Chapter

2

Vegetation Evolution of the Kabazi II Site

Natalia Gerasimenko

The vegetation history of the sedimentary sequence from Kabazi II was the subject of previous palynological studies published in the 1990s (Gerasimenko 1999). This paper is a summary of former data, and also presents new results obtained from a detailed, high resolution (5 cm) pollen study of the lower part of the sequence (8.0 m – 11.4 m) excavated during the 2000-2001 season.

The geographical setting of the site has been shown in the former publications (Chabai, 1998b; 2004c; Gerasimenko, 1999). The original landscape in the vicinity of the site can be summarised as a cuesta formed in Cretaceous-Palaeogene limestone, with mollic soils ('rendzinas') under steppe and oak forest (Bagrov, Rudenko, eds. 2004). The steppe vegetation consists mainly of Herbetum mixtum (mesophytic mixed herbs) and covers the cuesta plateau. The lower part of the cuesta slope is presently occupied by scrub, whose main components are as follows: oak (*Quercus pubescens* Willd.), hornbeam (*Carpinus orientalis* Mill.), hazelnut (*Corylus avellana* L.), and bloody dogwood (*Cornus sanguinea* L.). Oak and hornbeam also form the first level of mountain forest of the Main Ridge of the Crimean Mountains (below 600 m), and above 600 m, hornbeam and beech forest grow. Patches of pine occur here and there, though pure pine forest occupies the highest parts of slopes. As reported in many sources, in the forest-steppe belt of low ridges of the Crimean Mountains, the areas of forest were larger during the previous intervals of the Holocene. The composition of recent pollen spectra from different vegetation belts of the Crimea is already available (Artyushenko and Mishnev, 1978; Gerasimenko, 1999).

For our pollen study, 89 samples were used, these included 48 samples collected in 1992, and 41 new samples. These were processed using the same technique (treatment with HCl, HF, KOH, Na4P2O7 and flotation in heavy liquid), and in both cases the pollen frequencies and degree of pollen preservation were similar. In the new samples, the highest frequencies appeared at depths between 10.15-11.25 m (Stratum 14B), whereas between 8.0-8.7 m (Stratum 13) the samples contained smaller amounts of pollen. Pollen grains were also better preserved in Strata 14A and 14B than in Stratum 13. The spore-pollen diagram, published in the previous study (Gerasimenko, 1999) was compiled using the Grichuk's count method (percentages of arboreal and non-arboreal taxa were counted from the sums of arboreal and non-arboreal pollen correspondingly). In this paper, this diagram has been reproduced using the count of pollen percentages from the total sum of microfossils (Fig. 2-1). The diagram showing the new results (Fig. 2-2) was compiled in the same way.

Pollen Zones and Lithostratigraphical Succession

Whereas fourteen pollen zones (PZ I-XIV) were recognised in the deposits of Strata 4-14 of the Kabazi II sequence from the 1992 excavations (Gerasimenko, 1999), in the deposits from the lower part of the new sequence (Strata 13-14) four pollen zones (PZ A-D) were observed, two of which (PZ A and PZ C) were not present in the pollen sequence established in the former study. Below we give a short description of those previously published pollen zones, as well as extended descriptions of those recently studied. Pollen zones are given in relation to lithostratigraphical Strata, established by V. Chabai (1996, 1998b, 2004c).

Strata 14F – 14C: at the base of the sequence are non-soil deposits – light greyish-green clayey and sandy loams with rounded limestone debris, underlain by yellow clay with fine limestone debris (Stratum 15). According to V. Chabai (Chapter 1, this volume), Stratum 14E covers the whole area of the excavation, whereas Strata 14F, 14D and 14C are embedded as lenses in the sedimentary sequence. The Strata are bedded parallel to the slope surface, which would suggest that they are of colluvial origin. Pollen samples have been taken from Strata 14E and 14D, and the spectra obtained correlated to the previously

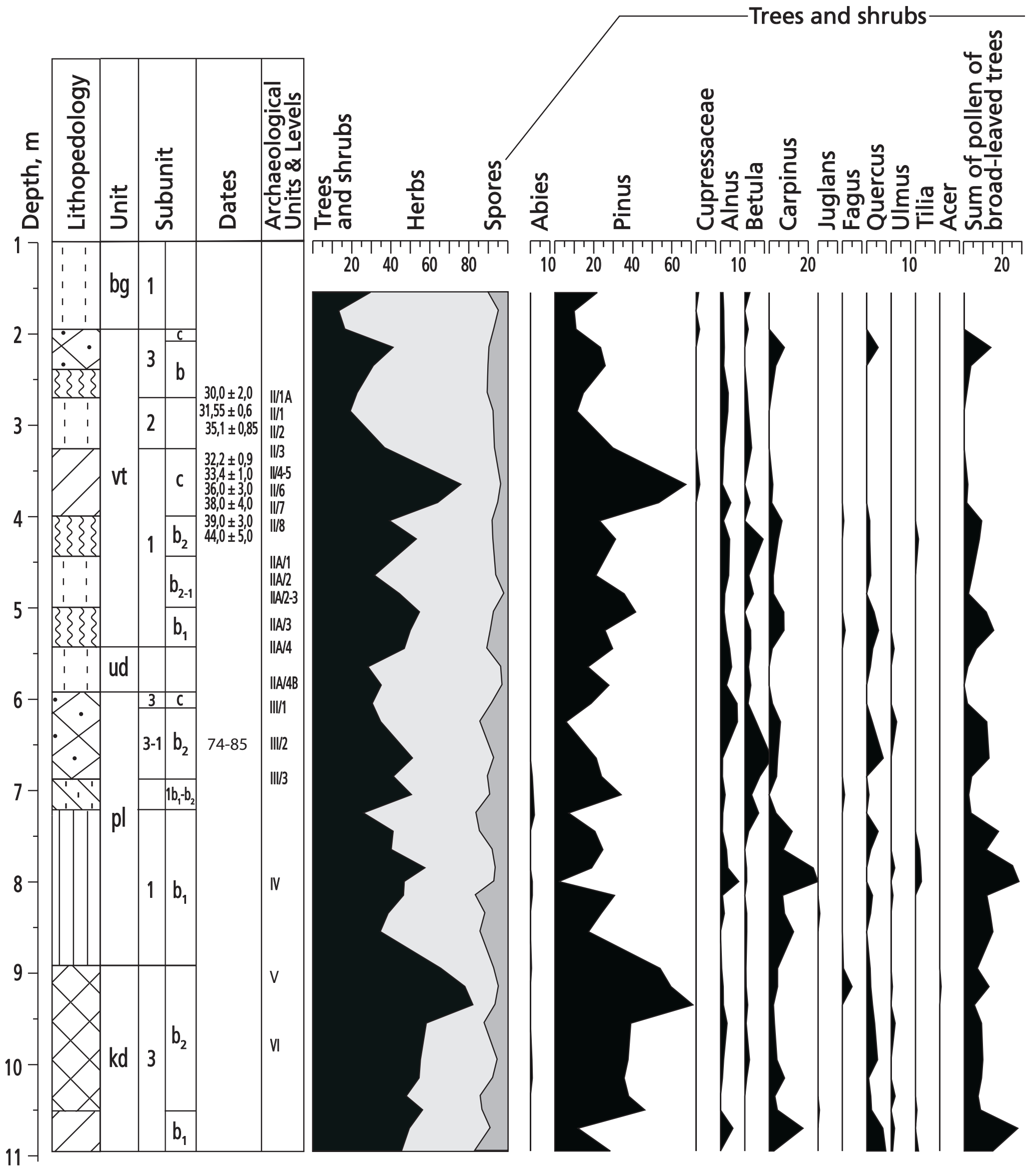

Fig. 2-1 Kabazi II: spore-pollen diagram of the deposits, section 1992 (modified after Gerasimenko, 1999).

established pollen zone I and the lower part of the pollen zone II (Gerasimenko 1999).

Pollen zone I (11.0-10.7 m, Fig. 2-1) corresponds to the greyish-green clayey loam of Stratum 14E. The pollen spectra, which is of a forest-steppe type (46-49 % AP, 38-42% NAP) displays a rather high proportion of broad-leaved taxa pollen (14-27%). The latter is mainly represented by *Quercus* and *Carpinus*, though a few *Ulmus* and *Tilia* also occur. *Alnus* pollen increases upwards together with *Carpinus*. The *Pinus* ratio is lower than its average for the diagram. Herbetum mixtum (mainly Lamiaceae) and Cyperaceae dominate NAP. Spores include Bryales, Filicales and Lycopodiales.

Pollen zone II (10.6-9.5 m, Fig. 2-1) has been recognised by such general characteristics as: 1) forest-steppe type of pollen spectra with predominance of *Pinus* pollen in AP, of Herbetum mixtum and Cyperaceae in NAP; 2) a sharp drop of pollen of broad-leaved taxa (7-9%) compared to PZ I; 3) a decrease in Cyperaceae pollen and an increase of Chenopodiaceae and Poaceae in comparison to PZ I. PZ II corresponds to the two Strata (14D and the lower part of 14B) and can be divided into two sub-zones.

Pollen sub-zone IIA (10.6-10.1 m, Fig. 2-1) is related to the light-grey sandy loam of Stratum 14D. The general composition of AP is the same as in PZ I, though *Pinus* pollen percentages are much higher

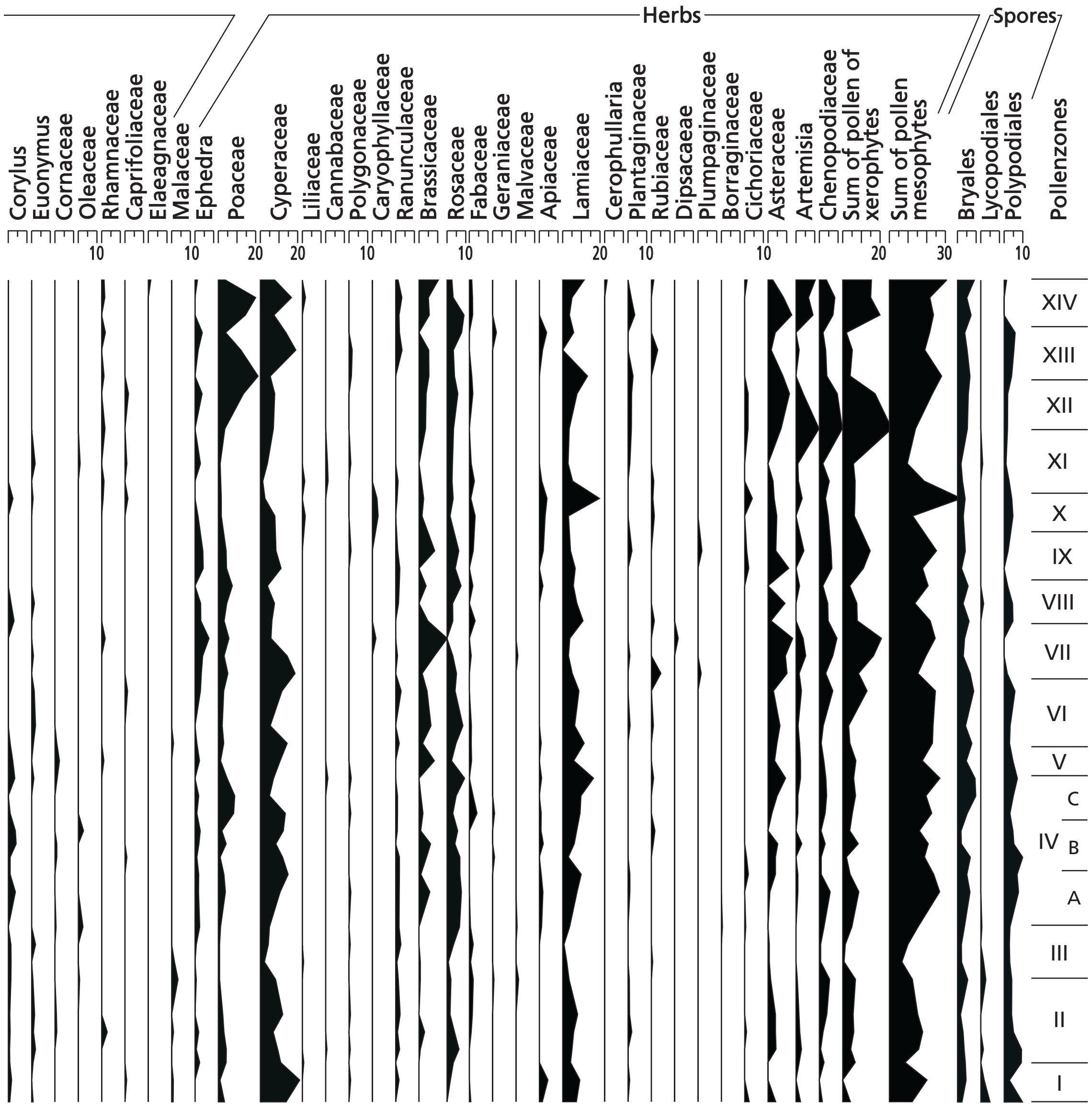

Fig. 2-1 continued. Pollen counts made from the general pollen sum. For lithopedology see Fig. 3.

(37-46%). In the NAP, the ratio of Poaceae increases and xerophytes (*Ephedra, Artemisia*) occur.

Pollen sub-zone IIB (10.0-9.5 m, Fig. 2-1) corresponds to the lower part of Stratum 14B, and is described below. Stratum 14C was not sampled for pollen.

Strata 14A and 14B correspond to the 1.5 m thick, soil genetic horizons of well-developed humiferous soil (mollisol). The soil material includes fine angular limestone debris. Stratum 14A is a humus horizon (A1) truncated by later erosion. It is a dark-grey compacted loam, 0.15-0.20 m thick, with a granular structure and undisturbed downward biogenic transition. Stratum 14B is a humus-transitional horizon (A1B) lighter in colour than the A1 horizon, and comprises a grey compacted clayey loam, with granular-prismatic structure and a distinct, rather sharp downward transition. Down the slope, the thickness of Stratum 14B increases (up to 4 m) at the expense of incorporation of humiferous colluvium. Stratum 14B cuts the underlying deposits. Its sharp lower transition is evidence of an incision at the beginning of the formation of Stratum 14B. Stratum 14B correlates to pollen zones IIB and III (Fig. 2-1), or to pollen zones A and B (Fig. 2-2). Stratum 14A corresponds to pollen zone C (Fig. 2-2), and was not sampled in 1992.

Pollen zone A (11.4-11.3 m, Fig. 2-2) falls in the lowest layer of Stratum 14B (grey loam at the base of A1B horizon of the mollisol). Judging from the pollen composition, this interval was not sampled in 1992. It displays a forest-steppe type of pollen spectra (45-65 % of AP, 22-35% of NAP, and 13-20 % of spores). As opposed to the preceding and following pollen zones, its AP consists almost entirely of *Pinus* pollen (few grains of *Alnus*). NAP is dominated by Herbetum mixtum (9-17%) and Cyperaceae (9-10%). Poaceae and Chenopodiaceae are represented by single pollen grains. Herbetum mixtum includes mainly microfossils of Ranunculaceae, Rosaceae and Lamiaceae. Pollen of Polygonaceae, Apiaceae, Rubiaceae and Asteraceae also occur. Spores include Bryales, Filicales and Lycopodiales. The proportion of the latter is the largest in the diagram.

Pollen zone B (11.3-10.1 m, Fig. 2-2) corresponds to the AIB horizon of the mollisol, and is characterised as follows: 1) forest type of pollen spectra (55-75 % of AP, 10-30% of NAP); 2) a sharp predominance of *Pinus* pollen (50-71%); 3) low percentages of broad-leaved taxa pollen (3-6%); 3) frequent occurrence of *Betula* pollen in small numbers; 4) predominance of Herbetum mixtum in NAP (6-17%); 5) very low percentages of xerophytes and Poaceae pollen, and absence of *Artemisia* (0-3%); 6) relatively low values of Cyperaceae and rather high proportion of Filicales (5-15%). Nevertheless, pollen zone B is not homogenous, and can be divided into distinct sub-zones. These can be correlated with pollen zones II (upper part) and III of the 1992 excavation (Fig. 2-1).

Pollen sub-zone B1 (11.3-10.9 m, Fig. 2-2) displays relatively high percentages of broad-leaved pollen within PZ B, particularly of *Carpinus*, whose pollen appears earlier than *Quercus* pollen. Another peculiar feature is the presence of *Abies* pollen (2%) and one pollen grain of Ericaceae. Microfossils of *Cupressaceae*, *Betula* and *Alnus* occur constantly (0.5-3%, *Alnus* up to 6%). *Corylus* and *Euonymus* pollen are also present in small numbers, and single *Ulmus* and *Tilia* appear at the top of PZ B1. In NAP, percentages of Herbetum mixtum are highest within PZ B (7-17%), and its composition is most diverse: Lamiaceae (dominate), Rosaceae, Ranunculaceae, Apiaceae, Liliaceae, Rubiaceae, Fabaceae and Polygonaceae. A characteristic feature is the permanent presence of Asteraceae and Cichoriaceae pollen (2-7 and 1-2% correspondingly). Among spores, Filicales significantly dominate over Bryales, and Lycopodiaceae are permanently present in small numbers (1-4%).

Pollen sub-zone IIB (10.0-9.5 m, Fig. 2-1) is an equivalent of PZ B1. The latter differs from PZ IIA (Fig. 2-1) by the appearance of *Betula* pollen and the disappearance of xerophytes (*Ephedra, Artemisia*). Both these characteristics are typical for PZ B1. The other common feature of PZ IIB and PZ B1 is the pattern in the occurrence of broad-leaved taxa – primarily only *Carpinus* appear, followed by *Carpinus* and *Quercus*, and *Ulmus* and *Tilia*. *Corylus* and *Euonymus* occur in both PZ. There is no *Abies* and no Ericaceae in PZ IIB. It is evident that these microfossils were wind-blown from the higher mountain belts. In the lower part of PZ B1, the percentage of AP and *Pinus* are higher, and the value of broad-leaved taxa lower than in PZ IIB (Fig. 2-1 and 2-2). This can be explained by the 10-cm sampling interval during 1992. This may have led to mixing with material from PZ IIA which is richer in NAP and broad-leaved taxa pollen. The predominance of Lamiaceae and notable Asteraceae values are characteristics of both PZ IIB and B1.

Pollen zone III (9.4-8.7 m, Fig. 2-1) has been recognised by pollen spectra of forest type (66-82% AP) and by a low proportion of broad-leaved taxa pollen (5-13%). *Pinus* dominated sharply in the AP, and Herbetum mixtum in the NAP. PZ III corresponds to the middle and upper parts of PZ B, and the palynological correlation between the individual spectra of PZ III and pollen sub-zones of PZ B is given below.

Pollen sub-zone B2 (10.9-10.65 m, Fig. 2-2) is characterised by an increase in *Pinus* pollen (64-69%) and by a drop in the frequencies of broad-leaved taxa pollen (small amount of pollen grains from *Quercus, Carpinus* and *Ulmus*). *Alnus, Betula* and *Corylus* occur in small numbers (0.5-2%, *Alnus* up to 4%). Herbetum mixtum (7-12%), rather rich in composition, and Asteraceae (1.5-8%) still dominate NAP, ant the ratio of Cyperaceae and Chenopodiaceae is low (0-2.5%). Poaceae pollen are now constantly present (1-2%). Bryales, Filicales and Lycopodiales are constant components among spores, but Filicales (7-17%) sharply dominate over Bryales (1.5-2%). Pollen spectra of forest-steppe and forest types alternate throughout PZ B2, with a strong prevalence of forest type in its upper part.

PZ B2 (Fig. 2-2) can be correlated with the pollen spectrum at the base of PZ III (Fig. 2-1). The latter is characterised by an almost complete disappearance of pollen of broad-leaved trees, and a maximum value for *Pinus*, the lowest ratio of Cyperaceae, Chenopodiaceae and Bryales, and a maximum of rich Herbetum mixtum (69% within NAP group). The composition of dendroflora pollen is the same as in PZ B2.

Pollen sub-zone B3 (10.65-10.35 m, Fig. 2-2) displays forest type pollen spectra (60-76% of AP, 10-25% of NAP, 8-18 % of spores). *Pinus* still dominates (50-68%), but less so than in PZ B2. *Betula* is constantly present (1-3%), though the occurrence of *Alnus* has now become less frequent than in the preceding pollen zones. Pollen of broad-leaved species again increases (4-6%). *Quercus* and *Carpinus* are represented by small numbers, but the characteristic feature is a constant presence of *Ulmus* (1-3%), as well as the appearance of *Tilia* (0-3%). As in PZ B1, shrubs include Cupressaceae, *Corylus* and *Euonymus*. The other characteristic feature of PZ B3 is the presence of a small number of *Picea* (0.5-2%) in its lowest part. The NAP ratio increases in the upper part of PZ B3 owing to an increase in both Herbetum mixtum (11-13%) and Cyperaceae (5-7%). Poaceae pollen also appears at this level. Asteraceae pollen is less common in PZ B3 than in the preceding pollen zones, and Chenopodiaceae almost disappear. In the spore group, Bryales has become dominant (with the exception of the lowest part of PZ B3). Samples K and L (from the 2000 excavation) also belong to PZ B3, and their indices have been given above.

PZ B3 (Fig. 2-2) can be correlated with the pollen spectrum in the middle part of PZ III (Fig. 2-1). The percentage of broad-leaved taxa pollen increases at this level, which occurs at the expense of *Pinus* pollen. The floristic composition of tree pollen is similar to that in PZ B3. The only difference is the absence of *Picea* microfossils, though *Fagus* pollen was observed at the similar level in the sequence of the 1992 excavation. *Fagus*, like *Picea*, is an inhabitant of high belts of mountain forests. Although *Picea* pollen is obviously wind-blown, its presence demonstrates the same trend of the downward encroachment of the borders of mountain vegetation belts, which is recorded in Crimea with a lowering of the *Fagus-Carpinus* forest belt. The disappearance of Chenopodiaceae, a drop in Asteraceae values, and predominance of Rosaceae in Herbetum mixtum are common features of NAP of PZ B3 and the middle part of PZ III.

Pollen zone B4 (10.35-10.10 m, Fig. 2-2) is characterised by a drop in both AP (58-65%) and *Pinus* pollen (43-56%) through an increase of NAP (25-32%). The proportion of broad-leaved taxa is the same as in PZ B3, but *Corylus* (2-3%) and *Quercus* pollen become more frequent. *Ulmus* occurs constantly (1-4%), whereas *Carpinus* pollen grains become few. An increase in *Betula* and *Alnus* pollen ratios (1-8% and 2-6% correspondingly) was also observed. The NAP ratio increases owing to an increase in percentages of Poaceae (3-4%), Cyperaceae (4-0%) and Asteraceae (2-6%) pollen. Herbetum mixtum values are the same as in PZ B3, though the composition of mixed herbs is more diverse: Ranunculaceae, Polygonaceae, Liliaceae, Rosaceae, Fabaceae, dominating Lamiaceae, Apiaceae, Plantaginaceae and Cichoriaceae. Filicales and Bryales are represented in equal numbers, and Lycopodiales drop sharply. The samples H, I and J (from the 2000 excavation) also belong to PZ B4 and their indices are included above.

PZ B4 (Fig. 2-2) demonstrates the same trend with a decrease in the AP ratio, which is similar to the upper part of PZ III (Fig. 2-1). On the other hand, the exact equivalent of PZ B4 shown in the pollen diagram for the 1992 excavation is absent. This may be connected with the ‘sterile’ pollen sample (# 11) included in this diagram. Only the very top of PZ B4 is similar to the pollen spectrum of the sample #12.

Pollen zone C (10.1-9.9 m, Fig. 2-2) lies in the humus horizon A1 of the mollisol (Stratum 14A) and in the top layer of A1B horizon of this soil (top of 14B Stratum). Stratum 14A was absent in the 1992 excavation. The most distinctive feature of PZ C is a sharp drop in *Pinus* pollen (6-22%), which also provokes a general drop of AP (30-49%). NAP goes up significantly (28-60%), and spore values are the same as in PZ B (10-23%). The pollen spectra are of a forest-steppe type. *Quercus, Carpinus, Pinus* and *Alnus* predominate. *Ulmus* and *Betula* occur only in the top layer. Shrubs include *Corylus* and Rhamnaceae. Herbetum mixtum (10-27%) and Cyperaceae (8-27%) prevail in the NAP, though Poaceae (1-6%) and Chenopodiaceae (1-5%) are constantly present.

Asteraceae occur only in the top layer (6%). Herbetum mixtum is as rich in diversity as in PZ B4 (Ranunculaceae and Lamiaceae pollen dominate). Bryales and Filicales are present in equal proportions, and Lycopodiales are absent.

Stratum 13A corresponds to soil colluvium that fills an incision in the underlying beds. It is between 0.4 and 0.5 m thick, and consists of thin coarse sand beds which alternate frequently with thin beds of brown clay. No pollen samples were taken from this Stratum.

Stratum 13 is a slope derivative of a Bt genetic soil horizon of a mountain brown forest soil (luvisol). The A1A2 horizon of the soil corresponds to the base of Stratum 11B (11 lower). Due to the type of pedogenic processes, the transition between A1A2 and Bt soil horizons is always sharp and well defined. On the other hand, the transition between a lighter A1A2 horizon and overlying colluvial deposits is often gradual. It is for this reason that the A1A2 horizon was originally related to Stratum 11A (11 lower). The pollen data indicate that the luvisol derivative includes pedosediments both of the A1A2 horizon (0.3 m thick) and Bt horizon (0.7 m thick). The A1A2 horizon is a light, loose, grey-brown loam with fine limestone debris. Pedogenic clay seldom occurs. The Bt horizon is a dark-brown compacted loam with some pedogenic clay coatings, preserved despite the existence of a colluvial component in the soil material. The lower transition is gradational – the base of the soil is formed on the sediment of Stratum 13A.

Stratum 13 corresponds to pollen sub-zones IVA and IVB (Fig. 2-1), or to pollen zone D (Fig. 2-2). The general characteristics of PZ IV and PZ D are a predominance of forest-steppe type of pollen spectra, as well as a rather high percentage of broad-leaved taxa pollen, particularly of *Carpinus*. Pollen counts of broad-leaved taxa are somewhat lower in PZ C than in PZ IV. On the basis of an increase in *Carpinus* pollen upwards, PZ D is divided into the sub-zones D1 and D2.

Pollen sub-zone IVA (8.6-8.1 m, Fig. 2-1) has equal proportions of AP (35-45%) and NAP (38-50%). *Pinus* pollen counts are very low (18-24%), quite comparable with broad-leaved taxa values (12-13%). Broad-leaved taxa are mainly represented by *Carpinus* (*C. orientalis* Mill. and *C. betulus* L.). *Corylus* is second in abundance. NAP is dominated by Herbetum mixtum and Cyperaceae. Pollen grains of *Ephedra* are present (1-2%). Spores include only Bryales and Filicales.

Pollen sub-zone D1 (8.7-8.3 m, Fig. 2-2) correlates with PZ IVA, and is characterised by a slight predominance of NAP (46-54%) over AP (34-42%). The pollen counts of broad-leaved taxa are 7-11%, and only in the lowest layer are they as low as 3%. *Carpinus, Ulmus* and *Quercus* are represented in that layer, whereas in the rest of PZ D1, there is an absolute predominance of *Carpinus*. *Corylus* and *Alnus* are represented in the same proportion (1-3%), but in the lowest layer, the *Alnus* ratio is higher (7%), as is the *Betula* pollen count (3%). The proportion of *Pinus* is still low (19-28%). In NAP, Herbetum mixtum (16-34%) dominates over Cyperaceae (8-15%). The counts of Poaceae (1-3%) and Chenopodiaceae (1-3%) are very low, and only a few pollen grains of *Ephedra* were found. Values of Asteraceae pollen

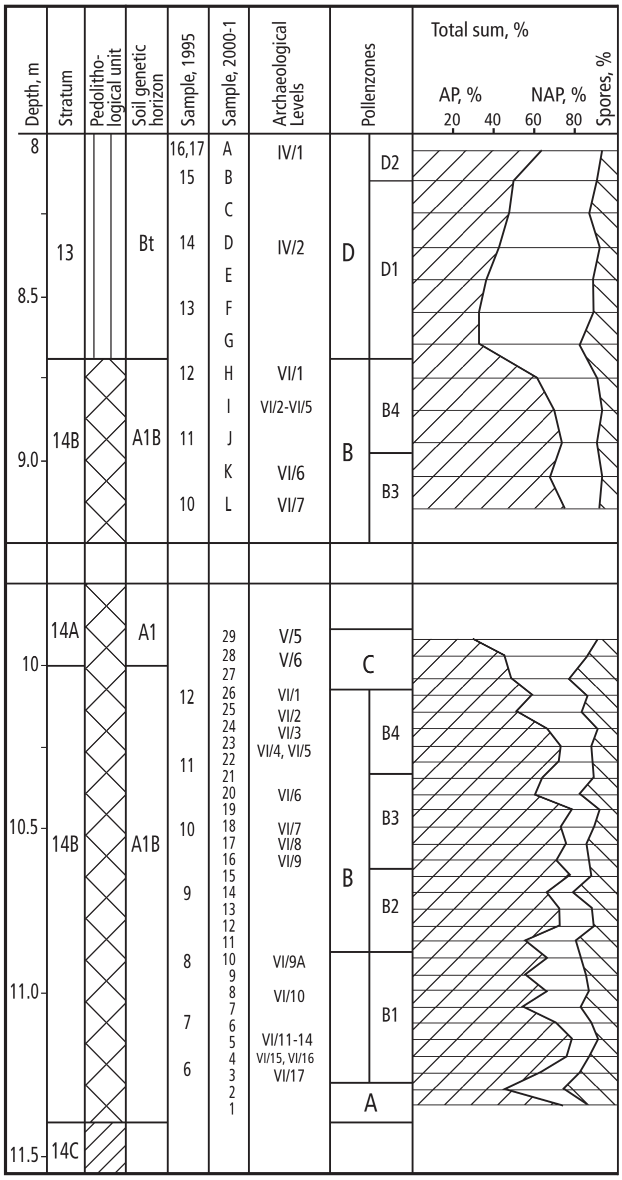

Fig. 2-2 Kabazi II: spore-pollen diagram of the deposits, section 2000-2001.

are 5-7%. Herbetum mixtum includes Brassicaceae, Ranunculaceae, Rosaceae, Fabaceae, Lamiaceae, Apiaceae, Rubiaceae and Cichoriaceae pollen (Rosaceae and Fabaceae dominate). Filicales spores (6-12%) are more abundant than those of Bryales (2-6%) and Lycopodiales are present (3%) only in the lowest layer.

Pollen sub-zone IVB (8.1-7.8 m, Fig. 2-1) differs from PZ IVA by showing a further increase of broad-leaved taxa (up to 25-28%), and particularly *Carpinus* (*Carpinus orientalis* Mill. strongly dominates). The percentage of *Pinus* is slightly higher at the base of the sub-zone (31%), but then sharply drops (2-19%). The occurrence of *Tilia* pollen (3%) is characteristic, as is a rather diverse shrub pollen: *Corylus* (4%), *Cornus* (1%), few Oleaceae and Caprifoliaceae. The top of PZ IVB displays a forest type of pollen spectra. The composition of NAP and spores is similar to that in PZ IVA.

Pollen sub-zone D2 (8.3-8.0 m, Fig. 2-2) is similar to PZ IVB. Such low pollen counts of *Pinus*, as in PZ IVB, have not been observed in PZ D2, and the percentage of broad-leaved taxa pollen is somewhat lower here (10-21%). Due to an increase in *Pinus* pollen (23-27%), the AP is also somewhat higher in PZ D2 (47-62%). *Carpinus orientalis* Mill. dominates

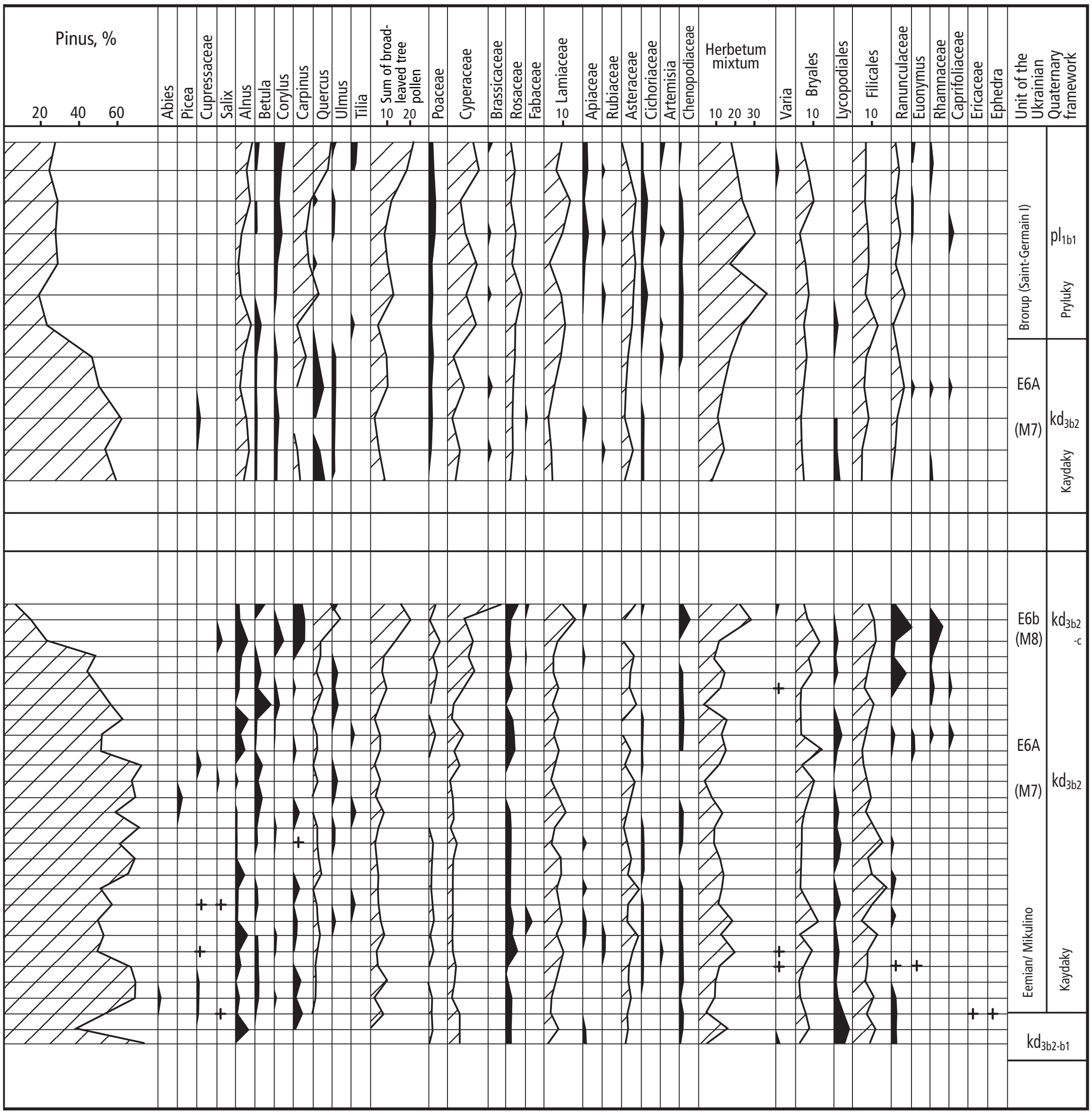

Fig. 2-2 continued. For lithopedology see Fig. 3.

within broad-leaved taxa pollen, and *Tilia* pollen is present in small numbers (1-2%). *Corylus* pollen occur (2-5%), and - as in PZ IVB - a local peak of *Alnus* was discovered (5-8%). Shrubs (*Euonymus* and Rhamnaceae) are represented by few pollen grains. Herbetum mixtum still dominates over Cyperaceae (16-21 and 6-15% correspondingly), and pollen counts of Poaceae and Chenopodiaceae are low (1-3% of each). In comparison to PZ D1 Asteraceae decrease, though Herbetum mixtum is still diverse in composition. The percentages of spores, represented by Bryales and Filicales, are the same as in PZ IVB (8-14%).

Stratum 11A (11 lower) is a light grey-brown loam, 0.9 m thick, loose, with fine limestone debris. Pedogenic features are observed in its lower layer (the A1A2 soil horizon, see above). Colluvial component increases upwards. Stratum 11A corresponds to PZ IVC and PZ V.

Pollen sub-zone IVC (7.7-7.4 m, Fig. 2-1) is characterised by a drop in broad-leaved pollen percentages (11-17%) as compared with PZ IVB. *Carpinus, Quercus* and *Tilia* are represented. The pollen spectra are of a forest-steppe type, with a slightly lesser proportion of AP than in PZ IVB. At the same time, the Poaceae ratio in the NAP is higher. The most characteristic feature of PZ IVC is the appearance of a small number of *Abies* pollen grains. Bryales spores dominate over Filicales.

Pollen zone V (7.3-6.8 m, Fig. 2-1) shows a sharp reduction of broad-laved taxa pollen (2-4%) and a considerable increase of *Betula* pollen (up to 8%). *Pinus* pollen counts slightly increase (up to 35%). The few microfossils of broad-leaved trees include *Carpinus, Quercus* and *Fagus* (the latter being an inhabitant of higher mountain belts). The pollen of shrubs becomes noticeable (*Corylus, Euonymus, Cornus* and Rhamnaceae). Pollen spectra are of forest-steppe type, and NAP composition is similar to that of PZ IV, though the proportion of xerophytes slightly increases (including the appearance of *Artemisia*). Pollen of Asteraceae and Brassicaceae have become consistent.

Stratum 11 corresponds to a soil of a rendzina type (mollic leptosol), 0.7 m thick, dark-grey-brown silty loam, with limestone debris. The upper A1 horizon is the darkest one, enriched with humus. The lower transition is gradational. The Stratum includes PZ VI and the lowest sample of PZ VII.

Pollen zone VI (6.7-6.2 m, Fig. 2-1) is characterised by a renewed increase in broad-leaved taxa pollen (11-13%), though less so than in PZ I and IV. *Carpinus* and *Quercus* dominate the group of broad-leaved taxa pollen. The characteristic features of PZ VI are as follows: 1) very low values of *Pinus* pollen (6-22%); 2) an increase of small-leaved taxa pollen: *Betula* (*Betula pendula* Ehrh.) 6-14%, and *Alnus* (*Alnus glutinosa* Gaertn.) 2-8%; 3) microfossils of shrubs (*Corylus, Euonymus* and Caprifoliaceae) are present in small numbers. A decrease in Cyperaceae pollen is typical of the NAP (5-11%), and Herbetum mixtum strongly dominate and have a diverse composition. The uppermost layer of the rendzina soil has a pollen spectrum which is transitional in its make up between PZ VI to PZ VII (see below).

Stratum 10A is the base of Stratum 10. It differs from the rest in the lighter colour – pale loam with fine limestone clasts. The lower transition is distinct. The Stratum 10A corresponds to PZ VII.

Pollen zone VII (6.1-5.6 m, Fig. 2-1) is the first zone with a distinct predominance of NAP over AP, though spectra are still of a forest-steppe type (28-47% AP and 49-68% NAP). The other characteristic features are a sharp drop in pollen of broad-leaved taxa (leading to their complete disappearance in the middle part of PZ VII), and the highest percentages of *Alnus* in the diagram (6-9%). The share of *Pinus* increases and the proportion of *Betula* drops. A typical feature of NAP is the increase of xerophytes (Chenopodiaceae, *Artemisia* and *Ephedra*, appearance of Plumbaginaceae and Dipsacaceae). Asteraceae and Brassicaceae pollen counts also go up at the expense of pollen of more mesophytic plants. Filicales disappear, and the spore content becomes very low (up to 4%). The lowest sample, which was taken from the rendzina soil, differs by the presence of a few broad-leaved taxa pollen (2% of *Carpinus*) and by much lowers counts of xerophytes. Just at this level, *Alnus* pollen reaches its maximum in the diagram.

Stratum 10 is represented by pedosediments with a strong colluvial component – yellowish-brown loam with fine limestone debris. PZ VIII corresponds to Stratum 10 and to the base of Stratum 9.

Pollen zone VIII (5.5-5.0 m, Fig. 2-1) demonstrates an increase in broad-leaved taxa pollen (6-15%). *Carpinus* and *Quercus* share dominance among these; few *Ulmus, Corylus, Euonymus* are found; and the presence of *Fagus* as a representative of higher forest belts is important. The percentages of *Pinus* and AP (48-58%) increase. The values of xerophytes in NAP decrease, and Herbetum mixtum again becomes diverse (Ranunculaceae, Fabaceae, Lamiaceae, Rosaceae and Brassicaceae). Spores include Filicales and Lycopodiales.

Stratum 9 is a light-yellow compacted loam with a large amount of fine debris and a distinct horizontal lower transition. The main part of the Stratum corresponds to PZ IX. The upper layers are related to PZ X (see below).

Pollen zone IX (4.9-4.6 m, Fig. 2-1) has a forest-steppe type of pollen spectra with a predominance of NAP (54-63%) over AP (31-44%), and with low values of broad-leaved taxa pollen (2-4%). The AP composition is poor: *Pinus* (dominating), *Alnus, Betula* (3-5% each), *Quercus* and *Carpinus* (1-2%). The pollen counts of xerophytes increase (particularly *Artemisia* and Plumbaginaceae), though Herbetum mixtum still prevails. Lycopodiales and Filicales have disappeared.

Stratum 7 consists of two parts. The upper part is a light-grey loam, and the lower part is a pedosediment with strong colluvial component – yellowish-brown compacted prismatic loam. The Stratum includes both fine and large limestone debris. The lower transition is distinct and horizontal. The lower part of Stratum 7 corresponds to PZ X and XI, and the upper part is related to PZ XII.

Pollen zone X (4.3-4.0 m, Fig. 2-1) differs from PZ IX in that it displays a higher proportion both of AP (41-55%) and broad-leaved taxa pollen (8-9%). The AP composition is diverse: *Pinus, Alnus, Betula, Carpinus,* and *Quercus* are constantly present, and *Fagus, Tilia, Corylus, Euonymus*, Rhamnaceae, and Caprifoliaceae occur. The Herbetum mixtum reaches its maximum at this level (mainly at the expense of Lamiaceae pollen). Filicales spores became consistently noticeable again.

Pollen zone XI (3.9-3.6 m, Fig. 2-1) has a forest type of pollen spectra (67-77% AP and 19-26% NAP) with a low proportion of broad-leaved taxa pollen (1.5-2%). The *Pinus* pollen counts are very high (53-67%). Broad-leaved taxa are represented by few *Carpinus* and *Tilia*, whereas *Alnus* counts reaches 5%. The composition of shrubs is very diverse: *Juniperus, Euonymus*, Oleaceae, Rhamnaceae, and Caprifoliaceae. NAP is similar to that in the previous zone in composition, and Lycopodiales appear for the last time in the diagram.

Pollen zone XII (3.3-2.6 m, Fig. 2-1) is notable for the first appearance of a steppe type of spectra (19% AP, 75% NAP). The maximum of xerophytes (both *Artemisia* and Chenopodiaceae), and the maximum of Poaceae in the diagram are observed here. The other characteristic feature is a disappearance of broad-leaved taxa pollen. AP mainly consists of *Pinus* (dominating), *Alnus* and *Betula*. Asteraceae, Cichoriaceae and Plantaginaceae pollen is noticeable in NAP. Bryales prevail strongly over Filicales.

Strata 5 and 6 correspond to the soil genetic horizons of brown rendzina soil (eutric leptosol). Stratum 5 is a humus A1 horizon – grey-brown, silty loam, compacted, with granular structure and fine debris, and 0.3 m thick. The lower transition is distinct. In many places, the horizon is truncated by later erosion. Stratum 6 is the transitional B horizon of the soil – light-brown, silty loam, compacted, and 0.5 m thick. In places, the lower transition is erosional. The lower part of Stratum 5 and Stratum 6 correspond to PZ XIII. The spectrum from the upper layers of Stratum 6 is similar in content to PZ XIV (see below).

Pollen zone XIII (2.4-2.1 m, Fig. 2-1) displays a forest-steppe type of pollen spectra (23-44% of AP, 46-66% of NAP). This is the last appearance of broad-leaved taxa pollen (4-14%) in this zone. These are represented by *Carpinus* and *Quercus*. *Pinus* dominates the AP (25-26%). The characteristic feature of the NAP is a peak both of Cyperaceae and Poaceae, whereas the xerophyte pollen is present in very low numbers. Spores include Bryales and Filicales.

Stratum 4 is related to a light grey loam of colluvial origin – loose, filled with fine and large limestone debris. The lower transition is erosional. It corresponds to PZ XIV.

Pollen zone XIV (2.0-1.5 m, Fig. 2-1) has a steppe type of pollen spectra (13-14% AP, 79-82% NAP), without broad-leaved taxa pollen. This is a maximum of NAP for the diagram. *Pinus* dominates the AP, and some *Betula, Alnus*, Cupressaceae, and Rhamnaceae occur. The presence of Eleaegnaceae pollen – the only case in the section – is noticeable. Herbetum mixtum dominates the NAP, though Poaceae are important (up to 23%). Xerophyte pollen also becomes significant, and Cyperaceae values go down. Counts of spores, represented by Bryales, are low.

The general characteristic of the spore-pollen diagram represented in Fig. 2-1, and the principles of interpretation of pollen diagrams used, have been previously published (Gerasimenko, 1999).

Vegetational and Environmental Evolution

Strata 14E -14C

During deposition of these Strata, pedogenic processes did not develop in the vicinity of the site. Pedogenesis does not transform subaerial sediments, neither under conditions of scarce (or absent) vegetation cover, nor in the case of high sedimentation rates. The Pleistocene stadials were characterised both by cold climate (unfavourable for vegetation) and by intense sedimentation (also partially provoked by poor vegetation cover). Nevertheless, Strata 14E and 14D are rich in well-preserved pollen. Pollen zones I and II indicate the distribution of a hornbeam-oak forest-steppe around the site. This might mean that sedimentation rates were too high on the slope to allow for the existence of a stable surface and the development of soil processes. This can also be proved by the bedding of Strata 14F – 14C at a steep angle (Chabai, 2004c). Pollen re-deposition could be suspected in connection with such a sedimentary environment. On the other hand, the source for pollen re-deposition would have been provided by the Cretaceous-Palaeogene clays, composing the bedrock of the cuesta. However, neither pollen of extinct flora of these ages, nor any other pollen of Neogene or Early Pleistocene floras, has been recovered. Good pollen preservation also contradicts any possibility of its distant transportation. It seems more logical that the local input of pollen into the colluvial deposits comes from the near vicinity.

During the formation of Stratum 14E (*pollen zone I*), the site area was occupied by a hornbeam-oak forest (with admixtures of elm and lime and with a well-developed shrub undergrowth) and by mesophytic steppe. The wetter, lower part of slope provided a home for sedges, whose pollen is abundant in Stratum 14E. The greenish colour of loams is indicative of a reducing sedimentary environment and an excessive ground-moisture. Judging from the broad-leaved taxa percentages, the climate was as warm as that presently prevailing.

During the formation of Stratum 14D (*pollen zone IIA*), the reduction of broad-leaved forest occurred at the expense of a further expansion of steppe vegetation. Xerophytic components appeared in the steppe assemblages, and shrub associations possibly spread separately from trees. The most important change was the spread downslope of the pine forest belt on the northern slope of the Crimean Mountains, which is indicated by a sharp increase in *Pinus* pollen. Birch also began to spread into the mountains at this time. All of these indicate a cooling and some aridification of the climate, which, however, was not dramatic.

Strata 14B and 14A

During the formation of these Strata, the thick mollisol developed. The considerable thickness of the soil might imply a synsedimentary type of soil formation (pedogenic processes developing simultaneously with sediment accumulation). At the beginning of the deposition of Stratum 14B, erosional incision occurred, followed in places by intense colluvial accumulation (Chabai, 2004c). In the section sampled for pollen analysis, the erosional break between Strata 14C and 14B also occurred (as evidenced by the sharp transition), but no colluvial sediments were formed, and the surface remained relatively stable, enabling pedogenesis. This process first started in a rather cool and dry environment (*pollen zone A*). Broad-leaved trees were strongly suppressed, and pine forest encroached down the mountain slopes. The site was occupied by a meadow, consisting of mesophytic mixed herbs and sedges. Mollisols are generally formed under herb vegetation, or under a well-lit forest (with enough light to enable a rich herbal ground cover). During the described time interval, pine evidently grew close to the site. This is also reflected in the high percentages of Lycopodiales, plants which are closely connected with pine stands. The climate was significantly cooler and drier than at present.

During the formation of the main part of the A1B horizon of the mollisol (*pollen zone B*), the forests grew immediately adjacent the site (probably slightly higher on the slope), and were dominated by pine. The rather light colour of the soil indicates that the environment was not too favourable for humus accumulation, either because of relatively humid climate, or because of high sedimentation rate - or, most likely, due to both factors. High sedimentation rates are indicated by the homogeneity of the pollen spectra in the A1B horizon. In Quaternary sediments, low sedimentation rates are normally reflected by sharp changes of pollen contents of subsequent beds. In such cases, climatic changes are not much slower than sediment accumulation. Relatively humid climate can be seen in the prevalence of arboreal pollen in the spectra, though pollen of fully mesophylic dendroflora is not abundant, and pine strongly dominates. At that time, birch was also distributed more extensively in the Crimean Mountains than nowadays. This indicates a cooler environment during the formation of the sediment of pollen zone B. Generally speaking, the climate was less mild than the modern one, but the alternation of a few wetter and drier intervals has been identified.

The environments of these intervals did, however, not contrast strongly, and they were in the same climatic zone - transitional from southern-boreal forest to forest-steppe.

During the formation of deposits of *pollen subzones B1 and IIB* (the correlatives in the two different sections of Kabazi II, Fig. 2-1 and 2-2), *pine* forests displayed a considerable admixture of broad-leaved trees. This means that the climate became warmer than at the very beginning of formation of the A1B horizon (pollen zone A). Firstly, hornbeam dominated amongst broad-leaved taxa, and later on, oak was constantly present, whilst elm and lime occurred sporadically. Hornbeam is a more moisture-dependent tree than the others. The higher humidity at the beginning of PZ B1 zone formation is also emphasised by occurrence of pollen of such moisture-loving plants as fir and Ericaceae in the assemblages of this level. At the end of the PZ B1-IIB interval, the forest areas were slightly reduced, and the role of herbal coenoses increased. The first human occupations of the site (archaeological levels VI-14 – VI-17) correspond to the wetter part of the described interval. Occupation of the archaeological levels VI-10 –VI-9A was during the later, drier part of the interval of PZ B1-IIB. Through the whole described period, the site had ground cover of rather diverse mesophytic herbs (Rosaceae and Lamiaceae families dominated) and probably of ferns. In any case, ferns were abundant at that time, together with mosses and (to a lesser extent) club-mosses. All of these could also grow under a transparent pine forest canopy. The role of sedges was less pronounced than during the preceding intervals, which meant that the site became drier and better drained at that time. The permanent presence of a noticeable quantity of Chenopodiaceae, Asteraceae and Cichoriaceae pollen might be evidence that erosion processes continued to develop on the slope, near the site.

The further increase of pine in the vegetation occurred during the formation of the sediments of *pollen sub-zone B2* and *pollen zone III-base*, which can be correlated in the two sections of the site (Fig. 2-1 and 2-2). The admixture both of broad-leaved and small-leaved trees slightly lessened in this period, and broad-leaved taxa were mainly represented by oak. In the arboreal vegetation, oak and pine are more xerophytic components than hornbeam and alder. Pollen of the latter is less in the described interval than in the underlying deposits. The trends to an increase of pine and a decrease of hornbeam and alder in the forests may be traced from the beginning to the end of the described time interval. In the well-lit pine stands, Filicales could grow extensively, whereas Bryales were less abundant than during the earlier times. Some xerophytization of the ground cover on the site is reflected in the noticeable presence of grasses. Judging from the amount of Chenopodiaceae pollen, the rate of erosion near the site slowed down. The climate of the described period was somewhat drier than that of preceding times. It is seen evident in the mollisol profile that humus accumulation became somewhat stronger during the drier period, however, this visual observation is not obvious, and it should be confirmed by chemical analytical data.

During the formation of the deposits of *pollen sub-zone B3* and *pollen zone III-middle part* (the correlatives in the two sections of Kabazi II, Fig. 2-1 and 2-2), pine forest grew around the site. The share both of birches and of diverse broad-leaved trees slightly increased compared to the preceding time interval. The characteristic feature of this period was the constant presence of elm, together with oak. Hornbeam and lime occurred at the beginning and at the end of the interval. It can be seen that at the beginning of the interval, the appearance of these taxa is related with the occurrence of spruce and beech pollen in the spectra. Both spruce and beech are indicators of wet and cool climatic conditions, which could affect the higher mountain vegetation belts. The downward encroachment of the beech forests might have occurred at this time in the Crimean Mountains, and the wind-blown *Picea* pollen could reflect the same process of lowering of forest belts in the southern Carpathians. A small amount of *Picea* pollen is found in the deposits of Saki Lake (Western Crimea) dated to the 'Little Ice Age' of the Holocene (Gerasimenko, in press). During the Late Holocene, spruce is not known to have grown in the Crimean Mountains, but its natural habitat spread extensively in the Carpathians at that time (Bezus'ko *et al.*, 1988). Thus, the very distant transport of Picea pollen to the Crimea does seem to be possible. At the end of the described interval, lime and hornbeam formed an admixture within the pine forest, together with hazel, spindle and Rhamnaceae. This diversification of forest composition might correspond to a slight warming. The role of pine and birch decreased at this time. Occupations of archaeological levels VI/9-VI/7 corresponded to the wetter beginning of the interval, whereas the occupation of archaeological level VI/6 was related to the warmer end of the period.

The ground cover of the site firstly consisted of mesophytic herbs, Filicales and Bryales (in the same ratios), but at the end of the period, the role of Herbetum mixtum increased, and grasses appeared. Generally, during the described time interval, the herbal cover of the site was more hygrophytic than during the preceding period (the role of sedges was higher and the share of grasses lower). Judging from the percentages of Chenopodiaceae and Asteraceae pollen, erosion near the site was not intense.

The trend to some reduction of pine forest at the expense of distribution of meadow steppe continued during the formation of the sediments of *pollen sub-zone B4* and *pollen zone III-top*, correlated in the two site sections (Fig. 2-1 and 2-2). At that time, pine stands still dominated in the vicinity of the site, and included a noticeable admixture of oak, elm and hazel. At the same time, the admixture of birch and alder also increased in the forests. The role of pine gradually decreased towards the end of the interval. Primarily, ground cover was similar to that of the preceding period, but later the role both of sedges and grasses increased, and mesophytic herbs became more diverse (particularly an increase of Ranunculaceae). Club-mosses practically disappeared from the ground cover. The retreat of the forests demonstrates the increase in climatic aridity, which progressed to the end of the described time interval. Human occupation of archaeological levels VI/5-VI/3 was during the earlier wetter part of the time interval, whereas occupation of the archaeological levels VI/2-VI/1 corresponds to the drier end of the period.

Thus, during the formation of sediments of PZ B, four microcycles can be recognised (pollen subzones B1 – B4). Each of them started with a wetter climate and ended with a drier one. The general trend to some aridification of the climate can be traced through the whole time span of pollen zone B, though cycle B2 was distinguished by a drier environment than in the following cycle B3. The beginnings of the cycles B1 and B3 were the wettest intervals of the whole time period that corresponds to PZ B.

During the formation of the A1 horizon of the mollisol (*pollen zone* C), the trend to climate aridification continued further. At this time, the site surroundings were occupied by forest-steppe with a predominance of meadow steppe vegetation. Judging from the soil profile, the conditions for humus accumulation improved markedly under a drier climate. A drastic environmental change is demonstrated in the almost complete disappearance of pine forest. Arboreal associations were formed by alder, hornbeam and oak. Bushes (hazel and Rhamnaceae) were more extensively distributed locally than during preceding times. This indicates that the time span of PZ C was dry and warm. Mesophytic herbs (Rosaceae and Lamiaceae dominated) alternated in the ground cover with hygrophytic vegetation (sedges and Ranunculaceae) and ferns. Club-mosses did not grow at this time. No erosion occurred near the site earlier in the interval (absence of pollen of Chenopodiaceae, Cichoriaceae and Asteraceae). The appearance of the latter at the top of PZ C might be connected with the general xerophytization of herb coenoses (here pollen types of Asteraceae are different from those represented in the underlying beds, and related to plants of disturbed ground). The high pollen percentages of sedges and Ranunculaceae show that the site was less well-drained than during the previous intervals. The trend to a retreat of arboreal vegetation, followed by an increase in herbal hygrophyte population, indicates the increase of ground moisture caused by poor drainage. Occupation of archaeological levels V/5-V/6 occurred during this period.

Stratum 13A

At the beginning of the formation of Stratum 13, intense erosional incision occurred at the site, followed by quite thick colluvial accumulation (Chabai, 2003b). The colluvial deposits include pedosediments –brown clay beds which are absent in the underlying sedimentary sequence. This might confirm that the sedimentation break could have persisted for a rather long period, and so might correspond to some climatic shift.

Strata 13 and 11B (11 lower-B)

During the formation of these Strata, thick slope derivatives of a luvisol were formed. The genetic type of the sediments indicates that post-sedimentary soil processes (i.e., clay translocation from A1A2 to Bt horizon) developed together with synsedimentary pedogenesis (constant input of sediment on the slope during the whole interval of the soil formation). Luvisols are normally formed under deciduous forest vegetation in conditions of relatively high precipitation. In a forest-steppe belt, luvisols develop in those localities with a better supply of atmospheric moisture. The rock slab behind the site might have trapped much of the water runoff, as well as provided a shadow for arboreal vegetation growth. Generally, the replacement of humus accumulation (the mollisol of Strata 14A and 14B) by forest pedogenetic processes (the luvisol derivatives of Strata 13 and 11A) indicates a regional increase in precipitation. Significant presence of broad-leaved vegetation through the whole period (and particularly during its optimum, sub-zone IVB) indicates a temperate climate, wetter than the modern one.

The derivatives of Bt soil horizon of the luvisol correspond to *pollen zones D* and *sub-zones IVA-B* (the correlatives in both sections of Kabazi II, Fig. 2-1 and 2-2). During the formation of this soil material (Stratum 13), a forest-steppe environment existed in the site vicinity. The site area was obviously occupied by hornbeam forest, mainly by low stands of *Carpinus orientalis* Mill. Hazel and alder were also rather abundant. The site surroundings were covered by meadow steppe (diverse mesophytic mixed herbs in combination with sedges). Xerophytic components of the ground cover were very infrequent. Erosive processes occurring near the site are reflected in the constant and noticeable presence of Asteraceae and Cichoriaceae pollen.

From the beginning of the formation of the Bt horizon (*pollen sub-zones D1* and *IVA*), the role of broad-leaved taxa, and particularly of hornbeam, gradually increased, and a few other broad-leaved trees and bushes started to appear (oak, elm and spindle). Thus, during the described times, there was a trend to a further climatic improvement. This reached its peak during the formation of the upper part of Bt horizon (*pollen sub-zones D2* and *IVB*). At that time, low stands of hornbeam forest were at their maximum distribution in the vicinity of the site. Hazel and alder population increased parallel to hornbeam, and lime appeared. The climate was wetter than at present. Soil weathering, argillisation and lessivage processes could develop in such an environment. Human occupation of archaeological level IV/2 occurred immediately before the climatic optimum of the period, and occupation of the archaeological level IV/1 was analogous to this optimum.

During the formation of the A1A2 soil horizon of a luvisol, leaching and clay translocation normally occur under a sufficient supply of moisture. A small number of clay coatings in the Bt horizon of the Kabazi II luvisol are an indication of downward clay translocation from the A1A2 horizon (Stratum 11B). During the formation of the A1A2 horizon (*pollen sub-zone IVC*), the vegetation was similar to that of the preceding time interval. However, the role of broad-leaved trees in the forest, particularly of hornbeam, considerably decreased. Hazel also disappeared from the undergrowth. The appearance of fir pollen in the spectra is an indicator of a downhill encroachment of mountain forest belts. All of this is the evidence of a wet but relatively cool climate. *Artemisia* started to grow near the site. The human occupations observed in the archaeological levels III/8E – III/8A occurred during this period.

Stratum 11A (11 lower-A)

During the formation of this Stratum, the input of colluvial silt to the site increased considerably. A drastic environmental change occurred, which can be seen in the sharp reduction of broad-leaved trees (*pollen zone V*). Once again, pine dominated in the forest, and the role of birches was also more pronounced. The temperate forest-steppe which existed during the formation of Stratum 13 was replaced firstly by a southern-boreal one (Stratum 11B), and, finally, by the establishment of a boreal forest-steppe (Stratum 11A). The presence of beech pollen indicates the downward migration of the mountain forest belts. The climate became significantly cooler, but was rather wet. The meadow steppe was still present with a relatively high ratio of sedges, though the participation of Brassicaceae and Asteraceae families in the herbal coenoses became stronger at the expense of a decrease in mesophytic herbs. *Artemisia* grew in small numbers. Such environments are characteristic of Early Glacial stadials. Human occupation of archaeological levels III/8-III/2A occurred at this time.

Stratum 11

The time period corresponding to Stratum 11 was marked by the formation of a rendzina type soil (mollic leptosol). Such soils, connected with limestone rocks, are rather rich in humus, and develop under herbal vegetation (or sparse woodland). During this soil formation, broad-leaved trees re-appeared in the forest-steppe around the site (*pollen zone VI*). Oak appeared, and was followed later by hornbeam and elm. The significant role of birch is a characteristic feature of the period. Toward its end, alder also became important. At no other time were these small-leaved trees so wide spread in the area. This indicates that the climate was much cooler than today. Broad-leaved species began by occupying environmentally protected habitats, and later on, during the optimum, were distributed rather more extensively. The pine disappeared at this time. During this period, forest areas became reduced, and meadow steppe dominated the landscape. Shrubs were also widespread. The site itself was occupied by mesophytic herbs and grasses, and xerophytes also increased during this period. The climate changed from cool and wet to dry and warm. This combination of boreal and temperate floristic elements is typical for an interstadial. Human occupation of archaeological level III/2 occurred around the climatic optimum of the period.

The environment of the final phase of soil formation (top soil layer) differed from those existing before, and was actually transitional to the next developmental stage. The disappearance of broad-leaved trees indicates a cold climate at this time. Only hazel occurred sporadically in the pine stands of this boreal forest-steppe. The characteristic feature of the period is the extensive distribution of hygrophytic vegetational components: alder and sedges. It is possible that decreasing evaporation (caused by the cooling) led to the development of an excessive moisture supply at the site and in the Alma valley. Human occupation of archaeological levels III/1A and III/A correspond to this time span.

Stratum 10A

During the formation of this Stratum, pedogenetic processes ceased, and the light colluvial material accumulated. It was a cold and dry spell (absence of broad-leaved trees in the area, prevalence of steppe over woodland). Forests were dominated by pine (a few Rhamnaceae occurred in the undergrowth), though alder was still abundant in patches wetted by ground water (*pollen zone VII*). The characteristic feature of this period is the distinct xerophytization of the former meadow-steppe. A role of mesophytic herbs decreased at the expense of distribution of diverse xerophytes: *Ephedra*, Chenopodiaceae, Plumbaginaceae, Dipsacaceae, and to lesser extent *Artemisia*. Filicales disappeared from the ground cover, which is indicative of a cold and dry environment of a stadial. Human occupation of archaeological levels II/A/4B occurred at this time.

Strata 10 – 9(base)

Pedosediments were formed here during a climatic warming and there was an increase in precipitation. The regional landscapes were forest-steppe (*pollen zone VIII*), and the most important feature of this time span was the re-appearance of broad-leaved trees (hornbeam and oak), despite the fact that pine still dominated the forest. Presence of beech pollen indicates that the climate was cooler than the modern one, and the high mountain forest belts came lower. This corresponds well with appearance of Lycopodiales and the re-establishment of ferns in the ground cover. Mesophytication of herb cover occurred again, and xeric plants lost their position (with exception of *Ephedra*). These environments are typical for an interstadial. The disappearance of alder might be connected with a new incision in the Alma valley and, correspondingly, on local slopes. This is confirmed by the formation of pedosediments instead of soils. Human occupation of archaeological levels IIA/3, IIA/3A and IIA/3B correspond to this time.

Stratum 9

During the formation of the main part of Stratum 9, pedogenetic processes ceased, and the light colluvial material was accumulated. The area was occupied by forest-steppe with a prevalence of meadow-steppe associations (*pollen zone IX*). The role of xerophytes (and particularly of *Artemisia* and Plumbaginaceae) increased considerably, whereas Filicales and Lycopodiales disappeared. This indicates climatic aridification. Cooling also occurred (retreat of broad-leaved trees, re-appearance of birches), but not as significant as that during formation of Stratum 10A. This arid interval with strong colluviation evidently corresponds to a stadial. Human occupation of archaeological levels IIA/2-3 and IIA/2 were found here.

Strata 9 (top) – 7 (base)

Pedosediments with strong colluvial components were formed at the site during this interval. Environments changed through the period, from southern-boreal forest-steppe (*pollen zone X*) to boreal forest (*pollen zone XI*). During the first developmental phase, pine forest dominated, with small admixtures of birch and alder. Hornbeam occupied environmentally protected habitats, and a small number of oak, elm, lime, hazel and spindle-tree also grew there. The climate was relatively warm, and characteristic of an interstadial. The very high proportion and great diversity of mesophytic herbs were typical for the steppe vegetation of the period. This, as well as the wider distribution of arboreal vegetation and ferns, indicates an increase in precipitation during the interstadial. Human occupation of archaeological levels IIA/1, II8/ and II/8C belong to this phase.

During the second development phase, broad-leaved trees practically disappeared from the forest, indicating significant cooling. Light pine forest surrounded the site. Diverse bushes occurred in the undergrowth, or could have formed separate stands down the slope. Juniper and Lycopodiales appeared, and this is usually connected with pine forests. The ground cover of the forests consisted of mesophytic herbs. The phase corresponds to a transition from interstadial to stadial environments. Human occupations of archaeological levels II7E – II/6 fall in this period.

Stratum 7

During the accumulation of this Stratum, no pedogenetic features were formed, and colluviation developed intensely. The typical grassland has become established locally for the first time in the vegetational history of the area (*pollen zone XII*). The role of mesophytic herbs declined profoundely, as did their diversity. There also occurred an extensive distribution of Poaceae, Asteraceae and xerophytes (*Artemisia*, Chenopodiaceae). The arboreal vegetation reduced drastically from the beginning to the end of the period. Initially, there were pine groves with an admixture of birch and Rhamnaceae, but later on the whole area was deforested. A few alder were able to grow along the Alma River. The absence of broad-leaved trees indicates the cold climate of this very dry stadial. Human occupations of archaeological levels II/3-II/1 correspond to this time span.

Strata 5-6

During the formation of these Strata, a brown rendzina soil developed. Humus accumulation in this soil type is less than in typical rendzina soils. At this time, the site's environments were dominated by south-boreal forest-steppe (*pollen zone XIII*). Broad-leaved trees (hornbeam and oak) reappeared indicating interstadial conditions. Their participation in the vegetation cover increased from the beginning of the interval (B soil horizon) to its optimum (A1 soil horizon). Steppe associations consisted of grasses and mesophytic mixed herbs. Immediately around the site, sedge and ferns grew. Xerophytes almost disappeared from the ground cover. The very top of the soil was formed under transitional conditions to the next stadial. Broad-leaved stands disappeared, but small-leaved trees (alder and birch) were still relatively abundant, as was juniper. Xerophytes had already increased in number, but the composition of Herbetum mixtum still was diverse. Human occupation of archaeological levels II/1A and A4 – A3A occurred at this time.

Stratum 4

The time which saw the formation of Stratum 4 was marked by strong colluviation and a complete suppression of pedogenic features. Typical grassland occupied the vicinity of the site during this period, with a noticeable presence of *Artemisia* (*pollen zone XIV*). The amount of hygrophytes in the area decreased, whereas ferns completely disappeared. This indicates a dry climate. Arboreal vegetation was drastically reduced: alder, birch and Rhamnaceae obviously grew near the Alma River. The appearance of Eleaegnaceae, which are drought-resistant, and heliophytic plants also indicates the existence of a vast open landscape during this pronounced stadial. Human occupations of archaeological levels A3 – A occurred at this time.

The environmental history of the Kabazi II site can be divided into two main parts. In the lower part of the sequence (Strata 14-11/base), soil processes dominated, and, on the evidence of pollen data, environments mainly fluctuated between temperate and southern-boreal ones. In the upper part of the sequence (Strata 11-4), a cyclic pattern of change occurred, which can be seen in alternation of pedogenetic and colluvial processes, as well as in the alternation of southern-boreal and boreal environments. A general trend - which saw a decrease in the broad-leaved flora and mesophytic components of herb assemblages - was pronounced from the beginning to the end of the described period. This indicates the advance of a cooler and more continental climate developing in an oscillatory pattern.

Climatostratigraphy and Correlations

The first approach to the stratigraphical division of the Kabazi II sedimentary sequence was made during the first pollen investigation of the site (Gerasimenko, 1999). Deposits attributed to both the Last Interglacial and the Last Glacial were recovered; and five stadials and four interstadials were determined within the Last Glacial. The Last Glacial part of the sequence was recorded *in situ* during the field trip (Strata 11-4).

Two pronounced markers within the pedological stratification of the section are humiferous soils at the base and at the top of the excavated facies in 1992. The lowest (Stratum 11, the upper part) has been morphologically correlated with the upper humiferous soil of the Pryluki unit elsewhere in the Ukraine. The second (Stratum 5-6) has been considered an equivalent of the upper rendzina soil of the Vytachiv unit in the forest-steppe belt of Ukraine. In the Ukrainian Stratigraphical Framework for the Quaternary (Veklitch (eds.), 1984; 1993), the Pryluky unit has been correlated primarily with the Mikulino Stage (Eemian, Substage 5e), and the Vytachiv unit has been related to the Substages 5c and 5a of the marine isotope-oxygenic Stage 5. Nevertheless, the TL-dates demonstrate the ages of the Vytachiv unit within 35-45 kyr, and the ages of Pryluky unit to 100-115 kyr (Shelkoplyas et al., 1986). The beginning of the typical Mikulino (Eemian) pollen succession has been found at the base of Kaydaky unit (Gerasimenko, 1988). The latter has been primarily related to Stage 7 (Veklitch (eds.), 1984, 1993). Based on pollen, pedo- and magnetostratigraphic correlations, recent publications (Rousseau et al., 2001; Gozhik et al., 2001; Gerasimenko, 2002; Haesaerts and Gerasimenko, 2002) have proposed that the Kaydaky unit correlates to the Mikulino (Eemian, Substage 5e), and the Pryluky unit is analogous to Substages 5c and 5a of MIS 5. However, another opinion states that the Kaydaky unit should be correlated with Stage 7, and the Pryluky unit with the whole of Stage 5 (Boguckyj and Lanczont, 2002; Lindner et al. 2002). In all the forenamed recent publications, the Vytachiv unit is related to Stage 3.

The "absolute" dates obtained from Kabazi II (Hedges et al., 1996; Pettitt, 1998; Rink et al., 1998; in press; McKinney, 1998) have clearly demonstrated that the upper Vytachiv rendzina was formed immediately after 32-30 kyr, i.e., at the end of Stage 3; and the humiferous Pryluky soil was formed in the interval between 117-81 kyr, i.e., in the second half of Stage 5. In the latter case, most of the dates are fall between 74-107 kyr, i.e., within the Substages 5c – 5a (the Early Glacial). The humiferous Pryluky soil is morphologically correlated with the Krutitsa soils of the Russian Plain, which are also related to the Early Glacial interstadials (Velichko, 1988; Bolikhovskaya, 1995). Thus, the succession between the top of the Pryluky rendzina soil (Stratum 11) and the top of upper Vytachiv soil (Stratum 5) fall in the interval of Stages 4 and 3.

Three main interstadials have been recovered within the pollen succession of Strata 10 – 4. Their correlation with the three Middle Valdai interstadials of the Russian Plain (Bolikhovskaya and Pashkevich, 1982; Bolikhovskaya, 1995) has been published (Gerasimenko, 1999). The first Vytachiv interstadial (pollen zone VIII) has been correlated with the Baylovsky (Krasnogorsky, Moershoofd) interstadial, the second Vytachiv interstadial (pollen zone X) corresponds to the Molodovsky (Kashinsky, Hengelo) interstadial, and the third Vytachiv interstadial, detected from the rendzina soil (pollen zone XIII), has been correlated to the Dnestrovsky (Dunaevsky, Arcy) stadial. In the field (the access, kindly provided to the Molodova V section by P.Haesaerts), the close morphological similarity of the rendzina, related to the Dnestrovsky interstadial in Molodova, and to the upper Vytachiv rendzina elsewhere, was recognised. In the Kabazi II section, the two lower Vytachiv interstadials correspond in most parts to the more strongly weathered, brown colluvial deposits (pedosediments). In the loess section of the forest-steppe belt of the Ukraine, the equivalents of the two lower Middle Valdai (Middle Pleniglacial) interstadials are found in the two boreal brown forest soils vt_{1b1} and vt_{1b2}. These soils are separated by a loess-like loam bed whose pollen content corresponds to a stadial (vt_{1b1-b2}). The loess bed which separates the brown soil vt1b1 and the upper Vytachiv rendzina is always better pronounced morphologically and, by pollen content, reflects harsher stadial conditions than those of the vt_{1b1-b2} stadial. Judging from this fact, the status of a loess subunit had been given to this second Middle Pleniglacial stadial – vt_2, instead of formerly to vt_{b2-b3}. Correspondingly, the two lower Vytachiv interstadials, with similar environments, have been related to subunit vt1, and the upper rendzina soil has been regarded as the soil subunit vt_3, instead of vt_{b3}.

Most of "absolute" dates obtained from the Vytachiv unit at the Kabazi II is related to the vt_2 sub-unit, and fit within the interval 31-35 kyr (Chabai *et al.*, 1999). Thus, the ages of the second Vytachiv stadial (*pollen zone XII*) correspond to the Huneborg stadial of Western Europe (Hammen, 1995). Thus, the interstadial above this unit should indeed correspond to the Denekamp (Arcy) interstadial. The recent ^{14}C-dates from the top soil of the Vytachiv alluvial suite of the Dnieper River terrace are between 28 and 27 kyr (Stepanchuk *et al.*, 2004) that fall at the end of last interstadial of the Middle Pleniglacial. The environment of the 28-27 kyr interval in the lower Dnieper valley was cool and similar to the transitional phase detected at the top of the Vytachiv rendzina at Kabazi II – vt_{3c} phase.

Judging from the dating of the vt_2 sub-unit, the positions of the two previous interstadials should correspond to the Hengelo and Moershoofd interstadials, though the few dates available for them indicate older ages. The transitional phase vt_{1c} (*pollen zone XI*), between the interstadial vt_{1b2} and the stadial vt_2, is dated to the Hengelo (36, 38 kyr), and the full interstadial vt_{1b2} deposits date to about 44 kyr (the age of the latest of the Moershoofd interstadials). On the other hand, Hengelo is known as the warmest interstadial of the Middle Pleniglacial, and that does not fit close to boreal environments detected in the vt_{1c} phase. Before high resolution data is available for this interval, we consider that the two main vt_1 interstadials (vt_{1b1} and vt_{1b2}) are equivalents to the two main Middle Pleniglacial interstadials. In the Middle Dnieper area, the interstadials of the vt_{1b1} and vt_{1b2} soils have been dated correspondingly and precisely to the Moershoofd and Hengelo.

The stadials after the last Vytachiv interstadial (*pollen zone XIV*) are related to the Bug unit (from the beginning of the Late Pleniglacial), and the stadial to before the first Vytachiv interstadial (*pollen zone VII*) corresponds to the Uday unit (the Early Pleniglacial). The pollen data on wetter environments of the Uday unit and the drier climate of the Bug unit (Gerasimenko, 1988) correspond totally to the characteristics obtained from these two intervals in the Kabazi II section.

Thus, the stratigraphy of the upper part of the Kabazi II sequence is generally confirmed by "absolute" dating, as well as by pollen and palaeopedological correlations. The lower part of the sequence (Strata 14 – 11 lower) has been firstly divided biostratigraphically solely on the basis of pollen data from the samples taken in the narrow sondage. The lithology and lateral relations of the Strata were not clearly known, and continuous sedimentation in the trap behind the fallen slab barrier was suggested and used for the interpretation of the pollen data. The base of the barrier in this part of the section was exposed during later excavation, when revealed new soil types, as well as an obvious discontinuity in the sedimentary record. Several erosional breaks were discovered (Chabai, 2003b), which make a reconstruction of the vegetational evolution and climatostratigraphical interpretation of the sequence much more complicated.

Below the humiferous Early Glacial soil (Stratum 11), two intervals of temperate climate have been discovered which correspond to high pollen percentages of broad-leaved trees. The lower optimum for broad-leaved trees (*pollen zone I*) was formed both by oak and hornbeam, and the upper optimum of broad-leaved taxa (*pollen zone IV*) by hornbeam. The cooling, documented by strong reduction of broad-leaved trees and extensive pine distribution (*pollen zones II and III*), is located between them. The two optima for broad-leaved vegetation have been correlated with two temperate climate stages during the Last Interglacial: namely, with the earlier xerothermic (mesocratic) stage of the Mikulino/Eemian, dominated by Quercetum mixtum, and with the later hygrothermic (telocratic) stage of the Mikulino/Eemian, dominated by *Carpinus* (Grichuk, 1972; Zagwijn 1961; 1992). The endothermal cooling between the two interglacial optima has been shown to occur in the Mikulino (Bolikhovskaya, 1982; 1995; Yelovicheva, 2001) and it has been suggested for the Eemian (Guiot et al., 1993; Field et al., 1994). The appearance of pollen of *Abies* at the end of hygrothermic stage (*pollen zone IVC*) is also indicative for the Last Interglacial. The thickness of the Mikulino deposits seemed to be too great, as compared with the deposits of the Early Glacial interstadials (*pollen zone IV*), but this could be explained by essentially higher depositional rates at the very beginning of the sedimentation in the trap behind the barrier.

All pollen counts made during the first study have been confirmed in recent research, and correlation between the sediments in the two excavations is clear (Table 2-1). However, it has been shown that a different interpretation of the data is equally possible, owing to the following points: 1) the hiatuses discovered in the sedimentary record of Kabazi II; 2) the change in the recent years of the stratigraphical position of the Last Interglacial within the Ukrainian loess-soil succession (Gerasimenko, 2001; 2002; Rousseau et al., 2001; Shovkoplyas et al., 2003); 3) the details in the pollen zonation recovered through high resolution data (frequent sampling), as well as through the counting of large pollen grain numbers (up to 500 grains per sample). The latter enables pollen of taxa to be found which only occur in a sample at very low frequency.

Thus, the recent field investigation has shown that Stratum 13 is a derivative of the Bt horizon of luvisol. This fits well with the pollen content of these deposits, which reflects the occurrence of hornbeam growth (the upper maximum of the broad-leaved flora). Stratum 14, which formerly (in sondage)

Strata	Lithopedological units	Pollen samples, 1992	Pollen samples, 2000-2001	Pollen zones, 1992	Pollen zones, 2001	Archeological levels	Vegetation	Ukrainian stratigraphical units	Correlation with European frameworks	Correlation with marine isotopic scale
4	Non-soil colluvium	48, 47		XIV		A, A1, A2, A3	Boreal grassland	Bug loess unit bg_1	Upper Pleniglacial, Upper Valday	Stage 2
5	Rendzina soil A1 horizon	46		XIV			Boreal grassland (with *Juniperus* and *Betula*)	Vytachiv soil unit vt_{3c}	The end of Middle Pleniglacial, the end of Dniester (the III Middle Valdai) Interstadial	Stage 2-3 transition
	Rendzina soil A1 horizon	45		XIII		A3A, A3B, A3C, A4	South-boreal forest-steppe	Vytachiv vt_{3b}	Middle Pleniglacial: Denecamp, Dniester (the III Middle Valdai) Interstadial	
6	Rendzina soil B horizon	44		XIII-XII			South-boreal to boreal forest-steppe			
		43				II/1A				
7	Non-soil colluvium	42		XII		II/1	Boreal xeric grassland	Vytachiv vt_2	Huneborg Stadial, the III Middle Valdai Stadial	
		41				II/2				
		40				II/3				
		39				II/4, II/5	No pollen			
	Grey-brown pedosediment	38		XI		II/6	Boreal to south-boreal forest	Vytachiv vt_{1c}	Huneborg Interstadial, the end of Molodova (the II Middle Valdai) Interstadial	Stage 3
		37				II/7				
				X		II/7AB-II/7E	South-boreal forest-steppe	Vytachiv vt_{1b2}	Hengelo, Molodova (the II Middle Valdai) Interstadial	
		36				II/8, II/8C				
9	Brown pedosediment	35				IIA/1				
		34					No pollen			
	Non-soil colluvium	33		IX		IIA/2	Boreal to south-boreal forest-steppe with	Vytachiv vt_{1b2-b1}	Hosselo, the II Middle Valdai Stadial	
		32				IIA/2-3				
	Brown pedosediment	31		VIII		IIA/3-IIA/3B	South-boreal forest-steppe	Vytachiv vt_{1b1}	Moershoofd, Baylovo (the I Middle Valdai) Interstadial	
		30								
10		29				IIA/4				
10A	Non-soil colluvium	28		VII		IIA/4B	Boreal forest-steppe	Uday loess unit ud	Early Pleniglacial, the I Middle Valdai Stadial	Stage 4
		27								
11	Rendzina soil A1 horizon	26				III/1A, III/1	Boreal to south-boreal forest-steppe	Pryluky soil unit: pl_3	Ognon Interstadial	Stage 4-5 transition
11	Rendzina soil	25		VI			South-boreal forest-steppe	Pryluky pl_{1b2} (pl_{1b2+3} ?)	Early Glacial: Odderade (Brörup-Odderade?), Saint-Germain II, the II Ealry Valdai Interstadial	Stage 5: Substage 5a (5a-b?), GRIP 21
		24				III/2				
		23								
11A	Non-soil colluvium	22		V		III/2A-III/3	Boreal to south-boreal forest-steppe	Pryluky pl_{1b2-b1} (pl_2?)	Rederstall (?), Melisay II, the II Ealry Valdai Stadial	Sub-stage 5b (GRIP 21-22 or 22-23?)
						III/4-III/6				
		21				III/7				
		20				III/8				
11B	Pedosediment (A1A2 horizon of luvisol)	19		IVC		III/8A-III/8E	South-boreal forest-steppe	Pryluky pl_{1b1}	Brörup, Saint-Germain I, the I Ealry Valdai Interstadial	Substage 5c
		18								
13	Pedosediment (Bt horizon of luvisol)	17	A	IVB	D2	IV/1	Forest-steppe of temperate climate			
		16								
		15	B	IVA	D1		South-boreal forest-steppe			
			C							
		14	D			IV/2				
			E							
		13	F			IV/3, IV/4				
			G			IV/5				
13A	Pedosediment & gully colluvium	Not sampled				V/1,V/2A		Tyasmin loess unit (?)	Herning, Melisay I, the I Ealry Valdai Stadial	Substage 5d
14A	Meadow-chernozem soil (Mollisol) A1 horizon				C	V/3	Forest-steppe of temperate to south-boreal climate	Kaydaky soil unit: kd_{3b2+c}	Eemian (E6b), Mikulino (M8)	
						V/4				
			XXIX			V/5				
			XXVIII			V/6				
			XXVII							
14B	Mollisol A1B horizon	12	XXVI, H	III	B4	VI/1	South-boreal forest to forest-steppe		Eemian (E6a), Mikulino (M7)	
			XXV			VI/2				
			XXIV, I			VI/3				
			XXIII			VI/4, VI/5				
		11	XXII, J							
			XXI		B3		South-boreal forest			
			XX, K			VI/6				
			XIX							
		10	XVIII, L			VI/7				
			XVII			VI/8				
			XVI			VI/9				
			XV		B2		Boreal to south-boreal forest			
		9	XIV							
			XIII							
			XII							
			XI							
		8	X	II	B1	VI/9A	South-boreal forest to forest-steppe			
			IX							
			VIII			VI/10				
			VII							
		7	VI							
			V			VI/11-14				
			IV			VI/15, VI/16				
		6	III			VI/17				
			II		A		Boreal forest-steppe	Kaydaky kd_{3b2-b1}		
			I							
14D	Non-soil colluvial deposits	5		II			South-boreal forest-steppe	Kaydaky kd_{3b2-b1} (?)	Eemian (E6a), Mikulino (M7) (?)	Substage 5d (?)
		4								
		3								
14E	Non-soil colluvial deposits	2		I			Forest-steppe of temperate climate	Kaydaky kd_{3b1} (?)	Eemian (E5), Mikulino (M6) (?)	Substage 5e (?)
		1								

included three pollen zones, really appears to be of a complex structure, but the connection of pollen data with the lithology is somewhat controversial. A pollen zone which indicated cooling actually corresponds to the well-developed humiferous soil (mollisol), whereas the first maximum of a broad-leaved flora is related to non-soil deposits (hillwash loam and clay, steeply bedded along the slope). The pollen data indicate that the mollisol clearly cannot correspond to the interglacial optimum of the broad-leaved vegetation. It can be related to the endothermal cooling within an interglacial - which is what the author considered this pollen zone to be in the former publication, - to the beginning of an interglacial, or to the end of an interglacial. Judging from the newly discovered erosional break and intense colluvial accumulation between the mollisol (Strata 14A-B) and luvisol (Stratum 13), the suggestion that the mollisol formation occurred during an endothermal cooling does not seem realistic. This single event could not include both the thick mollisol formation and the later erosion and colluviation. Thus, the opinions on the origin of the mollisol during an early interglacial or a late interglacial period need to be considered further.

The arguments which favour the formation of the mollisol during the beginning of the Last Interglacial are as follows. The trend to an increase in broad-leaved trees in the vegetation is seen from the beginning to the end of the time of mollisol formation, primarily by comparison of pollen content of Strata 14B and 14A. Pollen of *Quercus* dominates in the group of broad-leaved taxa, and *Ulmus* pollen is rather noticeable. These two trees appear first among broad-leaved species during the evolution of interglacial vegetation. It should be mentioned that *Carpinus* pollen has also been discovered, and is particularly pronounced in the first pollen sub-zone of zone B (Stratum 14B). This can only be explained by the specific character of vegetational evolution of the Crimean Mountains, which provided the refugia for all the species of the broad-leaved flora. In the Crimean Mountains, the extensive distribution of *Carpinus* during the Alleröd has been proven (Cohen et al., 1996; Cordova and Lehman, 2003), whereas in the whole plain area of the Ukraine, hornbeam was absent both in this time interval and also much later, during the Early Holocene. Generally, the suggestion for the early Mikulino age for the mollisol can only be accepted if one admits that the M1 zone of the Mikulino – wet and cool climate with extensive spruce distribution in the Russian Plain – could be correlated with the B1 sub-zone of Kabazi II – wet and relatively warm climate with other moisture-loving trees: hornbeam and some fir. Furthermore, it must be concluded that the forest soils characteristic for the first Quercetum mixtum optimum of the Mikulino in the forest-steppe belt of Ukraine was replaced in the Crimean low mountain ridges by humiferous soils (Stratum 14A). In the soil cover Mikulino, connected with the Mikulino Stage, such a phenomenon can be observed within the area of the modern steppe belt of Ukraine (Sirenko and Turlo, 1996).

Facts which also favour an early Mikulino age for the mollisol are both the absence of pollen of broad-leaved trees at the beginning of the soil formation (PZ A), and erosional incision at this time. If we accept an early Mikulino age for the mollisol, it becomes necessary to admit that there was a redeposition of all pollen in Strata 14D and 14 E. The incision and colluviation observed in Stratum 13A could then be related to the endothermal cooling of the Mikulino, and the *Carpinus* peak (luvisol derivatives of Stratum 13) could be regarded as the hygrothermal stage of the Last Interglacial, as it was suggested in the former publication. In the loess-soil series of the plain area of Ukraine, the forest soil corresponds to the hygrothermal stage of the Mikulino (Gerasimenko, 1988; 2001; Rousseau et al., 2001).

The second interpretation for Kabazi II is based on the recent detailed pedo- and palynostratigraphy of the Pryluky-Kaydaky soil complexes as an equivalent of MIS 5 (Rousseau et al., 2001; Haesaerts and Gerasimenko, 2002; Gerasimenko, 2002). According to this data, three forest soils could have developed during the Pryluky-Kaudaky pedogenesis, and three forest soils have been discovered in the Western European loess-soil sections, assignable to the time interval of Stage 5 (Haesearts et al., 2000; Antoine et al., 2003). In Ukraine, the highest of these soils belongs to the Pryluky unit (pl_{1b1}) and is characterised by a high proportion of pollen of broad-leaved taxa, including *Carpinus*. The difference for the Kaydaky forest soils encompasses the absence of a pollen succession typical for the Mikulino interglacial. All broad-leaved species appeared at the same time, as it has been shown to be characteristic for an interstadial (Zagwijn, 1992). The Mikulino pollen succession is shown to end at the top of the Kaydaky unit. Thus, the cold Tyasmin unit is related to the first stadial of the Early Glacial (Substage 5d), and the Pryluky unit corresponds to the Early Glacial. In the Stage 5 pedocomplex of Western Europe, the upper forest

◄ **Table 2-1** Kabazi II: vegetational succession and its relation to stratigraphy, lithopedology and archaeological levels.

soils have been primarily correlated with Early Glacial interstadials (Haesearts et al., 2000; Antoine et al. 2003). In such a way, the luvisol of Strata 13-11B might be correlated principally with the first Early Glacial interstadial, Substage 5c. The problem is that, in the plain area of the Ukraine, the pollen content of the pl1b1 soil has never been shown to be so strongly dominated by *Carpinus*, in spite of hornbeam pollen always being present in the soil. Here, the distinct prevalence of *Carpinus* is characteristic only in the upper forest Kaydaky soil – hygrothermical stage of the Mikulino. In the reference section of Grand Pile, France (Woillard, 1978), the pollen percentages of hornbeam are much higher in the Eemian than in the Saint-Germain I interstadial – Substage 5c.

On the other hand, the most environmentally similar sites to those of the foothills of Crimean Mountains could be the Southern European reference section with it high resolution record at Tenagi Philippon, northern Greece (Wijmstra, 1969; 1976). A high resolution record has been obtained from lacustrine deposits, accumulating with constant sedimentation rates, which enable the establishment of a time-depth relation for the sequence. The pollen contents of the upper Eemian/Pangaion (zones O2b and Q) and Brörup/Drama (pollen zone S) are rather similar to the corresponding pollen zones from Strata 14 and 13. Zone O2b corresponds to the appearance of hornbeam during the Eemian (hygrothermal stage), but in this southern area it is represented by oak forest with *Carpinus betulus*. Actually this vegetation type (with maxima of *Quercus* and *Carpinus* pollen) corresponds to pollen zone I at Kabazi II (Stratum 14E). The beginning of pollen zone Q (Tenagi Philippon) is marked by a rise in *pine* pollen and a decrease in *Quercus*, as well as by an increase in pollen percentages of *Artemisia* and Chenopodiaceae (Wijmstra, 1976). This corresponds well to the changes observed in pollen zone II (Stratum 14D). Further, at both the zones BII at Kabazi II and QI at Tenagi Philippon, pollen percentages of *Betula* and *Alnus* start to rise, *Carpinus* is quite noticeable, a few *Tilia* appears, and, most remarkably, the pollen of *Abies* occurs. It is known that in the late Eemian, a *Carpinus* zone was followed by an *Abies* pollen zone. It is not realistic to expect that fir would be extensively distributed in the low mountains of Southern Europe, but the simultaneous appearance of *Abies* pollen in both sections could be a reflection of the spread of fir in the other areas or in the higher mountain belts. In pollen zones Q2 (Tenagi Philippon) and B2 (Kabazi II), the further increase of *Pinus* pollen occurred together with a drop in pollen of broad-leaved taxa. In the pollen zones Q3 (Tenagi Philippon) and B3 (Kabazi II), pollen of *Ulmus* and *Corylus* became more important, *Tilia* re-appeared, and a few *Picea* occurred. A *Picea* pollen zone follows an *Abies* pollen zone in the Eemian sequences of Western and Central Europe. Appearance of *Picea* in both southern sections could be an important indication of the spread of spruce in more northern and western areas at the end of Eemian. All the similar, aforementioned changes occurred against the background of a constant higher ratio of arboreal pollen, particularly of oak, in the Greek section. This could easily be explained by its southerly position, as well as by its location in the lake depression.

It appears rather puzzling that pollen zones I and II, displaying a temperate vegetation, are discovered in non-soil deposits (Strata 14D and 14E), whereas pollen zone 14B, reflecting southern-boreal vegetation, belongs to the soil. Judging from the bedding of Strata 14D and 14E, the suggestion of pollen re-deposition is possible. Still, neither the pollen frequency and preservation, nor the pollen composition of these Strata indicates re-deposition. Pollen of specific taxa which are absent in the overlying Strata were not discovered. On the other hand, interglacial and interstadial pollen zones have previously been established within non-soil deposits in erosional depressions in the sections of the loess-soil series of Russian Plain (Bolikhovskaya, 1995; Bolikhovskaya and Pashkevich, 1982). In such sections, sedimentation rates were evidently much greater than the intensity of pedogenic processes.

In the next pollen zones, R1 (Greece) and B4 (Crimea), the fall in arboreal pollen amount, and particularly of *Pinus* pollen, at the expense of an increase of herb pollen, is observed. The difference is that at Tenagi Philippon, a proportion of broad-leaved trees also decreased, whereas at the Kabazi II, it is the same as in the preceding zone. Pollen zone R1 has already been related to the first Early Glacial stadial. In the recent publications (Kukla et al., 1997; 2003; Sanches Goni et al., 2001, Shackleton et al., 2003), the end of the classical Eemian pollen succession is also related to Substage 5d. In Eemian reference sections in France, an increase in herbs is related to dates of 114-110 kyr (Kukla et al., 2003), and broad-leaved trees are shown to have grown at this time. The reason for their sharp reduction in Greece was probably a more pronounced increase in aridity there – the lake dried up and took on the form of a peat-bog (Wijmstra, 1969). In pollen zone R2, an increase in broad-leaved pollen content (*Quercus, Carpinus, Ulmus* and *Tilia*) is observed, and this might possibly correspond to pollen zone C at Kabazi II. Pollen percentages of *Pinus* and *Betula* were lower in both of these zones than the pollen contents of broad-leaved taxa. An increasingly warmer and dryer trend is shown to mark the last phase of Eemian times around 110 kyr, during the Substage 5d (Sanches Goni et al., 2001).

In the Kabazi II section, the pessimum of Substage 5d (the first stadial of the Early Glacial) could correspond to the erosional break and colluvial sediments of Stratum 13A, whereas in Tenagi Philippon, it might be represented by pollen zone R3 (with predominance of non-arboreal pollen and low counts for both pine and broad-leaved trees). In Greece, pollen zone S is located above pollen zone R and correlated with Brörup (Wijmstra, 1969; 1976). The characteristic features of this zone are as follows. High pollen percentages of broad-leaved trees are observed. During the optimum they are higher than those of *Pinus*. Three maxima of broad-leaved tree pollen can be seen, separated by phases with some increase in *Pinus* pollen. The pollen percentages of *Carpinus* are the highest through the Upper Pleistocene and the Holocene, particularly at the middle optimum of broad-leaved vegetation (zones IVB, D2). Pollen of *Quercus* increased at the first and the last optimum, and *Juniperus* was most noticeable at the beginning of the zone. *Alnus* produced a peak together with *Carpinus*. Pollen of *Abies* appeared during the main peak of *Carpinus* and reached it maximum shortly afterwards. All these features can also be distinctly traced in pollen zone IV at Kabazi II.

Such a close similarity of two sets of pollen records constrain us rather to accept the second interpretation of the data, outlined for the lower part of the Kabazi II sequence, and correlate Strata 13-11B with the first Early Glacial interstadial (Substage 5c). It differs strongly in its environmental characteristics from the classical Brörup, as well as from the Saint-Germain I interstadial (Woillard, 1978). One may accept that contrasting relations of temperature and moisture in the different areas caused the difference. During this time span, it was probably too cool even in central France for an extensive distribution of the hornbeam. In southern Europe, the interstadial climate could not have been so cool, but still cool enough to decrease evaporation and to provide favourable moisture regime for *Carpinus*. It has been shown (Kukla et al., 1997; 2003; Sanches Goni et al., 2001; Shackleton et al., 2003) that even in the wet Western European area during the Eemian, the maximum distribution of hornbeam did not correspond to the thermical optimum.

The cool period depicted in pollen zone V (Stratum 11A) could possibly be correlated with the second stadial of the Early Glacial (Substage 5b), and with the pollen zone T at Tenagi Philippon. In the latter section, the next pollen zone U (Odderade, Substage 5a) has a complex structure, and such a complexity is also typical of the upper part of the Pryluky unit and it is represented in the stratigraphically complete sections (Rousseau *et al.*, 2001; Heasaerts *et al.*, 2002; Gerasimenko, 2002). It includes a very characteristic humiferous soil, pl_{1b2}, as well as the boreal brown forest soil, pl_{3b1}, and a set of later initial soils (all of them separated by thin loess beds). Such a detailed record does not exist in the Kabazi II sequence, and only the soil pl_{1b2} (Stratum 11) has been morphologically determined. A high resolution pollen sampling for this soil has not been undertaken, and this makes it difficult to determine the part of pollen zone U (Tenagi Philippon) with which the pl_{1b2} soil can be correlated. It seems that a large part of the Odderade and the later Early Glacial interstadials (Ognon I-III) are missing at Kabazi II, as it is frequently the case for sections of the loess-soil series of the Ukraine.

Conclusion

The palynological and pedostratigraphical study of the sequence at the Middle Palaeolithic site of Kabazi II shows the complicated environmental evolution which was taking place during the Late Pleistocene. The results of litho-pedological and pollen investigation usually correspond well. They enable the establishment of the main stages and their correlation with the wider Upper Pleistocene stratigraphical frameworks. On the other hand, the discontinuous sedimentary record represented in the lower part of the section requires the control of climatostratigraphic results constrained by "absolute" dating. Correlation with reference sections in the long continuous pollen records deposited in similar environmental conditions to the studied sequence is another useful tool.

According to the discovered environmental evolution, the sedimentary record of Kabazi II comprises the time interval from the second half of the Last Interglacial up to the first half of the Late Pleniglacial. The stratigraphical units of the Ukrainian Framework for the Quaternary (Veklitch, 1993) have been established at Kabazi II, starting from the Kaydaky unit and ending with the Bug unit (Fig. 2-3). The correlation of these stratigraphical units with the West European glaciochronology for the Late Pleistocene, as well as with the global marine oxygen-isotopic stages, has been proposed. For the upper part of the sequence, it corresponds completely to the previously published correlation (Gerasimenko, 1999).

The cool and relatively wet stadial of the Uday unit is related to the Early Pleniglacial (Stage 4). Three south-boreal interstadials of the Vytachiv unit (vt_{1b1}, vt_{1b2} and vt_{3b}) are correlated with the Middle Valdai interstadials of the Russian Plain, established by N.Bolikhovskaya and G.Pashkevich (1982), as well as with the Middle Pleniglacial interstadials of Moershoofd, Hengelo and Denekamp (Stage 3). Correspondingly, the stadials between them ($vt_{1b1\text{-}b2}$ and vt_2) are correlated with the Hasselo and Huneborg stadials of the Middle Pleniglacial established by Hammen (1995). The two transitional boreal phases are distinguished at the end of the second and the third Vytachiv interstadials (vt_{1c} and vt_{3c}). The cold and dry stadial of the Bug unit is correlated with the first half of the Late Pleniglacial. These correlations are confirmed by "absolute" dates (Hedges et al., 1996; Pettitt, 1998; Rink et al., 1998; in press; McKinney, 1998), though the dating of the vt_{1b2} soil appeared to be older than the Hengelo; a fact which is discussed in this paper.

The lithostratigraphy of the lower part of the sequence, which have been only recently exposed, (Chabai, 2003b), has demonstrated a discontinuity of the sedimentary record, which required a new pollen study based on high frequency sampling. The new approach to correlation of the Ukrainian stratigraphical framework with other regional and global scales for the Quaternary (Rousseau et al., 2001; Haesearts and Gerasimenko, 2002; Gerasimenko, 2002) has been used in the interpretation of the sequence. According to the new results, the Last Interglacial is related to the Kaydaky unit. Previously, the Mikulino interglacial was correlated with the whole Kaydaky unit and the lower forest soil of the Pryluky unit (Gerasimenko, 1988; 1999).

The long continuous pollen record at Tenagi Philippon, northern Greece (Wijmstra, 1969; 1976), located in an environment similar to that of the Kabazi II site, has been used in the correlation and interpretation of the pollen data recovered. The pollen diagram of deposits, sampled at high frequency at Kabazi II, corresponds to the part of sequence below the pl_{1b2} soil (Fig. 2-2), which is dated to the Early Glacial. This diagram has been compared to the Early Glacial-Last Interglacial interval for the Tenagi Philippon diagram, and this showed the close similarity in pollen zonation, including the consequence of the appearance of arboreal taxa and the extent of their distribution. In the Tenagi Philippon diagram, a *Carpinus* peak is shown for the Brörup interstadial, whereas in the diagrams for northern and western Europe, the *Carpinus* pollen zone is characteristic of the hygrothermic stage of the Eemian. This fact makes a correlation of the *Carpinus* pollen zone in the pl_{1b1} soil at Kabazi II with the Brörup interstadial of the Early Glacial (Saint-Germain I, Substage 5c) possible. The correlation of the soil pl_{1b1} with Substage 5c has been proven for other areas of the Ukraine using different environmental indicators (Rousseau *et al.*, 2001; Haesaerts and Gerasimenko, 2002; Gerasimenko, 2002). Thus, the revision of position of the pl_{1b1} soil to Substage 5c in the Kabazi II sequence makes the inter-regional correlations coherent.

In both the sequences of Kabazi II and Tenagi Philippon, the detailed pollen zonation of the deposits below the Brörup interstadial also correlated well. Based on this, the following conclusions are proposed. The sampled part of the sequence began with deposits from the second half of the Eemian (a transition from a temperate environment to a southern-boreal one, the end of phase M6/E5, $kd_{3b1\text{-}b2}$), represented by the hillwash facies. The erosional pulses and the accumulation on the slope might correspond to the alluvial erosion and accumulation in the Alma valley. The southern-boreal environment (light *pine* forest with an admixture of broad-leaved trees, and mollisol formation) existed at the end of Eemian (kd_{3b2}). The presence of pollen of *Abies* and *Picea* allows one to suggest a correlation of the A1B horizon of the mollisol mainly with the phase M7/E6a. The phase of dry *Pinus* forest M8/E6b (established in the northern sections), in the south could possibly correspond to the phase of reduction of forest areas and distribution of steppe vegetation. Humus accumulation increased at this time, and the A1 horizon of the mollisol was formed. In the marine oxygen-isotopic record, the south-boreal environments at the end of Eemian have already been related to the Substage 5d (Kukla et al., 1997; 2003; Shackleton et al., 2003).

At the first Early Glacial stadial (pessimum of Substage 5d, the Tyasmin unit), erosional incision and later colluvial accumulation occurred at Kabazi II. Erosional breaks and colluviation are commonly described for this time interval in Western European loess-soil sections (Heasaerts et al., 2000; Antoine *et al.* 2003). At the first Early Glacial interstadial (Brörup, Saint-Germain I, the phase pl_{1b1}), an oceanic climate pattern existed with cool and wet summers and rather mild winters (luvisol formation processes under the hornbeam forest above the site area). It should be mentioned that at Kabazi II *Carpinus* was mainly represented by *Carpinus orientalis* Mull. This species is a more drought-resistant plant than *Carpinus betulus* L., but, on the other hand, requires warmer temperatures. *Carpinus orientalis* Mull. is the species which is presently growing in the Alma valley at the same altitudes as those of Kabazi II. Cooling occurred at the end of the phase, as indicated by the arrival of fir pollen. The further strong

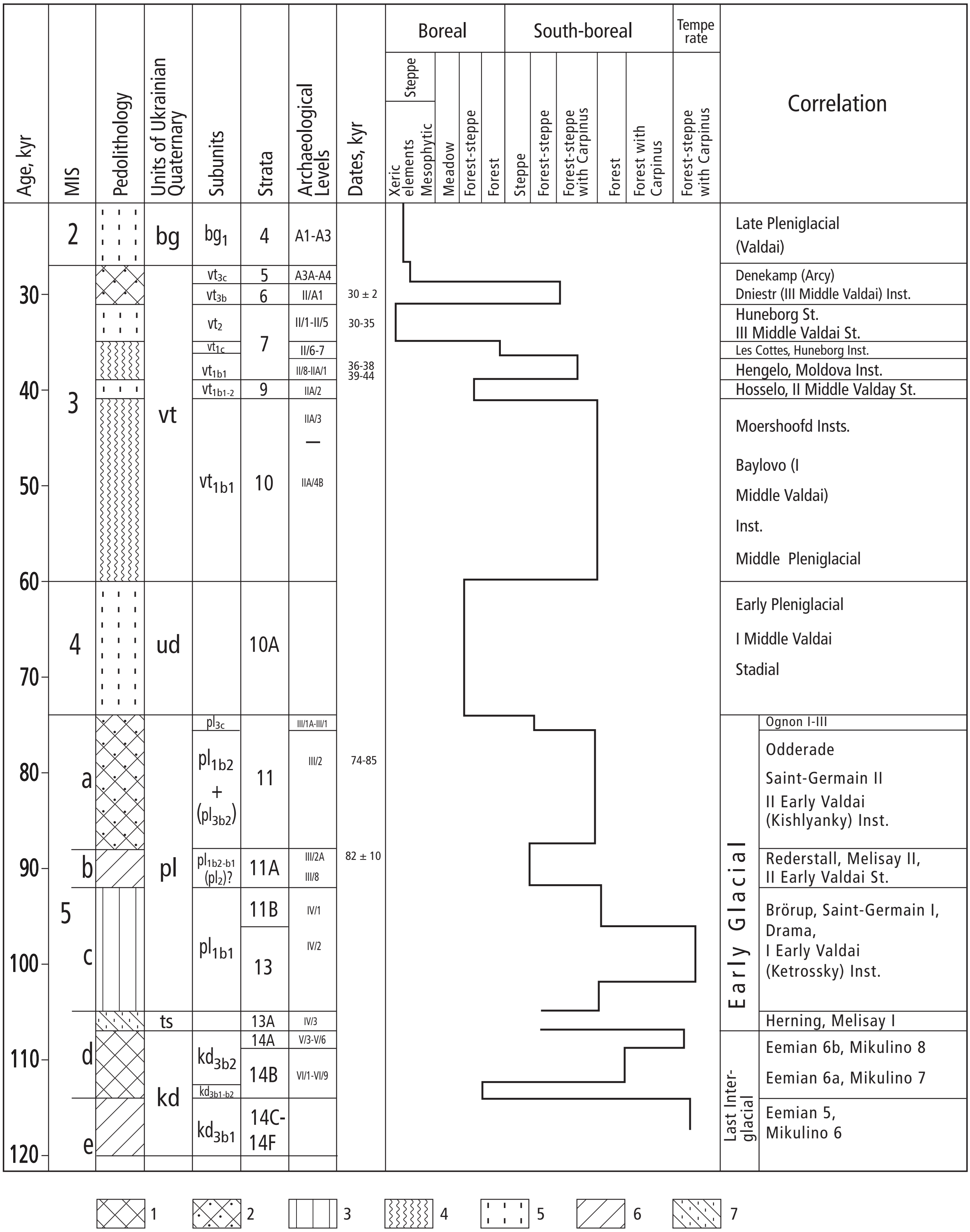

Fig. 2-3 Kabazi II: environmental dynamics during the Late Pleistocene. The lithopedology: 1 – meadow soil (mollisol), 2 – rendzina soil (leptosol and eutric leptosol), 3 – brown forest soil / luvisol (slope derivatives), 4 – brown forest soil / cambisol (pedosediments), 5 – non-soil light-yellow loam, 6 – non-soil light-grey loam, 7 – strongly bedded colluvial pedosediment.

reduction in arboreal pollen, as well as in pollen of broad-leaved taxa, coincides with an increase of colluviation (the second stadial of the Early Glacial, the phase pl_{1b1-b2}, or pl_2). The profile of humiferous soil pl_{1b2} (or pl_{1b2} +pl_{3p2}?) was mainly formed under the southern-boreal climate of the next Early Glacial interstadial. The transitional northern-boreal environment existed during the accumulation of the top layer of the soil (the Substage pl_3). There was no high resolution pollen sampling in this part of the Kabazi II sequence which would enable an accurate correlation with the later interstadials-stadials of the Early Glacial (Odderade/Saint Germain II/Substage 5a and Ognon I-III/ transition to Stage 4).

The other possible correlations for the lower part of the sequence were discussed above. The sedimentary breaks below and above the mollisol, as well as the absence of any 'absolute' dating, give ground to uncertainty. Nevertheless, the correlation, described in the conclusions, is presently more logical and coherent for the authors.

At the Kabazi II site, a cyclic pattern of environmental evolution occurred during the Late Pleistocene. This happened against the background of a general trend to a drop in temperatures and an increased aridity from the Last Interglacial and the beginning of the Early Glacial towards the Late Pleniglacial (Fig. 2-3). These regularities are clearly traceable elsewhere in Late Pleistocene sequence and provide the possibility of a correlation, based on the pattern of environmental changes. Nevertheless, each area has its own individual features. For the western foothills of the Crimean Mountains, they are as follows. The best pronunciation of environmental cyclicity can be seen in the alternation of expansions and retreats of broad-leaved woodlands. This reflects the oscillations of warm and cool intervals, mainly interstadials and stadials. The alternation of humid and arid time spans was not so well marked, and forest-steppe environments mainly dominated in Kabazi II. A steppe type of vegetation appeared much later than in the other areas of the Ukraine. It was established only from the last stadial of the Middle Pleniglacial, whereas in the forest-steppe belt of Ukraine, it recurrently occurred from the first Early Glacial stadial. A subtype of xerophytic steppe has not been discovered within the investigated interval. During the stadials and cool phases of the interglacial, the climate was constantly wetter than in the plain areas of the Ukraine. During the interstadials and warm phases of the interglacial, the climatic humidity was similar to that in the forest-steppe belt (an increase in precipitation was obviously compensated by an increase of evaporation). No periglacial floristic components were discovered in the vegetation of the stadials, and during the interstadials, broad-leaved species were much better represented in the Crimean forests than in the other areas of the Ukraine. Thus, during the Late Pleniglacial, the Western Crimea provided favourable conditions for the existence of refugia for a broad-leaved flora, as well as for permanent human occupation.

Abstract

КАБАЗИ II: ДИНАМИКА РАЗВИТИЯ РАСТИТЕЛЬНОСТИ

Н. П. ГЕРАСИМЕНКО

Палинологические и педостратиграфические исследования отложений стоянки Кабази II отображают динамику развития природной среды в позднем плейстоцене. В отложениях лугово-черноземной почвы kd_{3b2} в основании разреза (культурно-хронологический слой VI) установлена палинозона сосны с примесью широколиственных пород, сопоставляемая со второй половиной последнего межледниковья. В конце этого интервала расширялись площади лугово-степных ландшафтов (культурно-хронологический слой V).

Первый стадиал раннего валдая обозначен фазой эрозионного вреза и интенсивного коллювирования (ts), а I-ому межстадиалу раннего валдая (брерупу) соответствует аккумуляция склонового деривата бурой лесной почвы (pl_{1b1}), сформированной под лесостепью с широким распространением грабинника (культурно-хронологический слой IV). На II стадиале раннего валдая в условиях бореальной лесостепи накапливался непочвенный делювий ($pl_{1b1\text{-}b2}$), а на II-ом межстадиале (оддераде) под лесостепью с участием широколиственных пород формировалась дерново-карбонатная почва $pl_{1b2\text{-}3}$ (культурно-хронологический слой III).

Выше в разрезе прослеживается чередование педоседиментов и непочвенных отложений (культурно-хронологические слои IIA и II), для которых установлена следующая последовательность природных событий: бореальная лесостепь с ксерофитными элементами, ud, III стадиал раннего валдая; южно-бореальная лесостепь, vt_{1b1}, I межстадиал среднего валдая, моерсхоофд; бореальная лесостепь с ксерофитами, $vt_{1b1\text{-}b2}$, I стадиал среднего валдая; южно-бореальная лесостепь, vt_{1b2}, II межстадиал среднего валдая, хенгело; фаза сосновых лесов бореального/южно-бореального климата; vt_{1c}, прохладный интерстадиал Хунеборг / Ле Кот; бореальная степь с ксерофитными ценозами, vt_2, II стадиал среднего валдая. Выше залегает почва $vt_{3b\text{-}c}$, переходная от бурой насыщенной к дерново-карбонатной (культурно-хронологический слой A), сформировавшаяся под южно-бореальной лесостепью (III стадиал среднего валдая, денекамп), а в кровле разреза – непочвенный делювий (культурно-хронологический слой I), накопившийся в условиях бореальной ксерофитной степи.

На фоне цикличных изменений ландшафтов прослеживается тренд к аридизации климата от конца последнего межледниковья к началу позднего валдая.