshop a QUEEN Steering Committee meeting took place. A second Steering Committee meeting took place on 14-15 October 2000 in St. Petersburg.

QUEEN organised two symposia (one on marine and one on terrestrial research topics) at the EUG meeting in Strasbourg in April 2001. The symposia consisted of a series of posters and oral presentations highlighting the results of QUEEN to an international audience Strasbourg was also the location of the last Steering Committee meeting.

The last Steering Committee meeting was held at the end of November 2001, in Helsinki.

2000 Field Work

Denmark:

Danish QUEEN work was in connection with the Norwegian-Danish-Russian Arkhangelsk-Project. Coastal and river sections were studied along the lower Mezen River, the adjoining White Sea coast, and at the Kuloi and Pinega Rivers. The studies were concentrated on deciphering the various ice advances that have hit this area in the Weichselian (Valdai). A key site was discovered at Cape Tolstik on the White Sea shore, where evidence for three separate ice advances younger than the Eemian was recorded.

Finland:

A Finnish-Russian field campaign took place in Kola Peninsula and was also connected with the EU‘s ‚Eurasian Ice Sheet‘ Project. The research groups from the Geological Survey of Finland, Geological Institute of Kola Science Centre, RAS, Apatity and Geological Institute of Karelian Research Centre, RAS, Petrozavodsk carried out two weeks of field work in the Kola Peninsula in order to study past ice-sheet dynamics, stratigraphy and paleoenvironments during the last glacial cycle. The Finnish SC member also reported on QUEEN results at several international science meetings.

Sweden:

One of the main targets is the North Taymyr ice-marginal zone (NTZ), which is a complex formation of glacial, glaciofluvial and glaciolacustrine deposits, representing two or three Weichselian glacial advances. Work has also been done in the Taymyr Lake basin, along the Lower Taymyr River and in the Cape Chelyuskin area. Based on sedimentological, stratigraphical and geomorphological data combined with dating, the ice-sheet history (age, extent, origin) is reconstructed. Within the last glacial cycle (c. 100 000 years) three successively smaller ice sheets have inundated the Taymyr Peninsula from the Kara Sea. During the two older events the ice dammed large glacial lakes and during all three events the regional drainage was reversed from north to south. The scientific work is carried out together with the Arctic and Antarctic Research Institute (AARI) in St. Petersburg and the expedition logistics have been organised by the Swedish Polar Research Secretariat, Stockholm, in cooperation with the INTAARI company (St. Petersburg).

Norway:

The purpose was to investigate the Weichselian history of the eastern flank of Scandinavian Ice Sheet, and its border zone to the Barents Ice Sheet. The University of Bergen, St. Petersburg University, VESEGEI (St. Petersburg) and VNIIKAM (St. Petersburg) group cored a lake in the northern part of Pechora Basin from winter ice. Stratigraphical and sedimentological sections related to the large ice dammed Lake Komi were studied, and samples collected for cosmogenic isotope dating of different glacial events.

Germany:

Projects monitored permafrost soils (e.g. measuring temperature, methane concentrations) in the Lena Delta. Also as part of this expedition, a lake was drilled in the western section of the Lena Delta region to obtain a sediment record for palaeoclimatic studies. At the same time, modern conditions were investigated within the Laptev Sea and, for the first time, drill cores were obtained from the Laptev Sea shelf (TRANSDRIFT VIII expedition). Ice drilling continued on Komsomolets Island (Severnaya Zemlya) for palaeoclimatic studies. So far, the upper 500 were obtained during this summer season and will finish next year.

United Kingdom:

UK activities have concerned two main topics: first, numerical modelling reconstructions of the time-dependent behaviour of the Eurasian Ice Sheet over the past 30,000 years have continued. Model predictions have been tested against the dated geological record of ice sheet limits, especially those in the Russian Arctic sector. Secondly, the modern glaciology of the Russian Arctic islands has been the subject of continuing collaborative work with colleagues at the Russian Academy of Sciences, Moscow, and AARI, St. Petersburg. The reduction of airborne radar data on the surface topography and thickness of the ice caps on Severnaya Zemlya and Franz Josef Land is almost complete, and digital elevation models have been produced. The dynamics of these ice caps are also being investigated using synthetic aperture radar interferometry.

Russia:

Distribution and special features of glacial systems of Northern Eurasia during the Last Glacial Maximum (LGM) have been elaborated in details. Volumes of ice at LGM have been estimated

on a global scale using the reconstruction developed for Northern Eurasia as well as data on other glacial regions of the Earth. Glacio-climatic calculations for the Holocene Optimum and Eamean Interstadial were adapted to the Novaya Zemlya ice sheet.

An analysis of the Middle Pleistocene glaciation in Eastern Europe allowed a revision of the glacial chronostratigraphy of the region.

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