Polish Geological Institute Special Papers, 16 (2005): 103–108
Proceedings of the Workshop "Reconstruction of Quaternary palaeoclimate and palaeoenvironments and their abrupt changes"

VEGETATION AND CLIMATE CHANGES DURING MERKINE INTERGLACIAL (EEMIAN) IN LITHUANIA

Vaida SEIRIENE[1], Ona KONDRATIENE[1]

Abstract. The main features of vegetation and climate changes during Merkine Interglacial (Eemian) are discussed in the paper. Pollen data of about 34 sections were used in this study. Calculated climatic parameters indicate warmer and damper climate during the climatic optimum than at present in Lithuania. The mean year temperature fluctuated from +11 to +13°C, mean January temperature from +1 to –1°C and mean July temperature – from +22 to +23°C. Number of precipitation's ranged from 1080 to 1100 mm. The natural vegetational changes took place during the climatic optimum, climatic changes played an insignificant role.

Key words: pollen, vegetation, temperature, climate, Eemian Interglacial.

INTRODUCTION

The Upper Pleistocene Merkine Interglacial (Mikulino, Eemian) sediments are wide spread. These were found in different parts of Lithuania except the Seaside Lowland (Fig. 1). Most sections have been examined in the south-eastern area. Some of them are covered by the till of the Last Glaciation (Nemunas, Weichselian), other lies outside its limit. Very often they are exposed in the outcrops of river valleys and ravines. In all cases sediments are very rich in organic matter and palaeontological remains. The formation time of sediments in many sections comprises not only the Merkine Interglacial, but also the Medininkai Late Glacial (Saalian) and the first half of Nemunas Glaciation. Investigations of this interglacial are of special interest for palaeoclimatologists, because it is the most recent complete warm phase and presents vegetation and climate changes not influenced by human activity. Vegetation changes during the Merkine Interglacial in Lithuania were discussed in many papers (Riskiene, 1979a, b; Kondratiene, 1996), however the climate reconstructions are sparse (Kondratiene, 1979; Kondratiene, Seiriene, 2000).

MATERIAL AND METHODS

Pollen diagrams, of plant ecological groups, were constructed in order to resolve the climatic conditions during the interglacial and define more precisely the limits between the vegetation phases. For this purpose, the four most complete and characteristic sections were chosen. Three of them (Jonionys-4, Mickunai-9, Gaidunai-5) are from the area covered by the till of Last Glaciation and one (Medininkai-117) — outside the area of Last Glaciation. Pollen species were grouped into 6 groups: 1— broad-leaved trees (*Quercus, Ulmus, Tilia, Carpinus, Acer*), 2 — hazel and alder (*Corylus* and *Alnus*), 3 — representatives of boreal forest (*Pinus, Picea, Betula*), 4 — subarctic and arctic plants (*Betula nana, Selaginella selaginoides, Botrychium boreale, Lycopodium appressum, L. alpinum* etc.), 5 — mosses and ferns (spores), 6 — herbs.

For estimation of the range of climatic variability during the interglacial the method by Muratova *et al*. (1972) was used. It is based on the theory of probability. This method allows evaluation of the pollen composition and gradation of the trees according to their distribution. A limitation of the method is that it cannot be used for treeless landscapes. Pollen data of about 34 sections were included in the calculations.

The directions of tree migration were deduced using isopollen maps for the main tree taxa. The percentages of particular tree pollen in relation to all other trees were calculated in order to construct the maps. The maps were constructed for all climatic optimum phases.

[1] Institute of Geology and Geography, T. Sevcenkos 13, 03223 Vilnius, Lihuania; e-mail: seiriene@geo.lt

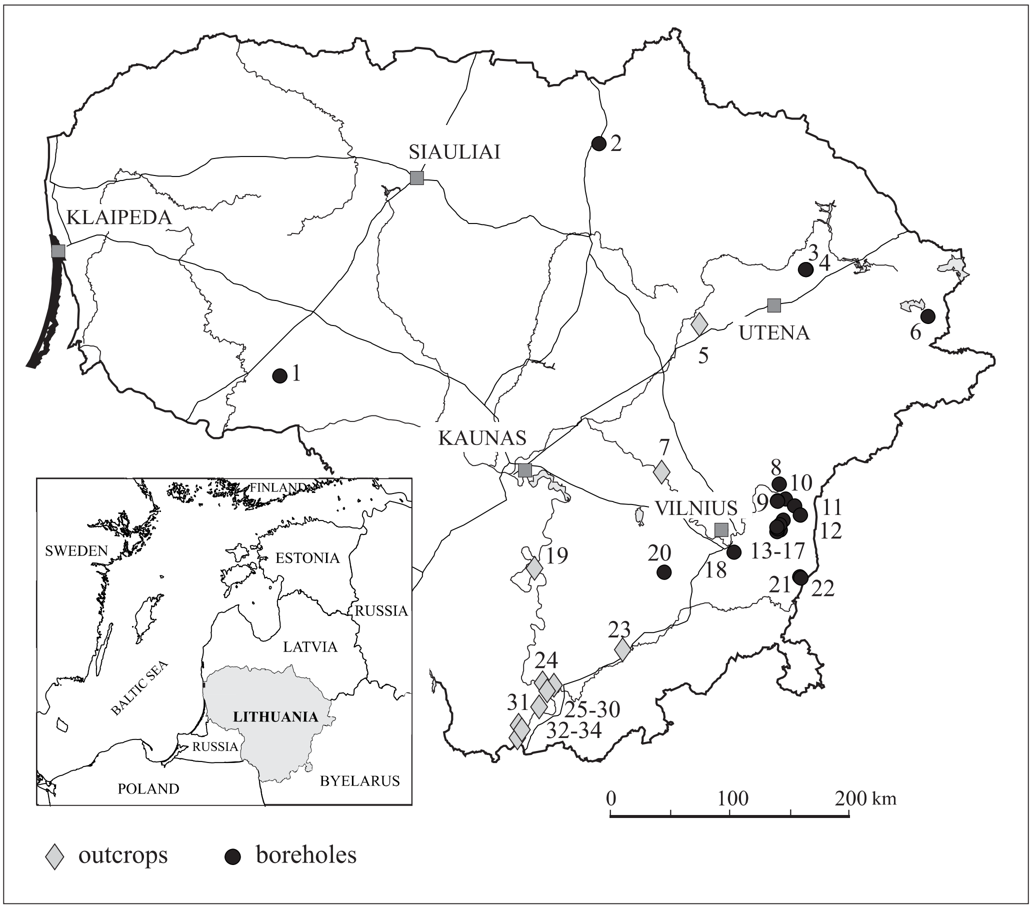

Fig. 1. Sites of the Merkine Interglacial palaeontological investigations

1 — Gaure, *2* — Pasvalys, *3* — Bikuskis-25, *4* — Bikuskis-80, *5* — Kurkliai, *6* — Gerveles, *7* — Kmitos, *8* — Skersabalis-110, *9* — Bezdonys-79, *10* — Bezdonys-296, *11* — Bezdonys-78, *12* — Skynimai-90, *13* — Gaidunai-95, *14* — Gaidunai-1, *15* — Gaidunai-5, *16* — Mickunai-9, *17* — Mickunai-7, *18* — Kirtimai, *19* — Giraitiskes, *20* — Puponys-674, *21* — Medininkai-2, 3, *22* — Medininkai-117, *23* — Smalininkai, *24* — Netiesos, *25* — Jonionys-1, *26* — Jonionys-2, *27* — Jonionys-3, *28* — Jonionys-4, *29* — Maksimonys, *30* — Kibysiai-1, *31* — Liskiava, *32* — Druskininkai, *33* — Ratnycia, *34* — Duskininkai fiz.p.

HISTORY OF VEGETATION CHANGES

On the basis on vegetation composition Merkine Interglacial can be subdivided into 7 zones (Kondratiene, 1996). The development of flora is characterised by a differentiation in the forest composition. The first among broad-leaved trees that appeared and spread were *Quercus* and *Ulmus*. At the beginning they made mixed forests with conifers, mostly *Pinus*. Later on, uniform forests of the broad-leaved trees formed, including *Tilia* that appeared and spread much later than *Quercus*. In the forests of the southeast Lithuania the *Tilia* was probably dominating (up to 70%). The *Corylus* underwood started forming during the maximum spread of the *Quercus* and reaches about 30% in spectra (estimated from the total sum of the pollen in the rest of the tree group). The maximum spread of the *Corylus* pollen is simultaneous between the maximum spread of the lime and oak pollen. *Carpinus* appeared in the forests only in the second half of the climatic optimum. Uniform *Carpinus* forests might have grown in some areas (about 78% in the spectra). Later *Carpinus* was replaced by *Abies*. The climatic optimum of the Merkine Interglacial can be divided into 3 subzones: M_{3a} – *Quercus*, M_{3b} – *Tilia*, M_{3c} – *Carpinus*.

All these successional stages are well represented in the diagrams of plant ecological groups (Fig. 2; $M_{1\text{-}5}$ stages) as well as the periods of late glacial (Md_1 and Md_2 stages) and the beginning of next glaciation (Nm-J stages). According to pollen data the first cooling of the Nemunas Glaciation (Weichselian) was considerably cold. It can be characterised by the disappearance of the broad-leaved trees and the spread of the vegetation of open areas.

Very informative is the diagram of the section Medininkai-117 where the periods of the glacial transgression and recession (Fig. 2; 1.8–3.9 m depth) of the end of the Nemunas Glaciation (Nm_2 stage) can be clearly distinguished as well.

Climate. The climate of Late Glacial period was quite severe (Fig. 3). The mean temperature in January may have fall down to –30°C and rise up to +17°C in July. Temperatures grow warmer quite rapidly at the beginning of the interglacial.

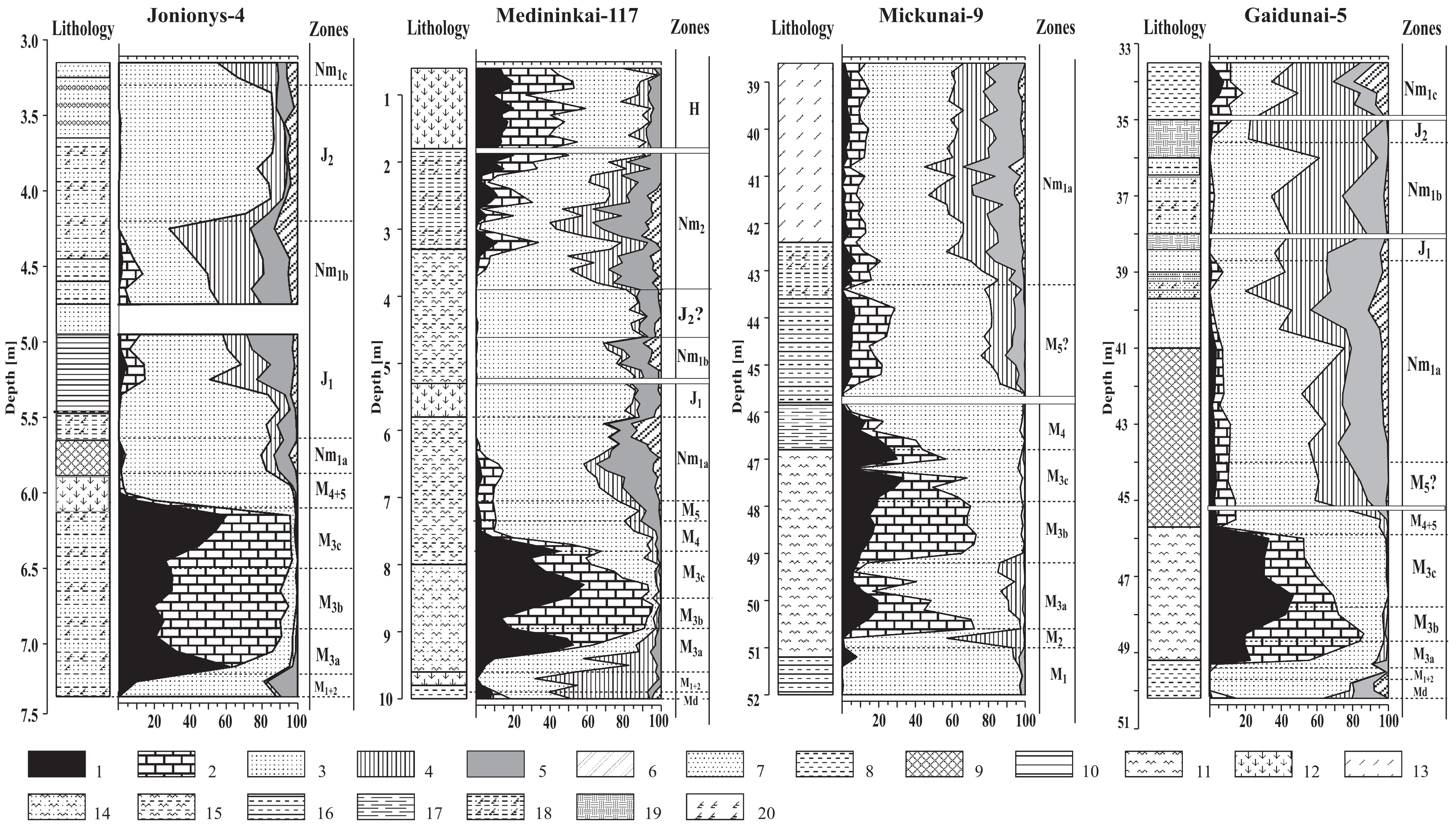

Fig. 2. Pollen diagrams of plant groups in sections Jonionys-4, Medininkai-117, Mickunai-9 and Gaidunai-5

Pollen and spores groups: *1* — broad-leaved trees, *2* — Alnus+*Corylus*, *3* — boreal taxa, *4* – spores, *5* — herbs, *6* — subarctic taxa; lithological signs: *7* — sand, *8* — silt, *9* — gyttja, *10* — clay, *11* — sapropelite, *12* — peat, *13* — clayey sand with organic, *14* — sandy sapropelite, *15* — silty sapropelite, *16* — clayey silt, *17* — marl with vivianite, *18* — silt with organic matter, *19* — burried soil, *20* — organic matter

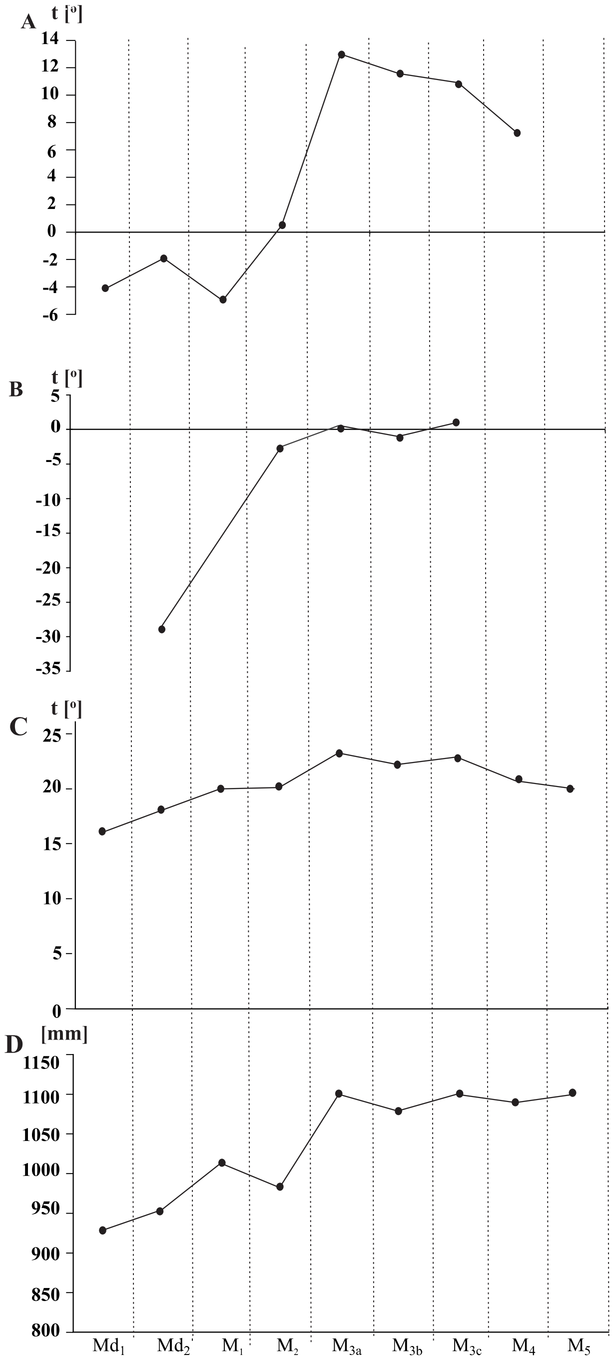

Fig. 3. Reconstructed climatic parameters: A — annual temperature, B — January temperature, C — July temperature, D — annual precipitation

Winter temperature increased up to –2°C (January), summer — up to +20°C and precipitation fluctuated between 950–1000 mm.

Obvious oscillations of broad-leaved pollen can be observed in the diagrams of plant ecological groups (Fig. 2) during the climatic optimum. Adding the black alder (*Alnus*) and hazel (*Corylus*) pollen can easily cancel these fluctuations. The present distribution of the latter points to their high requirements to climate conditions (Meusel *et al*., 1965). Slight fluctuations of the values of calculated climate parameters of climatic optimum were observed. The highest annual temperature registered for *Quercus* phase — +13°C and the lowest for *Carpinus* phase — +11°C. The mean January temperature ranged from +1°C during *Carpinus* phase to –1°C during *Tilia* phase and mean July temperature respectively from +22 to +23°C. Number of precipitation's ranged from 1080 to 1100 mm. These results don't indicate any considerable changes of climate during the climatic optimum.

After the climatic optimum, a gradual deterioration of climate began.

Directions of migration of individual tree taxa. First among broad-leaved trees appeared *Quercus* and *Ulmus*. *Quercus* spread faster and occupied the larger areas of the forests than *Ulmus*. In some places, especially in northern part of Lithuania *Ulmus* was not numerous during all interglacial (Kondratiene, Klivechkiene, 1983; Kondratiene, 1996). The isopollen maps for climatic optimum points that *Quercus* and *Ulmus* spread from south-east and south-west, *Tilia* — mainly from south and *Carpinus* — from south-west (Fig. 4). *Carpinus* were more numerous in the southern Lithuania.

During all the climatic optimum deciduous trees were more widely distributed in southern Lithuania. It might be caused by lithological composition of the soils: the light, sandy soils dominated in the northeastern part of Lithuania and — hard, sandy loam in southern.

After the climatic optimum, during phase M_4 the spruce was dominant in the southeastern part of Lithuania.

DISCUSSION AND CONCLUSIONS

A rapid warming was indicated at the beginning of the interglacial. Only one climatic optimum existed during the interglacial. Climate during the optimum was warmer and damper than at present in Lithuania with slight fluctuations. The mean year temperature ranged from +11 to +13°C, mean January temperature from +1 to –1°C and mean July temperature from +22 to +23°C. Number of precipitation's varied from 1080 to 1100 mm. Estimated climatic parameters points on the *Tilia* (M_{3b}) subzone as a relatively coldest period of the climatic optimum. The calculated magnitude of this cooling is about 2–3°C. Some decrease of broad-leaved trees at the end of *Quercus* zone was fixed in the pollen diagrams of plant ecological groups (Fig. 2) as well. According to the plant macroscopic remains data (Riskiene, 1979b) the warmest might have been *Carpinus* (M_{3c}) subzone during which the thermophilous plants were most numerous. Maybe the seasonal climate changes during the *Carpinus* subzone (M_{3c}) were less noticeable than during the *Quercus* and *Tilia* subzones. It seems that

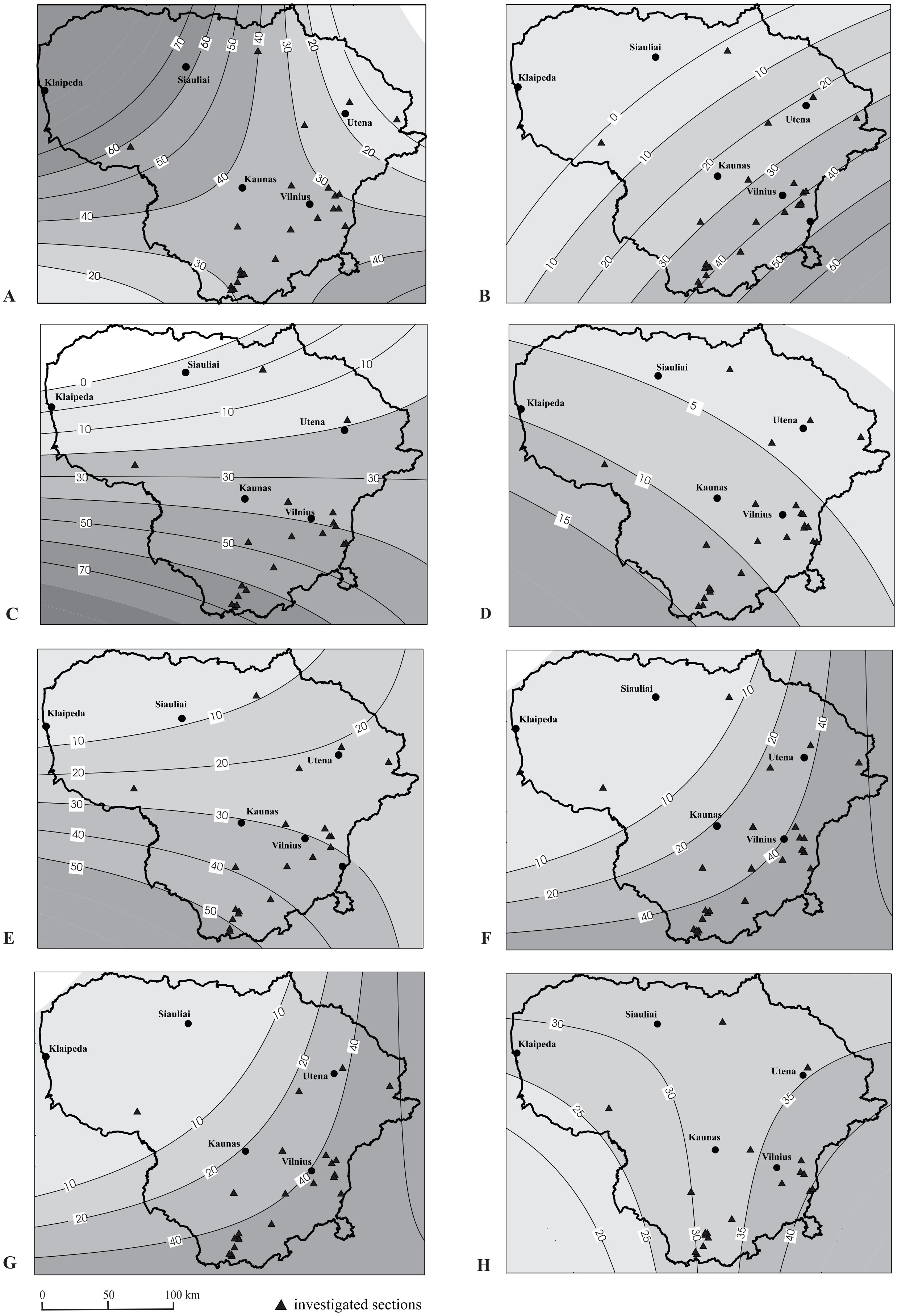

Fig. 4. Isopollen maps

A — for *Quercus* during the beginning of zone M_{3a};, **B** — for *Quercus* during the second half of the zone M_{3a};, **C** — for *Quercus* + *Ulmus* during the zone M_{3a}, **D** — for *Tilia* during the zone M_{3b}, **E** — for *Carpinus* during the zone M_{3c}, **F** — for broad-leaved trees with respect to deciduous trees during the first half of the zone M_{3a}, **G** — for broad-leaved trees with respect to deciduous trees during the second half of the zone M_{3a}, **H** — for *Picea* during the zone M_4

vegetation changes during the climatic optimum — *Quercus* and *Ulmus* were replaced by *Tilia* and then the *Carpinus* replaced the latter (*Tilia*) were the result of natural vegetation dynamics, not of the change of climate. Abrupt climate changes discussed by many investigators (Thouveny *et al*., 1994; Aaby, Tauber, 1995; Cheddadi *et. al*., 1998) in present study were not fixed. To join this discussion more precise calculations are needed. First, the method of Muratova *et al*. (1972) we used allows including to the calculations only the limited number of tree species and doesn't include herbs. It very complicates the calculations of the climatic parameters of the beginning and the end of the interglacial. Second, only one (mean) value of the temperature in each zone was calculated. So, this study is very preliminary and needs to be continued.

Quercus and *Ulmus* spread from southeast and southwest, lime appeared mainly from south and *Carpinus* from southwest.

Sandy soils dominated in north-eastern part of Lithuania while hard sandy loam soils covered its southern part.

Aknowledgments. This work was carried out within the National scientific programme LITHOSPHERE and partly supported by the Lithuanian State Science and Studies Foundation in the frame of IGCP 449 project "Global Correlation of Late Cenozoic Fluvial Deposits".

REFERENCES

AABY B., TAUBER H., 1995 — Eemian climate and pollen. *Nature*, **376**: 27–28.

CHEDDADI R., MAMAKOWA K., GUIOT J., de BEAULIEU J.-L., REILLE M., ANDRIEU V., GRANOSZEWSKI W., PEYRON O., 1998 — Was the climate of the Eemian stable? A quantitative climate reconstruction from seven European pollen records. *Palaeogegr., Palaeoclimatol., Palaeoecol*., **143**: 73–85.

KONDRATIENE O., 1979 — The climate of interglacial periods of Lithuania (in Lithuanian). *The Geographical Yearbook*, **16**: 61–65.

KONDRATIENE O., 1996 — The Quaternary stratigraphy and paleogeography of Lithuania based on paleobotanic studies (in Russian). Academia, Vilnius.

KONDRATIENE O., KLIVECHKIENE A., 1983 — New sections of Merkine Interglacial in the eastern part of Lithuania. Palinology in the geological investigations of the Baltic Sea and the Baltic Region: 51–53. Ryga, Zinatne.

KONDRATIENE O., SEIRIENE V., 2000 — Some palaeogeographical features of Merkinë (Mikulin, Eemian) Interglacial according to palynological data (in Lithuanian). *Litosfera*, **4**: 27–35.

MEUSEL H., JÄGER E., WEINNERT E., 1965 — Vergleichende Chorologie der zentraleuropäischen. *Flora*, **1**: 581.

MURATOVA N.V., BOYARSKAYA T.D., LIBERMAN A.A., 1972 — The appliance of theory of chances for climate reconstruction on the basis of pollen analysis (in Russian). Novejshaya tektonika, novejshiie otloženiya i cheloviek. Moscow.

RISKIENE M.A., 1979a — Anthropogenic flora of Lithuania (in Russian). Sovetskaya karpologia: 122–131. Nauka, Moscow.

RISKIENE M.A., 1979b — Flora of Merkine Interglacial. *The Geographical Yearbook,* **16**: 51–60.

THOUVENY N., de BEAULIEU J.-L., BONIFAY E., CREER K.M., GUIOT J., ICOLE M., JOHNSEN S., JOUZEL J., REILLE M., WILLIAMS T., WILLIAMSON D., 1994 — Climate variations in Europe over the past 140 kyr deduced from rock magnetism. *Nature*, **371**: 503–506.