Chapter 6

LATE PLEISTOCENE VEGETATIONAL HISTORY OF KABAZI II

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INTRODUCTION

Multiple changes of ecotones in the vicinity of Kabazi II have been revealed through palynological analysis of the site's sediments. During human occupations of the site, more than 11 meters of deposits accumulated behind a huge rock slab that fell to rest on a bench on the Kabazi Mountain slope (Chabai 1998a). The geomorphological-geological setting of the site, as well as the detailed sedimentologic characteristics of the Kabazi II sequence, have already been described (Chabai 1998a). The archeological sequence has been elaborated in detail in numerous publications (e.g., Kolosov et al. 1993; Chabai 1996, 1998).

The first palynological investigations of Upper Pleistocene deposits of the Crimean Mountains were conducted for the Mousterian site Zaskalnaya V, located in eastern Crimea (Gubonina 1985). Zaskalnaya V sediments have been correlated to the first half of the Valdai (Würm) Glacial—from the Krutitsa Interstadial (Brörup) to the beginning of Bryansk Interstadial (Hengelo-Denekamp) (Velichko 1988). Three stages of vegetational development have been established. The first one, corresponding to the Krutitsa Interstadial, was characterized by forest-steppe ecotones, including hornbeam forests. The second stage was marked by a predominance of xeric steppes during the Valdai stadial, while the third stage (the Bryansk Interstadial) was characterized by rather humid climatic conditions with the expansion of more mesophilic grasses and birch-alder forests.

Kabazi II is located in western Crimea, an area characterized by considerably higher humidity than eastern Crimea. The present annual precipitation around the site is between 500-550 mm, while in the Zaskalnaya V locality, it is between 400-450 mm. This results in distinctly different modern vegetational covers in western and in eastern Crimea.

Kabazi II is located within a belt of low mountain forest-steppe, characterized by an alternation of meadow steppes and moderately high forests. The area belongs to the Euxinian forest province, Crimean Mountain subprovince, forest-steppe region of forests (of *Quercus pubescens Willd.),* and meadow steppes (Barbarych 1977). The distribution of woodlands and grasslands depends partially on topography. The site is situated in the upper part of a scarp slope of a mountain cuesta (300 m above sea level). A plateau-like flat northern slope of the Kabazi cuesta is occupied by steppes: Gramineae-*Herbetum mixtum* associations, which are accomplished by a sparse growth of xeric *Herbetum mixtum.* A combination of typical steppe, meadow-steppe, and xeric grasses is a characteristic feature.

Arboreous vegetation is spread at the foot of the scarp slope: oak *(Quercus pubescens Willd., Quercus petraea Liebl.*, and *Quercus robur L.*, the first predominates); hornbeam *(Carpinus orientalis Mill.),* maple *(Acer campestre L.),* ash-tree (*Franxinus excelsior L.),* and elm *(Ulmus foliacea Gilib.).* All grow as low trees and are almost mixed with shrubs. Shrubs are very abundant and diverse: hazelnut (Corylus *avellana L.),* spindle tree *(Euonumus europaea L.),* Cornelian cherry (Cornus mas *L.),* bloody dogwood (Cornus *sanguinea L.),* buckthorn *(Rhamnus cathartica L.),* Christ's thorn *(Paliurus spina-Christi Mill.),* hawthorn *(Crataegus pentagyna* Jacg.), blackthorn *(Prunus spinosa L.),* rose *(Rosa corymbifera L.),* pear *(Pyrus elaeagrifolia Pall.)*, smoke tree *(Cotinus coggygria Scop.)*, and juniper *(Juniperus Sabina L.)*. Shrubs also occupy the lower part of the slope, which is dissected by ravines. The middle part of the slope is vegetated by recently planted pine trees.

The significant human impact on the vegetational cover of the area is evident. Historical documents and maps record that the western foothills of the Crimean Mountains were covered with dense forests. The occasional gigantic broad-leaved tree, as well as shade-loving plants in the grass-covered foothills, attest to the tall tree growth and dense canopies of the past. Nevertheless, the chernozem-type soils of the gently sloping plain of Kabazi cuesta indicate that the mountain plateau has never been entirely forested.

The scarp slope of the cuesta on which Kabazi II is located faces the lower part of the northern slope of the Main Range of Crimean Mountains. Its vegetation could also impact the formation of pollen spectra in the site's sediments. The lower part of the slope of the Main Range (up to 650 m in height) is occupied by a belt of oak forests (Kochkin 1967). *Quercus pubescens Willd.* and *Quercus petraea Liebl.* predominate and form the first level of forests, while hornbeam forms the second level with the above-mentioned shrubs as undergrowth. Patches of pine and juniper trees occur here and there. Above 600 m, oak woodlands are replaced by hornbeam and beech forests. Lime-tree, ash-tree, maple *(Acer campestre L.)*, and pine occur as admixtures, while higher in the mountains, unadulterated pine forests grow. It should be noted that the Chatyrdag Yaila mountain massif, which is just above the Kabazi locality, is distinguished by limited pine forests.

Surface samples of the Chatyrdag Yaila soils show a lower value of pine pollen (10-45% in 4 samples and 40-70% in 2 samples) than the surface samples of the other mountain massifs of the Main Ridge (40-80%) (Artiushenko and Mishnev 1978). The surface samples have been taken from the soils of mountain meadow-steppes which are surrounded by the forest types discussed above, and are characterized by 33-78% of arboreal pollen (AP) and by 22-60% of non-arboreal pollen (NAP), depending on the distance to the forest boundary. Beech dominates among broad-leaved taxa pollen (3-7%), due to its prevalence in the forest composition. Hornbeam, oak, elm, maple, and lime-tree also occur, while alder, juniper, and other shrubs represent the rest of the AP. *Herbetum mixtum* prevails in NAP. The following dominate in the NAP: Fabaceae (5-16%), Polygonaceae (1-17%), Asteraceae (1-6%), Rosaceae (1-5%), Caryophyllaceae (2-5%), Lamiaceae (2-3%), and Brassicaceae (2-4%). The values of Gramineae are 2-4%, and Chenopodiaceae 2-6%, although all samples have been taken under *Herbetum mixtum*-Gramineae associations and no Chenopodiaceae have been fixed in the modern grass cover. Polypodiaceae spores sharply prevail over Bryales.

Surface samples taken by author in the *Herbetum mixtum*-Gramineae steppe in the vicinity of Saki Lake (about 50 km north-west of Kabazi II) are quite different in their NAP composition; they include the xerophytes Chenopodiaceae and *Artemisia* (27-64%), Gramineae (4-20%), *Herbetum mixtum* (28-49%), and Cyperaceae (1-3%). Bryales sharply prevail over Polypodiaceae. Annual precipitation is above 900 mm on the Chatyrdag Yaila and less than 400 mm in the Saki Lake vicinity.

Surface samples of forest soils have been taken in beech forests (1150 m a.s.l.) and in oak-hornbeam forests (600 m a.s.l.), and both are characterized by 80% AP (Artiushenko and Mishnev 1978). In the former, beech shares the second place in abundance with pine (26-27%), while alder dominates (40%), although it is related to water outlets only. There are 1-2% of oak, elm, and juniper pollen grains. In oak-hornbeam forests, pine pollen dominates (50%), while oak and hornbeam share the second place (16-17%). Lime, elm, ash-tree, maple, hazelnut, and Cornus are represented by 2-5% of pollen grains.

METHODOLOGY

Forty-eight 100-gram samples have been processed following the methodology of Saint Petersburg University. This involves treatment with 10% HCI, 10% KOH, cold treatment of HF, disintegration in a solution of sodium pyrophosphate (Na4 P2 O7), and flotation in heavy liquid (KdJ2 + KJ2) of specific gravity 2.2. The pollen grains were mostly well preserved and their frequency varied from 11 to 52 grains per slide. Six of the 48 processed samples contained only a few microfossils and could not be used for plotting a pollen diagram. Apart from certain irregularities in pollen frequency distribution, the general tendency is a frequency decrease upwards through the Kabazi II section. The deposits were more rich in pollen at the depth of 11.0-7.0 m below datum (Strata 14, 13, and a lower part of Stratum 11). Between 6.9-3.6 m (Strata 11-9, lower part of Stratum 7) there was a moderate pollen frequency, while the interval between 3.5-1.5 m (Strata 7-4) showed a low concentration of microfossils (with the exception of the uppermost level). This demonstrates a direct correlation between pollen frequency and the content of clay particles in the sediments; as shown by grain size analysis, Stratum 13 to the lower part of Stratum 11 are most rich in clay, while the upper part of Stratum 7 through Stratum 4 have the lowermost content (Chabai 1998a: 176).

Special studies of pollen spectra of surface samples in modern vegetational zones and subzones have been carried out in order to correctly interpret pollen spectra in Quaternary deposits (Grichuk and Zaklinskaya 1948; Grichuk 1950; Berezina and Tyuremnov 1969; Bolikhovskaya 1976; Dinesman 1977). Correction factors between vegetation and the resulting palynospectra for different vegetational zones of Ukraine have been elaborated (Arap 1972, 1976; Bezus'ko et al. 1992). These studies provide a methodological and comparative basis for the reconstruction of paleovegetational history with pollen data.

The peculiarities of pollen spectra formation in mountainous regions have also been studied (Klopotovskaya 1973, 1976). It has been demonstrated that in mountains, the pollen of most plants is insignificantly distributed aerially; only pine and alder pollen can be aerially transported long distances in these areas. Hornbeam, beech, and oak, as plants of insignificant pollen productivity, can be represented by only a small portion of pollen in comparison with pine. This is true even when pine is absent in the studied area, but present within the orographical region. The most local spectra have been shown to be formed under forest vegetation in soil, proluvial, and hillwash deposits.

In the accompanying spore-pollen diagram, the total sum of microfossils includes pollen of arboreous plants, herbs, and spores (fig. 6-1). The percentages of different spore taxa have been calculated in relation to the total sum, while the percentages of different arboreous (and herbaceous) taxa are related to the sum of trees and herbs, assumed equal to 100%

POLLEN ZONATION

Fourteen pollen zones have been recognized in the deposits of Kabazi II based on the 48 samples taken from Strata 4-14 (figs. 6-1, 6-2; Table 6-1).

Pollen zone I, observed at the depth 11.0-10.7 m below datum, is characterized by forest-steppe pollen spectra (46-49% AP, 38-42% NAP) and by a high proportion of broad-leaved taxa pollen (32-56%). The latter is mainly represented by *Quercus* and *Carpinus* (fig. 6-1). The percentage of *Quercus* pollen in this zone (21-22%) is the highest for the section. *Ulmus* and *Tilia* pollen occur, as well as that of *Corylus, Euonymus,* Caprifoliaceae, and arboreous Rosaceae (2-5% each). The percentage of pine in the AP is less than average for the section. There is an insignificant peak of alder for the section (up to 13%). The characteristic feature of NAP is a very low value of xerophytes (*Artemisia* and Chenopodiaceae): 0-8% total, and

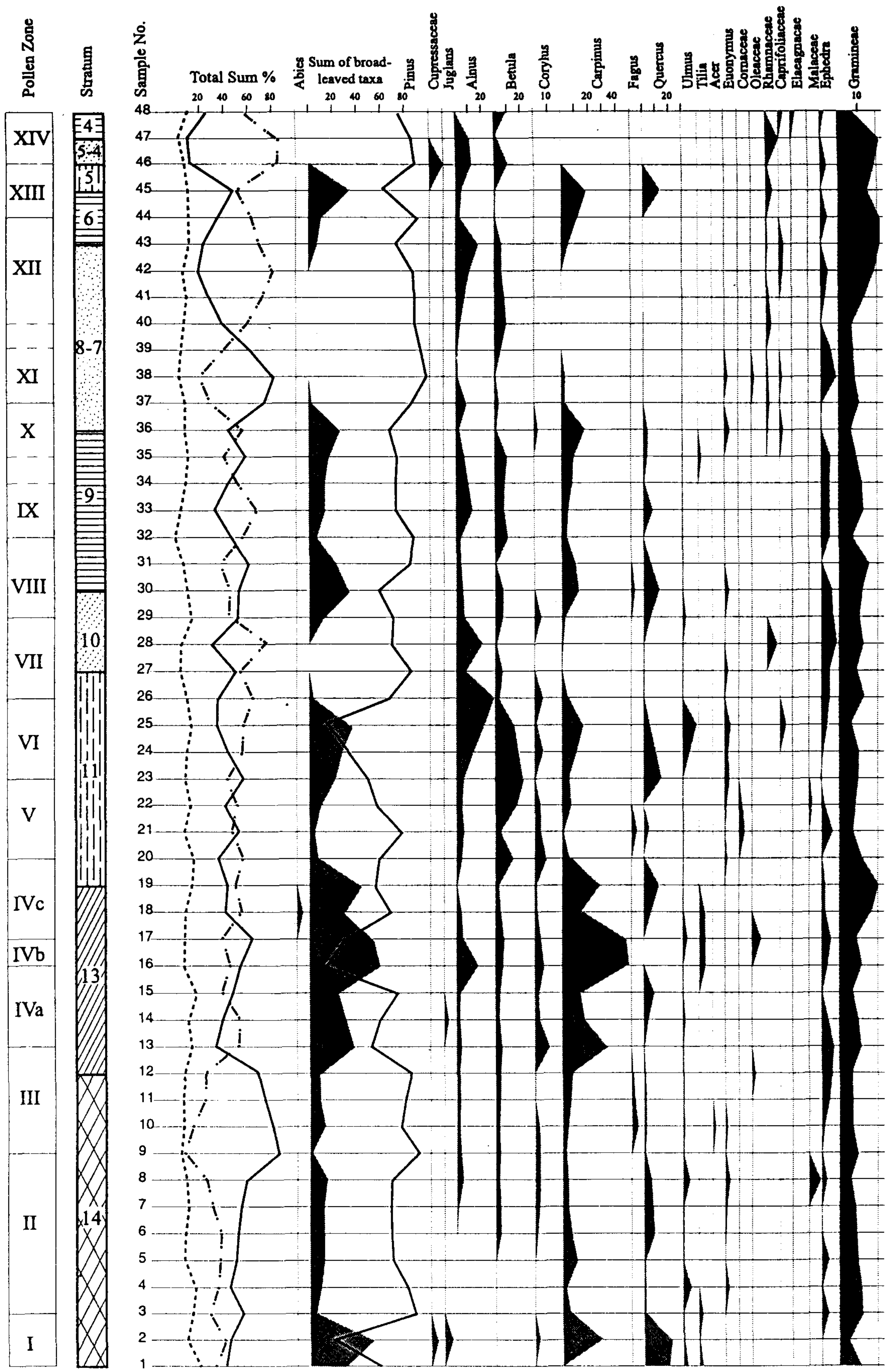
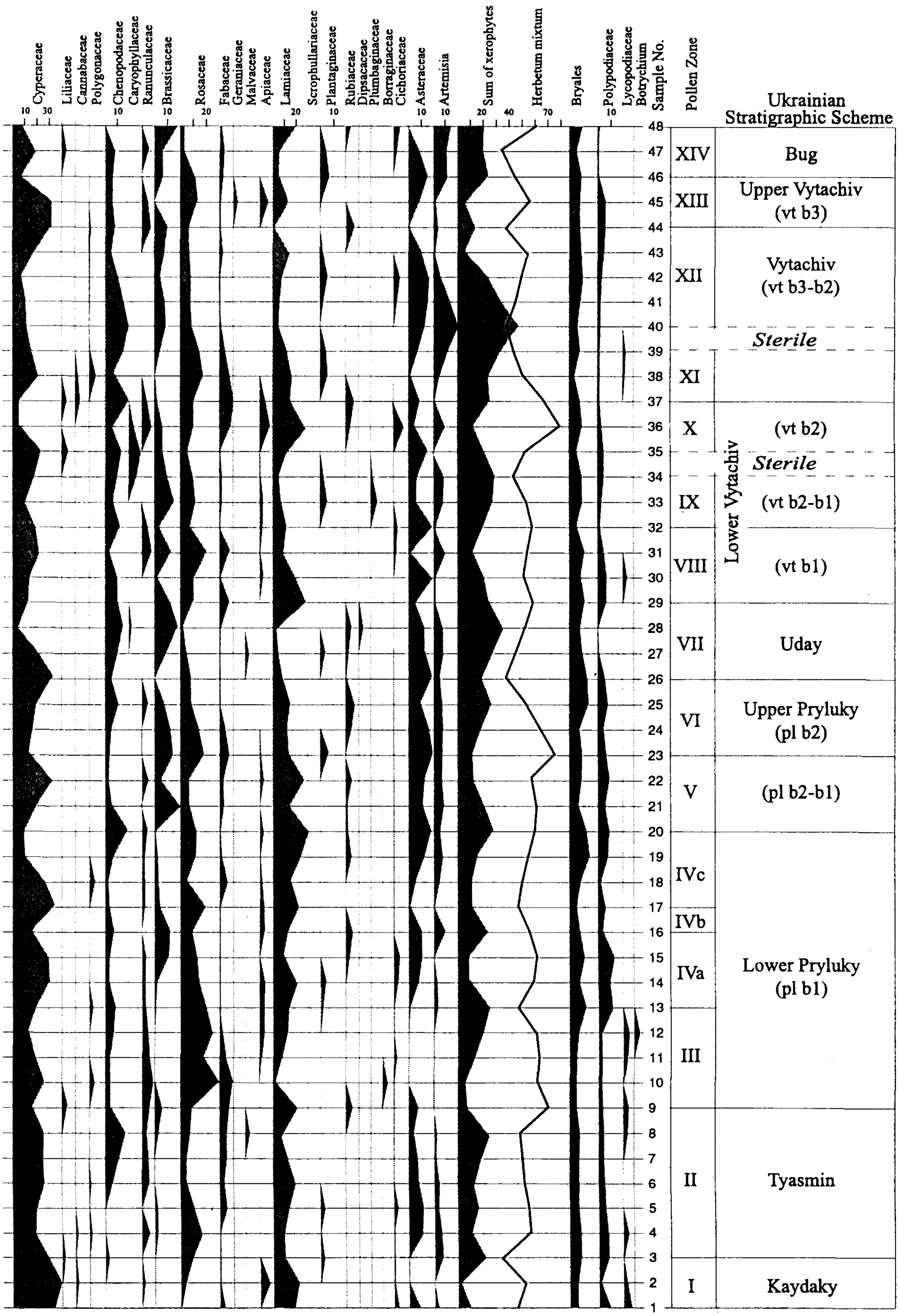
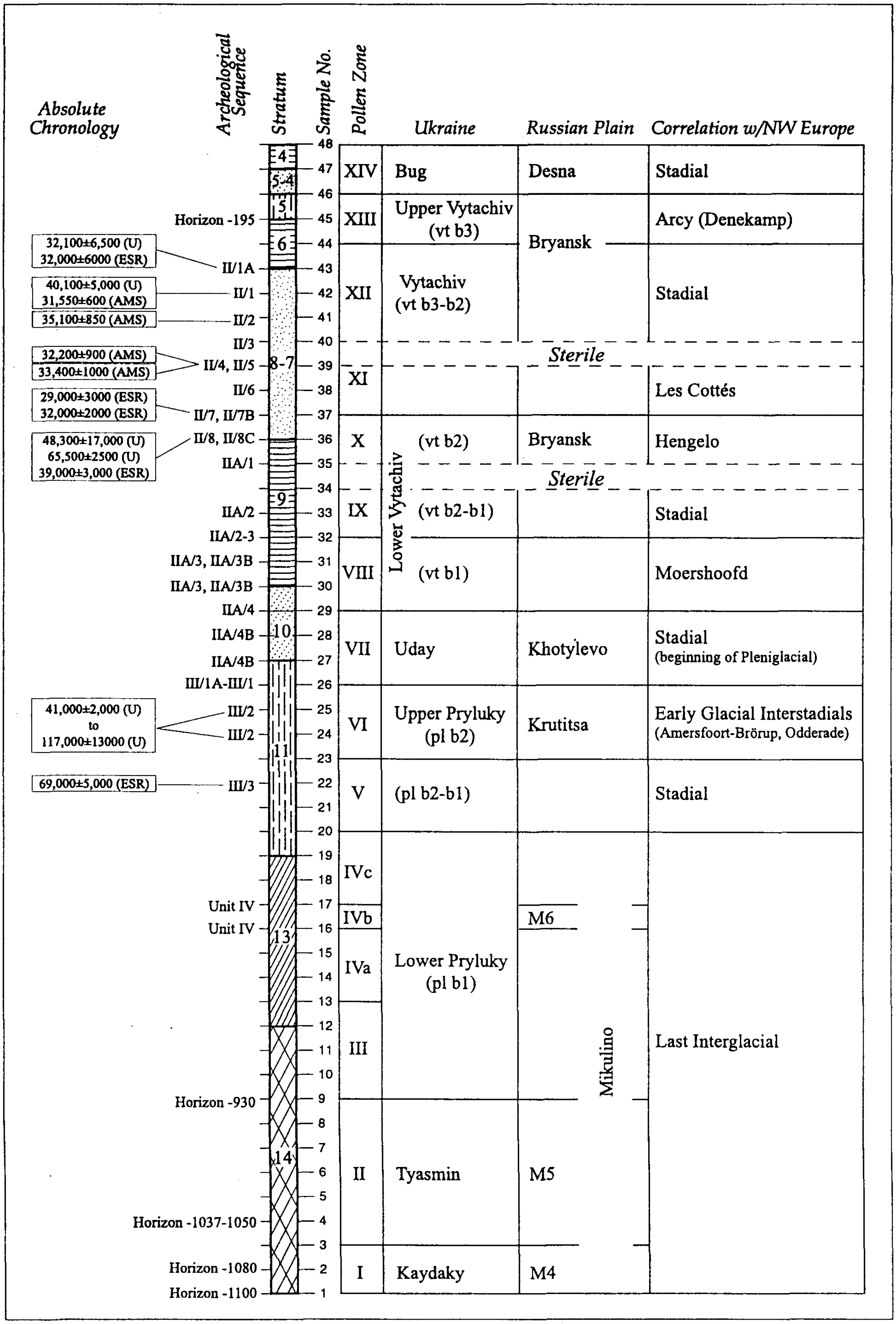


Fig. 6-1—Kabazi II, pollen diagram.


Cyperaceae
Liliaceae
Cannabaceae
Polygonaceae
Chenopodiaceae
Caryophyllaceae
Ranunculaceae
Brassicaceae
Rosaceae
Fabaceae
Geraniaceae
Malvaceae
Apiaceae
Lamiaceae
Scrophulariaceae
Plantaginaceae
Rubiaceae
Dipsacaceae
Plumbaginaceae
Borraginaceae
Cichoriaceae
Asteraceae
Artemisia
Sum of xerophytes
Herbetum mixtum
Bryales
Polypodiaceae
Lycopodiaceae
Botrychium
Sample No.
Pollen Zone
Ukrainian Stratigraphic Scheme
XIV
Bug
XIII
Upper Vytachiv (vt b3)
XII
Vytachiv (vt b3-b2)
Sterile
XI
X
(vt b2)
Sterile
IX
(vt b2-b1)
VIII
(vt b1)
Lower Vytachiv
VII
Uday
VI
Upper Pryluky (pl b2)
V
(pl b2-b1)
IVc
IVb
IVa
Lower Pryluky (pl b1)
III
II
Tyasmin
I
Kaydaky


Absolute Chronology
Archeological Sequence
Stratum
Sample No.
Pollen Zone
Ukraine
Russian Plain
Correlation w/NW Europe
32,100±6,500 (U)
32,000±6000 (ESR)
40,100±5,000 (U)
31,550±600 (AMS)
35,100±850 (AMS)
32,200±900 (AMS)
33,400±1000 (AMS)
29,000±3000 (ESR)
32,000±2000 (ESR)
48,300±17,000 (U)
65,500±2500 (U)
39,000±3,000 (ESR)
41,000±2,000 (U)
to
117,000±13000 (U)
69,000±5,000 (ESR)
Horizon -195
II/1A
II/1
II/2
II/3
II/4, II/5
II/6
II/7, II/7B
II/8, II/8C
IIA/1
IIA/2
IIA/2-3
IIA/3, IIA/3B
IIA/3, IIA/3B
IIA/4
IIA/4B
IIA/4B
III/1A-III/1
III/2
III/2
III/3
Unit IV
Unit IV
Horizon -930
Horizon -1037-1050
Horizon -1080
Horizon -1100
4
5-4
5
6
8-7
9
10
11
13
14
48
47
46
45
44
43
42
41
40
39
38
37
36
35
34
33
32
31
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
XIV
Bug
Desna
Stadial
XIII
Upper Vytachiv (vt b3)
Bryansk
Arcy (Denekamp)
XII
Vytachiv (vt b3-b2)
Stadial
Sterile
XI
Les Cottés
X
(vt b2)
Bryansk
Hengelo
Sterile
IX
(vt b2-b1)
Stadial
VIII
(vt b1)
Moershoofd
Lower Vytachiv
VII
Uday
Khotylevo
Stadial
(beginning of Pleniglacial)
VI
Upper Pryluky (pl b2)
Krutitsa
Early Glacial Interstadials
(Amersfoort-Brörup, Odderade)
V
(pl b2-b1)
Stadial
IVc
IVb
M6
IVa
Lower Pryluky (pl b1)
III
Mikulino
Last Interglacial
II
Tyasmin
M5
I
Kaydaky
M4

an extremely high value of Cyperaceae: 37-50%. The percentage of Polypodiaceae and Lycopodiaceae spores (5-14%) is high for the section. *Herbetum mixtum* pollen (45-48%) comprises 8 families, but Lamiaceae predominates by far.

Pollen zone II (10.6-9.5 m) is conspicuous for a decrease in broad-leaved taxa pollen (13-18%) and a predominance of pine (68-86%). Broad-leaved trees are mainly represented by *Carpinus* and *Quercus,* but at some levels, *Ulmus* is just as abundant. In the lowermost level, single pollen grains of *Juglans* and *Tilia* occur. *Corylus, Euonymus,* and *Cornus* are consistently present in small numbers, and arboreous Rosaceae becomes noticeable in the upper levels. Single pollen grains of birch appear throughout the pollen zone.

The pollen spectra of zone II are still of forest-steppe type (47-59% AP, 29-40% NAP). The percentage of *Herbetum mixtum* is the same as in pollen zone I, but Cyperaceae decreases at the expense of an increase of xerophytes (12-23%), especially Chenopodiaceae (up to 19%). *Ephedra* is constantly present (up to 8%). The *Herbetum mixtum* composition becomes more diverse, predominating in Lamiaceae, Rosaceae, and Asteraceae. Polypodiaceae prevails over Bryales, and single Lycopodiaceae spores occur.

Pollen zone III (9.4-8.7 m) is characterized by pollen spectra of forest type (66-82% AP, 11-26% NAP) and by a low proportion of broad-leaved taxa pollen (7-16%). *Pinus* pollen predominates sharply (75-83%). Broad-leaved trees are represented by *Carpinus, Fagus,* and *Quercus,* single pollen grains of *Ulmus* and *Acer* also occur. *Betula, Alnus,* and *Corylus* pollen grains are consistently present in small numbers, while *Euonymus*, Cornaceae, Oleaceae, and arboreous Rosaceae occur sporadically. The NAP is characterized by a higher value of *Herbetum mixtum* (60-69%), dominated by Rosaceae, Lamiaceae, Ranunculaceae, and Fabaceae. Cichoriaceae and Borraginaceae are present consistently, while Asteraceae and *Artemisia* disappear. The proportion of Gramineae and Cyperaceae is within their average ranges, but the proportion of xerophytes is small (7-18%), although *Ephedra* pollen peak (up to 9%). This is the last pollen zone with a diverse spore composition, including Bryales, Polypodiaceae, Lycopodiaceae, and *Botrychium.*

Pollen zones I-III are in geological Stratum 14, represented by light grey loam with abundant *Helix* mollusca. The division of the geological strata used here follows Kolosov et al. (1993) and Chabai (1998a).

Pollen zone IV (8.6-7.4 m) is complex in structure and is divided into three subzones. The main features of zone IV are a predominance of forest-steppe pollen spectra and high values of broad-leaved taxa pollen, especially of *Carpinus.* Subzone IVa (8.6-8.1 m) is characterized by an approximately equal proportion of AP (35-45%) and NAP (38-50%). Broad-leaved tree pollen accounts for 23-37%. *Carpinus* (16-37%) sharply predominates over *Quercus, Corylus* becomes more abundant that in zones I-III, and few pollen grains of *Juglans* and *Ulmus* appear. *Alnus* and *Betula* pollen are consistently present in low percentages. The NAP

Key for figure 6-1, Table 6-1:

soil sediments | loesses | humic soil horizons | Bt soil horizons | dark loams | light loams

arboreous pollen | non-aboreous pollen | spores

AMS dates: Hedges et al. 1996; U-series dates: McKinney 1998, Rink et al. 1998; ESR dates (all LU): Rink et al. 1998

Facing page: Table 6-1—Kabazi II, correlation of pollen zones, absolute dates, archeological and geological sequences, and European glacial stages.

components and their proportions are typical for the section: a low value of Gramineae, an insignificant proportion of xerophytes, and considerable Cyperaceae and *Herbetum mixtum.* The latter is more diverse in composition and represented invariably by Lamiaceae, Rosaceae, and Brassicaceae (which dominate), Asteraceae, Ranunculaceae, Apiaceae, and Plantaginaceae. Spores are rather abundant (12-17%), but include Bryales and Polypodiaceae only.

Pollen subzone IVb (8.0-7.8 m) is conspicuous for having the highest content of broad-leaved taxa pollen (50-56%), represented almost entirely by *Carpinus* (42-50%). *Tilia* pollen grains (5-6%) also occur. Shrubs include *Corylus* (7-8%), Cornaceae, and Oleaceae. A peak of *Alnus (Alnus glutinosa Gaertn.)* pollen (7-19%) is observed, while the percentage of *Pinus* (13-28%) is the lowest in the section. AP values of subzone IVb (50-57%) are highest within zone IV and make the spectra similar to a forest type. NAP and spore composition do not differ from that of subzone IVa.

Pollen subzone IVc (7.7-7.4 m) is characterized by the same proportion of broad-leaved taxa pollen (23-43%) as subzone IVa. *Carpinus* still predominates (18-29%). The AP composition of the lower part of subzone IVc is similar to that of IVb *(Tilia, Alnus, Coryus)*, except *Pinus* pollen increases (62%). In the upper part of subzone IVc, *Quercus* pollen (14%) becomes noticeable again, *Betula* somewhat increases, and few pollen grains of *Abies* appear—the only occurrence in the section. A particular feature of the NAP is a peak of Gramineae pollen (16-20%) at the expense of a drop in Cyperaceae. Within *Herbetum mixtum,* an increase of Fabaceae pollen at the expense of Brassicaceae is also observed. The other NAP characteristics are the same as in the entire zone IV. Bryales spores prevail somewhat over Polypodiaceae.

The subzones of pollen zone IV distinctly show a climatic optimum (subzone IVb) with its initial and final substages. Zone IV corresponds to the main part of Stratum 13, which consists of a greenish-grey loam.

<u>Pollen zone V</u> (7.3-6.8 m) shows a sharp reduction of broad-leaved taxa pollen (5-10%) and a considerable increase of *Betula* pollen (up to 18-20%). Broad-leaved trees are represented mainly by *Carpinus*, although *Fagus* and *Quercus* also occur. Shrub pollen grains are not abundant but they are diverse: *Corylus* (dominating at 3-9%), *Euonymus*, Cornaceae, Oleaceae, and arboreous Rosaceae. Pollen spectra are still of forest-steppe type (33-49% AP, 41-53% NAP). The NAP composition is similar to that of zone IV, but a drop of Gramineae (3-8%) takes place again, at the expense of Cyperaceae, but also owing in part to an increase of the xerophytes Chenopodiaceae and *Ephedra.* Brassicaceae becomes consistently noticeable beginning from zone V. Zone V is within the uppermost part of Stratum 13 and the lower part of Stratum 11.

<u>Pollen zone VI</u> (6.7-6.2 m) comprises pollen spectra of a forest-steppe type (32-52% AP, 40-54% NAP) with a considerable percentage of broad-leaved taxa pollen (23-33%). The latter, however, is lower than that of pollen zones I and IV. *Carpinus* and *Quercus* share a dominance within the group of broad-leaved trees. *Ulmus, Corylus, Euonymus,* and Caprifoliaceae also occur. The characteristic feature of zone VI is a high proportion of *Betula (Betula pendula Ehrh.)*: 17-23%, which is the maximum for the section. Pollen of the other small-leaved taxa *Alnus (Alnus glutinosa Gaertn.)* become abundant (25%) in the uppermost level. Concomitantly, the proportion of *Pinus* pollen is low (17-46%). A high ratio of *Herbetum mixtum* is typical for NAP (50-71%), while Cyperaceae values become lower beginning from zone VI (13-21%). *Herbetum mixtum* is dominated by Rosaceae, Lamiaceae, Asteraceae, and Brassicaceae. Xerophyte pollen, consisting mainly of Chenopodiaceae, is not abundant (8-23%). Spores include Bryales and Polypodiaceae in equal proportions.

Pollen zone VI corresponds to the main part of Stratum 11, described as a dark-brown loam with limestone clasts. Its upper part, exposed by the excavation, represents a soil humic

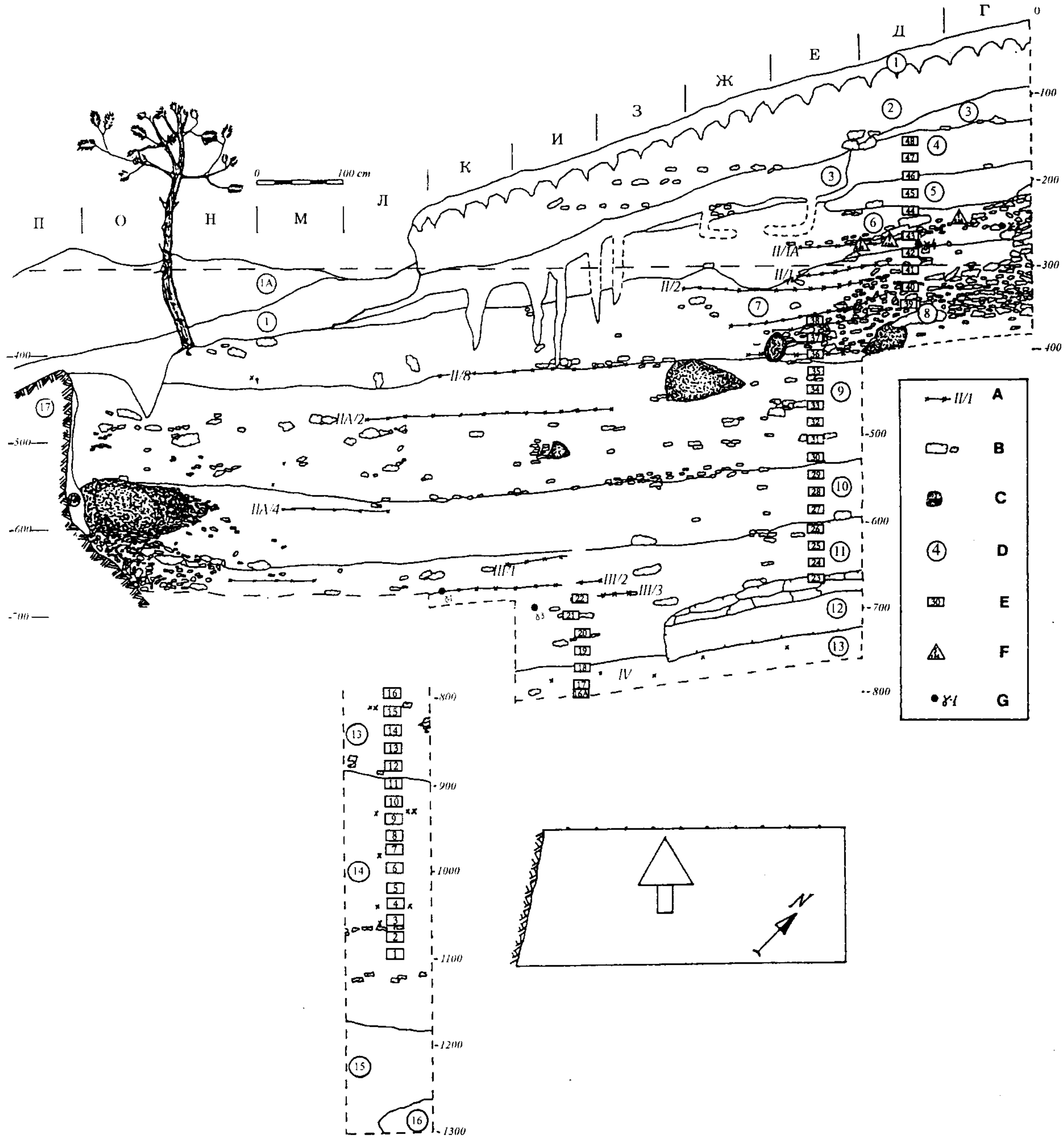


Fig. 6-2—Kabazi II, section along the line of squares "9": *A*–archeological levels; *B*–limestone blocks; *C*–large animal tunnels; *D*–numbers of strata; *E*–numbers of pollen samples; *F*–ESR samples; *G*–ESR dosimeters.

horizon, supposedly of a turf-carbonate soil. Pedogenic features have been also described by Ferring (in Chabai 1998a) for the lower part of Stratum 11—presence of pedogenic clay and carbonate leaching from the middle of Stratum 11. Nevertheless, there is a decrease in pollen frequencies beginning from this zone.

Pollen zone VII (6.1-5.6 m) is the first zone with a distinct predominance of NAP over AP, although the spectra are still of a forest-steppe type (28-47% AP and 49-68% NAP). A prominent feature of zone VII is also a sharp drop in broad-leaved taxa pollen, up to their complete disappearance in the middle part of the interval. A few pollen grains of *Carpinus* occur in the lower part, while single grains of *Quercus* and Rhamnaceae pollen occur in the upper part of the zone. AP is dominated by *Pinus* (61-79%) and *Alnus* (9-28%). This is the highest percentage of *Alnus* recorded in the section. *Betula* is present in a smaller number (up to 9%).

The changes in NAP composition through the zone show a trend towards decreasing Cyperaceae and increasing xerophytes and *Herbetum mixtum*. All xerophytes become more abundant (up to 33% total) and include Chenopodiaceae, *Artemisia*, and *Ephedra*. The percentages of *Artemisia* and *Ephedra* are highest for the section. In addition, pollen of such xeric taxa as Plumbaginaceae and Dipsacaceae appear. The increase in *Herbetum mixtum* is due to an increase in Brassicaceae (up to 20%). With the exception of the lowermost level, spore values are very low (4%), due to the disappearance of Polypodiaceae.

Pollen zone VII is within the uppermost level of Stratum 11 and the main part of Stratum 10. The latter is represented by a yellowish-grey loam with small limestone clasts. Its lower part, exposed in the excavation, is of pale-yellow color.

Pollen zone VIII (5.5-5.0 m) was recognizable by a new increase in broad-leaved taxa pollen (13-30%), which is not less than that of pollen zone VI. *Carpinus* predominates, although *Quercus* is noticeable, and single grains of *Ulmus* and *Fagus* also occur. The distinction from zone VI is that the AP value (48-58%) is higher than the NAP (34-42%), and pollen grains of small-leaved taxa (*Alnus* and *Betula)* are not prominent, though constantly present (4-10% each). A few *Corylus* and *Euonymus* grains appear at some levels. The NAP composition is close to that of zone VII. Nevertheless, a drop in xerophytes pollen (12-20%) is observed, while there is a slight increase in both Cyperaceae and Gramineae. Chenopodiaceae and Artemisia decrease, while *Ephedra* is still high. The dominant components of *Herbetum mixtum* become more diverse, now including Ranunculaceae and Fabaceae, as well as Lamiaceae, Rosaceae, Brassicaceae, and Asteraceae. Polypodiaceae spores appear again in equal numbers with Bryales, and single Lycopodiaceae spores occur.

Pollen zone IX (4.9-4.6 m) consists of forest-steppe spectra with a predominance of NAP (54-63%) over AP (31-44%), and with low values of broad-leaved tree pollen (5-13%). Very few taxa contribute to AP composition: *Alnus* and *Betula* (up to 13% each) and *Carpinus* and *Quercus* (up to 60% each). The remainder belongs to *Pinus* pollen. No specific features appear in NAP, except for some increase in xerophytes (namely *Artemisia* and Plumbaginaceae) at the expense of an Asteraceae drop within *Herbetum mixtum*. Low values of spores, represented mainly by Bryales, are also typical (2-6%).

Zone IX is separated from the following pollen zone X by a palynologically sterile level (4.5-4.4 m).

Pollen zone X (4.3-4.0 m) differs from the previous zone not only by a higher proportion of AP (41-55%) and broad-leaved tree pollen (17-25%), but also by a more diverse AP composition. After *Pinus*, *Carpinus* pollen is next in abundance (10-17%). *Alnus, Betula,* and *Quercus* are constantly present in a middling number, but *Fagus*, *Tilia, Euonymus, Corylus,* Rhamnaceae, and Caprifoliaceae also appear. The *Herbetum mixtum* maximum for the section (79%) occurs within zone X. Besides the commonly occurring Lamiaceae, Rosaceae, Asteraceae, and Brassicaceae, Caryophyllaceae, Ranunculaceae, Fabaceae, Apiaceae and Cichoriaceae also contribute significantly to its number. This abundance exists partly at the expense of a decrease in xerophytes, but is mainly due to a sharp drop in Cyperaceae, which generally looses its high values beginning from this zone. Polypodiaceae becomes noticeable again in the spore composition.

Pollen zones VIII-X are within Stratum 9. This stratum is described as a yellow loam with limestone clasts. A brown color of some levels has also been observed, and suggests that Stratum 9 is composed of pedosediments of a brown rendzina soil type.

Pollen zone XI (3.9-3.6m) has a forest type of pollen spectra (67-77% AP, 19-26% NAP). At the same time, the proportion of broad-leaved tree pollen is very low (2-4%). The *Pinus* value is maximal for the section (76-89%). *Carpinus, Betula,* and *Juniperus* are 24% each, while the other taxa *(Alnus, Tilia, Euonymus,* Oleaceae, Caprifoliaceae, and arboreous Rosaceae) are represented by single pollen grains. *Herbetum mixtum* is very abundant at the lower level, owing to a low value of Cyperaceae, but at the upper level, all components of NAP are within their average range for the section. Despite the forest type spectra, xerophytes are noticeable (24-25%), and *Ephedra* attains its last peak (12%). It is also the last zone in which Lycopodiaceae spores are observed.

Zone XI corresponds to the lowermost part of Stratum 7, represented by yellow loam with a great number of limestone clasts. Zone XI is separated from the following pollen zone by a palynologically sterile level (3.5-3.4 m).

Pollen zone XII (3.3-2.6 m) is notable for the appearance of a steppe type of spectra (19% AP, 75% NAP), for maxima of both xerophytes (44%) and Gramineae (18%) pollen, and for the absence of broad-leaved taxa. The lower pollen spectrum is of a forest-steppe type (36% AP, 57% NAP). *Pinus* consistently predominates in AP (78-80%). *Alnus* and *Betula* pollen (5-10% of each) are noticeable, while a few grains of Caprifoliaceae and Rhamnaceae appear. The peak of xerophytes is produced by Chenopodiaceae mainly in the lower part of zone XII, while the Gramineae peak occurs in its upper part. Concomitantly, the Cyperaceae value is low, and *Herbetum mixtum* is not abundant (39-48%). The latter is dominated by Asteraceae and Lamiaceae. Besides Rosaceae and Brassicaceae, Plantaginaceae and Cichoriaceae are also notable. Bryales prevail sharply over Polypodiaceae.

Zone XII corresponds to Stratum 7. Beginning from zone XII, there is a low concentration of observable pollen grains.

Pollen zone XIII (2.4-2.1 m) is characterized by forest-steppe types of pollen spectra, although NAP predominates (23-44% AP, 46-66% NAP). This is the last appearance of broad-leaved taxa pollen (6-33%), represented by *Carpinus* and *Quercus.* The former prevails slightly over the latter. A few pollen grains of *Alnus* and Rhamnaceae also occur, but *Pinus* usually predominates considerably (up to 83%). The characteristic feature of the NAP is a peak both of Cyperaceae (32-33%) and of Gramineae (10-21%). The percentage of xerophytes is very low (5-12%), and *Herbetum mixtum* is not abundant (33-54%), although diverse in composition. Polypodiaceae spores are about equal to Bryales.

Zone XIII corresponds to Stratum 6 and the lower part of Stratum 5. Stratum 6 is described as a yellowish-grey loam, while Stratum 5 is described as a grey loam, both with limestone clasts. From a pedological viewpoint, the strata comprise humus and humus-transitional horizons of a specific turf-carbonate soil, which has been formed under conditions of intensive accumulation of clastic material.

Pollen zone XIV (2.0-1.5 m) contains a steppe type of pollen spectra and the absence of broad-leaved pollen (13-14% AP, 79-82% NAP). This is the maximum of NAP for the section. The uppermost level of the zone is only slightly different (29%AP, 59% NAP, and a single *Fagus* pollen grain). *Pinus* dominates the AP and some *Betula, Alnus,* Cupressaceae, and Rhamnaceae appear. The presence of Elaeagnaceae pollen—the only occurrence in the section—is noticeable. *Herbetum mixtum* dominates the NAP (36-68%), though Gramineae becomes prominent (up to 25%). Xerophytes, represented by Chenopodiaceae and *Artemisia,* are not abundant (14-25%), and Cyperaceae drop in this zone. Asteraceae and Brassicaceae prevail in *Herbetum mixtum* (up to 16-17%), while Lamiaceae becomes dominant at the uppermost level only. Low values of spores, represented by Bryales, also increase at the uppermost level, in which Polypodiaceae and Lycopodiaceae appear.

Zone XIV corresponds to Stratum 4, described as a yellow loam with abundant limestone clasts, and to the uppermost part of Stratum 5. Stratum 4 underlies a carbonate illuvium (Ck horizon) of the modern soil. The latter is represented by well-developed turf-carbonate soil (humus horizons 1 m thick) with visual features of intensive carbonate leaching (deep and expressive sinter-like carbonate accumulations in the subsoil).

Main Characteristics of the Pollen Diagram

Three main intervals are distinguished by the AP/NAP ratio: pollen zones I-III with a predominance of AP, pollen zones IV-X with approximately equal ratios of AP and NAP, and pollen zones XIII-XIV with a predominance of NAP. Pollen zones X and XII are separated by pollen zone XI, in which AP dominates. Despite this fact, the general trend of decreasing AP can be observed in the diagram (fig. 6-1).

The second feature of the diagram is its division into two parts by the content of broad-leaved taxa pollen. Pollen zones I-VI are characterized by its constant presence (whether in small or large percentages), while pollen zones VII-XIV are notable for an alternation of zones without broad-leaved pollen (VII, XII, and XIV) and zones with it (VIII-XI and XII). Furthermore, the broad-leaved taxa values in the upper part of the diagram are not as rich as those observed in its lower part. Thus, a general trend towards decreasing broad-leaved taxa pollen upwards can be also be seen in the diagram.

Another characteristic of the diagram is a rhythmic alternation of zones which are high in broad-leaved taxa pollen (I, IV, VI, VIII, X, and XIII) and zones which are low or absent in broad-leaved taxa pollen (II-III, V, VII, IX, XI-XII, and XIV). In general, positive correlation exists between zones rich in AP and broad-leaved taxa pollen, on one hand, and zones rich in NAP and poor in broad-leaved taxa pollen, on the other hand. But these correlations do not hold true for all pollen zones; although the most rich in AP, pollen zones III and XI are notable for low values of broad-leaved taxa pollen, while pollen zones I and VI, with high values of broad-leaved taxa, are not richer in AP than the adjacent pollen zones.

The diagram can also be divided into two parts by values of small-leaved tree pollen. *Betula* and *Alnus* pollen form significant curves in the upper part of the diagram only, beginning from the boundary of zones IV and V. *Pinus* pollen is a constant dominant in the diagram, which is fully expected given the high productivity and long-distance dispersal of pine pollen. The lower *Pinus* values correspond to pollen zones I and IV-VI and tend to be inversely correlated with broad-leaved taxa pollen.

Herbetum mixtum and Cyperaceae are constant dominants of NAP in the diagram, while xerophyte pollen is not very abundant, forming a significant maximum in zone XII only. As Kabazi II faces the lower part of the northern slope of the Main Range of the Crimean Mountains, the predominance of mesophyte pollen is not surprising. *Herbetum mixtum* and Gramineae compose the present-day grass cover of the area under investigation. Judging from the incomplete representation of the Gramineae family in the modern surface samples (Arap 1972, 1976; Bolikhovskaya 1976), it is possible there was a higher proportion of Gramineae in the past vegetational cover than is observed in the fossil pollen spectra. Cyperaceae could be very abundant throughout the deposits because of the shade conditions produced by the collapsed rock slab. Their values are more than 20% in zones I-IV, about 20% in zones V-X, and less than 20% in zones XI-XIV. In fact, Cyperaceae pollen is directly correlated with AP in the diagram, and shows the same trend of decreasing upwards. In contrast, Gramineae is more abundant only in zones XII-XIV. *Herbetum mixtum* is inversely correlated with xerophyte pollen, but not in all zones. Polypodiaceae spores show the same trends as broad-leaved taxa pollen. They are constantly present and more abundant in pollen zones I-VI, while they disappear at many levels in pollen zones VII-XIV. In the upper part of the diagram, their high values coincide with pollen zones VIII, X, and XIII, which are more rich in broad-leaved taxa pollen. So, a general trend to a decrease of Polypodiaceae upward is also a characteristic feature of the diagram.

VEGETATIONAL AND CLIMATIC DYNAMICS

Pollen Zone I: Environment

Pollen zone I indicates a spread of hornbeam-oak forests in the vicinity of Kabazi II, while the immediate locality was possibly surrounded by grass coenoses of *Herbetum mixtum* and Cyperaceae (fig. 6-1). The latter might be drawn towards the shady growth conditions behind the rock slab. The absence of pedogenic features in the studied deposits gives evidence that a deep cleft behind the slab was not completely vegetated. Such shade-loving mesophytes as sedges, ferns, and club-mosses could grow nearby. The prevalence of Lamiaceae in *Herbetum mixtum* is evidently related to the limestone substrata, since a number of representatives of the family are regarded as petrophytes, e.g., *Thymus L.* and *Teucrium L.* Typical xerophytes such as Chenopodiaceae, *Artemisia,* and *Ephedra* were practically absent.

In the forests, there was an admixture of elm and lime-tree, while diverse shrubs (hazelnut, spindle tree, Caprifoliaceae, and arboreous Rosaceae) formed the undergrowth. The appearance of walnut pollen just above zone I suggests its growth during the formation of sediments of pollen zone I, too, as it is doubtful that this warmth-loving tree would suddenly appear when other broad-leaved taxa in zone II decrease. The number of walnut trees in the forests was obviously not significant enough to result in their consistent appearance in the pollen spectra. Alder *(Alnus glutinosa Gaertn.),* which produces long-distance transport pollen, was abundant in the Alma River valley. The amount of pine was very low, even in the forests of the higher mountain belts, as it is at the present day.

The reconstructed vegetational cover indicates a warm climate during this interval, which might be compared with modern conditions. The presence of walnut is a specific feature that can be explained, on one hand, by even warmer climatic conditions than today, but on the other hand, by the more relict character of the flora.

The archeological horizons -1100 and -1080 are within pollen zone I. (Description and position of archeological horizons, levels, and units of the Kabazi II sequence can be found in Chabai 1998a.)

Pollen Zone II: Environment

Pollen zone II shows a reduction of broad-leaved and alder valley forests. Does the observed increase of *Pinus* pollen indicate an expansion of pine forests in the studied area? It has been shown that the proportion of *Pinus* pollen in pine forests is not less than 90%, while the AP is also not less than 90% (Klopotovskaya 1976). The AP/NAP ratio of zone III is the same as in pollen zone I. It is more probable that the recession of broad-leaved forests from the site increased the possibility for an intensive influx of omnipresent *Pinus* pollen into the more open landscapes. The floral composition of broad-leaved forests did not change significantly and shrubs became even more diverse including Cornaceae, Oleaceae, and abundant Rosaceae.

The recession of broad-leaved trees was accompanied by some changes in grass cover: a drop of sedges (though still dominant) and an insignificant increase in the xerophytes wormwood, ephedra, and Chenopodiaceae. The more diverse composition of *Herbetum mixtum* (Ranunculaceae, Rosaceae, Fabaceae, and Asteraceae became abundant) can be explained by their expansion to more suitable soils left by an arboreous vegetation. Ferns and club-mosses confirm that the herbaceous vegetation generally preserved its mesophytic character, despite a spread of xerophytes.

The noticeable feature of pollen zone II is the presence of *Betula* pollen, which is also a long-distance transport pollen. Birch is not at all typical for the modern vegetation of Crimea. Small birch groves occur in the uppermost mountain forest belt only, and are regarded as relicts of the glacial epoch (Maleev 1948). *Betula* pollen has not been found in modern pollen spectra, even in the highest Crimean Mountain meadow-steppes (yailas), although it is present in the lowermost layers of their soils (Artiushenko and Mishnev 1978). These layers have been correlated to the Early Holocene, characterized by a considerably cooler climate than the present day (Artiushenko and Mishnev 1978).

This suggests that in the higher mountain forest belt of Crimea, the spread of birch and pine was more extensive during the interval corresponding to pollen zone II than it is at present, indicating a cooler climate during that time. Thus, the recession of broad-leaved forests, as well as some xerophytization of herbaceous coenoses, might have been caused by the climate becoming cooler and slightly drier. Nevertheless, the changes were not drastic and no taxa disappear from the floral composition.

The archeological horizons -1037-1050 and -980 correspond to pollen zone II.

Pollen Zone III: Environment

Pollen zone III is very similar in composition to the spectra of mountain pine forests as described by Klopotovskaya (1976). This suggests that mountain pine forests occurred near Kabazi II, probably covering at least a considerable part of the northern slope of the Main Ridge opposite the site. The appearance and noticeable value of *Fagus* pollen are important, since at the present, beech grows in the upper mountain belt, as well as pine. The spectra of pollen zone III are similar to the surface samples taken at the upper boundary of a beech forest which contain 80% AP, composed of 67% *Pinus*, 3% *Fagus*, 1% each of *Carpinus*, *Ulmus*, *Alnus*, and *Corylus*, with *Juniperus* making up the remainder (Artiushenko and Mishnev 1978). An exclusion of the latter from the pollen sum produces values very similar to those of pollen zone III.

Thus, a lowering of forest belt borders might have taken place during the interval corresponding to pollen zone III and was possibly a result of further climatic cooling. Nevertheless, the cooling was not significant enough to prevent the growth of broad-leaved trees. A lowering of the forest belt could also occur with increasing humidity, and, in fact, there are no indications of aridity in pollen zone III. Mesophytic *Herbetum mixtum* (Ranunculaceae, Rosaceae, Fabaceae, Lamiaceae, and Asteraceae are absent) became more abundant in the grass cover than during previous intervals, while xerophytic coenoses were reduced (wormwood disappeared completely). The presence of *Botrychium*, together with other ferns and club-mosses, also supports the evidence for an increase in humidity.

The archeological horizon -930 is within pollen zone III.

Pollen Zone IV: Environment

Pollen zone IV represents a completely different environment and vegetation, dominated by broad-leaved forests and forest-steppe. The prevalence of hornbeam forests is a characteristic feature of this interval. During the first stage (subzone IVa), hornbeam forests grew in the vicinity of the site, with abundant hazelnut at their borders. The immediate locality was surrounded by grass coenoses of *Herbetum mixtum* and Cyperaceae, the former having a diverse composition. Brassicaceae, Plantaginaceae, and Apiaceae attained their previous composition, and Asteraceae appeared again. This, together with disappearance of club-mosses, shows that conditions became suitable for a wider spectrum of herbs, not just for moisture-loving ones. Nevertheless, typical xerophytes such as wormwood and Chenopodiaceae were not noticeable.

Oak, elm, and warmth-loving walnut grew as admixtures in the forests, while the proportion of birch was miserable, up to its complete disappearance in the spectra. Beech and pine forests, judging from the pollen composition, receded upwards into the mountains again. This suggests a warmer and somewhat drier climate during this interval as compared with the previous one. The subzone IVa indicates interglacial conditions.

The absence of pedogenic features in the sediments represented by pollen zone IV shows that the cleft bottom was still not vegetated during this interval. The high clay content (highest among all strata) and very low frequency of larger eboulis, however, suggest greater slope stability above the site, slower deposition on the site, and warmer/moister conditions than those represented in younger sediments (Chabai 1998a) through the whole interval of zone IV.

The next stage (subzone IVb) was characterized by an even more extensive spread of hornbeam coenoses. Forests, almost completely dominated by hornbeam, approached quite close to the site. Lime-trees occurred in small numbers, while the disappearance of oak was a characteristic feature. Hazelnut, Cornaceae, and Oleaceae grew at the border of the forest, and alder became abundant in the Alma valley again. Peaks in alder correspond to those of hornbeam. The increasing climatic humidity caused the expansion of mesophilic hornbeam on drained slopes, and of hygrophilic alder (*Alnus glutinosa Gaertn.*) on the valley floor. Shade hornbeam forests prevented an influx of pine pollen. The grass cover was the same as that seen in subzone IVa. Subzone IVb corresponds to a climatic optimum of an interglacial, with the most favorable conditions for the growth of mesophilic arboreous vegetation.

Archeological Unit IV was formed during this interval.

During the last substage (subzone IVc), the vegetational cover was rather similar to that of subzone IVa. Some reduction of broad-leaved forests took place at the expense of hornbeam associations, while oak spread more extensively again. Not only lime tree and alder, but also hazelnut and other shrubs became less abundant during the substage, and the proportion of birch increased slightly. Ferns and Cyperaceae decreased in the ground cover, while Gramineae became one of its dominant components. Cyperaceae-*Herbetum mixtum* coenoses have been changed by more xeric *Herbetum mixtum*-Gramineae associations. All of these features indicate some climatic aridization, although the proportion of broad-leaved forest pollen still indicates interglacial conditions. A notable feature is the appearance of fir (*Abies*) pollen just at the moment of a birch increase, at the end of subzone IVc. The spread of dark-coniferous trees is generally regarded as a characteristic feature of the final stage of interglacials. While both birch and fir pollen are dispersed over long distances, the spread of these taxa in the higher mountain belt can also be significant evidence for the final stage of the interglacial.

Pollen Zone V: Environment

Pollen zone V confirms this conclusion. A sharp reduction of broad-leaved trees (both hornbeam and oak) took place, more considerable than that of the time interval corresponding to pollen zones II-III. The broad-leaved trees were possibly characterized by sparse growth, while shrubs (hazelnut, spindle tree, arboreous Rosaceae, Cornaceae, and Oleaceae) spread among and around them. A replacement of arboreous formations by shrub-arboreous formations might have taken place on the southern slope of Kabazi Mountain.

The northern slope of the Main Ridge opposite Kabazi II might have been characterized by rather different vegetation. There is a high percentage of *Betula* pollen (*Betula pendula Ehrh.*) beginning from zone V, and *Fagus* pollen appears again. The presence of both taxa, which today grow in the higher forest belt, suggests a lowering of mountain forest belt borders during pollen zone V. In addition, the proportion of beech was lower and birch was much higher than at the present, which may indicate considerably cooler climatic conditions. The percentage of *Betula* pollen might indicate its growth not far from the site.

Changes in the grass coenoses surrounding the site were not significant. The less mesophytic herbs Brassicaceae and Asteraceae became more noticeable components of *Herbetum mixtum* beginning with zone V. Xerophytes, such as Chenopodiaceae and *Ephedra*, extended their spread slightly at the beginning of interval corresponding to zone V. Later on, however, Cyperaceae became dominant again, demonstrating an increase in humidity. Overall, grass cover was mesophytic. This suggests that the reduction of broad-leaved trees was caused not so much by aridization, as by a considerable climatic cooling.

Neither fir (*Abies*) nor walnut (*Juglans*) appeared after the beginning of the interval corresponding to pollen zone V. This may indicate the end of a major interglacial stage in vegetational development. The predominance of such a boreal element as *Betula*, as well as a depletion of broad-leaved taxa, provide evidence that this interval corresponds to the beginning of the Early Glacial.

After the deposition of 4 meters of sediment, a spot behind the rock slab became suitable for vegetation growth. This can be concluded from the pedogenic features of the lower part of Stratum 11 (Chabai 1998a) which correspond to pollen zone V. Weathering of the slab's surface appears to have occurred under moist and temperate conditions, leading to dissolution rather than spalling. This further supports our conclusion of rather humid climatic conditions in pollen zone V.

Archeological Level III/3 of Unit III corresponds to the upper part of this zone.

Pollen Zone VI: Environment

Pollen zone VI represents a rather specific pattern of forest-steppe vegetation. Broad-leaved and birch formations shared a dominance on the slope of Kabazi Mountain, while the site itself was surrounded by herbaceous coenoses. Broad-leaved forests consisted of hornbeam, oak, and elm, with hazelnut, spindle tree, and Caprifoliaceae at the borders. These forests expanded considerably as compared with the previous interval, but did not reach the prevalence they possessed during both optima of the foregoing interglacial (pollen zones I and IV). Birch, which spread extensively during the previous climatic cooling, competed with them. The existence of favorable growth conditions for birch indicates a temperate climate, less warm than the present-day one.

An extensive spread of alder (*Alnus glutinosa Gaertn.*) characterizes the upper part of zone VI. Since nothing indicating increasing climatic humidity is observed, it might be caused by a deterioration of drainage conditions in the Alma River valley, probably related to channel dynamics, such as abundant silt accretion.

The grass cover was dominated by *Herbetum mixtum*. At the beginning of the stage, it was composed mostly of meadow coenoses. Peaks of arboreous vegetation, of birch, and of mesophytic herbs are directly correlated and indicate more humid and less warm conditions at the beginning of the stage. Later on, the proportion of grass coenoses increased, parallel with a spread of xerophytes (Chenopodiaceae and *Ephedra*).

This corresponds well to the observed pedogenic features in Stratum 11—carbonate leaching in the middle of the stratum and humus accumulation in its upper part (Chabai 1998a). The characteristics of the vegetation and environment suggest this interval experienced interstadial conditions. The archeological Level III/2 of Unit III was formed during this interstadial of the Early Glacial.

Pollen Zone VII: Environment

Pollen zone VII indicates an expansion of grass vegetation and a drastic depletion of broad-leaved flora. The percentage of the latter in the vegetational cover was so insignificant that its pollen is not present (or present in single grains only) in the spectra. The area of birch growth was also reduced. With extensive open grass landscapes, pollen of long distance transport (pine and alder) became dominant. A peak of alder (*Alnus glutinosa Gaertn.*) pollen shows that this hygrophyte continued to grow in abundance in the Alma River valley, so drainage conditions did not improve.

The herbaceous coenoses were dominated by *Herbetum mixtum* and sedges at the beginning of the interval, but later on, the extent and diversity of xerophytes increased. The commonly occurring Chenopodiaceae and *Artemisia* were accompanied by especially abundant *Ephedra* and by Plumbaginaceae and Dipsacaceae. The less mesophytic Brassicaceae and Asteraceae prevailed in *Herbetum mixtum*. The proportion of spore plants decreased, while moisture-loving ferns disappeared completely. In general, the grass cover preserved its mesophytic character, but features of xerophytization became more prominent than foregoing stages.

This type of vegetation can be correlated to stadial conditions of a glacial period. The changes in vegetation indicate more significant climatic deterioration than those recorded in pollen zones II-III and V. Only a few broad-leaved trees survived in refugia, which might include the ravines dissecting the southern slope. Hazelnut, spindle tree, and abundant Rhamnaceae also grew in refugia.

Climatic deterioration during pollen zone VII is confirmed by the soil/lithological features of the Kabazi II sequence. Beginning just at the upper part of Stratum 11, patterns of rapid eboulis deposition are demonstrated, contrasting with the fine sediments and weathering of the lower strata (Chabai 1998a). Humic soil formation still occurred at the beginning of the interval of pollen zone VII, but later on, it declined and was replaced by light non-soil loam accumulation. These facts prove that the climate became more continental.

Archeological Levels III/I and III/1a of Unit III were formed during the interval of pollen zone VII.

Pollen Zone VIII: Environment

Pollen zone VIII is represented by the alternation of forest and steppe formations. A new expansion of broad-leaved flora is the most noticeable feature of the interval. Hornbeam and oak, together with their concomitants hazelnut and spindle tree, spread from refugia. Their proportion in the vegetational cover was approximately the same as during the interval of pollen zone VI, while birch did not attain its former percentage. No features of xerophytization, which could account for the decrease of alder, were observed. An improvement of the drainage regime in the Alma River valley, erosional incision for example, possibly took place.

Grass coenoses were meadow-steppe type, dominated by *Herbetum mixtum*, sedges, and Gramineae. They differed from those of the previous interval by their more diverse composition of mesophytic herbs and a decline of xerophytes. Concurrently, spore plants increase; ferns and even club-mosses reappeared, together with the expansion of arboreous vegetation.

The vegetation of pollen zone VIII shows an interstadial pattern. In comparison with the previous stadial, areas occupied by arboreous vegetation have been extended at the expense of broad-leaved assemblages. Nevertheless, their expansion did not approach that of the previous interstadial.

The archeological Level IIA/4 of Unit IIA was formed during this interval.

Pollen Zone IX: Environment

Pollen zone IX represents another oscillation in the distribution of forest and steppe formations and of broad-leaved taxa. A direct correlation between broad-leaved taxa and arboreous vegetation proves that forests of the southern slope of Kabazi Mountain consisted mainly of broad-leaved trees. An expansion of forests from refugia might have been caused by climatic amelioration, while a decline of forests might have been caused by more continental climatic conditions. The latter regime is recorded in pollen zone IX. Landscapes were dominated by meadow steppes. Later, xerophytes (wormwood) became somewhat more abundant. Hornbeam and oak receded to refugia, and concomitantly, ferns disappeared from grass coenoses adjacent to the site. The proportions of birch and alder, which are not so dependent on a benign climate, did not change.

The climatic deterioration occurring in pollen zone IX was not so prominent as that recorded in pollen zone VII. Nevertheless, the decline of arboreous and broad-leaved vegetation indicates rather stadial conditions.

The archeological Level IIA/2 of Unit IIA was formed during this interval.

Pollen Zone X: Environment

Pollen zone X represents a vegetation complex very similar to that of the previous interstadial (pollen zone VIII). The ecotones were dominated by meadow steppes and broad-leaved forests that expanded from refugia. Hornbeam prevailed in the composition of the latter, while oak and lime tree occurred as admixtures. Diverse shrubs (hazelnut, spindle tree, Rhamnaceae, and Caprifoliaceae) grew at the border of the forests. Boreal birch also was part of the vegetational cover, as well as alder in the Alma River valley.

Grass cover was mesophytic and, at the end of the interval, it was represented by meadows with a rich and diverse composition of *Herbetum mixtum*. Ferns appeared with the forest expansion, while xerophytes decreased. Some decline of sedges began during this interval and might have been caused by local factors: after the deposition of 7 meters of sediment, growth conditions behind the rock slab decreased in shade and humidity.

The AP/NAP ratios are approximately the same in pollen zones I and IV, which represent interglacial conditions, and in pollen zones VIII and X, which correspond to interstadials. The proportion of pine, however, is higher in the interstadial deposits. This indicates that forests occupied smaller areas during these intervals and the more open landscapes provided optimal conditions for an intensive influx of *Pinus* pollen. In addition, the presence of *Fagus* pollen in spectra of both interstadials might indicate the lowering of the higher forest belt, consisting of beech and pine, on the northern slope of the Main Ridge, opposite the site.

Brown pedosediments within Stratum 9 could correspond to the interstadials represented in pollen zones VIII and X. The lithological study shows rounding of small clasts, which may signify weak, pedogenically-related dissolution of carbonate clasts. The presence of larger angular clasts suggests persistent cold winters that are highly probable for interstadials. Factors inhibiting an intensive pedogenesis might be due not only to a continental climate, but to high sedimentation rates (Chabai 1998a).

Archeological Levels IIA/1, II/8C, II/8 (II/7F8) correspond to this interstadial.

Pollen Zone XI: Environment

Pollen zone XI is distinctive in the presence of the highest percentage of *Pinus* pollen in the sequence. According to Klopotovskaya's methodological studies (1973, 1976), pine forests should have grown very close to the site. The intensive influx of *Pinus* pollen masks other wind-transported pollen—birch and alder—although, possibly, their actual portion in the vegetational cover also decreased. Even the overall pollen frequency became much higher due to the abundance of *Pinus* pollen.

A decline of broad-leaved flora is the other prominent feature of the interval. A few occurrences of hornbeam and lime tree pollen grains prove their growth in refugia only. On the other hand, shrubs (Rhamnaceae, Caprifoliaceae, Oleaceae, arboreous Rosaceae, and spindle tree) became more abundant and probably formed separate stands on the Kabazi slope. Pollen grains of juniper, a concomitant of pine forests, are present. Judging from the poor preservation of *Juniperus* pollen in fossil conditions, it probably had an extensive range in the area. Grass coenoses were mesophytic, dominated by rich and diverse *Herbetum mixtum*. Under conditions of restricted growth of broad-leaved vegetation, ferns and club-mosses were, probably, also connected with pine forests.

Environmental conditions characteristic of a transitional phase between an interstadial and the next stadial, or of an interphasial, seem to be present in pollen zone XI. The climate became more inclement as compared with the previous stage. The intensive spalling of the large boulder (Stratum 8) confirms its weathering under continental climatic conditions.

The archeological Levels II/7 and II/6 of Unit II correspond to the interval recorded in pollen zone XI.

Pollen Zone XII: Environment

Pollen zone XII represents an important stage in the vegetational development of the area, when steppe coenoses became dominant. A distinct trend towards the reduction of forested areas from the beginning to the end of the stage is observed. At the beginning of the interval, pine formations with admixtures of birch and Rhamnaceae still existed, although not in close vicinity to the site. Later on, an extensive deforestation of the whole orographical region took place. Arboreous vegetation, even pine, grew in refugia only. Alder, related to the Alma River valley, increased against the background of a general decrease in AP.

The meadow-steppe and meadow coenoses of the previous intervals have been replaced by typical steppe (*Herbetum mixtum*-Gramineae) assemblages. They were characterized by a higher proportion of xerophytes; the maximal extent of wormwood in the site's vicinity occurred during this interval. The Asteraceae family, which includes a lot of xerophytic plants, dominated in the *Herbetum mixtum*. The climatic aridization, recorded in NAP, could itself cause a decline of arboreous vegetation if it takes place on a plain. In mountains with a diversity of growing conditions, however, deforestation more likely occurs not only with an arid, but a cold, stadial climate.

Stratum 7, corresponding in its upper part to pollen zone XIII, is notable for its low clay content and abundance of clasts produced by an intensive spalling of the large boulder (Stratum 8). These are further evidence of a harsh continental climate.

Archeological Levels II/3 through II/1A of Unit II were deposited during the interval represented by pollen zone XII.

Pollen Zone XIII: Environment

Pollen zone XIII indicates the gradual expansion of arboreous vegetation from refugia. Broad-leaved trees (hornbeam and later oak) expanded their habitats. They almost approached the same proportion in the vegetational cover characteristic of previous interstadials. A poor representation of different taxa of arboreous vegetation is possibly caused by the overall lower pollen frequency in the zone. In grass cover, ferns, and particularly, sedges, became more abundant. Steppe *Herbetum mixtum*-Gramineae assemblages have been replaced by meadow-steppe *Herbetum mixtum*-Cyperaceae coenoses, while xerophytes decreased sharply. This shows a significant mesophytization of the grass cover occurring in parallel with the proliferation of broad-leaved flora. From these features, the interval can be regarded as an interstadial.

The corresponding deposits of Stratum 6 and the lower part of Stratum 5 are characterized by pedogenic features, including humus accumulation. Though the latter is obscured by an intensive silt-clast accretion, its increase in Stratum 5 is observed concurrently with the climatic amelioration recorded in the pollen data. Judging from soil development, the area of the site proper was also covered by herbaceous vegetation.

The archeological Horizon -195 was formed during this interstadial.

Pollen Zone XIV: Environment

Pollen zone XIV demonstrates a resumption of steppe ecotones on the Kabazi slope. *Herbetum mixtum*-Gramineae assemblages dominated. Neither sedges nor xerophytes were abundant. Some shrubs (Juniper and buckthorn) occurred, as well as a few birches, while the proportion of broad-leaved trees was so insignificant that they were not represented in pollen spectra. An expansion of pine (which even included a few beech trees and club-mosses) was recorded at the uppermost level only, in parallel with an increase of mesophytic herbs. The appearance of Elaeagnaceae pollen is interesting. Besides being cold- and drought-resistant, these shrubs are known for being completely heliophytic, perhaps proving the existence of vast open landscapes during the interval. All of these features could evidence a cold and continental climate of stadial pattern that limited the spread of arboreous, and especially broad-leaved, vegetation, although it was not arid enough to allow an advancement of xeric steppes.

Humus accumulation developed initially under the above conditions (Stratum 5), but later, pedogenic processes were depleted by more intensive silt accumulation, producing the light loams of Stratum 4.

Summary of Environmental Changes

The changes in the vegetational cover on the Kabazi slope are characterized by a cyclic pattern, and, at the same time, show a distinct trend towards the reduction of forest formations and the expansion of grass coenoses to the end of the interval under investigation. A trend towards decreasing broad-leaved flora elements, as well as decreasing mesophytic components of grass assemblages, also took place. Meadow-steppe and meadow coenoses (Cyperaceae-*Herbetum mixtum*, Gramineae-*Herbetum mixtum*) have been replaced at the end of the Kabazi II sequence by steppe *Herbetum mixtum*-Gramineae assemblages. The boreal element birch extended its habitats during the second part of the interval under investigation. These features reflect an advance of a more cool and continental climate. It developed, however, in an oscillatory pattern. Stages of forest expansion, including broad-leaved ones, and of more mesophytic herbaceous vegetation alternated with stages of steppe expansion and of delimited forest areas. The latter have been commonly connected with a decline both of broad-leaved flora and mesophytic components of ground cover, including ferns.

The analysis of pollen spectra and the reconstructed vegetation of Kabazi II indicate that the site's deposits were formed during the interglacial (zones I-IV) and glacial stage (zones V-XIV) of the Late Pleistocene. The interglacial stage includes two optima, separated by a cool climatic spell (zones II-III). The glacial stage comprises 5 stadials (zones V, VII, IX, XII, and XIV) and 4 interstadials (zones VI, VIII, X, and XIII).

CORRELATIONS

The Late Pleistocene Mikulino Interglacial is generally considered to represent the Eastern European equivalent of the Eemian Interglacial. Seven classical pollen zones (M1-M7), reflecting vegetational successions on the Russian Plain during the Last Interglacial, have been established (Grichuk 1972b). It was later shown (Yelovicheva 1989; Bolikhovskaya 1992, 1995) that the Mikulino stage is characterized by two climatic optima (M4 and M6) separated by a stage of cooling (M5). According to the Ukrainian stratigraphic scheme of the Pleistocene (Veklitch 1993), the Pryluky warm stage is regarded as equivalent to Mikulino. On the basis of pollen data, however, it has been proposed that the Mikulino Interglacial be correlated with both Pryluky and Kaydaky warm stages, separated by the Tyasmin cold stage (Bolikhovskaya 1995; Gerasimenko 1988, 1997). Only the uppermost steppe soil of the Pryluky soil complex forms a separate unit.

In the forest and forest-steppe belts of the Russian Plain, the lower climatic optimum of Mikulino (M4, xerothermic optimum) was characterized by a spread of oak and elm forests initially (M4a), and by hornbeam and lime tree later (M4b) (Grichuk 1972b). The upper climatic optimum (M6, hygrothermic optimum) is known by a spread of hornbeam forests. These successions are similar to the two interglacial climatic optima (zones I and IV) recorded in the Kabazi II sequence.

Vegetational reconstructions for the Mikulino Interglacial at the site Molodova I (Bolikhovskaya 1982), located at the border of north-eastern Moldova and western Ukraine, provide an even more convincing case for correlation. The xerothermic optimum was represented by oak forests with hornbeam, walnut, elm, and maple. The appearance of walnut at the end of the optimum is remarkable, since it correlates completely with the Kabazi II records. The hygrothermic optimum of Molodova I was characterized by hornbeam forests with oak and walnut—an analogue of the observed vegetation in zone IV (subzones IVa and IVb). An expansion of pine with spruce (*Picea*) and shrub birch has been detected for the interval between two optima in Molodova I, although a few broad-leaved species also occurred. This interval is being confidently correlated with zones II-III of Kabazi II. It is difficult to expect an appearance of such boreal and arcto-boreal floristic elements as spruce and shrub birches in the southern Crimean Mountains, but it is worth emphasizing that arboreous birch, which also represents a boreal flora, appeared just at this interval in the Kabazi II sequence.

Finally, the following stage in Molodova I of pine forests with diverse broad-leaved trees can be correlated with the final stage of the upper optimum (subzone IVc) of Kabazi II. The presence of fir (*Abies*)—a single case in both sequences—is a highlight of the correlation. The last stage recorded in the Molodova I sequence, a spread of wormwood and

Chenopodiaceae, is related, in our opinion, to the Early Glacial. The composition of grass cover in Molodova I was much less mesophytic than in Kabazi II, which is to be expected, given the different orographical locations of both sequences. The striking resemblance of forest vegetational successions forms a reliable basis for the correlation of the two sites.

Thus, just the Mikulino (Eem) Interglacial is recorded in pollen zones I-IV of Kabazi II. In the coeval Pryluky-Kaydaky stages, the plains of Crimea were occupied by steppes, initially of *Herbetum mixtum*-Gramineae composition (xerothermic optimum), and later composed of Gramineae-*Herbetum mixtum* coenoses (hygrothermic optimum) (Sirenko and Turlo 1986).

The upper subunit of the Pryluky stage, represented by a turf-chernozem soil even in the northern regions of Ukraine, is correlated with the Krutitsa Interstadial of the Russian Plain established by Velichko (1975). It has been proposed as equivalent to the Early Glacial interstadials Amersfoort (Grichuk 1972a; Bolikhovskaya 1995) and Brörup-Amersfoort (Velichko 1988). Velichko (1988) correlated the Krutitsa Interstadial to the pedosediment of a humic soil at the Zaskalnaya V site (cultural layer V), while all characteristic pedogenic features of the Upper Pryluky soil are represented in the upper part of Stratum 11 at Kabazi II. Pollen data indicate that forest-steppe landscapes, including hornbeam forests, were typical for both Kabazi II and Zaskalnaya V (Gubonina 1985). In eastern Crimea (where Zaskalnaya V is located), the area occupied by forests was much less extensive, the forest composition less diverse, and steppe coenoses more xeric than in western Crimea (where Kabazi II is located). That corresponds well to the present-day differences in precipitation between eastern and western Crimea. The scanty pollen material of Zaskalnaya V does not enable a more detailed correlation.

At Kabazi II, the most characteristic features of the vegetation corresponding to the Upper Pryluky turf-carbonate soil (recorded in pollen zone VI), is an equal coexistence of birch and broad-leaved trees within the same orographical region, and a decrease of forests to the end of the stage. In the forest and forest-steppe belts of Ukraine, the interstadial correlated to the Krutitsa and Upper Pryluky soils was characterized by the spread just of pine-birch forest-steppe with admixtures of oak, elm, and lime (Grichuk 1972a; Gerasimenko 1998; Bolikhovskaya 1995). In the pollen diagram of Molodova I, the lowermost peak of *Betula* corresponds to the interstadial correlated to Brörup (Bolikhovskaya and Pashkevich 1982). The first half of this interstadial was characterized by forest-steppe landscapes (birch, hornbeam, oak, elm, and lime tree in a forest composition), while later on, the steppe *Herbetum mixtum*-Gramineae coenoses expanded. These features could support the correlation of the stage recorded in Kabazi II, pollen zone VI with the Krutitsa Interval and so with the Brörup-Amersfoort Interstadials.

U-series dates of Level III/2, which corresponds to pollen zone VI, fluctuated in a wide range between 41,100 ± 2,000 and 117,000 ± 13,000 (McKinney 1998: 347; table 14-1). At the same time, McKinney assumed that the average date for Level III/2 might be 60,000 ± 3,000. The results of ESR LU dating were 61,000 ± 1,000 for Level III/2 and 69,000 ± 5,000 for Level III/3 (Rink et al. 1998: 333; table 13-4). Also, it is possible that the Level III/3 could be dated 70,000 ± 5,000 (Rink et al. 1998: 336). Since the latter is generally considered to demonstrate the upper age limit, the corresponding intervals might be regarded as those older than 70,000 BP.

The preceding cool spell (pollen zone V), notable for the first maximum of birch pollen and a decline of broad-leaved flora, should correspond to the first stadial of the Early Glacial. This characteristic is in agreement with the vegetation, revealed in the first Late Pleistocene stadials in the vicinity of Molodova I site, namely, an alternation of light pine-birch forests and steppe ecotones. The vegetational cover of northern Moldova was distinct in the presence of arcto-boreal floristic elements: *Betula* sect. *Fruticosae et Nanae* and *Alnaster*, as well as by more xerophilic (and cryophilic) grass cover. In Crimea, on the other hand, broad-leaved trees still occurred in forest composition and herbaceous assemblages were essentially mesophilic.

Pollen zone VII at Kabazi II was characterized by a more significant depression of thermophytic floristic elements, as well as by a more extensive spread of herbaceous coenoses, including xerophilic elements. Judging from the above correlation, this interval corresponds to the Uday (Khotylovo) cold stage of loess formation, established for the plain territory of Ukraine and Russia (Veklitch 1993; Velichko 1988). The present-day forest belt of Ukraine was covered at that time by *Herbetum mixtum*-Gramineae steppe. Chenopodiaceae-wormwood assemblages and shrub birch formations also proliferated (Grichuk 1972a; Gerasimenko 1988; Bolikhovskaya 1995). The steppes of the Crimean plain were represented by xerophilic coenoses (Sirenko and Turlo 1986). The second pollen complex of Zaskalnaya V (Gubonina 1985) is characterized by an increase of herbs, including *Artemisia* and Chenopodiaceae in particular, and by the presence of few pollen grains of birch, hazelnut, and beech. This complex can likely be correlated with pollen zone VII at Kabazi II.

Pollen zone VII at Kabazi II might be correlated with the interval in Molodova I above the disappearance of dark-conifer taxa, and which is also characterized by a drop in *Betula*. It is described as the Middle Valdai (Würm) stadial, with a predominance of *Herbetum mixtum*-Gramineae steppe. Sedges, wormwood, and Chenopodiaceae were also extensive. Light, sparse forests were formed by pine and arboreous birch, with shrub birch in the undergrowth. It is worthwhile to mention that in pollen zone VII at Kabazi II, alder achieves its maximum proportion during this interval. Thus, the proposed correlation might have a confident basis, and the beginning of the Pleniglacial can be recorded in pollen zone VII.

The interstadials represented in pollen zones VIII and X are separated by a stadial (pollen zone IX) characterized by a less harsh climate than that of the preceding and following stadials. An expansion of herbaceous coenoses took place during the stadial, as well as some increase of xeric herbs and a decline of broad-leaved trees, although the latter still grew in a noticeable number. Both interstadials were characterized by similar vegetational cover, dominated by mesophilic Gramineae-*Herbetum mixtum* meadow steppes and oak-hornbeam forests, with admixtures of elm and lime. Beech was also present within the orographic region of Kabazi II.

According to the Ukrainian stratigraphic scheme of the Pleistocene (Veklitch 1993), the Vytachiv warm stage followed the Uday cold stage. A pedocomplex of brown sods was formed during the stage, including a thin loess layer subdividing separate soils. In the present-day forest and forest-steppe belts of Ukraine, the soils were formed under pine-broad-leaved forests (few beeches were present), while the embedded loess was formed under pine forest-steppes, with a few broad-leaved trees in refugia (Gerasimenko 1988). The growth of hornbeam, oak, and elm as an admixture in pine forests has been also shown (Bolikhovskaya 1995) for the lower part of the Bryansk soil, established by Velichko (1975) above the Khotylevo loess. The same broad-leaved trees grew in valley forests of the southern steppe regions of Ukraine during the Vytachiv stage (Sirenko and Turlo 1986).

Two stages of climatic amelioration have been demonstrated for the Middle Valdai (Würm) sequences of Molodova I (Bolikhovskaya and Pashkevich 1982). They were characterized by forest-steppe landscapes, with oak, elm, hazelnut, and sporadic hornbeam and lime in forest composition. A stage of climatic deterioration, which separated the interstadials, was notable for a decline of arboreous vegetation, disappearance of broad-leaved trees, and occurrence of a few shrub birches. The first warm stage is being correlated by Bolikhovskaya and Pashkevich (1982) with the Moershoofd Interstadial, while the second with the Hengelo Interstadial. This correlation is based on charcoal in the marker sooty layer, represented both in Molodova I and the neighboring Korman IV, which yielded a radiocarbon date of 44,400 ±

2,050 (Ivanova 1977).

Similar vegetational changes during both Middle Valdai (Würm) interstadials have been demonstrated for the sequences of the Kiev, Moldova, and Crimea regions. The first interstadial was characterized by a prevalence of oak and elm, while hornbeam and lime were more abundant (or at least present) in the second interstadial. On the whole, in the three studied regions, the latter was characterized by a more diverse floristic composition of forests, including rich undergrowth. At Molodova V and Korman IV, the coeval paleosols (according to Ivanova 1977, 1987) are characterized by spectra with a considerable predominance of pine pollen. Nevertheless, the upper paleosol shows more diverse AP composition, including a few elm and hazelnut grains (Pashkevich 1977, 1987). This indicates its warmer climate and also supports the reliability of the above correlation.

The soil-lithological correlation of the described deposits is not easy, since they are represented by a well-developed soil complex in one case, and by colluvial or proluvial sediments in other cases. However, pedogenic features (presence of brown pedosediments or ferruginous-gley layers) are attributed to both colluvial and proluvial sediments. In all cases, soils are separated by the light non-soil stratum, with features of climatic cooling detected from pollen analysis.

The U-series dating of the archeological Level II/8 (II/7F8), corresponding to pollen zone X, shows to a range from 48,300 ± 17,000 to 65,500 ± 2,500 kyr (McKinney 1998: 347; table 14-1). By ESR LU, the level has been dated to 39,000 ± 3,000 (Rink et al. 1998: 334). It does not contradict a correlation of the interstadials recorded in pollen zones VIII and X with the Moershoofd and Hengelo intervals respectively. More contradictions appear with the correlation of these intervals with the Vytachiv stage. At the present, there exist two ranges of chronological timing of the Vytachiv interval, both based on TL-dating. One relates it to 90-75 kyr (Veklitch 1993), while the other to 45-35 kyr (Shelkoplyas et al. 1986). It seems the above data corroborate the latter conclusion. However, further investigation is needed to elucidate the chronological age of the Vytachiv stage.

The specific conditions of the interval represented by pollen zone XI are relevant to an interphasial or a transition from an interstadial to stadial. Light pine forests with an undergrowth of diverse shrubs and with a mesophilic surface cover, including ferns and club-mosses, replaced broad-leaved formations. Broad-leaved trees occurred sporadically only, while juniper appeared in a vegetational cover. The peak of arboreous vegetation (at the expense of a pine increase) is shown in the pollen diagram of Molodova I above the Hengelo interval, and the peak of juniper is fixed a bit higher. The upper layers of the soil, correlated with the Hengelo Interstadial at Molodova V, have also been shown by pollen data to have been formed under light pine forests (Pashkevich 1987).

This indicates that the described interval might have not only local significance. The Level II/7B, related to the interval, has been ESR LU dated to 32,000 ± 2000 (Rink et al. 1998:333; table 13-4), while by the U-series method for Level II/7 to 46500 ± 8000 (McKinney 1998). A correlation of the interval with the short Les Cottes stage, established for Western Europe (Raynal et al. 1985), might be suggested, judging from the fact that the next stage, pollen zone XII, has AMS dates 35,100 ± 850 (Level II/2) and 31,550 ± 600 (Level II/1) (Hedges et al. 1996: 190). The archeological Levels II/4 and II/5, which correspond to the pollen hiatus between zones XI and XII, are dates by AMS to 32,200 ± 900 and 33,400 ± 1,000 respectively (Hedges et al. 1996).

The pollen zone XII represents a stadial with the expansion of typical steppe (*Herbetum mixtum*-Gramineae) coenoses and the decline of an arboreous, particularly of broad-leaved, vegetation. The corresponding interval in the Molodova I and Molodova V sequences might be that recorded under the Bryansk (Denekamp) soil and also characterized by a decrease of AP and an absence of broad-leaved trees. The proportion of Chenopodiaceae and *Artemisia*, however, is lower than in Kabazi II. In the forest and forest-steppe belt of Ukraine, the corresponding interval was characterized by pine forest-steppe with *Herbetum mixtum*-Gramineae coenoses (Gerasimenko 1988). The pollen diagrams of radiocarbon-dated sites of Romania show the cold spell with the disappearance of broad-leaved trees and a sharp predominance of herbaceous coenoses as occurring between 29,500 and 35,000 BP (Carciumaru 1988).

The last interstadial of the Kabazi II sequence, corresponding to pollen zone XIII, is younger than 31550 ± 600 (by AMS), 32,000 ± 6000 (by ESR LU) for archeological Level II/1, and 39,800 ± 5,000 by U-series dating for Unit II as a single unit (Hedges et al. 1996, Rink et al 1998, McKinney 1998). A spread of oak-hornbeam forests against the background of forest-steppe landscapes took place during the interstadial. The main part of the coeval Bryansk (Denekamp) soil of Molodova I site (28-29 kyr BP) is characterized by forest-steppe pollen spectra with a predominance of broad-leaved forests during the climatic optimum. Hornbeam dominated in a diverse floristic composition, even including beech (Bolikhovskaya and Pashkevich 1982). At Molodova V and Korman IV (Pashkevich 1977, 1987) and in the forest belt of Ukraine (Gerasimenko 1988), the ecotones of coeval soils were dominated by pine forest-steppes. However, they included lime-tree and oak as admixtures. The remarkable features of all these soils and that of Kabazi II are that the upper layers of the soils are characterized by pollen spectra with a predominance of NAP. In Kabazi II, that pollen spectra are related to the next pollen zone XIV, representing a stadial, while in the Moldovan sites they are regarded as evidence of increased climatic continentality and cooling.

It should be mentioned that the original Bryansk soil, described from the Russian Plain, is considered as polygenetic and is correlated with the Hengelo-Denekamp time span, including the stadials in between (Velichko 1988).

The last stadial at Kabazi II, recorded in pollen zone XIV, was characterized by a sharp predominance of steppe (*Herbetum mixtum*-Gramineae) vegetation and the almost absolute disappearance of broad-leaved trees. Shrubs mainly (juniper, buckthorn, and Elaeagnaceae) represent an arboreous vegetation. During the stadial, following the Bryansk interval at Molodova I, Molodova V, and Korman IV, periglacial forest-steppe ecotones were distributed in northern Moldova (Bolikhovskaya and Pashkevich 1982; Pashkevich 1977, 1987). *Artemisia* dominated in steppe assemblages, while pine and juniper dominated in light forests. The presence of arcto-boreal elements of arboreous and grass vegetation is a notable feature. A similar vegetation type has also been demonstrated for the forest belt of Ukraine (Gerasimenko 1988). In Crimea, the climate on the plain was more harsh than in the foothills.

Thus, all stages of vegetational evolution of the Kabazi II site can be correlated with the vegetational succession of Russian Plain and represent the general climatic stages of the Late Pleistocene.

CONCLUSION

Pollen studies of the sequence at the Mousterian site Kabazi II show a complicated picture of vegetational development during the Late Pleistocene. The pollen analysis, which is corroborated by the results of the absolute chronology and pedological-lithological studies, enables the following conclusions.

The vegetational succession of the Mikulino (Eem, Kaydaky-Early Pryluky) interglacial is recorded in the lower part of the sequence. The early climatic optimum of Mikulino, dominated by hornbeam-oak forests, is separated from the late climatic optimum, represented by hornbeam forests, by a stage of cooling. The latter was characterized by the reduction of broad-leaved flora and the expansion pine and herbaceous coenoses. The Early Glacial interstadial, correlated with Brörup (Late Pryluky, Krutitsa) intervals), was characterized by forest-steppe ecotones: meadow steppes shared dominance with birch and broad-leaved formations.

The vegetation of the first stadial of the Pleniglacial (Uday?, Khotylevo), with a prevalence of grass assemblages and a decline of broad-leaved flora, indicates a more cold and continental climate than that revealed from the vegetation of the Early Glacial stadial. The latter was characterized by forest-steppe ecotones with the reduced, but still noticeable, broad-leaved assemblages.

Two interstadials and the interphasial revealed above in the sequence, are correlated respectively with Moershoofd, Hengelo, and Les Cottés. During the interstadials, meadow-steppe ecotones alternated with broad-leaved formations that spread from refugia. The proportion of the latter in the vegetational cover, however, never reached that of the interglacial. Light pine forests dominated at the interphasial. From the pollen data, the above interstadials might be correlated with the Lower Vytachiv warm substage of forest and forest-steppe belt of Ukraine. Since in the last edition of the Ukrainian Stratigraphical Scheme of Pleistocene (Veklitch 1993), the Vytachiv is correlated to the end of the Early Glacial, the correlation with Vytachiv stage is still under a question. The vegetation of the stadial between the intervals correlated with Moershoofd and Hengelo, was somewhat similar to that of the Early Glacial stadial and indicates a less cold and continental climate than of the first Pleniglacial (Uday?, Khotylevo) stadial. In contrast, the stadial following the "Les Cottes" interphasial was characterized by a considerable predominance of typical steppe ecotones, a drastic decline of broad-leaved flora, and therefore by a harsh climate.

The vegetation of the last interstadial represented in the Kabazi II sequence resembles those of the two foregoing interstadials. Broad-leaved trees spread from refugia, and mesophytization of grass coenoses took place. This stage is correlated by radiocarbon dating with the Denekamp (Bryansk) Interstadial. It is still a question whether it corresponds to the Late Vytachiv substage or to the Dofinivka stage of the Ukrainian Stratigraphical Scheme. However, on the basis of pollen data, it resembles the Late Vytachiv of the forest-forest-steppe belt of Ukraine.

The last stadial represented at Kabazi II was characterized by typical steppe vegetation, with an almost complete decline of broad-leaved trees and the appearance of drought-resistant heliophilic shrubs. Both the evolutionary changes of vegetation and climate and their dynamics during the Late Pleistocene are depicted in the vegetational succession seen at Kabazi II. The most warmth-loving (walnut) and moisture-loving (fir) species disappeared with the end of the Mikulino (Eem) Interglacial, while the boreal element birch became noticeable or even prominent. Cold-resistant juniper, buckthorn, and Elaeagnaceae appeared at the Pleniglacial, particularly at its second half. A trend towards contraction of areas occupied by arboreous vegetation can be observed, in parallel with a replacement of meadow-steppe and meadow grass assemblages by typical steppe ones. A considerable predominance of open steppe ecotones is confirmed by the appearance of typical drought-resistant steppe shrubs which are utterly heliophilic (Elaeagnaceae). This demonstrates the trend of increasing climatic cooling and continentality in the second half of the Pleniglacial. The alternation of stadial and interstadial environments show that the above trend developed in a cyclic pattern. The correlation of the Kabazi II sequence with coeval ones of the Eastern European Plain shows the same mode of vegetation dynamics at the Late Pleistocene. Nevertheless, the pollen data evidence that during all cold spells, the climate of the Crimean foothills was milder than at the plain. No arcto-boreal elements, most typical for stadials at the plain area, have been found in the Kabazi II sequence, and the proportion of broad-leaved trees was consistently higher. This suggests that the southern slope of Kabazi Mountain provided favorable conditions for the formation of broad-leaved flora refugia during Late Pleistocene cold spells. The ecosystem of the whole orographical region comprising Kabazi

II showed more stability in its Late Pleistocene vegetational development than the plain ecosystems. Possibly, it was one of the reasons that the region was densely populated by Paleolithic humans. In order to recognize the environmental conditions of the complete last glacial-interglacial cycle, an important task is to study pollen records both of the uppermost and lowermost segments of the sequence.