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The Middle Palaeolithic Site of Buzdujeni in Moldova: Establishing the Archaeological and Environmental Record

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Abstract The work carried out at the site of Buzdujeni in 1993, and the subsequent study of the material, is described. The archaeological inventory, classified as a Denticulate Mousterian, is published in detail for the first time. Sedimentological, palynological and micro-morphological studies have permitted an evaluative reconstruction of the development of the environment through time. The human occupation of the site took place in periglacial conditions, which likely correspond to the last (Valdai) glacial period, though more exact dating of the site remains to be achieved.

Keywords Moldova · Middle Palaeolithic · Stratigraphy · Environmental evidence

Introduction: the Research Project in Moldova

In 1992–1993, a programme supported by the British Academy and the McDonald Institute for Archaeological Research was initiated, a primary objective of which was to obtain samples for dating at the Oxford Radiocarbon Laboratory, from three countries,

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Chetraru, Borziac, and Medyanik are now deceased.

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Moldova, Ukraine and Russia, with particular reference to the early Upper Palaeolithic and the late Middle Palaeolithic in those countries. Forty-four radiocarbon dates from 10 sites, and the results of the programme as a whole, have been published (Hedges et al. 1996; Allsworth-Jones 2000). So far as Moldova is concerned, a full account of the work done at Ciuntu was produced (Borziac et al. 1997) and a similar report concerning Brînzeni has been prepared (Allsworth-Jones et al. 2018). The third site included in the programme was Buzdujeni, the subject of the present work, which was originally investigated in the 1970s but has hitherto been only very briefly reported by the excavator (Chetraru 1973). All these are cave sites, in a quite restricted area of north-western Moldova. In all cases, new small-scale control excavations permitted environmental evidence to be recorded for the first time, which widened the scope of the programme, as well as providing the opportunity for an archaeological reassessment of the cultural remains, in part stimulated by sometimes unexpected dating results.

Thus, the single layer of occupation at Ciuntu was originally regarded as Early Upper Palaeolithic and was assigned to the 'Brînzeni' archaeological culture (Borziac and Chetraru 1978). The three AMS radiocarbon dates obtained in the Oxford laboratory however produced a mean uncalibrated age of $20,500 \pm 180$ BP, which was not consistent with the idea that the site could be taken as belonging to the beginning of the Upper Palaeolithic. A re-examination of the archaeological inventory suggested rather that it belonged to the Gravettian techno-complex, which was dominant in Europe at that time. The deposits in the cave seemingly owed their origin to a number of factors: the accumulation of fine-grained aeolian material, the exfoliation of limestone from the walls and roof, the build-up of organic matter on the terrace and at least a small anthropogenic element. The micromorphological analysis suggested that there was some soil development which probably took place over a long period of time. The pollen analysis, on the basis of four samples, indicated that the overall environment was that of a periglacial steppe, although there were also sparse pine woods in the vicinity. In general, it was concluded that the site was occupied only seasonally by small groups of itinerant hunters and gatherers.

It is a matter of regret that the publication of Brînzeni itself was so much delayed (Allsworth-Jones et al. 2018). As in the preceding case, a control excavation was carried out in 1993, but by far the larger area of the site was excavated already by Chetraru in the years between 1960 and 1975 and by Borziac in 1987. The main cultural layer was much thicker than at Ciuntu (up to 70 cm or so) and more difficult to interpret. An analysis of the sediments in the interior of the cave by Grishchenko (1966, 1969) already demonstrated that this layer was complex in its formation. The micromorphological analysis carried out as part of this project reinforced that interpretation. There was no real soil formation, and the loess-like sediments were subject to much freeze-thaw activity. The pollen analysis suggested that the vegetation at that time could be characterised as a periglacial wooded steppe, somewhat warmer and wetter than the colder and more arid conditions already observed at Ciuntu. Twelve AMS radiocarbon dates have been obtained for the site, all but one carried out by the Oxford laboratory. They cover a very wide spectrum, the two uncalibrated results from the 1993 section being $19,780 \pm 260$ and $20,140 \pm 200$ BP respectively. If these samples or others from the site were to be re-dated using ultrafiltration, they might turn out to be several thousand years older than this, but even so the 'Brînzeni culture' can hardly any longer be regarded as Early Upper Palaeolithic. A re-examination of the archaeological inventory suggests that its so-called 'archaic' aspect has hitherto been much

exaggerated (Noiret 2009; Allsworth-Jones et al. 2018, Figs. 16–20) and this would accord with the revised chronological position suggested for it.

The third site selected for inclusion in the programme, Buzdujeni, unlike the other two, was said to have had an exclusively Middle Palaeolithic occupation, hence it was thought that it would be good to investigate further for comparative purposes. This site was first excavated in 1970–1976, but no comprehensive account of it has ever been published. As in the case of the first two caves, a control section was established at the site in 1993, and an investigation was carried out with the following objectives: (1) to make a new and precise study of the stratigraphy; (2) to collect samples of bone and teeth for radiocarbon and ESR dating; (3) to obtain monoliths suitable for soil micromorphological study, as well to collect samples for palynological purposes; and (4) to provide further information with regard to the archaeological finds. These finds have now been described for the first time in some detail by Chetraru. The study of the deposits from a sedimentological and palynological point of view by Mihailescu and Medyanik respectively, supported by French's targeted micromorphological evaluation, in combination have allowed a relatively detailed picture of the Pleistocene succession to be established. Nonetheless, it must be borne in mind that the work reported here was carried out some time ago, and that what could be achieved on the basis of a control section cannot be regarded as exhaustive. The resolution of the conclusions presented is necessarily somewhat coarse grained, but in our view they still make a significant contribution to the Quaternary history of the area.

Discovery and Excavation of Buzdujeni Cave

Buzdujeni cave is situated in north-western Moldova, with approximate geographical coordinates of 48° 06′ N and 27° 16′ E (Fig. 1). The north-western region of the country is sometimes referred to as a kind of mini-Dordogne on account of the many occupied caves situated in adjacent river valleys in a relatively restricted area, valleys that (as shown on the
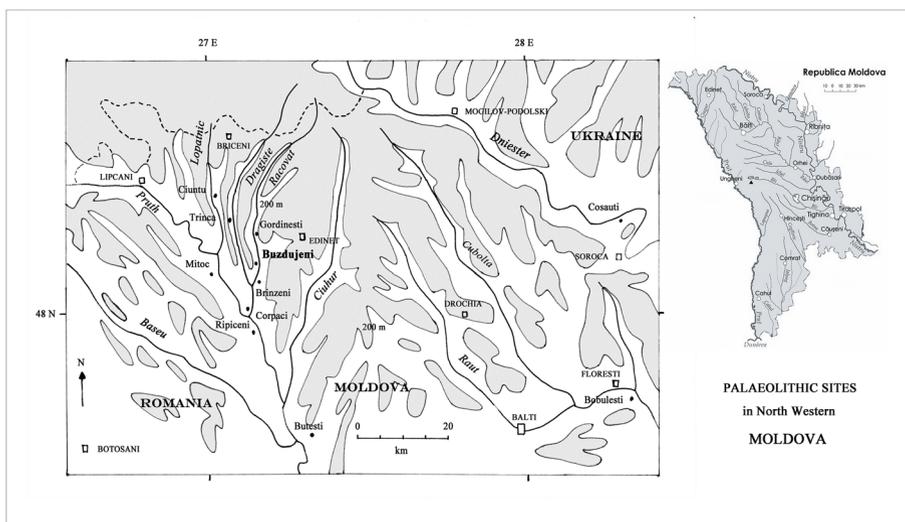

Fig. 1 Palaeolithic Sites in North Western Moldova

map) are separated from each other by narrow ridges rising above 200 m in height. This cave is on the right (western) bank of the river Racovăț, which here flows in a north-south direction, about 2 km northeast of Buzdujeni village and 4 km north-west of Brînzeni village, in the Edineț region. Strictly speaking, the site is known as Buzdujeni I, since there are other sites with the same name in the vicinity, but none of them are as large or significant as this site, hence it will be referred to here simply as Buzdujeni. The cave is near the top of a limestone ridge, about 66 m above the river and 13 m below the plateau into which the gorge is cut. The river follows the line of a tectonic fault, and the limestones flanking it belong to the Miocene series described as 'Toltry' (Verina 1980). They formed as reefs, containing many micro-organisms, in Tortonian and lower Sarmatian times. The lower series ('Medobory') tend to be compact and in the past were heavily wooded, whereas the upper series are more weathered, usually by karstic processes, and tend to form separate outcrops supporting only a shrub vegetation.

The cave was discovered by I.A. Borziac in 1970, and he put down a small test trench at the entrance. Large-scale excavations were conducted by N.A Chetraru in 1971 and 1974–1976, beginning with a 2 × 1 metre test pit in 1971. Only the results from 1971 were hitherto published in any detail (Chetraru 1973). In 1993, a new profile was prepared at the back of the cave, covering the larger part of the sequence, and designed specifically to obtain samples for dating and environmental study purposes. The fieldwork was supervised by I.A Borziac, with the assistance of S. Covalenco and the participation of C.D. Mihailescu, as well as that of N.A. Chetraru, who visited the site and provided valuable information linking the old results and the new.

The cave opens to the east, its width according to Chetraru being between 7 and 11 m at the entrance and up to 9 m in length from front to back (Fig. 2, after Chetraru).
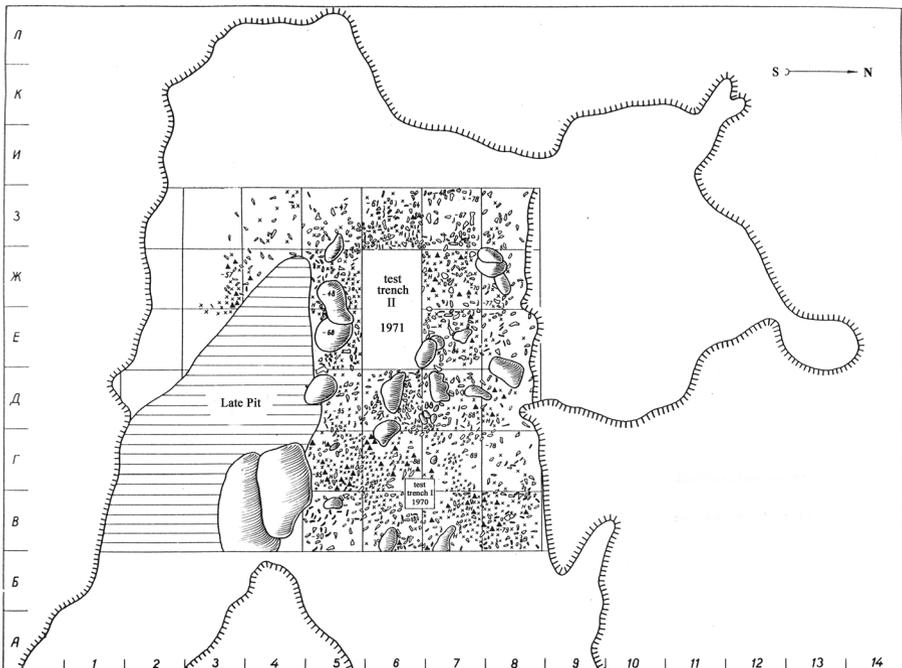

Fig. 2 Plan of Buzdujeni cave [after N.A. Chetraru]

The maximum height of the cave at present is about 5.5 m. There is a side chamber to the north, but this is marked off by a sill and has practically no depth of deposits. Chetraru's plan shows a large area to the south, inside the cave, disturbed by what is called a 'late pit'. The test trenches of 1970 and 1971 are also shown. The total area of the cave interior is estimated at about 60 m^2, and according to Chetraru the total area of his excavations in the end approached 42 m^2. The area at the back of the cave, in other words the western part, was that which remained available for study in 1993. There is a narrow terrace in front of the cave, blocked by several large boulders. A precipitous slope descends far to the valley below, as can be seen from the photographs taken at the time of Chetraru's excavations (Fig. 3) and more recently (Fig. 4).

Hitherto, the only published profile has been that of the west wall of the 1971 test trench (Chetraru 1973, Fig. 16). According to the excavator, the maximum depth of deposits did not exceed 2.70 m. It is obvious from the drawn section that the recognised layers are likely to have differed considerably in extent and orientation from one part of the cave to another, and this has been confirmed by an examination of Chetraru's other unpublished sections. He recognised 14 stratigraphic layers and 8 cultural layers, the latter being confirmed by Anisyutkin (1990). Chetraru's first account of the stratigraphic layers may be summarised as follows. Layer 1 (black earth and dung) was underlain by layer 2 (a burnt lens) and then by Pleistocene layers 3–10 which contained the cultural material. This is exclusively Middle Palaeolithic; no Upper Palaeolithic material has been found at the site. Stratigraphic layers 3–10 were all described as yellowish or light brown loams with varying amounts of limestone rubble. They were underlain by layers 11–13 (sterile sand and clay, with large limestone blocks) above layer 14 (bedrock). In the new section prepared in 1993 at the back of the cave, cultural layer 8 rested directly on bedrock,


Buzdujeni
during
Chetraru's
excavations
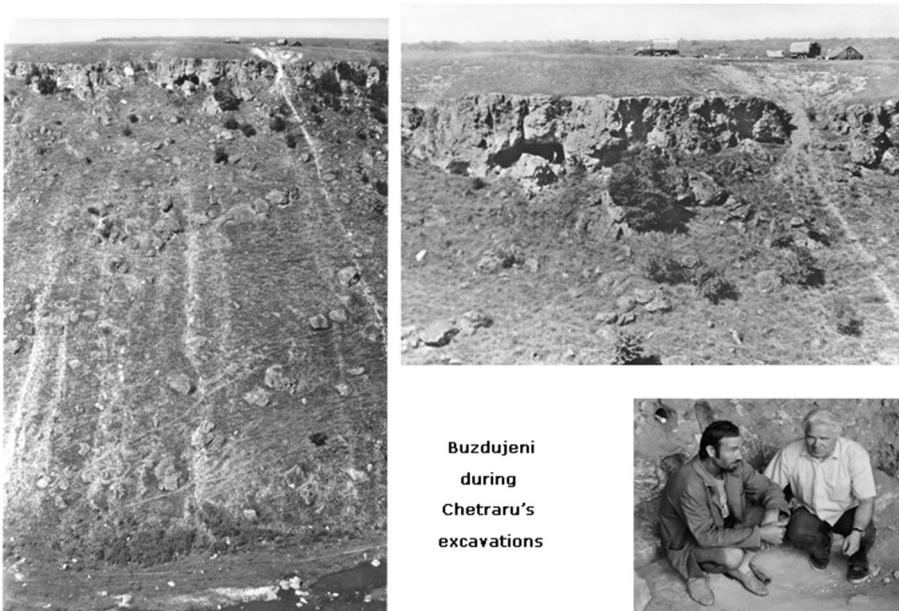
Fig. 3 Buzdujeni during Chetraru's excavations. Chetraru and Borziac at the site, 22 August 1993
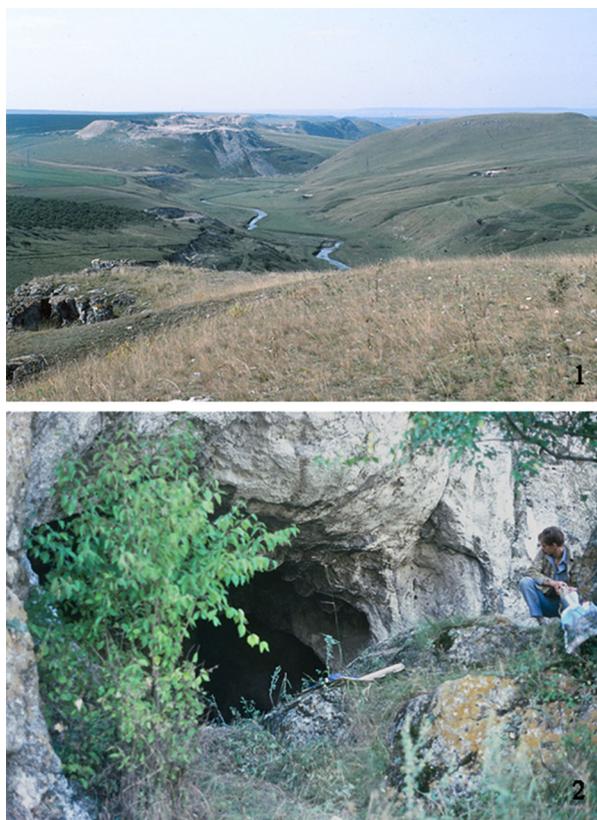
Fig. 4 1 View south from above the site down river Racovăț towards Brînzeni. 2 Entrance to Buzdujeni cave

as it did in the majority of Chetraru's unpublished sections, hence the presence of underlying sterile deposits in the west wall of the 1971 test trench seems to be an exception. The bedrock can be referred to as layer 9. Cultural layers 1–3 could not be examined in 1993, due to the crumbly state of the section at the top, although Mihailescu was subsequently able to provide a description of them.
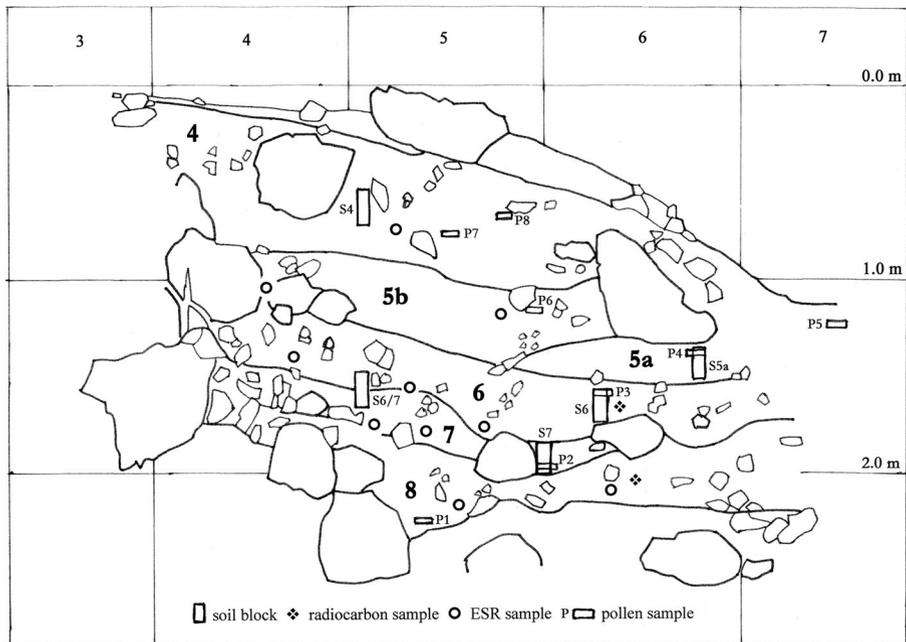
The re-examination of the stratigraphy and new sampling for palynological, micromorphological and chronological analyses at the site took place over a 7-day period in August 1993, with further time devoted to it at the museum in Chişinău. The new profile at the back of the cave is shown at Fig. 5(2). It is in excellent agreement with the profile that Chetraru established at this point (Fig. 5(1)). Chetraru's excavations stopped on the line з/и running south-north; due to the crumbly state of the deposits, the new profile in squares 3–7 is not exactly vertical, and in particular the top is stepped back. Thus the lower part of the section in within line и and the upper part extends as far as line к. The layers indicated are cultural layers numbered according to Chetraru's system. As in his excavations, they coincide with lithologically distinct horizons, and their position agrees closely with that established for them by Chetraru at the end of his excavations. The nature of the layers was discussed with him, and the description given here takes account of that, while being based principally on the field
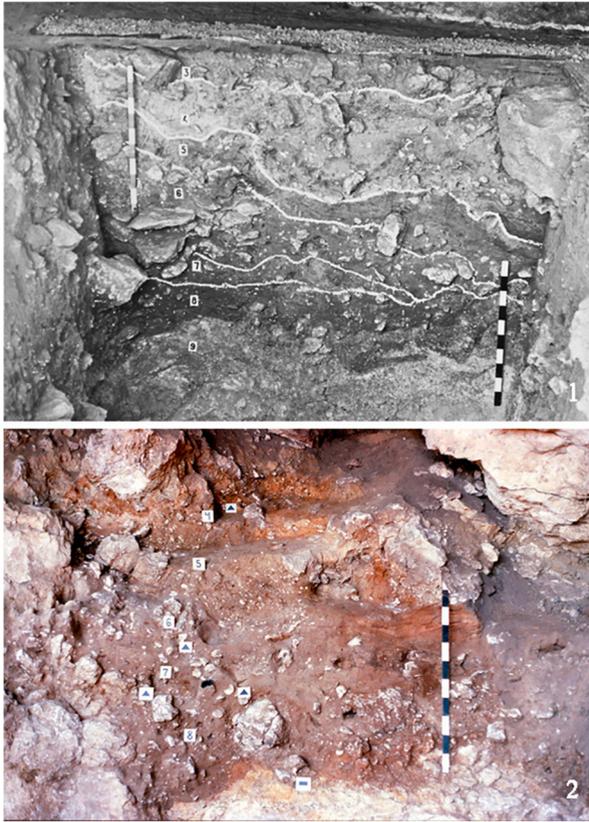
Fig. 5 1 Chetraru's west wall section on the 3/И line running south-north. 2 1993 west wall section in squares 3–7, equivalent to the above

observations made by Constantin Mihailescu. He also took the samples for palynological analysis, while W.J. Rink was responsible for the ESR samples; in addition, the team took a set of five sediment blocks for micro-morphological analysis and collected five samples for radiocarbon dating. Only two of these were subsequently published, their positions being shown on the drawn profile. The position of the sediment blocks, and the sampling locations for ESR dating and pollen analysis, are also indicated (Fig. 6).

In the following account, the archaeological inventory, relying on Chetraru's data, is described from the top down, since we possess much more detailed information about cultural layers 2 and 3 than we do for the lower layers. In this account, it is preceded by the stratigraphic and environmental data. The samples making up the palynological record are numbered from the base up, but for ease of reference the layers are also described from the top down. The micro-morphological assessment can be quite easily compared with the stratigraphic account, and in fact complements it very well. Details of the faunal record, previously available only for the site as a whole, are now also available in terms of provenance by layer. The dating evidence concludes the story, but there is clearly a great deal yet to learn about this aspect.

Fig. 6 Buzdujeni 1993 drawn section

Stratigraphy and Palynology

Eight samples were examined for the purposes of pollen analysis. The position of the samples in relation to the layers is shown in Fig. 7. In all samples apart from layer 5a [sample 4], the quantity of pollen and spores was sufficient to permit a full analysis (Table 1). The amount of redeposited pollen and spores in the samples varies from 0.5 to 80.3%. This reflects humidity and temperature variations in the cave, in overall cold and continental conditions, with consequent changes in weathering intensity of its walls and vault. The redeposited examples are distinct from in situ pollen and spores in terms of their dark colour and degree of corrosion. They include *Pinus* s/g diploxylon and *Pinus* s/g haploxylon (both Miocene), as well as *Cedrus*, *Tsuga*, *Eucommia*, *Myrica*, *Ulmus*, *Gleichenia* and others. In situ pollen and spore totals in terms of deciduous and coniferous arboreal pollen (AP) and non-arboreal pollen (NAP) percentages and their stratigraphic positions are shown in Figs. 7 and 8. An increase in NAP (and corresponding changes in AP) generally indicates a worsening of the climate and an increase in aridity and continentality. On the other hand, an increase in AP and the appearance of deciduous species may indicate a certain improvement, with a warmer and wetter climate. Ruderal (disturbance-tolerant) plants and weeds are rare and do not exceed 10% of the pollen sum in any of the samples. They include *Plantago major*, *Polygonum aviculare* and some species of Cichoriaceae, but in quantities close to their occurrence in natural phytocoenoses. Therefore, there appears to be no indication of any great degree of disturbance due to human activity.
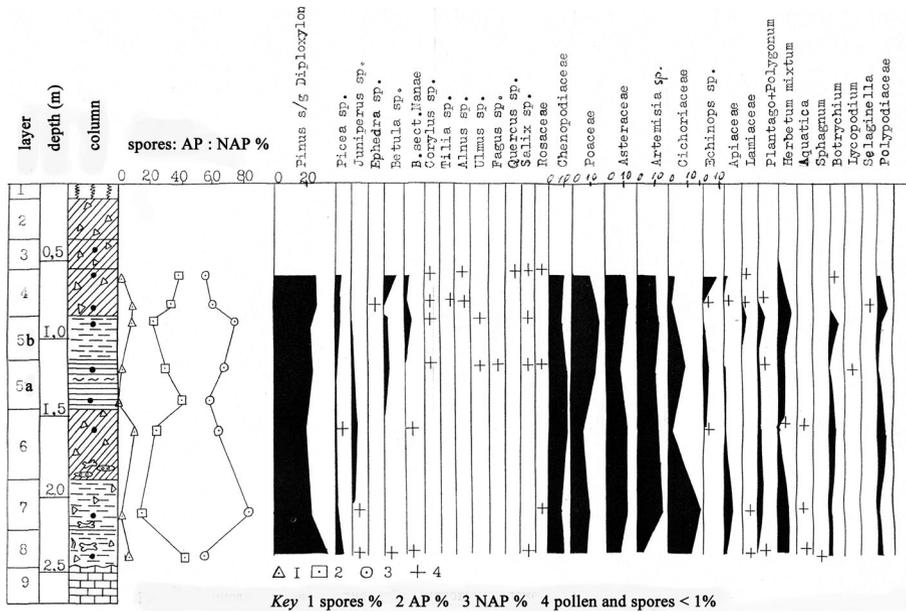
Fig. 7 Detailed palynological analysis of samples from Buzdujeni

The lithological and palynological characteristics of each layer are given below. Layers 3–1 were not sampled in 1993, but they were examined on a different occasion (Mihailescu 1999).

Layer 1. Recent dark grey silty loam, much mixed with ash and powdery limestone from the roof of the cave; 10 cm thick. Above the zero datum, there are some dark smoke stains and burnt areas where the limestone is less solid and has many pustular formations of calcite.

Layer 2. Light grey silty loam with fragments of charcoal and traces of hearths. On the northwest side of the cave at this level (30 cm below the zero datum), one can clearly see some traces of black salts, also iron oxides (Fe), manganese (Mn) and magnesium (Mg). Their presence indicates the repeated penetration of rainwater along the walls of the cave. The thickness of the layer is 20–30 cm. There are indications of a moister and moderately warm climate, but the archaeological material is still of exclusively Middle Palaeolithic type.

Layer 3. Light greyish-yellow loam, macro-porous, much humified, not structured and not layered, with many fragments of limestone, animal bones and flints. The boundaries of the layer are gradual, not sharp. Its thickness varies from 30 to 40 cm. The climatic conditions were analogous to those of layer 4, with a predominance of mechanical weathering processes and aeolian transport of fine particles. The abundance of large limestone blocks is likely to be the result of intensive tectonic activity, either in this layer or at the boundary with layer 4 beneath.
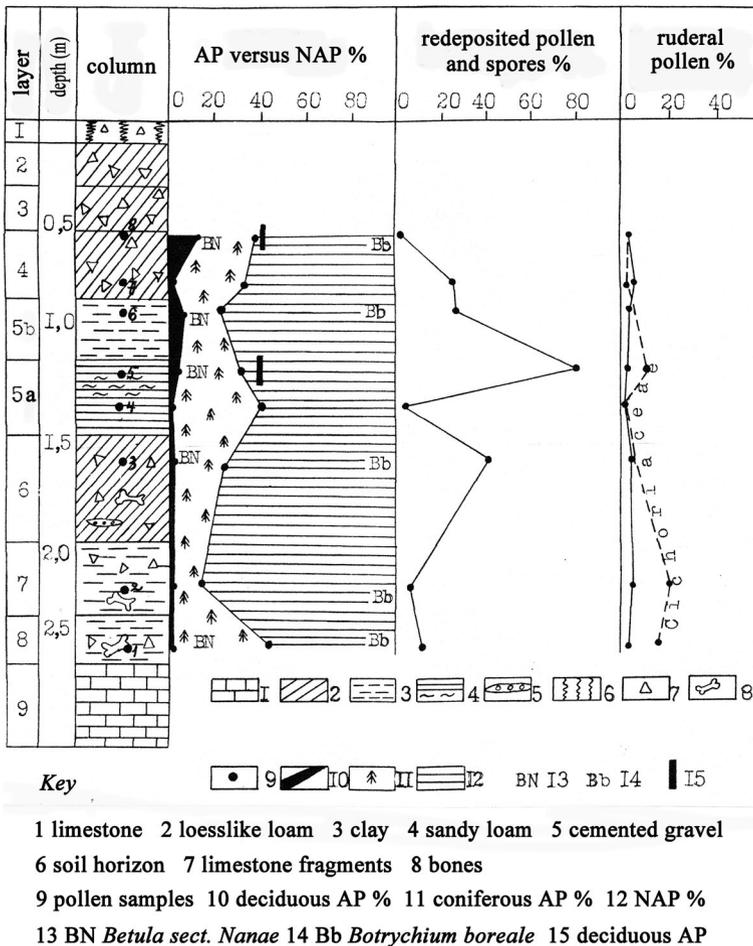
Layer 4 [samples 7 and 8]. Pale yellow loam, micro-porous, not layered, with a considerable quantity of quartz sand, sharp-edged limestone fragments (estimated at about 30% of the matrix) and thin silt lenses [*yellowish-brown* (10YR5/4) to

Table 1 Palynological analysis of samples from Buzdujeni (*AP* arboreal pollen, *NAP* non-arboreal pollen)

Species	Layer numbers							
	8	7	6	5a	5a	5b	4	4
	Sample numbers							
	1	2	3	4	5	6	7	8
In situ pollen and spores *N*	245	382	207	10	300	192	188	347
AP %	40.8	14.9	23.7	4	30.0	21.4	32.4	39.2
NAP %	55.1	81.4	65.7	6	68.3	71.4	60.6	58.5
Spores %	4.1	3.7	10.6	–	1.7	7.2	7.0	2.3
Redeposited pollen and spores %	10.2	5.5	40.0	3.2	80.3	24.5	24.5	0.5
Pinus s/g diploxylon	35.5	12.6	20.3	4	23.0	14.6	28.7	26.0
Picea sp.	3.3	–	0.5	–	–	1.6	1.1	1.7
Juniperus sp.	0.8	0.5	2.4	–	–	–	–	–
Ephedra sp.	–	–	–	–	–	–	0.5	–
Betula sp.	0.4	–	–	–	2.3	–	–	7.2
B. sect. nanae	0.4	–	0.5	–	1.7	3.1	–	1.4
Corylus sp.	–	–	–	–	0.6	0.5	0.5	0.6
Alnaster sp.	–	–	–	–	–	–	0.5	–
Alnus sp.	–	–	–	–	–	–	0.5	1.2
Tilia sp.	–	–	–	–	0.3	–	0.5	–
Ulmus sp.	–	–	–	–	1.0	0.5	–	–
Fagus sp.	–	–	–	–	0.3	–	–	–
Quercus sp.	–	–	–	–	–	–	–	0.6
Salix sp.	0.4	1.6	–	–	0.3	0.5	–	0.3
Rosaceae	–	0.3	–	–	0.3	–	–	0.6
Chenopodiaceae	9.8	4.7	20.3	2	16.7	10.8	9.0	10.6
Poaceae	8.2	11.5	6.3	1	13.7	17.7	16.0	9.2
Asteraceae	10.6	14.5	13.5	2	10.3	12.0	14.4	12.1
Centaurea sp.	–	0.3	–	–	–	–	–	–
Artemisia sp.	4.5	17.8	15.9	1	12.3	17.2	14.4	11.9
Cichoriaceae	15.5	20.9	3.9	–	10.3	4.2	1.1	3.4
Echinops sp.	–	–	0.5	–	2.0	–	0.5	8.9
Apiaceae	1.6	5.5	1.4	–	–	–	0.5	1.8
Lamiaceae	0.4	1.0	–	–	–	1.6	0.5	0.9
Campanulaceae	–	–	–	–	–	–	–	0.3
Ranunculaceae	0.8	0.5	–	–	–	4.2	1.6	–
Cannabinaceae	–	–	0.5	–	1.3	–	1.6	–
Brassicaceae	–	–	–	–	–	–	0.5	–
Plantaginaceae	–	–	1.5	–	–	2.6	0.5	–
Cyperaceae	–	–	–	–	–	1.6	–	–
Polygonaceae	0.8	2.6	1.4	–	0.7	–	–	–
Caryophyllaceae	–	–	–	–	1.3	–	–	–
Sparganiaceae	0.8	–	0.5	–	–	–	–	–
Fabaceae	2.0	0.6	–	–	–	–	–	–

Table 1 (continued)

Species	Layer numbers							
	8	7	6	5a	5a	5b	4	4
	Sample numbers							
	1	2	3	4	5	6	7	8
Typhaceae	–	0.3	–	–	–	–	–	–
Papaveraceae	–	0.6	–	–	–	–	–	–
Dipsacaceae	–	0.5	–	–	–	–	–	–
Botrychium cf. *boreale*	1.6	2.4	3.8	–	–	4.2	–	0.3
Sphagnum sp.	0.6	–	–	–	–	–	–	–
Lycopodiaceae	–	–	–	–	0.3	–	–	–
Selaginella sp.	–	–	–	–	–	–	0.5	–
Polypodiaceae	2.0	1.3	6.8	–	1.3	3.1	6.6	1.0

1 limestone   2 loesslike loam   3 clay   4 sandy loam   5 cemented gravel
6 soil horizon   7 limestone fragments   8 bones
9 pollen samples   10 deciduous AP %   11 coniferous AP %   12 NAP %
13 BN *Betula sect. Nanae*   14 Bb *Botrychium boreale*   15 deciduous AP

Fig. 8 Generalised palynological analysis of samples from Buzdujeni

dark yellowish-brown (10YR4/4)]. The very light colour and the structure of the loam makes it comparable in external appearance to the Valdai loesses of the region. The upper boundary of the layer is not always clear. Its thickness varies from 30 to 40 cm. Evidently, the layer was formed in dry and cold climatic conditions, with an increase in aeolian processes, which did not allow the formation of a continuous vegetation and soil cover on the watershed plateaux of the area. An apparent increase in pine and birch pollen may be due to long distance wind transport, whereas the NAP component is consistent with a poorer climate. The trees present included pine, spruce and birch. Arctic-boreal species grew in the swampy areas, including dwarf birch, willow, *Alnaster* and *Botrychium*. Together, the evidence suggests that this was a predominantly xerophile periglacial steppe landscape. In addition, there was alder in the floodplain areas, and lime, oak, and hazel could still be found in refugia. The role of xerohalophile grasses was somewhat reduced, but there was a good representation of Poaceae and some of the variegated mesophile grasses.

Layer 5b [sample 6]. Light brown loam, weakly humified with many sharp edged limestone fragments, flints and animal bones [*very pale brown* (10YR7/4)]. The material is not rounded and not sorted, the matrix has no clear signs of layering or indications of water transport. The boundaries are clear, the upper with pockets, the lower more even and horizontal, differentiated by a change in colour, structure and origin by comparison with layer 5a, which is assumed to be older. Evidently, layer 5b was formed in sub-aerial conditions, in an arid and cold climate, which facilitated the mechanical weathering of the sides and roof of the cave and the aeolian transport of fine particles from outside. The anomalously high proportion of redeposited pollen and spores in layer 5a may be a by-product of this process. The palynological data indicate a predominance of periglacial steppe conditions. The wooded area was reduced. Pine and spruce were predominant, with rare hazel and elm. Dwarf birch, willow, *Botrychium* and Cyperaceae were characteristic of the swampy areas. NAP was dominated by Chenopodiaceae, *Artemisia*, Poaceae and Asteraceae, with some mesophile variegated grasses, constituting meadow-steppe coenoses of the watershed plateaux, the slopes of ravines and the floodplain areas, among others.

Layer 5a [samples 4 and 5]. Brown to dark brown loam, horizontally layered, clearly of subaqueous origin [*brownish-yellow* (10YR6/6) to *brown* (10YR4/3)]. Well sorted darker horizons are clearly visible, the remnants of fossil soils of chestnut type, characteristic for this region in the Middle Pleistocene. The layered nature of the deposits is best shown in the north-western part of the cave, where there are erosional traces of a stream, in the form of narrow channels with slight widening at the base. One metre to the northwest of the excavated area, slightly higher up, a small 20-cm-thick lens could be observed. This consisted of grey to blue-grey lacustrine clays with thin silt horizons coloured yellowish brown by limonite. The thickness of this lens increased to 35–40 cm in a north-western branch of the cave, which up to now is still almost completely filled with sediment. Here, it has a darker colour and contains some inclusions of coarse grained material. The deposit was sampled to try to detect the presence of molluscs and small mammals, but without result. Evidently, the body of water in which this deposit accumulated was acidic, and this has prevented the preservation of such

materials. Such acidity could be due to the presence of organic material and the influx of humic acids derived from fossil soils. This is suggested also by the distinctive colour of the layer which is quite different from the others in the cave. The fact that rainwater could wash in surface soils is clearly demonstrated by the presence of many fissures and karst funnels on the plateau watershed above the cave. All this leads to the conclusion that the layer in question was formed in favourable, relatively warm and damp, climatic conditions. As before, there were periglacial wooded steppes in the vicinity, but they contained a larger proportion of mesophile variegated grasses. The limited wooded area was composed of pine and birch. In swampy areas, there could be found dwarf birch, willow and club moss (*Lycopodium*). In some protected places (refugia), elm, beech and lime were also present. On the open watershed plateaux, there was a xerohalophile vegetation cover, including Chenopodiaceae, *Artemisia* and Poaceae. In general, at this time, there was an improvement in the climate, with moister and possibly somewhat warmer conditions as indicated by the presence of deciduous trees. The layer as a whole is surmounted by a second horizon of large limestone blocks from 20 to 60 cm in diameter. It evidently corresponds to a further phase of intensive tectonic activity in the region.

Layer 6 [sample3]. Light brown loam, neither structured nor layered, with many limestone fragments, small calcium carbonate nodules, coloured inclusions, flints, charcoal, tiny pieces of burnt bone and traces of hearths [*yellowish-brown* (10YR5/4) to *brown* (10YR4/3)]. In the northern part of the cave at the base of the layer were two small lenses of cemented limestone gravel, each 3–4 cm thick and 15–20 cm long. The general thickness of the layer decreases from 50 cm in the south-eastern part of the cave to 25–30 cm in the north-western part. The lower boundary of the layer is clear-cut, marked by lenses of alluvium, whereas the upper is more gradual. Evidently, the climate at this time became more temperate and relatively moist, as borne out by the palynological data. There was some expansion of the area occupied by pine woods, with an admixture of spruce and juniper. Arctic-boreal species are represented by dwarf birch and *Botrychium*, as well as *Sparganium* and some species of Poaceae on swampy ground. On the open watershed plateaux, there was a xerophile vegetation cover, including Chenopodiaceae, *Artemisia* and Poaceae, with some variegated grasses.

Layer 7 [sample 2]. Dark brown loam with many small inclusions of limestone fragments, pebbles and animal bones [*dark yellowish-brown* (10YR4/4)]. The maximum thickness of the layer is 20 cm, and it wedges out in the northern part of the cave. Its upper border is uneven, in the form of pockets, showing signs of having been washed away in parts. Palynological indications are that at this time there was an increase in meadow and steppe coenoses in the vicinity of the cave. The area of pine woods decreased, and there was no spruce. Increasingly dry and continental climatic conditions were reflected in significantly larger areas occupied by *Artemisia* and other xerohalophile grasses. In limited swampy areas and along the rivers, there could be found willow, *Botrychium*, some species of Poaceae and reed mace (*Typha latifolia*).

Layer 8 [sample 1]. Dark brown humified loam with considerable organic material, oxides and hydroxides of iron, sharp edged limestone fragments (5–10 cm in size, estimated at about 40% of the matrix), as well as flint artefacts including many

broken pieces, and animal bones [*dark yellowish-brown* (10YR4/4) to *light yellowish-brown* (10YR6/4)]. The thickness of the layer increased from 15 to 20 cm in the northern part of the cave to 30–35 cm in the southern part. In the upper part of the layer, at the contact with the one above, there was an accumulation of large limestone blocks from 15 to 20 to 30–40 cm in diameter. Evidently, they represent a phase of increased tectonic activity in the region. In view of the absence of any lenses deposited by water action and the disappearance of any signs of erosional activity, it can be supposed that the climate at this time had become drier. Seemingly, this led to the drying up of the stream and the cessation of temporary flooding. Probably, the change in climate towards a drier regime marked the end of the phase of chemical weathering which formed the cave and the beginning of a phase of mechanical weathering. It is clear that the drier climate would have been accompanied by an increase in cold and in seasonal contrasts, as evidenced by the intensive mechanical disaggregation of the rocks forming the cave. This is shown in the large quantity of sharp edged limestone fragments fallen from the walls and the roof. Palynological data indicate the existence of a widespread periglacial steppe with some rare pine-birch woods and a little spruce. In swampy areas in the narrow river valleys, one could encounter dwarf birch, willow, *Botrychium* and *Sparganium*. On the open watershed plateaux, the ravine slopes were occupied by Chenopodiaceae, Poaceae, *Artemisia*, Cichoriaceae and some mesophile variegated grasses.

Layer 9. The basal (archaeologically sterile) deposit in the cave consisted of poorly cemented white limestone with numerous horizontal fissures. The upper part of this layer and the sides of the fissures were coloured brownish yellow by limonite (Fe_2O_3-nH_2O). The surface of the layer was slightly inclined at an angle of 8–10° from the northwest to the southeast. In the central part of the cave, there were clear traces of erosional activity in the form of small pocket-like depressions, the remains of an ancient streambed up to 30 cm in depth and 20–25 cm wide. The visible thickness of the layer was up to 40 cm.

In general, it seems that the cave was formed at a time of warm and relatively moist conditions, corresponding perhaps to the Mikulino interglacial. In support of this version are the traces of erosion on the floor of the cave and also the absence of any older deposits of Early or Middle Pleistocene age. Its chronological position, therefore, may be analogous to that of Stînca Ripiceni in Romania (Moroşan 1938). The accumulation of deposits occurred only in the Late Pleistocene, basically during the Valdai or last glacial period. This process was much accelerated during brief relatively warm interstadials, when material was transported not only by wind but by water as well. The most favourable climatic conditions occurred during the accumulation of layer 5a, which may correspond to the Krutitsky interstadial in Velichko et al. (1989) scheme or to the Nandru II interstadial of Cârciumaru (1989). This would imply an age of about 80,000 BP, approximately equivalent with the Brørup interstadial (Chabai 2004, Table 1–8, 31). However, the data at our disposal do not allow a more reliable correlation than this.

In the watershed area near the cave, there is now a part of the original landscape which has been preserved in the form of a feather grass and fescue steppe (with *Stipa* and *Festuca*). With intensive cattle grazing, feather grass and thyme have almost completely vanished from the vegetation cover, but fescue, *Artemisia* and small hawthorn bushes remain.

The palynological data indicate that over the entire time when the layers in the cave were formed, a periglacial steppe with rare pine and birch woods was the predominant feature of the surrounding landscape. NAP meadow and steppe coenoses were the commonest. Significant components included Chenopodiaceae, Poaceae, Asteraceae and *Artemisia*. There were also large numbers of variegated grasses (such as Apiaceae, Lamiaceae, Ranunculaceae, Brassicaceae, Polygonaceae, Leguminosae and others). Arctic-boreal species were present, such as *Betula sect. nanae*, *Alnaster fruticosus* and *Botrychium boreale*, indicative of a cold and continental climate. These species together with willow, alder, *Sphagnum* and some varieties of Cyperaceae, as well as Typhaceae, constituted swamp coenoses, facilitated by the presence of insular permafrost (Nechaev 1988).

Confirmation of a continental climate is provided by the presence of *Ephedra*, *Artemisia* and xerohalophile components among the Chenopodiaceae. An analysis of present relict areas occupied by *Betula sect. nanae* (*B. humilis* and *B. nana*) in the Carpathians (*Arealy* 1977) indicates a mean January temperature of − 7 °C and a mean July temperature of + 12 °C, providing a possible analogy for the Late Glacial period. Possibly there was some climatic amelioration in layers 5a and 4 (although in the latter case, the possible effect of long distance wind transport should not be ignored). Certainly in refugia at that time, there were deciduous species such as hazel, elm, beech and oak.

The data characterising the flora of this site agree with the results from Molodova IV (Bolikhovskaya and Pashkevich 1982; Pashkevich 1987), Chetrosy (Levkovskaya 1981; Bolikhovskaya 1981) and Ripiceni Izvor (Cârciumaru 1989) among others.

Micromorphological Assessment

The application of soil micromorphology techniques (Bullock et al. 1985; Courty et al. 1989; Murphy 1986) is of great significance, especially in areas where little geological or sedimentological investigation has been carried out. These techniques aim to provide an insight into the composition and derivation of the occupation and/or natural deposits (Goldberg and Macphail 2006, 170ff). They can augment and help to interpret other sedimentary, faunal and palynological analyses, particularly by offering a clear distinction between sedimentary events and post-depositional processes. In the context of Buzdujeni, they should be seen in conjunction with the lithological and palynological analyses carried out independently by Constantin Mihailescu and Svetlana Medyanik respectively. As stated above, the sediment blocks were taken by the team on site and not in person by the author of this assessment.

Methodology

Five intact block sediment samples from Buzdujeni were impregnated and made into thin sections using the methodology of Murphy (1986) in the McBurney Laboratory of the McDonald Institute for Archaeological Research. Julie Boreham was responsible for making the thin section slides. The sections were described using the terminology of Bullock et al. (1985) and Stoops (2003). Detailed micromorphological descriptions are found in Appendix 1, and a summary of the results is provided in Table 2.

Table 2 Summary of micromorphological results for Buzdujeni

Site/layer	Main fabric	Structure	Interpretation
Layer 4	Silt aggregates over laminar fine sandy/silt loam, CaCO$_3$ nodules alternating with silty clay loam and phosphatised bone	All fine aggregated and laminar	Water-lain loessic-like material; alternate wet/dry; bioturbated/freeze-thaw; surface weathering; phosphatisation
Layer 5a	Silt and silty clay loam, with CaCO$_3$ nodules and phosphatised bone fragments	Laminar, aggregated; with two disturbed zones of limestone fragments intermixed with aggregates of silty clay in the centre and fine laminations of irregular silty clay aggregates in the upper part	Waterlain; wet/dry; bioturbated/freeze-thaw; interrupted by roof fall
Layer 6/7 interface	Silt and silty clay loam, with CaCO$_3$ nodules and phosphatised bone fragments	Aggregated; in the upper third of the slide, there are two lenses of silt aggregates in the upper part and a 3–8-mm-thick lens of sub-rounded nodules of calcium carbonate with fragments of phosphatised animal bone in the middle	Waterlain; surface weathering; wet/dry; bioturbated/freeze-thaw
Layer 7	Silty clay aggregates, with CaCO3 nodules and phosphatised bone fragments	Aggregated, with blocky peds	Silt loam with freeze-thaw ped structure; surface weathering; inwash; wet/dry

In addition, all the soil blocks prior to impregnation were scanned using a magnetic susceptibility meter by Dr. L-P. Zhou in order to identify any possible soil and/or occupation surfaces. Small bulk samples taken from each layer were also used for laboratory analysis of their magnetic susceptibility. All the laboratory measured readings were relatively low, and none suggested that any real soil formation had occurred nor were any old land surfaces present. Nonetheless, the highest readings occurred in layer 6, associated with the most abundant artefactual assemblage in the entire sequence. The results are set out in Table 3.

Sample Descriptions and Interpretations

Five soil blocks were taken from layers 4 to 7 of the 1993 section, as shown in Fig. 6, of which four in layers 4, 5a, 6/7 and 7 were analysed in thin section. In addition, bulk samples (not shown on the diagram) were taken from layers 4 to 8.
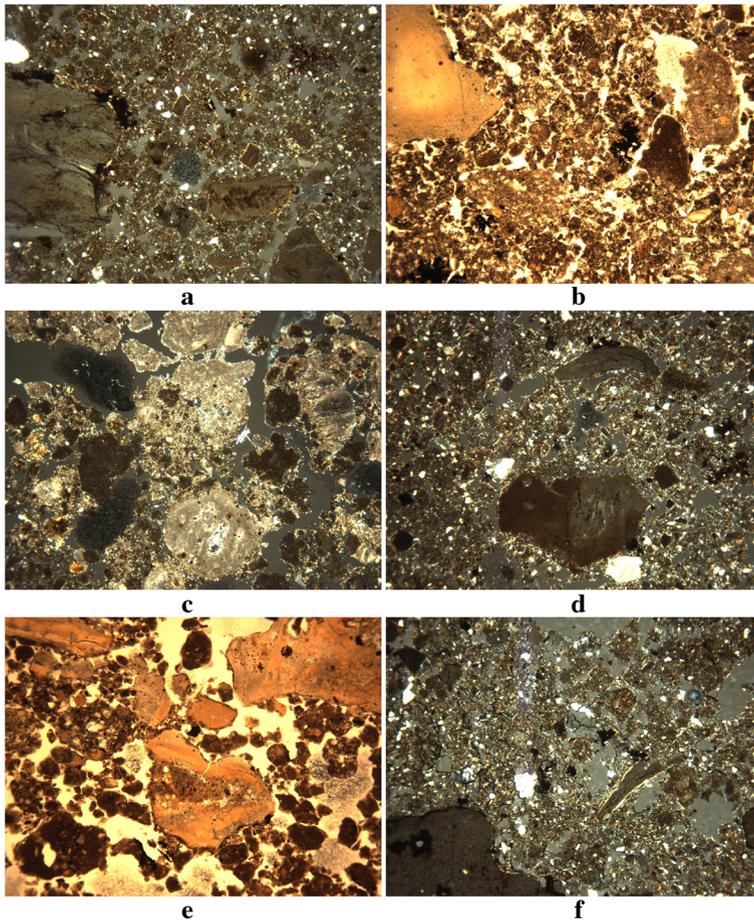
Layer 4 exhibits a sequence of finely laminated sediments of two main alternating types. (1) The 'fine' fabric laminae consist of fine sandy/silt loam with small sub-rounded calcium carbonate nodules and non-laminated dusty clay with many fine fragments (< 100 μm) of phosphatised bone, integral within the fine groundmass. The whole fabric is organised in small pellety aggregates < 300 μm in diameter. The fine groundmass exhibits weak reticulate striations of pure clay, which also coats the aggregates (Fig. 9a). (2) The 'coarse' fabric laminae are basically similar, but they contain more fine quartz, the fine groundmass exhibits only discontinuous striations, and the fabric is arranged in irregular to sub-rounded aggregates (300–750 μm), larger than in the first case (Fig. 9b).

The upper 15 mm of the slide has a zone of irregular to sub-rounded silt aggregates with very small sub-rounded bone fragments and calcium carbonate nodules, all with a 'halo' or coating of phosphatised dusty clay. The succeeding 15–95 mm has alternating fine/coarse laminae, whereas the lower 95–138 mm has coarse laminae alone, indistinct because of later mixing processes. All the laminae are tilted downwards at an angle of 10–30° towards the mouth of the cave.

This layer represents a lens of bioturbated silt aggregates over successive/episodic in-washings with finely laminated, loessic-like sediments that may have been water-lain. These sediments are probably derived either from within the cave or through the

Table 3 Magnetic susceptibility results for Buzdujeni

Sample number	Layer	Magnetic susceptibility (10^-8^3/kg)
MDV 8	4	7.45
MDV 9	5b	7.9
MDV 10	5a	11.2
MDV 11	6	13.5
MDV 12	6	13.55
MDV 13	7	11.25
MDV 14	8	12.1

Fig. 9 a Photomicrograph of the finely aggregated fabric with phosphatic-clay 'halos' and striations in the groundmass, sample 4 (frame width 4.5 mm; cross polarised light). b Photomicrograph of the aggregated fabric and phosphatised rounded bone fragments, sample 4 (frame width 4.5 mm; plane polarised light). c Photomicrograph of weathered bone and limestone fragments, sample 5a (frame width 4.5 mm; cross polarised light). d Photomicrograph of the finely aggregated and phosphatised fabric, sample 6/7 (frame width 4.5 mm; cross polarised light). e Photomicrograph of the finely aggregated fabric, calcium carbonate and sub-rounded weathered bone fragments, sample 6/7 (frame width 4.5 mm; plane polarised light). f Photomicrograph of the finely aggregated and phosphatised silty clay fabric, sample 7 (frame width 4.5 mm; cross polarised light)

roof, with relatively large amounts of calcium carbonate nodules and bone fragmentation consequent on wetting/drying and severe surface weathering.

Layer 5a is a disrupted laminated silt loam sediment with abundant sub-rounded limestone fragments (2–8 mm) and calcium carbonate nodules (< 1 mm), as well as small (< 200 μm) to large (25 mm) bone fragments (Fig. 9c). All the bone fragments exhibit phosphatisation. In addition, there are a few (5–10%) iron pyrite spherules (< 50 μm) present throughout the groundmass.

There are two major zones of disturbance in layer 5a. The first occurs as a large zone (30 × 45 mm) in the centre of the slide with a 'jumbled' mass of limestone fragments intermixed with aggregates of silty clay and small (< 250 μm) bone fragments and

calcium carbonate nodules (< 1 mm). The second occurs in the upper 17 mm of the slide and consists of vertically and horizontally oriented fine laminations of irregular silty clay aggregates. In addition, the lower 60 mm of the slide exhibits much coarser laminae of silt loam, 2–10 mm in thickness.

As in layer 4, the laminar silt fabric is suggestive of a water-lain origin, interrupted by two lens of intrusive material. The upper zone of disturbance with its tilted aggregates has probably been caused by a combination of physical disturbance, bioturbation and/or frost-heave, whereas the middle zone is more suggestive of roof-collapse and small-scale gullying by water erosion in the loess. Since most of the bone fragments are found together with limestone fragments and calcium carbonate, the implication is that the faunal material has been incorporated into the sediment from elsewhere in the cave.

As in layers 4, 6 and 7, small calcium carbonate nodules are present in some numbers throughout the groundmass. In addition to this—an indicator of wetting and drying conditions—there were also a few iron pyrite spherules. These are believed to be contemporaneous with deposition and may possibly be an indicator of standing water and/or in-wash conditions (Wiltshire et al. 1994; Mees and Stoops 2010, 544).

The layer 6/7 interface is composed of silty clay aggregates with a little very fine quartz, exhibiting both zones of laminae and structureless areas. There is occasional (10%) very fine organic matter present in the groundmass, many (up to 25%) sub-rounded calcium carbonate nodules (< 2 mm), few (< 5%) irregular to sub-rounded bone fragments (< 2 mm) all phosphatised and a few (< 5%) iron pyrite spherules (< 50 μm) throughout the groundmass (Fig. 9d, e). Within the upper third of the slide, there are two conjoined lenses of silt aggregates (< 3 mm), and there is a 3–8-mm-thick lens of sub-rounded nodules of calcium carbonate with fragments of phosphatised animal bone in the middle of the slide.

The layer 6/7 interface is similar in composition to layer 7 below, but it does not exhibit a blocky ped structure. Instead, the upper half of the slide shows irregular laminae of silt and silty clay aggregates, whereas the lower half is relatively dense and non-laminar, with irregular to sub-rounded aggregates. Nonetheless, it does contain phosphatised fragments of animal bone and calcium carbonate nodules throughout, as well as one distinct lens of such nodules. The presence of iron pyrite spherules and small zones of sequioxide/manganese impregnation of the groundmass suggests periods of standing water alternating with dry conditions. In summary, the layer 6/7 interface is probably a water-lain, loessic sediment subject to wetting and drying, bioturbation and/or frost-heave, and the inclusion of material derived from roof fall.

Layer 7 is all one fabric, a silt loam, which exhibits a medium, sub-angular blocky ped structure. Within the peds, the sediment is arranged into a dense mass of smaller, sub-rounded to irregular aggregates (Fig. 9f). The groundmass is characterised by a general brown 'staining' with amorphous organic matter, in greater or lesser zones, as well as occasional very fine fragments of organic material in the groundmass. There are also some (< 5% of groundmass) small, discrete but discontinuous zones of amorphous sesquioxide/manganese impregnation of the groundmass, as well as a few (< 5%) iron pyrite spherules (< 50 μm). There is also one large fragment of carbonised wood, several small limestone pebbles, numerous calcium carbonate nodules (< 5 mm) and a few (< 5%) bone fragments, ranging in size from 100 μm to 9 mm, all exhibiting phosphatisation.

Layer 7 exhibits good structural ped development well defined by vertical/
horizontal channels with included fine and amorphous organic matter, phosphatised
bone fragments and rounded calcium carbonate nodules, all well integrated with the
groundmass (Fig. 10a, b). Nonetheless, this horizon appears to have been subject
either to periods of standing water, and/or the in-washing of sediments, often finely
laminar (Fig. 10c), as suggested by the presence of calcium carbonate nodules and
iron pyrite spherules (Fig. 10d). It is suggested that the distinctive sub-angular
blocky ped structure was caused by freeze-thaw cycles (Van Vliet-Lanoe 2010, 84)
(Fig. 10a, b). The horizon is not sufficiently 'dirty' to indicate the incorporation of
any direct evidence of human occupation.
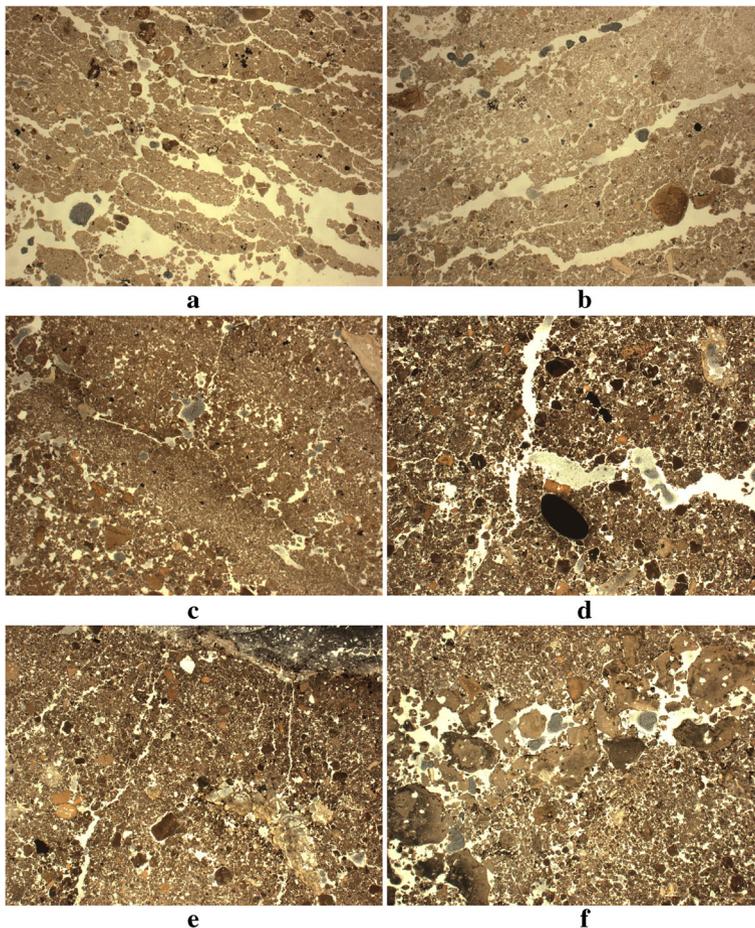
Fig. 10 **a** Photomicrograph of the well-defined sub-angular ped blocky structure defined by prismatic
channels, layer 7 (frame width = 1.5 cm; plane polarised light). **b** Photomicrograph of blocky peds defined
by fine channels, layer 7 (frame width = 1.5 cm; plane polarised light). **c** Photomicrograph of laminar loessic-
like, finely aggregated or pellety silt with fine bone fragments, layer 4 (frame width = 1.5 cm; plane polarised
light). **d** Photomicrograph of finely laminar silt with iron pyrites, layer 5a (frame width = 1.5 cm; plane
polarised light). **e** Photomicrograph of lens of sub-rounded bone fragments, mid-slide of layer 6/7 (frame
width = 1.5 cm; plane polarised light). **f** Photomicrograph of finely laminar silt with iron pyrites and fine sub-
rounded bone fragments, layer 5a (frame width = 1.5 cm; plane polarised light)

A number of micromorphological features occurred consistently throughout the slides. First, the horizon fabrics were all finely aggregated to a greater or lesser degree (Fig. 10c), with layer 7 exhibiting a well-developed sub-angular blocky ped structure (Fig. 10a, b) and layers 4 and 5a exhibiting some degree of fine lamination (Fig. 10c–f). At first glance, this fine aggregation could be seen as indicative of a high degree of faunal mixing or bioturbation (Kooistra and Pulleman 2010) and even soil formation. But these structural elements may also be caused by cryoturbation freeze-thaw effects (Van Vliet-Lanoe 2010, 84), and certainly the blocky ped structure in layer 7 is definitely a result of freeze-thaw action. Rapid cooling in silty clays may cause rapid shrinking, and lead to the development of angular blocky ped structures or prismatic peds such as observed in layer 7 (ibid., 85). Similarly, the bone fragments were all < 1 mm in size, sub-rounded and highly phosphatised (Fig. 10e). This high degree of bone fragmentation could conceivably result from butchery on site but is more probably the result of bone diagenesis associated with physical and chemical breakdown, surface weathering, freeze-thaw effects, physical mixing and re-working within the cave over a long period of time (Goldberg and Macphail 2006, 174ff; Karkanas et al. 1999; 2000). The ubiquitous phosphatisation could reflect the influence of other animals living in the cave but is more likely to result from long-term weathering of the bone on exposed surfaces. Almost all the fine silty clay aggregates had distinctive thin coatings of pure to fine dusty (or silty clay) coatings, which are probably indicative of successive in-washings of fine material from bare, exposed surfaces (Kuhn et al. 2010). Calcium carbonate nodules are also ubiquitous throughout and iron pyrites less so (Fig. 10d). They most probably reflect a secondary process at the time of deposition, as a result of surface wetting and drying, forming in pore spaces and then being re-worked into the matrix by mixing and diagenetic processes (Durand et al. 2010; Goldberg and Macphail 2006, 174ff).

Thus what is present is a series of finely laminar, mainly loessic-like fine sediments, probably water-lain, gradually accumulating in the cave (Fig. 10c–f). These have been subject, to a greater or lesser degree, to severe mixing processes, ostensibly through wetting and drying, bioturbation and/or freeze-thaw processes. There is a distinct lack of any cultural layer or midden-type debris which could represent human use of the cave, and little in the way of secondary pseudomorphs of included plant material. Much may have been lost as a result of oxidation, mixing processes and physical destruction in the past. Nonetheless, the minute, generally phosphatised, faunal remains found in every layer attest the amount of surface physical weathering, disturbance by wind or water, comminution by freeze-thaw and soil fauna and physical mixing processes, which have occurred, although (as suggested by David (1980)) the fragmentation of the bones may have owed something to human agency.

These conclusions generally are congruent with the observations made in the field by Mihailescu, particularly with regard to the influence of water in the formation and re-working of these deposits, both water flowing or standing within the cave and deriving from the limestone roof. Freeze-thaw cycles and the effects of alternate wetting and drying episodes were seen to be much in evidence, and the likely effects of roof fall were also noted. There is little to suggest evidence of prolonged human occupation.

Fauna

The fauna from Buzdujeni cave was identified by A.I. David (1980, 37–38, Table 6) but was published without distinction by layer. A total of 11,292 bones was examined, of which 3409 (or 30.2%) could be identified. David commented on the fact that the majority of the identified bones belonged to cave bear, which he regarded as having been deliberately hunted. These bones were cut into small pieces, and there were many cave bear molars, canines and incisors. In general, many of the mammalian long bones were said to have signs of butchery, and some were burnt. It appears, however, that David did carry out an analysis by layer, and some of these details were published by Anisyutkin (2001, 129, Table 15). The full account is now available (Table 4). The total for all the bones is now given as 10,255, of which 3133 (or 30.6%) could be identified. The figures for the individual species do not differ greatly from the ones which were previously published, the minimum number of individuals (MNI) being 138. Cave bear by number of identified specimens (NISP) constitute 68.9% of the total, but in terms of MNI they are no more than 22.5%. The second most common animal, horse, accounts for only 8.8% by NISP but 10.9% by MNI, with hyena and bison not far behind. Layer 6 is the most abundantly represented, with 27.3% of the remains by NISP. Usually for each layer, the number of unidentified specimens is more than twice those identified by NISP, but this is not the case in layer 5 where the numbers are practically equal. Layer 5 also produced the fewest remains by NISP. There is little manifest change in species frequency over time, although giant deer, reindeer and saiga do not appear until layer 6.

The Archaeological Succession

Nicolae Chetraru took the view that the archaeological succession at the cave could be divided into four main horizons, numbered from the top down, where horizon I corresponded to layers 2–5, and horizons II–IV corresponded to layers 6–8 respectively. Layers 2 and 3 have been described quite comprehensively, but for the remainder only the broad outlines are known. The material was classified according to the well-known system of François Bordes, including the various indices which he suggested (Bordes 1961; cf. Klein 1989). This classification has been followed here. Quantitative details for layers 2 and 3 are summarised in Table 5, and a selection of drawings and photographs of artefacts, from layers 2–3 and 6–7 respectively, is shown in Figs. 11, 12 and 13.

Layer 2

The principal raw material employed in layer 2, as in all the others at the site, was good quality flint derived from Cenomanian (Late Cretaceous) outcrops along the valley of the Pruth. This material can be found in particular abundance along the banks of the river between the present villages of Şirăuţi and Pererîta, south of Lipcani. Moreover, 53.6% of the artefacts in this layer were of grey flint and 46.4% of black flint. In other layers, although not here, a small minority of the raw material consists of quartzite, quartz, sandstone, schist and limestone. The total number of artefacts recovered in this layer is 372. The fact that only 31% of these artefacts had traces of cortex suggested to the excavator that a good deal of preliminary work had already taken place at the raw

Table 4 Faunal remains from Buzdujeni, according to provenance by layers

Species	Layer 2 NISP	Layer 2 MNI	Layer 3 NISP	Layer 3 MNI	Layer 4 NISP	Layer 4 MNI	Layer 5 NISP	Layer 5 MNI	Layer 6 NISP	Layer 6 MNI	Layer 7 NISP	Layer 7 MNI	Layer 8 NISP	Layer 8 MNI	Total NISP	Total MNI
Vulpes sp.	3	1	2	1	2	1	1	1	3	1	5	2	3	1	19	8
Crocuta spelaea	5	1	22	2	56	2	9	1	70	3	26	2	48	2	236	13
Ursus spelaeus	112	4	309	4	380	6	154	3	639	6	226	3	338	5	2158	31
Mustela sp.	–	–	–	–	–	–	2	1	2	1	–	–	–	–	4	2
Panthera spelaea	–	–	–	–	1	1	–	–	–	–	–	–	–	–	1	1
Lepus sp.	–	–	–	–	1	1	–	–	5	2	–	–	–	–	6	3
Marmota bobac	2	1	22	2	8	2	3	1	24	2	9	2	9	1	77	11
Spalax sp.	3	1	2	1	1	1	1	1	2	1	–	–	–	–	9	5
Mammuthus primigenius	–	–	1	1	8	1	2	1	29	1	2	1	2	1	44	6
Equus latipes	25	3	39	2	46	2	14	1	110	3	27	2	15	2	276	15
Asinus hydruntinus	–	–	1	1	2	1	–	–	2	1	1	1	–	–	6	4
Coelodonta antiquitatis	4	1	2	1	2	1	1	1	11	1	–	–	2	1	22	6
Cervus elaphus	–	–	7	2	4	1	–	–	19	2	4	1	1	1	35	7
Megaloceros giganteus	–	–	3	1	1	1	1	1	2	1	–	–	–	–	7	4
Rangifer tarandus	3	2	17	2	6	1	2	1	12	2	–	–	–	–	40	8
Saiga tatarica	–	–	2	1	1	1	–	–	–	–	–	–	–	–	3	2
Bison priscus	9	1	13	2	16	2	8	1	108	3	23	1	13	2	190	12
Total identified	166	15	442	23	535	25	198	14	1038	30	323	15	431	16	3133	138
Total UID	365		1074		1089		221		2347		935		1091		7122	
Total combined	531		1516		1624		419		3385		1258		1522		10,255	

Table 5 Buzdujeni layers 2 and 3: artefact characteristics

	Layer 2	Layer 3
Basic statistics		
Cores	14	17
Levallois flakes and blades	33	43
Non-levallois flakes and blades	134	122
Tools	138	260
Débitage	53	191
Total	372	633
Bordean indices [%]		
Levallois technical	19.7	26.0
Levallois typological	15.9	6.5
Facetting [I Fl]	37.0	46.4
Blade [I lam]	9.6	5.4
Tool types		
Typical Levallois flakes	7	10
Atypical Levallois flakes	15	7
Pseudo-levallois points	–	1
Sidescrapers	10	37
Endscrapers	1	11
Burins	–	3
Awls	6	7
Backed knives	11	13
Raclettes	6	10
Notched tools	14	36
Denticulates	28	34
Becs	3	5
Utilised flakes	31	66
Various	6	20

material outcrop before partially worked cores were imported for further processing. The fact that such processing did take place in the cave, however, is attested by the presence of numerous waste flakes and fragments (or débitage).

Fourteen cores were located in this layer, 8 complete and 6 fragmentary. Of those which were complete, four were classified as Levallois, two as disc cores and two as spherical or irregular. Then, 130 blanks were considered suitable for measurement, as a result of which their mean dimensions were established as follows: length 3.5 cm, width 2.95 cm, thickness 0.8 cm. In other words, this was a predominantly flake and not a blade industry, with a blade index (Ilam) estimated at 9.6, although the retouched tools tend to be on the larger side. According to Chetraru's calculations, there were 33 Levallois flakes and blades, and 134 non-Levallois. The number of classifiable striking platforms, taking both classes together, amounted to 100, and of these 37 could be regarded as facetted in the broad sense (IFl in Bordes's terminology). The Levallois technical index (i.e. the proportion of Levallois flakes and blades as a percentage of all blanks) was 19.7.
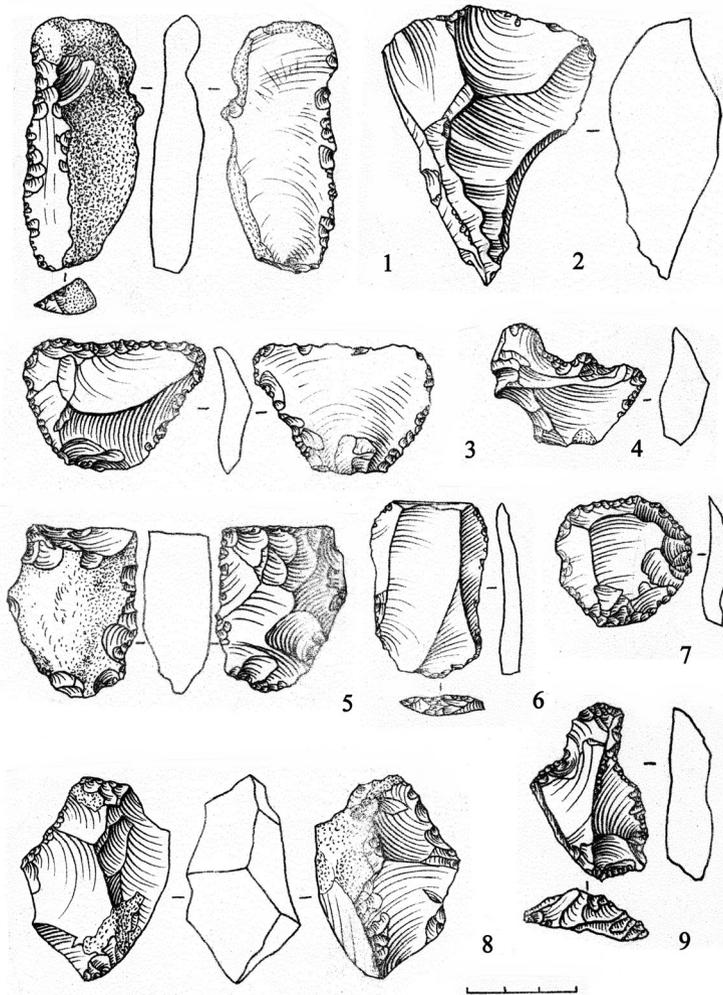
Fig. 11 Artefacts from layer 2 (1–4, 6–8) and 3 (5, 9) [after N.A. Chetraru]. 1 Naturally backed knife. 2 1-Platform Levallois core. 3 Sidescraper. 4 Notched tool. 5 2-Platform Levallois core. 6 Levallois blade. 7 and 9 Endscrapers. 8 Spherical core

The tool type list is based on that used by Bordes, but some categories, e.g. sidescrapers, have here been amalgamated for the sake of simplicity. The 22 Levallois flakes correspond to a Levallois typological index of 15.9, which is considered to be quite high. The sidescrapers are mainly on thick flakes, however, and in Chetraru's opinion they are not comparable to those found in Levallois dominated sites such as Molodova I and V. The backed knives include 6 where the back is formed by cortex and 5 where it consists of retouch. Notches and denticulates are clearly dominant in terms of numbers, 42 all together or 30% of the total in this layer. The becs correspond to Bordes's class of 'becs burinants alternes', where a projection is formed by the intersection of two notches, one on the dorsal and one on the ventral side (Bordes 1961, 37). The utilised flakes, as Bordes said, may in some cases be no more than 'pseudo-tools' (Bordes 1961, 45).
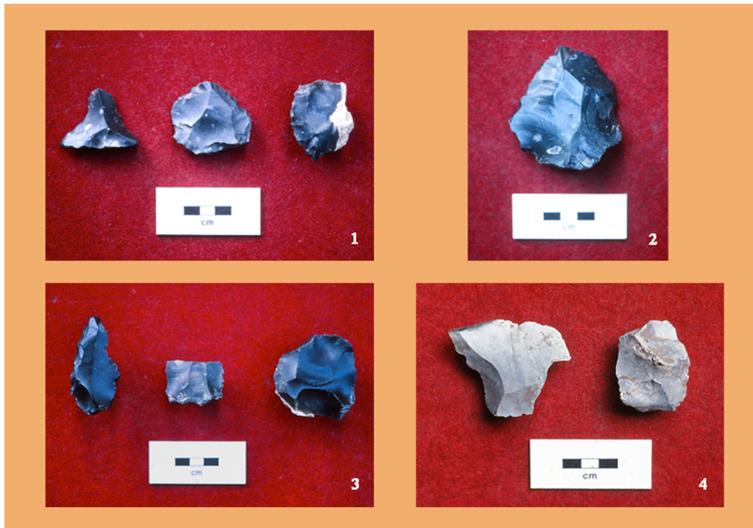
Fig. 12 Artefacts from layer 6 [Chişinău Museum collection, unless otherwise stated]. 1 Sidescraper, Levallois flake, disc core. 2 Levallois flake (in situ, 1993). 3 Point, Levallois blade, disc core. 4 Flake, disc core (in situ, 1993)

Layer 3

The total number of artefacts recovered in this layer is 633. Black flint accounts for 77.3% and grey flint for 20.5% of the total. The remaining 2.2% is made up of the minority raw materials mentioned above. Only 21% of the artefacts had traces of cortex, suggesting once more that a good deal of

Fig. 13 Artefacts from layer 8 [Chişinău Museum collection]. 1 Awl, flake, disc core. 2 Sandstone pebble. 3 Sidescraper, quartzite Levallois flake, disc core removal flake. 4 Sidescraper and two disc cores

preliminary work had already taken place elsewhere, before partially worked cores were imported for further processing. But there are even more numerous waste flakes and fragments than in the preceding layer, 191 pieces, constituting 30% of the total, so some flint working certainly took place in the cave. Thirty-five percent of the artefacts have significant degrees of patination, which suggested to the excavator that they had been exposed on the surface for a considerable length of time, although they are all sharp edged.

Seventeen cores were located in this layer, all of them complete. Two were classified as Levallois, eight as disc cores, three as spherical or irregular and one as prismatic, whereas three were said to be no more than 'atypical'. Further, 162 blanks were considered suitable for measurement, as a result of which their mean dimensions were established as follows: length 3.8 cm, width 3.4 cm, thickness 0.9 cm. These figures are not too different from those in the preceding layer, but the blade index at 5.4 is markedly lower. According to Chetraru's calculations, there were 43 Levallois flakes and blades, and 122 non-Levallois. The number of classifiable striking platforms, taking both classes together, amounted to 140, and of these 65 (or 46.4%) could be regarded as facetted in the broad sense. The Levallois technical index (Levallois flakes and blades as a percentage of all blanks) was 26.

The tool type list is constructed according to the same principles as in the previous case. The 17 Levallois flakes correspond to a Levallois typological index of 6.5. There are relatively large numbers of sidescrapers, generally small sized, as one would expect from the mean dimensions of blanks in this layer. There are also significant numbers of endscrapers, but many of them are of quite a specific type, where opposed notches serve to create a marked projection, referred to variously as a 'beak' (*kliuv*) or a 'spike' (*zhalo*). The backed knives include nine where the back is formed by cortex and four where it consists of retouch. Notches and denticulates are once again dominant in terms of numbers, 70 all together or 27% of the total in this layer. It is noticeable that out of the 20 pieces lumped together as 'various', 15 are described as having 'beaks' of one kind or another.

Some characteristic tools from both layers are shown in Fig. 11. Nos. 11.5 and 9 belong to layer 3, the remainder belong to layer 2. The endscraper at Fig. 11(7) is a fairly conventional type on a small round flake. The one at Fig. 11(9) is the type distinguished by Chetraru where two notches form a projection referred to by him as a 'beak' or 'spike'.

Layers 4 and 5

No precise details are available regarding layers 4 and 5, but since they are grouped together with layers 2 and 3 into a single horizon, it can be assumed that they differ little from the above. As in the layers above, the degree of artefact patination was marked. A single bifacial leafpoint was recorded in layer 4. Anisyutkin (1990, 2001) was able to study some of the material from these layers, and he agreed that they showed little or no evolution over time. He presented some indices as follows—IL 14.5, IFl 35.1, Ilam 5.3—which, as he said, differed little from those in layers 2 and 3. All the layers were classified, both by him and by Chetraru, as a Denticulate Mousterian.

Layer 6

Only basic details are available for layers 6–8 (equivalent to horizons II–IV). In these layers, the raw materials used were the same as before, in similar proportions. Layer 6, up to 60 cm thick, and covering the entirety of the cave floor, was the most abundant archaeologically in the entire sequence, with approximately 4000 artefacts, more than all the other layers combined. No distinct subdivisions within this layer could be discerned, hence the material is considered as a whole. More black flint than grey flint was employed, and, as could be expected, there was a considerable amount of débitage. There were > 70 disc cores, as well as 1- and 2-platform Levallois cores, spherical cores and 'atypical' cores. There were relatively few Levallois blanks, as reflected in a Levallois technical index of 10. There were also relatively few blades (with a blade index of 7) and a broad facetting index of 30. Among the retouched tools, there were relatively many sidescrapers (up to 12%) and some which were combined with other tools. Notwithstanding the low figure for IL, the Levallois typological index at 16 was quite high. The tool types represented in smaller numbers included two bifacial leafpoints. As previously, notches and denticulates were clearly predominant, constituting 50–60% of the total.

Layer 7

The finds from this layer, while fewer in number, are somewhat larger in size, with average dimensions of 7–8 rather than 5–6 cm (or even less) as previously. There are relatively more Levallois cores and blanks, reflected in an increased Levallois technical index of 20. Both blade and broad facetting indices are also increased at 15 and 35 respectively. Sidescrapers amount to 6% of the retouched tools, but there are no backed knives, endscrapers, burins or awls. The Levallois typological index amounts to 17. Notches and denticulates are again dominant, although reduced in numbers, accounting for 20% of the total retouched tools.

Layer 8

The basal layer is quite thick in places, but does not occupy the entire floor of the cave, and although there are a fair number of artefacts, the number of retouched tools is reduced. In principle, the industry does not differ from those in the preceding layers in terms of raw material and technology, and in the presence of a considerable débitage component, but since the totals are so few, no meaningful figures can be given for Levallois technological and typological, blade or broad facetting indices. Sidescrapers amount to 11% of the retouched tools, and the smaller categories include what are described as two chopping tools on sandstone pebbles. Notches and denticulates are as usual dominant, with 30% of the total.

   A selection of tools from layers 6 and 7 is shown at Figs. 12 and 13. Most are from the Museum collection in Chişinău, but some were found in situ in 1993.

Whatever differences there may be between the various layers in the stratigraphic succession, the entire sequence, including layers 6–8, was described as a Denticulate Mousterian. Although the details available for the lower layers are incomplete, it is likely that the fuller picture we possess for layers 2 and 3 does give a fair impression of the industry as a whole.

Comparative Framework

According to Chetraru, there are essentially two Middle Palaeolithic variants represented in Moldova, a Typical and a Denticulate Mousterian. The Typical Mousterian is divided into two facies, a non-Levallois and a Levallois facies. The non-Levallois is represented at such sites as Trinca (Anisyutkin et al. 1986), whereas the Levallois facies is particularly well represented at the now destroyed rock shelter of Buteşti (Chetraru 1970, 1973; cf. Anisyutkin 1990, 2001). According to Chetraru, the archaeological inventory here consists of 560 artefacts, including 26 cores and 211 tools. The indices calculated by him were as follows—IL 35, ILty 49.2, IFl 56 and Ilam up to 24. Sidescrapers form 16.5% of the tool total, and notches and denticulates 5.7% (somewhat different figures are given by Anisyutkin, but the general balance of the industry is the same). In comparison with Buzdujeni, this is a strongly Levallois industry, nonetheless classed as Typical Mousterian because of the large numbers of sidescrapers. There are very few notches and denticulates. Both authors agree that on the territory of Moldova, Buzdujeni alone represents a Denticulate Mousterian.

In a wider perspective, however, it is claimed that further variants need to be taken into consideration. Anisyutkin (1990, 2001) suggested that there was a great similarity between the material recovered at Buzdujeni and that from Stînca, a site he excavated on the right bank of the Dniester, north-west of the Ukrainian city of Hotin, such that one could speak of a 'Stînca culture' uniting the two. Chetraru did not accept this idea, and it has not found favour with others either (Borziac et al. 1998). The latter authors emphasise the distinctiveness of the Levallois dominated industries further south along the Dniester river (Molodova I and V, Cormani and Chetrosy), and this also accords with Chetraru's view. Ripiceni-Izvor, on the Romanian side of the Pruth, is regarded as part of the Late Micoquian, because of its substantial bifacial component, as well as undoubted Levallois elements. Like all the other writers on the subject, these authors agree that Buzdujeni is a Denticulate Mousterian, and so far the only such site in the region.

As to why the long-lasting occupation of the site should have taken this particular form is a question that has yet to be answered. It is evident from the above account that our information about the archaeological succession so far is incomplete. In particular, a full study needs to be made of the material from layer 6. The framework employed, using Bordean indices, needs to be complemented by other methods. A new study of the archaeological material from Brînzeni (Noiret 2009) suggested that the role of notches and denticulates in that case had been exaggerated, so these and other aspects may need reconsideration.

Dating of the Site

Two samples obtained from the control section in the cave in 1993 (out of a possible total of five) were dated at the Oxford Radiocarbon Accelerator Unit as follows (Hedges et al. 1996).

Lab. No.	Sample	^{14}C age	δ^{13}C	Layer	Depth
OxA-4897	Long bone	35,400 ± 1400 BP	− 18.3	6	1.65 m below datum
OxA-4896	Long bone	35,300 ± 1500 BP	− 20.8	8	2.05 m below datum

The difference between these two dates is very slight, and, as was pointed out at the time, they do not agree with the tentative geological interpretation of these layers (Allsworth-Jones 2000). At one time, it was claimed that the Middle Palaeolithic in neighbouring Romania continued until very late (Cârciumaru 1989), but the grounds for this assertion are very weak (Allsworth-Jones 1990, 215–221, Table 7.11; Mertens 1996), even more so in the light of recent developments summarised below. The dates published in 1996 can now be calibrated (at the 95.4% level) using the latest programs (OxCal 4.3.2 and IntCal 13) from the Oxford Radiocarbon Accelerator Unit (Bronk Ramsey 2017; Reimer et al. 2013) as follows.

OxA-4897 40,811–34,952 cal BP	OxA-4896 40,936–34,631 cal BP

These results are perhaps marginally more acceptable, but according to the estimates provided by Higham et al. (2014), they come right at the end of the Middle Palaeolithic period and are still not compatible with the other evidence from the site. According to information received by Borziac et al. (1998, 39), preliminary electron spin resonance dates for the lower layers at the site suggested that they were in the range from 120 to 80 thousand years old, but no full account of these results has been published. In the interpretation favoured by Medyanik and Mihailescu, layer 5a corresponds to an interstadial early in the last glacial period, perhaps the equivalent of Brørup. It remains to test this hypothesis. It would be desirable in general to re-date the existing samples from the site, or to obtain new ones, so that the chronology of its Middle Palaeolithic occupation could be put on a firmer footing.

Conclusion

A diagram giving summary details of the entire sequence at the site is shown in Table 6. From this, it can be seen that there were clear environmental fluctuations over time, from the base upwards. After the cessation of stream activity, which probably took place during the last interglacial, there was an accumulation of deposits over a time corresponding to the last glacial period. The most favourable climatic conditions occurred in layers 5a and 6, the suggestion being that 5a corresponds to an interstadial episode early in that period. For the most part, conditions in and around the site reflected the existence of a cold periglacial steppe. Freeze-thaw structures are much

Table 6 Buzdujeni site summary

Layers	Field description	Micromorphology	Magnetic susceptibility	Palynology	Fauna	Archaeology
1 (10 cm)	Dark grey silty loam. Recent					Denticulate Mousterian throughout in layers 2–8
2 (20–30 cm)	Light grey silty loam. Repeated penetration of rainwater. Hearths				Total NISP MNI 166 15; Cave bear 112 4	Horizon I total artefacts 372. IL 19.7 ILty 15.9| IF 37.0 I lam 9.6
3 (30–40 cm)	Light greyish-yellow loam. Large limestone blocks at the base				Total NISP MNI 442 23; Cave bear 309 4	Horizon I total artefacts 633. IL 26.0 ILty 6.5. IFI 46.4 I lam 5.4
4 (30–40 cm)	Pale yellow loam. Sharp edged limestone fragments, thin silt lenses. ≈ Valdai loess. 10YR5/4-4/4	Water-lain loessic-like material; alternate wet/dry; bioturbated/freeze-thaw; surface weathering; phosphatisation	7.45	[8 and 7] Dry and cold. Xerophile periglacial steppe. Some deciduous trees in refugia. [8] AP 39.2 NAP 58.5 spores 2.3%. [7] AP 32.4 NAP 60.6 spores 7%	Total NISP MNI 535 25; Cave bear 380 6	Horizon I (both layers 4 and 5). Comparable to layers 2 and 3. Combined indices IL 14.5 IFI 35.1 I lam 5.3
5b (20–30 cm)	Light brown loam. Sharp edged limestone fragments 10YR7/4		7.9	[6] Arid and cold. Periglacial steppe. Wooded area reduced. AP 21.4 NAP 71.4 spores 7.2%	Total NISP MNI 198 14	
5a (20–40 cm)	Brown to dark brown loam, horizontally layered. Subaqueous. ≈ Krutitsky interstadial. Large limestone blocks at the top. 10YR6/6-4/3	Waterlain; wet/dry; bioturbated/freeze-thaw; interrupted by roof fall	11.2	[5 and 4] Relatively warm and damp. Limited wooded area. Some deciduous trees in refugia. [5] AP 30 NAP 68.3 spores 1.7%	Cave bear 154 3	
6 (25–50 cm)	Light brown loam, with many limestone fragments. Hearths. 10YR5/4-4/3. OxA-4897 35,000 ± 1400 BP equivalent to 40,811–34,952 cal BP	Waterlain; surface weathering; wet/dry; bioturbated/freeze–thaw	13.5–13.55	[3] Temperate and relatively moist. Some expansion of wooded area. AP 23.7 NAP 65.7 spores 10.6%	Total NISP MNI 1038 30; Cave bear 639 6	Horizon II IL 10 ILty 16 IFI 30 I lam 7 ≈ 4000 artefacts, the most abundant layer in the site

Table 6 (continued)

Layers	Field description	Micromorphology	Magnetic susceptibility	Palynology	Fauna	Archaeology
7 (10–20 cm)	Dark brown loam, with many limestone fragments. 10YR4/4	Silt loam with freeze-thaw blocky ped structure; surface weathering; inwash; wet/dry	11.25	[2] Dry and continental conditions. Wooded area reduced. AP 14.9 NAP 81.4 spores 3.7%	Total NISP MNI 323 15 Cave bear 226 3	Horizon III IL 20 ILty 17 IFI 35 I lam 15
8 (15–35 cm)	Dark brown loam, many sharp edged limestone fragments, considerable organic material. Large limestone blocks at the top. Cessation of stream activity. 10YR4/4-6/4 OxA-4896 35,300±1500BP equivalent to 40,936–34,631 cal BP		12.1	[1] Dry, increase in cold. Periglacial steppe, with rare pine-birch woods. AP 40.8 NAP 55.1 spores 4.1%	Total NISP MNI 431 16 Cave bear 338 5	Horizon IV characteristics as before, a large débitage element, but few retouched tools
9	Basal limestone deposit, some traces of an ancient streambed					

in evidence and there are signs of water action throughout. Layer 6 corresponds to a phase of maximum human occupation, although there are no signs of soil formation or anthropogenic deposits. It also corresponds to a time when cave bear, always the most commonly represented species, were most prolific at the site. The archaeological inventory from layer 6 needs to be fully published, and a reconsideration of the entire material might throw fresh light on what the long-lasting dominance of a Denticulate Mousterian might mean. The existing radiocarbon dates, even as calibrated, cannot be regarded as satisfactory, and there is a manifest contradiction between them and the suggested age of layer 5a. Granted that there are still problems, it is nonetheless worth emphasising that the number of Middle Palaeolithic cave sites in the area which have been studied in such detail as this are few, and the record deserves to be widely known. Further multi-disciplinary investigations are needed, involving several sites, as well as cooperation between all parties concerned, in order to provide a secure environmental and chronological framework for both the Middle and the Upper Palaeolithic in this part of south-eastern Europe as a whole.

In that light, it is apposite to be reminded of what that current framework is, a framework rather different to what it was when the fieldwork described in this report was undertaken, and when the research project of which this work is part was initiated in 1992–1993.

Comparative Framework

The change from Middle to Upper Palaeolithic in Eurasia and the concomitant change from Neanderthal to anatomically modern humans—with which our research project was concerned—continues to be a centre of scientific interest, as is shown by a number of recent broad surveys on the subject (Allsworth-Jones 2014; Higham et al. 2014; Davies et al. 2015; Hublin 2015). In some respects, our perspective on this matter has altered drastically, due in large part to the impact of improved dating methods. Radiocarbon dating of bone and charcoal using ultrafiltration and an acid-base-oxidation: stepped combustion (ABOx-SC) protocol, respectively, has produced a succession of results which are markedly older than those previously obtained, particularly when taken in conjunction with an improved calibration curve now extending back for some 50,000 years (Higham 2011; Bird et al. 1999; Reimer et al. 2013). Also important are methods completely independent of radiocarbon dating, such as TL and tephrochronology, especially in relation to the Campanian Ignimbrite. This ignimbrite layer, originating in a volcanic explosion at the Phlegrean Fields in Italy, is clearly detectable over a wide area of Europe, including Kostenki, where it has an estimated age of 39.3 ka on the basis of Ar/Ar measurements (Pyle et al. 2006). In the present context, we are particularly concerned with the Middle Palaeolithic side of this equation. Because of the more refined methods now being adopted, Mellars in 2006 already warned that the 'long tail' of existing dates for supposedly late Mousterian sites (younger than 35,000 years) might well be at risk, and Higham in 2011 went so far as to say that 70% of the supposedly oldest such dates (both Middle and Upper Palaeolithic) might well represent serious underestimates (Mellars 2006; Higham 2011). These predictions have been amply fulfilled, both at the western end of the continent in Spain and at the eastern end in the Caucasus. Thus, at Mezmaiskaya, in the northern Caucasus, a Neanderthal neonate skeleton from layer 3 was originally dated to

$29{,}195 \pm 965$ BP, but now infant cranial fragments from the overlying layer 2 have been dated (using ultrafiltration) to $39{,}700 \pm 1100$ BP, equivalent to 42,300–45,600 cal BP (Golovanova et al. 2010; Pinhasi et al. 2011). Both layers are characterised as Middle Palaeolithic. There are similar dates for the Middle Palaeolithic in the southern Caucasus at Ortvale Klde, Sakazhia and Ortvala (Pinhasi et al. 2012). The idea that this area served as some kind of Neanderthal refugium therefore has to be abandoned.

In 2014, Higham and his colleagues presented new radiocarbon dating results from 40 Mousterian and Neanderthal sites in Europe, and concluded that the Middle Palaeolithic as a whole came to an end by 41,030–39,260 cal BP (Higham et al. 2014, Fig. 1c, probability distribution function for the latest of these sites at 95.4% level). Commenting on these results, Davies (2014, 261) remarked that in the future, researchers would have to 'try hard to demonstrate Neanderthal survival in Europe after 40,000 years ago'. In the chart subsequently produced by himself and his colleagues, it is noteworthy that all the dated Mousterian sites occur up to and before an isochron marked by the Campanian Ignimbrite and not afterwards (Davies et al. 2015, Fig. 5). This diagram may be compared to the one subsequently produced by Hublin, where the Campanian Ignimbrite is also taken as a continent-wide valid marker (Hublin 2015, Fig. 7). In both cases, various 'transitional' industries as well as the first indications of the Aurignacian also make their appearance before the Campanian Ignimbrite. That suggests the possibility of some degree of interaction between the two entities and their presumed makers, which is borne out by the current estimate that the proportion of Neanderthal-derived DNA in present-day populations outside Africa amounts to some 1.5–2.1% (Sánchez-Quinto and Lalueza-Fox 2015). Nonetheless, that does not mean that there were not substantial differences between the two. Relying mainly on archaeological evidence, Roebroeks has listed some of the main points of divergence (Roebroeks 2008, Table 1). He pointed out that, in comparison with early modern humans, the Neanderthals are likely to have had a relatively restricted diet and a shorter effective foraging radius, with a low population density in the areas which they did occupy. Approaching the matter more recently from a strictly palaeogenetic angle, Sánchez-Quinto and Lalueza-Fox (2015) have come to a remarkably similar conclusion, that the Neanderthals had a long-term small population size, with isolated groups probably practising inbreeding at times, and that these characteristics could have played a role in their extinction (cf. Rogers et al. 2017). The early moderns did not share these characteristics, so there is still a marked contrast between the two.

This is the contemporary context within which the sequence available at Buzdujeni, reported above, and the other sites we studied in Moldova, reported elsewhere, should now be seen.

draw attention to the rich archaeological potential which that country possesses, and encourage the initiation of other projects which will realise that potential.

Compliance with Ethical Standards

Conflict of Interest   The authors declare that they have no conflict of interest.

Appendix 1: Detailed micromorphological descriptions of the sediment blocks at Buzdujeni

Layer 4

Structure: laminated throughout with fine vughy micro-structure; comprised of three distinct fabrics; *Porosity*: <15%; <10% vughs, irregular to sub-rounded to interconnected, <300 μm; <5% channels, mainly horizontal between laminations, <6 cm across, <500 μm wide, weakly serrated, irregular to accommodated, occasionally vertical; *Basic Components*: uppermost 15 mm of slide: silt aggregates, irregular to sub-rounded, 300–750 μm, with internal fine crack structure, generally coated with non-laminated dusty clay, with small bone fragments; upper 15–95 mm of slide: alternating fine/coarse laminations of loam; composed of 15–20% very fine quartz, 50% silt and 30–35% clay with weakly developed, reticulate striations, organised in pellety aggregates, sub-rounded, 50–500 μm; fine laminations 1–5 mm thick; coarse laminations up to 10 mm thick; lower 95–138 mm of slide: coarser and laminations less well defined, with more medium quartz (<5%), less very fine quartz (10%), >55% silt and <30% oriented clay; fine lamination composition: porosity <20%; limit 100 μm; coarse/fine ratio: 5/95; coarse fraction: 2% medium and 3% fine quartz, sub-rounded to sub-angular, 100–250 μm; fine fraction: 15% very fine quartz, 50–100 μm; >40% silt and <25% clay; 15% bone fragments, <500 μm; speckled to weakly reticulate striated; yellowish brown (CPL), pale yellowish brown (PPL), whitish yellow (RL); coarse lamination composition: 30% porosity; limit 100 μm; coarse/fine ratio: 10/90; coarse fraction: 5% medium and 2% fine quartz, sub-rounded to sub-angular, 100–250 μm; fine fraction: arranged in sub-rounded to irregular aggregates, 300–750 μm; 15% very fine quartz, 50–100 μm; 45% silt and 20% clay; 10% bone fragments, <500 μm; speckled top discontinuous striated; golden brown (CPL), medium brown (PPL), pale yellow (RL); *Pedofeatures*: *Textural*: very abundant (30–35%) non-laminated dusty clay as coatings of aggregates, moderate birefringence, yellowish gold (CPL); *Amorphous*: few (5%) rounded aggregates of silt with 'halo' of phosphatised silty clay, < 250 μm; very abundant bone fragments, up to 10–15% of groundmass, sub-rounded, 50–500 μm, all with 'halo' of phosphatisation; very few (<5%) small, irregular, amorphous zones of sesquioxide impregnation; very few (<5%) calcium carbonate nodules, sub-rounded, pale brown (PPL), black (CPL), <100 μm.

Layer 5a

Structure: less well laminated than layer 4 above, with upper 17 mm part-inverted and disturbed fine laminations, <5 mm, middle 17–72 mm of slide with fine, horizontal

laminations, and lower 72–133 mm of slide with coarser laminations, 2–10 mm; *Porosity*: < 30%; < 20% vughs, irregular to sub-rounded to interconnected, < 300 μm; < 10% channels, mainly horizontal/planar between laminations, < 6 cm across, < 1 mm wide, smooth to weakly serrated, accommodated; rarely vertical, irregular to 'wavy', weakly accommodated, with discontinuous infills of finely aggregated fine fraction material; *Mineral Components*: all same fabric throughout three zones; limit 100 μm; coarse/fine ratio: 5/95; coarse fraction: 2% medium and 3% fine quartz, 100–250 μm, sub-rounded to sub-angular; fine fraction: 15% very fine quartz, 50–100 μm; remainder in aggregates, irregular to sub-rounded, < 500 μm; composed of silty clay aggregates of < 300 μm, evenly mixed with very fine quartz and silt aggregates; with 50–60% silt, 20–30% clay; speckled to not speckled; greyish/yellowish white (CPL), pale/very pale brown (PPL), yellowish brown (RL); *Pedofeatures*: *Textural*: in silty clay aggregates, all non-laminated dusty clay, weak to moderate birefringence, yellow (CPL); occasional (< 5%) iron impregnated limpid clay throughout groundmass, moderate birefringence, reddish gold (CPL); rare (< 2%) fragments of limpid clay, sub-angular, < 75 μm; in 'coarser' aggregates, minor non-laminated dusty clay, weak birefringence, < 10% of aggregate, pale yellow (CPL); *Amorphous*: few (5%) sub-rounded fragments of bone, < 250 μm, all phosphatised; small irregular and sub-rounded zones of amorphous sesquioxide impregnation throughout groundmass, < 500 μm; 5–10% iron pyrites spherules throughout groundmass, < 100 μm; calcium carbonate nodules, up to 25% of groundmass, < 1 mm, sub-rounded, very pale yellowish brown (PPL), opaque greyish white (CPL).

Layer 6/7 interface

Structure: 2 main, homogeneous fabrics; *Basic Components*: main fabric (1): 15–43 mm and 60–135 mm of slide; < 20% vughs, < 1 mm, sub-rounded to irregular to interconnected; silty clay aggregates with very fine quartz, < 3 mm, and numerous calcium carbonate nodules, < 2 mm; greyish/pale orangey brown (CPL), brown/pale yellowish brown (PPL), pale greyish brown (RL); main fabric (2): irregular zone of silt aggregates between 10–13 and 22–60 mm of slide; open, interconnected vughy structure, 20% vughs; aggregates 100 μm to 1 mm, sub-rounded to irregular; brown to orangey brown (CPL), brown (PPL); also lens at 68–76 mm on slide of calcium carbonate nodules, sub-rounded to sub-angular, < 5 mm; *Pedofeatures*: *Amorphous*: many calcium carbonate nodules, up to 25% of total groundmass, < 5 mm, often phosphatised; few (5%) bone fragments in groundmass, < 1 mm, all phosphatised; few (< 5%) iron pyrites spherules, < 50 μm, sub-rounded to rounded; few (< 5% of groundmass) discontinuous zones of amorphous sesquioxides/manganese.

Layer 7

Structure: all one fabric with medium, sub-angular blocky peds, 15–50 mm; *Porosity*: 5–10% inter-aggregate channels, < 5 cm long, < 1 mm wide, walls partially accommodated, weakly serrated, prismatic vertical and horizontal; *Organic Components*: greater or lesser amounts of amorphous organic matter staining of fine groundmass; occasional (10%) very fine fragments of organic matter in groundmass, < 50 μm; *Basic Components*: 2 large sub-rounded limestone fragments, 10–25 mm; limit 100 μm; coarse/fine

ratio: 10% quartz and 10% CaCO3 nodules; coarse fraction: 5% medium and 5% fine quartz, sub-angular to sub-rounded, 100–250 μm; 10% calcium carbonate nodules, sub-rounded to irregular, 100–500 μm and 0.5–2 mm; fine fraction: 10% very fine quartz, 50–100 μm; 60% silt and 20% clay; weakly speckled/weak birefringence; grey/brown (CPL) in alternate, amorphous zones, brown (PPL), pale greyish brown (RL); *Pedofeatures*: *Textural*: all fine limpid to dusty clay, moderate birefringence, yellow to gold (CPL), as channel/crack linings between and within peds and within groundmass; very rare (< 1%) fragments of limpid clay, < 25 μm, oblong; *Amorphous*: 5% bone fragments throughout groundmass, irregular to sub-rounded, < 300 μm and 1–2 mm, all phosphatised; 10% calcium carbonate nodules (as above); very few (< 5%) iron pyrites spherules, sub-rounded to rounded, red/black (PPL), < 150 μm.

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