8 Palaeoenvironmental and dating evidence for the Unit IV-C sites: an evaluation

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Palaeoenvironmental and dating evidence for the Unit IV-C sites: an evaluation

8.1 Introduction

The aim of this chapter is to present and evaluate data pertaining to the palaeoenvironmental and chronostratigraphical context of the most important archaeological phenomena in the pit, the Unit IV-C sites. As already stressed earlier (chapter 5), we do not have a clear idea of the time interval between the formation of the Unit IV-C-I and the IV-C-III sites, and in fact all the Unit IV-C sites reported on in this volume could be considered contemporaneous in a very strict sense, i.e. in terms of hundreds of years. Before we discuss the palaeoenvironment of these sites, however, it has to be stressed that hardly any environmental indicators are known from the Unit IV-C 'upper level' sites (cf. chapter 2). As there are no geological reasons to assume large time differences between the formation of the sites at the two levels (see 5.1) the discussions in the present and the following chapters are based on the assumption that Sites A, D, F and K were formed under the same environmental and climatological conditions as the Unit IV-C-I sites, for which we do have sound evidence[1]

The data relevant to the discussion of the environment and climate during the formation of 'the' Unit IV-C archaeological assemblages will be presented in paragraph 2 of this chapter, while paragraph 3 will focus on the dating evidence.

The dating evidence and its interpretation brings us to a more general topic, that of the correlation of local events with stratigraphical schemes of a larger scale, a step which concerns the inferred 'established-fact' character of the local and the general sequences. The problems encountered in this step will be discussed in the final part of this chapter (8.4).

8.2 Environment and climate during the formation of the Unit IV-C-I archaeological assemblages

8.2.1 THE SEDIMENTOLOGICAL EVIDENCE

According to Vandenberghe *et al.* (1985) and Mücher (1985), the finely-grained Unit IV-C sediments were deposited in a low-energy fluviatile environment. Levee-like structures, bordered by backswamp-deposits and a gulley, were identified in a 115-m long section (Vandenberghe *et al.* 1985) (see also: Ruegg 1982).

The archaeological remains of Site C appeared to be situated on such a 'levee', which had been affected by karst formation. Figure 129 gives a reconstruction of the original geomorphology of the site prior to the karst disturbances, based on data obtained in the 1981-1983 field campaign. This figure was constructed as follows. The disturbances postdate the formation of the Unit 3 gravel, the top part of which is assumed to have had a more or less horizontal surface originally. The palaeorelief of Unit IV during the formation of the archaeological Site C assemblage is basically reflected by the distance between the top of the gravel layer and the surface occupied by man. The top of the Unit 3 gravels was recorded along the excavation grid-lines by means of manual and mechanical borings. The vertical distance between the top of the gravel and the average depth at which artefacts were found was plotted per square metre along the grid-lines and the cross-sections produced in this way were converted to obtain a rough approximation of the palaeorelief of the levee during the occupation of the site.

The evidence obtained in this way corresponds to data from sections not affected by karst disturbances (to the northwest of the site) and confirmed our expectations, based on the lateral grain-size sequence of the site, where the sediments were loamier in the lower northern and eastern parts and less finely-grained in the higher central, western and southern parts.

8.2.2 THE MOLLUSCAN EVIDENCE

Analysis by T. Meijer (1985) of the rich molluscan faunal remains from the Unit IV-C sediments containing the archaeological assemblages allowed a detailed reconstruction of the environment and climate during the formation of the archaeological assemblages of sites B and C. The site G assemblage occupied the same stratigraphical position. The molluscan faunal remains from site G have not yet been analysed completely but are expected to confirm the picture presented below, which is based on samples taken from a large number of sections (eleven in total; see: Meijer 1985). This paragraph summarizes Meijer's work (1985).

Section Moll.2, situated northeast of the Site C excavation in a low palaeotopographical position (fig. 130), was sampled for molluscs and the remains of small vertebrates before the Site C excavation was started. In his study of the

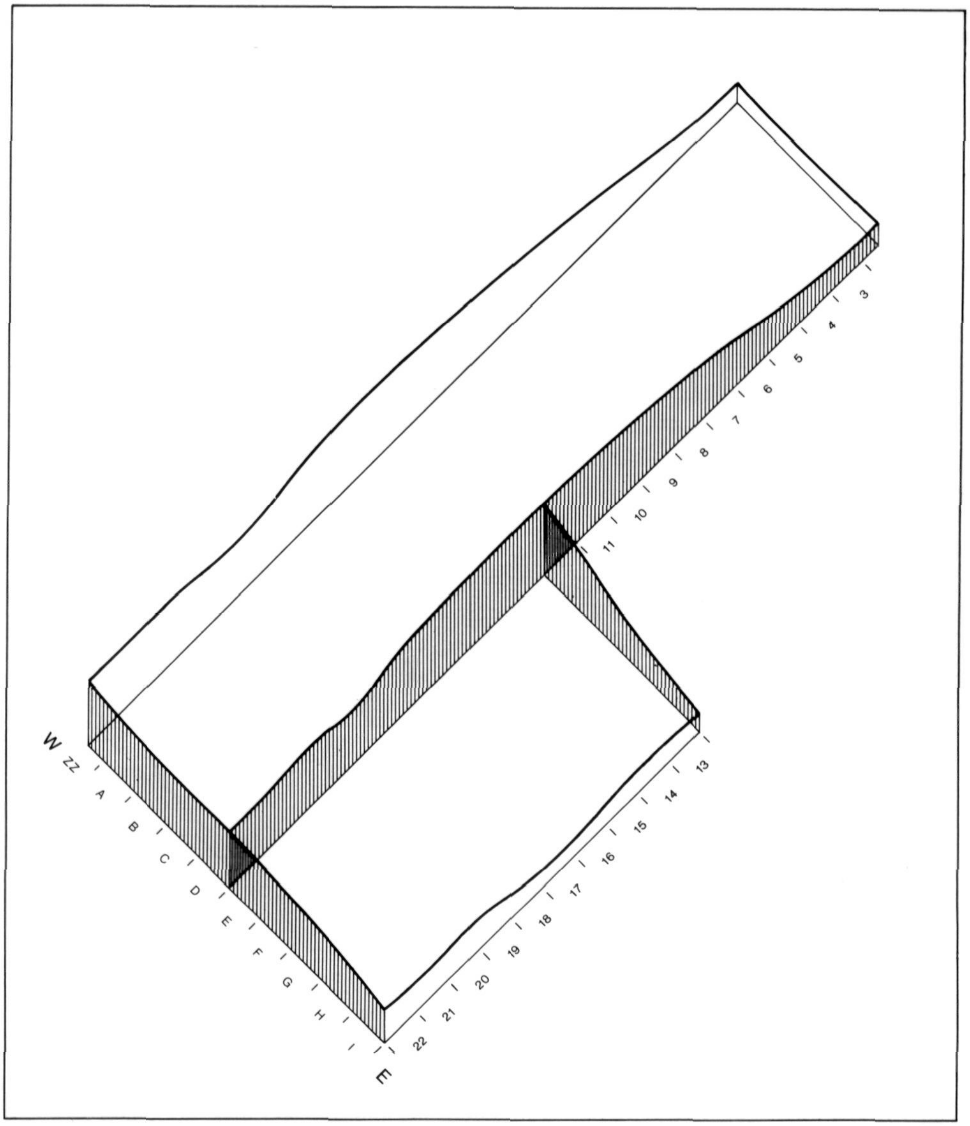

Fig. 129. Axonometric reconstruction of the morphology of the Site C area at the time of the formation of the archaeological assemblage. See the text for an explanation.

Unit IV molluscan fauna, Meijer noticed stratigraphical differences in species composition that seemed to be semi-independent of the sedimentary facies. Meijer was able to define five zones (A-E), each zone being characterized by the first occurrence of certain mollusc species at its base. These were interpreted as chronological zones (see fig. 130). The first artefacts encountered at site C were situated in the lower part of Meijer's molluscan zone D (fig. 130). Since we had ascertained that the post-depositional vertical disturbance of artefacts ranged up to 25 cm, we inferred that the archaeological assemblage of Site C had been formed at the time of the deposition of the molluscs in the upper part of zone C and the lower part of zone D. No flints were found in the calcareous tufa in the upper half of zone D and zone E, nor at Site C itself or anywhere else in the Belvédère pit.

In the immediate surroundings of the area sampled a pool of gently flowing to stagnant water with a maximum depth of 1.5 to 2 m was indicated in the composition of the fauna. The area itself was protected from the main stream of the river and had a dense aquatic vegetation, which Meijer has described as a lacustrine 'niche' in a mainly fluviatile environment. Along its borders this vegetation was of the Magnocaricion type, which grows in marshy places with at most about 20 cm of water. Periodically, perhaps in the winter, the borders on which the vegetation grew dried out. In all probability the majority of the sites sampled and analysed by Meijer in molluscan zones C-E were situated near or formed part of this Magnocaricion vegetation belt.

At a higher level in the palaeotopography the Magnocaricion was mixed with -or bordered by- alder (*Alnus*) forests with ash trees (*Fraxinus*; charcoal remains of *Fraxinus* were

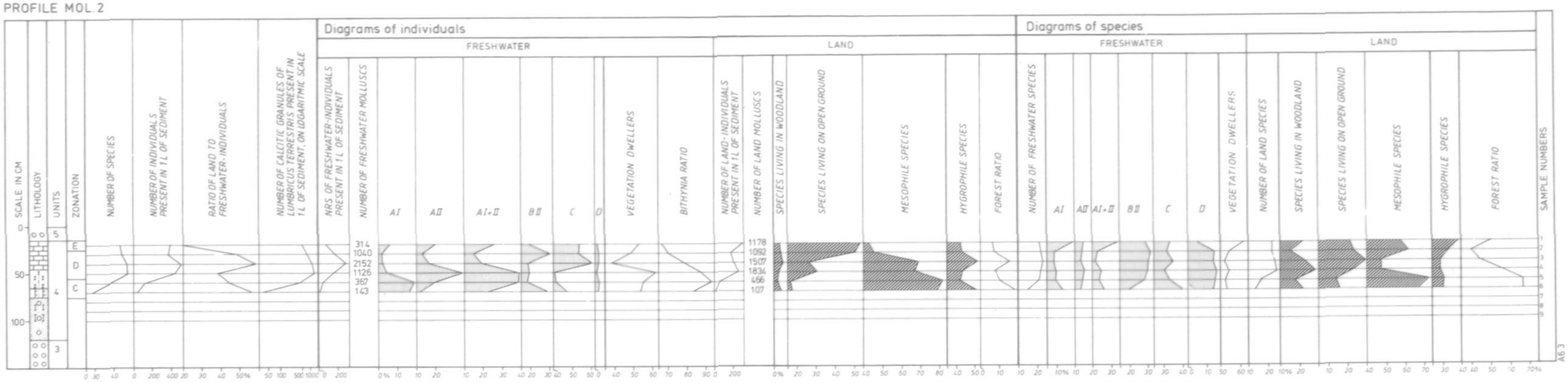

Fig. 130. Profile Moll.2, situated at the northeastern border of Site C (from Meijer 1985, figure 3).
A, B, C and D of the freshwater ecological diagrams refer to species of:

- marshes (A-I),
- stagnant, poorly vegetated waters (B-I),
- stagnant, well vegetated waters (B-II, B= B-I + B-II),
- stagnant and flowing waters (C)
- flowing waters (D).

The Bithynia ratio reflects sorting effects caused by movement of the water, a 1:1 ratio of opercula and shells being expressed as 50%, and a 2:1 ratio as 100% (see Meijer 1985).

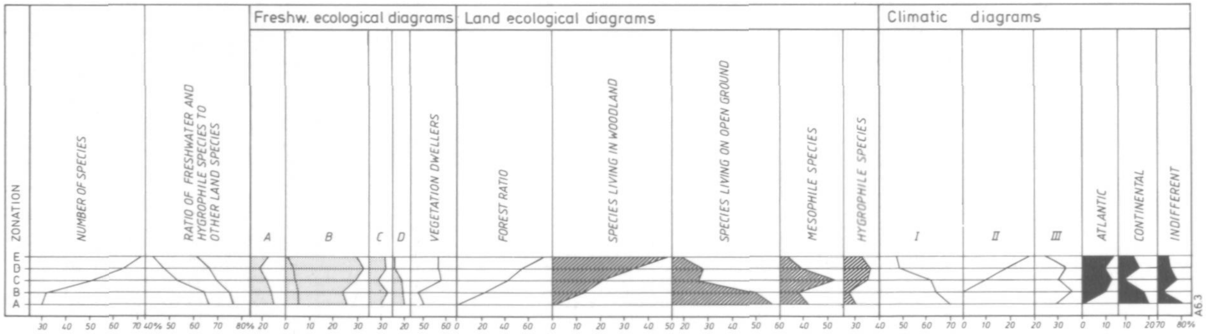

Fig. 131. Diagrams of mollusc species based on a compilation of all species present in each zone (from Meijer 1985, figure 6). See fig. 130.
I, II and III in the climatic diagrams indicate:

I species extending north of the arctic circle, most of these are common on the European mainland too; species with a restricted arctic distribution are absent in Unit 4.

II species with a habitat extending to the arctic circle or not far south of it.

III species with a habitat extending only to the southernmost part of Scandinavia or confined to the European mainland.

found at Site C). On even higher grounds the alder woods changed into deciduous forests of drier habitats; there the vegetation could have been of an open forest type with an abundant undergrowth and a dense vegetation of grasses and herbs in open areas. The possibility that there was a pine forest or a dense deciduous forest with little or no undergrowth can be excluded. The forests of the drier habitat may have been of the Fago-Quercetum type with an admixture of hazel. According to Meijer (1985), there are indications that *Ilex* also grew here. Open areas had a dense vegetation of grasses and herbs. Finally, it is to be stressed again that this reconstruction of vegetational characteristics is based solely on the study of *mollusc* assemblages!

As can be seen in figure 131 (taken from Meijer 1985), a climatic transition took place during the deposition of the Unit IV sediments. The evidence points to a slightly more continental climate before zone D than afterwards. This is in accordance with the results obtained in the study of vertebrate remains by Van Kolfschoten (1985), who arrived at an identical climatic transition (see 8.2.3).

The climatic trends are well expressed by the development of the *terrestrial* fauna. The percentage of molluscan species living in woodland environments increases from 0% in zone A to almost 50% in zone E; the percentages of species living in open terrain decreases from 58% in A to 18% in E.

Seventy species were identified in zone E; this number and the variety in species indicate the 'interglacial' status of the fauna. The most important species are *Bithynia troscheli*, which occurs in Lower and Middle Pleistocene interglacial deposits in the Netherlands, *Corbicula fluminalis*, which is associated with warm-temperate stages, *Spermodea lamellata*, which is characteristic of old woodland, and *Zonitoides sepultus*, which is an extinct species that lived in moist deciduous forests on calcareous soils and is known from Lower and Middle Pleistocene pre-Eemian interglacial deposits.

Meijer also inferred absolute data on the climate during the formation of the archaeological assemblage by comparison with the present living conditions of the various molluscan species. He concluded that the zones from zone D upward had been formed in a climate characterized by high annual rainfall (at least 800 mm vs. less than 700 mm at present). The mean annual temperature was at least 10°C (today 9.5-10°C). Mean July temperatures were certainly not below 15°C and probably reached 18°C (today 17.5°C). Mean January temperatures were more difficult to estimate, but were certainly above 0°C (today 2-2.5°C).

According to Meijer, the climatic optimum was reached in molluscan zone D, since no new mollusc species of the most demanding climate group were found in zone E, which zone contained evidence of species occurring in old woodland.

The preliminary results of the analysis of the Site G molluscan fauna (Duistermaat 1987) are essentially the same as those arrived at by Meijer (1985).

At Site G the Unit 4 sediment of 14 m^2 was sieved through a 0.5-mm mesh screen in levels of 5 cm. Duistermaat (1987) analysed the sieve residue from square 48/106. The species composition of the fauna was comparable to that of Meijer's molluscan zones D and E. In the Site G faunal remains, however, four species were identified which were not represented in the remains analysed by Meijer: *Azeca goodalli*, *Belgrandia marginata*, *Cochlodina laminata* and *Vertigo alpestris* (see 8.4.2).

The *freshwater* faunal remains point to the proximity of gently flowing to stagnant water; at Site G itself the picture is dominated by stagnant water, rich in vegetation, which gradually changed into a swamp. Furthermore, the fauna points to the presence of a Magnocaricion vegetation with dispersed alder-carrs. Like Meijer (1985), Duistermaat infers that a mixed deciduous forest grew on higher grounds. Finally, it is worth mentioning that the number of forest species indeed gradually increases in upward direction in the Site G section, but that the archaeological remains were deposited in a period in which the number of forest species had decreased significantly. The molluscan evidence indicates that the site G artefacts were deposited in a period in which the area formed a temporarily open place in a forested environment.

8.2.3 THE VERTEBRATE EVIDENCE

The results of Van Kolfschoten's (1985) study of the vertebrate remains collected from Unit IV (Units IV-A/IV-C) support Meijer's (1985) ideas on the climatological transition during the formation of Unit IV.

The faunal remains collected in the (mostly sandy) lower parts of Unit IV (IV-A/IV-B) (Van Kolfschoten's 1985 Fauna 3; see table 19) included steppe elements, for example steppe pika, *Ochotona pusilla*, ground squirrel, *Spermophilus* cf. *undulatus*, and hamster, *Cricetus cricetus praeglacialis*, which led Van Kolfschoten to conclude that the sediments had been deposited in a steppe environment, in a temperate continental climate. Species indicating the presence of woods may have come from the upper part of the IV-A/IV-B sequence (Van Kolfschoten, in press).

In 1987, Unit 4.4 yielded a large number of articulated bones of an almost complete skeleton of an adult steppe rhinoceros, *Dicerorhinus hemitoechus*, found over an area of about 7 m2 (Van Kolfschoten 1988). Figure 132 shows bones from the hind legs of this individual, while figure 133 shows a series of upper jaw molars. Close to this skeleton, which was partially saved from destruction by quarrying activities by De Warrimont and Groenendijk (1988), an ulna of another, more robust rhinoceros individual was found. These remains were not associated with any arte-

Table 19: Composition of the vertebrate faunal remains from the lower part of Unit IV (IV-A/B) (Fauna 3 in: Van Kolfschoten 1985).

fish:	
Leuciscus cephalus	chub
Chondrostoma nasus	nase
mammals:	
Talpa europaea	mole
Sorex araneus	common shrew
Neomys fodiens	water shrew
Ochotona pusilla	steppe pika
Spermophilus cf. *undulatus*	ground squirrel
Cricetus cricetus praeglacialis	hamster
Clethrionomys glareolus	bank vole
Arvicola terrestris	water vole
Microtus gregalis	narrow-skulled vole
Microtus arvalis and/or *Microtus agrestis*	vole
Microtus sp.	vole
Apodemus sylvaticus	wood mouse
Apodemus maastrichtiensis	
Mammuthus sp.	mammoth
Dicerorhinus hemitoechus	steppe rhinoceros

Table 20: Composition of the vertebrate faunal remains from the upper part of Unit IV (IV-C-I/II) (Fauna 4 in: Van Kolfschoten 1985; also: Van Kolfschoten in press).

fish:	
Leuciscus cephalus	chub
Chondrostoma nasus	nase
Esox lucius	pike
reptiles:	
Emys orbicularis	European pond tortoise
birds:	
Anatidae indet.	
mammals:	
Erinaceus cf. *davidi*	hedgehog
Talpa europea	mole
Sorex araneus	common shrew
Sorex minutus	pygmy shrew
Neomys fodiens	water shrew
Crocidura sp.	
Eliomys quercinus	garden dormouse
Clethrionomys glareolus	bank vole
Arvicola terrestris	water vole
Pitymys cf. *subterraneus*	pine vole
Microtus oeconomus	root vole
Microtus agrestis	short-tailed vole
Microtus arvalis	common vole
Apodemus sylvaticus	wood mouse
Apodemus maastrichtiensis	
Mustela cf. *nivalis*	weasel
Elephantidae indet.	
Elephas cf. *antiquus*	straight-tusked elephant
Dicerorhinus hemitoechus	steppe rhinoceros
Bovidae indet.	
Cervus elaphus	red deer
Cervus (M.) giganteus	giant deer
Capreolus capreolus	roe deer

facts, and belong to the 'natural background fauna' (see chapter 9.4).

The faunal remains of the lower part of Unit IV and also the faunal assemblages higher up in the Unit IV sediments included remains of a small- to medium-sized murid, *Apodemus*, which, according to Van Kolfschoten (1985), differs from all other *Apodemus* species in the steepness of the slopes of the cusps in its lower molars. Van Kolfschoten has named this species *Apodemus maastrichtiensis* after the town of Maastricht. Other sites from which this species is known are Fransche Kamp at Wageningen (the Netherlands) and Miesenheim (West Germany), both Middle Pleistocene sites, dating from an intra-Saalian warm-temperate and a pre-Saalian warm-temperate phase, respectively.

The faunal remains of the upper part of Unit IV -where human activities are attested (Unit IV-C)- do not include steppe species, but instead a great number of species indicative of a more humid environment. Table 20 (Van Kolfschoten 1985) lists the vertebrate species present in Unit IV-C-I/II.

That there were deciduous woods and also open country in the vicinity is indicated by the composition of the faunal assemblage of small mammals. Noteworthy is the presence of the garden dormouse *Eliomys quercinus*, which inhabits deciduous and mixed forests and is nowadays widely distributed in the southern part of western Europe up to the (southern part of the) Netherlands.

A rather warm climate is indicated by the presence of the European pond tortoise *Emys orbicularis*, which inhabits ponds, lakes and rivers with calm waters (Stuart 1979, 1982), and requires mean July temperatures exceeding 17-18°C to hatch its eggs. The northern limits of its current breeding range in northwestern Europe lie to the south of the Netherlands. Further eastwards, in central Europe, it extends further to the north (Stuart 1982).

The larger mammals convey the same impression of the environment as the smaller ones. The weasel *Mustela nivalis* lives in forests with a high, dense vegetation. The rhinoceros *Dicerorhinus hemitoechus* and the giant deer *Cervus (M.) giganteus* are associated with open areas. Nowadays, the red deer *Cervus elaphus* prefers a temperate climate and a wooded habitat, but it has proven to be a very adaptive species (Van Kolfschoten 1985). Finally, *Capreolus capreolus*, roe deer, prefers a forested habitat.

To summarize, the species represented in Van Kolfschoten's Belvédère Fauna 4 indicate that Unit IV-C was deposited in an environment consisting of grasslands and forests and in a warm-temperate climate, which might have been somewhat warmer than our present-day climate.

8.2.4 THE PALAEOBOTANICAL EVIDENCE

Despite intensive research at pollen laboratories of the Institute of Prehistory of Leiden University and the State Geological Survey Haarlem, no fossil pollen has been found in the Unit IV sediments (De Jong 1982). The only palaeobotanical evidence from Unit IV consists of tiny charcoal particles, most of which were found at Site C. A sample of a small concentration of charcoal particles found in the eastern part of Site C was analysed by W. Schoch (Labor für Quartäre Hölzer, Birmensdorf, Switzerland), who determined that they came from coniferous as well as from deciduous trees (Schoch, in litt. 1982). He identified eight particles from the larger charcoal concentration in the western part of the site as *Fraxinus* sp. (Schoch, in litt. 1982) and a piece of charcoal collected in the upper part of Unit IV (Unit IV-B or IV-C) in the neighbourhood of Site G as cf. *Quercus* (Schoch, in litt. 1982).

8.2.5 DISCUSSION

In the previous sections data have been presented that are relevant for reconstructing the palaeoenvironment and the climate during the formation of the Unit IV-C archaeological assemblages. Even though they are based on various kinds of evidence and relate to different parts of the palaeoenvironment on different scales, these data support each other. The sedimentological evidence, for example, is confined to the river sedimentation area, while the molluscan assemblages provide information about a larger area, mainly the river valley. The larger vertebrates certainly roamed an area that was much more extensive than the river valley. The small mammal assemblage is partly a product of the activities of birds of prey, such as kestrel and buzzard (Mayhew 1977; Van Kolfschoten, pers.comm., 1985). The role of the predatory birds in the accumulation of fossil remains of small mammals in open sedimentary environments has been stressed by Mayhew (1977) in an examination of the Cromerian Upper Freshwater Bed sediments at West Runton, England. Mayhew also stressed that the excellent state of preservation of vertebrate material in owl pellets means that teeth of small mammals contained in these pellets cannot be distinguished from teeth incorporated from most other sources, except pellets of diurnal raptors. The Unit IV assemblage of remains of small mammals, therefore *partly* represents the biotope of diurnal birds of prey, filtered through their food preferences.

Finally, it is worth mentioning that large herbivorous mammals such as elephants and rhinoceros may have been partly responsible for the presence of grasslands as indicated by the molluscan and small mammal evidence presented above. Lock (1972) has given a detailed description of the effects of grazing by *Hippopotamus* in the grasslands of East Africa, and has shown that these animals are the main cause of the observed zonation of vegetation alongside permanent water sources. Turner (1975) has suggested that large Pleistocene herbivores like rhinoceros and elephants may have had a considerable effect on the vegetation by means of their grazing, browsing and trampling activities, which could have effectuated an increase in open terrains at the cost of woodland. Turner furthermore stresses that pollen spectra of sites with rich fossil vertebrate faunas have to be interpreted very carefully because false interpretations are possible on two levels: in the study of the local vegetational succession and in comparisons with other pollen spectra, which may have been affected less by 'disturbance' by larger herbivores (Turner 1975: 18).

8.3 Unit IV-C: the dating evidence

8.3.1 RELATIVE DATING EVIDENCE

8.3.1.1 Terrace stratigraphy

At Belvédère the Unit III gravels of the Caberg terrace are overlain by the fine-grained Unit IV sediments, which are genetically related to the deposition of the gravels. Unit IV was deposited towards the end of the 'Caberg Maas' activity, when less energetic conditions prevailed (Vandenberghe *et al.* 1985). According to Paulissen (1973), the Caberg Terrace can be dated to an earlier part of the Saalian. Paulissen recorded an Eemian soil that had been formed in coversands on top of the Middle Terrace of Eisden-Lanklaar (see chapter 2), which is separated from the higher Caberg Terrace by an important erosive period. Paulissen dates the Caberg Terrace to Riss I and the terrace of Eisden-Lanklaar to Riss II.

On the basis of the terrace chronology, the Unit IV assemblages therefore have to be dated to the Saalian, that is, if 'Riss' is correlated with the 'Saalian'.

8.3.1.2 Palaeosols and loess-stratigraphy

As shown above (chapter 2), the soil that had developed in the top part of the Unit IV/V-A complex is overlain by Unit V-B deposits, the upper part of which consists mainly of redeposited loess (Vandenberghe *et al.* 1985). On top of Unit V-B a distinct argillic horizon was observed, which is correlated with the Eemian Rocourt palaeosol (Mücher 1985). According to its heavy mineral associations, the loessic parent material of this luvisol dates from a pre-Weichselian loess cycle (Meijs 1985).

These data point to a Saalian or pre-Saalian date for the formation of the Unit IV assemblages.

8.3.1.3 Biostratigraphy

1. The mammalian faunal remains collected in the Belvédère pit provide the basis for assigning a *terminus ante quem*

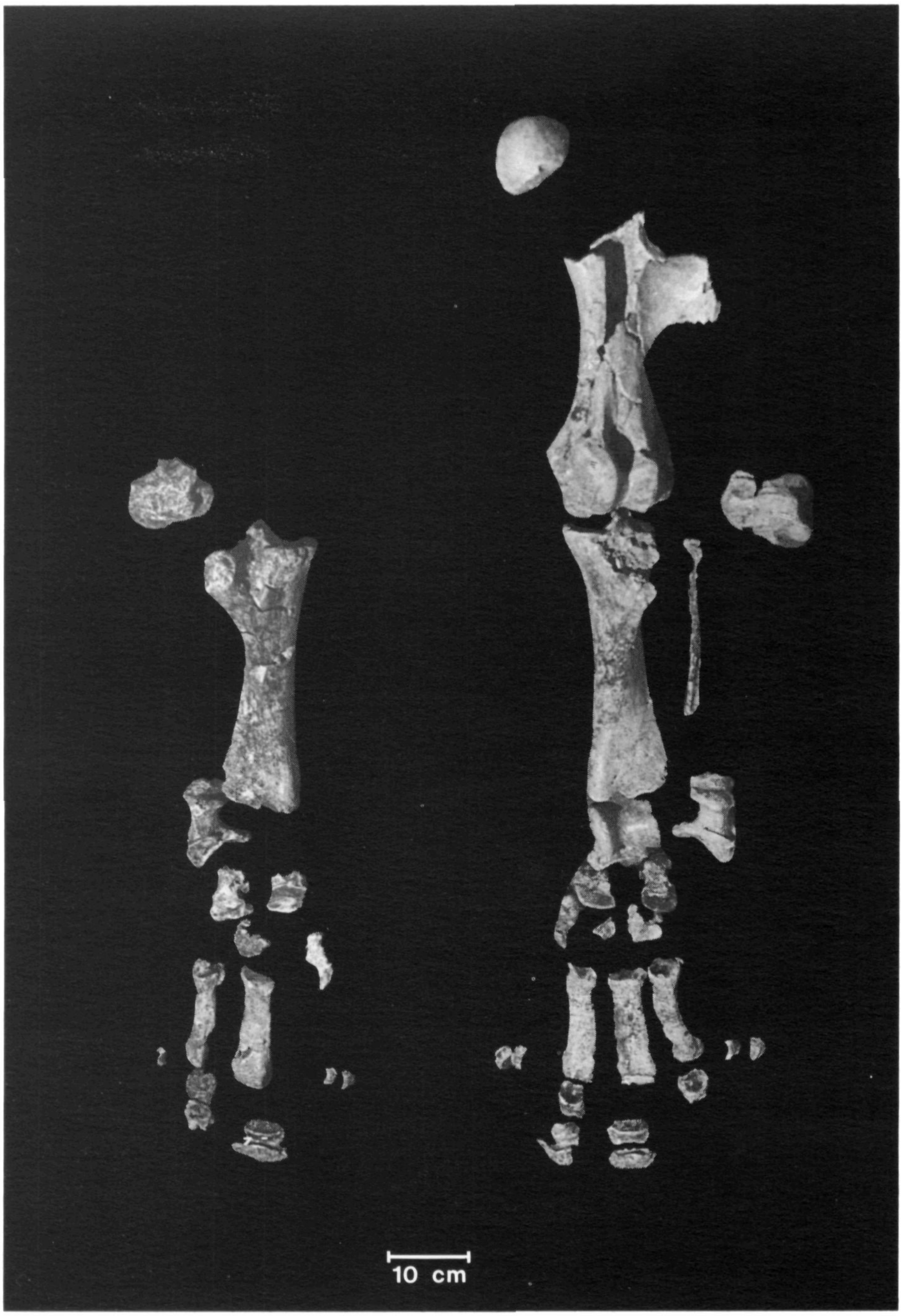

Fig. 132. Bones from the hind legs of a *Dicerorhinus hemitoechus* individual found in 1987 in Unit 4.4. sediments.

and a *terminus post quem* to Unit IV and the formation of the archaeological assemblages (Van Kolfschoten 1985).

a: *Terminus ante quem*: The faunal assemblage of Unit IV included the remains of a subspecies of watervole (*Arvicola terrestris*) which has a type of differentiation in enamel thickness that is more primitive than that of *A.terrestris* found at Rhenen (central Netherlands) in ice-pushed sediments that were deposited before the advance of the Saalian ice-sheet (Van Kolfschoten 1981, 1985, in press)[2]. The Belvédère Unit IV-C faunal remains, and consequently also the formation of the Unit IV-C archaeological assemblage, can be placed in a warm-temperate climatic stage well before the advance of the Saalian glacier in the central Netherlands.

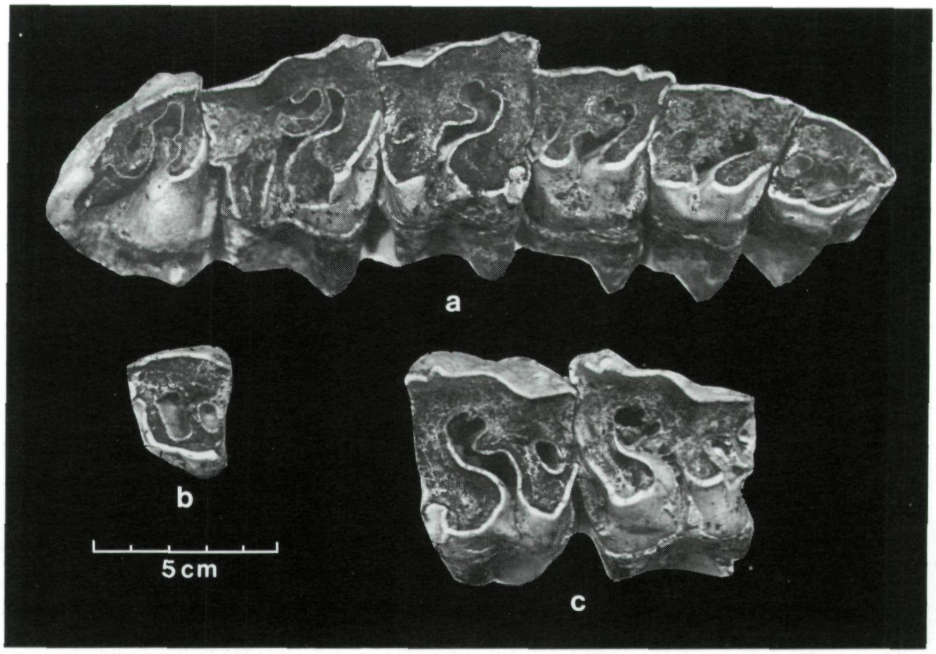

Fig. 133. Dental elements from the upper jaw of a *Dicerorhinus hemitoechus* found in 1987 in Unit 4.4. sediments.
a P2-M3 dext. (from right to left)
b P2 sin.
c M1 and M2 sin.

b: *Terminus post quem*: In the Unit III gravels underlying the finely-grained fluviatile deposits of Unit IV the remains of woolly rhinoceros (*Coelodonta antiquitatis*) and mammoth (*Mammuthus primigenius*) were found. According to present knowledge these two species do not occur in deposits older than the Saalian and its stratigraphical equivalent, the Riss glacial of central and southwestern Europe (Van Kolfschoten 1985).
The picture emerging from these data allows us to place the faunal assemblage between the Holsteinian and the advance of the Saalian ice sheet in the central Netherlands (Van Kolfschoten 1985). Therefore, the warm-temperate stage of Unit IV-C must be intra-Saalian.

2. According to Meijer (1985), the rich molluscan assemblage from Unit IV-C (76 identified species) has to be dated to an interglacial stage. In Meijer's opinion, this stage must predate the Eemian and postdate the Holsteinian.
3. The combined biostratigraphical evidence, based on analyses of the mammal and molluscan faunal remains from Unit IV-C, allows us to date the Unit IV-C assemblages to a warm-temperate intra-Saalian climatic phase between the Holsteinian and the advance of the Saalian ice sheet in the central Netherlands.

8.3.2 ABSOLUTE DATING EVIDENCE

8.3.2.1 Thermoluminescence dating

Table 21 gives the individual ages of the analysed flints, as published by Huxtable and Aitken (1985), together with some new results obtained with burnt flints from Site G and Site K. These new results confirm the TL age published for Unit IV, which was based on the measurement of four flints found close to one another at Site C (K4, 5, 6 and 13) and one burnt flint from Site F (K11). The average age obtained was 270 ka (± 11, ± 22 ka, OxTL 712k). According to Huxtable and Aitken (1985), the inclusion of K12 (a burnt flint found in a section) and K14 (one of the first Site G finds recovered outside the excavated area) would reduce this age by only 3%. The first error limit gives the standard error derived from the scatter of the individual ages around

Table 21: TL ages obtained for burnt flints from the IV-C deposits at Maastricht-Belvédère, based on data in Huxtable and Aitken 1985: Huxtable, pers.comm., 1986-1987 (see fig. 134).
* K17, K19 and K23 are single age determinations, which have not yet been incorporated in the average age.

context	find No.	Oxford Laboratory reference	TL age
Site C	Az 12/19	712 K4	300 ± 32 ka
Site C	Cz 19/15	712 K5	263 ± 27 ka
Site C	Bz 20/2	712 K6	238 ± 20 ka
Site F	22/22-44	712 K11	307 ± 28 ka
Unit 4.5	dW 84/2	712 K12	250 ± 21 ka
Unit 4.5	dW 84/1	712 K13	269 ± 26 ka
Site G	1984 11/bf	712 K14	219 ± 20 ka
Site G	49/106-2	712 K17*	238 ± 25 ka
Site G	46/105-10	712 K19*	220 ± 20 ka
Site K	7/203-1	712 K23*	218 ± 24 ka

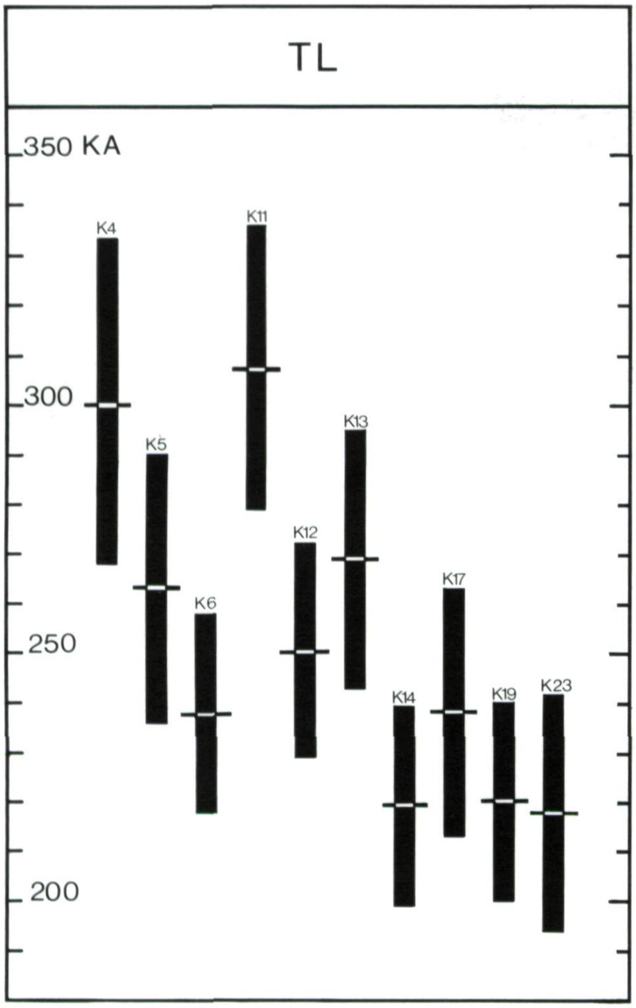

Fig. 134. Scatter of the individual TL ages of burnt flints from Unit IV-C (see table 21).

the mean value, while the second one is the predicted error, which is based on results from all quantifiable sources of uncertainty (Huxtable/Aitken 1985). With 68% confidence the age can be said to lie within a range of 250-290 ka, and with 95% confidence within a range of 225-315 ka.

After the publication of the age of 270 ± 22 ka, two more burnt flints found in the 1985 excavation of Site G, K17 and K19, and one from Site K (K23) were dated. The TL ages of these three flints are shown in table 21. Eventually, these three single age determinations will be incorporated in a new average age. This has not been done yet because the Oxford Research Laboratory is still working on samples from Belvédère.

An 'absolute' *terminus ante quem* for the formation of the Unit IV-C assemblages of 175 ± 35 ka was obtained by TL dating of a calcite concretion ('*loess kindl*') found in the top part of Unit IV-C, near Site G (Huxtable/Aitken 1985). These calcite concretions were probably formed during the first period of soil formation, i.e. during the formation of the soil in the top part of the Unit IV/Unit V-A complex.

It should be mentioned here that for the Belvédère TL age determinations on-site measurements were made with the aid of TL capsules and by means of a portable gamma spectrometer (Huxtable/Aitken 1985). Furthermore, because the annual dose, determined by both laboratory and on-site measurements, is influenced by the water content of the sample and the soil in antiquity, uncertainty about the water content is one of the factors that limit the accuracy attainable. Therefore, the author called in the help of Messrs Burrough, Dirksen and Van der Westeringh, (who at that time worked at the Agricultural University of Wageningen) who analysed the moisture content of the Site C/Unit 4.5 matrix (see Huxtable/Aitken 1985). Further TL dating work by the Oxford laboratory is in progress.

8.3.2.2 Electron Spin Resonance dating

R. Grün and O. Katzenberg (University of Cologne, West Germany) analysed a mollusc sample and five tooth-fragments from Unit IV-C for ESR dating purposes (for details of this dating method see Grün *et al.* 1987). The environmental radiation dose of the investigated sample was known only for the mollusc assemblage, which was collected especially for the ESR dating programme. The environmental radiation dose of the tooth-fragments, which were collected in 1981 and 1982, had to be estimated in the 1985 ESR analysis.

Enamel and dentine of fossil teeth always show higher uranium contents than recent teeth. In ESR dating of teeth the question is how and when the uranium uptake took place. For the Belvédère sample Grün calculated two ages, one using an *Early Uptake* (EU) model, in which the uranium migrated into the dentine and enamel shortly after the tooth was buried, and a *Lineair Uptake* (LU) age, which is based on the assumption that uranium was absorbed at a constant rate after the time of burial of the tooth. LU dates tend to agree with independent age assessments made with other methods, whereas EU dates are normally younger, down to about half of LU dates (Grün *et al.* 1987; Schwarcz *et al.* 1988). The age determinations of the Belvédère material yielded a rather large scatter of ages with an average LU age of c. 200 ka, and an EU age of c. 170 ka (Grün, pers.comm., 1985 and 1987). It should be noted that these are only preliminary results, and that further work on teeth samples from Belvédère is in progress.

ESR analysis of the mollusc sample provided results that were consistent with the TL dating evidence and that gave the Unit IV-C assemblages a provisional ESR age of 220 ± 40 ka (Grün/Katzenberg, pers.comm., 1985). Further ESR dating work is in progress.

8.3.3 DISCUSSION

The combined dating evidence, which is schematically summarized in table 22, points to a warm-temperate period between the Dutch Holsteinian Interglacial and the arrival of the Saalian ice-sheet in the central Netherlands. According to the TL dates and the provisional ESR dating results, this warm-temperate period can be placed *roughly* around 250 ka.

The accepted Dutch stratigraphy for this part of the Middle Pleistocene (figure 135, after Zagwijn 1973) is based primarily on a combination of the classic geomorphological northern European model and detailed pollen analysis. Although the Belvédère biostratigraphy is based on faunal evidence, we may assume that the warm-temperate Unit IV deposits were formed in the relatively warm early Saalian *Hoogeveen Interstadial* (Zagwijn 1973), which is represented in pollen diagrams between Holsteinian beds and late Saalian tills. In his 1973 paper in which he presented the Hoogeveen Interstadial, Zagwijn argued that this temperate phase could be classified as an 'interglacial', but 'For the time being ...', he writes, '... it is preferred to classify the temperate stage ... as an interstadial of the Saalian glaciation ...' (Zagwijn 1973: 154). This preference is based on two arguments. First, it seemed to be a relatively short phase as compared with the Holsteinian interglacial. Secondly, -maybe as a result of this short time range- *Pinus* and *Betula* were still the dominant trees in his diagrams. There was a short cold interval between the Hoogeveen Interstadial and the somewhat cooler *Bantega interstadial* (figure 135).

Turning now to the Oxygen Isotope Stratigraphy, which is the main chronological framework of the Pleistocene, we have to consider that oceanic and terrestrial events can usually only be correlated by means of geochronometric dating (Roebroeks 1986a). However, the current limits of geochronometric dating techniques and the relative values of the estimated dates of the different ^{16}O/^{18}O stages (Shackleton/Opdyke 1976) make correlating oceanic and

Table 22: Schematic representation of the methods employed to date the Unit IV-C deposits and the results obtained. The *maximum* range of individual TL ages as shown in table 21 is given between brackets.

Dating Method	Results
1. Terrace stratigraphy	'intra-Saalian'
2. Paleosols and loess-stratigraphy	'intra- or pre-Saalian'
3. Biostratigraphy	post-Holsteinian and predating the arrival of the Saalian ice cover
4. TL age determination	270 ± 22 ka (194-332 ka)
– *terminus ante quem*	175 ± 35 ka
5. ESR (molluscs)	220 ± 40 ka

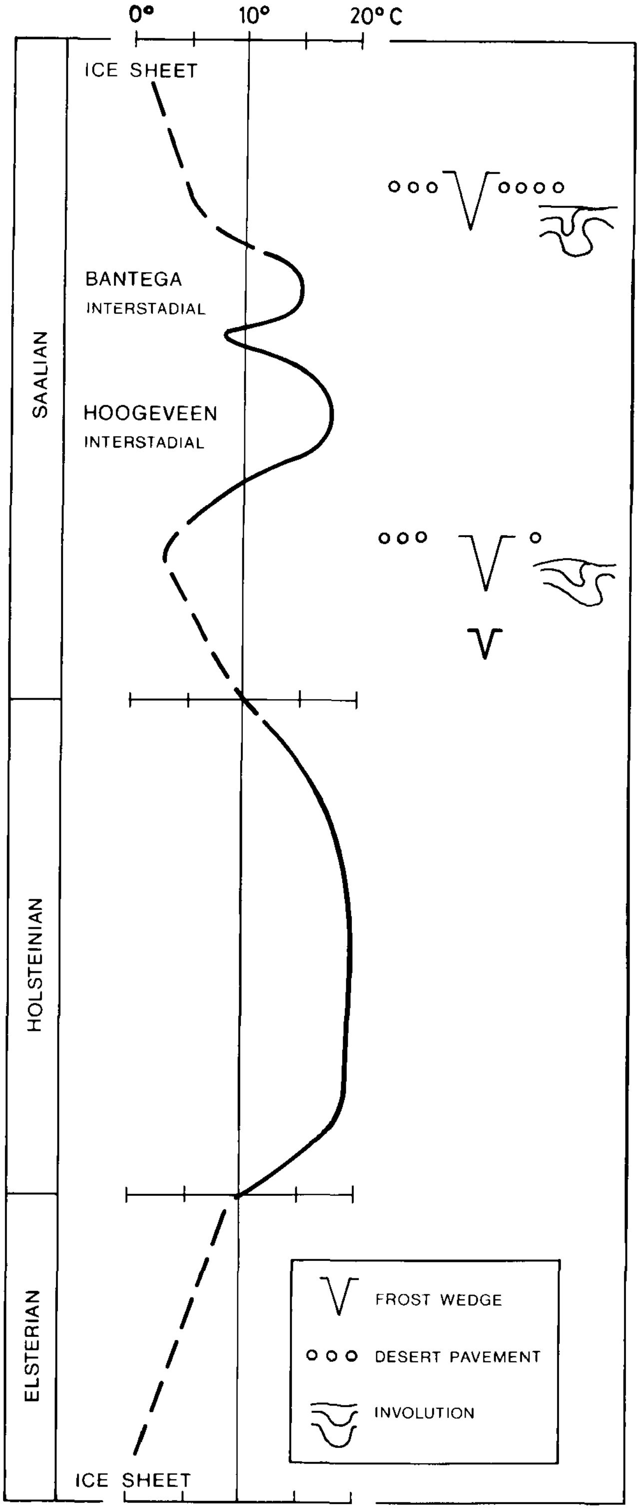

Fig. 135. Estimated changes in mean summer temperatures from Elsterian to Saalian times (redrawn, after Zagwijn 1973).

terrestrial events a hazardous enterprise. If, however, we wish to play the 'Oceanic-Terrestrial Game' the current state of research allows us to suggest that the Unit IV-C warm-temperate phase can be correlated with Stage 7 of core V28-238 (Shackleton/Opdyke 1973). The estimated date of Stage 7 in cores V28-238 and V28-239 is 195-251 ka (Shackleton/Opdyke 1973, 1976). The age of this stage is relatively well known thanks to the presence of a volcanic ash layer in several Pacific cores, dated by means of the K/Ar method to around 230 ka (Ninkovich/Shackleton 1975). Two separate periods have been distinguished in the Stage 7 period of low ice volume, subdivided by Stage 7b, which began around 230 ka and was characterized by a significant increase in ice volume. This Stage 7b period of ice advance is considered by some authors to represent a global 'short ice age' (Ruddiman/McIntyre 1982; Andrews 1983).

The current dating evidence for the Belvédère Unit IV-C sediments does not allow correlation of the Unit IV-C warm-temperate phase with one of the two substages of low ice volume that can be distinguished within Stage 7.

An important implication of the proposed correlation of the intra-Saalian warm-temperate phase attested at Maastricht-Belvédère with Oxygen Isotope Stage 7 is that the Dutch Holsteinian interglacial has to be correlated with Oxygen Isotope Stage 9 or an even earlier odd-numbered Stage (but see 8.4.3).

8.4 The chronological background: an evaluation

8.4.1 INTRODUCTION

In the course of the interdisciplinary investigation of the Belvédère pit a considerable amount of time and energy has been -and still is- invested in the study and description of sections and the identification of the lithological units as the necessary basis for the local lithostratigraphy, which in turn, is the basis for the establishment of a chronological framework for the study of the archaeological finds.

Earlier in this chapter we have discussed the various different types of relative and 'absolute' dating evidence used in this approach. We have furthermore tried to interpret the local stratigraphical records of the pit in terms of Quaternary history against the background of other frameworks, such as the pollen-based chronostratigraphical subdivision of the Dutch Pleistocene and the oxygen isotope record.

These excercises in correlation may have seemed relatively simple and straightforward in view of the 'fits' which were found between the chronology of the Belvédère framework and other chronologies of Quaternary events. However, the 'mighty state of confusion' (Hubbard 1982) in Middle Pleistocene stratigraphy cannot be overstressed in Palaeolithic archaeology, in which many scholars are trying to study changes in human behaviour on Pleistocene timescales. It is the classification of the locally recorded events in terms of Quaternary history that gives rise to most problems:

> 'Tendencies to oversimplify in this way lead to new discoveries being forced into a pigeon-holed classification. Such arbitrary methods tend to perpetuate an illusion of security and precision in an apparently repeated confirmation of the original model. This tendency to confirm discoveries from limited amounts of data has been called *The Reinforcement Syndrome* by Watkins (1971).' (Bowen 1978: 8)

In order to stress that an interpretation of the Belvédère dating evidence in terms of Quaternary history schemes should only be regarded as a valuable working hypothesis, this paragraph will deal briefly with some of the basic assumptions of the general Quaternary schemes referred to above. We will see that (in addition to the presented 'fit-options') alternative interpretations are still possible.

8.4.2 BIOSTRATIGRAPHICAL SUBDIVISION OF THE DUTCH QUATERNARY

The biostratigraphical subdivision of the Dutch Quaternary beds is based mainly on pollen analysis (Zagwijn 1985) (see fig. 136). Meijer (1986) has presented a preliminary, non-marine mollusc biozonation of the Dutch Quaternary, while Van Kolfschoten is working on an improved vertebrate zonation (Van Kolfschoten 1985, in press).

The pollen evidence:
So far, pollen analysis has revealed 15 stages of warm-temperate climatic conditions after the first major cooling of the pre-Tiglian cold stage, which started about 2.3 million years ago. Zagwijn (1985: 18) has given a review of the different chronostratigraphical subdivisions of the Pleistocene of the Netherlands applied since 1950, showing that the number of cold and warm phases identified has increased dramatically in the last decades. The climate curve currently in use (fig. 136) has a time scale based on
- radiocarbon dates of up to 50 ka
- the first influx of augite in fluvial Rhine sediments, connected with 400-500 ka old lava flows in the Eifel
- palaeomagnetic data for the periods before 700 ka.

Zagwijn observed some striking similarities in the Dutch Quaternary climate curve and the oxygen isotope stratigraphy, '... but more dating checks would be needed to demonstrate an exact match ...' (Zagwijn 1985: 20). One of the warm-temperate phases whose 'absolute' age is the subject of a heated international discussion is 'the' Holstein interglacial (Zagwijn 1973). We will return to this topic later on in this paragraph.

The basic assumption in this approach is that individual temperate phases produce distinguishable pollen sequences. Zagwijn *et al.* (1971) have pointed to the inherent danger in

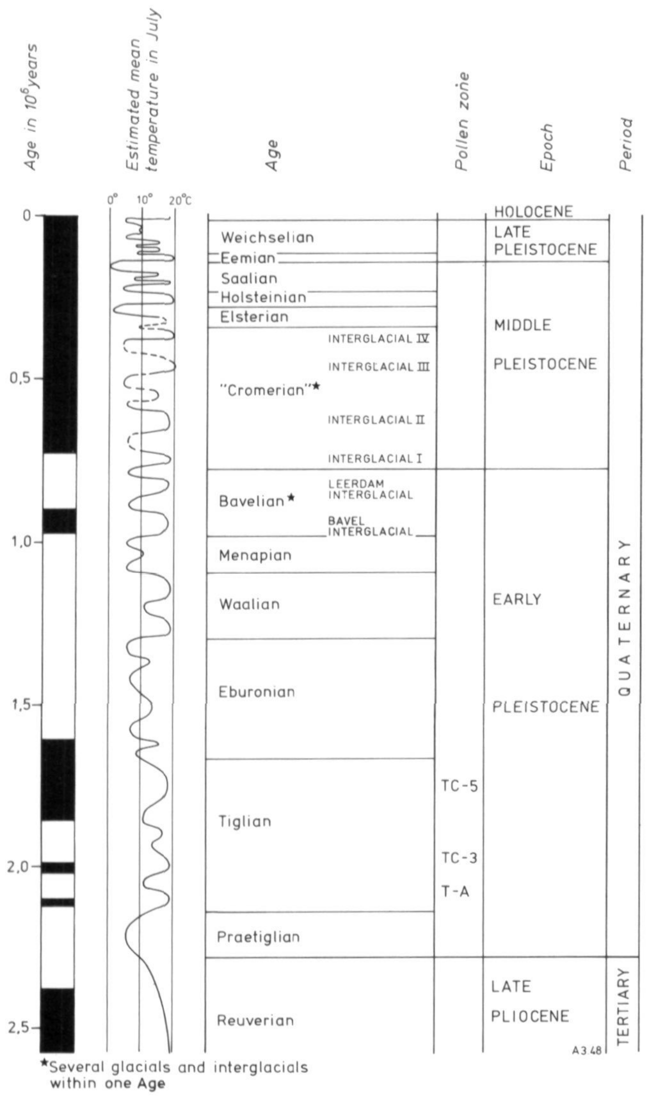

Fig. 136. Climate curve for the Quaternary in the Netherlands (source: Zagwijn 1985).

this assumption by focussing on the identification of Middle Pleistocene interglacials as 'Holsteinian'. One of the cases described is a boring in the southern part of the IJsselmeer:

> '... Here from 86-104 m in the basal part of the augite-bearing .... formation a well developed, more or less complete, interglacial sequence was found ... At first it was thought that it was of Holsteinian age, but later it was found that ... the actual Holsteinian beds are situated much higher (about 30 m...).' (Zagwijn/Van Montfrans/Zandstra 1971: 51-53)

The point is that *other* biostratigraphical subdivisions generally use palynological 'dates' as their point of departure, which means that, theoretically, an 'incorrect' identification of an interglacial, and thus of the chronostratigraphical position of the reference fauna, constitutes the basis of a complex system of interrelated false assumptions. For instance, it must be explicitly stressed here that two of the main 'vertebrate' arguments for dating the Belvédère Unit IV faunal remains to a *post-Holsteinian* warm-temperate phase are

- the presence of *Coelodonta antiquitatis* remains in the Unit III gravels. According to Guérin (1980), this animal migrated from Asia to Europe at the beginning of the 'Riss-period' (Van Kolfschoten 1985).
- the presence of remains of a particular subspecies of *Arvicola terrestris* that indicate that the Belvédère Unit IV faunal assemblage is younger than the faunal assemblage of Neede (the Netherlands), which was dated to the Holsteinian interglacial on the basis of pollen analysis (see: Zagwijn 1973: 145; Van Kolfschoten 1985).

The 'vertebrate' argument is therefore *essentially based on the Holsteinian classification of the Neede flora*, because the period referred to by the term 'Riss' was probably so long that it cannot have been preceded by the Dutch Holstein *sensu* Zagwijn (1973). What if -theoretically- the Neede finds should turn out to date from a pre-Holstein interglacial?

The molluscan evidence:
Meijer's (1986) preliminary non-marine molluscan zonation of the Dutch Quaternary has four zones, one of which includes the Cromerian IV (Noordbergum) and the Holsteinian interglacials, whose faunas are fairly similar. Basically, Meijer's biozonation is based on the disappearance of demanding species in the course of the Pleistocene, such as woodland and purely fluviatile species which depended on a warm-temperate climate:

> 'Actually it is a regressive development: every cold stage took its toll of the most sensitive part of the fauna. Placing the moments of extinction of these species in the more or less established pollen zonation is the first step to an independent Dutch non-marine molluscan zonation.' (Meijer 1986: 162)

Meijer used the *absence* of the freshwater molluscs *Valvata naticina*, *Neumayria crassitesta*, *Belgrandia marginata* and *Pisidium clessini* to establish a ***terminus post quem*** for the Belvédère Unit IV faunas. These species are not known to have occurred later than the Holsteinian and at Belvédère they are absent although their habitats are well-represented. So their absence[3] (and the occurrence of *Zonitoides sepultus*) led Meijer to infer a post-Holsteinian intra-Saalian age for the Belvédère Unit IV faunal remains (Meijer 1985: 96). The close relation between this zonation and the pollen zonation will be clear.

8.4.3 THE OXYGEN ISOTOPE RECORD

'It is generally agreed that to a first approximation, the oxygen isotope record that is recovered by analysing foraminifera in deep-sea sediment cores gives a history of global continental ice volume and hence of the glacio-eustatic component of sea-level change.' (Shackleton 1987: 183).

The complexity of the sequence of events that are attested by the isotope record has been summarized by Bowen (1978) and by Shackleton in a paper referred to above (1987). According to Shackleton, one of the most serious complications is that no deep-sea core has preserved a perfect history of the isotope composition of the ocean. An aspect of this complication is that whatever foraminifera are chosen for isotopic analysis, variations in the temperature of the ocean water in which they lived have to be considered.

'Another is the generality that no geological record is perfect; in particular, bioturbation is a virtually universal source of degradation for deep-sea records.' (Shackleton 1987: 183)

It is, however, common opinion that a shift to a higher ^{18}O level indicates a shift to a colder and more glacial climate and that the record does provide the best opportunities for determining the sequence of ice-sheet advances and retreats over the past several hundred thousands of years (Covey 1984). The oxygen isotope record has two advantages over the more traditional terrestrial geological data. It is, in the first place, a global record, which is thought to reflect changes in the total amount of ice on land the world over, as there is remarkably little variation among cores taken from different areas. Secondly, it is a rather continuous record, providing an arguably complete survey of the entire Quaternary.

One of the problems associated with the oxygen isotope record has always been the displaying of the various data sets as time series. Paleomagnetic studies and dating of ash layers proved to be very helpful methods in this context (Shackleton/Opdyke 1973; Ninkovich/Shackleton 1975), but a major breakthrough was the rehabilitation of the Milankovitch theory, which suggests that Pleistocene changes in global ice volume were controlled by the earth's orbital geometry (Hays *et al.* 1976). This theory has been used as a basis for the development of fine time scales for the oxygen isotope record (Imbrie *et al.* 1984). In the context of the present volume we are especially interested in the second half of the Middle Pleistocene and the Upper Pleistocene, a time period for which a detailed oxygen isotope data set is

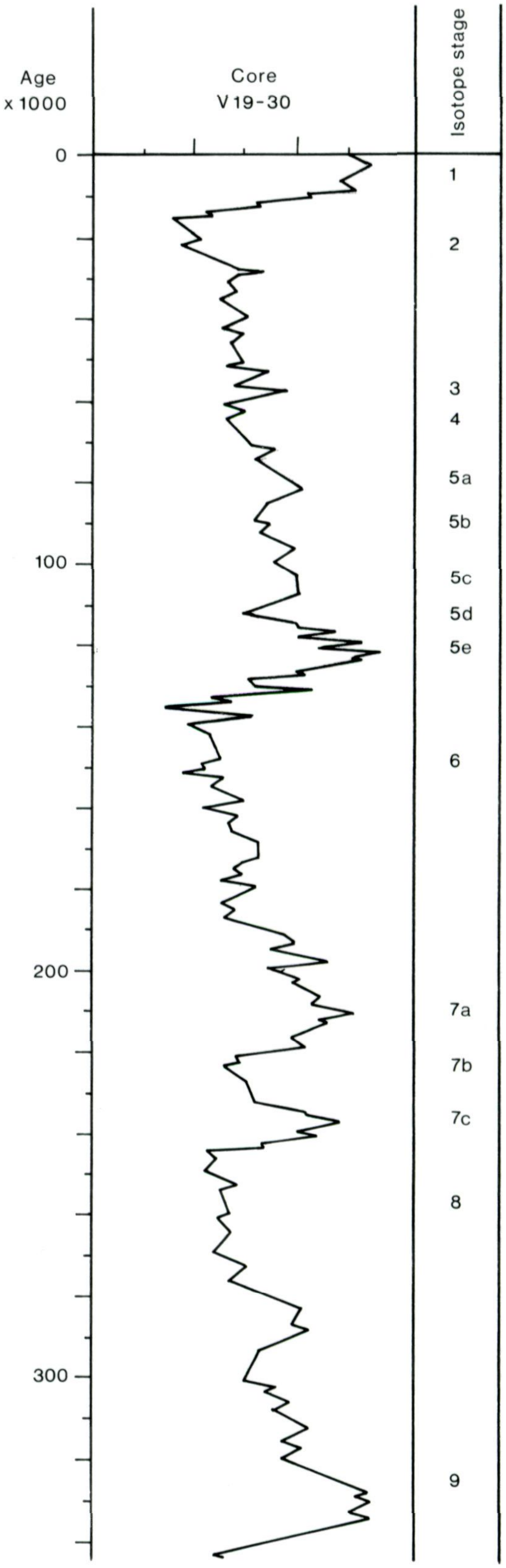

Fig. 137. Oxygen isotope stratigraphy core V19-30, showing stages 1-9 and age estimates for stage boundaries (redrawn after Shackleton and Pisias 1985, by courtesy of N. Shackleton).

now available, on a very fine time scale (Shackleton/Pisias 1985).

Figure 137 shows core V19-30, published with the permission of N.Shackleton (Cambridge, in litt. 1988). The figure shows the ^{18}O record in *Uvigerina senticosa* from V19-30, from Stage 9 to the Holocene (Stage 1). We refer to Shackleton and Pisias (1985: 308-310) for details on the method with which the time scale was obtained. It is worth mentioning here that, in their interpretation of Pacific core V28-238, Shackleton and Opdyke (1973) already stressed the fact that Stage 7 of that core was in all probability not to be equated with the 'Hoxnian' interglacial. The reason for this has recently been worked out in detail by Shackleton (1987), who has tackled the problem of the sea levels of the glacial and interglacial stages of the Brunhes period. On the basis of the analysis of a large number of cores he concludes that the extremes of stages 1, 5e, 9 and 11 are very similar:

> 'At present I do not believe that we can confidently state that any one of these four interglacials reached a significantly different level than another.' (Shackleton 1987: 186)

These four 'interglacial' peaks 1, 5, 9 and 11 are, however, isotopically significantly lighter than those of Stages 7, 13, 15 and 19. Only with Stage 23, in the Jaramillo normal event, is an 'interglacial' attested which is isotopically similar to the Holocene. Shackleton suggests that during the Stage 7, 13, 15 and 19 'interglacials' more extensive ice caps remained present in the northern hemisphere, resulting in a relatively low sea-level.

In discussing the Unit IV-C dating evidence we have already suggested a correlation of the Unit IV-C warm-temperate phase with Stage 7, a period of low ice volume which is interrupted by a short period of ice-increase (substage 7b) which may represent a cooling of glacial intensity (Ruddiman/MacIntyre 1982; Andrews 1983).

We therefore have to consider the possibility that substages 7c (250-230 ka) and 7a (220-200 ka), being divided by an approximately 15,000 years-long period of global cooling, were characterized by different floras and faunas, which might be one of the explanations for the interglacial 'traffic-jam' in this later part of the Middle Pleistocene: the current margins of error of geochronometric dating methods are too large to allow us to ascribe faunas to Stage 7c or Stage 7a on the basis of the 'absolute' dates alone. This means that hypothetically biostratigraphically different floral and faunal assemblages may sometimes be assigned 'the same age'.

At present, only few researchers would correlate Stage 7 with 'the' Holstein interglacial. In a review of the Swanscombe geological deposits and organic remains, Hubbard (1982), for instance, has proposed a correlation with Stage 11, while Brunnacker (in: Brunnacker *et al.* 1982: 245) seems to take a similar position by placing two interglacials in the 'Saale-Kaltzeit' (see also: Kukla 1977; Sarntheim *et al.* 1986; Shackleton 1987).

The limits of so-called 'absolute' dating methods (and especially of many of the 'correlation games' based on it) are illustrated by the current discussion between two groups of specialists who used the ESR dating method on shell samples from Holsteinian beds in the type area in order to determine the chronostratigraphical position of the Holstein interglacial and its correlation with the isotope stratigraphy. Sarntheim *et al.* (1986) conclude that the Holsteinian correlates with oxygen isotope Stage 11, whereas Linke *et al.* (1985) assign it to Stage 7. In the discussion generated by these conflicting results (see: Schwarcz/Grün 1988 vs. Barabas *et al.* 1988) we observe that the main cause of the differences lies in the fact that the two groups both have their own methods for deducing ages from the ESR signals of the samples studied. So here we have the (highly informative!) situation that the Holsteinian at its *locus typicus* in northwestern Germany has been assigned 'absolute' dates ranging from approximately 200 to 440 ka!

If we limit ourselves to the Dutch Pleistocene data, it is impossible to reject a correlation of the Dutch Holsteinian with substage 7c: the Belvédère Unit III gravels could have been deposited in the 'cold' phase 7b, which would then mean that the Unit IV warm-temperate phase would have to be shifted upwards to substage 7a. The pre-Eemian luvisol formed in the top part of the Unit IV/V-A sediments could then be fitted neatly into the 'temperate' beginning of Stage 6, contemporaneous with the formation of the 'temperate' faunal assemblage of Biache-Saint-Vaast in northern France and the temperate small mammals assemblages containing *Arvicola terrestris* found in sediments pushed up by the Saalian ice at Rhenen (the Netherlands, Van Kolfschoten 1981). Choosing this interpretation, however, means dismissing the 'sea level arguments' of Shackleton and others referred to above.

The point I wish to make here is that the relative ease with which different correlation games can be played means that archaeologists working with data from this time range have to be extremely careful in developing models depending strongly on behavioural events 'precisely' pinpointed in the Pleistocene time scale.

notes

[1] It is, however, worth mentioning that Meijer's study of the Unit IV-C molluscs led him to infer that by the time of the formation of the upper part of the Unit IV-C-II calcareous tufas '... the climatic optimum had already been passed ...' (Meijer 1985: 94).

[2] In earlier publications on the Belvédère fauna (e.g. Roebroeks *et al.* 1983; Van Kolfschoten 1985; Roebroeks 1986a) this species was described as *Arvicola cantiana/terrestris*. Recently, Van Kolfschoten (*in press*) has decided to also classify the Belvédère Unit IV *Arvicola* as *Arvicola terrestris*. However, he stresses the biostratigraphical position of the Unit IV *Arvicolas*.

[3] Recently, however, Duistermaat (1987) determined the *presence* of *Belgrandia marginata* in the Site G mollusc assemblage (see 8.2.2).