САНКТ-ПЕТЕРБУРГСКИЙ ГОСУДАРСТВЕННЫЙ УНИВЕРСИТЕТ

Материалы совещания рабочей группы INQUA Peribaltic

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«ГЕОМОРФОЛОГИЯ И ПАЛЕОГЕОГРАФИЯ ПОЛЯРНЫХ РЕГИОНОВ»,
симпозиума «Леопольдина» и совещания рабочей группы INQUA Peribaltic,
Санкт-Петербург, СПбГУ, 9 – 17 сентября 2012 года

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«ГЕОМОРФОЛОГИЯ И ПАЛЕОГЕОГРАФИЯ ПОЛЯРНЫХ РЕГИОНОВ»: Материалы совместной международной конференции «ГЕОМОРФОЛОГИЯ И ПАЛЕОГЕОГРАФИЯ ПОЛЯРНЫХ РЕГИОНОВ», симпозиума «Леопольдина» и совещания рабочей группы INQUA Peribaltic. Санкт-Петербург, СПбГУ, 9 – 17 сентября 2012 года / Отв. ред. А.И. Жиров, В.Ю. Кузнецов, Д.А. Субетто, Й. Тиде. – СПб., 2012. – 475 с.

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Сборник содержит материалы совместной международной конференции "Геоморфологические и палеогеографические исследования полярных регионов", симпозиума «Леопольдина» и совещания рабочей группы INQUA Peribaltic. Обсуждается целый ряд актуальных вопросов, связанных с изучением проблем теоретической геоморфологии и практики геоморфологического картографирования и исследования полярных областей Земли, палеогеографической реконструкции событий среднего и позднего неоплейстоцена, а также голоцена Арктики и Субарктики, практическими изысканиями на срединно-океанических хребтах в связи с их рудными ресурсами. Сборник представляет интерес для широкого круга специалистов, изучающих геоморфологию, геологию и палеогеографию четвертичного периода.

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The volume presents proceeding of the joint international conference “Geomorphology and Quaternary Paleogeography of Polar Regions”, Symposium “Leopoldina and the INQUA Peribaltic working group Workshop. Discussed is a wide range of issues related to the study of theoretical problems of geomorphology, geomorphological mapping, research in the field of Polar Regions, paleogeographic reconstructions of Middle and Late Pleistocene and Holocene events, and applied studies of ore resources of mid-ocean ridges (MOR). The book is topical for specialists studying geomorphology, geology and paleogeography of Quaternary period.

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Организационный комитет включает в себя представителей следующих учреждений:
Санкт-Петербургский государственный университет; Российский государственный педагогический университет им. А.И. Герцена; INQUA Peribaltic Working Group; Arctic Palaeoclimate and its Extremes (APEX); Германская национальная академия естествоиспытателей «Леопольдина»; Русское географическое общество; Арктический и антарктический научно-исследовательский институт; ФГУП «ВНИИОкеанология им. И.С. Грамберга»; ФГНПП «Полярная морская геологоразведочная экспедиция» (ПМГРЭ); Всероссийский научно-исследовательский институт океанологии им. П.П. Ширшова РАН; НОУ «Прикладная экология»; Геологический центр СПбГУ; Всероссийский Геологический Институт им. А.П. Карпинского.

INQUA PERIBALTIC WORKING GROUP WORKSHOP

ПРЕДИСЛОВИЕ

Международная конференция "Геоморфологические и палеогеографические исследования полярных регионов" имеет своей целью обсудить целый ряд актуальных вопросов, связанных с изучением проблем теоретической геоморфологии и практики геоморфологического картографирования и исследования полярных областей Земли, попытками палеогеографической реконструкции событий среднего и позднего неоплейстоцена, а также голоцена Арктики и Субарктики, практическими изысканиями на срединно-океанических хребтах в связи с их рудными ресурсами. Актуальность выбранной тематики конференции и её международный статус определяются важным межгосударственным значением, как исследуемых регионов (Антарктика, Арктика и Субарктика, Мировой океан), так и затрагиваемых проблем, не только научного, но и экономического, политического и экологического плана. Арктика, Субарктика и Антарктика выступают своеобразными индикаторами климатических изменений на земном шаре, что особенно важно в условиях глобальных изменений климата, последующих негативных изменений окружающей среды, зачастую губительных для живых организмов и наносящих значительный ущерб объектам материальной культуры (деградация многолетней мерзлоты, термоабразия берегов, повышение уровня океана и пр.). Реконструкция климатических условий и экологических обстановок прошлого посредством изучения континентальных межледниковых отложений, озерных осадков Арктики и Субарктики интересна и сама по себе, но ещё более значима с позиций прогнозирования экологических последствий изменений климата в настоящем и ближайшем будущем, хотя, то, что происходило ранее, не обязательно с точностью повторится в будущем. Выступления по данной тематике объединены в секции "Результаты и проблемы палеогеографических реконструкций четвертичного периода полярных регионов".

Данные области также крайне богаты ресурсами, которые, возможно, трудно доступны сейчас, но уже очень скоро станут основным источником минерального сырья, обеспечивающего устойчивое развитие человечества. В связи с этим, особое значение приобретают радиоизотопные геохронологические (включая радиохимические, геохимические, микропалеонтологические) исследования не только традиционных глубоководных осадков и морских карбонатных отложений, но и менее изученных железомарганцевых конкреций и корок, недавно открытых вблизи срединно-океанических хребтов (СОХ) гидротермальных сульфидных руд: чем долговременнее функционирует рудогенерирующая система, тем больший объём рудного материала накапливается в гидротермальных постройках. Изучение и выявление возможных пространственно-временных закономерностей формирования гидротермальных рудных полей в пределах крупных структур океанского дна является насущной задачей, направленной на понимание эволюции процессов гидротермального рудообразования в четвертичной истории океана. Государственная заинтересованностью России и других стран в приобретении права на рудные ресурсы и их будущую разработку в океане может быть подтверждена лишь проведением детальных всесторонних исследований этих рудных формаций. Доклады, освещающие вопросы возраста, происхождения и состава отложений, как континентальных, так и морских, сгруппированы в секции "Результаты и проблемы изучения четвертичных отложений".

В отдельную секцию выделена целая группа докладов, посвященных изучению четвертичных отложений Северо-Запада России, которые представлены участниками INQUA PERIBALTIC Group, приурочившими свою полевую школу к данной конференции.

С позиций геоморфологии, сложно найти менее изученные объекты на земном шаре в настоящее время, чем подледная и подводная поверхность Антарктиды или СОХ, поверхность которых исследована, но рельеф не проанализирован. Необычайно молодой, тектонически обусловленный рельеф поверхности СОХ, не "отпрепарированный" денудацией, и, наоборот, "старый", сохранившийся в уникальных условиях подледной "консервации", рельеф Антарктиды представляют собой две крайности среди объектов изучения геоморфологии, познание которого способно не только раскрыть многие неизведанные пока аспекты рельефообразования, но и дать "ключ" к минеральным ресурсам данных регионов. Особый интерес представляет одновременное рассмотрение не только субаэрального, субаквального и субгляциального рельефа по-отдельности, а вместе, в комплексе. С данной позиций, вполне логичным выглядит объединение докладов по данной тематике в секции "Геоморфологические исследования рельефа полярных стран и Мирового океана"

Некоторая разобщенность научной и образовательной деятельности в России и за рубежом в названных областях, а также нарастающий дефицит молодых исследователей и специалистов по полярной и морской тематике, обусловили наличие ещё одной секции конференции - молодёжной, которая объединяет участников германско-российского общества молодых ученых «Леопольдина».

Проведение и организация подобной Международной конференции в стенах Санкт-Петербургского государственного университета выглядит обоснованно в свете организации здесь в конце 2010 года при поддержке гранта Правительства РФ лаборатории "Геоморфологических и палеогеографических исследований полярных регионов и Мирового океана" под научным руководством известного немецкого ученого проф. Йорна Тиде, специалиста в области морской геологии, океанографии и палеоокеанологии. Лаборатории планируется присвоить имя В. П. Кёппена, известного географ, метеоролог и палеоклиматолога, родившегося в 1846 г. в Санкт-Петербурге, обучавшегося и работавшего, как в России, так и в Германии. Созданная лаборатория единственная в своем роде, а проводимые здесь исследования не дублируют изыскания, проводимые в других организациях города и региона. В область научных интересов сотрудников лаборатории входит получение, геолого-геоморфологической, палеогеографической и геохронологической информации о рельефе и разных типах континентальных и морских отложений полярных стран и Мирового океана. Создание современной и эффективно функционирующей лаборатории, проведение полевых изысканий, лабораторных аналитических исследований и картографических работ, а также связанной с этим образовательной деятельности, организация данной конференции - всё это взаимосвязанные действия для превращения СПбГУ в один из ведущих российских и международных центров полярных и морских исследований и подготовки научных кадров и специалистов данного профиля использующего не только свой творческий научных потенциал, но и потенциал многих достойных научных, производственных и образовательных организаций региона - от РГО, РГПУ им. А. И. Герцена и Полярной академии до ААНИИ, ПМРГЭ и ВНИИОкеангеология. Не следует забывать также, что лаборатория создавалась не на пустом месте: в СПбГУ, на факультете географии и геоэкологии, в частности, на протяжении сорока лет проводятся широкие и целенаправленные радиоизотопные геохронологические (радиохимические, геохимические, микропалеонтологические) исследования, а кафедра геоморфологии СПбГУ является старейшей в стране и ведёт свою историю с конца 1918 г. -

начала 1919 г. Уже десять лет осуществляется подготовка магистров в области морских и полярных исследований на российско-немецкой магистерской программе POMOR, а осенью этого года возобновлена подготовка бакалавров "географии" по профилю "география полярных стран", что вполне логично для университета, расположенного в самом северном миллионном городе мира.

Полагаем, что проведение данной конференции и её итоги будут способствовать разработке научно обоснованной стратегии России по освоению полярных и морских регионов, согласованию научных позиций российских ученых и их иностранных коллег, дальнейшей успешной работе по подготовке кадров в области полярных и морских геоисследований, с учетом всё возрастающей роли полярных регионов и Мирового океана в развитии не только России, но и всего человечества, в условиях глобальных изменений климата и нехватки минеральных ресурсов.

Оргкомитет совместной международной конференции «ГЕОМОРФОЛОГИЯ И ЧЕТВЕРТИЧНАЯ ПАЛЕОГЕОГРАФИЯ ПОЛЯРНЫХ РЕГИОНОВ», симпозиума «Леопольдина» и рабочей группы ИНКВА «Перибалтик».

INTRODUCTION

The joint international conference "“Geomorphology and Quaternary Paleogeography of Polar Regions” aims at discussing a wide range of issues related to the study of theoretical problems of geomorphology, geomorphological mapping, research in the field of polar regions, paleogeographic reconstructions of Middle and Late Pleistocene and Holocene events, and applied studies of ore resources of mid-ocean ridges (MOR). Relevance of the themes of the conference is determined by their importance in scientific, economic, political and environmental planning. The conference is subdivided into three major parts, namely sessions devoted to the (1) scientific aims of the “megagrant” acquired by SPbGU to enlarge its scope of geomorphologic investigations; (2) studies of Quaternary sediments in North-West Russia conducted by the INQUA PERIBALTIC Group; and (3) results obtained by the modern Russian-German cooperation in the scientific exploration of Northern Siberia and the adjacent Arctic Ocean (Leopoldina Symposium).

The Arctic, Subarctic and Antarctic are subject to and indicators of climate changes on the Earth. It is especially important in the context of monitoring of global climate change that causes significant damage and hazards for mankind (degradation of permafrost, thermoabrasion of the coastal line, sea level rise, etc.). Reconstruction of climatic and ecological environments of the past through the study of continental glacial and interglacial deposits, lake sediments in the Arctic and Subarctic is interesting in itself; they are even more significant in terms of predicting the environmental consequences of climate change in the present and near future. Reports related to this subject are collected in the section "Results and problems of the Quaternary paleogeographic reconstructions of the polar regions".

These areas are extremely rich in resources ensuring sustainable development of mankind. In this regard, methods of radioisotope geochronology (including radiochemical, geochemical, micropaleontological tchniques) of ferromanganese nodules and crusts, recently discovered near the mid-ocean ridge (MOR), have significant importance. Investigations of spatial and temporal relationships of hydrothermal field formation are urgent tasks, aimed at understanding the evolution of the processes in the Quaternary history of the ocean. Reports covering the issues of age, origin and composition of the sediments, are grouped in the "Results and problems in the study of Quaternary deposits."

A separate section of reports is devoted to the study of Quaternary sediments of the North-West of Russia and is presented by INQUA PERIBALTIC Group.

From the standpoint of geomorphology, subglacial and submarine areas of Antarctica are poorly known, or MOR, whose surfaces are investigated, but the reliefs has to be analyzed. Extremely young reliefs of MOR´s formed by tectonical processes, and relatively old and unique reliefs of Antarctica are two extremes among the objects of study of geomorphology. It is especially important to consider subaerial, subaqueous, and subglacial types of reliefs in one complex. From this position, it seems logical to consolidate reports on the subjects in the section "Geomorphological Studies of the Polar Terrains and Ocean".

The importance of the growing generation of young researchers and specialists in the field of polar and marine researches reflected in the presence of the Leopoldina-Symposium based on the modern Russian-German cooperation in the Scientific Exploration of Northern Eurasia and the Adjacent Arctic Ocean.

Organization of such an international conference in Saint-Petersburg State University was made possible through a “megagrant” for establishing a new laboratory "Geomorphological and Paleogeographical Studies of the Polar Regions and Oceans," under the supervision of the German scientist Professor Jörn Thiede, a specialist in the fields of marine geology, oceanography and paleoceanology. The new laboratory will be named in honor of W.P. Köppen, a famous geographer,

meteorologist and paleoclimatologist, born in 1846 in St. Petersburg, who studied and worked in Russia and later in Germany.

The modern established laboratory is unique in this type of research. It aims of gaining geological, geomorphological, paleogeographical and geochronological information of continental and marine sediments of polar regions and oceans. Creating a modern and well-functioning laboratory, conducting field studies, laboratory analyses will lift Saint Petersburg State University (SPbGU) into one of the leading Russian and international centers for Polar and Marine Research; this development is supported by various other institutes in Saint-Petersburg: Herzen State Pedagogical University, Arctic and Antarctic Research Institute (AARI), Russian Geographical Society (RGS), All-Russian Research Institute for Geology and Mineral Resources of the World Ocean (VNIIOkeangeologia), Polar Marine Geosurvey Expedition (PMGE).

We should not forget that new laboratory was created on the base of existing laboratory of radioisotope geochronology at Faculty of Geography and Geoecology. In addition, during the last ten years the *POMOR* Master Programm offers a chance for students to get a degree in polar and marine sciences.

We believe that results of this conference will make an important contribution to the development of research of polar and marine regions and build strong and successful cooperation with our foreign partners.

Organizing Committee of the Joint International Conference “GEOMORPHOLOGY AND QUATERNARY PALEOGEOGRAPHY OF POLAR REGIONS”, Leopoldina Symposium and INQUA Peribaltic Working Group Workshop

INQUA PERIBALTIC WORKING GROUP WORKSHOP

UPPER PLEISTOCENE IN THE FAR NORTH OF EUROPEAN RUSSIA (BOLSHEZEMELSKAYA TUNDRA)

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A complex studying of the four Neopleistocene sections, where Byzovaya (Middle Valdai, Leningrad) deposits are exposed, conducted in the north of Bolshezemelskaya tundra. They are located in the sublatitudinal area of the Chyornaya River between the mouths of Seykargayaha and Nivyaha creeks. In three sections alluvial and lacustrine deposits of 4-8,5 m thick, with layers of peat overlie the Vychegda (Moscow) till with a stratigraphic unconformity. In one case they cover the 6-meter-thick layer of Polar (Ostashkov) till. These data allowed us to reconstruct the paleogeographical conditions of a short and rather cool Byzovaya megainterstadial. Polar horizon is widespread. Polar till is a key horizon making up the relief in this region, it composes the surface of the water divides, the upper parts of the river banks, sometimes, it comprises entire coastal bluffs. The thicknees of till is 4-15 m. In some sections, where till is represented by basal and ablation facies, the thicknees reaches 20-22 m. Often the Polar till is covered by Holocene lacustrine and alluvial sediments, sometimes with peat up to 1-2 m thick.

The Polar till is presented by massive diamicton, dark-gray with brown tinge, sometimes bluish-gray with fragments of mollusk shells, has low sorted rock flower (average Sc = 0,18), the mean particles diameter d = 0.017 mm. The content of gravel-sand, silt and clay fractions on the average consists of 17.4, 44.6 and 38% respectively.

Siderite, epidote, garnet, amphibole and pyrite dominate in the heavy fraction of the Polar till. The content of pyrite and siderite and their proportions are volatile, but the trend of the dominanting role of siderite appears in all sections. The number of ilmenite, amphibole and garnet is quite considerably variable in different sections, and the contents of ilmenite and garnet increase north-eastward. In the same direction the content of heavy fraction increases from 0.4-0.5 to 0.94-1.2%.

The petrographic composition of boulder-pebble material of the Polar till is characterized by high (50%) content of carbonate rocks. In this group there is a considerable proportion of light-colored limestones, especially in the downstream, north-eastern part of the Chyornaya River valley. Here they make up 27.4-34.4% in number of all fragments contained in the till. Upstream in the south-western direction the number of them decreases down to 14.8-22.1%. The content of the local Jurassic and Cretaceous sandstones, siltstones and mudstones is higher (18.1-28.3%) than the north-eastward (14.9-16.7%). The content of transit rocks – the Permian and Triassic clastic rocks (14.6-20%) is more stable. The content of igneous and metamorphic rocks, and quartzites and quartzitic sandstones like the exotic to the area is variable: the number of them varies from 10.3 to 24 9%. A specific feature of the polar till is the presence of limestone fragments with crinoids and moss animals from the Novozemelsky source area in the petrographic composition. moreover, the Payhoy-Novaya Zemlya glaciation center of the Polar till is confirmed by the direction of the clastic material orientation from the north-north-east to south-south-west.

The analysis of palynological data obtained from all four sections indicates accumulation of sediments during Byzovaya time. Seven phases of vegetation are revealed in the spore-pollen diagrams. BzI phase – birch light forests, where pine and fir are less developed. The scrub and the grassy associations formed by Chenopodiaceae, grass, wormwood were wide spread. BzII phase – fir-birch, fir-pine and birch forests. Open areas were occupied by forb meadow cenoses and grass associations of Artemisia sp., Chenopodiaceae and Poaceae. Flora, formed in this time, included the

boreal elements and periglacial hypoarctic and xerophytic elements. BzIII phase – birch low-density forests with pine and fir. The forest group has lost its dominant position. The shrub and herbaceous association of open habitats more widespread. There were swampy-tundra formations along with the xerophytic communities formed by wormwood Chenopodiaceae and grass. BzIV phase – birch, birch-fir, birch-pine light forests. Part of the territory was occupied by meadows, that is reflected in the content of pollen of herbaceous plants, including grasses and meadow grasses (Caryophyllaceae, Ranunculaceae, Rosaceae, Asteraceae families), as well as periglacial xerophytic communities. The bog played significant part in the vegetation. BzV phase – birch-pine low-density forests with fir. The shrubs, the bog-tundra associations along with the xerophytic communities are common. BzVI phase – fir-birch, fir, pine and birch light forests. Open spaces were occupied by meadow cenoses, that is reflected in the pollen of herbaceous plants (a lot of grasses and herbs pollenare indicated). BzVII phase – birch light forests and a variety of shrubs. Considerable development of hygrophilous herbaceous associations is revealed, which is characteristic for forest tundra and tundra biomes.

Thus, according to our studies, the formation of deposits occurred during the time interval corresponding to Byzovaya (Middle Valdai) time. Vegetation phases confirm the absence of climatic optima during the Middle Valdai in the study area. There are three warm intervals. The vegetation during warm phases is characterized by spread of low-density forests, where the part of fir and pine with predominance of birch trees increases, and the bog and meadow associations occupied open spaces. The climate was cooler in comparison with previous interglacials.

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TALE OF TWO LAKES: HR-ICP-MS STUDY OF LATE-GLACIAL LAKE SEDIMENTS FROM THE SNELLEGEM POND IN BELGIUM AND THE LAKE MEDVEDEVSKOYE IN NW RUSSIA. IN SEARCH FOR FINGERPRINTS OF THE LATE PLEISTOCENE EXTRATERRESTRIAL EVENT

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Introduction

Concentrations of trace elements in Late-Glacial lake sediments from the Snellegem pond (SP) in Western Belgium and the Lake Medvedevskoye (LM) in NW Russia were studied using HR-ICP-MS. Trace elements may indicated sources for sediments deposited in lake's environment. We used concentrations and distributions of trace elements in lacustrine sediments of Europe in order to check a hypothesis about the Late Pleistocene extraterrestrial (ET) impact (Firestone et al., 2007). This hypothesis suggests that ca. 12,900 cal a BP, just before the onset of the YD cooling, a large bolide exploded over the North American Laurentida Ice Shield. The consequences of such a catastrophic event led to abrupt climate change. If the impact occurred over North America, transportation of the impact-related microparticles eastward by the dominating west winds could have delivered such particles as far east as Europe.

Snellegem Pond

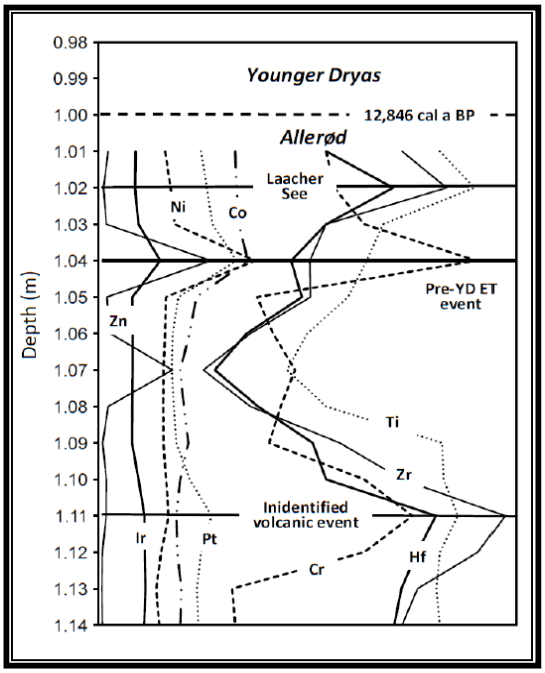

Figure 1. Distribution of trace elements across the Late Pleistocene sedimentary sequence of the SP. The solid lines mark stratigraphic levels corresponding to the time of various events. A distribution is schematic and does not show an absolute concentration of the elements

Distribution of trace elements across the sequence of the Late Pleistocene sediments (mostly carbonaceous lake marl) in the SP suggests that they experienced addition of compositionally anomalous material during a short single event. This event resulted in enrichment (up to 200% of the elements' background values) of a thin layer located 4-5 cm below the lower YD boundary (LYDB) in Cr, Co, Ni, Zn, Ir and Pt (Fig. 1). All these elements are much more abundant in meteorites than in terrestrial sediments, and addition of the ET material seems to be the most likely cause for the observed geochemical feature. We used an age-depth chronological model based on three chronological pinpoints to obtain timing of various events. The first pinpoint is a radiocarbon date located at a depth of 100 cm (Fig. 1) and corresponds to the age of 12,846 cal a BP coinciding with the onset of Greenland Stadial-1 in Lowe et al. (2008). The second one is related to the sudden rise of *Pinus* pollen at a depth of 130 cm (not in the sampled part of the sequence), and corresponds to the age of 13,200 cal a BP (Hoek, 2001). The third one is the onset of the Older Dryas biozone at a depth of 170 cm (not in the sampled part of the sequence) corresponding to Greenland Interstadial-1d (14,025 cal a BP; Lowe et al., 2008). A stratigraphic position of the "enriched" layer suggests, according to the age-depth model, that it was deposited 12,880 cal a BP, just before the onset of the YD cooling in the region. The pre-YD ET event, resulting in enrichment of sediments in "meteoritic" elements, may have occurred between two volcanic eruptions: (i) an older volcano probably in the Massif Central of France, and erupting more basic ash (Kuznetsov and Subetto, 2004); and (ii) a younger Laacher See volcano of East Eifel in Germany erupting more felsic ash (Wörner et al., 1983; van den Bogaard, 1995). These eruptions, separated by 115-130 years, might have resulted in the addition of volcanic material to the SP sediments (Fig. 1).

Lake Medvedevskoye

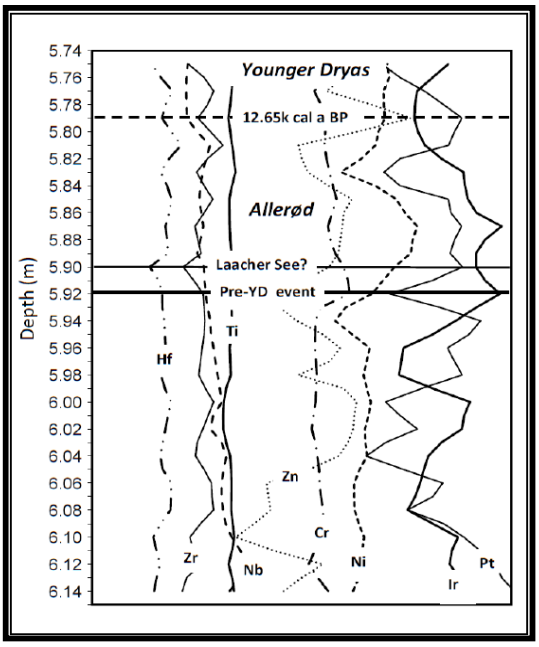

Figure 2. Distribution of trace elements across the Late Pleistocene sedimentary sequences of the LM. The line 12.65k cal a BP corresponds to the LYDB in Russia (Subetto, 2009). The solid lines mark stratigraphic levels corresponding to the time of various events. A distribution is schematic and does not show an absolute concentration of the elements

Distribution of trace elements across the Late Pleistocene sediments of the LM also displays features which may be consistent with addition of materials other than those delivered from usual sources for lake sediments. Such addition is pronounced in enrichment of some stratigraphic horizons in elements that are not entirely typical for lake sediments. The enrichment coincides within the limits of determination errors with both time of the Laacher See volcano eruption (van den Bogaard, 1995) and the time of the ET impact in question (Firestone et al., 2007). However, the enrichment up to 25% above the elements' background occurs mostly in elements, which are abundant in meteorites such as Ni, Cr, and Zn, and not in elements, which are abundant in volcanic material such as Ti, Zr, Hf, and Nb (Fig. 2), As a consequence, we suggest a possibility that sediments of the LM, like their counterparts from the SP, may carry fingerprints of the Late Pleistocene ET event. An age-depth model based on three radiocarbon dates in the LM Late Pleistocene sedimentary sequence was used in our calculations. The first dated point is located at a depth of 513 cm (not in the sampled part of the sequence) and corresponds to the age of 10,900 cal a BP proposed for a change of a nival climate to a humid climate Subetto (2009). The second one is located at a depth of 548 cm (not in the sampled part of the sequence), characterized by appearance of hydrotroilite, and corresponds to the age of 11,350 cal a BP (Subetto, 2009). The third radiocarbon date of 12,650 cal a BP at a depth of 579 cm (Fig. 2) marks the transition from the Allerød to the YD in the region (Subetto, 2009). According to this age-depth model, a sedimentation rate of ~0.35 mm a^{-1} could be calculated. Platinum group elements, the most indicative elements to determine between terrestrial and ET components, display some disturbances in distribution around the time of the impact in question. In particularly, Ir and Pt show no coherency before the time of the ET event, and, on the other hand, behave coherently with each other and Ni for some time after the event (Fig. 2). An increase in concentrations of "meteoritic" elements occurs, according to our depth-age model at ca. 13,000 cal a BP, which is within the error limits of the suggested time of the Late Pleistocene impact. Eruption of the Laacher See volcano might have added volcanic material to the LM sediments as well as in the case of the sediments from the SP. Some disturbances in distribution of such "volcanic" elements as Zr, Hf, and Nb can be observed just above the horizon enriched in "meteoritic" elements (Fig. 2). However, a low sedimentation rate and small spatial interval between the layers do not allow for reliable discrimination between the events separated by just 50-60 years. Moreover, in contrast to the lake marl sediments of the SP sequence, the aleuritic sand and aleurite of the LM sequence are relatively abundant in trace elements. That makes it difficult to catch low degrees of trace element enrichments.

Conclusions

Geochemical features of the Late-Glacial lake sediment sequences of the Snellegem pond of Belgium and to the lesser extent of the Lake Medvedevskoye of NW Russia are consistent with addition of meteoritic material ca. 12,900 cal a BP.

There are still no decisive data about the connection between the ET event and the beginning of the Younger Dryas cooling.

Because of very low degrees of indicative trace element enrichments, we suggest that the NW Russia can represent the eastern limit of the extension of the Late Pleistocene ET material.

Both sedimentary sequences can contain volcanic material from the eruption of the Laacher See volcano and probably from other Late Pleistocene volcanoes of Western Europe as well.

References

[1] *van den Bogaard P.,* 1995. $^{40}Ar/^{39}Ar$ ages of sanidine phenocrysts from Laacher See Tephra (12,900 yr BP): Chronostratigraphic and petrological significance. Earth Planet. Sci. Lett., 133, 163-174.

[2] *Firestone R.B., West A., Kennett J.P., Bunch T.E., Revay Z.S., Schultz P.H., Belgya T., Kennett D.J., Erlandson J.M., Dickenson O.J., Goodyear A.C., Harris R.S., Howard G.A., Kloosterman J.B., Lechler P., Mayewski P.A., Montgomery J., Poreda R., Darrah T., Que Hee S.S., Smith A.R., Stich A., Topping W., Wittke J.H., Wolbach W.S.,* 2007. Evidence for an extraterrestrial impact 12,900 years ago that contributed to the megafaunal extinctions at the Younger Dryas cooling. Proc. Nat. Acad. Sci., 104, 16016-16021.

[3] *Hoek W.Z.,* 2001. Vegetation response to the ~ 14.7 and ~ 11.5 ka cal. BP climate transitions: is vegetation lagging climate? Global and Planetary Change, 30, 103-115.

[4] *Kuznetsov D.D, Subetto D.A.,* 2004. Tephrochronology and its application to palaeolimnology. Reports of the Russian Geographic Society, 134, 79-82 (in Russian).

[5] *Lowe J.J., Rasmussen S.O., Björck S., Hoek W.Z., Steffensen J.P., Walker M.J.C., Yu Z.C., INTIMATE group.,* 2008. Synchronisation of palaeoenvironmental events in the North Atlantic region during the Last Termination: a revised protocol recommended by the INTIMATE group. Quaternary Sci. Rev., 27, 6-17.

[6] *Subetto D.A.,* 2009. Lake sediments: paleolimnological reconstructions. Saint Petersburg, Publishing House "A. Herzen Russian State Pedagogical University", 333 p. (in Russian).

[7] *Wörner G., Beusen J.-M., Duchateau N., Gijbels R., Schmincke H.-U.,* 1983. Trace element abundances and minera/melt distribution coefficients in phonolites from the Laacher See Volcano (Germany). Contrib. Mineral. Petrol., 84, 152-173.

COSMOGENIC 10BE NUCLIDES DATING OF WEICHSELIAN SIS IN MECKLENBURG-WESTERN POMERANIA (NE-GERMANY)

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Prominent moraines crossing Mecklenburg-Western Pomerania (MWP), northeastern Germany, mark the former southern margin of the Late Pleistocene Scandinavian Ice Sheet (SIS). The presence of two main moraines, the Pomeranian Moraine (W2), and the Mecklenburg Moraine (W3) suggests a millennial timescale response of the SIS to the North-Atlantic climate variations according to previously published exposure ages from further southeast in Brandenburg (Rinterknecht et al. 2010)

This paper report 21 cosmogenic ^{10}Be ages on prominent end moraine belts and boulders on morainic uplands deposited by the Scandinavian Ice Sheet margin between the Oder- ice lobe in the E and the Trave- ice lobe in the W. The samples were processed and analysed at the Laboratoire

National des Nucléides Cosmogéniques, France. The ^{10}Be-ages were calculated using the CRONUS-Earth online ^{10}Be exposure age calculator version 2.2 (Balco et al. 2008) using a time-dependent production rate model. We corrected the exposure ages for snow and erosion effects and interprete the results as minimum ages.

Previous time estimations for the deposition of ice marginal positions (IMP) along the southern margin of the SIS are mostly based on geomorphology and stratigraphy, and on few radiocarbon dates (Rinterknecht et al. 2010, Heine et al. 2009, Kozarski 1992). In N-Germany Heine et al. (2009) deduced based on three ^{10}Be ages on large boulders from the Brandenburg area that the SIS reached its maximum extent during the Weichselian glaciation at 21–20 kyr (n =2) and started to melt back from the Brandenburg IMP at around 19 kyr (n = 1). Recently the W2-Moraine has been dated in NE-Germany between 17-15 ^{10}Be kyr (n = 3) (Heine et al. 2009) and 16.0 ± 0.5 ^{10}Be kyr*^{1} (n = 4) (Rinterknecht et al. 2010). These data constrain the timing of three significant ice-margin fluctuations between 23 and 15 kyr. In MWP the deglaciation of Pomeranian Moraine (W2) has been dated around 16.4 ± 0.6 ^{10}Be kyr*^{1} (n =12) from W2-IMP and W2-morainic uplands. This result is in good agreement with published exposure ages in NE-Brandenburg (Heine et al. 2009; Rinterknecht et al., 2010). The last Weichselian ice-margin retreat started in the northern part of MWP with the final recession of the Mecklenburg phase (W3) dated at around 14.3 ± 0.7 ^{10}Be kyr*^{1} (n =5).

The preliminary results from MWP provide critical geochronological data to fill in the gap between the data of SE Baltic and Poland and Denmark where a clear chronology of the maximum advance of the SIS and the following recessional moraines is still to be confirmed.

References

[1] *Balco, G., Stone, J.O., Lifton, N.A. & Dunai, T.J.* (2008): A complete and easily accessible means of calculating surface exposure ages or erosion rates from 10Be and 26Al measurements. – Quaternary Geochronology, 3: 174–195.

[2] *Heine, K., Reuther, A.U., Thieke, H.U., Schulz, R., Schlaak, N., Kubik, P. W.* (2009). Timing of Weichselian ice marginal positions in Brandenburg (northeastern Germany) using cosmogenic in situ 10Be. Z. Geomorphol. N.F. 53 (4), 433–454.

[3] *Kozarski, S.* (1992): Eine auf der Radiokarbonmethode basierende Abschätzung der Rückzugschronologie des letzten Inlandeises in Nordpolen. – In: Billwitz, K., Jäger, K.D. & Janke, W. (eds.): Jungquartäre Landschaftsräume: 16–22; Berlin.

[4] *Rinterknecht, V.R., Braucher, R., Böse, M., Bourlès, D. & Mercier, J.-L.* (2010): Late Quaternary ice sheet extents in northeastern Germany inferred from surface exposure dating. – Quaternary Science Reviews, DOI: 10.1016/j.quascirev.2010.07.026

DEGLACIATION DYNAMICS OF ICE STREAMS: A MATTER OF BALANCE. CASE STUDY HONDSRUG – EMS ICE STREAM, SAALIAN, THE NETHERLANDS

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Ice streams always reflects an unbalance between accumulation and ablation in ice sheets and along ice sheet margins they are highly variable and dynamic in space and time. Present-day and Last Glacial examples of ice streams demonstrate a behaviour of switching on and off; acceleration and deceleration, migration and change of direction. The situation at the ice margin provides a main control on the mass (in)balance of the ice stream, for example where melting or calving occurs in ice lakes, seas and oceans. The knowledge on controlling factors and process dynamics of present day ice streams has much grown. For paleo-ice-streams, however less studies truly assess process-relations, especially in NW Europe. We have focussed on the Hondsrug – Ems Ice Stream of Saalian age (Drenthe Substage, within MIS 6) in NE Netherlands and NW Germany, glaciated in the penultimate glacial, but not in the last glacial. The best expression is a 60 km long mega flute complex landform, known as 'Hondsrug' (e.g. Rappol, 1984; Van den Berg & Beets, 1987). Because of its unique genesis and preservation, the Province of Drenthe has nominated the Hondsrug to be a UNESCO - GEOPARK.

We have importantly updated the reconstruction of phases of the glaciation for the wider region and have collected new data on the paleo-ice stream using road-cut outcrops, boreholes, seismics and ground penetrating radar and "new" till-characterisation techniques (XRPD analyses of clay minerals).

Results are discussed and related to Winsborrow et al. (2010) hierarchy of controls of ice streams. We have strong reasons that ice streams of the terrestrial ice margins of the former Scandinavian ice sheets of the North Sea, German, Polish and Baltic area are controlled in a different way than e.g. Antarctic actuo- and North American palaeo-examples. The ice-streams appear regional initial deglaciation phenomena, affected by substrate and ice-margin control primarily, rather than larger scale expanding ice-cap phenoma. This conclusion opens new approach in understanding the scales and dynamics of ice streaming at the tipping point of maximum glaciation to initial deglaciation, and input for further research between the North Sea and the Baltic.

References

[1] Rappol, M. (1984), Till in Southeast Drente and the origin of the Hondsrug complex, the Netherlands, Eiszeitalter und Gegenwart 34, p. 7-27

[2] Van den Berg, M.W., Beets, D.J., 1987. Saalian glacial deposits and morphology in the Netherlands. In: Van der Meer, J.J.M. (Ed), Tills and Glaciotectonics. Balkema, Rotterdam, 235–251.

[3] Winsborrow, M.C.M., Clark, C.D. and Stokes, C.R. (2010). What controls the location of ice streams? Earth Science Reviews. 103(1-2), 45-49.

POST-GLACIAL COAST DEVELOPMENT AND HUMAN SETTLING OF THE NORTH EUROPEAN ICE MARGINAL LANDSCAPE (IML)

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In North Europe, in the Ice Marginal Landscapes (IML) from the Netherlands to Estonia, human settling is in the Late-Pleistocene - Holocene strongly influenced by post-glacial relative coast development(MESO, 2010; SINCOS, 2002-2009; Machu, 2006-2009, IGCP project 346, CoPaF, 2009-2012) and glacio-isostasy. Geological processes like updoming and tectonic block displacements not only influenced sedimentation of river systems in delta's (e.g. Cohen, 2003), but influenced coastal development and human settling too in the North Sea area (e.g. Peeters, 2008; Cohen, 2011) the Wadden areas (e.g. de Langen, 2011) and lagoons (e.g. Druzhinina, 2010). An overview of shoreline development at the distal side of the Late Glacial forbulge related to glaciological and geophysical processes however does not exist and coastal development models are also not correlated with human settling.

Aims of our project(2012 -2018) are in general to describe the influence of shifting coast on the way of settling and living of ancient man in the IML:

To get insight into and to describe temporal and spatial development of the post-glacial geological and morphological setting of the IML as the base for understanding colonization processes

To define and describe reflection of prehistoric human subsistence as part of the landscape ecosystem to get more insight in the implications of environmental dynamics on adaptation, mobility and settling strategies, with focus on coastal landscapes

To share out time periods of most dynamical environmental changes; to define their possible influence on HGF subsistence; to define correlations between fast changing environment and implications for social-economic- and cultural development

Detailed integrated studying of "key-areas", with attention to deep geology (e.g. Baltrunas, e.a. 2005), will allow to get new insight of the impact of post-glacial shoreline changes and history of man on the coast in the IML with focus on his past (history of relations) and future (impact of climate change. The project is an international project, with participation of institutes all over the IML.

References

[1] *Baltrunas, V.,Sliaupa, S., Karmaza, B.,* 2005. Origin of the great Nemunas loops, South Lithuania.Géographie physique et Qautenaire 2005, vol.59, no.1. p. 3-15.

[2] *Cohen, K.M.,* 2003. Differential subsidence within the\ a coastal prism. Late- Glacial – Holocene tectonics in the Rhine-Meuse delta, the Netherlands. Netherlands Geographical Studies 216. 172 pag. KNAG/Faculteit Ruimtelijke Wetenschappen Universiteit Utrecht.

[3] *Cohen, K.M., Mac Donald, K., Joordens, J.C., Roebroeks, W., Gibbard, P.L.,* 2011. Earliest occupation of northwest Europe: a coastal perspective. Quaternary International, doi: 10.1016/j.quaint.2011.11.003.

[4] *Druzhinina, O.A.; Skodnov, I.,* 2010. Investigations of the evolution of the Baltic Sea and early human settlement in the eastern Baltic Area (based on materials from Kaliningrad Region). Archeaeologica Baltica 14. pag. 219-225.

[5] *Langen, G.J. de,* 2011. De gang naar een ander landschap. In Gevormd en omgevormd landschap. Pag. 70-98. DPV. Nienkus, M.J.L.Th., red.

[6] *Peeters, H.,* 2008. North Sea Prehistory Research and Management Framework (NSPRMF). Draft 1.1. Amersfoort, the Netherlands.

REFLECTION OF CLIMATE CHANGES ON PERIGLACIAL SEDIMENTS IN SOUTH–EAST LITHUANIA UPLANDS

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The greatest amount of evidence about the historical climate changes can be derived from the glacial record as well as from the structure and bedding of related deposits. Sediments of the former glaciolacustrine basins contain especially important palaeoenvironmental information. At the time of rapid glacier recession, a large part of Lithuania's territory was inundated by glaciolacustrine basins where thick sediment layers have accumulated in a few thousand years.

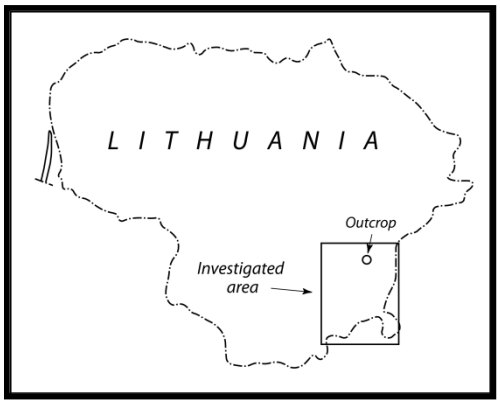

Fig 1. Investigated area.

The SouthEast Lithuanian relief was formed by the Medininkai Glacier (Fig. 1).. In this zone, there are specific indicators of periglacial processes such as icewedges, pseudomorphoses and other periglacial forms are good indicators for stratigraphy differentiation and correlation with climatic rhythms, which were fixed in glacial sediments.

The relief forms were investigated by the cartographic, descriptive and granulometric analysis of sediments.

Investigations were based on a special relief form classification. Distinguished were some types of relief form complexes: glacial, nival, glaciofluvial, glaciokarst, glaciofluvial–thermokarst, erosion and suffusion. Epigenetic processes (plane outwash, solifluction, slides, erosion, coastal abrasion, wind erosion and accumulation) substantially changed the glacial relief forms. Under their influence the relief became polygenetic.

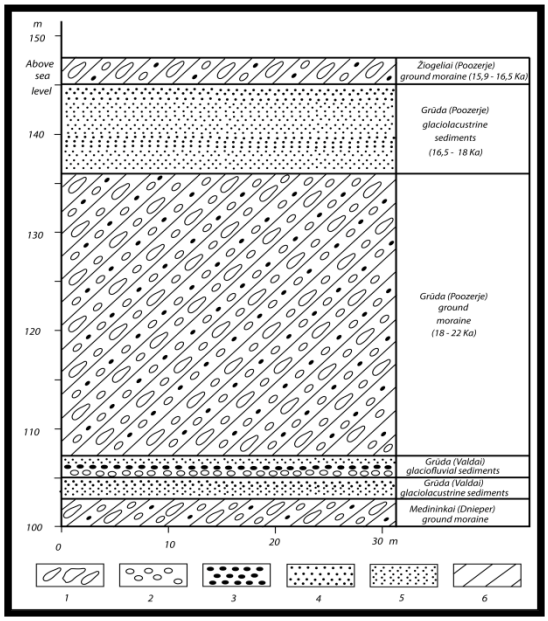

Fig.2. Sediments layers in fresh outcrop of Neris River valley.

During the periglacial epoch, sculptural hilly – ridges and hills were formed, which show more complicated and epigenetically transformed glacial relief complexes. Nival holes and kettles under went epigenetic transformation: the forms became shallower and their slopes flatter. After epigenetic transformation, typical glaciofluvial forms – stream valley – became shallow, with flat bottom and slopes.

Important data can be obtained from the water level fluctuations in the glaciolacustrine basins. The profiles of the glaciolacustrine basins can be rather easily traced in the current topography. They are former littoral zones of glaciolacustrine basins which have been converted into

glaciolacustrine terraces due to falling water levels. Glacier melt water has inundated a large part of uplands base.

Analysis of periglacial sediments was carried out using different field investigation methods: field measurements (shoreline altitudes, length and inclination of terraces slope) in

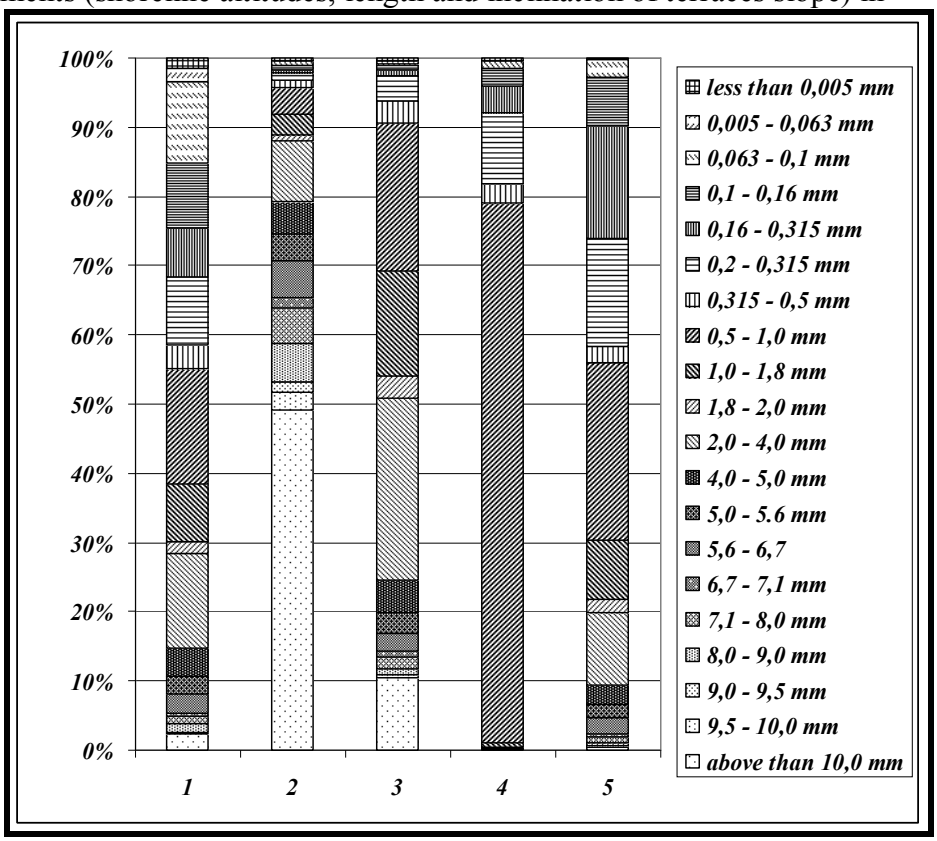

Fig. 3. Granulometry composition of glacial, glaciofluvial and glaciolacustrine sediments.

situ were done and sampling of sediments. For reconstruction of the evolution of the relief, the data reported by other authors (Ber, 2006; Marks, 2002; Satkunas et al,. 2003; Molodkov et al., 2002; Satkunas, Molodkov, 2005; Gaigalas, 2000; Šinkūnas et al. 2001; Baltrūnas 2002; Stančikaitė et al. 2002) have also used. Geomorphological, lithological and cartographic data collected during the field investigations form base of the present report.

Glaciers of the Late Nemunas glaciation reached Lithuania at ca 23 000 years ago. The glacier lobes of Grūda Stage (23 000 yrs by present) in the region started to melt ca 20 000 years ago and the subsequent glaciers of the Žiogeliai Stage (19 500 yrs) started to melt ca 18 000. The latter glacier mainly designed the topography of the region (Baltrūnas 2002). The melt-water sediments covered Weischelian glacial deposits (Gruda stage) and levelled uplands depressions and foots. The fresh outcrop in Neris River valley exposed complicated sediment layers composition (Fig. 2). The base of outcrop is on 103 m above sea level and top is on 148 m. Outcrop exposed some glacial, glaciofluvial and glaciolacustrine formations. Sediment particles analysis show, that paleoenvironmental condition was changeable, especially in early Gruda (Poozerje) glacial stages (Fig. 3).

The investigation show, that changeable situation was in coastal zone of glaciolacustrine lakes, where aquatic environmental transformed in terrestrial complexes. In Gruda stage was permanent accumulation of moraine material. This material accumulated in base level and western slopes of Medininkai Upland. In lower parts pond up wide glaciolacustrine basins which water level subsided during Late Pleistocene and Holocene. Next ice-sheet transgression occupied only small part of East-Lithuania and accumulated thin ground moraine layer.

References

[1] *Baltrūnas V.* 2002. Stratigraphic subdivision and correlation of Pleistocene deposits in Lithuania (methodical problems). Vilnius: Institute of Geology. 74 p.

[2] *Ber A.* 2006. Pleistocene interglacials and glaciations of northeastern Poland compared to neighbouring areas. Quaternary International. Vol. 149. Iss. 1. 12 – 23.

[3] *Gaigalas A.* 2000. Correlation of 14 C and OSL dating of Late Pleistocene deposits in Lithuania. Geochronometria. Vol. 19. 7 – 12.

[4] *Marks L.* 2002. Last Glacial Maximum in Poland. Quaternary Science Reviews. Vol. 21. Iss. 1- 2. 103 – 110.

[5] *Molodkov A., Bolikhovskaya N., Gaigalas A.* 2002. The last Middle Pleistoceneinterglacial in Lithuania: insights fro ESR – dating of deposits at valakampiai, and from stratigraphic and paleoenvironmental dating. Geological Quarterly. 2002. Vol.46, Iss. 4. 363 – 374.

[6] *Satkunas J., Grigiene A., Velichkevich F., Robertsson A-M., Sandgren P.* 2003. Upper Pleistocene stratigraphy at the Medininkai site, eastern Lithuania: a continuous record of the Eemian-Weichselian sequence. Boreas. Vol. 32, iss. 4, 627 – 641.

[7] *Satkūnas J., Molodkov A.* 2005. Middle Pleistocene stratigraphy in the light of data from the Vilkiškes site, Eastern Lithuania. Polish Geological Institute. Special Papers. Vol. 16., 94 - 102.

[8] *Stančikaitė M., Kabailienė M., Ostrauskas T., Guobytė R.* 2002. Environment and man in the vicinity of Lakes Dūba and Pelesa, SE Lithuania, during the Late Glacial and Holocene. Geological Quarterly, 46 (4), 391–409.

[9] *Šinkūnas P., Stančikaitė M., Šeirienė V., Kisielienė D.* 2001. The results of Ūla outcrops investigations. In Stone Age in South Lithuania (geological, palaegeographical and archaelogical data).(Baltrūnas, V., ed.).pp.67 – 82. Vilnius.

MORAINE REEFS ON THE LITHUANIAN OFFSHORE, SOUTH-EASTERN BALTIC

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The detailed studies of moraine reefs in the South-eastern Baltic Sea were performed during 2010-2011. The investigations were concentrated on the sea bottom area about 2.5 km to the west from the Lithuanian coastline, on the so-called Klaipėda-Ventspils Plateau. The large-scale moraine ridges oriented in meridian direction is generally prevailing in the mentioned part of plateau. A few groups of small-scale moraine ridges entitled as moraine reefs were discovered in this region during investigations.

The genesis of moraine reefs was one of the main objectives of investigations. The studies of sea bottom geomorphology and lithology was based on the results of detailed mapping made by multibeam echosounder and side-scan sonar. Geological structure and lithological composition of reefs forming deposits were tested by petrographic, mineralogical, granulometric and fabric analysis. All the samples from the sea bottom were collected by divers. Two Baltic Sea cliffs composed by moraine deposits as well as a few onshore boreholes were tasted by the same methods also.

According to morphological analysis of the sea bottom, the moraine reefs are surrounded by moraine plain and have elongated forms, oriented in West-East direction. The length of reefs vary from 8-10 to 150-155 meters, width – from 0.5 to 20 meters, height – from 0.5 to 4.5 meters. Prevailing length-width ratio is 3:1. The reefs have very steep slopes – very often close to 90°, they

surfaces are overgrown by molluscs (*Mytilus edulis*). The moraine reefs are composed by very compact grey sandy loam (till). According to the results of complex investigations, the reefs-forming moraine (till) and the large-scale moraine ridges were formed during the Middle Weichselian (MIS 4) glacial advance. The fabric analysis shows that reefs-forming till was left by glacier advanced from the West, whereas large-scale ridges-forming till have not well expressed gravel orientation.

A few relief-forming hypotheses were developed and discussed: the large scale moraine ridges could by De Geer moraines; or it could be marginal moraine ridges composed by deformational till. The moraine reefs could be as erosional remnants of more compact part of the till. The significant role in the relief-forming process take part marine abrasion during the Ancylus Lake and the Litorina Sea transgressions when the deposits formed by the Late Weichselian glacial advance was eroded and removed by waves and currents. The problem of moraine reefs genesis is still under discussion.

References

[1] *Bitinas, A., Damušytė, A., Grigienė, A., Molodkov A., Šeirienė V. and Šlauteris, A.,* 2011. The Last (Nemunas, Weichselian) Glacial in the Western Lithuania. Late Pleistocene Glacigenic Deposits from the Central Part of the Scandinavian Ice Sheet to Younger Dryas End Moraine Zone (Excursion Guide and Abstracts), Geological Survey of Finland, pp 78-79.

[2] *Damušytė, A.,* 2011. Post-glacial geological history of the Lithuanian coastal area. Summary of doctoral dissertation, Vilnius University, Vilnius, 84 p.

PROBLEM OF IDENTIFICATION OF KAME TERRACES IN THE INTERLOBATE INSULAR UPLANDS OF EASTERN LATVIA

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Interlobate insular uplands occupy the topographically highest areas in the inner zone of the peripheral cover of the last Scandinavian ice sheet. These type glacial uplands are some thousands of square kilometres in area. Their formation included subglacial, englacial, marginal and stagnant ice phases (Āboltiņš, 1972; Karukapp et al., 1999). The difference in conditions of formation and hypsometric position of the glacial landforms between central and peripheral zone of such uplands, and the steepness of ice-contact slopes and sides of glaciotectonic hummocks were favourable for development of morphological features associated with melting of stagnant ice.

This paper synthesizes the present-day knowledge on kame terrace identification in the territory of the Alūksne, Vidzeme and Latgale interlobate insular uplands that locate in Eastern Latvia. Since the first discovery of kame terraces here, the problem of their identification has often provoked serious disagreements. The distinction between kame terraces and lateral drainage channels has been most important point of contention because both their distribution along the ice-contact slopes that are common in the peripherial zone of the interlobate insular uplands, and some morphological similarity. In many cases the lateral drainage channel floors have been interpreted as distinct levels of kame terraces. For solution this problem we have applied geomorphic and lithofacial approach in combination with OSL age determination for stratified sandy sediments.

Along the ice marginal slopes the kame terraces and lateral channel floors occur in a series of up to 6-7 steps sloping downstream and overlying still another one in a stairway fashion. Usually upper levels or at least their headwards record erosion by lateral meltwater streams that is marked by concentration of boulders or boulder pavement on the stairway step. The lower stair-step levels represent the typical accumulative ice-contact formations that pass downstream into kettled surface topography at the distal edge of the kame terrace.

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References

[1] *Āboltiņš, O.P.,* 1972. K voprosy o formirovanii ostrovovidnykh vozvyshennostey [On problem of formation of insular uplands]. In: Danilans, I. (ed.), Lednikovy morfogenez [Glacial morphogenesis]. Zinatne, Riga, pp. 51-61 (in Russian).

[2] *Karukäpp, R., Raukas, A. and Āboltiņš, O.,* 1999. Glacial accumulative insular heights (Otepääs) – specific topographic features in the Baltic States. In: Miller, U., Hackens, T., Lang, V., Raukas, A. and Hicks, S. (eds.), Environmental and Cultural History of the Eastern Baltic Region. PACT. Rixensart, 57, 193-205.

NEW DATA ON PALAEOENVIRONMENT OF SOUTH-EASTERN BALTIC REGION: RESEARCHES OF 2011 - 2012

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The study of the processes of South-Eastern Baltic settling by primitive tribes against the background of the evolution of the environment continued in 2011 – 2012. Researches had the aim to obtain new palaeogeographic data (information about the variability of the climate, vegetation, the geological and geomorphological and hydrological processes over the last ~ 13 000 years) and to approach to the reconstruction of the Late Glacial and Holocene landscapes as a natural basis of settling processes in South-Eastern Baltic.

Palaeoecological studies were carried out on one of the most ancient sites of the Kaliningrad region – Late Paleolithic site Ryadino 5 (palinological, geochemical analysis, radiometric dating and OSL, stratigraphical and geophysical studies, typological and trasological analysis of collections) (Druzhinina, 2011). Obtained results of palynological analysis allow us to proceed with the reconstruction of the local natural environment during the period of site existence, and before coming of people to this territory.

Paleogeographic studies took place on a group of small lakes of Vishtynetskaya highland, and included drilling and sampling of bottom sediments of Kamyshovoe lake, one of the most interesting hydrological objects of this territory. Comparison of palaeogeographic characteristics of this lake with the ones of moraine hills of Lithuania and Poland indicates, that the reservoir can be the one of the oldest in the region, and its formation should be related directly to deglaciation processes of Vishtynetskaya highland territory. The bottom sediments sampling took place for radiometric dating (AMS), palynological, geochemical, and other analyzes. The obtained samples confirm the assumption about the age of the lake: sediment cores are presented by both stages: late glacial and the column of Holocene sediments. The total capacity of organogenic deposits exceed 8.7 m. Nine sediment cores were received, processing of the material started (under the head of prof. D. Subetto, A.Herzen State Pedagogical University, St. Petersburg).

One of the expeditions was related with the investigation of the group of Stone Age sites in Sheshupe river valley in the context of geological and geomorphological study of Sheshupskaya plain, aimed at collecting and analyzing data on the geological and geomorphological development of this area (water level fluctuations, neotectonics and shifting riverbed, etc.) and analysis of spatial location of archaeological sites. Field studies (in conjunction with dr. A. Bitinas, Klaipeda University, Lithuania, and drs. E. Bregman, University of Utrecht / Province of Drenthe, The Netherlands) included specification of geomorphological situation; drilling of sediments was conducted to determine their genesis.

The researches allow to make some conclusions about the spatial and chronological features of

the early stages of settling processes in South-Eastern Baltic and with greater certainty to justify the hypothesis of the existence of Late Glacial stage in settling of the region.

This exploratory project was financed by the Russian Foundation for Basic Research (project 09-06-00150a).

References

[1] *Druzhinina O., Skhodnov I* . 2011. Investigations of the Evolution of the Baltic Sea and Early Human Settlement in the Eastern Baltic Area (on the Materials of Kaliningrad Oblast). Archaeologia Baltica, vol.14, p. 221-227.

PALAEOGEOGRAPHY OF THE WARTA RIVER VALLEY (CENTRAL POLAND) OF THE LATE WEICHSELIAN

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The area of the study is situated in the lowland part of central Poland, within the open pit area of the Miocene lignite exploitation of the Adamów Lignite Mine. Geomorphologically, it lies on the low terrace of a Late Weichselian age, on the western side of the Warta River valley. The studied terrain was last time covered by the ice sheet during the Saalian Stage glaciations. The Weichselian Cold Stage was an ice-free period there; the closest position of the ice sheet front (about 20 km) took place during the Last Glacial Maximum (Fig. 1A). Palaeogeography of the Warta River valley (Central Poland) of the Late Weichselian and Holocene was studied on the basis of investigations of the complex of sediments underlying and overlying the organic unit with subfossil tree trunk horizon (Dzieduszyńska, Petera-Zganiacz 2011).

The base of the studied sequence is formed of the sand bed braided river deposits developed in the coldest part of the Late Weichselian. Sedimentary environment of the lower mineral unit was investigated in details earlier (Petera 2002, Petera-Zganiacz, Adamiec 2010).

The present study concerns the palaeoecological properties of the organic as a reference of palaeogeographical reconstructions. Among palaeoecological investigations, palynological and Cladocera analyses have been carried out. Moreover preliminary conclusions from dendrological and geochronological studies are available.

The rapid and deep environmental changes of the very end of Pleistocene are recorded in properties of the organic unit. The intensification of fluvial activity is expressed by the deposition of the upper mineral unit (Fig. 1B). The outstanding feature of the organic unit is the occurrence of the trees which are remnants of forest existing in the valley bottom. The deposition of this unit was synchronous with the forest growing. In the light of the results from dendrological studies obtained so far, the forest must have been fallen in a very short period of time, of no more than 20 years, possibly by an increase of water level.

Previous interpretation of the results of the pollen analysis with comments by a palynologist have been presented earlier (Turkowska et al., 2004). In 2011 the new pollen

profile have been elaborated. The results of pollen analysis indicated an open pine forest with a slight admixture of Betula. Pollen spectrum contains single grains of rush plants and aquatic species. The top of the profile reflects standing waters or a pool with very limited discharge. Spectrum contains single grains of Selaginella selaginoides. Therefore the organic unit must have been formed under cold climatic conditions of Alleröd and Younger Dryas and possibly the Holocene beginning. Such chronology of the profile has been confirmed by the results of palaeozoological analysis of subfossil Cladocera. The Cladocera analysis results prove the existence of episodic shallow water basins in the valley floor in the period of accumulation of the organic sediments.

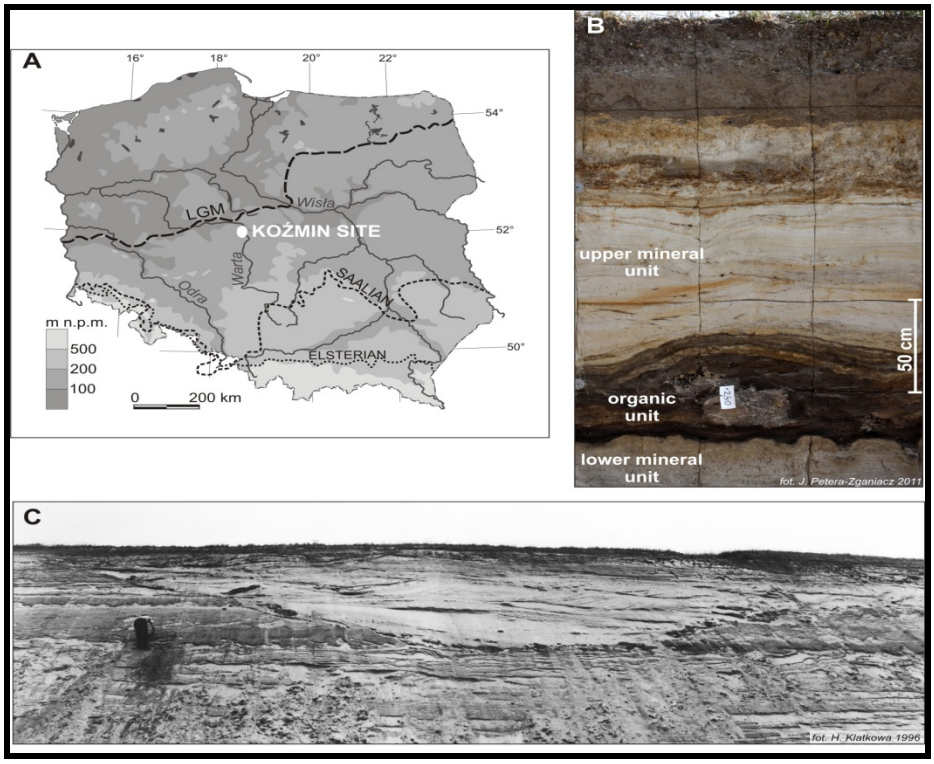

Fig. 1. The Koźmin site
A. Location of the investigated site and main glacial limits in Poland
B. Late Weichselian and Holocene deposits; organic unit with trees remnants is visible
C. Channel of the anabranching river system

The stratigraphy of the organic unit was determined based on radiocarbon dating of the samples of the organic material and the tree trunks. The conventional dates of the trees obtained so far are: 10 310 ± 90 BP (Lod 1402), 10 660 ± 50 BP (MKL-1070), 10 710 ± 50 BP (MKL-1071), 10 730 ± 60 BP (MKL-1072). In general the pine (Pinus sylvestris L.) forest represented by subfossil trunks was growing in the area in question in the period between 12 680 and 11 985 cal BP (prob. 68,2%). The period between >13 150–11 550 cal years BP corresponds to the turn of the Greenland Interstadial 1 (GI – 1c/1b) and the cold Greenland Stadial 1 (GS – 1), according to the scheme proposed by the INTIMATE group (Björck et al., 1998). The 14C data of organic material achieve results since 10 870±170 BP (Lod 699) up to 9780 ± 110 BP (MKL 1077), i.e. 12 935 – 10 875 cal BP (prob. 68,2%). Geochronological results confirm synchronous accumulation of organic sediments and pine forest existence.

Sedimentological properties of the upper mineral unit (of about 2-3 m thick), reflect river interference and are characteristic for various energy of the overbank sedimentary environment. The unit starts with sandy layers of generally coarse grains with horizontal bedding or ripple stratification prevailing. Above dominates sandy silty material with horizontal or flaser bedding as the most common sedimentary structures. Then the alternating parts of increasing and decreasing

dynamics follow. The unit is believed to represent overbank facies of an anabranching river. At places the channels of this anabranching river cutting the organic unit have been registered (Fig. 1C).

In the very end of Pleistocene the environment in the Warta River valley was stable for a short time, minor river inundations did not interrupt deposition of the organic deposits in the valley floor. Climate deterioration during Younger Dryas did not resulted in rapid changes in the Warta valley in the beginning, but finally a destabilization of the environment caused uplifting of the ground water table and intensification of fluvial processes.

The research is financially supported by a grant from the National Science Centre, No N N306 788240 "Palaeogeographical conditions of existence and destruction of the Late Weichselian forest in the Warta River Valley (the Koło Basin)".

References

[1] Björck*, S., Walker, M., Cwynar, L., Johnsen, S., Knudsen, K.-L., Lowe, J., Wohlfarth, B. and INTIMATE Members*. 1998. An event stratigraphy for the last Termination in the North Atlantic region based on the Greenland ice-core record: a proposal by the INTIMATE group. Journal of Quaternary Science 13, 283–292

[2] *Dzieduszyńska D., Petera-Zganiacz J.,* 2011 – The Younger Dryas subfossil forest (Central Poland). [W:] Johansson P., Pekka Lunkka J., Sarala P. (ed.) INQUA Peribaltic Working Group Meeting and Excursion - Late Pleistocene Glacigenic Deposits from the Central Part of the Scandinavian Ice Sheet to Younger Dryas end Moraine Zone, Rovaniemi, Finland 12-17 June 2011; 90-91.

[3] *Petera, J.* 2002. Vistuliańskie osady dolinne w basenie uniejowskim i ich wymowa paleogeograficzna (Vistulian valley deposits in the Uniejów Basin and their palaeogeographical significance). Acta Geographica Lodziensia 83, p.164

[4] *Petera-Zganiacz, J. & Adamiec, G.* 2010. The age of the Warta river valley deposits based on 14C, TL, OSL dating methods (Kotlina Kolska, Middle Poland). 10th International Conference "Methods of Absolute Chronology". Gliwice, 22-25.04.2010, 112

[5] *Turkowska, K., Forysiak, J., Petera, J. & Miotk-Szpiganowicz, G.* 2004. A Warta River system during the Younger Dryas in the Koło Basin (Middle Poland). Quaestiones Geographicae 23, 83–107

RECONSTRUCTION OF PALAEOVEGETATION DURING THE BEGINNING OF THE LAST DEGLACIATION IN THE MIDDLE VYCHEGDA VALLEY, NORTHEASTERN EUROPEAN RUSSIA

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Pollen sequences with four radiocarbon dates (Zaretskaya et al., 2011) obtained for the site (borehole, 22"Biostation" outcrop of the Vychegda 1-st terrace) in the Middle Vychegda valley provide a basis for reconstruction of vegetation and climate dynamics during Late Wiechselian (Valday) in this area. Pollen and radiocarbon evidence for time span after the LGM in the northeastern European Russia have been found for the first time.

The first significant warming after the LGM (Polar = Ostashkovian) is identifiable by spore-pollen spectra, supported by radiocarbon date 13890±50 BP (GIN-14192). This warming corresponds to Raunis Interglacial in the north-west of Russian Plain. The areas occupied by tundra-type landscapes with dwarf birch, willow and alder, alternating with steppe elements (Poaceae, Artemisia, Chenopodiaceae, Linum). Pollen of spruce in the spectra (10% of trees pollen sum) indicates very limited spread of woodland. Open spruce woodland occurred in the catchment of

Vychegda River only. Sandy sediments, overlying the Raunis peaty loam deposits, contain spectra with dominated herbaceous vegetation (the content of herb pollen reaches 65% of the total pollen sum).

Followed by the Raunis Interglacial cooling and drying of climate has contributed to expanding of the areas, occupied by periglacial-steppe formations with dominated Poaceae (the content of their pollen is 50-70% of the grass pollen sum). There tundra-type communities with Betula nana remained dominant during Older Dryas. Also this period is clearly identifiable by the degradation of the open woodland.

Spectra of the superposed strata show the vegetation and climate fluctuations during the Late Glacial. The pollen data are supported by radiocarbon dating of abandoned channel deposits: 12560±80 BP (GIN-14190), 10530±80 BP (GIN-14189), 10480±130 BP (GIN-14188). Within this time span there are two cold (the Middle Dryas and Younger Dryas Stadials) and two warm (the Bölling and Alleröd Interstadials) periods occurred. The spectra composition indicates the dominance of periglacial landscapes with wormwood, wormseed and gramineous communities, tundra associations with dwarf birch, alternating with open birch and spruce woodland during the Stadials. The Younger Dryas spectra are marked by the Poaceae pollen peak. The Interstadials caused an increase of spruce in the open woodland composition. The maximum content of spruce pollen is characterized for the Alleröd spectra. This pollen peak can be correlated with the "lower spruce maximum" (according to M. I. Neustadt), established for Alleröd as in adjacent regions (Neustadt, 1957; Pyavchenko, 1957; Khotinsky, 1977, etc.), and in this area (Nikiforova, 1980; Golubeva, Marchenko-Vagapova, 2010).

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References

[1] *Golubeva Yu. V. and Marchenko-Vagapova T. I.,* 2010. Palynological characteristics of the Late Glacial sediments in Biostantsiya outcrop, the Middle Vychegda River. Proceedings of the XIX scientific conference “Structure, matter, history of lithosphere of Timan-North-Urals cap”, Syktyvkar: the Geoprint, P. 26-30.

[2] *Nikiforova L. D.,* 1980. Environment dynamics during the Holocene in the Northeast of the European part of the USSR. Thesis for a degree of D. Sc. (Geol. & Min.) Moscow, 25 p.

[3] *Neustadt M. I.,* 1957. History of woodland and palaeogeography of USSR during the Holocene, Moscow: Publishers of the USSR Academy of Sciences, 403 p.

[4] *Pyavchenko N. I.,* 1957. The lower spruce in peat bogs. Proceedings of Forest Institute of the USSR Academy of Sciences, V. 36, Krasnoyarsk, P. 178-186.

[5] *Khotinsky N. A.,* 1977. The Holocene in the Northern Eurasia, Moscow: Nauka, 200 p.

[6] *Zaretskaya N. E., Panin A. V., Chernov A. V.,* 2011. Geochronology and palaeogeography of the Late Pleistocene to Holocene transition within the Vychegda – North Dvina system. Proceedings of the VII Russian Conference on Quaternary Research, Apatite-SPb, V. 2, p. 203-206.

MODELING OF ICE-DAMMED LAKES AND WATER NETWORK TRANSFORMATION IN DEGLACIATION TIME OF THE LAST SCANDINAVIAN ICE-SHEET IN VALDAY REGION

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Geological structure and topography of the East European Platform, in particular, the location of the main watershed zones determined the formation of large bodies of water during the maximum advance of glaciers and their subsequent degradation. Various hypotheses on formation

of Quaternary deposits dominated at different times. Therefore active investigation of ice-dammed lakes in the south-eastern sector of the Late Weichselian glaciation began only in the 60s of the 20th century. The last overview on ice-dammed lakes of this territory was made by D.Kvasov [1975].

Modern modelling allows using results of latest researches and digital technologies. The preliminary model presented here (Fig. 1) is based on SRTM data and on the latest ideas about the ice marginal positions [Kalm 2010]. For further analysis and correction of the model an inspection of the results in the field and a comparison with previous models is still required.

According to the model, at the time of maximum distribution of ice in the Valdai Heigths, there were several proglacial lakes with water levels at 220-237 m above current sea level, with separate flow directions to the Volga River drainage (Caspian Sea basin). For the Vepsa stage glaciers melted from the uppermost part of Valday Heighs and water level in ice-dammed lakes decreased to 208-225 meters. South of Valday Heights meltwater flow direction changed to south-west, towards the Baltic Sea basin. During the Krestets stage the meltwater runoff from the Valdai Hills area took place along the ice margin through a chain of lakes with water levels at 159-210 m.a.s.l., and then by Kabozha Valley towards the basin of Caspian Sea. Few lakes on western side of Bezhanitsy Heigths flew out to the direction of modern basins of upper Lovat and Daugava rivers. At the Luga stage all ice-dammed lakes located west of the Valdai Heigths, including the lake in the current Msta Valley, were drained towards the Baltic Sea basin. The largest ice-dammed lake in the area was located in the area of current valleys of Lovat and Velikaya rivers, which were connected between the Sudoma and Bezhanitsy heights, when the water level was 103 m a.s.l.

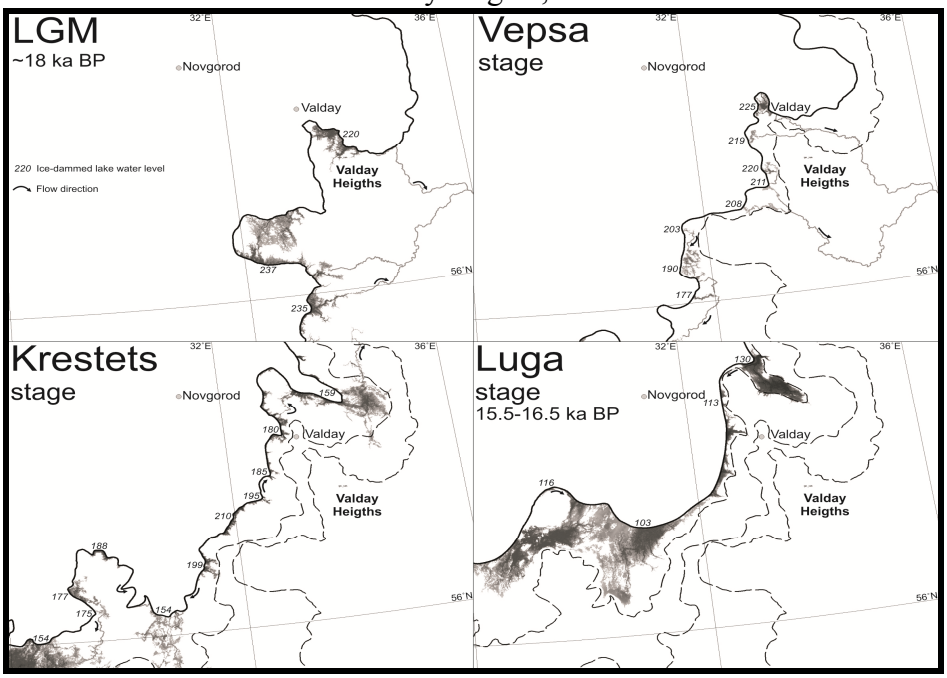

Fig. 1. Ice-dammed lake distribution (shown in gray colour) and flow directions (arrows) at the time of LGM and at subsequent deglaciation stages until the Luga stage. Numbers indicate water level altitudes relative to current sea level.

References

[1] International Centre for Tropical Agriculture. 2004. Hole-filled seamless SRTM data V1.

[2] http://gisweb.ciat.cgiar.org/sig/90m_data_tropics.htm [12.03.2009]

[3] *Kalm, V.,* 2010. Ice-flow pattern and extent of the last Scandinavian Ice Sheet southeast of the Baltic Sea, Quaternary Science Reviews, doi:10.1016/j.quascirev.2010.01.019

[4] *Kvasov D.,* 1975. Late Quaternary history of large lakes and inner seas of Eastern Europe, Leningrad: Nauka (in Russian)

IVALOJOKI – A PROPOSED GEOPARK IN FINNISH LAPLAND

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The river Ivalojoki in northern Finland flows in an ancient preglacial valley. It begins from the watershed near the Norwegian border, and stretches 180 kilometres through wilderness areas towards the lake Inari and the Barents Sea, merging with dozens of small streams and tributaries along its length. For a distance of some ten kilometres between the tributaries of Appisjoki and Sotajoki, it flows through a canyon up to 150 metres deep. Historical sites related to gold prospecting and mining, not to mention modern-day gold panning can also be found here.

The bedrock belongs to the Precambrian granulite zone of Lapland, which was formed during the Svecokarelidic orogeny about 1,900 million years ago. The most common rock type found in the bedrock is quartz-feldspar gneiss, which is pink and gray in colour and contains garnet, a distinctive dark red mineral. Gold deposits in the bedrock formed gradually over the course of millions of years. Recrystallization evidently formed lenses consisting of quartz, sulphides and gold, the same type as the richest bedrock gold deposits of the Klondike in Canada. During the Quaternary glaciers carved and eroded the rock, weathered bedrock and previously deposited layers of soil. The most common glacial deposit, basal till, contains gold grains loosened from the bedrock and weathered bedrock. In the final stage of the last glaciation, the ice sheet flowed from the south-west to the north-east. The area deglaciated around 10,500 years ago. Various depositional and erosional landforms created by melt water are closely associated with the retreat of the glacier. During deglaciation, melt water from an expansive area pooled in the Ivalojoki river valley, from where it flowed towards the Barents Sea. The melt water streams that formed during the last glaciation, as well the ones before it, played a significant part in enriching the gravel deposits along the shores and in the channels of the river Ivalojoki and its tributaries, such as Sotajoki and Palsinoja, with gold nuggets from till. They are the result of being repeatedly eroded, transported and deposited as placers by the flowing water. Placers do not contain gold throughout, but rather separate pockets of gold-rich areas or layers can be found in them.

Among the formations eroded by glacial melt water, the most impressive are the overflow channels carved into the fell ridges. They appear as sharp slits in the otherwise steeply sloping, rounded fell formations. The gorge of Kulmakuru, more than 20 metres deep, was formed subglacially as a powerful melt water stream passed over the fell ridge. Rounded pot holes, eroded by the subglacial melt water stream, appear on the bottom of the Ivalojoki river valley. Marginal channels formed at the headwaters of the tributaries of Moberginoja and Palsinoja between the margin of the melting ice lobe and the fell slope. They are several metres deep and more than a kilometre in length. From their shape it can be concluded that large volumes of melt water that had broken out from the glacier margin or from ice-dammed lakes flowed through them. They form channel networks which describe the gradient of the ice surface, its thinning out and the retreat of its margin. Esker chains are discontinuous and consist of several hummocks and ridges in succession. They reflect the flow of melt water from inside the ice sheet toward its margin. The highest esker ridges in the Ivalojoki river valley rise more than 25 metres above the surface level of the river.

Figure: The Ivalojoki river canyon

The gold history of Finnish Lapland begins with the river Ivalojoki in 1868, when the first discoveries of gold nuggets in the gravel were made there. The discovery led to a great gold rush amid the uninhabited wilderness. At its peak, close to 500 men could be counted in the area, digging and panning for gold in the hopes of striking it rich. The river valley was transformed into a gold-panning community and life there was a unique phenomenon in Europe. Authorities under the Russian Empire distributed prospecting permits, exchanged gold for cash and upheld law and order in the area. Between 1870 and 1910, 464 kilos of gold were discovered, but in all likelihood, only one third of the actual amount of gold finds made it into the official statistics. The great gold rush came to end within a few years, but panning for gold in the area still continues today. The Gold Museum at Tankavaara and Metsähallitus, Natural Heritage Services (Lapland), have carried out valuable work in inventorying old gold-mining areas and restoring partially destroyed structures. The Geological Survey of Finland has mapped and researched geological formations in the area, as well as gold deposits and their origins. If Ivalojoki is chosen to be part of the European Geoparks Network (EGN), it would become the northernmost geopark in the world. It would represent an impressive combination of unique untouched nature, geological formations and monuments, gold prospecting history and modern-day outdoor recreation and gold panning.

References

[1] *Johansson, P., Huhta, P., Nenonen, J. & Hirvasniemi, H.* 2000. Kultakaira. Geological outdoor map Ivalojoki – Saariselkä 1:50 000. Map and Guidebook. 44 p.

[2] *Nenonen, J. & Johansson, P.* 2011. Tracing the origin of gold nuggets at Palsinoja and Kultaoja in Finnish Lapland. In: 25th International Applied Geochemistry Symposium 2011, 22-26 August 2011, Rovaniemi, Finland: programme and abstracts. B 92-1. Espoo: Vuorimiesyhdistys, 148.

[3] *Saarnisto, M., Tamminen, E. & Vaasjoki, M.* 1991. Gold in bedrock and glacial deposits in the Ivalojoki area, Finnish Lapland. Journal of Geochemical Exploration 39, 3, 303-322.

CLIMATIC SIGNATURE OF COVERSAND DEPOSITS DISTRIBUTED ON GLACIOLACUSTRINE BASINS IN ESTONIA AND POLAND – A COMPARATIVE ANALYSIS

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Three areas (Fig. 1A) of coversand deposits from north-eastern Estonia (Iisaku 1 and Iisaku 2 sites in the Ida-Virumaa) central Poland (Plecewice sites in the Mazovian Lowland) and southern Poland (Rachów drillhole in Lublin Upland) were studied. All sites belong to so called "European sand and loess belt" (Zeeberg, 1998) and document its central (Plecewice and Rachów) and north-eastern (Iisaku 1,2) parts. Coversand deposits from Iisaku sites form parabolic-like dunes up to 9.5 relative meters high, while the Polish coversands build a flat and shapeless forms with a small denivelations (Plecewice) or are located in the bottom of the wide valleys (Rachów). All investigated deposits lie directely on the glaciolacustrine sediments: Iisaku on glacial Lake Peipsi, correlated with the Pandivere marginal zone (Hang, 2003; Kalm et.al., 2011), Plecewice on the varved clays (Merta, 1987) of the Warsaw Ice-Damed Lake that existed during the LGM in Poland (Marks, 2010), and Rachów on the deposits of the Sandomierz Ice-Damed Lake (Szczepanek, 1960; Kwapisz, 1978) correlated with the maximal stage of Odra glaciation (Drenthe, the Older Saalian) in Poland (Lindner, Marks, 1999).

Coversand samples (133 all togehter: 37 from Iisaku 1, 40 from Iisaku 2, 42 from Plecewice and 14 from Rachów) were examined in order to establish interpretation value of the selected textural features. The following features were used to indicate the significance of climatic processes on sediment accumulation: relationship between the granulometric indices of Folk & Ward (1957), shape of the cumulative curves on a probability scale (Visher, 1969), rounding and frosting of quartz grains of sandy fraction (0.5-0.8 mm), and content (%) of the light minerals – quartz, feldspars and micas in particular.

Coversand deposits in both, Estonia and Poland, represent medium- and ocassionally coarse-grained, moderately sorted sands. Estonian deposits are slightly negatively skewed while the value of skewness in Polish sediments can be both, slighty negative or slighty positive. It refers to enrichment of sediments with coarser or finer fractions respectively. Relationship between the values of standard deviation ($\sigma 1$) and mean grain size (Mz) represents the third co-ordinate system (Mycielska-Dowgiałło, Ludwikowska-Kędzia, 2011) with a relatively constant degree of sorting rate ($\sigma 1$) and variable mean (Mz). This type of system prevails in sandy sediments which form active parabolic dunes (Ruz, Allard, 1995; Rizzetto et.al., 1998) and in the majority in Polish fossil dunes (Mycielska-Dowgiałło, 2007). Cumulative curves demonstrate a well-sorted (steeply inclined) population of saltation with admixtures of coarser (in the all sites) and finer (in Plecewice and Rachów) fractions. Two groups of quartz grains in the sandy fraction with relatively high degree of rounding represent aeolian/periglacial climate conditions: EM/RM – partially rounded, matt and RM – well-rounded matt grains (Mycielska-Dowgiałło, Woronko, 2004), hence the highest frequency of round and matt grains in area of "European sand belt" (Goździk, 2007). Round and matt grains are highly spread especially in Polish sites: from ca. 70% to 93% in Plecewice site (Kalińska, in print) and ca. 86-91% in Rachów (Kalińska, 2011). Sands in Estonian sites are rich in matt, but non-abraded grains (NU/M), which in some parts of investigated profiles are dominating (ca. 27-61%). Configuring the values of non-abraded quartz grains and grains with the higher frequency of round (EM/RM+RM) (Fig. 1B) as well as the number of feldspars and quartz in the mineral composition (Fig. 1C) the tendency line is linear and shows the relationship of the particular sites. The most northern Estonian sites (Iisaku) are characterized by the biggest type-grain variability (mixture of EM/EM, EM and NU/M grains) and the biggest content of feldspars – minerals of low resistance to mechanical abrasion. The most southern site (Rachów), in turn,

reveals the higher maturity of quartz grains and mineral content. Hence, the climatic conditions were most favorable for aeolian processes.

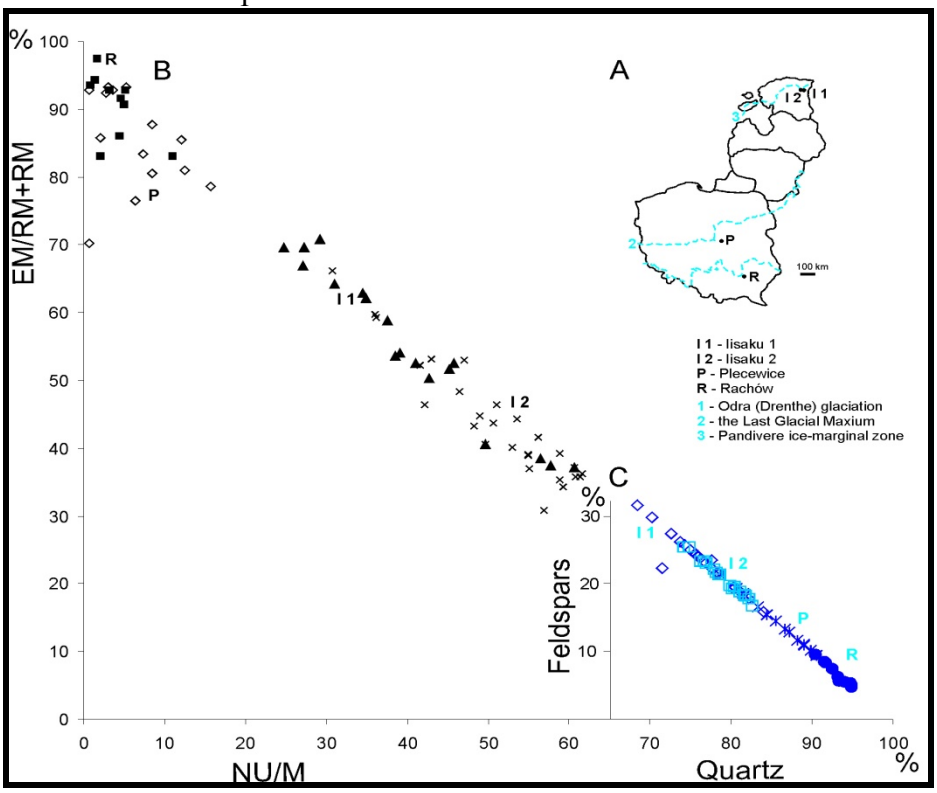

Fig.1. A – the marginal position of Odra (Drenthe) glaciation, LGM and Pandivere with the location of the studied sites; B – the relationship between the matt quartz grains with the higher roundness (EM/RM+RM) and non-abraded (NU/M) of the sandy fraction (0.5-0.8 mm); C – the relationship between content of feldspars and quartz of the sandy fraction (0.5-0.8 mm).

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References

[1] *Folk, R.L., Ward, W.,* 1957. Brazos River bar: A study in the significance of grain size parameters. Journal of Sed. Petrol., 27, 3-26.

[2] *Goździk, J.,* 2007. The Vistulian aeolian succession in central Poland. Sedimen. Geol., 193, 211-220.

[3] *Hang, T.,* 2003. A local clay-varved chronology and proglacial sedimentary environment in glacial lake Peipsi, eastern Estonia. Boreas, 32, 416-426.

[4] *Kalińska, E.,* in print. Geological setting and sedimentary characteristics of the coversands distributed in the western part of the Błonie glaciolacustrine basin (Central Poland) – preliminary results. Bull. of the Geol. Soc. of Finland.

[5] *Kalińska, E.,* 2011. Cechy teksturalne osadów form pokrywowych rejonu Annopola - wyniki wstępne. Materiały konferencyjne. VI Świętokrzyskie Spotkania Geologiczno-Geomorfologiczne Rekonstrukcja środowisk depozycyjnych na podstawie badań sedymentologicznych, geochemicznych i stratygraficznych, 43-45.

[6] *Kalm, V., Raukas, A., Rattas, M., Lasberg, K.,* 2011. Pleistocene glaciations in Estonia. In J. Ehlers, P.L. Gibbard and P.D. Hughes, editors: Developments in Quaternary Science, 15, 95-104.

[7] *Kwapisz, B.,* 1978. Quaternary of the Upper Mierzawa basin. Kwart. Geol., 22(1), 197-211.

[8] *Lindner, L. and Marks, L.,* 1995. Zarys paleogeomorfologii obszaru Polski podczas zlodowaceń skandynawskich. Prz. Geol., 43(7), 591-594.

[9] *Lindner, L. and Marks, L.,* 1999. New approach to stratigraphy of paleolake and glacial sediments of the younger Middle Pleistocene in Mid-eastern Poland. Geol. Quater., 43(1). 1-7.

[10] *Marks, L.,* 2010. Timing of the Late Vistulian (Weichselian) glacial phases in Poland. Quaternary Science Reviews, 21, 103-110.

[11] *Merta, T.,* 1978. Extraglacial varved deposits of the Warsaw Ice-Dammed Lake (younger Pleistocene), Mazovia Lowland, Central Poland. Acta Geologica Polonica, 28, 1(2), 241-272.

[12] *Mycielska-Dowgiałło, E., Woronko, B.,* 2004. The degree of aeolization of Quaternary deposits in Poland as a tool for stratigraphic interpretation. Sed. Geol., 168, 149-163.

[13] *Mycielska-Dowgiałło, E., Ludwikowska-Kędzia, M.,* 2011. Alternative interpretations of grain-size from Quaternary deposits. Geologos, 17(4), 189-203.

[14] *Rizzetto, F., Mycielska-Dowgiałło, E., Castiglioni, G.B.,* 1998. Some aeolian feature in the Po plain near Este (North Italy). Geogr. Fis. e Dinam. Quater., 21, 245-253.

[15] *Ruz, M.H., Allard, M.,* 1995. Sedimentary structures of cold-climatic dunes. Easter Hudson Bay, Canada. Sedimentology, 42, 725-734.

[16] *Szczepanek, K.,* 1960. Dryas flora from the village of Makoszyn near Sandomierz. Biul. Inst. Geol., 150, 131-138.

[17] *Visher, G.S.,* 1969. Grain size distribution and depositional processes. Journal of Sed. Petrol., 39, 1074-1106.

[18] *Zeeberg, J.J.,* 1998. The European sand belt in eastern Europe and comparision of Late Glacial dune orientation with GCM simulation results. Boreas, 27, 127-139.

TEXTURAL VARIABILITY OF THE SELECTED COVERSAND DEPOSITS IN LATVIA – PRELIMINARY RESULTS

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The interpretation possibilities of the results of textural analyses of coversand deposits, such as (1) grain size distribution, (2) rounding and frosting (matt) of quartz grains in the sandy fractions, and (3) mineral composition of the deposits range widely and can be applied for reconstruction of energy and nature of the transporting medium, as well as for identification of the origin of sediments.

Four sediment sections in northern and eastern Latvia – Silezers, Smilškalni, Kanči and Majaks – were examined in detail. All sections were in landforms resembling parabolic dunes with relative height from 6 to 16 meters. All study sites are underline by glaciolacustrine sediments that accumulated in ice meltwater and proglacial lakes formed after Gulbene (Majaks, Smilškalni) and Linkuva (Silezers, Kanči) deglaciation phases of the Weichselian glaciation (Zelčs et.al., 2011). Altogether 71 samples were taken for repeated analysis: grain size with cumulative curves and Folk & Ward (1957) indices, the rounding and frosting of quartz grains in the sand fraction (0.5 - 0.8 mm) for 120-150 randomly selected quartz grains, and mineralogical-petrographic composition in the sand fraction (0.5-0.8 mm) for 200-220 randomly selected grains.

Five lithofacies were distinguished in analysed sediments: massive structures (Sm), horizontal (Sh) and wavy (Sw) lamination, tabular cross-stratification (Sx) and high-angle inclined stratification (Sp). Coversand deposits form the lags of medium- and fine-grained, moderately to well sorted and usually symmetricly skewed sands. The course of cumulative curves of grain size distribution represents a rare example of deposits which came from various sedimentary environments. The presence of subpopulations in saltation population (A) refers (Visher, 1969) to a

temporary changing transportation conditions, and steep inclination of the cumulative curves is most often characteristic to aeolian deposits (Mycielska-Dowgiałło, Ludwikowska-Kędzia, 2011; Kalińska, in print). Population of grains deposited from suspension (B) is slightly visible. Sediment population C is represented by two groups: (1) with steep inclination of the cumulative curves, which is observed in deluvial deposits, which transportation was triggered by splashing (Smolska, 2003) but also can characterize sediments with different depositional history (Mycielska-Dowgiałło, Ludwikowska-Kędzia, 2011), and group (2) with more gentle inclination of the cumulative curves which reflects the presence of coarser fractions transported by traction. Quartz grains of sand fraction (0.5 – 0.8) are characterized by frosted (matt) surface and three types of roundness: well-rounded – 0.7 – 0.9 in Krumbein (1941) roundness scale, and RM-type in Cailleux (1942) methodology, partially rounded (0.3 – 0.6; EM/RM) and non-rounded (0.1 – 0.2; NU/M). These characteristics refer to aeolian depositional environment. Great number of all types of matt grains indicates their formation under strong aeolian conditions. At the same time the dominance of non-rounded grains reflects their short transportation. Short-distance aeolian transport observed in western and northern Europe (Seppälä, 1972; Schwan, 1988; Käyhko et.al., 1999) was probably responsible for transformation of source sediments into aeolian coversands (Mycielska-Dowgiałło, 1993). Although a very short total duration of aeolian processes, it succeeded in forming distinct dunes. According to the varying contents of three types of matt grains and other types of grains (e.g. shiny, "beach-like" grains), phases with higher and lower intensity of aeolian processes may be distinguished. A higher content of shiny, non-rounded quartz grains (NU/L) are noted in Kanči site (up to 21%) and in some parts of Silezers (up to 29%) and Smilškalni (up to 20%) sections. These grains are firmly connected with the fluvial ("water") environment and were incorporated into coversand from the adjacent areas. The presence of the phases reflecting different intensity of aeolian processes is also confirmed by the variation in mineral composition of sediments. Among light minerals in the 0.5 – 0.8 mm fraction, quartz, feldspars and micas have a particular value in interpretation of genesis. Feldspar is characterized by low resistance to mechanical abrasion, hence its impoverishment in deposits transformed through aeolian processes is observed (Kobojek, 1997). Relatively great number (up to 30%) of feldspars noted in sediments of all sites confirms short duration of aeolian processes. Minerals with a lamellar structure like muscovite or biotite are first eliminated during aeolian processes and their concentration decreases gradually in the repeatedly reworked deposits (Krzyszkowski, 1993). Presence of the mica-group minerals in some parts of Kanči (up to 8%) and Silezers (up to 8% in the whole profile and 81,4% at the depth of 3.0 m) sites may refer to more humid areas e.g. floodplains, where micas were intercepted by water. Hence, some parts of the studied profiles point on fluvio/niveoaeolian origin of the sediments.

The study was funded by the Postdoctoral Research Grant ERMOS (FP7 Marie Curie Cofund the "People" programme) "Age and climatic signature of coversands deposits distributed on glaciolacustrine basins along the Scandinavian Ice Sheet margin southeast of the Baltic Sea".

References

[1] *Folk, R.L., Ward, W.,* 1957. Brazos River bar: A study in the significance of grain size parameters. Journal of Sed. Petrol., 27, 3-26.

[2] *Kalińska, E.,* in print. Geological setting and sedimentary characteristics of the coversands distributed in the western part of the Błonie glaciolacustrine basin (Central Poland) – preliminary results. Bull. of the Geol. Soc. of Finland.

[3] *Käyhko, J. A., Worsley, P., Pye, K., Clarke, M.L.,* 1999. A revised chronology for aeolian activity in subarctic Fennoscandia during the Holocene. Holocene, 9(2), 195-205.

[4] *Kobojek, S.,* 1997. Zawartość skaleni w utworach neoplejstoceńskich okolic Częstochowy. Acta Univ. Lodz., Folia Geogr. Physica, 1, 196-202.

[5] *Krzyszkowski, D.,* 1993. The Warthanian Siedlec Sandur southwards the Trzebnica Hills, Silesian Lowland, Southwestern Poland: re-examination after fifty years. Eiszer. u. Gegenwart, 43, 53-63.

[6] *Mycielska-Dowgiałło, E.,* 1993. Estimates of Late Glacial and Holocene aeolian activity in Belgium, Poland and Sweden. Boreas, 22, 165-170.

[7] *Mycielska-Dowgiałło, E. , Ludwikowska-Kędzia, M.,* 2011. Alternative interpretations of grain-size from Quaternary deposits. Geologos, 17(4), 189-203.

[8] *Schwan, J.,* 1988. The structure and genesis of Weichselian to early Holocene aeolian sand sheets in Western Europe. Sedim. Geology, 55, 197-232.

[9] *Seppälä, M.,* 1972. Location, morphology and orientation of inland dunes in northern Sweden. Geogr. Ann., 54A, 85-104.

[10] *Smolska, E.,* 2003. Cechy deluwiów na przykładzie osadów stokowych pagórka w okolicy Łopuchowa na Pojezierzu Suwalskim. In E. Smolska, P. Szwarczewski editors: Cechy teksturalne osadów stokowych i fluwialnych. Prace i Studia Geogr., 22, 45-57.

[11] *Visher, G.S.,* 1969. Grain size distribution and depositional processes. Journal of Sed. Petrol., 39, 1074-1106.

[12] *Zelčs, V., Markots, A., Nartišs, M. and Saks, T.* 2011. Pleistocene Glaciations in Latvia. In J. Ehlers, P.L. Gibbard and P.D. Hughes, editors: Developments in Quaternary Science, Vol. 15, Amsterdam, The Netherlands, pp. 221-229.

EXAMINATION OF THE MICRO FABRIC OF LATE WEICHSELIAN TILL FROM WESTERN LATVIA

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In the last decades the micromorphology is an established tool in the glacial geology (e.g. Phillips et al., 2011). Large size thin sections from glacial tills are prepared on the routine basis and examined under the polarised light, stereo or electron microscopes. However the terms used to describe the till micromorphology are largely subjective and statistically based approaches are rare. Here a method is presented to analyse the till microfabric, by measuring elongated sand grains visible in the thin section. As a result large microfabric data set is obtained and visual analysis as well statistical of the micro fabric distribution can be performed.

The apparently elongated sand grains are indentified and measured using freely available image analysis tools in the digital images of the thin sections. The micro fabric data are processed similarly to the till macro fabric data. The micro fabric measurement results is visualised as a grid of diagrams and statistical parameters, are calculated for each diagram. The microfabric data is visualised using data density plots (Fisher et al., 1985) and summary orientation and fabric strength is calculated according to two-dimensional eigenvalue method (Thomason and Iverson, 2006). Using this method micro fabric strength and orientation variations in a resolution as fine as 1 mm can be examined (figure 1).

Late Weichselian till from Western Latvia is studied. Large variations in spatial distribution of fabric strength and its preferred orientation are observed. Several micro fabric spatial distribution types are distinguished: strong monomodal and uniform distribution; weak and in small distances highly variable distribution; consistently bimodal distribution and domain-like pattern of preferred sand grain orientation.

It is suggested that the presented approach can be readily used to identify the till formation processes, especially those active during the last stages of the till formation. It is noted that the micro fabric is significantly influenced by the larger grains. As the till is heterogonous sediment, the source of observed micro fabric pattern can be somewhere outside the section plane. To minimise this uncertainty it is suggested to consider only the cases when the inducer of micro fabric perturbations is clearly identified, e.g. the thin section is cut across a gravel grain. Additionally, statistically based approach is needed and large number of cases shall be examined.

Theoretical considerations and practical observations suggest that the elementary processes

such particle lodgement, simple-shear with rotating or non-rotating gravel grains, pure shear (vertical compaction, e.g. melt out) and sedimentation in a still water environment can be easily identifiable by this approach.

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References

[1] *Fisher N. I., Huntington J. F., Jackett D. R., Willcox M. E. and Creasey J. W.,* 1985. Spatial analysis of two-dimensional orientation data. Mathematical Geology, 17 (2), 177-194.

[2] *Phillips, E., van der Meer, J.J.M. and Ferguson, A.,* 2011. A new 'microstructural mapping' methodology for the identification, analysis and interpretation of polyphase deformation within subglacial sediments, Quaternary Science Reviews, 30 (19-20), 2570-2596.

[3] *Thomason J.F. and Iverson N.R.,* 2006. Microfabric and microshear evolution in deformed till. Quaternary Science Reviews, 25 (9-10), 1027–1038.

RELIEF OF SKEIÐARÁRJÖKULL END MORAINE AT GIGJUKVISL GAP, ICELAND

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Skeiðarárjökull is an outlet glacier streaching from the vast ice–cap of Vatnajökull Glacial, with a surface area of 8100 km2. The average thickness of the Vatnajökull ice reaches 400 m, with a maximum of 1000 m. The width of the Skeiðarárjökull is about 22 km at it's end. A distance of 23 km separates the end of the glacier and Atlantic Ocean. In 1993, after the advance of Skeiðarárjökull glacier in 1991, its steep snout in the western part was situated at a distance of 2,5–2,7 km to the north of the end moraines indikating the maximum distribution of the glacier at the end of the 19th century (Wiśniewski, Andrzejewski, Molewski, 1997). After 1993, the steep of the glacier snout began to flatten and retreat. This process is still going on today. On 5-7 November 1996, as a result of a several–hour–long jökulhlaup (a term jökulhlaup implies a glacial outburst flood. This Icelandic term has been adopted by the English language), large changes took place in the glacial relief of the marginal zone of Skeidararjökull Glacier (Figure 1).

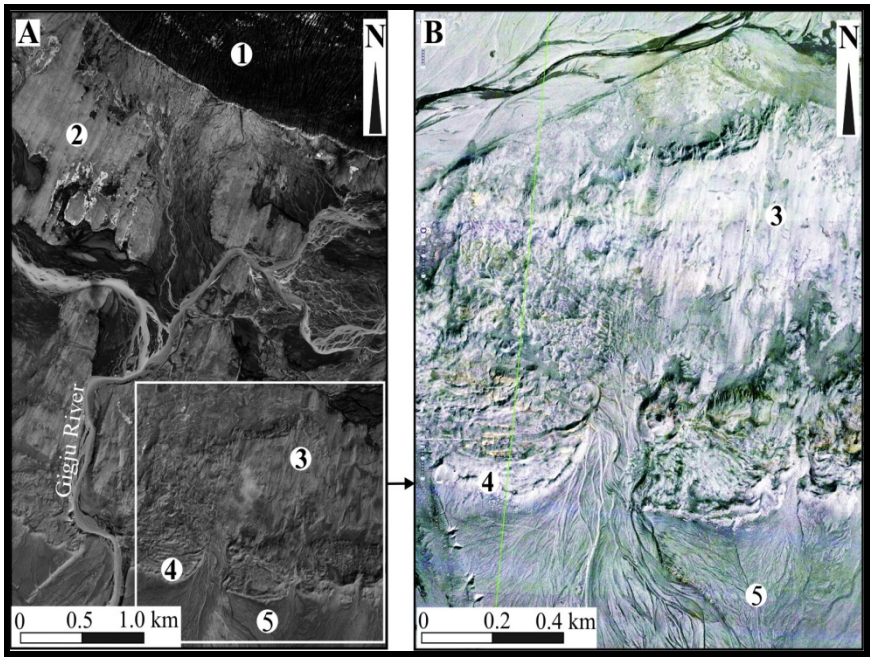

Fig. 1. A fragment of Skeiðarárjökull marginal zone with the gap of Gigju river gap crossing the end moraines: a) aerial photograph 7/8 1992, b) montage of the aerial photographs after the catastrophic jökulhlaup in 1996. 1 – glacier, 2 – drumlinised ground moraine, 3 – drumlinised forms on the hinterland of the end morains, 4 – end moraine, 5 – Skeiðarársandur.

In 2011 survey of the relief and geological structure of the deposits in the Skeidarįrjökull marginal zone streaching along the Gigju river gap was carried out. Detailed analysis of the geological structure of the deposits was carried out on the western slope of the gap whereas tye and geomorphological survey applied on the eastern slope of the gap. As a result of the erosional activity of the meltwater the surface of ground and undulating moraine islands was reduced, and some were completely washed away. At the same time the area of older, drumlinised glacial relief indicated on the proximal side of the end moraines and dated back to the end of the 19th century, was reduced. Subsequently a proglacial lake occured (Figure 2).

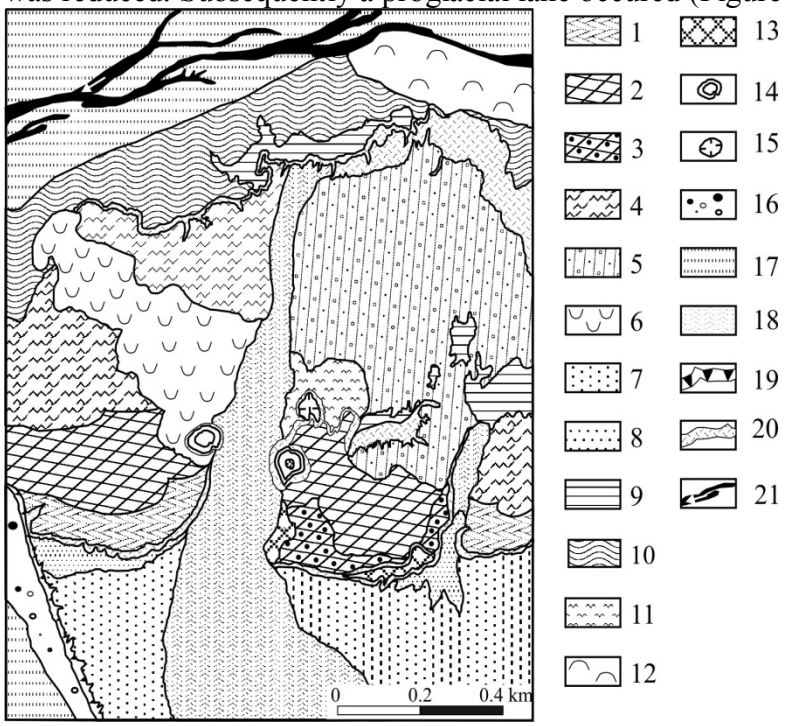

Fig. 2. Preliminary geomorphological sketch of the area in the vicinity of the Gigjukvisl gap after the catastrophic jökulhlaup in 1996: 1 – position of terminal moraines dated back to the end of the 19th century, 2 – marginal moraines, 3 – erosion marginal moraines, 4 – hummocky moraine, 5 – drumlinized ground moraine, 6 – pitted sandur, 7 – older marginal outwash plains, 8 – fans, 9 – the plains of the ice–dammed proglacial lake, 10 – the plains of the proglacial lake with the kettle holes, 11 – kame terrace, 12 – fluvioglacial terrace, 13 – erosion terrace, 14 – kame, 15 – glaciokarst hole, 16 – the kettle holes formed after the retreating of the ice bloks transported to the alluvial plains by the 1996 jökulhlaup, 17 – alluvial plains, 18 – dry braided stream channel plains, 19 – slopes formed as a result of erosion by waters during jökulhlaup, 20 – slopes, 21 – direction of the water flow.

The end moraine exposed at the Gigjukvisl gap is composed of the deposits formed of the melted-ice, glaciofluvial, glaciolacustrine, mass–transport and probably other facies related to terminoglacial and proglacial sub-environments.

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References

[1] *Wiśniewski, E., Andrzejewski, L., Molewski, P.,* 1997: Fluctuations of the snout of Skeiðarárjökull in Iceland in the last 100 years and some of their consequences in the central part of its forefield. Landform Analysis 1, 73–78.

PALAEOENVIRONMENTAL CHANGES, CYCLICITY AND DYNAMICS DURING QUATERNARY WARM PERIODS IN LITHUANIA

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The aim of the project "Ciklas" is analysis and modelling of cyclicity and dynamics of palaeoenvironmental changes during Quaternary warm periods in long-term perspective.

For the successful achievement of the aim the following problems need to be solved:

1 – to describe the palaeoenvironmental (palaeogeomorphological, palaeoclimate and its causes) changes during Quaternary warm periods in key sections;

2 – to compare the palaeoenvironmental changes of the Quaternary warm periods and factors causing them;

3 – to assess the differences of Quaternary warm periods cyclical nature and dynamics in the context of regional and global processes.

The sediments of 5 Quaternary warm periods from 9 sections, mainly interglacials, were selected for the investigations. They are: Daumantai, Šlavė, Butėnai, Snaigupėlė, Netiesos outcrops and Vindžiūnai-136, Kudrė-915, Jonionys-938, Snaigupėlė-705 boreholes sections. Complex proxies of geochemical, radioisotopic, palaeomagnetic, magnetic susceptibility, palaeobotanical and palaeogeomorphological studies will be applied to establish the cyclicity and dynamics of palaeoenvironmental changes and compile their models for the assessing their impact on patterns of species migration, invasion and adaptation.

The main features of the cyclicity of Quaternary warm periods in time and regional scale were described finding out and using the most informative biological, geochemical and magnetic susceptibility indicators. Peculiarities of the vegetation development and their causing main natural factors were established as well. Also the possibilities of the use of mire biological and geochemical indicators of the environmental changes in older Quaternary warm period (interglacial) investigations were studied.

The authors are grateful to the Research Council of Lithuania for support of the project "Ciklas"(reg. No LEK-12007) and to a large working team for assistance in implementation of the project.

KAME TERRACES AS AN INDICATOR OF CONDITIONS OF DEGLACIATION IN LITHUANIA DURING THE LAST GLACIATION

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Over the recent years, while executing the geological mapping of the North Lithuanian territory at a scale of 1:50 000, an attention have been given a new geological material on the structure of the Pleistocene strata deposits and formation peculiarities of kame terraces in Lithuania is presented. The kame terraces formed between dead ice blocks and the external (with respect to the glacier lobe), i.e. distal slopes of the marginal morainic ridges left by glacier lobes of the Last (Upper Nemunas, Late Weichselian) Glaciation. The kame terraces have been subdivided into the glaciofluvial (sand, gravel) and glaciolacustrine (clay, silt) according to their lithological composition. The kame terraces adjoining the distal slopes of the recessional marginal morainic ridges of the Last Glaciation have been found and examined. The origin of these terraces could be explained only by the hypothesis that the accumulation of the above-mentioned marginal ridges and kame terraces took place between the margin of active ice lobes and the blocks of dead ice (Fig.1.)

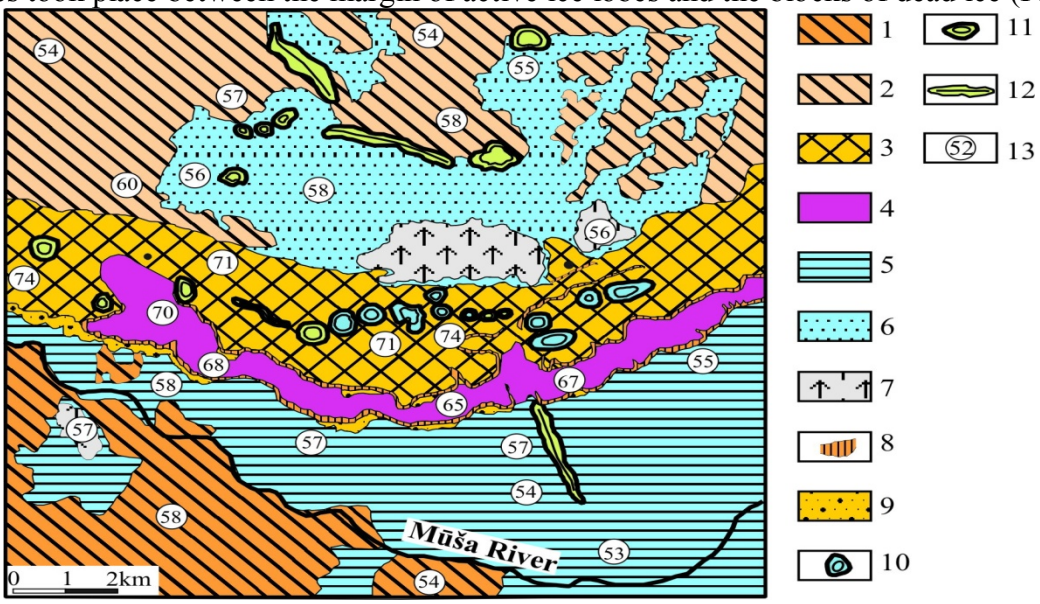

Fig.1. Fragment of geomorphological scheme of marginal morainic ridge and glaciolacustrine kame terrace of Linkuva area. 1 - basal till plain of Middle Lithuanian phase; 2 - basal till plain of North Lithuanian phase; 3 - marginal morainic ridge; 4 - glaciolacustrine kame terrace; 5 - glaciolacustrine plain of ice-dammed lake of Middle Lithuanian phase; 6 - glaciolacustrine plain of ice-dammed lake of North Lithuanian phase; 7 - moor plain; 8 - steep slope; 9 - solifluction sheet; 10 - glaciolacustrine kame; 11 - glaciofluvial kame; 12 - esker; 13 - prevailing altitude of relief, in metres.

Supposing that when the glacier of the Last Glaciation was melting, it was the arial and not the frontal deglaciation that was definitely dominating. The cold periods of glacier activation (so-called stadials and phasials) were changed with warmer periods. However, the latter periods were too cold and too short that the territory could be deglaciated completely, that is why they cannot be interpreted as interstadials or interphasials according to the climatostratigraphic criterion.

NATURAL AND ARTIFICIAL GROUNDWATER LEVEL CHANGES AND THEIR EFFECT TO THE SLOPE STABILITY IN PÄRNU AREA, WESTERN ESTONIA

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Ground water level (pore pressures) fluctuations are widely accepted as one of the major landslide trigger. In order to measure pore pressures and record variability during the hydrological year ten automatic piesometers were installed in quasi-stable slopes in south-western Estonia. Piesometers were deployed in vertical clusters, six in clayey slope in Sitsi test site and four in sandy Tammiste test site. Two test sites show different pore pressure distribution and response to the external parameters, explained by different hydrogeological setting. Pore pressures values, meteorological and hydrological data were analysed with non-parametric correlation and cluster analysis in order to quantify the influence of external parameters to the pore pressures. Changes of external boundary conditions generate larger and faster pore pressure changes in the clayey slope, whereas pore pressure fluctuations penetrate deeper into the sandy slope. Temperature has the greatest effect to the pore pressures via evapotranspiration and phase change of the precipitation (snow accumulation and thaw). Data from 51 groundwater monitoring wells, covering the period from 1960 to 2009, were analysed in order to evaluate long-term changes of the artesian aquifer, underlying quasi-stable slopes. The development (1960 – 1988), refilling (1988 – 2009) and movement (1988 – 2009) of the consumption-generated groundwater depression are evident from this analysis.

Pore pressure field was interpolated with finite element groundwater model and used as an input for slope stability model. Spencers method, one of the limited equilibrium methods was used for slope stability modelling. Therefore we can quantify seasonal and long-term changes of the slope stability and those models also allow modest possibility to estimates the influence of the ongoing climate change to the slope stability in western Estonia.

Climatic analyses have shown that the precipitation has approximately 30 year cycle in Estonia and currently is at the peak of one of this cycle. In south-western Estonia precipitation has risen ca 25 % during the 1960 to 2000 period. Those conditions support high background level of the pore pressures and also amplify the influence of extreme events, like severe rainstorms. Concurrently amount of both extremely dry and wet days have risen during the period 1957-2006. Elongated dry periods may cause further dehydration of the uppermost part of the varved clay. Dehydration causes decrease of the clay volume (shrinkage) and therefore formation or deepening of the water-conductive (micro)crack system . Extremely rainy days cause rapid rise of the pore pressures in clayey slopes near Sauga River, sandy slopes near Pärnu and Reiu River are less sensitive. However, as sandy slopes conduct water relatively well, they are also in danger of seepage erosion that itself can lead to slope failures. Climate change in Estonia manifests mostly by rising temperatures and increasing precipitation in spring and winter. This causes generally thicker snowcover and earlier, probably more intensive spring thaws followed by higher pore pressures in soil due to infiltration and increasing erosion in river channels due to run-off.

SEDIMENTOLOGY AND FACIES ARCHITECTURE OF LATE GLACIAL ALLUVIAL SEDIMENTS OF THE RIVER MIEGUPE, NORTH VIDZEME, LATVIA

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The main outlines of the drainage network in Latvia result from the retreat of the last Scandinavian Ice Sheet. Studies of the evolution of the largest river valleys and their comprehensive geomorphological analysis started in sixties and early seventies of the last century (Majore, 1962; Āboltiņš, 1971; Eberhards, 1972; Veinbergs, 1975). Later on major focus was directed to modern alluvial processes (Eberhards, 1984). Geological and geomorphological research in smaller valley forms was not systematic and paid less attention.

The River Miegupe drainage basin is located in Northern Vidzeme lowland. The River Miegupe itself is left bank tributary of the River Gauja that occupies the proglacial spillway valley. The River Miegupe crosses the Trikata drumlin area. It starts N of the Starti village, in Priekuļi district. So far detailed studies of morphology and evolution of this river valley were not performed.

Geological and geomorphological field works were carried out in the the River Miegupe valley and its adjoing area. The field observations were aimed at detection and mapping of river terraces, fixing of gullies and tributaries. In order to revealing the internal structure of terraces hand-drilled geological boreholes were made, lithological composition and textures of sediments were studied, and facies analysis of the sediment units was performed in several outcrops. In three outcrops detailed studies of sediment lithofacies were resulted in numerous sedimentary logs and photomosaics. The lithofacies were indicated by a slightly modified lithofacies code (Miall, 1978; Eyles et al., 1983; Wysota, 2002). Geospatial attraction of boreholes, outcrops and profile lines was fixed by high-precision GPS receiver. The detailed environmental reconstruction was based on all available data combined into facies description and interpretation. Genetic classification of sediments, contacts of layers between them and lithofacias were described using generally recognized methods (Zieliński, 1995; Zieliński, 1998; Jones et al, 2001). From Lejas Briški palaeobasin, situated in the River Miegupe middle course samples of plants were collected to determine macroscopic remains and their possible age using AMS 14C method. Using GIS software ArcMap 10 and information on recent surface topography derived from topographic maps at scale of 1:10,000 digital terrain model of the River Miegupe valley, its longitudinal profiles were created and spatial distribution of the fluvial terraces and the major stages of the valley development were revealed.

In the upper reaches the River Miegupe has shallow valley without clearly expressed morphological features. Besides up to the village of Mūrmuiža the course of the river is straightened and represents excavating ditch. In upper reaches river flows in north-east. Near the village of Jaunvāle it sharply turns west and accepts a right tributary, the Grūžupe, then its flow changes in south-west. From Mūrmuiža to the Grūžupe tributary a depth of the valley varies from 7 m to10 m. In the downstream direction up to the confluence point with the Gauja spillway valley the depth of the Miegupe valley gradually increases reaching almost 20 m. In the River Miegupe valley from its headwaters up to middle course two river terraces can be distinguished. The surface relative height of both terraces steadily increases in the downstream direction. A relative elevation of Terrace MII along upper reaches is 4-5 m, but in lower reaches it increases up to 5-6 m. Topographically it can be correlated with Terrace III of the River Gauja. Near the Sapas Mills it has an absolute height of 40-41 m a.s.l. It should be mentioned, that near sanatorium ”Līči” in Terrace III of the River Gauja below floodplain alluvium macroscopic plant remains were found. Accumulation of these plant remains occurred as early as 10,535±0,25 (Ri-33) and 10,282±0,25 (Ri33A) 14C years BP (Stelle et al., 1975a, b). A relative height of Terrace MI of the River Miegupe along upper reaches is 3-4 m, increasing up to 4-5 m downstream. Terrace MI ends in a sand pit near the estuary of the River Miegupe. According to topographical data Terrace MI correlates with Terrace II surface of the

River Gauja. Formation of Terrace II of the River Gauja is associated with BglIIIb phase shoreline of the Baltic Ice Lake (Āboltiņš, 1971). Besides terraces MI and MII the local terrace along the River Miegupe is detectable at a distance of 550 m. Its relative height varies from 3 to 3.5 m. Topographically this local terrace can be correlated with Terrace I surface of the River Gauja that formation corresponds to Littorina Sea transgression. The River Miegupe floodplain is 5-12 m wide and well expressed. In a height of 1.5 m a high local floodplain is traced between the tributary of Bērkupīte and the Miegupe estuary in Gauja.

In the section that outcrops on the right bank of Miegupe, 700 m upstream from Cēsis - Valmiera highway bridge Terrace MII sediments underlie interlayered glaciolacustrine fine- to medium grained sand, aleurite, aleurite with clay admixture. Thickness of glaciolacustrine sediments reaches 3 m. At the lower part of the glaciolacustrine sequence 0.6 m thick layer of scattered macroscopic and microscopic remains of plants was found. According to analyis performed by Aija Ceriņa (pers. communication), sediment saturation with plants is insignificant. In total content of plant remains are notable leaves of Dryas octopetala, also there have been encountered some leaves of Salix polaris and Salix herbacea, and separate Carex and Betula nana nuts. Since there were not found any seeds of water plants it is most likely that macroscopic remains of plants were washed from the shore adjacent to basin area. Still unanswered question about age of these plant remains. It is probably the same age as mentioned findings at the sanatorium "Līči" (Ābolkalns et al., 1960; Stelle et al., 1975a, b). According to O. Āboltiņš (1971) opinion, the real age could be greater because lithological composition of Terrace III of Gauja downstream Miegupe estuary shows that lower part of alluvium could conform to the second part of Allerød. Formation of Terrace III of the River Gauja correlates with BglII stage transgression shoreline of Baltic Ice Lake (Grīnbergs, 1957; Āboltiņš, 1971).

References

[1] *Ābolkalns, J., Majore, M. and Stelle, V.,* 1960. Driasa floras atliekas Gaujas ielejas trešās virspalu terases nogulumos. Latvijas PSR ZA Vēstis, 8 (157), 99 - 107.

[2] *Āboltiņš, O.,* 1971. Razvitije dolini reki Gauja. Zinatne. Riga, 105 pp.

[3] *Eberhards, G. and Miidel, A.,* 1984. Main features of the development of river valleys in the East Baltic. Proceedings of the Academy of Sciences of the Estonian SSR. Geology, 33, 136 – 145.

[4] *Eberhards, G.,* 1972. Stroenie i razvitie dolin bassejna reki Daugava. Zinātne, Rīga, 131 pp.

[5] *Eyles, N., Eyles, C.H. and Maill, A.D.,* 1983. Lithofacies, types and vertical profile models; an alternative approach to the description and environmental interpretation of glacial diamict and diamictive sequences. Sedimentology, 30, 393 - 410.

[6] *Grīnbergs, E.,* 1957. Pozdnelednikovaja i poslelednikovaja istorija poberezja Latvijskoj SSR. Rīga, 122 pp.

[7] *Jones, S.J., Frostick, L.E. and Astin, T.R.,* 2001. Braided stream and flood plain architecture: the Rio Vero Formation, Spanish Pyrenees. Sedimentary Geology, 139, 229 - 260.

[8] *Majore, M.,* 1962. Daugavas ielejas attīstība. Latvijas valsts izdevniecība, Rīga, 76 pp.

[9] *Miall, A.D.,* 1978. Lithofacies types and vertical profile models in braided river deposits: a summary. In: Miall, A.D. (ed.), Fluvial Sedimentology. Canadian Society of Petroleum Geologists Memoir, 5, 597 - 604.

[10] *Stelle, V., Savvaitov, A.S. and Veksler, V.S.,* 1975a. Datirovaniye pleystotsenovykh otlozheniy na territorii Latvii. In: Savvaitov, A.S. and Veksler, V.S. (eds), Opyt i metodika izotopno-geokhimicheskikh issledovaniy v Pribaltike i Belorussii. Riga, 80 - 81.

[11] *Stelle, V., Veksler, V.S. and Āboltiņš O.,* 1975b. Radiouglerodnoye datirovanije allyuvialnykh otlozheniy srednego techeniya reki Gauyi. In: Savvaitov, A.S. and Veksler, V.S. (eds), Opyt i metodika izotopno-geokhimicheskikh issledovaniy v Pribaltike i Belorussi. Riga, 87 - 88.

[12] *Veinbergs, I.,* 1975. Formirovaniye Abavsko- Slotzyenskoy sistyemi dolin stoka talix lyednikovix vod. In: Danilāns, I. (ed.), Voprosi chyetvyertichnoy gyeologii. Zinatne, Riga, 82 – 101.

[13] *Wysota, W.,* 2002. Stratigrafia i środnowiska sedimentacji zlowacenia wisly w południowej części dolnego Powiśla. Universytet Mikołaja Kopernika w Toruniu, Toruń, 144 pp.

[14] *Zieliński T.,* 1998. Litofacjalna identyfikacja osadów rzecznych (Lith o- facial dentification of alluvial sediments). In. Mycielska- Dowgiałło E. (ed.), Struktury sedymentacyjne i postsedymentacyjne w osadach czwartorzędowych i ich wartość interpretacyjna (Sed i- mentological and postsedimentological structures in Quaternary sediments and their value for interpretation) Wydział Geografii I Studiów Regionalnych Un i wersytetu Warszaw skiego, Warszawa, 195 - 257.

[15] *Zieliński, T.,* 1995. Kod litofacjalny i litogenetyczny — konstrukcja i zastosowanie. In: Mycielska-Dowgiałto, E. and Rutkowski, J. (eds), Badania osadow czwartorzedowych. Wybrane metody i interpretacja wynikow). Wydział Geografii i Studiow Regionalnych Uniwersytetu, Warszawskiego, 220 – 235.

NEW POSSIBILITIES FOR THE ^{230}TH/U METHOD IN DATING BURIED TRAVERTINE AND WOOD

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The ^{230}Th/U radioisotope dating method may be applied to Holocene and Neopleistocene Interglacial (Interstadial) deposits in the range from 1-2 to 300-350 kyr. Age data for a number of buried peat and gyttia samples, as well as travertine and wood, have already been obtained [1-12]. Some of these dates are disputable, however, so it is increasingly vital to obtain reliable ^{230}Th/U ages for further palaeogeographical, palaeoclimatic, and stratigraphic reconstructions. For this purpose, we applied both the ^{14}C and ^{230}Th/U dating methods in a complex geochronological study of buried travertine and wood.

Our geochronological study focused first on a buried, freshwater carbonate layer of biogeochemical origin from a travertine deposit within the Izhora plateau (Leningrad Province, North-Western Russia). The thickness of this carbonate massif is abnormally great relative to similar deposits on the Izhora plateau. Its maximal thickness is about 7.6 meters, over an area of about 2.5 kilometers length and about 300 meters width.

We determined U and Th isotope abundances in five samples from the uppermost, middle, and bottom part of a 1-meter travertine section exposed in a quarry near the Pudost railway station. Similar analyses were also carried out on the same layer in coastal deposits of the Izhora River near Antelevo village. We then obtained ^{230}Th/U dates for travertine samples from both sites, as well as ^{14}C and ^{230}Th/U dates for underlying peat deposits and wood remains in the Antelevo Site. The ^{14}C method was not applied to travertine samples due to contamination by "dead" (ancient) carbon from Pre-Quaternary, Ordovician carbonate formations.

Travertine samples from the Pudost Site contained a negligible concentration of ^{232}Th, which indicated the absence of contamination by ancient mineral detritus. Each direct (conventional) ^{230}Th/U date from 6.8±0.4 kyr at the top to 7.5±0.4 kyr at the base also corresponded to the stratigraphic sequence. Travertine samples from the Antelevo Site contained a measurable concentration of ^{232}Th, which artificially inflates the model ^{230}Th/U age. Therefore, we applied the isochron method [1-7] for the correction of direct ^{230}Th/U dates and calculated an age of 6.8±0.5 kyr for the travertine layer from the Antelevo Site. The ^{230}Th/U dates of travertine layers from both the Pudost and Antelevo Sites are in good agreement and confirm the assumption of their simultaneous formation. In addition, ^{14}C dates of 10.92±0.24 kyr (cal BP) and 10.94±0.23 kyr (cal BP), as well as a ^{230}Th/U date of 9.5±0.3 kyr obtained for the underlying peat and wood remains in the Antelevo

Site corroborate this conclusion, as well as the ^{230}Th/U ages of travertine deposits [10].

It is known that wood remains are often found in Middle and Late Pleistocene sediments. The first attempts to date Late Pleistocene wood remains in Eastern Canada by the ^{230}Th/U method were made in the mid-1980s [11], but subsequent applications were sporadic and not exhaustively developed [12].

The application of multiple independent methods to the dating of any sediment, in combination with radiometric dates of overlying sediments, allows us to increase the reliability of geochronological data significantly. Therefore, we applied both the ^{230}Th/U and ^{14}C methods to a buried larch trunk from the Lipovka Site (the Tobol River, Siberia). Detailed radiochemical analysis of layers from the edge to the central part of the trunk revealed that the system was closed geochemically—and thus suitable for the ^{230}Th/U method—only for inner horizon. Radiocarbon dates from 36.40 - 37.93 cal BP and ^{230}Th/U ages of 39.1±5.7 kyr and 40.3±3.9 kyr from the inner trunk horizon were in good agreement. These data are corroborated by ^{14}C-ages of other tree and plant remains from the same stratigraphic layer [8]. Retrospectively, these results confirm, to a certain degree, the reliability of our previously obtained ^{230}Th/U date for wood remains from the Antelevo Site.

Another object of our geochronological study was a subfossil trunk found in central Poland, within the middle section of the Warta River valley near Koźmin village. The well-preserved forest remains occur in an organic unit 0.5-0.3-meter thickness. The age of the organic unit formation and subfossil trunk, determined by the ^{14}C method, ranges between 13 870-13 450 cal BP and 12 940-10 660 cal BP [13, 14]. The results of radiochemical analysis of the trunk precluded application of the ^{230}U/Th method, since the trunk sample emitted a very low specific activity of U and Th isotopes and was contaminated by ancient mineral detritus. Future study of this subfossil trunk will include application of the isochron correction method as well as an increase in the weight and number of samples for dating. Such research is necessary to the development of a modernized approach of the ^{230}U/Th dating method to these complicated natural materials.

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References

[1] *Kuznetsov V.Yu. Radiokhronologia chetvertichnikh otlozheniy* (Radiochronology of Quaternary deposits). 2008. Saint-Petersburg. 312 p. (in Russian).

[2] *Heijnis H.* Uranium/Thorium dating of Late Pleistocene peat deposits in N.W.Europa. Rijksuniversitet Groningen, 1992. 149 p.

[3] *Geyh M.A., Miller H.* Numerical ^{230}Th/U dating and palynological review of the Holsteinian/Hoxnian Interglacial // Quaternary Science Reviews. 2005. Vol. 24. P. 1861-1872.

[4] *Kuznetsov V.Yu., Arslanov Kh.A., Alekseev M.N., Pisareva V.V., Chernov S.B., Maksimov F.E., Baranova N.G.* New age data of buried peat deposits from the Site “Fili Park” (Moscow, Russia) by the uranium-thorium dating and palynological analysis and its stratigraphic significance // Geochronometria. 2002. Vol. 21. P. 41-48.

[5] *Laukhin S.A., Arslanov Kh.A., Maksimov F.E., Kuznetsov V.Yu.* The first Early Interstadial of Zirianian traces (Early Würm) Glaciation in Siberia: U/Th date and palaeobotanical data // Geologija. 2007. No. 59. P. 47-58.

[6] *Razjigaeva N.G., Ganzey L.A., Grebennikova T.A., Belyanina N.I., Kuznetsov V.Yu., Maksimov F.E.*. Last interglacial climate changes and environments of the Lesser Kuril arc, north-western Pacific // Quaternary International. 2011. Vol. 241. P. 35-50.

[7] *Maksimov F.E., Kuznetsov V.Yu., Zaretskaya N.E., Subetto D.A., Shebotinov V.V., Zherebtsov I.E., Levchenko S.B., Kuznetsov D.D., Larsen E., Lyső A., and Jensen M.* The First Case Study of ^{230}Th/U and ^{14}C Dating of Mid-Valday Organic Deposits // Doklady Earth Sciences. 2011.

Vol. 438. Part 1. P. 598-602.

[8] *Maksimov F.E., Kuznetsov V.Yu., Laukhin S.A., Zherebtsov I.E., Levchenko S.B., Baranova N.G.*

On the application possibility of ^{230}Th/U method for dating of Neopleistocene buried wood // Bulletin of the Moscow society of naturalists. The Department of Geology. 2012. Vo. 87. No. 1. P. 46-54 (In Russian).

[9] *Mercier N., Hatte C., Fontugne M., Reyss J.-L., Valladas H., Wengler L., Brugal J.-P., Ouammou A., Weisrock A.* Chronology of Upper Pleistocene sequences at Sidi Messaoud (wadi Noun, southwestern Morocco) based on ^{14}C, optical and U-series dating // Quaternary geochronology. 2009. Vol. 4. P. 326-334.

[10] *Nikitin M.Yu., Medvedeva A.A., Maksimov F.E., Kuznetsov V.Yu., Zherebtsov I.E., Levchenko S.B., Baranova N.G.* Genesis and geological age of travertine carbonates from the Pudost Massive // Society, Environment, Development. 2012. No. 4. P. 231-236 (In Russian).

[11] *de Vernal A., Causse C., Hillaire-Marcel C. et al.* Palynostratigraphy and Th/U ages of upper Pleistocene interglacial and interstadial deposits on Cape Breton Island, eastern Canada // Geology. 1986. Vol. 14. P. 554-557.

[12] *Oschadleus H.D., Vogel J.C., Scott L.* Radiometric date for the Port Durnford peat and development of yellow-wood forest along the South African east coast // S. African. Journ. of Science. 1996. V. 92. P. 43-45.

[13] *Dzieduszynska D., Petera-Zganiacz J.* The Younger Dryas subfossil forest (Central Poland) // International Field Symposium "Late Pleistocene Glacigenic Deposits from the Central Part of the Scandinavian Ice Sheet to Younger Dryas End Moraine Zone". June 12 - 17, 2011. Kevo, Finland. P. 90-91.

[14] *Dzieduszyńska D., Petera-Zganiacz J., Krąpiec M.* The age of the subfossil trunk horizon in deposits of the Warta River valley (central Poland) based on 14C datings // Geochronometria. 2011. Vol. 38. 334-340.

К ВОПРОСУ О ГРАНИЦАХ РАСПРОСТРАНЕНИЯ НИЖНЕВАЛДАЙСКОГО ОЛЕДЕНЕНИЯ

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В ходе составления карты четвертичных отложений масштаба 1:1 000 000 по листу O-(35),36 (Псков, Петербург) (8) вновь возник вопрос о границах распространения и масштабах оледенений в позднем неоплейстоцене. Несмотря на практически повсеместное распространение и достаточно высокую изученность отложений валдайского надгоризонта на данной территории, вплоть по настоящее время среди исследователей существуют значительные разногласия по данной проблеме. В первую очередь это касается вопросов о границе распространения ранневалдайского (подпорожского) оледенения и наличии его морены в пределах листа. Нет также единства мнений по поводу того, какой из валдайских ледниковых надвигов был максимальным – ранне- или поздневалдайский. Спорной также является и проблема дробности расчленения валдайского надгоризонта. Значительные разногласия остаются также в области палеогеографических реконструкций.

На карте предыдущего издания (1) в составе нижневалдайского горизонта были представлены отложения лишь озёрного генезиса. Выделенный же на ряде карт четвертичных отложений масштаба 1:200 000 (по данной территории) комплекс нижневалдайских ледниковых и водно-ледниковых образований был отнесен к московскому либо осташковскому горизонтам.

В ходе работы по составлению карты, при изучении материалов предыдущих исследований выяснилось, что имеющиеся многочисленные данные о наличии на данной территории подпорожской морены, приведённые И. И. Красновым, Е. П. Зарриной, Д. Б. Малаховским, И. В. Котлуковой, Е. А. Спиридоновой и другими исследователями (2-7, 9-11), не были доказательно опровергнуты. В связи с этим, однозначно говорить об отсутствии на данной территории подпорожской морены нельзя. Наличие в пределах Молого-Шекснинской низменности разрезов с отложениями ленинградского горизонта не перекрытых мореной, также свидетельствует о том, что поздневалдайское оледенение не выходило за пределы конечно-моренного комплекса вепсовской стадии (10). В подготовленной к изданию карте четвертичных отложений масштаба 1:1 000 000 по листу О-(35),36 (Псков, Петербург) принята концепция, отраженная В. Г. Легковой и В. Г. Ауслендером в «Карте четвертичных отложений Северо-Запада Российской Федерации масштаба 1:500 000, 1994 г.» (10), а также Е. П. Зарриной, Д. Б. Малаховским и И. И. Красновым, Спиридоновой Е. А. (4, 5), согласно которой граница осташковского оледенения фиксируется вепсовским конечно-моренным поясом, а подпорожское оледенение распространялось далее, на восток и юго-восток за кромку листа.

Литература

[1] Геологическая карта СССР. Масштаб 1:1 000 000 (новая серия). Лист О-(35),36-Ленинград. Объяснительная записка. / Отв.ред. Яновский А.С. Л, 1989 г.

[2] Геологическая карта СССР масштаба 1:200 000. Серия Тихвинско-Онежская. Лист О-36-XVI. Объяснительная записка. Буштуев А.Г., Котлукова И.В. / ред. Семененко Л.Т., Никитин М.Р., М., 1968.

[3] Геологическая карта СССР масштаба 1:200 000. Серия Ильменская. Лист О-35-XII. Объяснительная записка. Скворцова А.А., Насонова Л.Д. / ред. Кириков В.П.. Л., 1982.

[4] *Зарина Е.П., Краснов И.И., Малаховский Д.Б., Спиридонова Е.А.* Климатические ритмы позднего плейстоцена (Северо-Запад и Центр Европейской части СССР). // Палеоклиматы и оледенения в плейстоцене. М. 1989. С. 47-58.

[5] *Заррина Е.П.* Четвертичные отложения Северо-Западных и Центральных райнов Европейской части СССР. Л. 1991.

[6] *Шульц С.С., Можаев Б.Н., Можаева В.Т.* и др. Судомская возвышенность. Геолого-геоморфологический очерк. М.- Л. 1963, С. 120.

[7] *Апсит Э.В.* и др. Геологическое строение и гидрогеологические условия северо-восточной части Валдайской возвышенности». Отчёт о геолого-гидрогеологической съёмке масштаба 1:200 000 листа О-36-XXII. Л. Фонды ВСЕГЕИ. 1961.

[8] *Свириденко М.М., Вербицкий В.Р., Кямяря В.В., Кротова-Путинцева А.Е. и др.* Геологический отчет о результатах работ по объекту: «Создание комплектов государственных геологических карт масштаба 1:1 000 000 по Северо-Западному, Уральскому, Западно-Сибирскому, Средне-Сибирскому и Дальневосточному регионам». СПб. 2010.

[9] *Гречко Ю.И., Малаховский Д.Б., Полуэктова Т.А. и др.* Отчет о комплексной геолого-гидрогеологической съёмке в верхнем течении р. Ловать (район г. Великие Луки) масштабов 1:200 000 и 1:50 000. СПб. Фонды ВСЕГЕИ. 1964.

[10] *Легкова В.Г., Ауслендер В.Г., Щукин Л.А., Москаленко П.Е.* Карта четвертичных отложений Северо-Запада РФ. Масштаб 1:500 000. Объяснительная записка. СПб. Фонды СЗРГЦ. 1994.

[11] *Саммет Э.Ю., Скворцова А.А., Насонова Л.Д. и др.* Отчет о результатах геологического доизучения в масштабе 1:200000 территории листов О-35-XXIX, XXX, О-36-XXV, XXVI, проведенного Новоржевским отрядом Псковской партии за 1979-1982 г. Л. Фонды ВСЕГЕИ. 1982.

SUBGLACIAL BEDFORMS OF THE ZEMGALE PALAEO-ICE LOBE, CENTRAL LATVIAN LOWLAND, SE BALTIC

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The Central Latvian Lowland (CLL) represents glaciated lowland of the divergent type because in general it widens in the direction of regional ice movement that caused divergent flow in the Zemgale palaeo-ice lobe (Zelčs, 1993). The subglacial bedform assemblage in CLL mainly consists of divergent drumlin fields as Vadakste, Zemgale and Iecava (Zelčs, 1993; Zelčs et al., 1990), Madliena drumlin field (Lamsters, 2011; in press) with more convergent ice flow pattern, and of ribbed moraines classified as Zemgale ribbed moraines (Zelčs, 1993; Zelčs & Dreimanis, 1998).

The Vadakste and Madliena drumlin fields were formed by the Zemgale paleo-ice lobe (ZPL) of the Riga ice stream during oscillatory retreat of the Late Weichselian Scandinavian Ice Sheet in the Middle Lithuanian glacial phase (MLGP) that is locally termed as the Gulbene phase and correlated with the Haanja phase in Estonia (Zelčs et al., 2011). It is assumed that areal deglaciation was more common during ice retreat from MLGP due to good preservation of drumlins and absence of superimposed glacial landforms that are characteristic to frontal deglaciation. Ice retreat from MLGP was replaced by the reactivation of ZPL in the North Lithuanian glacial phase that is locally termed as the Linkuva and correlated with the Ottepaa/Sakala ice-marginal formation in Estonia (ibid). During this activation Linkuva push moraine, Rogen moraines (between Linkuva push moraine and Zemgale drumlin field), Zemgale and Iecava drumlin fields were formed but later on as a result of active ice marginal retreat Zemgale ribbed moraines were reshaped of drumlins. Such frontal deglaciation prevailed at least in the E part of ZPL, where Zemgale ribbed moraine topography is common and occurs six large esker systems. Some of the eskers are superimposed on the Zemgale ribbed moraines proving the subglacial genesis of the latter.

The internal composition of drumlins until now is studied in several outcrops and excavated trenches where important details of drumlin internal structures are revealed. The most part of drumlin consists of deformed sorted sediments capped by the overthrust of deformation till in the case of the Brencēni pit and of undeformed or slightly deformed sorted sediments capped by lodgement till in the Lāči pit. The directional measurements of planar structural elements in the contact zone between till overthrust and underling sorted sediments in the Brencēni pit indicates on the ice stress directed from the inter-drumlin depression. The contact between lodgement till and underlying sorted sediments in the Lāči pit can be interpreted as glaciodynamic traction zone contact. Till is characterized by quite large amount of pebbles and boulders, some of them have faceted and striated lower surfaces suggesting that they had been included in the debris rich basal part of ice that was sliding over already lodged till. The striations from large boulders indicate on the ice stress direction from ZZE that coincides with direction of the longitudinal axis of drumlin. The two fabric measurements in till (50 pebbles in each case) shows different local ice stress directions from NNW and NE. In the central part of the drumlin flowage-like features occur in lodgement till. Most likely these features resemble density-driven structures in glacigenic consolidated diamicts described by Rijsdijk (2001).

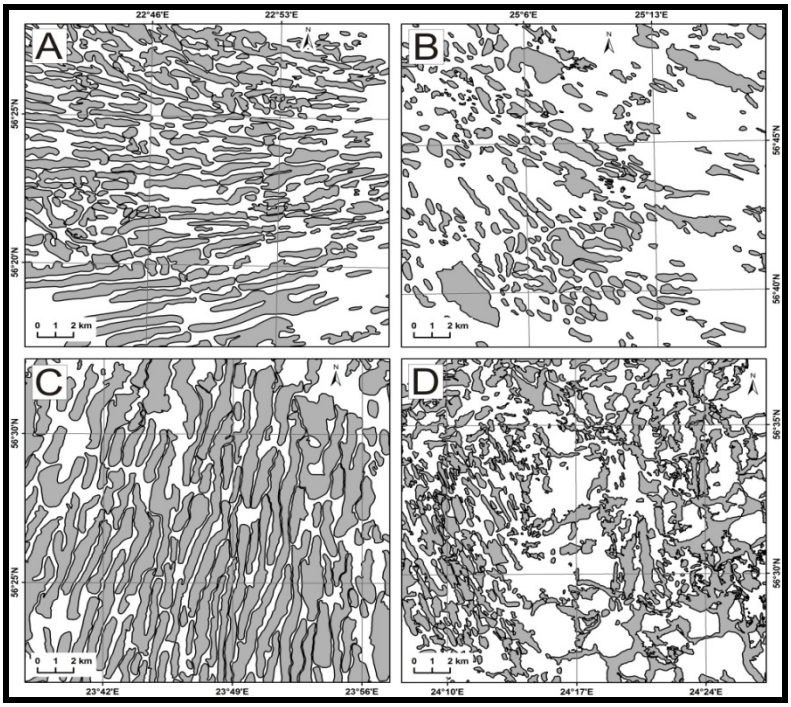

Fig.1. The subglacial bedform patterns in the Central Latvian Lowland. A – The Vadakste drumlin field; B – The Madliena drumlin field; C – The Zemgale drumlin field; D – The Iecava drumlin field and the Zemgale ribbed moraine field. All sampling plots are 20x20 km large reproduced at an equale scale.

The database of glacigenic landforms is being compiled by digitizing glacial topographic features from the topographical maps of scale 1: 10,000. At now the database consists of approximately 3000 landforms. The database includes such landforms as drumlins, ribbed moraines, end moraines, recessional moraines, marginal ridges and eskers, and their morphometric parameters. The mapped drumlins and ribbed moraines (Fig. 1) shows different morphology and spatial arrangement demonstrating divergent ice flow pattern. Elongation ratios of drumlins suggest that ice flow rate was the most greatest in the central part of ZPL, where the average mean elongation ratio of Zemgale field drumlins is 6.3, it reaches 10 and more for the 20 percentage of the drumlins (Fig. 1C). The average mean elongation ratio of the Vadakste field drumlins shown in Fig. 1A is 5.2; it reaches 10 and more for the 10 percentage of the drumlins. The elongation ratio of the drumlins in the Madliena field (Fig. 1B) is 3 and only some drumlins have it higher than 10. Note also the highest density of drumlins in the Zemgale field and smaller in the Madliena field that coincide also with elongation ratios being higher in the Zemgale field and smaller in the Madliena field.

The spatial distribution of bedforms has been compared with topography of bedrock surface, and it is suggested that ice flow direction and velocity were mainly controlled by the topography of the pre-existing bedrock surface. The spatial distribution and superimposition of bedforms indicates on such development sequence – Linkuva push moraine – Rogen moraines – drumlins – Zemgale ribbed moraines – eskers, although some of these landforms could be formed synchronously

But in different subglacial position. The location of the Zemgale ribbed moraines (Fig. 1D) suggests that they were superimposed on the drumlins at the passive and active ice boundary during ice margin retreat from the Linkuva push moraine (Zelčs, 1993; Zelčs & Dreimanis, 1998). The topography of former drumlins is quite changed and seen as connected and curved radial and

transverse segments that cannot be separated as individual forms. The most likely model for the ribbed moraines is their formation during or after the ice stream shut-down proposed by Stokes et al. (2008), who also associated them with the development of localized compressional flow, i.e. sticky spots.

References

[1] Lamsters, K. 2011. Glaciotectonic landforms in the Madliena Tilted Plain. In: Zelčs, V. (ed.-in chief), *Acta Universitatis Latviensis. Earth and Environmental Sciences* 767. University of Latvia, 48–61 (in Latvian with English summary).

[2] Lamsters, K., in press. Drumlins and related glaciogenic landforms of the Madliena Tilted Plain, Central Latvian Lowland. *Bulletin of the Geological Society of Finland, Special issue.*

[3] Rijsdijk, K.F. 2001. Density-driven deformation structures in glacigenic consolidated diamicts: examples from Traeth y Mwnt, Cardiganshire, Wales, U.K. *Journal of Sedimentary Research* 71(1), 122–135.

[4] Stokes, C.R., Lian, O.B., Tulaczyk, S. and Clark, C.D. 2008. Superimposition of ribbed moraines on a paleo-ice-stream bed: implications for ice stream dynamics and shutdown. *Earth Surface Processes and Landforms* 33, 593–609.

[5] Zelčs, V. 1993. *Glaciotectonic landforms of divergent type glaciodepressional lowlands. Dissertation work synthesis.* University of Latvia, Riga, 105 pp.

[6] Zelčs, V., Markots, A. and Strautnieks, I. 1990. Protsess formirovaniya drumlinov Srednelatviyskoy gliaciodepressionnoy nizmennosti. [Genesis of drumlins in the Middle Latvian lowlands]. In: Eberhards, G., Zelčs, V. and Vanaga, A (eds.*) Acta Universitatis Latviensis 547.* University of Latvia, 111–130 (in Russian).

[7] Zelčs, V. and Dreimanis, A. 1998. Daugmale ribbed moraine: Introduction to STOP 1. Stop 1: Internal structure and morphology of glaciotectonic landforms at Daugmale. Area. In Zelčs, V. (ed.), *The INQUA Peribaltic Group Field Symposium on Glacial Processes and Quaternary Environment in Latvia, May 25–31, 1998, Riga, Latvia. Excursion guide*. University of Latvia, pp. 3–14.

[8] Zelčs, V., Markots, A., Nartišs, M. and Saks, T. 2011. Chapter 18: Pleistocene Glaciations in Latvia. In: Ehlers, J., Gibbard, P.L., Hughes P.D. (eds.), *Ouaternary glaciations – extent and chronology. Developments in Quaternary Sciences* 15. Elsevier, pp. 221–229.

MAIN LOCATIONS OF THE FINDS OF PLEISTOCENE MAMMALS ON THE TERRITORY OF VOLOGDA REGION

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The natural conditions of the Pleistocene have been studied in recent years in Russia and abroad. The use of museum materials provides new opportunities for analyzing the evolution of species, populations and ecosystems.

Now, the information about the numerous discoveries of Pleistocene fauna in the territory of the Vologda region is accumulated. The aim of this work is systematization and classification of the finds.

During the Pleistocene, the main groups of mammals were mammoths and rhinoceroses, many species of herbivorous large and medium sizes - bison, horses, reindeer, elk, and several species of small mammals. They determined the structure of communities.

The basis for this work for are the collections of the Vologda State Museum, Nature Museum and the Museum of Archaeology Cherepovets museum association, the Museum of Geology VSPU, Cyril-Belozersk Museum and Totma museum, as well as information of the Paleontological Museum in Moscow.

The Vologda State museum has a large collection of fossil bones of animals that lived on the Russian Plain in the Pleistocene time. This is mainly teeth, tusks and bones of mammoths. They are found in the quarry Sannikovo and Lisitsyno, in the valleys of the Shuya, the Sukhona, the Staraya Totma, the Suda, the Ug and the tributaries. There are isolated finds of teeth forest horse Tarpan in the valleys of the rivers Sodima, Andoga, and the discovery of horns of musk ox in the Nikolsk area. These are materials of expeditions, construction and soil works (in quarries, in digging wells) and surface materials, found on the banks of rivers.

In the archives of the Vologda Museum of Natural History the information about the 73 teeth of mammoth contains. Five of the teeth have a scientific value, as brought from the quarries and in some cases accompanied by a description of the geological conditions, which allows determining the age of fossils. 20 teeth - the material gathered on the banks of rivers the Sukhona, the Kubena, the Vychegda, the Kokshenga.

There is information about finding 51bones of mammoths. They were founded in Vologda, the Vologda river basins, the Tolshma, the Staraya Totma, the Lezha, the Sukhona, the Sodima, the Sheksna. 11 of them are the material from the banks of rivers and taluses, 10 of them were found during excavation works.

The Museum of Nature had seven tusks, now keeps five, and 35 parts of tusks of mammoths. 11 subjects were transferred to the museum from expeditions of Vologda Society for the Study of the Northern Territory.

If we know the place fossils were found we can define the age of these fossils. For some bones of the findings their age was determined with the help of radiocarbon analysts. It is listed in the table. We can say that most of the finds are dated with the sediments of the Late Weichselian.

Table 1. The established age of the finds

Date of discovery	Finding	Place finds	Age finds by radiocarbon analysis
1996	The bones of the mammoth	Zhidihovskoe swamp in the upper reaches of the basin r.Sheksna	9800±100 ka
1994 г. Andrianov L.S.	Tooth of mammoth	D. Selmenga, Dmitrovsky s/s, careers	10000±80 ka
	A fragment of a mammoth tooth	River Sosnovka is located 50 km from Cherepovets on the right bank of the river Sheksna	31600±1200 ka
1924	Half the mammoth tooth	*Harlamovskoe, which is located on the left bank of the river Mologa within 50 km from its mouth.*	42700±1400 ka
1984 Nikitinsky I. F.	**The teeth of the mandible, fragments of skull and tusks of the mammoth**	**Estuary. Old Tot'ma**	**43 200 ± 900** ka

We investigated more than 200 fossil remains of large mammals of the middle and late Pleistocene in the Vologda region. There was given information about the 166 bones of mammoth, 31 bones of rhinoceros, 6 horns and horns with fragments of skull of a bison, the 8 bones of horses, 6 bones of elk and a horn of a deer. The problem of studying the collection is almost complete absence of descriptions of locations and conditions of the accuracy of the findings. Analysis showed that in the late Pleistocene the fauna of the region consisted of the arctic, steppe and forest species. Pleistocene fauna of the Vologda region includes several species of mammals from the orders of Proboscidea, Perissodactyla and Artiodactyla.

In general, these findings may be divided into several points on the territory of Vologda region. This are Vologda District, Nyuksenitsa District, Sokol District, Gryazovets District, Syamzha District, Cherepovets District, and Totma District. Findings are situated in basins of the Sukhona, the Sheksna and the Northern Dvina rivers.

On the basis of the used published materials, and data of museums, the author has created a map of the main localities of Pleistocene mammals (Fig. 1).

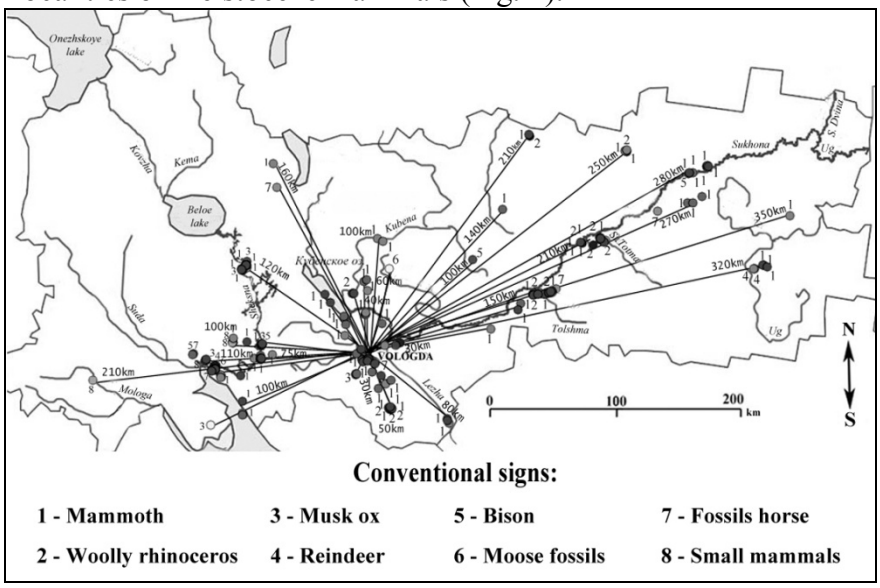

Figure1. Scheme of the main locations of the finds of Pleistocene mammals.

The localities of findings are unevenly distributed, and they almost absent to the west of the region. Most localities are situated in the lower river valleys and belong to Moreno-plain and lacustrine-alluvial plain. Most of them are concentrated in 50 km from Vologda. The accumulations of tusks, teeth and bones of a mammoth, and several bones of a woolly rhinoceros are mainly represented. In the peripheral part (200 km) findings are not numerous and represented with the specimens of the woolly rhinoceroses, musk oxen, bisons and mammoths.

The leading place among finding belongs to the fings of mammoths, at least woolly rhinoceros wild horses and bison. The bones of musk oxen, deer and elks are rare in evidence

New data are important for the solution of stratigraphic problems, as well as a comprehensive study of the Quaternary sediments of the investigated region and adjacent territories.

A HIGH-RESOLUTION RECORD OF LATE-GLACIAL ENVIRONMENTAL AND CLIMATIC CHANGE IN THE EASTERN BALTIC AREA: LITO- AND BIOSTRATIGRAPHICAL EVIDENCE FROM LAKE LIELAIS SVETINU, LATVIA

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The geochemistry of lake sedimentary organic matter provides important information that can be used to reconstruct paleoenvironmental changes in lakes and their watersheds (Bertrand et al., 2010). Variations in the composition of organic matter in lake sediments can be described by C/N ratios. Organic matter from terrestrial sources shows C/N ratios that typically exceed an atomic ratio of 20 and greater, whereas in-lake produced algal organic matter is characterized by C/N ratios between 4 and 10 (Meyers and Ishiwatari, 1993). This distinction is due to their biochemical properties: (i) non-vascular plants, such as phytoplankton, contain little or no cellulose and lignin and have relatively large proportions of nitrogen-rich proteinaceous material and (ii) vascular plants, such as grasses, shrubs, trees on land and emergent macrophytes in lakes, contain large proportions of woody tissues and can be relatively rich in waxy hydrocarbons (Meyers, 2003).

Grain size measurements of lake sediments provide information about sedimentological processes, e.g. turbulence, wave energy, proximity of shoreline, water level oscillations etc and through them the changes in sedimentary environment. Grain size evidence may indirectly reflect changes in the climate.

The aim of the present study is to evaluate late-glacial environmental and climatic changes in the eastern Baltic area using lake sediment organic matter geochemical parameters and results of grain-size analyses. In addition, our new sediment evidence is compared with previously published biological proxies such as pollen evidence, pollen accumulation rates and plant macrofossil data (Veski et al., 2012).

Lake Lielais Svētiņu is located in eastern Latvia Rezekne district (56˚45.5 N; 27˚08.8 E), in the Lubana depression between the Latgale and Vidzeme uplands. The sediment was cored from lake ice using a 10-cm diameter Russian corer in March 2009. Sediment age-depth model is based on 19 dated terrestrial plant macrofossils and indicates a complete record of late-glacial environmental history since the Bølling (GI-1e) warming 14,550 cal yr BP which provides a minimum age for the deglaciation of the area.

The core section spanning a period of ca. 4000 years from 14,550 to 10,700 cal yr BP was studied. Altogether 75 samples for the analyses were taken at 5 to 20 cm intervals (temporal resolution of sampling interval is after 10-100 years). C_{org} and N_{tot} contents were measured in

freeze-dried powdered sub-samples treated with 4M hydrochloric acid using a FLASH 2000 Organic Elemental Analyzer. The grain-size distribution was analysed using the Horiba Instruments laser scattering particle size distribution analyser LA-950V2. Organic matter was removed from the samples with 32% H_2O_2. To avoid grain flocculation the samples were pre-treated with 0,1% solution of sodium pyrophosphate $Na_4P_2O_7 \cdot 10(H_2O)$.

Biostratigraphical proxies such as pollen accumulation rate (PAR) and plant macrofossil data show that the Bølling warming in the eastern Baltic area was a treeless tundra community consisting of the shrubs *Betula nana*, *Dryas octopetala* and *Salix polaris*. The Older Dryas cold spell is clearly recognised as a decline in the total concentration of plant macrofossils and PAR. With the onset of GI-1c warming at 13,500 cal yr BP *B. nana* macrofossils are replaced by tree birch *Betula* sect. *Albae*, marking the start of the forest phase. During the warmest period of the GI-1a, between 13,000 and 12,700 cal yr BP, a mixed pine forest with deciduous trees (birch - *B. pendula* and aspen - *Populus tremula*) developed. The Younger Dryas (GS-1) cooling strongly affected the forest in eastern Latvia, yet there is evidence that pine and spruce survived throughout the GS-1 harsh conditions. The Pleistocene/Holocene boundary at 11,650 cal yr BP is marked by forest re-expansion and changes in vegetation composition in eastern Latvia (Veski et al. 2012).

The results of sediment C_{org} and N_{tot} content and the C/N ratio follow also paleoclimatic changes of the area. During the Older Dryas and Younger Dryas cooling the C/N ratio in the sediments varies between 6,6–10,0 suggesting that aquatic algal production was essentially the main source of organic matter. During the Bølling and Allerød warming, the C/N values were slightly higher ranging from 11,0–14,6. This evidence suggests *that* during warmer periods the organic matter originates both from aquatic and terrestrial sources and indicates larger terrestrial input from the surrounding land area compared with colder intervals.

The grain size analysis reveals that in between 14,550–12,700 cal yr BP the accumulation of fine and medium silts dominate, while during the Younger Dryas fraction of clay increases and the coarse silt decreases. This pattern of grain size is likely linked with the change in sediment transport dynamics and source area and might correspond to the isolation of Lielais Svētiņu basin from Lubana basin.

References

[1] *Bertrand, S., Sterken, M., Vargas-Ramirez, L., De Batist, M., Vyverman, W., Lepoint, G., Fagel ,N.,* 2010. Bulk organic geochemistry of sediments from Puyehue Lake and its watershed (Chile, 40°S): Implications for paleoenvironmental reconstructions. Palaeogeography, Palaeoclimatology, Palaeoecology, 294, 56–71.

[2] *Meyers, P.,A.,* 2003. Applications of organic geochemistry to paleolimnological reconstructions: a summary of examples from the Lautentian Great Lakes. Organic Geochemistry, 34, 261–289.

[3] *Meyers, P. A., Ishiwatari, R.,* 1993. Lacustrine organic geochemistry — an overview of indicators of organic matte sources and diagenesis in lake sediments. Organic Geochemistry, 20, 867–900.

[4] *Veski, S., Amon, L., Heinsalu, A., Reitalu, T., Saarse, L., Stivrins, N., Vassiljev, J.,* 2012. Lateglacial vegetation dynamics in the eastern Baltic region between 14,500 and 11,400 cal yr BP: A complete record since the Bølling (GI-1e) to the Holocene. Quaternary Science Reviews, 40, 39–53.

ENVIRONMENTAL SETTING AND STABLE C-O ISOTOPE COMPOSITION OF COLD CLIMATE CARBONATES

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Secondary carbonate precipitates in glacial sediments can form either during glacial time or during subsequent non-glacial conditions by a variety of mechanisms that lead to dissolution and reprecipitation of carbonates. Carbonate cementation has been recorded in glacial outwash deposits from several places in Estonia, Latvia and Lithuania. These glacial sediments are associated with ice-marginal glaciofluvial forms, end moraines, eskers and drumlins deposited during the last, Late Weichselian deglaciation about 18-12 ka BP. Cemented deposits occur as laterally continuous layers, entire piles or patches either at the contact between two different sedimentary facies within outwash deposits or around the contact between the outwash and the overlaying till, or along the glaciotectonic deformation structures. Calcareous concretions have been found within varved clays from Pärnu area in Estonia.

The cement occurs mostly as a carbonate crust or fringe with variable thickness around detrital grains or fills intergranular pores. In coarser gravel-facies the cement occurs as a crust with variable thickness (up to 1 mm) around clast surface, occasionally acting like glue sticking clasts together. In finer sandy-facies the cement is distributed uniformly in the matrix filling almost overall intergranular porespace as a massive cemented sand between coarser particles. The micromorphology of the cement shows micrite (≤4 μm), microsparite (4-10 μm) and sparite (≥10 μm) angular equant to elongated rhombohedron and scalenohedral or prismatic calcite crystals, no dolomite or aragonite have been found. Micritic calcite often occurs as a massive subhedral calcite with some rhombohedron faces. Micrite is usually located tightly around the grains or fills completely intergranular voids. It is often going over microsparite and sparite towards the intergranular porespace indicating that micrite preceded microsparite or sparite precipitation. This could refer to several stages of calcite precipitation. The cementation could have started in vadose conditions and continued in phreatic environment. There are also traces of dissolution and secondary formations on the surface of crystals indicating some later dissolution and reprecipitation of calcite.

The chemistry of cold-climate carbonates is controlled by the isotopic composition of the parent water and temperature at which the precipitation took place. The isotopic composition of studied calcite cement vary in wide range - δ18O values between -15,0‰ and -5,6‰ and δ13C values between -20,9‰ and -1,4‰ (VPDB). δ18O values indicate that the parent water from which calcite precipitation occurred originates from strongly 18O-depleted glacial meltwater, but had been affected by the infiltration of meteoric and surface waters and thereby the isotopic composition of the water became less negative in time. This is supported by the isotopic composition of meteoric water measured nowadays and also composition of modern groundwater which is related to meteoric and surface waters. Wide range of δ13C values indicate a mixture of different source of carbon and different precipitation mechanism. Vegetation and decomposition of organic matter in soil system could lead to more negative isotopic values, whilst anaerobic bacterial decay, dissolution of primary bedrock carbonate, evaporation and influence of atmospheric CO2 could lead to less negative values. In case of the studied cement, the important factor that could have affected the isotopic composition is probably atmospheric CO2, as the circulating water was occasionally open to atmospheric air, evaporation of the water could have occured as well and removed somewhat of the lighter isotopes into vapour. The dissolution of carbonate bedrock could have shifted the isotopic values towards the host rock. The influence of organic matter should also be considered, especially in near-surface sediments, but this was probably not the main factor affecting

the carbon isotope composition. Depending on the area and nature of the cemented deposits, some general trends in the O-C isotopic compositions could be distinguished which indicates locally similar conditions of the cementation.

The formation and development of secondary calcite cement in outwash sequences is attributed to carbonate precipitation from calcite-rich waters either close to the ice margin or somewhat later in periglacial conditions where meltwater fluxes and groundwater circulation were controlled by water-driving pressures, textural changes and boundaries of sediment facies, and barriers to water flow resulted by permafrost or partly frozen sediments. The isotopic composition shows that solute-bearing waters were enriched in light isotopes, probably somewhat mixed with meteoric and surface waters and affected by atmospheric and biotic factors. Radiocarbon datings of the cement show occasionally the relation with ice-marginal zones and precipitation close to the ice margin or little after the ice retreat, whilst some ages are relatively old compared to the ages of ice-marginal positions. This suggests either subglacial precipitation or contamination by primary carbon from the bedrock. A few exeptional determinated ages indicate precipitation much later in Holocene.

LATE QUATERNARY PALAEOHYDROLOGY IN NE GERMANY – PAST CHANGES, RECENT TRENDS AND NEW APPROACHES FOR LINKING LAKE SEDIMENTS AND CATCHMENT PROCESSES

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Palaeohydrological knowledge is of great importance for understanding and reconstruction of landscapes within Weichselian glaciated areas. Furthermore it is essential for recent environmental issues, such as determination of hydrologic changes, evaluation of land use strategies or implementation of wetland restoration measures. Also the interpretation of modeled or estimated future impacts of climatic and land-cover changes needs the improvement using (pre-) historic analogies. An overview on drainage-system evolution during the late Pleistocene and Holocene will be given, focusing on the regional development of rivers, lakes and peatlands (Kaiser et al. 2012). Assembled data can be examined on three time scales: (1) millennial – landscape formation with a radiocarbon, luminescence and pollen based chronology as well as archaeological data of key sites; (2) centennial – landscape formation and land use history based on absolute datings, historical maps, archaeological data, written archives, pollen diagrams and few gauging data; and (3) decadal to annual – numerical evidence of land use and climate by maps, gauging and monitoring sites.

River and channel development was examined with a focus on valley formation and depositional changes, river course and channel changes, and evidences of palaeo-discharge and floods. Lake development was analysed with respect to lake-basin formation and depositional changes. Furthermore, lake-level changes have been in the focus, showing highly variable local records with some conformity. The overview on peat-land development concentrated on phases of mire formation and on long-term groundwater dynamics. Close relationships between the development of rivers, lakes and peat lands existed particularly during the late Holocene by paludification processes in large, low lying river valleys. Until the late Holocene, regional hydrology was predominantly driven by climatic, geomorphic and non-anthropogenic biotic factors. Since the late Medieval times (13th century AD), human activities have strongly influenced the drainage pattern and the water cycle, for instance, by damming of rivers and lakes, construction of

channels and dikes, vast deforestation, and peat-land cultivation. Eventually, the natural changes caused by long-term climatic and geomorphic processes have been exceeded by impacts resulting from short-term human actions during the last c. 50 years as discharge regulation, hydromelioration and formation of artificial lakes. Since the 1980s, a trend of declining lake levels is observed for some lakes in the vicinity of the Pomeranian ice marginal zone. A drop of 1.5-3.0 m of the ground water level can be summarized and is reflected in the levels of non-drained lakes. Ongoing investigations on historical lake-level fluctuations, forest and hydromelioration history as well as climate data will try to disentangle climate and human impact.

To focus further research capacities and expertise in the study of climate and landscape evolution in a historical cultural landscape, the Virtual Institute for Integrated Climate and Landscape Evolution Analyses (ICLEA, www.iclea.de) has been formed in 2011 by the following members: Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences, University of Greifswald, Brandenburg University of Technology Cottbus and the Polish Academy of Sciences (PAN). A novel concept of linking time scales has been developed through combining instrumental monitoring and gauging data (climate, hydrology, limnology, isotopes) with remote sensing information and high resolution proxy data analyses (varved lake sediments, dendrochronologies). The main attention is turned on the inclusion of natural archives with a seasonal time resolution in order to enable a direct link and calibration of proxy data with instrumental data. Supplementary investigations deal with e.g. soils, landforms, littoral processes and vegetation changes in the catchment. The investigation areas will be instrumented to serve as a natural laboratory utilizing this systematic and holistic approach.

Holocene lake sediments with seasonal resolution were recovered in a 7 m long core from Lake Tiefer See (62 m) in the Klocksin Lake Chain (Mecklenburg Lake District, 180 km N of Berlin). This record enables the linkage of studies on millennial and annual time scale. Sediment composition and microfossils from cores in the littoral zone indicate the main phases of basin development since the Weichselian Lateglacial, whereas geophysical investigations (Sonar, Seismic) reveal the subaquatic morphology. Palaeolimnological and palaeoecological analyses will be complemented by a monitoring program projected for the upcoming five years. The concept comprizes high-resolution sampling of deposition (detritus and autochthonous production) in a depth cascade in the pelagial and littoral zones in the framework of water chemistry, automatically logged limophysics and on-site meteorology.

References

[1] *Kaiser, K., Lorenz, S., Germer, S., Juschus, O., Küster, M., Libra, J., Bens, O., Hüttl, R.F.* 2012: Late Quaternary evolution of rivers, lakes and peatlands in Northeast Germany reflecting past climatic and human impact - an overview. E&G Quaternary Science Journal 61 (in press).

GEOARCHAEOLOGY AND FLOODPLAIN DEVELOPMENT AT THE OUTSTANDING MULTIPERIOD DWELLING SITE OF VEKSA IN THE SUKHONA BASIN

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The multiperiod settlement remains by the confluence of the River Vologda and its small tributary River Veksa represent a key site for the reconstruction of prehistoric and historic cultural developments in the North-Eastern European forest zone (Недомолкина & Пиецонка 2010). The archaeological complex is situated in Vologda district in the southern part of Vologda province c. 20 km east of the province's eponymous capital in the Upper Sukhona basin. Initial archaeological investigations at Veksa started in 1981. The exceptional importance of the Veksa sites is due to the clearly stratified, up to 3 m thick sequence of archaeological layers in alluvial sediments starting in the 6th millennium cal BC and covering all periods from the Early Neolithic to the Early Middle Ages. In addition, the archaeological importance of the sites is enhanced by the excellent preservation conditions of organic materials especially in the lower, waterlogged layers.

In September 2011, a first joint field campaign of Russian and German archaeologists and geographers took place. The geomorphological investigations were carried out by driving core equipment reaching depths up to 8 m below surface and offering the possibility to sample cores of 5-8 cm diameter. A total of 15 drillings were put down in the area of old excavation trenches close to the River Vologda and in a loose grid across the adjacent meadows. The aim was to investigate the general sediment stratigraphy and to record the extension of the archaeological layers. All 15 drilling cores show a comparable stratigraphy and can be described as a general profile consisting of three sedimentological units:

1. The lower part of the stratigraphy is formed by a silicate gyttia which generally starts at the fourth meter below surface. These light brown to grey clayey sediments with thin sandy/silty layers probably have been deposited in a large lake with high sediment influx and are interpreted as the silicate gyttias of an extensive palaeolake which had developed during the Valday deglaciation in the Upper Sukhona basin.

2. A distinct change in the substrate marks the transition to an organic silicate gyttia. These sediments which vary in thickness between 1-2.5 m consist mainly of silt and show dark to olive grey colours. They are characterized by interbeddings of organic layers with abundant plant remains especially at the transitions between the upper and lower horizons. Mollusc remains are detectable in small numbers. The deposits are interpreted as lacustrine or calm fluvial backwater sediments with (seasonal?) sediment influx. They probably bear witness to the advancing infill of the basins during the Early to Mid Holocene or to the change of fluvial patterns such as channel morphology or river sinuosity (Sidorchuk et al. 2001).

3. The upper part consists of loamy floodplain sediments. These clayey to silty deposits vary in thickness and reach between 1.2-3 m below the surface, with a slight incline from the river being noticeable. Stagnic and gleyic soils with iron concretions are the result of a remarkable annual alteration of the ground water table. Apparently the hydrological regime has been characterized by annual flooding already for a very long time with siliceous material from the sediment load of the river leading to a successive heightening of the floodplain. An accumulation of humic soil contents from the vegetation cover does not seem to have been relevant or has been compensated by strong mineralization. All archaeological layers are associated with these floodplain sediments, reaching up to 3 m below the ground surface. They are well recognizable by their grey to black colouring and

frequently contain large amounts of charcoal. Archaeological dating places this uppermost part of the geomorphological stratigraphy in the Mid to Late Holocene.

A special feature at the Veksa site is the existence of well-preserved wooden piles in the lower part of the bank of the River Vologda. Stratigraphical evidence as well as a radiocarbon date suggest that at least part of these timbers stem from the Neolithic period (Недомолкина 2005). In September 2011, very low water levels had led to the exposure of the wooden remains thus enabling the recording of their location on a 3D topographical plan. Possible interpretations of these structures include constructions for fishing as well as building remains or platforms for buildings.

In summary, excavation and geoarchaeological survey results underline the exceptional potential for comprehensive multidisciplinary studies. Geoscientific work will focus on regional landscape genesis, especially on the interplay of Holocene floodplain development and human occupation (cf. Vandenberghe et al. 2010).

References

[1] *Недомолкина Н.Г.,* 2005. Результаты работ на комплексе многослойных поселений Векса в 2003г. (К вопросу о периоде энеолита в бассейне Верхней Сухоны) In: Европейский Север в судьбе России: общее и особенное исторического процесса (Вологда 2005), 41-47.

[2] *Недомолкина Н. Г., Пиецонка Х.,* 2010. Многовариантный анализ и распространение неолитической посуды в лесной зоне: на примере памятника Векса 3, северо-запад России. In: III. Северный Археологический Конгресс: Тезисы докладов (Екатеринбург, Ханты-Мансийск 2010), 117-119.

[3] *Sidorchuk, A., Borisova, O. & Panin, A.,* 2001. Fluvial response to the Late Valdai/Holocene environmental change on the East European Plain. Global and Planetary Change 28: 303-318.

[4] *Vandenberghe, J., Gracheva, R., Sorokin, A.,* 2010. Postglacial floodplain development and Mesolithic-Neolithic occupation in the Russian forest zone. Proceedings of the Geologists' Association 121: 229–237.

ICE SHEET DYNAMICS OF THE LATE SAALIAN GLACIATION IN THE NORTHERN PART OF THE POLISH-BELARUSIAN TRANS-BORDER REGION

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The Sokółka Hills and the Grodno Highland in the northern part of the Polish-Belarusian trans-border region form a glaciotectonicly deformed interlobal area that has been developed during the Warta/Sozh Stadial of the Odra/Prypiat Glaciation (Saalian). The landscape of this area has been ascribed either to frontal deglaciation, expressed at present by numerous end moraines, or to areal deglaciation, represented by different kames and kame-like landforms.

Geological investigations carried through for over 50 years in the Grodno Highland proved that in the sub-Quaternary surface of this area there are numerous local elevations (e.g. at Sopotskin, Lishki and Grandichi). Their orientations, shapes and dimensions indicate connection both with tectonic structures in the bedrock and with neotectonic movements. On the other hand the Cainozoic deposits of the Grodno Highland are glaciotectonicly deformed and commonly form not only vast glacial depressions and elevations expressed by push moraines, composed of scales, folds, diapirs and anticlines.

Morainic plateaux to the south of the outwash plains of the Vistulian/Poozierian Glaciation and tp the south of the Biebrza River valley occur up to 229.2 m a.s.l. in the Sokółka Hills and to 247.0 m a.s.l. in the Grodno Highland, with local altitude difference up to 40 m. There are

numerous and large depositional and push end moraines, commonly arranged in rows that indicate location of ice sheet margin during successive retreat phases. Lobal orientation of end moraines is particularly distinct in the vicinity of Sokółka where there are high and elongated hills and large marginal fans, building proximal zones of recessional outwash fans. On the morainic plateaux there are also numerous kames and glaciolacustrine plains. To the south of the Biebrza River valley kames and dead-ice moraines occur in the inner areas of the glacial lobe margins indicated by end moraines. In these areas there are also sites with organic deposits of the Eemian Interglacial. The landscape of the Grodno Highland is similar to the one of the Sokółka Hills, with numerous high and long push and depositional end moraines but also with glaciolacustrine and outwash plains.

Glaciotectonic deformations of Cretaceous and Cainozoic rocks are common in different deposits and landforms as glacial structures and rafts. A chalk of the Upper Cretaceous is the oldest rock that has been deformed in scales, folds, anticlines and rafts, commonly together with Palaeocene and Eocene deposits, particularly in the vicinity of Grodno and Sopotskin. In the Sokółka Hills there are glaciotectonic deformations, indicated both by superficial (glacioelevations and glaciodepressions, push and ice-shoved moraines) and buried (glacioelevations and glaciodepressions, scales, folds, anticlines and diapirs) features, either rooted or as glacial rafts, locally exposed at the land surface. Analysis of the Digital Terrain Model (DTM) in the Triangulated Irregular Network (TIN) enabled to find univocally that the Sokółka Hills and the Grodno Highland were occupied by several ice sheet advances of two glacial lobes during the Warta/Sozh Stadial. They were the Biebrza lobe in the west and the Neman lobe in the east, comprising several secondary lobes, the marginal landforms of which reflect probable directions of ice sheet movement.

The Biebrza lobe, indicating the main ice movement from NW to SE, in the south locally changing to N-S and NE-SW, comprised the northern and central part of the Sokółka Hills. It reached south as far as the Supraśl River valley, acting at that time as a marginal valley. The landforms analyzed within the lobe indicate presence of several subordinate transgressive-recessive features, comprising mainly glacioelevations and glaciodepressions, the latter commonly with numerous kames or filled with ice-dam deposits. In the south-eastern part of the Sokółka Hills, the Biebrza lobe formed a narrow ice tongue that entered the area which has been earlier occupied by the Neman lobe.

The Neman lobe, with general direction of ice sheet movement to south-west, occupied the Grodno Highland and a part of the Sokółka Hills to the south of Sokółka, reaching the Narew River valley. It seems very probable that it was more widespread to the south-west than the Biebrza lobe. A hypothetical boundary between these two lobes, running NE-SW, can be demarcated along the longitudinal reach of the present Neman valley and further to the south, along the rivers Tatarka and Łososna.

DTM analysis and other observations supply with new information on number, extent and orientation of morainal zones. In the Grodno Highland they have not confirmed the occurrence, of the landforms oriented east-west, with the only exception of the scarp of the Svisloch River valley where there are probably the structures of the valley glaciotectonics.

A funding of the poject was granted by the Polish Ministry of Science and Higher Education (Decision 497/N-BIAŁORUŚ/2009/0). A crucial part of the project constituted an elaboration of the geological map in scale 1 : 250,000 for the northern part of the Polish-Belarusian cross-border area (Marks & Karabanov, 2011).

References

[1] *Marks L. & Karabanov A. (eds),* 2011. Geological map of northern part of Polish-Belarusian cross-border area, 1 : 250,000. Państwowy Instytut Geologiczny – Państwowy Instytut Badawczy, Warszawa.

PERIGLACIAL PHENOMENA IN THE EDGE-ZONE OF ŁÓDŹ PLATEAU AND ITS PALAEOGEOGRAPHICAL SIGNIFICANCE (CENTRAL POLAND)

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Thermal-contraction cracks are the most important evidence of permafrost occurrence (e.g. Dylik 1966, Romanovskij 1973). These structures have been reported all over Europe in extraglacial area of glacial periods in Pleistocene. Nowadays it is possible to observe modified structures due to thawing of permafrost as ice-wedge pseudomorph, composite- wedge pseudomorph or sand-wedge cast (relict sand wedges) (e.g. Goździk 1973). The most common are ice-wedge pseudomorph, which occur in different types of sediments and geomorphological situations. The sand-wedges appear rarely, usually in the uplands and they are associated with the stone pavement which is regarded as level of stratigraphical significance (e.g. Klatkowa 1965). A lot of authors claim that the most favourable conditions for cracking and stone pavement formation occurred during the coldest period of Weichselian, and that phenomena was synchronous. Results of investigation shows that in places the cracks and pavement are separated by vary-grained sediment of several centimeters or more what suggests that the issue is more complex.

The study area is located in central Poland, about 15 km north of Łódź. The terrain was last time covered by the ice sheet during the Wartanian Stage. The Weichselian Glaciations was an ice-free period there. During Wartanian the edge-zone of the so-called Łódź Plateau definitively developed as system of steplike levels between plateau and Warsaw-Berlin ice-marginal streamway. The edge-zone is build from glaciogenic deposits, usually strongly deformed due to glaciotectonic. Moreover, characteristic feature of the area is occurrence of numerous dry valleys which cut the slopes of the levels and dunes developed in the surfaces of the levels. The Rosanów site is situated in the third level – the Katarzynów level, on altitude 154 m a.s.l.

In the investigated site, on the depth of 1-1,5 m the glacial loamy sand was documented. The glacial deposits in places are covered by about 0,5 m vary grained sediment probably developed due to solifluction. On the depth of several centimetres, continuous pavement occur, which consist of gravels including large clasts (0,3 m diameter), on the surface of some grains effects of wind-abrasion are visible. In the top part of the profile aeolian sand was documented. The aeolian unit is continuous and about 1 metre thick, but thickness raise north from the site, where dune developed.

In the glacial deposits of the lower unit a large wedge-shaped structures occur with following features: very clear, not deformed outline, V-shaped and visible vertical lamination of infilling sand (Fig. 1B). This characteristic suggests that structures originated as wedges with primary sand infilling (Goździkk 1973, Kolstrup 1986, Murton 1996). The upper parts of structures are usually covered by vary grained, deformed deposits, which separate the cracks and stone pavement.

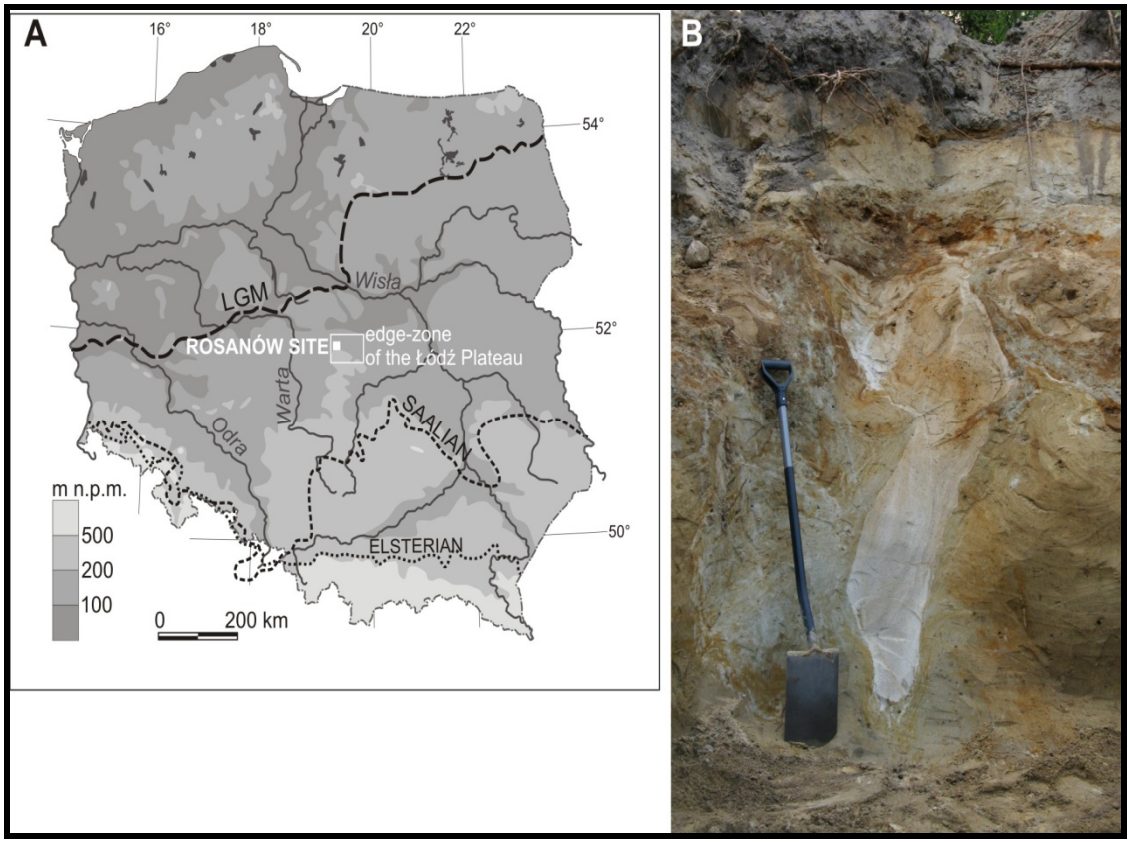

Fig. 1. The Rosanów site
A. Location of the investigated site and main glacial limits in Poland
B. Example of the relict sand wedge

Not strictly synchronous development of the frost cracks and stone pavement was reported previously by e.g. Klatkowa (1965) and Goździk (1973). Sand-wedge formation occurred during the coldest period of the Weichselian, but formation of the pavement probably lasted for a longer time and finished at the beginning of the Older Dryas (Goździk 2007), when aeolian activity weakened due to progressive invasion of vegetation. Stabilization of the aeolian system in the Older Dryas, including dunes, lead to permanent – in places – covering of the surface by aeolian deposits.

References

[1] *Dylik J.,* 1966 – Problems of ice-wedge structures and frost-fissure polygons. Biuletyn Peryglacjalny, 15; 241-291

[2] *Goździk J. S.,* 1973 – Geneza i pozycja stratygraficzna struktur peryglacjalnych w Środkowej Polsce. Acta Geographica Lodziensia, 31; pp. 117

[3] *Goździk J. S.,* 2007 – The Vistulian aeolian succession in central Poland. Sedimentary Geology, 193; 211-220

[4] *Klatkowa H.,* 1965 – Niecki i doliny denudacyjne w okolicach Łodzi. Acta Geographica Lodziensia, 19; p. 141

[5] *Kolstrup E.,* 1986 – Reappraisal of the Upper Weichselian periglacial environment from Danish frost wedge cast. Palaeogeography, Palaeoclimatology, Paleoecology, 56; 237–249

[6] *Murton J. B.,* 1996 – Morphology and paleoenvironmental significence of Quaternary sand viens, sand wedges and composite wedges, Tuktoyaktuk Coastland, Western Arctic Canada. Journal of Sedimental Research, 66(1); 17–25

[7] *Romanovskij N.N.,* 1973 – Regularities in formation of frost-fissures and development of frost-fissure polygons. Biuletyn Peryglacjalny, 23; 237-277

NEW COOPERATION PROJECT OF APPLIED QUATERNARY GEOLOGY: ABCGHERITAGE

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National and international level strategies in the Barents area include tourism and experience industry to be a potential growing business sector in the future. Based on that, nine partners decided to plan a cooperation project "Arctic Biological, Cultural and Geological Heritage", in which the tourism services of those branches of science will be boosted and harmonized with the environment. In the spring 2012 project was started with the partial funding of the EU Kolarctic ENPI program. Lead partner in this multidisciplinary project is Metsähallitus / Natural Heritage Services (Lapland). In the geological part of the project main implementing partners are the Geological Survey of Finland, Northern Finland Office and the Geological Institute of the Kola Science Centre of the Russian Academy of Sciences.

Figure 1. Khibiny Tundra with its mineralogy and morphology provides an excellent base for geological outdoor map.

Totally ten different actions are planned to be implemented in the geological part of the project. One of the biggest tasks is to prepare a geological outdoor map of the Khibiny Tundra. In Finland already 11 those kinds of maps have been published, for example one from the Pyhä-Luosto area. The experiences of their production techniques will be used in this project, too. Geological heritage trail to the Khibiny Tundra will also be created. Other geological activities in the project are for example consisting of developing the mobile services of cultural geology for visitors in Pyhä-Luosto area. Seminars focusing on geology and geotourism will be arranged in Finland and Russia. In Salla, northeastern Finland, new geological demonstration sites will be studied. "Lapland Tour for Geotourists"-guide will be printed. That will include the best geological demonstration sites along the circle route from northern Finland to northeastern Norway, from there to Kola Peninsula and then back to Finland. The purpose is also to prepare some educational material of geology and organize field courses to the participants coming from tourism companies. The implementation time of the project is lasting to the end of 2014.

References

[1] *Johansson, P., Räisänen, J., Räsänen, J., Hirvasniemi, H., Molkoselkä, P., Silén, P. & Valkama, J.* 2007. Pyhä-Luosto : Geological outdoor map 1:50 000. Geological Survey of Finland, Rovaniemi.

[2] *Johansson P., Ojala, A., Räisänen, J. & Räsänen, J*. 2007. Pyhä-Luosto: Geologinen retkeilykartta - geological outdoor map 1:50 000: Opaskirja – Guidebook. Geological Survey of Finland, Rovaniemi. 47 p.

[3] *Johansson, P.; Itkonen, P.; Pihlaja, J. & Voytekhovsky, Y.* 2011. Development of geotourism in North Finland and Kola Peninsula, Russia. In: Geoconservation for the future : regular meeting, working group of ProGEO - Northern Europe, Oslo, Norway, 21-23 September 2011. Oslo: Naturhistorisk museum, 20-21.

[4] *Pihlaja, J., Itkonen, P., Johansson, P. Lehtinen, K. & Voytekhovsky, Y.* 2010. Future prospects for the development of geotourism in northern Finland and north-western Russia. In: 35. Hauptversammlung der Deutschen Quartärvereinigung DEUQUA e. V. & 12th Annual Meeting of the INQUA PeriBaltic Working Group, Greifswald, 13.-17.9.2010: Tagungsunterlagen - Conference proceedings. Deutsche Quartärvereinigung DEUQUA, 145-146.

TRUSTWORTHINESS OF TL AND OSL DATES IN QUATERNARY STRATIGRAPHY

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In many well-known papers (Lamothe et al., 1984 a.o.) was mentioned that luminescent dating provides an overhelming advantage over many other techniques, and should play a majore role in deciphering the time-stratigraphy of the Pleistocene. However our new results (Raukas, 2004, Raukas, Stankowski, 2005, Raukas et al., 2010) show that the potential of the TL and OSL methods is highly overestimated.

In 1974, Dr. Galina Hütt founded a radiometrical dating laboratory in the Institute of Geology at Tallinn University of Technology (former Institute of Geology of the Estonian Academy of Sciences), which soon became internationally well known. She analysed a great amount of samples of glaciofluvial sediments from different parts of Estonia. The untimely death of Dr. Hütt did not allow us to complete the project. This work since 2003 was followed in the frames of scientific cooperation between the Estonian and Polish Academies of Sciences. Both feldspars and quartz were used for dating.

In the seventies and eighties of the last century all types of the Pleistocene deposits, including tills were dated by TL method. As we know the basal till was mostly formed below the moving ice and therefore its mineral grains could not be bleached. From all genetic types of Quaternary sediments traditionally most promising objects are thought to be aeolian and glaciofluvial sediments. In general, glaciofluvial deposits show great variations in the granulometric, lithological and mineral composition.

In the first step of our studies we tried to sample all genetical varieties of glaciofluvial deposits (Raukas, 2004, Raukas, Stankowski 2005), but received mostly unreliable dates. For example, for radial eskers of the last glaciation the age dates were close to 100,000 OSL years. Sampling of kames (crevasse fillings) was not promising either. It is understandable, because eskers and kames formed in dead ice, often below or inside the ice and had very limited possibilities for bleaching.

Later we sampled mainly outwash and glaciofluvial delta sediments from Finland, Lithuania, Latvia and Estonia. Based on the palynological, varvometrical and ^{14}C dates from both the study area and its neighbourhood, it may be concluded that the deglaciation started in Lithuania somewhere 18,000 ^{14}C years ago and Estonia was freed from the ice no later than 11 000 14C years ago. It means that reliable OSL dates from the Baltic States must fit to this time span. Unfortunately most of received dates were far from that (Raukas et al., 2010). Depending on different sediment concentrations, turbidity and depth of water, velocity of outwash streams and transport duration,

incorporation of older unbleached particles, limited time of exposure to the sun in winter time a.o. factors, the extent of bleaching of luminescence signal in studied environments is variegated and difficult to reconstruct in laboratory, so causing variability of dates. It should be pointed that even analytical error is rather high, according to G. Hütt ±1,100–1,500 years for the dates between 10,000-13,000 years and ±2,500–6,000 years for dates between 16,000–25,000 years. To our mind, this all limits the use of the TL and OSL methods in solving the problems related to deglaciation history. Even more it influences the dating of older intermorainic sediments, where most of limiting factors are unknown.

References

[1] *Lamothe, M., Dreimanis, A., Morency, M., Raukas, A.* 1984. Thermoluminescence dating of Quaternary sediments. In: Mahaney, W.C. (ed). Quaternary Dating Methods. Elseviers Science Publishers, Amsterdam, 153-170.

[2] *Raukas, A.* 2004. Application of OSL and ^{10}Be techniques for the establishment of deglaciation chronology in Estonia. - Proceedings of the Estonian Academy of Sciences, Geology, 53, 4, 267 – 287.

[3] *Raukas, A., Stankowski, W.* 2005. Influence of sedimentologiacal composition on OSL dating of glaciofluvial deposits: examples from Estonia. - Geological Quarterly, 49, 4, 463-470.

[4] *Raukas, A., Stankowski, W.T.J., Zelčs, V., Šinkunas, P.* 2010. Chronology of the last deglaciation in the southeastern Baltic region on the basis of recent OSL dates. – Geochronometria 36, 47-54.

NEW DATA ON SHORELINES OF THE BALTIC ICE LAKE ALONG WESTERN COAST OF THE GULF OF RĪGA, LATVIA

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Numerous proglacial lakes were formed with the decay of the Scandinavian ice sheet during Late Weichselian in the territory of Latvia. After the Scandinavian Ice Sheet retreated further to the north, proglacial lakes flew together in the present Baltic Sea depression, creating a large proglacial basin that extended along the southern margin of the ice sheet. In the development of the Baltic Ice Lake (BIL), there have been many outlets which appear on the shorelines of the basin profiles. The shorelines of the ancient reservoirs are basic information source to obtain the information about glacio-isostatic rebound and relative sea level changes. In Latvia the first observations of shoreline displacement of the ancient Baltic Sea stages were done by Grīnbergs (1957) and continued by Veinbergs (1964). Recently shorelines displacement studies that partially cover the coastal area of the Gulf of Rīga using modern research methods were carried out in Estonia (Rosentau et al., 2009; Saarse et al., 2003, 2007). The latest investigations were undertaken along the eastern coast of the Gulf of Rīga, in the coastal plains of Western Vidzeme (Nartišs et al. 2008; Buls, 2009). These latest findings obtained from using modern surveying technologies and GIS analysis require critical reinterpretation of previous shoreline information. This research is aimed to obtain more precise data about spatial location of BIL shorelines in the Western Coast of the Gulf of Rīga.

The scope of the research covers 90 km long, but relatively narrow zone along the coast of the Gulf of Rīga starting from the north of the Kurzeme peninsula, where ancient shorelines of BIL appear as the bluffs of Slītere Zilie kalni ("Blue Hills"), up to the resort Jūrmala. Distance from BIL shorelines to Baltic Sea coast varies from ~7.5 km in the north to more than 18 km in the middle portion at the village Mērsrags and 2 - 3 km in south near the village Apšuciems. Elevation diapason of shorelines displacement is from 15 to 56 m a.s.l. In the territory of Latvia BIL shorelines are divided in three stages – BglI, BglII and lower located three phases of BglIII stage – BglIIIa, BIIIglb and BIIIglc (Grīnbergs, 1957). It is commonly accepted that BglII and BglIIIb shorelines are well traceable in all coastal area of Latvia.

In the realization of the research, a database of BIL palaeo-shorelines was created to compose diagram of the BIL shorelines along the western coast of the Gulf of Rīga. For this study 69 of 132 shorelines levels were used. Shorelines with uncertain elevation were eliminated or reinterpreted. In BIL shorelines data base were derived displacement information from previous studies by Grīnbergs (1957) and Veinbergs (1964) as well as all available geological cartographic material in scale of 1:50,000 and 1:200,000 from the Latvian Geological Fund was analysed. Location of the historical profile lines were reconstructed by using digital terrain model. Data from these profile lines included in database as well as information from newly surveyed profile lines. The newest data are from 6 cross-sections with overall length of 15 km using post-processing GPS and total station. The length of the profiles varies from 0.85 up to 2.4 km. Vertical error of measured points is less than 0.1 m.

Diagrams of the shorelines were created using BIL data base. As a result 5 hypsometrical location shoreline polynomial function curves were produced. It is important stress that potential elevation of BglI stage was reconstructed to the south of village Roja as well as BIIIc to the north of village Nariņciems.

The particularly important for solving of palaeogeographical problems of BglIII phases is the middle course of the River Roja. Here the river valley is incised in a depression occupied by the ancient inlet of Kundums that has been situated between the mainland truncated by BglI and BglII shorelines and depositional landforms along the BIL coast. Because of blocking by accumulative landforms of littoral drift – spit and barrier the river turns right to SE. After curving around the end of the Lube barrier, the river flows into the plain of the BIL underwater slope.

For case study of the River Roja digital terrain model were derived from large scale (1:10,000) topographical maps using QuantumGIS and SAGA software. During the fieldworks hand-drilled geological boreholes were made and one geological outcrop was studied in details. River terraces were surveyed in 9 cross-sections in the valley of River Roja.

In cross-section across the Lube spit were established the elevation of the RIII terrace of the River Roja at 33.0 m a.s.l. Hypsometrically it is 0.5 m higher than shoreline elevation on sea side (32.5 9 m a.s.l.). In territory of ancient mouth RIII terrace of the River Roja is 30.6 m and RII terrace is 26.3 m a.s.l. Topographically RIII terrace of the River Roja can be correlated with BglIIIb phase shoreline but RII terrace conjugates with BglIIIc stage (accordingly 30.5 m and 25.9 m a.s.l. from shorelines displacement diagram). Maximum shoreline tilting gradient for BglI is 33 cm/km, for BglII – 28 cm/km, BglIIIa – 26 cm/km, BglIIIb – 23 cm/km, BglIIIc – 20 cm/km. There was identified a sign of wave action near the village Lube in the geological test drilling core at level of 43.8 m a.s.l. It concurs with BglI stage level derived from shoreline diagram (43.3 m a.s.l).

The gradient of the maximum land uplift acquired from geomorphological map made by Grīnbergs (1957) after georeferencing is ~334.5° on area of the Gulf of Riga. It is in very good agreement with the gradient of the maximum land uplift 335º established by Nartišs et al. (2008). The reconstruction of the palaeo-shorelines was made for territory of the River Roja valley. These results draw attention to type of accumulative coastal landform which is more similar to spit instead of barrier spit as pointed out by Veinbergs (1964). Spit extension to SE – Lube barrier was under water at the time of BglII stage and only after BglII regression it blocked the River Roja.

Stored data in BIL data base shows no evidence of uneven land uplift along the Western Coast of the Gulf of Riga. It is possible the fault in the diagrams of the BIL shorelines elaborated by Grīnbergs (1957) can be interpreted as surveying mistake.

References

[1] *Buls, T.* 2009. Baltijas ledus ezera akumulatīvi krasta veidojumi Vidzemes piekrastē.Maģistra darbs [Accumulative landforms of the Baltic Ice Lake in coastal zone of Vidzeme. Master thesis]. Latvijas Universitāte, Rīga, 98 lpp.

[2] *Grīnbergs, E.,* 1957. Pozdnelednikovaya I poslelednikovaya istoriya poberezhya Latviyskoy SSR. [The Late-glacial and Post-glacial history of the coast of the Latvian SSR]. Rīga, Publishing House of the Academy of Sciences of the Latvian SSR, 122 pp (in Russian).

[3] *Nartišs, M., Markots, A. and Zelčs, V.,* 2008. Late Weichselian and Holocene shoreline displacement in the Vidzeme Coastal Plain, Latvia. In: S. Lisiscki (ed.), Quaternary of the Gulf of Gdansk and Lower Vistula Regions in Northern Poland: sedimentary environments, stratigraphy and palaeogeography. Warszawa, Polish Geological Institute, 39-40.

[4] *Rosentau, A., Vassiljev, J., Hang, T., Saarse L. and Kalm V.,* 2009. Development of the Baltic Ice Lake in the eastern Baltic. Quaternary International, 206(1-2), 16-23.

[5] *Saarse, L., Vassiljev, J. and Miidel A.,* 2003. Simulation of the Baltic Sea Shorelines in Estonia and Neighbouring Areas. Journal of Coastal Research, 19(2), 261-268.

[6] *Saarse, L., Vassiljev, J., Rosentau, A. and Miidel A.,* 2007. Reconstruction of late glacial shore displacement in Estonia. Baltica, 20(1-2), 35-45.

[7] *Veinbergs, I.* (1964), Coastal morphology and dynamics of the Baltic Ice Lake on the territory of the Latvian SSR. In: Daņilāns I. (ed.), Questions of Quaternary Geology, III. Rīga, Zinātne, 331–369 (in Russian with English summary).

THE LAST DEGLACIATION OF THE SOUTH-EASTERN SECTOR OF THE SCANDINAVIAN ICE SHEET

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The Scandinavian Ice Sheet was an important component of the global ice sheet system during the Last Glacial Maximum. Nevertheless, the timing of its growth to or retreat from its maximum extent remains poorly constrained, preventing an assessment of the sensitivity of the Scandinavian Ice Sheet to climate change and its contribution to global sea level change. This paper reports 115 previously published cosmogenic 10Be ages on six prominent end moraine belts deposited by the south-eastern Scandinavian Ice Sheet margin (Figure 1). These data, combined with 70 radiocarbon ages, constrain the timing of three significant ice-margin fluctuations between 25 and 12 kyr BP. These results make this sector of the ice sheet among the best dated of any of the former Pleistocene glaciers and ice sheets. Accordingly, these results allow to assess the contribution of the ice sheet to the large and often abrupt sea level and climate changes since the Last Glacial Maximum 21,000 years ago.

The south-eastern Scandinavian Ice Sheet margin advanced into the Baltic lowland after 24 cal kyr BP and reached its maximum extent after 21 cal kyr BP, indicating a near-synchronous expansion of the western and southern Eurasian Ice Sheet margins during the Last Glacial Maximum. Initial deglaciation at 19.0 ± 1.6 10Be kyr indicates that the Scandinavian Ice Sheet may have been an important source of an abrupt 10-15 m rise in global sea level 19 kyr BP. Subsequent fluctuations of the south-eastern Scandinavian Ice Sheet margin occurred at the same time as changes in North Atlantic climate, demonstrating a high sensitivity of Scandinavian Ice Sheet surface mass balance to changes in the Atlantic meridional overturning circulation (AMOC). However, the chronology reveals that the sign of Scandinavian Ice Sheet response to AMOC changes during cold climates was opposite to that during warm climates, reflecting the dependence of ice sheet mass balance on mean climate state. These responses are exactly of the kind that are expected for the Antarctic (cold climate) and Greenland (warm climate) ice sheets as the Earth's surface temperature warms in the coming century, and thus provides a striking validation of such behaviour. In addition, the slow rate of ice-margin retreat starting at 14.6 ± 0.3 ^{10}Be kyr suggests that the Scandinavian Ice Sheet was not a significant contributor to global sea level rise in response to Bølling warming.

Further work is needed to build direct chronologies of other sectors of the Scandinavian Ice Sheet east and west of this study to refine our understanding of the demise of the ice sheet and its

implications for climate and sea level changes. Current projects focus on the deglaciation of northern Germany and western Russia.

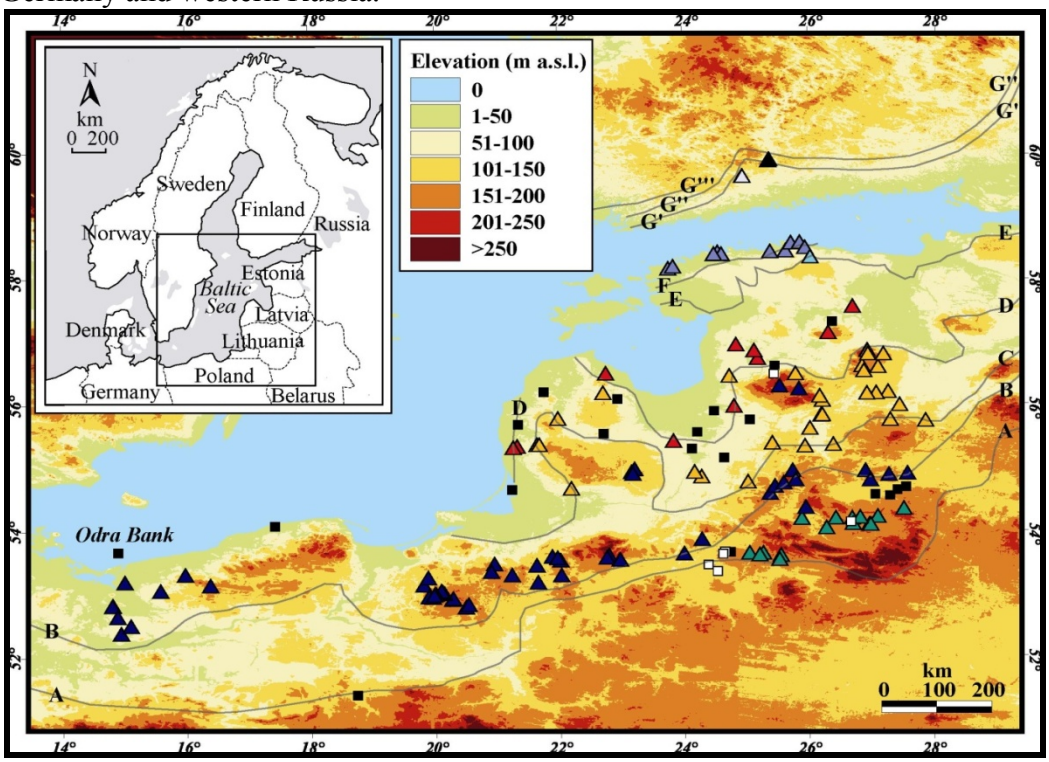

Figure 1: Digital elevation model of the sampling area. Main ice-marginal positions are outlined in grey: A, LGM Moraine; B, Pomeranian Moraine; C, Middle Lithuanian Moraine; D, North Lithuanian Moraine; E, Pandivere Moraine; F, Palivere Moraine; G', Salpausselkä I Moraine; G'', Salpausselkä II Moraine, G''', Salpausselkä III Moraine. ^{10}Be sites: LGM Moraine (green-blue triangles), Pomeranian Moraine (dark blue triangles), Middle Lithuanian Moraine (orange triangles), North Lithuanian Moraine (red triangles), Pandivere Moraine (light blue triangle), Palivere Moraine (purple triangles), Salpausselkä I Moraine (grey triangle represents nine samples), Salpausselkä I Moraine (black triangle represents four samples). 14C sites: this study (white squares), previous studies (black squares).

DYNAMICS OF THE PŁOCK ICE LOBE (CENTRAL POLAND) DURING THE LAST GLACIAL MAXIMUM

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"Płock lobe", the notion introduced by Skompski (1969), refers to the terminal part of the ice sheet that invaded the territory of Poland flowing southward along the depression of the Vistula palaeovalley, reached the Płock Basin and the surrounding morainic plateaus and delineated the Last Glacial Maximum (LGM) in central Poland. Together with the Gopło lobe, in the west, both the lobes constituted a characteristic broad element in the last Scandinavian ice sheet configuration, said to have been the Vistula lobe (cf. Wysota et al. 2009). The extent of the LGM in the Płock lobe has precisely been determined as against geomorphological and geological criteria (Skompski 1969, Baraniecka 1989, Roman and Balwierz 2010). Latest litho- and kinetostratigraphical data along with thermoluminescsence (OSL) datings of sediments found the number and age of glacial events in the lobe, and only a single ice sheet advance was determined to have occurred in the Late Vistulian (Weichselian). Its age as against sand OSL dating beneath and above the till lies between

22,9 and 18,7 ka BP (Roman 2010). The result obtained corresponds well with the Last Scandinavian ice sheet maximum in Poland as to have been within 24 – 19 ka BP (Marks 2010), although in the question under discourse of phase age for the advance, there is no unequivocal answer.

Questionable is the dynamics of the ice sheet and the transgressive or recessive picture of the marginal zones in the LGM hinterland. Essential was to find whether the lobe constituted an ice-stream terminal or whether it only expressed a further and southbound inflow of ice masses onto the relief-predisposed area.

Complex sedimentological research and luminescence (OSL) age indices of deposits along with mezostructural analysis of glaciotectonic deformations have been carried out at several-odd exposures. Detailed geological charting has been applied for glaciomarginal zones, the last glacial maximum limit (LGM) and two belts of hillocky landforms apparent in the LGM hinterland, the Czamanin – Otmianowo - Paruszewice (preLGM-1) and Izbica Kujawska - Pagórki Chodeckie – Szewo – Korzeń Królewski (preLGM-2). Spatial distribution of subglacial and ice-marginal linear landforms were analyzed against the digital elevation model (DTED2) and also the relief and lithology of the subglacial surface has been reconstructed.

Dynamics of the Płock lobe were influenced by local conditions - topography, subglacial hydrology and ice base thermics. Derived from geological evidence, the ice sheet featured a warm base system. Only in the marginal part during the LGM the ice base was cold in patches. Dominant in the mechanism of the ice movement, prior to the subglacial channel drainage build-up and stabilizing the ice front at the LGM line, was a basal sliding on a thin water film resulting in an apparent acceleration of ice speed and a pervasive subglacial deformation.

As against the analysis of glaciotectonic structures, sedimentological records and geomorphological evidence, ice flow vectors were reconstructed (Roman 2008, 2010). It has been proved that the ice travel geometry in the Płock lobe was of a fan-like character, typical for a distal part of a land-based ice stream (cf. Stokes and Clark 2001). A low ice thickness in the lobe (ca 100 – 300 m) and its flattened longitudinal profile derived from modified Orowan formula (Piotrowski and Tulaczyk 1999) is supportive to admit the lobe to have had an outlet nature.

Transgression proceeded with brief standstills along terrain obstacles close to the preLGM-1 and preLGM-2 trains. Such transverse trains, were so far believed to have been recession moraines, they represent, however, narrow multi-crested overridden push moraines (preLGM-1), regarded as the effect of a consequent ice advance and propagation of compressive structures towards the foreland (Bennett 2001) or a range of overridden glaciomarginal fans among whom included were older, pre-Vistulian marginal forms (preLGM-2). It was also found that such a transverse large-scale glacial lineation appeared as an effect of rhythmical building of structures and forms at the front of the fast moving thin ice sheet.

Self-elaborated parameters for the dynamics and geometry of the ice masses inflow admit to accept as valid that the Płock lobe evolved at the end of the fast moving ice stream intensively fed from its hinterland. That distinctive element of the LGM margin contour has featured the main ice flow artery in the distal part of the Vistula palaeo-ice stream (ice stream B3 after Punkari 1997).

References

[1] *Baraniecka M. D.,* 1989. Zasięg lądolodu bałtyckiego w świetle stanowisk osadów eemskich na Kujawach. Studia i Materiały Oceanologiczne, 56, Geolgia Morza, 4: 131 – 135.

[2] *Bennett M. R.,* 2001. The morphology, structural evolution and significance of push moraines. Earth-Science Reviews, 53: 197 – 236.

[3] *Marks L.,* 2010. Timing of the Late Vistulian (Weichselian) glacial phases in Poland. Quaternary Science Reviews, doi:101016/j.quascirev.2010.08.008

[4] *Piotrowski J. A. and Tulaczyk S.,* 1999. Subglacial conditions under the last ice sheet in northwest Germany: ice-bed separation and enhanced basal sliding? Quaternary Science Reviews, 18: 737 – 751.

[5] *Punkari M.,* 1997. Glacial and glaciofluvial deposits in the interlobate areas of the Scandinavian Ice

Sheet. Quaternary Science Reviews, 16: 741 – 753.

[6] *Roman M.,* 2008. Ice flow directions in a distal part of the Vistula Lobe during the Last Glacial Maximum. [In:] S. Lisicki (ed.), The Quaternary of Gdańsk Bay and Lower Vistula regions in North Poland: sedimentary environments, stratigraphy and palaeogeography, International Field Symposium of the INQUA Peribaltic Group, September 14-19, Frombork: 44 – 45.

[7] *Roman M.,* 2010. Reconstruction of the Płock ice lobe during the last glaciation. Acta Geographica Lodziensia, 96: 171 pp. (in Polish with English summary).

[8] *Roman M. and Balwierz Z.,* 2010. Eemian and Vistulian pollen sequence at Kubłowo (central Poland): implications for the limit of the Last Glacial Maximum. Geological Quarterly, 54,1: 55 -68.

[9] *Skompski S.,* 1969. Stratygrafia osadów czwartorzędowych wschodniej części Kotliny Płockiej. Biul. Inst. Geol., 220: 175 – 258.

[10] *Stokes C.R. and Clark C.D.,* 2001. Palaeo-ice streams. Quaternary Science Reviews, 20: 1437 – 1457.

[11] *Wysota W., Molewski P. and Sokołowski R. J.,* 2009. Record of the Vistula ice lobe advances in the Late Weichselian glacial sequence in north-central Poland. Quat. Intern., 207, 1-2: 26 – 41.

GEOCHRONOLOGICAL SEQUENCE OF PALEOGEOGRAPHICAL VARIATION IN NORTHERN LITHUANIA BASED ON DENGTILTIS OUTCROP (DUBYSA RIVER VALLEY) STUDIES

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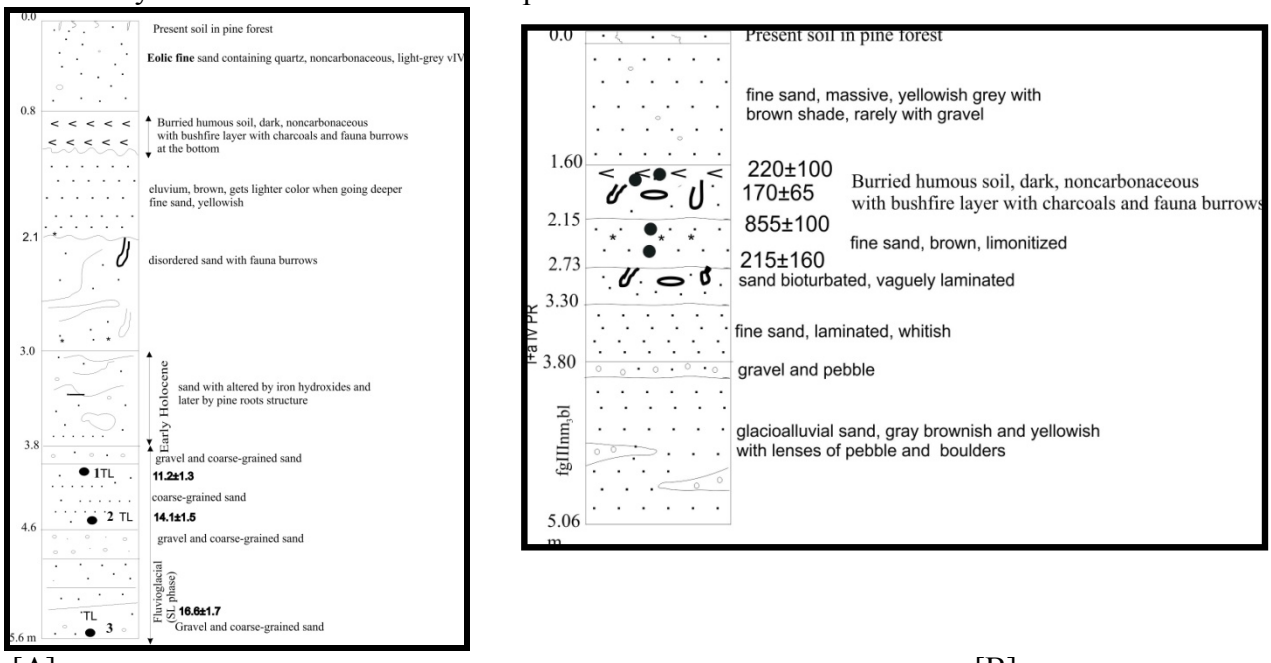
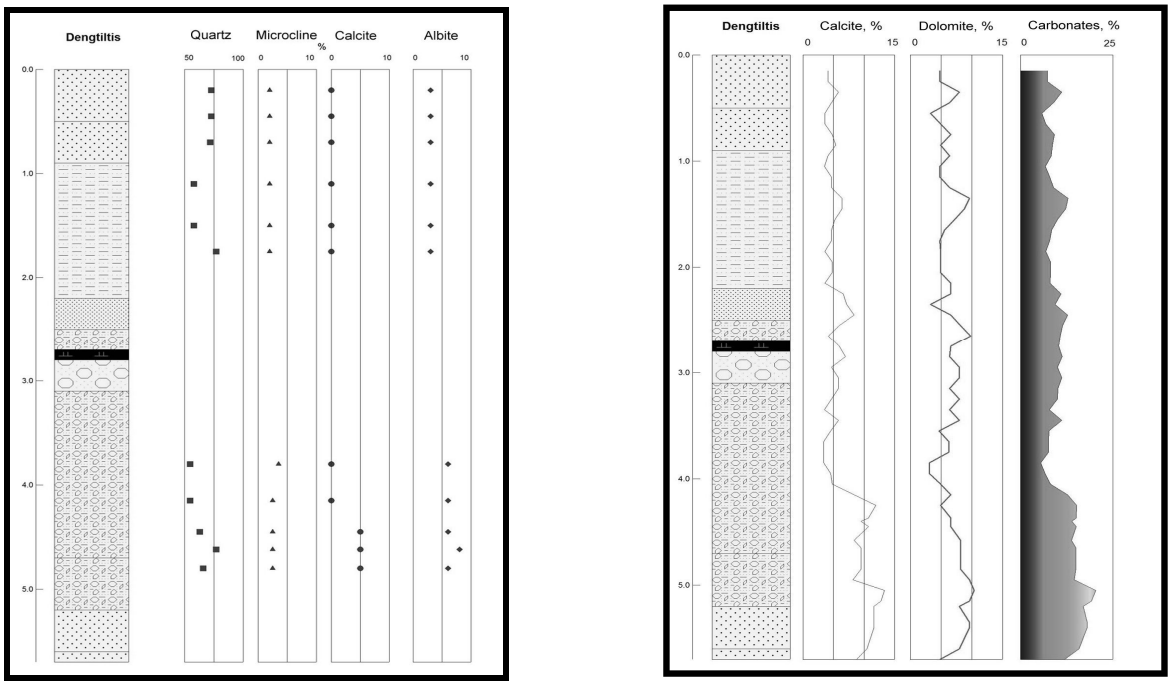
Kurtuvėnai Regional Park is situated on the right side of Dubysa riverbank. The slopes of Dubysa, especially from the right side, are densely seamed with ravines and washs. The remains of five terraces could be seen. The wide riverbed of the old valey of Dubysa has steep slopes and is seamed with intakes, valeys and meanders. The hooks of river and the old riverbeds, tree-covered slopes, overbank meadows, watery and rapid intakes running through deep valeys make a distinctive ecosystem rich in flora and fauna species.



[A] [B]

Fig.1. Dengtilis outcrop sections with thermoluminescence datings



[A] [B]

Fig. 2. A – mineralogical composition variation; B – distribution of carbonates in Dengtiltis outcrop section

Our studied outcrops situated at the abrupt bend of Dubysa. The heigh of outcrop is 5.6 meters. The mineralogical and carbonate content analyses were done for the sediments taken from the outcrop. The burrows of fauna were identified and described as well. The age of sediments was determined in two side-by-side sections using TL analysis (Figs. 1A and 1B).

The percentage of quartz (SiO_2), albite ($NaAlSi_3O_8$), microcline ($KAlSi_3O_8$), rutile (TiO_2), pyrite (FeS_2) and calcite ($CaCO_3$) was determined. The main constituent in studied wells and in the outcrop is quartz (Fig. 2). On average there are 67% and 5% of quartz and microcline, respectively, in Degtiltis outcrop. The physical weathering could be estimated using the mineralogical index of alteration, given by the ratio of quartz to the sum of quartz+ K-feldspar + plagioclase (Fig 2A).

The variation of carbonates within the studied section is uneven (Fig. 2B). The composition and quantity of carbonates reflect climatic conditions that prevailed during sedimentation. It enabes to reconstruct general climatic features, judge about a situation in the sedimentary basin during sedimentation. The cyclicity of maximal carbonate content values reflects the climate change cycles.

The sediments from the outcrop were dated by thermoluminescence method. The obtained values are from 16.6±1.7 ka BP to 0.17±65 ka BP. The sediments geochronologicaly could be atributed to The Southern Lithuanian Phase of Pleistocene – Subatlantic and to climate change events.

The burrows of fauna were identified at the depth of 0.8 meters. The burrows are present deeper as well (Figs. 1A and 1B). Bioturbations that were found in Dengtiltis outcrop have been formed during the Holocene climate optimum. The bioturbations were left by burrowing fauna before and after winter. We can also spot activities left by beavers: remains of trunks of trees in the sediment layers. The holes left by beetles (Coleoptera) and, probably, by moles (Talpidae) as well as by marmots (Marmata) could be also found in Dengtiltis outcrop.

The carbonate, mineralogical and carbonate content in the remains of trees analyses along with the carbonate content variation is in a good agreement with the paleogeographical conditions variation. Using mentioned and another geochemical techniques valuable information on paleogeographical conditions reconstruction could be obtained. The analytical data obtained could

be used for chemical and physical weathering indices determination as well. It should be noted, however, that for chemical index of alteration a determination of CaO and MgO in non carbonate minerals is essential.

The turning point from Pleistocene to Holocene is clearly seen in the studied outcrop. The climate warming-cooling continued and was predetermined by natural conditions not excluding and human activities.

QUATERNARY DEPOSITS AND HISTORY OF DEVELOPMENT OF THE LAKE ILMEN IN NEOPLEISTOCENE-HOLOCENE

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The Lake lmen has a special place among the largest lakes in Northwest Russia. It is shallow (maximum depth - 6m), with a large surface area. Quaternary sediments cover the bottom of the continuous cover. Maximum thickness of anthropogenic deposits is connected with the buried valleys (more them 50 meters). At the same time the thickness of the Quaternary cover near the south-west coast (the so-called Ilmen the limestone cliff), the formed of Devonian deposits, is reduced to a few meters.

Glacial deposits of Ostashkov horizon underlie at the base of the section of quaternary cover. Their thickness fluctuates from the first up to 20-24 m, while they reach a maximum in the central and northern parts of the lake. The layer of glacial-tectonit consisting of mixed green and brown clay, and limestone debris submerged in the clay-sand matrix in the north of the lake was fixed. Their thickness reaches 40 cm. Till presented by loam. It is very dense, brown and reddish brown containing an admixture of gravel and pebbles of sedimentary and crystalline rocks (10-30%). Two strata of till are usually separated by series of layered fluvioglacial sands. Reducing of the thickness of the glacial deposits results to the preservation of only one horizon of moraine.

Limno-glacial deposits of Ostashkov horizon form the bulk of the Quaternary section. Summary the vertical section of limno-glacial clays can be represented as:

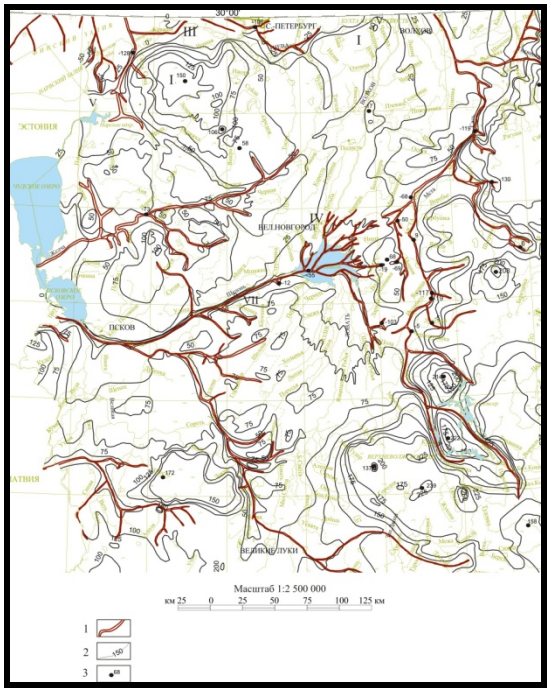
• Clay horizontally layered (varve). The increasing of arenosity of the clays is marked at the bottom of section. Coarse laminas presented by silt. Gravel appears in basal layers. It are proximal layers of glacial-lacustrine sediments.

• Clay ribbon. Lamination is a thin, similar to the rhythmic. These layers represent the distal facies of clays.

• Sand or silt are often horizontally layered. The layer is are usually thin, rarely more than 2-3 meters. Apparently the formation of this horizon is associated with the drawing of proglacial lakes.

The thickness of limno-glacial clays not exceed 20 m according to the drilling and it may reach 25 m in the buried valleys areas by geophysical data. Age of the described sediments was determined according to the palinological analysis. A typical periglacial nature of the spore-pollen spectra allowed the authors to include the basal sediments to the Late Drias. Holocene lacustrine and alluvial-lacustrine deposits are crowned the quaternary section in the deep of Lake Ilmen, and occupy a large part of its bed (80%). Lacustrine deposits are represented by two genetic types: wave lacustrine sediments (undaluvium) developed along the shoreline to a depth of 1-1.5 meters. They are presented by fine-grained well-sorted essentially quartz sands. The thickness of described sediments may reach 5-6 m; nepheloid lake sediments occupy the central part of the lake, from the depths of 2.0 meters. They are represented by clay and silty muds of dark greenish-gray and dark brownish-gray. The thickness can not exceed 10 meters. The sediments of the lower horizon are presented by sandy silt-pelitic and pelitic deposits. However, for most of the sediments are characterized by a mixed composition (mixite) with a predominance of fine fractions. Age

nepheloid sediments is set according to the palinological and diatom analyzes. The employees of the Institute of Limnology was studied section contains all parts of the Holocene, from Preboreal to sub-Atlantic.



Formation of Volkhov depression is connected with a period of Neogene-Eopleistocene tectonic activization occurred when was occurred the initial stage of an ancient river system with deep paleovalleys. The system this paleovalleys installed on geophysical and geological data indicates that in Neopleistocene there are at least two main directions of flow. The first of these is connected with the main valley, stretches along the western slope of the Valdai upland. The discharge of water was directed by this valley toward Lake Onega. But in the Late Pliocene - early Neopleistocene a runoff began in the west through the river Paleoshelon and further into the basin of Lake Peipsi and the river paleosistem of the Gulf of Finland. The forming of the lake is connected with the degradation of the Valdai (Ostashkov) glacier. The Ilmen Deep was filled by water of Ilmen-Nearvalday proglacial lakes after the retreat of the glacier from the Luga Stage boundary (14-15 thousand years of so-called). During the Neva oscillations the modern waters area of the Ilmen Lake was the deepest part of the vast Novgorod Lake, which in the Early Drias (about 13,000 years of so-called) was drained. It is possible that during this period was formed the paleo-Volkhov and the drainage was directed to the Neva lowlands, where proglacial lakes already existed 13,000 years ago, although in this respect, there are other opinions.

The accumulation of silty-pelitic sediments takes place throughout the early and middle Drias and interstage Belling. The varved lamination is gradually changed by think layering up the section, reflecting the gradual removal of the glacier and the gradual shallowing of the lake. Stadial overlap of ice in Later Drias, when the edge of the glacier reached southern Finland (stage Salpauselkya), caused a partial shallowing of the lake and increased of entrance of clastic material. It is resulted the formation in relatively shallow areas of series of clayey silt interbedded with fine sands. The total decreasing of Baltic Glacial Lake level in connection with the formation in the Middle Sweden of the strait about 10,000 years, was accompanied by a sharp (about 20m) reduction of general base level of erosion and to a significant increase of the level of the Lake Ilmen. The runoff during this period probably continued through channel Prashelon towards the Peipsi Lake and rivers Msta, Volkhov and Lovat fell into an ancient Ilmen Lake. The average size of the PraIlmen in Middle Preboreal reduced to its present or were even smaller. The process of lacustrine mud deposition began in Preboreal and Boreal. The level of the lake in thies time had some fluctuations,

approaching to the modern. Maximum level of the water was reached in the climatic optimum. Such a mode of existence of the lake Ilmen was maintained throughout the early and middle Holocene. The deltas of Msta and the Lovat began to actively shape and develop at this time. The small river there was in channel of Pravolkhov flowing into the Ilmen Lake. It forms single delta together the Msta River. The next decrease of Ilmeno-Ladoga watershed had place in the Subboreal time. Base level of erosion was Lake Ladoga. This led to the formation of the modern Volkhov, which, in essence, as the Neva River, is a duct between two lakes. The fall of Lake Ilmen level, and possibly raising the Shelon-Lovat watershed led to a stopping of drainage through the river Shelon to the west. It begins starting with Subboreal to fall into the Ilmen Lake. Short duration of this phenomenon is reflected in almost complete absence of alluvial-lacustrine deposits (delta) at the mouth of Shelon. Thus, the inversion runoff from Lake Ilmen occurred in the Subboreal Time. Starting with the sub-Atlantic time when there was an active accumulation of sediments, whose thickness 2-2.5 per thousand higher than 1.2 m

GEOMORPHOLOGY OF THE KUUSAMO-WHITE SEA ICE LOBE DURING THE LAST DEGLACIATION IN THE KUUSAMO REGION, EASTERN FINLAND

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Glaciation phases of the cyclically repeated ice ages over the Quaternary period have formed characteristic landform associations for the landscape and the mixture of sediments that was deposited under numerous processes occurred in the ice sheets (Boulton et al. 2001, Johansson et al. 2011). These features represent the changes in glaciers' dynamics (Sarala 2005 and 2007) and therefore they are an important source for paleoenvironmental applications.

The study area in Kuusamo, eastern Finland is situated in the eastern sector of the Scandinavian Ice Sheet. It is geomorphologically variable region, where one of Finland's largest drumlin fields is located (Aario & Forsström 1979). It consists of thousands of drumlins that were formed under two ice flow stages of which the older flowed from the west-northwest to the east-southeast (Aario & Forsström 1979). This represents the Kuusamo-White Sea ice lobe's (G) main flow stage during Younger Dryas, when it extends to the White Sea Gorlo Strait region (cf. Punkari 1985). The younger flow in the region represents the northwest to the southeast ice flow direction of the Kuusamo ice lobe (Aario & Forsström 1979) i.e. the Tuoppajärvi flow stage (Putkinen & Lunkka 2008) of the G (Fig. 1).

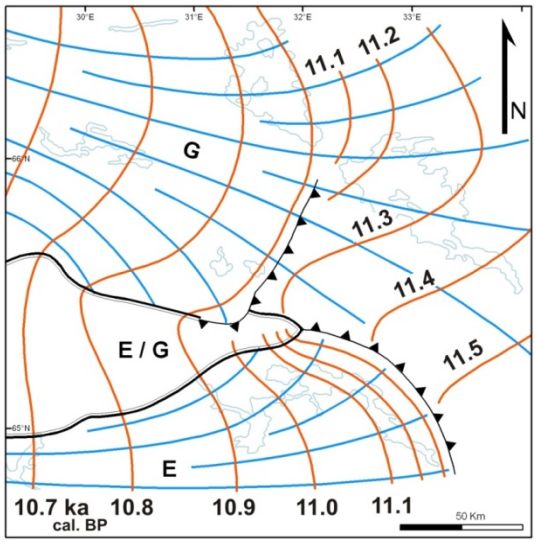

Fig. 1. Deglaciation of the Northern Karelian (E) and Kuusamo - White Sea (G) ice lobes modified after Putkinen & Lunkka 2008. The interlobate area (E/G) between the ice lobes is also indicated

Nowadays, the development of this ice lobe is presented by two overlapping drumlin fields with contrasting orientations as well as various erosional landforms. In the region, there is also large variety of other glaciogenic formations, such as flutings, hummocky moraines and eskers (Räisänen et al. 2012).

The deglaciation history of the Kuusamo region aged back to some 10,500 to 11,000 years ago (Räisänen et al. 2012). The Kuusamo ice lobe activated and advanced to the Pääjärvi end moraine position, in Russian Karelia. At the same time, a wide, almost uninterrupted drumlin field began to form in Finland and partly on the Russian side of the border. After this event, ice flow still occurred in the region and deglaciation continued time-transgressively until it reached the hill area between the Oulanka and Kitkanjoki river valleys in Kuusamo. In this certain part, the stagnant ice area appeared whereas in northern and sourthern sides the Kuusamo ice lobe still remained active.

The culmination of deglaciation in the southern part of the region took place when the ice margin reached the Ruka hill area. Large melt water input directed to the east, to the Oulanka River, forming a large esker chain to the north side of Ruka. Simultaneously, G stagnated in the northern part of the Oulanka River Valley and melted in place forming an extensive hummocky moraine field to overlap a pre-existing drumlins. Finally, this all formed a mosaic of upper mentioned landforms. Kuusamo region was deglaciated about 10,500 calendar years ago (Johansson & Kujansuu 2005).

References

[1] *Aario, R. and Forsström, L.* 1979. Glacial stratigraphy of Koillismaa and North Kainuu, Finland. Fennia 157:2, 1-49.

[2] *Boulton, G. S., Dongelmans, P., Punkari, M. and Broadgate, M.* 2001. Palaeoglaciology of an ice sheet through a glacial cycle: the European ice sheet through the Weichselian. Quaternary Science Reviews 20 (4), 591-625.

[3] *Johansson, P. and Kujansuu, R.* 2005. Pohjois-Suomen maaperä : Maaperäkarttojen 1:400 000 selitys. Quaternary deposits of Northern Finland : Explanation to the maps of Quaternary deposits 1:400 000. Geological Survey of Finland. 236 p.

[4] *Johansson, P., Lunkka, J. P. and Sarala, P.* 2011. The Glaciation of Finland. In: Ehlers, J., Gibbard, P. L. & Hughes, P. D. (eds.) Quaternary glaciations: extend and chronology. Developments in Quaternary Science 15. Amsterdam: Elsevier, 105-116.

[5] *Punkari, M.* 1985. Glacial geomorphology and dynamics in Soviet Karelia interpreted by means of satellite imagery. Fennia 163, 113-153.

[6] *Putkinen, N. & Lunkka, J. P.* 2008. Ice stream behaviour and deglaciation of the Scandianvian Ice

Sheet in the Kuittijärvi area, Russian Karelia. Bulletin of Geological Society of Finland 80 (1), 19-37.

[7] *Räisänen, J., Johansson, P., Räsänen, J., Sarala, P. Valkama, J. and Väisänen, U.* 2012. Ruka-Oulanka: geologinen retkeilykartta – geological outdoor map 1:50 000, kartta ja opaskirja – map and guidebook. Rovaniemi, Geological Survey of Finland. (In press)

[8] *Sarala, P.* 2005. Glacial morphology and dynamics with till geochemical exploration in the ribbed moraine area of Peräpohjola, Finnish Lapland. PhD thesis. Espoo, Geological Survey of Finland. 17 p. with 6 original papers.

[9] *Sarala, P.* 2007. Glacial morphology and ice lobation in southern Finnish Lapland. Geological Survey of Finland, Special Paper 46, 9-18.

GEOMORPHIC AND SEDIMENTARY SIGNATURES OF GLACIAL MELTWATER ACTIVITY DURING THE LAST GLACIATION IN THE LUBAWA UPLAND (NORTH POLAND)

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The Lubawa Upland, located close to the last glacial maximum extent in northern Poland, reveals spectacular morainic landscape of highly elevated glacial insular height (cf. Ber 2009). Most studies of this area (e.g. Marks 1979, Gałązka 2006) suggest intensive glaciotectonic processes occurring between two ice lobes on southern margin of the last Scandinavian Ice Sheet – Vistula Ice Lobe and Mazury Ice Lobe. Here we present geomorphic and sedimentary signatures which may indicate a significant influence of glacial meltwater action on the ice sheet dynamics in this region and dispute its interlobate location during the last glaciation.

Geomorphologic analyses of high resolution digital elevation model reveal the occurrence of meltwater channels dissecting the highest parts of the study area. Two systems of channels have been identified, one consisting incisions oriented consistently NW–SE and second with valleys oriented mostly NE–SW. Based on spatial distribution, geomorphometric indicators and relation to superficial geology, NW-SE oriented incisions have been interpreted as subglacial and proglacial channels and NE-SW oriented valleys as marginal/submarginal channels (cf. Greenwood et al. 2007). Subglacial channels have been possibly formed time–transgressively during the last ice sheet advance and decay whereas proglacial and marginal channels have developed subaerially as a result of progressive ice sheet decay (cf. Syverson & Mickelson 2009). Therefore we argue both NW-SE and NE-SW sets of channels were likely formed during the last ice sheet advance-decay cycle. Some sedimentary data such as: lenses of sorted sediments within basal till layers, hydrofracture structures, melt-out facies of subglacial till as well as thick sequences of ice marginal fluvioglacial gravel, reported at investigated field sites may also indicate subglacial and marginal meltwater activity. Till fabric data do not confirm convergent ice flow pattern of the last ice sheet in this region what is also consistent with ice flow direction inferred from spatial distribution of subglacial channels.

References

[1] *Ber, A.,* 2009. Vertical stress of the Pleistocene continental glaciers and its hypothetical evidence in present relief of northern Europe. Polish Geological Institute Special Papers, 29, 7–12.

[2] *Gałązka, D.,* 2006. Detailed geological map of Poland at the scale 1:50 000, sheet Lubawa. Central Geological Archive, Polish Geological Institute-National Research Institute, Warsaw.

[3] *Greenwood, S.L, Clark, C.D. and Hughes, A.L.C.,* 2007. Formalising an inversion methodology for reconstructing ice-sheet retreat patterns from meltwater channels: application to the British Ice Sheet. Journal of Quaternary Science, 22(6), 637-645.

[4] *Marks, L.* 1979. Foreland influence on ice-sheet movement during the Vistulian (Würm) glaciation: the case of the Lubawa Elevation (Mazury Lakeland). Bulletin de L'Academe Polonaise des Sciences, 26,

203-213.

[5] *Syverson, K.M. and Mickelson, D.M.,* 2009. Origin and significance of lateral meltwater channels formed along a temperate glaciar margin, Glacier Bay, Alaska. Boreas, 38, 132–145.

PALAEOECOLOGICAL SITUATION OF THE KLAIPĖDA STRAIT AREA IN THE LATE GLACIAL AND HOLOCENE (WESTERN LITHUANIA)

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Lithuanian coast began to take shape after the last glacier melting, when the recent Baltic Sea basin became free of ice. The beginning of the Curonian Spit formation is related to the Litorina Sea stage in the Middle Holocene. The final structure of the present spit was formed about 3 500 yr BP (Kabailienė, 1998). As a result, the Curonian Lagoon was formed after formation of the spit. The lagoon has connection with the Baltic Sea via the Klaipėda Strait. The Curonian Spit and coastal area developed under different palaeogeographical conditions. A large thickness of deposits in the northern part of the Curonian Spit was formed during the relatively short time from the Middle Holocene. Emerging lagoon had influence to the coastal area at that time.

Investigation of two boreholes in the Klaipėda Strait area, located on the opposite coasts (Fig. 1), gave possibility to follow palaeoecological conditions in the Late Glacial and Holocene. Complex studies (pollen, diatom, and carbonate analyses) of boreholes 65a and 90c were used for reconstruction of postglacial environment in the Klaipėda Strait (Western Lithuania). Boreholes 65a and 90c were drilled during the detail geological mapping at a large scale (1:50000) in 2005.

According to palaeobotanical data the oldest sediments (the Late Glacial) were found in the northern part of Curonian Spit (borehole 65a) and the Preboreal – in the Lithuanian coastal area (borehole 90c).

The birch was dominant in forest in the northern part of Curonian Spit (borehole 65a) during the Younger Dryas. Signs of typical cold and dry climate, unstable soils, open habitats of tundra vegetation were found (Artemisia, Salix, Juniperus, Ephedra, Selaginella selaginoides). Planktonic freshwater diatoms were characteristic of the Baltic Ice Lake (Kabailienė et al., 2009).

Pollen data of both boreholes (65a and 90c) demonstrate, that forest was not very dense in Preboreal. They consisted almost entirely of birch and pine. The amount of herbs was not significant. Previous investigations prove that Yoldia Sea level was low and Lithuanian coastal area was the land (Kabailienė, 1995; Gelumbauskaitė, 2002).

Warming of the climate in Boreal time characterizes with dense pine forest, decreasing in birch, Artemisia and Chenopodiaceae. The latest investigations show, that the Ancylus Lake level was low and didn‘t reach Lithuanian coast (Damušytė, 2011). Organogenous sediments (gyttija and peat) represent Boreal time in sections. Freshwater planktonic (Aulacoseira sp.) diatoms characteristic for the Ancylus Lake were found. It support the idea, that sediments could be deposited in a very shallow bay of the Ancylus Lake and oncoming thansgression of the Litorina Sea redeposited freshwater planktonic diatoms from deeper part of the basin.

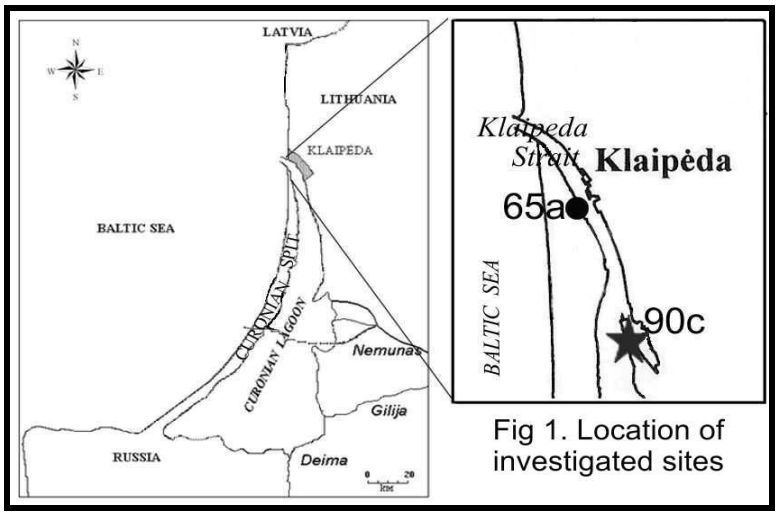

Fig 1. Location of investigated sites

The warmest and the most humid climate was during the Atlantic period. Broadleaved trees (elm, oak, lime and ash) were widespread in the western part of Lithuania. It is possible to distinguish two Litorina Sea transgressions according to diatoms. The first small brackish water inflow took place at the begining of Atlantic, when freshwater planktonic diatoms prevailed in the area of recent strait. The second transgression was major. It shows increased number of brackish diatoms in both boreholes. However, freshwater epiphytic diatoms prevailed in the western part of the strait and freshwater planktonic in the eastern part during the second Litorina Sea transgression. Acording to diatoms it seams, that very shallow nearshore freshwater environment existed in the western part of the strait and deep freshwater in the eastern part at the end of Atlantic. It is possible, that local environmental conditions were significant at that time in the strait and diatom complexes were influenced by currents and redeposition (Trimonis et al., 2011).

Decreasing of broadleved trees and spreading of spruce, pine and hornbeam in forest is characteristic for Subboreal. Significant increase in number of freshwater benthic and epiphytic diatoms can be related with dryer climate and decreased Postlitorina Sea level at that time.

Mixed coniferous-broadleaved forest was widespread in the Subatlantic. Formation of the Curonian Spit continued under aeolian processes from the begining of Middle Subboreal (burried soils in borehole 65a). Almost freshwater bay of the Postlitorina Sea existed in the easten part of the strait during Subatlantic.

References

[1] *Damušytė, A.* 2011. Post-glacial geological history of the Lithuanian coastal area. Summary of doctoral dissertation. Vilnius University, Nature Research Center, Institute of Geology & Geography, Vilnius, 84 p.

[2] *Gelumbauskaitė, L.Ž.,* 2002. Holocene history on the northern part of the Kuršių Marios (Curonian) Lagoon. Baltica 15, 3-12.

[3] *Kabailienė, M.* 1995. The Baltic Ice Lake and Yoldia Sea stages on data from diatom analysis in the Central, South – Eastern Baltic. Quaternary international, 27. 69-72.

[4] *Kabailienė, M.,* 1998. Vegetation history and climate changes in Lithuania during the Late Glacial and Holocene according to pollen and diatom data. In: Kabailienė, M., Miller, U., Moe, D., Hackens T., (Eds.), Environmental history and Quaternary stratigraphy of Lithuania. PACT, 54, 13-31.

[5] *Kabailienė, M., Vaikutienė, G., Damušytė, A., Rudnickaitė, E.* 2009. Post-glacial stratigraphy and palaeoenvironment of the northern part of the Curonian Spit, Western Lithuania. Quaternary international, 207, 69-79.

[6] *Trimonis, E., Vaikutienė, G., Gulbinskas S.* 2010. Seasonal and spatial variations of sedimentary matter and diatom transport in the Klaipėda Strait (Eastern Baltic). Baltica, 23 (no.2). 127-134.

THE CHANGEABILITY OF THE LATE WEICHSELIAN TILLS PETROGRAPHIC COMPOSITION, NORTHERN POLAND

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This paper discusses the outcomes of some selected works associated with a project which the main objective was to reconstruct geological processes accountable for the formation of the Late Weichselian till profiles in northern Poland. The research concerns the area which was engulfed by the Vistula palaeo-ice stream of the last ice sheet. There exist separate till beds in the southern part of the considered district, which represent successive phases of the Late Weichselian (Poznań (Frankfurt) Phase and Leszno (Brandenburg) Phase, see Wysota et al. 2009). The authors focussed on the northern quarter of the mentioned region, which remained under the Vistula palaeo-ice stream and which, despite changes to ice sheet extent during subsequent re-advances, stayed under the cover of ice. The whole Late Weichselian is there represented by a single till bed, though often being characterized by a complex vertical profile. The observed in the area variation of petrographic composition of youngest tills is, among others, a consequence of the described situation. To examine this variation thoroughly, experimental works were planned, based on a high-resolution vertical sampling followed by analysis of petrographic composition changeability within vertical sequences (see Woźniak and Czubla 2011), rather than taking relevant arithmetic means of the number of rocks in different groups, taken for the entire till bed under investigation.

Vertical variation analysis of the selected till beds petrographic compositions was applied to seek for a track record of any changes to debris delivery to the examined area during successive re-advances. It appears that subhorizons can be distinguished in till profiles, in majority of the key exposures, which differ in composition of the fine gravel fraction (5-10 mm). The mentioned composition variations often divulge an abrupt, irregular nature: one can observe here significant changes to the values of petrographic coefficients and a large divergence in the presence of some rocks, in that the rocks of local provenance. In most cases, one can speak about profiles duality. In some of the key exposures, such a duality is suggested also by additional attributes: variation of petrographic composition of the coarse gravel fraction, alterations to till fabric, presence of a shear zone or some other macroscopic features which indicate successive re-advances of ice sheet. During the above-mentioned analysis, attention was also given to the relationship between the properties of debris and the corresponding facial type of till.

It should be emphasized that in case of some of the examined key exposures, the outcomes delivered during the discussed studies are not quite unambiguous. Namely, in certain key exposures, low till unit thickness (less than 2 m, and only approx. 40-60 cm of which correspond to lodgement till) is an impediment and it makes a thorough examination of the petrographic composition changeability difficult, even in case of high resolution sampling (sections of 30 cm, or lower, length), or it simply hinders notably the collection of statistically reliable samples. Moreover, only in some key exposures macroscopic features of till are observed which may indicate signs of ice sheet reactivation and formation of one till bed during successive re-advances.

The carried research also aspired to identify the properties of the Fennoscandian erratics assemblages which are characteristic for successive glacial advances during the Late Weichselian. The performed research was based on the methodology proposed by Lüttig (1958) with its later modifications (Smed 1993, Czubla 2001). The obtained results revealed some diversity of the quantitative ratios of erratics, coming from different Fennoscandia provinces, within vertical profiles of the the Late Weichselian glacial sediments. Contrary to the authors expectations, certain

variations of the till coarse gravel fraction compositions were observed also between different key exposures. This fact seems to suggest a large and diverse contribution of older glacial sediments, incorporated by advancing ice sheet. Such hypothesis is supported also by a considerable horizontal changeability of the amount of erratics of the local provenance, resulting from a local differentiation of ice sheet substratum in the Eastern Pomerania and the Lower Vistula Region.

It is worth noting that the results of thermoluminescence (TL) of the sub- and over-till sediments, performed as a part of the project in the University of Gdańsk Laboratory, clearly reveal the formation time-frame of the examined tills. The major part of the data obtained for sub-till sediments indicates the age of about 23-30 TL ka, thus corresponding to a period before the Last Glacial Maximum in Poland. On the other hand, over-till sediments can be found in some of the considered key exposures, which are related to deglaciation of the investigated regions. And the corresponding TL dating results suggest that those sediments were formed at the close of the last glacial period, however in some cases a rejuvenation can be observed of the age of the examined sediments.

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References

[1] *Czubla P.,* 2001. Eratyki fennoskandzkie w utworach czwartorzędowych Polski Środkowej i ich znaczenie stratygraficzne [with English summary: Fennoscandian Erratics in Quaternary Deposits of Middle Poland and their Value for Stratigraphic Purposes]. Acta Geographica Lodziensia, 80, 1-174.

[2] *Lüttig G.,* 1958. Methodische Fragen der Geschiebeforschung. Geologisches Jahrbuch, 75, 361-417.

[3] *Smed P.,*1993: Indicator studies: a critical review and a new data-presentation method. Bull. of the Geol. Soc. of Denmark, 40 (3-4), 332-344.

[4] *Woźniak, P. P. and Czubla, P.,* 2011. Geological processes record in the vertical and horizontal changeability of the Weichselian tills profiles in northern Poland – a concept of the research project and preliminary results. In: Johansson P., Lunkka J-P. and Sarala P. (eds.), Late Pleistocene glacigenic deposits from the central part of the Scandinavian Ice Sheet to Younger Dryas End Moraine Zone. GTK, Rovaniemi, 137-138.

[5] *Wysota, W., Molewski, P., Sokołowski, R. J.,* 2009. Record of the Vistula ice lobe advances in the Late Weichselian glacial sequence in north-central Poland. Quaternary International, 207, 26–41.

WIECHSELIAN GLACIATIONS IN MID-NORTHERN POLAND: CHRONOLOGY AND PALAEOGEOGRAPHY IN THE LIGHT OF OSL DATING

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There is a broad consensus that after the Eemian interglacial major advances of the Scandinavian Ice Sheet occurred during marine isotope stages 5d, 4/3 and 2, however the delineation of particular ice limits and synchronicity of ice advances in different areas are still uncertain. Problems with constraining glacial events of the Scandinavian Ice Sheet during the Weichselian glaciation are perplexing also in the type area of this glaciation in mid-northern Poland. Previous investigations in this area considered three ice advances, i.e. the Torun advance in the Early Weichselian (MIS 5d), the Świecie advance in the Middle Weichselian (MIS 4) and the Main advance in the Late Weichselian (MIS 2), separated by ice-free interstadials. However dating control of the age of these ice advances and retreats is highly uncertain.

Weichselian sediments in mid-northern Poland were dated with the OSL method. A total of 142 OSL samples were dated from 34 sites spread along a N-S transect covering the area of the Weichselian glaciation from its maximum extent to the Pomeranian ice marginal position. Wherever possible, waterlaid deposits bracketing till units were dated. The OSL method was supported by radiocarbon dating (6 samples). Additionally, numerous luminescence (OSL,TL) and radiocarbon dates for sites known from literature were also included to generate a synthetic event-stratigraphical diagram of Weichselian glaciations in mid-northern Poland.

The OSL ages obtained do not yield support for the ice advance during MIS 5d, neither do they show any unequivocal evidence of MIS 4 glacial sediments. We speculate that the first Weichselian ice advance might have occurred in the early MIS 3, c. 55–50 ka BP. The OSL dates suggest occurrence of till deposits of the late MIS 3 glaciation, c. 30–28 ka BP but more dating control of this suggested ice advance and the delineation of its presumable extent are needed. The results undoubtedly prove two ice advances along the Vistula (Weichsel) River in mid-northern Poland during the MIS 2, c. 22-18 ka BP: the older one (c. 22-21 ka BP) is correlated with the Leszno (Brandenburg) phase and the younger one (c. 19-18 ka BP) is correlated with the Poznań (Frankfurt) phase.

KUR'JADOR KEY-SECTION WITHIN THE UPPER VYCHEGDA – A PALAEOENVIRONMENTAL ARCHIVE OF THE EUROPEAN NORTH-EAST

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The Kur'jador site (N 61.68517; E 054.89310) is located at upper stream of the Vychegda river which is a large right tributary entering into the North Dvina basin near Kotlas sity (Archangelsk region). This two rivers compose a Vychegda - North Dvina fluvial system that is a key-area for glacial-interglacial studies, as ice sheets from Barents Sea and Scandinavian centers affected this region during the Late Weichselian (Kjaer et al., 2003; Svendsen et al., 2004; Larsen et al., 2006). On the other hand, since 1989 the Kur'jador site was stated as a natural geological landmark because this is a unique natural exposure containing loess deposits in the Komi republic (Geological heritage..., 2008); now this is a narrow and sharp-crested remnant of an old structure which is significantly eroded, and it is impossible to estimate the character of its initial surface. One of its sides is a steep outcrop on a right bank of Vychegda, ca 200 m long and of 15-16 m height. Its very complicate structure and a long natural archive attracted many geologists from 1970-ties till now (Guslitser, Duriagina, 1983; Lavrov, Potapenko, 2005; Andreicheva, 2009; 2011; Zaretskaya et al., 2011; Lysa et al., 2011). Our research group worked on this section in 2010-2011 for extensive radiocarbon and ^{230}Th/U dating of organic horizons and palaeoenvironmental studies of the Vychegda – North Dvina system. Hereafter we present the site description (from bottom to top) with various interpretations and our results and notions concerning its formation and evolution during the Late Pleistocene.

1. The lowermost unit of 2.4-2.5 m thickness consists of coarse grayish and rusty sand and gravel, horizontally or cross-bedded, typical for fluvial (river bed) sediments. OSL dating results (Lysa et al., 2011) are around 240 ka BP, and a huge erosional gap is separating this unit from upper horizons.

2. The next stratigraphic unit corresponds to Early to Middle Weichselian transition and Middle Weichselian (Valday) period of interstadial warming. Transitional horizon is presented by 1.5 m of gray clayey silt with poorly expressed lamination and rare thin lenses of gray sand. This layer is covered by thin (8 cm) lamina of peaty loam. Macrofossil analysis determined fen bog plants, and the ^{14}C date is 41.700±600 BP (GIN-14324), that is 45.6-44.7 kyr BP calibrated. According to (Lysa et al., 2011; Andreicheva, 2011) gray silts have been deposited in a lake basin; probably our date obtained on fen bog deposits determines the period of lake regression and paludification after a start of Middle Valday warming.

Organic horizon is overlain by a 2 m stratum of fine gray to beige sands and silts, horizontally and wedge-bedded, with traces of ice-wedges though the whole strata and strong deformations. In previous works this horizon was identified as shallow lake deposits (Andreicheva, 2009; 2011; Lysa et al., 2011); ice-wedges could indicate a cooling period within the Middle Valday warming stage. The upper horizon of Middle Valday period is the organic-rich strata of 0.7-0.8 m thickness, which was described as a peat horizon in the previous works (Andreicheva, 2009; 2011; Lysa et al., 2011). Our studies including plant and spore-pollen analyses showed that there were no evidences of water or mire environment during the accumulation of this layer; many remains of gramineous (30-90 %) and shrub (10-70 %) plants and the micro-structure of the matter indicates that this layer was forming in the subaerial meadow or grassland conditions. Radiocarbon dating of three samples from this horizon showed the continuous accumulation from 39.170±260 BP (GIN-14323) to 31.200±230 BP (GIN-14321) of organic matter.

The lower, most organic-rich layer of this horizon has been dated parallel by ^{14}C (39.170±260;

36.920±330 (GIN-14322-23)) and ^{230}Th/U methods. Using a new version of ^{230}Th/U isochronic dating, we received the age of 47.8±2.3 ka after L/L model and 42.8±4.0 after TSD model. The concordance is rather good between the ^{230}Th/U dates according to both models. The results are in a very good agreement with ^{14}C dates: calendar age 43.6-41.6 kyr BP of buried organic matter falls into the summary interval of ^{230}Th/U age; and the TSD-model Th/U date fits well into the ^{14}C calibrated interval.

3. Unit 3 consists of two sub-units corresponding to Late Weichselian (Valday) period. The lower sub-unit of 2 m thickness is a grey massif silty aleurite with many nodules in the bottom part; the transition from the organic-rich layer to this grey aleurite is very gradual, and organic matter within the "nodule" level allowed us to obtain two 14C dates - 30.800±170 BP (GIN-14569) and 26.200±400 BP (GIN-14320) (35.4–30.6 kyr BP calibrated). Plant composition (shrub remains) indicates the subaerial depositional environment. The uppermost sub-unit is of 5.5 m thickness; this is a non-layered yellowish porous aleurite, very dry and compact, forming vertical walls.

Unit 3 is a matter of great discussion between various scientists (Guslitser, Duriagina, 1983; Andreicheva, 2009; 2011; Zaretskaya et al., 2011; Lysa et al., 2011). In Lysa et al. (2011) these deposits are described as of ice-dammed lake origin (the so-called LGM Lake). According to their notions, when the glacier reached its maximum position during Late Weichselian (17-16 ka) this lake exceeded the 135-m a.s.l. level and through the Kelt'ma passpoint was overflowing into the Volga basin. The OSL dates 16.9±1.1 and 14.0±0.8 ka from the upper part of Kurjador section mark the uppermost level of the LGM lake altitude (Lysa et al., 2011).

On the other hand, the grain-size data (Andreicheva, 2009; 2011) points the origin of these strata as loess-type deposits formed in the dry and windy conditions of Late Valday periglacial environment; similar deposits of aeolian genesis have been described in Pechora lowlands (Astakhov, Svensden, 2011). Our dating and spore-pollen results obtained on this section and other outcrops along the Upper and Middle Vychegda give evidence of the very cold and dry periglacial environment within this area during the LGM (Zaretskaya et al., 2011) with deep incision of Vychegda river bed. Furthermore, in the bottom part of "Biostation" section (Middle Vychegda, modern water level) we have obtained ^{14}C dates on abandoned channel deposits 13.890±50 (GIN-14192) and 12.900±60 (GIN-14190) that is 17–14.5 kyr BP calibrated (Zaretskaya et al., 2011), and is synchronous to OSL dates 16.9-14.0 ka from the upper Kur'jador section; so we consider the Vychegda river level during the LGM close to or slightly lower than the modern one and a fluvial, not a lake palaeoenvironment within this area.

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References

[1] *Andreicheva L.N.* (2011) Palaeoenvironmental conditions of deposits formation in the Upper Pleistocene "Kur'jador" key-section in the European North-East (Vychegda basin) // Litosphera, n. 2, p. 122-127.

[2] *Astakhov V.I., Svensden J.-I.* (2011) A cover formation of the Final Pleistocene in the extreme European North-East // Regional geology and metallogeny, v. 47, p. 12-27

[3] *Guslitser B.I., Duriagina D.A.* (1983) Palaeoenvironment within the Upper Vychegda during the Middle-Late Valday time // Geology and resources of the European North-East of the USSR, Syktyvkar, p. 26-27

[4] *Lysså A., Jensen M., Larsen E., Fredin O., Demidov I.* (2011) Ice-distal landscape and sediment signatures evidencing damming and drainage of large proglacial lakes, NW Russia // Boreas, v. 40, n. 3, p. 481-497.

[5] Zaretskaya N.E., Panin A.V., Chernov A.V. (2011) Geochronology and palaeogeography of the Late Pleistocene to Holocene transition within the Vychegda – North Dvina system // Proceedings of the VII Russian Conference on Quaternary Research, Apatite-SPb, v. 2, p. 203-206

COMPARISON OF DEPOSITIONAL CONDITIONS OF THE LATE WEICHSELIAN FLUVIO-AEOLIAN SEQUENCE IN WESTERN POLAND AND WESTERN UKRAINE

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Fast climatic changes, which started from the climate pessimum in connection to the maximal extent of the Scandinavian Ice Sheet in Plenivistulian and lasted until the warm phase in the Yearly Holocene, occurred between the Vistulian (Weichselian) and the Holocene. These changes resulted in the evolution of depositional environments which has been particularly noticeable in the profiles of fluvial terraces flunking the sides of fluvial valleys in the extraglacial zone of the Last Glaciation. A typical sequence of facies is the following: deposition in the environment created by the sand-bearing river in a fluvial valley; fluvio-aeolian facies; and aeolian environment. The increasing number of documented sites from the European Aeolian Sand Belt allows the reconstruction of the variability of character, dynamics and the age of depositional processes. The stratigraphic position of these processes is mainly determined on the basis of radiocarbon dating and/or palynological analysis of organogenic strata. However luminescence dating, e.g. TL and OSL has been used more frequently due to scarcity of organic matter in the analyzed sediments.

Because of definitely more research being conducted within the western part of the Aeolian Sand Belt, it seemed justified that a comparative study should be undertaken in the middle and eastern part of the Belt. The aim of the study was to assess the similarities and differences of sedimentation conditions and the dynamics of climatic changes in dependence on geographic location of the analyzed sites within the Belt stretching from western Poland to western Ukraine.

The study consisted of: a) lithofacial analysis of the sediments from chosen exposed sites, b) laboratory analyses (grain-size analysis, morphoscopy and the identification of heavy minerals) of the selected representative profiles, and absolute dating of sediment by using TL method.

For comparative purposes, two sites were chosen, i.e. Żabinko in western Poland and Berezno in western Ukraine. Geomorphological conditions at both sites were very similar because they were located within the range of aeolian forms located on accumulation terraces of fluvial origin from Plenivistulian. On the other hand, the sedimentation profile generally consisted of three units, as follows:

2) middle unit formed due to aeolian accumulation within the floodplain via frequent low-energy flows. In Żabinko aeolian sands deposited on humid surface were definitely dominant, while in Berezno aeolian deposits were often cutting through rather small, quickly filled river beds. Sediment wedges affected by syn-sedimentation, small faults and flexural bends were documented within this unit.

3) upper unit represented by sediments of aeolian origin. In Żabinko the unit's floor depicted accumulation of the aeolian sheet, and the material was mainly deposited as large mobile dunes. These forms originated due to prevalent western winds. In Berezno the most frequent were sediments deposited within aeolian sheet with very scarce culmination points in the form of small dunes. Two almost equally important wind directions were documented at this site, i.e. from the west (NNW to SE) and from the east and NE.

The described lithological variability of the analyzed profiles definitely indicates fast climatic changes in relation to a) temperature and humidity changes, i.e. transition from deposition in the fluvial valley river to fluvio-aeolian deposition, and b) degradation of permafrost resulting in mobilization of large amounts of material followed by dune formation. On the other hand, the

differences between the profiles show clearly the influence of the oceanic climate on the depositional forms in Żabinko, and of continental climate in Berezno.

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