TREUGOL’NAYA CAVE IN THE NORTHERN CAUCASUS, RUSSIA: CHRONOLOGY, PALEOENVIRONMENTS, INDUSTRIES, AND RELATIONSHIP TO THE LOWER PALEOLITHIC IN EASTERN EUROPE

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Abstract

Today, only Treugol’naya Cave has reliably dated evidence for human settlement in eastern Europe from the beginning through the middle of the Middle Pleistocene, as well one of the oldest Lower Paleolithic occupations in Europe. The cave is a small karst cavity situated at 1,500 m above sea level in the Upper Kuban’ Basin, infilled by ca. 4.5 m of matrix-supported conglomerates with limestone nodules in a matrix of clay, silt, and sand. At the site, new data have expanded our knowledge about cultural development during the Lower Paleolithic in eastern Europe and the Caucasus. Detailed research at this site, using modern analytical methods, has revealed extensive information about the paleoenvironmental conditions. Layers containing stone artifacts have been dated (by ESR, paleomagnetism, magnetostratigraphy, pollen, and fauna) to the early part of the Middle Pleistocene, from approximately 600,000 to 350,000 years ago. Four artifact assemblages in the cave are assigned to the Lower Paleolithic flake industries, generally defined as “Tayacian” or “Proto-Charentian”, and a core-chopper pebble industry, all completely lacking in Acheulian handaxes.

INTRODUCTION

Eastern Europe occupies a huge territory, extending from the Arctic Ocean in the north to the Caspian and Black Seas, including the northern slope of Caucasian Mountains (northern Caucasus) in the south, and from Carpathian mountains in the southwest to Ural Mountains in the east. Much of eastern Europe is covered by the vast Russian Plain with elevations rarely exceeding 300 m above sea level. Evidence for the Lower Paleolithic occupation in eastern Europe is very problematic. A recent reappraisal of the artifacts and chronological evidence for the earliest occupation in Europe as a whole (Roebroeks and Kolfshoten, 1995) failed to recognize any location in the Russian Plain with solid evidence for a Lower Paleolithic occupation (Doronichev, 2001; Hofacker, 2002).

In Luka-Vrublevskaya in the Dniester River Valley, nearly 50 artifact-like flint lithics were collected from a huge number of natural pebbles found along the river bank. Most of the finds had been heavily abraded and their age is highly problematic. Teimbal and Ignatenkov’s Kutok non-stratified find spots in the lower Kuban River Valley have been also assigned to the Lower Paleolithic (Liubin and Bosinski, 1995; Liubin, 1998). At Teimbal, only two lithic pieces were found on a heavily eroded surface containing late Lower Pleistocene mammal fauna from the Tamanian Complex (dated ca. 1.1–0.8 Myr). No
definitive association of these artifacts with the faunal remains was ever confirmed despite long discussion in the literature (Nesmeyanov, 1999: 184). Ignatenkov's Kutok yielded several artifacts, which were collected under a 35-meter river terrace containing the Lower Pleistocene mammal fauna from the Pseups Complex (dated ca. 2.5–1.97 Myr). Moreover, the last typological analysis of the material attributed most of these finds to the Upper Acheulian (Golovanova, 1986). All the locations above provided undisputed artifacts, but lacked any reliable stratigraphical position.

In Gerasimovka on the Sea of Azov coast, seven heavily weathered and abraded artifact-like pieces were collected among a huge number of natural flint pebbles in a coarse gravel horizon. This gravel was correlated with the late Lower or early Middle Pleistocene (Cromerian) based on its Tiraspolian fauna (several boxes of Archidiskodon wasti) and its rodents, including Mimomys, Ellobius, Microtus, and Lagurus (Praslov, 1995, 2001). These pieces (Praslov, 1968, Fig. 2) were probably produced by natural weathering rather than humans (Doronichev, 2001; Hofacker, 2002: 44) and thus may be regarded solely as "possibilitics" or "incertofacts" (as defined by Roebroeks and Kolfschoten, 1995: 304).

At Pogreby and Dubossary, situated only few kilometers apart in the lower Dniester River Basin, 259 and 415 lithics respectively were found on eroded surfaces on the high VI and VII river terraces. Only a few lithics were found in the loess units attributed to the Dnieper Glaciation (OIS 6 or OIS 8), on the eroded surfaces of two paleosols that correlated with the OIS 11 or OIS 13, where a reworked Mammutus trogontherii tooth fragment was documented (Anisjutkin, 1992). They could have been redeposited from younger (i.e., later Middle Pleistocene or even Upper Pleistocene) sediment. For example, Ivanova (1985: 212) noted that the deeply stratified loess-like units with intercalated interstadial paleosols, that cover the high terraces in the lower Dnieper Basin, mostly date to the Upper Pleistocene. Some Mousterian or Upper Paleolithic artifacts appear to be reworked with Pogreby (Anisjutkin, 1987: 8) and many randomly fractured pieces occurred in both locations (Hofacker, 2002: 47). Nevertheless, Anisjutkin (1992: 36; Pospelova and Levkovskaya, 1994, Fig. 1) correlated these reworked lithic assemblages with OIS 11 or rather OIS 13, although slightly earlier Anisjutkin (1987: 13) had suggested that the Pogreby industry most likely correlated with the OIS 6 or OIS 8.

At Khryashchi and Mikhailovskoe, situated only 2 km from one another in northern Donets River Valley, most of the artifacts were found in the third river terrace or on the eroded surface of a modern fluvial point bar. At Khryashchi, a few lithics were recovered when excavating the upper level of the third terrace alluvial gravel, exposed by the modern point bar, as well as from the lower and middle paleosols within this terrace. The pollen for the third terrace alluvial gravel suggested a very cold paleoenvironment, which was tentatively correlated (Praslov, 1995) with the Dnieper Glaciation (OIS 8), while the lower and middle paleosols were correlated with the cold mid-Dnieper Odintsovo Interstadial (OIS 7). Praslov (2001: 21) has reassigned the gravel to the Don Glaciation (OIS 12) and the paleosols to the Likhvin Interglacial (broadly correlated with OIS 11), but fails to provide new data to support this change. No good faunal material was recovered from these units. Moreover, only modern rodents (Citellus, Ellobius, Clethrionomys, Arvicola ex. gr. terrestris, Microtus arvalis, Microtus ex. gr. oeconomys) were found in the third terrace alluvial gravels, while some Ursus spelaeus, Equus hydruntinus, and Allactaga ex. gr. jaculus remains were recovered from the lower paleosol. Three Lower Paleolithic assemblages were identified at Khryashchi and Mikhailovskoe. The alluvial gravel at Khryashchi yielded 60 lithics representing the oldest assemblage. The artifacts are clearly rolled and many of them appear to be naturally fractured pieces (Hofacker, 2002: 48). Found in the lower paleosol at Mikhailovskoe, the middle assemblage included 220 lithics. The middle fossil soil at Khryashchi yielded 20 lithics that comprise the upper assemblage. Redating these materials to the OIS 12 and OIS 11 (Praslov, 2001: 21) seems unwarranted at this time due to the regional climato-stratigraphic correlation (Zubakov et al., 1985: 135) that supports the earlier suggested (Praslov, 1984: 96–97) OIS 7 and OIS 8 age for these industries.

Although Khryashchi and Mikhailovskoe were proposed to be the only stratified pre-Mousterian locations on the Russian Plain (Praslov,
2001: 22), like the problematic locations above, no stratified context was provided for most of the finds, including the few lithics dug from the upper level of the third terrace alluvial gravel at Khryashchi (Praslov, 1968: 24, Fig. 4). Only one flint flake was found in a section at the top of the middle paleosol at Khryashchi (Praslov, 1968: 24, 34), but seven flints were excavated from the lower paleosol at Mikhailovskoe (Praslov, 1968: 44, Fig. 13).

Therefore, while one could suggest Pogreby, Dubossary, Khryashchi and Mikhailovskoe as possible evidence for a Lower Paleolithic occupation in eastern Europe (Fig. 1), they appear to date to OIS 8 or OIS 7 (corresponding to Dnieper Glaciation and Odintsovo Interstadial in the Russian Plain respectively). Obviously, more solid finds from better stratified contexts are needed in order to document the origin and development of the Lower Paleolithic culture in this region. No unquestionably Lower Paleolithic sites have yet been found in the Russian Plain, probably because no systematic surveys have occurred here. Of course, glacial advances and the Caspian and Black Sea transgressions could have destroyed any evidence for Lower Paleolithic occupations (Praslov, 1995: 61). The colder, drier climates in eastern Europe may have prevented hominids from colonizing the area until the Neanderthals, whose physical morphology was well adapted to the cold, could colonize this region during the milder conditions in the Last Interglacial (Hoffecker, 1999; 2002: 41–42). Other reasons (see for example, the “mammoth steppe” hypothesis, Gamble, 1995) also could explain why this vast territory, larger than the rest of Europe, has not yet provided clear evidence for Lower Paleolithic occupation, even during the warmest interglacial periods in the Middle Pleistocene.

The picture of the initial human occupation in eastern Europe becomes even more intriguing, because evidence for early Middle Pleistocene
human settlement is known today both in the western and in the southern mountainous boundaries of eastern Europe. These are the Korolevo 1 open-air site in the western Carpathians (Gladiilin and Sitliviy, 1990) and Treugolnaya Cave in the northern Caucasus. These two sites shed light on the initial human colonization and the development of the Lower Paleolithic culture in eastern Europe. Moreover, at present Treugolnaya Cave provides the earliest undoubtedly and well documented Lower Paleolithic occupations in eastern Europe proper.

**TREUGOL’NAYA CAVE SITE**

Treugolnaya Cave is located in the upper Kuban River Basin, approximately 7.5 km northeast of Stanitsa Pregradnaya in the Karachaev-Cherkessia Republic, in the north Caucasus region of Russia. It sits in the northwestern foothills of the Greater Caucasus Mountains at 43°54' north and 41°12' east (Fig. 1). The cave is situated on the Baranakha Plateau, which represents an uplifted segment of the Skalisty Range between the Urup River (a tributary of the Kuban) and Kuva River (Fig. 2). The cave lies in the middle
part of the plateau along the upper reaches of a large ravine (Gamovskaya) at an elevation of 1,510 meters asl and 40 m above a small river flowing in the ravine bed. The cave occurs in an Upper Jurassic limestone cliff, which reaches 17 m in height (Fig. 3). This is a relatively small gallery type karstic cave, measuring 11–12 m in length, 2.5–3.0 m in width, and no more than 5 m in height at the entrance, which opens to the southwest. The cave under the overhang occupies about 30 m², but in front of the entrance a small open area has been unroofed (Fig. 4). A small unnamed cave without Pleistocene sediments and another excavated cave (Kispap Cave) with poorly preserved Lower Paleolithic (?) occupations is located south of Treugol’naya Cave at the same stratigraphic level in the limestone (Fig. 5).

Following its discovery in 1986 by L. V. Golovanova and V. B. Doronichev, Doronichev excavated 43 m² at Treugol’naya Cave during 1987–1991, 1995, and 2000 (Fig. 6; Doronichev, 1992, 2000, 2001). Today, with its extensive data relating to the Middle Pleistocene, Treugol’naya Cave has provided the first solid evidence for a Lower Paleolithic human occupation in eastern Europe (Doronichev, 2000; 2001; Doronichev and Golovanova, 2003).

**TREUGOL’NAYA CAVE: STRATIGRAPHY OF THE DEPOSITS**

Treugol’naya Cave contains a stratified sequence of typical cave fill deposits that range from 3 m to 4.5 m in total depth. The cave formed along a tectonic crack formed in the Upper Jurassic limestone, while it was under the sea. The crack was filled by fine marine sands, remnants of which still coat the cave walls in scattered locations up to 1.5–2.0 m in thickness. At the bottom of the stratified sequence, a similar green-gray glauconite sandstone (Layer 8) contains marine fossils. Apparently, secondary erosion of the sandstone unit coupled with continued chemical erosion of the limestone reopened a fissure along the fault (Nesmeyanov, 1999: 303).

The stratigraphy of the Treugol’naya cave deposits is recorded in eight cross-sections (Table 1; Fig. 6) and a longitudinal profile, of which a cross-section designated PR is the basic one. It
has the greatest sedimentary thickness with up to 4-4.5 m, contains the most complete stratigraphic sequence, and has been studied using several different techniques (Fig. 7).

All the cave layers tend to slope toward the western cave wall, where several erosional features filled by later sedimentation interrupt the sequence. Some steeply dipping beds or minor syn-depositional normal faults hint at possible slumping or subsidence under the middle part of the cave floor. These deposits comprise several silty to sandy units containing variable amounts of clay, angular and moderately to heavily weathered limestone éboulis of various sizes derived from the cave roof and walls, weathered calcareous tufa, and subrounded marine sandstone cobbles, and finer debris derived from the sandstone unit, which partly armor the cave walls.

Layers 3-5 and 7 also contain numerous bones and artifacts, some covered with calcareous and calcite concretions. In Layer 6, gravel-sized limestone pebbles dominate in the coarse fraction,
which contains bones, but lacks lithic artifacts. Layer 6 represents fluvially deposited gravel mixed with some slopewash debris and in situ deposition. The fine, archaeologically sterile, glauconitic sand in Layer 8 also represents fluvial deposition, but probably under phreatic conditions, while the cave was below ground. Two large erosional lenses also occur in the sequence exposed in the main profile, Section PR (Fig. 7). Lens R postdates the deposition of Layer 4c, while Lens B occurred somewhat later (Nesmeyanov, 1999: 307, Fig. 19.3). Several minor depositional hiatuses in the sequence occur between Layers 4a and 4b, 4b and 4c, 4e and 5a, 5c and 6, and between 7b and 8, as well as a large one postdating the deposition of Layer 4a. No unconformities are identifiable between Layers 5a to 5c or 6 to 7b (Doronichev, 2000; Nesmeyanov, 1999).
The general stratigraphy presented in Section PR is also observed in the transverse profiles, Sections EF and HK (Fig. 6), but with some differences. A remnant of Layer 4d occurs in Sections EF and HK along the left wall of the cave. The large erosional channel fill lens (Lens R) seen in Section PR does not occur in Sections EF and HK, nor do the redeposited Layers 6 and 7a. Layers 4a–b are not easily distinguished, and Layer 4c is not present (Fig. 8). The Layer 4d remnant contains a specific core-chopper industry found in situ at Treugol’ naya Cave. Section HK clearly shows the position of Layer 4d within the sequence. Layer 4d is orangish brown sandy silt that is lighter in color than Layer 4a with heavily corroded éboulis, and many rounded fragments of limestone tufa, some up to 10–15 cm in size. In both Sections EF and HK, Layer 4d directly overlies Layer 5a, as Lens B does elsewhere (Fig. 8).

TREUGOL’NAYA CAVE: THE CHRONOLOGY OF THE DEPOSITS

According to local geomorphologic data, the Treugol’ naya Cave deposits correlate with the upper part of the Vozdvijensk (early Middle Pleistocene) Stage of the Kuban Basin Formation. This implies that the cave was opened by erosion at the beginning of the Middle Pleistocene (Nesmeyanov, 1999: 307). A paleomagnetic analysis of the cave sediments indicates that they are normally magnetized, suggesting that the cave deposits were formed in the Brunhes Chron, i.e., they postdate the Brunhes-Matuyama boundary at 780 ka. The available paleomagnetic data cannot date the sediment to the specific time interval within the Brunhes Chron during which they were deposited (Pospelova et al., 1996: 764).

The most ancient strata in the cave deposit is Layer 8, a fine-grained greenish gray glauconitic sand, mostly formed when the marine sandstone unit which previously filled the cave was eroded by karst processes. Layer 8 contains aquatic plant remains and pollen from the orders Pennales and Centrales. The sand in Layer 8 shows typical fluvial and slack water sedimentary features. The parts of the walls covered by Layer 8 show no evidence for weathering features typical of subaerial conditions (Nesmeyanov, 1999: 304).

The lower sedimentary deposits (Layers 4a–7b) are dated to the Middle Pleistocene on the basis of ESR (electron spin resonance) dates,
<table>
<thead>
<tr>
<th>Unit</th>
<th>Mineralogy</th>
<th>Thickness (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Black, humic-rich silty sand with Medieval ceramics and domesticated animal bones</td>
<td>0.05-0.35</td>
</tr>
<tr>
<td>2</td>
<td>Dark gray sandy silt with many angular limestone and sandstone blocks and éboulis</td>
<td>0.05-1.10</td>
</tr>
<tr>
<td>3a</td>
<td>Orangish brown sandy silt with rounded limestone éboulis fragments</td>
<td>0.05-0.46</td>
</tr>
<tr>
<td>3b</td>
<td>Dark brown sandy silt with small limestone fragments and rubble</td>
<td>0.05-0.35</td>
</tr>
<tr>
<td>4a</td>
<td>Orangish brown sandy silt with many rounded fragments of limy tufa and heavily corroded éboulis</td>
<td>0.65-0.90</td>
</tr>
<tr>
<td>4b</td>
<td>Grayish brown sandy silt with small éboulis</td>
<td>0.10-1.06</td>
</tr>
<tr>
<td>4c</td>
<td>Light gray sandy silt with small éboulis</td>
<td>0.05-0.60</td>
</tr>
<tr>
<td>Lens b</td>
<td>An erosive cut filled with thin layers of orangish brown, grayish brown, and dark brown sandy silt and silt</td>
<td>0.05-2.00</td>
</tr>
<tr>
<td>5a</td>
<td>Grayish brown sandy silt with small éboulis and occasional pebbles</td>
<td>0.10-0.50</td>
</tr>
<tr>
<td>5b</td>
<td>Dark brown silt with small corroded éboulis and occasional pebbles</td>
<td>0.10-0.15</td>
</tr>
<tr>
<td>5c</td>
<td>Brown sandy silt with small éboulis and occasional pebbles</td>
<td>0.15-0.35</td>
</tr>
<tr>
<td>Lens R</td>
<td>Gray sandy loam with éboulis and sandstone rubble</td>
<td>0.05-1.50</td>
</tr>
<tr>
<td>6</td>
<td>Alluvial fill with limestone pebbles and cobbles in a reddish brown sandy silty matrix</td>
<td>0.10-0.55</td>
</tr>
<tr>
<td>7a</td>
<td>Brown sandy silt with occasional small weathered éboulis and gravel</td>
<td>0.05-0.20</td>
</tr>
<tr>
<td>7b</td>
<td>Greenish brown sandy silt with occasional weathered éboulis</td>
<td>0.05-0.30</td>
</tr>
<tr>
<td>8</td>
<td>Fine-grained green glauconitic sand</td>
<td>0.05-0.30</td>
</tr>
</tbody>
</table>

Paleomagnetic data, flora, and fauna. Layers 3a and 3b contain a Late Quaternary fauna adapted to cold conditions, including the snow vole (*Chionomys nivalis*), that dates to the Late Pleistocene (Nadachowski and Baryshnikov, 1991: 441). The large mammal fauna from Layers 3a–b is typical of the Late Pleistocene faunas in the Greater Caucasus, while the uppermost Layers 1 and 2 are dated to the Holocene (Baryshnikov, 1993: 42–43).

Molodkov (2001) provided the first ESR dates using aragonitic terrestrial mollusc shells (*Monacha caucasicula*) found in Layers 7a and 5b. Six ESR dates yielded an average age $583 \pm 25$ ka for Layer 7a, while two ESR dates for Layer 5b averaged $393 \pm 27$ ka (Table 2). These dates suggest that Layer 7a correlates with Oxygen Isotope Stage (OIS) 15, and Layer 5b with OIS 11 (Molodkov, 2001).

Although these were the first ESR dates in the world obtained for terrestrial mollusc shells recovered from Middle Pleistocene sediment, unfortunately, the growth curves for these analyses used fewer than 10 aliquots, making them less reliable than recommended (Grün and Brumby, 1994). In order to confirm the molluscs ESR ages and to establish the suitability of using ESR enamel dating at the site, one cervid tooth, RT60, from Layer 5b at Treugol'naya Cave was dated, which produced six independent standard ESR dates and an isochron analysis that confirmed that the U uptake for the site follows generally an LU model (Blackwell et al., 2001a, 2001b). Assuming linear U uptake (LU), a time-averaged external dose rate, $D_{ext}^{(t)} = 0.375 \pm 0.062$ mGray/y, RT60 averaged $406 \pm 15$ ka (Table 3). The isochron indicates that no significant U leaching or secondary uptake has affected this tooth. This age agrees well with the ESR mollusc date for Layer 5b at 393 $\pm 27$ ka (Table 2). Therefore, these ages together suggest that Layer 5b correlates best with OIS 11. The strong agreement between the ESR ages for RT60 and the molluscs (Molodkov, 2001), two dating methods that use different ESR signals in different minerals from different fossil species and that require different assumptions
about U uptake, do suggest that the age reported here for Layer 5b is accurate. If so, these dates indicate that deposits at Treugol'naya predate any other archaeological artifacts recognized in eastern Europe.

Since at least three teeth per layer need to be dated to ensure accuracy for the ESR ages for the sediment deposits (Blackwell and Schwarz, 1993b), and to ensure that teeth have not been re-worked by sedimentary processes (Blackwell, 1994), another eight teeth from Treugol'naya were analyzed (Table 3).
Fig. 8. Section HK in Treugol’naya Cave: 1 – limestone éboulis; 2 – marine sandstone blocks; 3 – a charcoal lens in layer 1; 4 – layer number; 5 – layer boundary; 6 – lithic artifact; 7 – Upper Jurassic bedrock.

Therefore, 33 enamel ESR dating analyses from another nine Treugol’naya teeth have been completed thus far (Table 3). For two teeth from Treugol’naya, Blackwell et al. (2003) determined that the LU uptake model was the correct uptake model to choose for the ESR age calculations, because the time-averaged external dose rates from their isochron analyses did not differ significantly from their external dose rates determined by volumetrically averaged sediment dosimetry (Blackwell et al., 2001a, 2001b). Consequently, LU provides a reasonable first estimate for the uptake model, and is often advocated for teeth of this age when no uptake model can be determined.
ESR Dates for Aragonitic molluse shells from layers 5b and 7a at Treugol’naya Cave

<table>
<thead>
<tr>
<th>Layer</th>
<th>Sample number</th>
<th>Radionuclide concentrations (Bulk sediments)</th>
<th>Radionuclide concentrations (Mollusc shells)</th>
<th>Dose rates</th>
<th>Accumulated dose (Gy)</th>
<th>ESR age (ka)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5b</td>
<td>171–062</td>
<td>1.43 (ppm) 4.52 (ppm) 0.76 (wt%)</td>
<td>0.53 (ppm) 1.469 (µGy yr⁻¹) 189</td>
<td>700±56</td>
<td>420±39</td>
<td></td>
</tr>
<tr>
<td>5b</td>
<td>171–062</td>
<td>1.43 (ppm) 4.52 (ppm) 0.76 (wt%)</td>
<td>0.43 (ppm) 1.410 (µGy yr⁻¹) 152</td>
<td>570±36</td>
<td>365±28</td>
<td></td>
</tr>
<tr>
<td>5b</td>
<td>Mean</td>
<td>1.43 (ppm) 4.52 (ppm) 0.76 (wt%)</td>
<td>0.48 (ppm) 1.440 (µGy yr⁻¹) 171</td>
<td>635±65</td>
<td>393±27</td>
<td></td>
</tr>
<tr>
<td>7a</td>
<td>161–062</td>
<td>0.91 3.55 0.61</td>
<td>0.51 1.065 198</td>
<td>720±48</td>
<td>570±54</td>
<td></td>
</tr>
<tr>
<td>7a</td>
<td>162–062</td>
<td>1.07 2.31 0.43</td>
<td>0.43 846 171</td>
<td>610±21</td>
<td>600±46</td>
<td></td>
</tr>
<tr>
<td>7a</td>
<td>163–062</td>
<td>0.91 3.55 0.61</td>
<td>0.61 1.047 147</td>
<td>745±45</td>
<td>610±54</td>
<td></td>
</tr>
<tr>
<td>7a</td>
<td>164–062</td>
<td>1.07 2.31 0.43</td>
<td>0.42 857 170</td>
<td>560±33</td>
<td>545±41</td>
<td></td>
</tr>
<tr>
<td>7a</td>
<td>166–062</td>
<td>1.07 2.31 0.47</td>
<td>0.31 886 114</td>
<td>565±37</td>
<td>565±41</td>
<td></td>
</tr>
<tr>
<td>7a</td>
<td>167–062</td>
<td>0.65 3.36 0.51</td>
<td>0.36 936 144</td>
<td>660±45</td>
<td>610±51</td>
<td></td>
</tr>
<tr>
<td>7a</td>
<td>Mean</td>
<td>0.95 2.90 0.51</td>
<td>0.44 940 157</td>
<td>643±72</td>
<td>583±25</td>
<td></td>
</tr>
</tbody>
</table>

1 Data adapted from Molodkov (2001).
2 Abbreviations: \( D_{ew}(t) \) = external dose rate; \( D_{int}(t) \) = internal dose rate.
3 Since the low U concentration in the shells produces a lower internal dose rate, which is much less than the external dose rate, little uncertainty in the ages arises from assuming a U uptake history for the shells.
4 The low variation in the U concentration within the shells may indicate little or no post-depositional U uptake.

(Blackwell, 2001; Schwarz, 1994). Until \(^{239}\text{Th}^{235}\text{U}\) and isochron analyses can be completed for all of the teeth, LU ages for other teeth have been assumed to be the most reliable.

For Layer 4b, eight independent analyses gave a mean age of 366 ± 12 ka. For Layer 4c, 17 independent analyses averaged 375 ± 9 ka. For RT87 from Layer 5b, its mean age is 315 ± 10 ka. The dentinal U concentration for RT87 is higher than dentinal U concentrations for other teeth from Layer 5b (Blackwell et al., 2003), hinting that RT87 may have originated from another layer, possibly the upper part of 4b or 4a. RT87 was found in very thinly bedded units near the edge of Lens R, which cut into several layers (Fig. 7). If RT87 was reworked, then Layer 5b averaged 406 ± 15 ka based on six other analyses.

Together with the paleomagnetic analyses, magnetic studies on the Middle Pleistocene sediment at Treugol’naya Cave have revealed the relationship between the scalar magnetic parameters for the sedimentary deposits, especially their magnetic susceptibility, \( K \), natural remnant magnetization, \( J_m \), anhysteretic remnant magnetization, \( J_{ar} \), saturation remnant magnetization, \( J_{sr} \), and saturation magnetization, \( J_s \), and climatic variation derived from palynological evidence (Pospelova and Levkovskaya, 1994; Pospelova et al., 1996). Sixty oriented samples for paleomagnetic studies were collected in Section PR, with two to eight samples per layer from Layers 4a through 8 and from the marine sandstone coating the cave wall (Pospelova et al., 1996, Fig. 1). No oriented sample could be obtained in Layer 6, the gravel. The palynological samples were collected from the same units in Section PR as the paleomagnetic ones.

The paleomagnetic analyses showed that composition and domain structure in the magnetic grains, which contribute most to the values for \( K \), \( J_m \), \( J_{sr} \), and other magnetic parameters, are, on the whole, uniform throughout the section studied. Therefore, the sediment found in Layers 4a–7b was derived from a single geological province.
Table 3

<table>
<thead>
<tr>
<th>Sample (Sub-samples)</th>
<th>Layer</th>
<th>Accumulated dose, AΣ (Gray)</th>
<th>Dose rate $\overline{D}_{\alpha}(t)$ (mGray/yr)</th>
<th>Weighted means for standard ESR ages $^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>EU (ka)</td>
</tr>
<tr>
<td>RT78 (2)</td>
<td>a. 4B</td>
<td>219.03±7.02 3.21%</td>
<td>0.234±0.045</td>
<td>194.6±10.0 5.13%</td>
</tr>
<tr>
<td>RT50 (5)</td>
<td>4B</td>
<td>232.30±3.15 1.39%</td>
<td>0.256±0.050</td>
<td>243.3±8.2 3.37%</td>
</tr>
<tr>
<td>RT83 (1)</td>
<td>4B</td>
<td>254.47±4.20 1.65%</td>
<td>0.277±0.052</td>
<td>228.4±14.4 6.22%</td>
</tr>
<tr>
<td><strong>Layer 4B (8)</strong></td>
<td></td>
<td></td>
<td></td>
<td>228.5±5.9 365.8±11.9</td>
</tr>
<tr>
<td>RT82 (4)</td>
<td>4C</td>
<td>239.12±3.33 1.39%</td>
<td>0.290±0.050</td>
<td>246.7±8.7 3.54%</td>
</tr>
<tr>
<td>RT90 (4)</td>
<td>4C</td>
<td>228.97±3.70 1.62%</td>
<td>0.290±0.051</td>
<td>229.2±16.2 4.51%</td>
</tr>
<tr>
<td>RT75 (1)</td>
<td>4C</td>
<td>229.15±10.30 4.49%</td>
<td>0.291±0.049</td>
<td>238.8±18.4 7.7%</td>
</tr>
<tr>
<td>RT91 (6)</td>
<td>4C</td>
<td>252.44±2.25 0.89%</td>
<td>0.291±0.048</td>
<td>242.9±6.4 2.64%</td>
</tr>
<tr>
<td><strong>Layer 4C (17)</strong></td>
<td></td>
<td></td>
<td></td>
<td>240.1±4.3 374.6±8.5</td>
</tr>
<tr>
<td>RT87$^4$ (4)</td>
<td>5B</td>
<td>356.49±4.15 1.16%</td>
<td>0.301±0.046</td>
<td>183.8±5.2 2.81%</td>
</tr>
<tr>
<td>RT60 (6)</td>
<td>5B</td>
<td>381.10±6.65 1.74%</td>
<td>0.375±0.062</td>
<td>261.9±8.3 3.16%</td>
</tr>
<tr>
<td><strong>Layer 5B$^4$ (6)</strong></td>
<td></td>
<td></td>
<td></td>
<td>261.9±8.3 406.0±14.9</td>
</tr>
</tbody>
</table>

$^1$ Volumetrically averaged external dose rates were calculated using concentrations determined by NAA for 78 sedimentary subsamples (see methodology in Blackwell et al., 2000; Blackwell and Blickstein, 2000).

$^2$ Abbreviations: EU = assuming early U uptake; LU = assuming linear (continuous) U uptake; RU = assuming recent U uptake. Calculated assuming:

- efficiency factor $k = 0.15 ± 0.02$
- initial U activity ratio $^{234}\text{U}/^{238}\text{U}}_0 = 1.20 ± 0.20$
- enamel water concentration $W_{\text{em}} = 2. ± 2.\text{ wt%}$
- dentine water concentration $W_{\text{dm}} = 5. ± 2.\text{ wt%}$
- cementum water concentration $W_{\text{cm}} = 5. ± 2.\text{ wt%}$
- enamel density $\rho_{\text{em}} = 2.95 ± 0.02\text{ g/cm}^3$
- dentine density $\rho_{\text{dm}} = 2.85 ± 0.02\text{ g/cm}^3$
- cementum density $\rho_{\text{cm}} = 2.75 ± 0.02\text{ g/cm}^3$
- radon loss from the tooth $R_{\text{tooth}} = 0. ± 0.\%$
- sediment density $\rho_{\text{sed}} = 2.65 ± 0.02\text{ g/cm}^3$
- cosmic dose rate $D_{\text{cos}}(t) = 0.000 ± 0.000\text{ mGray/yr}$
- sedimentary water concentration $W_{\text{sed}} = 20. ± 5.\text{ wt%}$

$^3$ Calculated using the U uptake parameter $p = 10$.

$^4$ Meas for this layer omits RT87, which appears to have been reworked from higher in the sequence.
Fig. 9. Correlation between the magnetic susceptibility, $K_m$, in Section PR with the oxygen isotopic curve: I – the first variant of correlation; II – the second variant of correlation.
Variation in the concentration of magnetic grains caused the variation in K and Jm seen down the section (Pospelova et al., 1996, Fig. 2, Tables 1, 2). The uniformity in composition and domain structure of magnetic grains permitted four magnetic zones to be distinguished from the values for K, Jm, and Jm0. Three of the zones could be subdivided. Somewhat surprisingly, the magnetic zone boundaries do not coincide with the lithological unit boundaries. The magnetic zones are most clearly distinguished by K, the magnetic susceptibility. Because the magnetic and palynological analyses were performed on well-correlated samples selected from Section PR, the magnetic zones could be reliably compared with palynological data (Pospelova et al., 1996, Fig. 2) and the OIS curve.

Based on ESR dates for mollusc shells above, two possible correlations between the magnetic variation in the Treugol’naya Cave sediment and the OIS curve are proposed here (Fig. 9). The correlation 1 assumes that no long hiatus exists between the deposition of Layers 5a and 4c. This correlation is more consistent with the recent ESR enamel dates. In this case, Layer 5a correlates with earlier OIS 11, with Layer 4c somewhat later in OIS 11. This correlation provides a slightly different interpretation from the correlation II that earlier proposed (Pospelova et al., 1996: 764; Daronichev, 2001, Table 1).

Paleoclimatic interpretations as determined by palynological analyses at Treugol’naya Cave correlated well with the magnetic susceptibility in the sediment (Pospelova and Levkovskaya, 1994; Pospelova et al., 1996). ESR dates and palynological data attribute the lower deposits in the Treugol’naya Cave section to the earlier Middle Pleistocene. The abundance of exotic species in Layers 7b–5b suggests (Pospelova et al., 1996: 764) that these layers are older than Layer 5c in Kudar 1 (Levkovskaya, 1980; Liubin et al., 1985). The diversity of east-Asian and American–east-Asian exotics in Layers 7b–5b provide significant support for the older age assigned to the lower section at Treugol’naya Cave.

A synthesis of ESR dates, paleomagnetic and palynological data permits the Treugol’naya Cave deposits to be correlated with the OIS curve from deep ocean cores (Imbrie, 1985, Fig. 15). With an ESR age of 583 ± 25 ka, Layer 7a correlates well with OIS 15 (Fig. 9; Pospelova et al., 1996: 764). Palynological evidence indicates a humid temperate climate, somewhat cooler and moister than that during the deposition of Layer 7b, which agrees with the relatively low magnetic susceptibility (K) measurements. Layer 7a probably correlates with a cooler phase within OIS 15. The majority of Layer 7b correlates with one of the warmer phases within OIS 15, because it formed under a warm, arid climate, with higher susceptibility values (magnetic subzone IVb). The base of Layer 7b, characterized by the lowest magnetic values (subzone IVc), can be correlated with later part of OIS 16 (Pospelova et al., 1996, Fig. 2).

Since the lower part of Layer 5c shows moderately higher magnetic susceptibilities (magnetic subzone IIIId), it likely correlates with the warm phase, OIS 13. The upper part of Layer 5c yielded much lower magnetic susceptibilities (subzone IIlc), while in the middle of Layer 5c, herbaceous bushes strongly dominate the palynological spectrum, which indicate the high alpine character of the woods, and hint at significantly cooler temperatures than in the lower part of this unit. These data suggest that the upper part of Layer 5c probably correlates with OIS 12 (Pospelova et al., 1996, Fig. 2).

Layer 5b correlates with a very warm phase within OIS 11, probably OIS 11.3 ("Holsteinian Interglacial"). Layer 5b formed during an interglacial optimum which resulted in the highest diversity of pollen from arboreal east Asian and American–east-Asian exotics and forest environments seen in the cave. The walnut (Juglans) dominates the flora. This layer also has the highest values for scalar magnetic parameters in the cave (magnetic subzone IIIb which has a maximum with a double peak for K and Jm; Fig. 9). The mollusc and enamel ESR ages agreed very well (Tables 2, 3), and both indicated an age near 400 ka, which agrees well with the reported age for OIS 11.3 (Fig. 9).

Layer 5a and the lower part of Layer 4c have the lowest values for the magnetic parameters (magnetic subzone IIb in Pospelova et al., 1996, Fig. 2) as well as dwarf (i.e., smaller than normal) pollen from arboreal and herbaceous plants. Herbaceous plants dominated the vicinity around the cave at this time. These data suggest a fairly cold climate. In view of the deep erosional cut between
Table 4

Bird species remains from Middle Pleistocene layers of Treugol’naya Cave (1986–1991 excavations)

<table>
<thead>
<tr>
<th>Taxon</th>
<th>Biome 1</th>
<th>Layer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>4a</td>
</tr>
<tr>
<td>Galliformes</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Alectoris graeca mediterranea</em></td>
<td>R</td>
<td></td>
</tr>
<tr>
<td><em>Perdix paleperdix</em></td>
<td>MS</td>
<td>2</td>
</tr>
<tr>
<td><em>Coturnix colurnix</em></td>
<td>M</td>
<td></td>
</tr>
<tr>
<td><em>Phasianus colchicus</em></td>
<td>F</td>
<td></td>
</tr>
<tr>
<td>Columbiformes</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Columba livia occitanica</em></td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Strigiformes</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Asio flammeus</em></td>
<td>S</td>
<td>1</td>
</tr>
<tr>
<td>Apodiiformes</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Apu apus</em></td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>Passeriformes</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Hirundo rustica</em></td>
<td>R</td>
<td></td>
</tr>
<tr>
<td><em>Delichon urbica</em></td>
<td>R</td>
<td></td>
</tr>
<tr>
<td><em>Melanocorypha calandra</em></td>
<td>S</td>
<td>1</td>
</tr>
<tr>
<td><em>Melanocorypha yeltoniensis</em></td>
<td>S</td>
<td></td>
</tr>
<tr>
<td><em>Eremophila alpestris</em></td>
<td>M</td>
<td></td>
</tr>
<tr>
<td><em>Lullula arborea</em></td>
<td>F</td>
<td>1</td>
</tr>
<tr>
<td><em>Alauda arvensis</em></td>
<td>S</td>
<td></td>
</tr>
<tr>
<td>Aliaadidae indet.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Motacilla alba</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Pyrrhocorax pyrrhocorax</em></td>
<td>MS</td>
<td>2</td>
</tr>
<tr>
<td><em>Pyrrhocorax graculus</em> vettis</td>
<td>M</td>
<td>1</td>
</tr>
<tr>
<td>Fringillidae indet.</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td><em>Emberiza calandra</em></td>
<td>MS</td>
<td></td>
</tr>
<tr>
<td>Passeriformes indet.</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Aves indet.</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>2</td>
<td>11</td>
</tr>
</tbody>
</table>

1 Ecological groups: R – rocky; M – meadow; S – steppe; MS – meadow-steppe; F – forest (data from Baryshnikov and Potapova, 1995, Table 1).

Layers 5a and 4c, which left only a small residue from Layer 4d, the lower part of Layer 4c was previously correlated with OIS 8 (Pospelova et al., 1996, Fig. 2; Doronichev, 2001, Table 1). Given the ages for the surrounding layers, however, this event dates to 375–390 ± 15 ka. As such, it appears to correlate best with a cold stadial within OIS 11, probably OIS 11.2, rather than OIS 8 or 10.
According to palynological data, the upper part of Layer 4c appears to have formed under warm and humid conditions similar to those found in the modern low alpine climate in western Georgia, suggesting that it correlates with a warm period in the OIS record. Palynological data from the lower part of Layer 4b, where magnetic parameters are low (magnetic subzone IIa) shows that humid subalpine meadows dominated the area. At 366–375 ± 12 ka, the ESR dates for the upper part of Layers 4c and 4b suggest that they correlate with the later part of OIS 11, probably OIS 11.1 (Table 3).

Because Layer 4a has not been dated, its correlation is less certain. RT87, the reworked tooth from Layer 5b, however, may have originally come from Layer 4a. If so, then Layer 4a would date to about 300–320 ka. This hypothesis, however, must be confirmed with dates for teeth that are found in situ within Layer 4a. The magnetic susceptibility (K) for Layers 4a and 4b is higher than for Layers 5a. At the boundary between Layers 4b and 4a, the susceptibility drops abruptly from 10 × 10⁻⁶ to 6.5 × 10⁻⁶ CGSM. This could be interpreted to indicate a break in sedimentation between these layers which is also supported by geological data. This suggests a discontinuity between the layers (Nesmeyanov, 1999: 308). In Layer 4a, the palynological data indicates a steppe environment formed under a warm, arid climate, in which xerophytes and opportunistic species dominate the herbaceous spectrum. Juglans pollen is the major arboreal species (Pospelova et al., 1996: 762). Therefore, while Layer 4a may correlate with a late warm phase in OIS 11 or in 10, it could also correlate with any warm phase within OIS 9, 8, or even 7.

At Treugol’naya Cave, more than 5,000 bone fragments from large mammals and birds, as well as many hundreds of rodent teeth and bones were found during the excavations. Since most of the microfaunal remains have not been studied, only preliminary results are available now (Baryshnikov, 1990; Nadachowski and Baryshnikov, 1991). Detailed studies have been conducted on the birds (Potapova and Baryshnikov, 1993; Baryshnikov and Potapova, 1995;), the large mammal fauna (Baryshnikov, 1993), and their taphonomy (Hoffecker et al., 2003).

The Middle Pleistocene fauna at Treugol’naya cave includes 22 bird species (Table 4; Potapova and Baryshnikov, 1993; Baryshnikov and Potapova, 1995, Table 1), belonging to both extant and extinct forms. The extinct taxa include Alectoris graeca mediterranea, Perdix palaeoperdix, Columba livia occitanica, Pyrrhocorax primigenius primigenius, P. graculus vetus. These species allow comparisons between the fossil birds at Treugol’naya Cave and those from the Middle Pleistocene in southern France (Baryshnikov and Potapova, 1995: 245), particularly those from Mas Rambault (“ Günz”), Cimay à Evenos, and Grotte de l’Escale (“Mindel”), Lunel-Viel (“Mindel-Riss”; Mourer-Chauviré, 1975).

At Treugol’naya, the avifaunal composition looks very similar to the Middle Pleistocene avifauna in the Mediterranean Basin, while the Treugol’naya fauna lacks endemic species typical of the southern Caucasus during the Middle Pleistocene (e.g., Gypaetus osseticus, Lyrurus mlokosiewiczi) found at Kudaro 1; Potapova and Baryshnikov, 1993; Baryshnikov and Potapova, 1995).

Among the 3,800 large mammal remains studied so far from the Middle Pleistocene layers at Treugol’naya (excavations 1986–1991), 38% were identifiable to genus or species (Baryshnikov, 1993). The large mammal remains included representatives from 22 species in three orders, Carnivora, Perissodactyla, and Artiodactyla. Table 5 lists the large mammal fossils found in Layers 4a–7b. The overall carnivore assemblage is typical for the European “Mindel” faunas, with the exception of Meles hollitzi, which is known from older deposits (early Pliocene). The German Middle Pleistocene archaeological site, Miesenheim I, (van Kolfschoten and Turner, 1996) yielded a strikingly similar carnivore assemblage.

At Treugol’naya Cave, the most abundant carnivore remains belong to the Middle Pleistocene cave bear Ursus (Spelaeocastor) dentigeri (Hoffecker et al., 2003).

The Perissodactylus found at Treugol’naya included Equus altidens (previously classified as Equus cf. namadicus) and Stephanorhinus hundsheimensis (previously assigned to S. etruscus brachyccephalus; Baryshnikov, 1993). European paleontologists currently distinguish S. hundsheimensis as a separate species from S. etruscus.
Large mammal remains from Middle Pleistocene layers of Treugol’naya Cave 1986-1991 excavations (Baryshnikov, 1993; Hoffecker et al., 2002)

<table>
<thead>
<tr>
<th>Taxa</th>
<th>Layer</th>
<th>4a</th>
<th>4b</th>
<th>4c</th>
<th>4d</th>
<th>B</th>
<th>5a</th>
<th>5b</th>
<th>5c</th>
<th>5d</th>
<th>6</th>
<th>7a</th>
<th>7b</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Canis mosbachensis</em></td>
<td>3/2</td>
<td>3/1</td>
<td>-</td>
<td>4/1</td>
<td>-</td>
<td>-</td>
<td>6/3</td>
<td>2/1</td>
<td>-</td>
<td>2/1</td>
<td>6/1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><em>Vulpes vulpes</em></td>
<td>-</td>
<td>1/1</td>
<td>1/1</td>
<td>1/1</td>
<td>1/1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<td>-</td>
</tr>
<tr>
<td><em>Selenarctos thibetanus mediterraneus</em></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>3/1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><em>Ursus (Spelaearctos) deningeri</em></td>
<td>11/2</td>
<td>13/2</td>
<td>3/2</td>
<td>4/2</td>
<td>1/1</td>
<td>-</td>
<td>16/2</td>
<td>40/3</td>
<td>1/1</td>
<td>19/2</td>
<td>19/4</td>
<td>28/3</td>
<td>-</td>
</tr>
<tr>
<td><em>Meles hollitzeri</em></td>
<td>1/1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1/1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><em>Mustela nivalis</em></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1/1</td>
<td>3/1</td>
<td>-</td>
<td>-</td>
<td>1/1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><em>Crocuta spelaecae cf. Praespelaeae</em></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1/1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><em>Panthera spelaecae</em></td>
<td>1/1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<td>1/1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><em>Felis cf. F. lycica</em></td>
<td>-</td>
<td>2/1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<td>-</td>
</tr>
<tr>
<td><em>Equus altidens</em></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1/1</td>
<td>-</td>
<td>13/2</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><em>Stephanorhinus hundsheimensis</em></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1/1</td>
<td>8/1</td>
<td>1/1</td>
<td>8/4</td>
<td>-</td>
<td>1/1</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><em>Capreolus cf. C. sussensebornensis</em></td>
<td>6/2</td>
<td>5/2</td>
<td>-</td>
<td>3/1</td>
<td>1/1</td>
<td>-</td>
<td>2/1</td>
<td>-</td>
<td>5/1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>cf. <em>Praedama</em> sp.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1/1</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>cf. <em>Dama</em> sp.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1/1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><em>Cervus elaphus</em> (f. aconoratus)</td>
<td>39/3</td>
<td>118/6</td>
<td>33/3</td>
<td>41/2</td>
<td>27/2</td>
<td>-</td>
<td>177/9</td>
<td>276/10</td>
<td>42/3</td>
<td>46/3</td>
<td>27/2</td>
<td>15/1</td>
<td>-</td>
</tr>
<tr>
<td><em>Bison</em> sp. (ex gr. priscus-schoetensacki)</td>
<td>4/1</td>
<td>7/1</td>
<td>3/1</td>
<td>-</td>
<td>2/1</td>
<td>-</td>
<td>23/2</td>
<td>33/2</td>
<td>16/2</td>
<td>5/1</td>
<td>1/1</td>
<td>2/1</td>
<td>-</td>
</tr>
<tr>
<td><em>Capra</em> sp. (ex gr. caucasica)</td>
<td>2/1</td>
<td>2/1</td>
<td>1/1</td>
<td>-</td>
<td>4/1</td>
<td>13/2</td>
<td>17/3</td>
<td>15/2</td>
<td>1/1</td>
<td>-</td>
<td>-</td>
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<td>-</td>
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</tbody>
</table>

while *S. hundsheimensis* is considered to be the characteristic species in the early Middle Pleistocene (Sala and Fortelius, 1993). The small *E. altidens*, which is diagnostic of the early Middle Pleistocene Galtalian fauna, also occurs at localities such as Sussenborn in Germany, Tiraspol in Moldavia, and D'manisi in Georgia (Gabunia and Vekua, 1989). At Treugol'naya, artiodactyls are represented by six taxa. From their tooth dimensions, the roe deer at Treugol'naya Cave are somewhat smaller than *Capreolus sussenebornensis*, a characteristic early Middle Pleistocene species in western Europe. On the other hand, the Treugol'naya red deer are larger than *Cervus elaphus* cf. *aconoratus* from Caune de l’Arago, France (Lister, 1986). Treugol’naya’s bison may be assigned to a steppe form with morphometric similarities to *Bison schoetensacki*, which occurs in the Tiraspolian Complex in the early Middle Pleistocene (Flerov and David, 1971).

The large mammal fauna from Layers 6–7b at Treugol’naya Cave have been assigned to the Urup Faunal Complex from the northern Caucasus (Baryshnikov, 1993: 42). This complex correlates with the later Tiraspolian fauna in eastern Europe dated to the early Middle Pleistocene, as
Table 6

Chronology of the Treugol’naya Cave deposits based on ESR dates, geomorphological, stratigraphical, paleomagnetic, magnetic, floral and faunal data

<table>
<thead>
<tr>
<th>Layer</th>
<th>Archaeological industry</th>
<th>Flora</th>
<th>Fauna</th>
<th>Climate</th>
<th>Mean ESR dates (ka)</th>
<th>Magnetic subzones</th>
<th>Correlation with OIS Curve</th>
<th>Ages for OIS Stages 1/2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deep erosion</td>
<td>“Proto-Charentian” flake tool industry</td>
<td>Wooded steppe</td>
<td>Sangilian Faustral Complex: Canis mosbachensis</td>
<td>moderate, dry</td>
<td>1</td>
<td>Stage 11?</td>
<td>364</td>
<td></td>
</tr>
<tr>
<td>Erosion</td>
<td>“Proto-Charentian” flake tool industry</td>
<td>Subalpine meadows</td>
<td>Vulpes vulpes Ursus cf. denticini</td>
<td>cool, dry</td>
<td>366±12 enamel (LU)</td>
<td>Ia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deep erosion, lenses</td>
<td>“Proto-Charentian” flake tool industry</td>
<td>Low altitude deciduous woods</td>
<td>Capreolus cf. nisseborensis</td>
<td>warm, humid</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Erosion</td>
<td>“Proto-Charentian” flake tool industry</td>
<td>Subalpine meadows</td>
<td>Cervus elaphus cf. acoronatus Bison priscus-schoenoni</td>
<td>cold, dry (stadial extremum)</td>
<td>375±9 enamel (LU)</td>
<td>IIb (or IIc)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4d</td>
<td>Core-chopper industry</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5a</td>
<td>“Tayacian” or “Proto-Charentian” flake tool industry</td>
<td>Subalpine meadows</td>
<td>Late Tiraspolian Faustral Complex: Canis mosbachensis Ursus cf. denticini Musculista nivealis Stephanorhinus hundsheimersis Equus altidens Capreolus cf. stussbourrissis</td>
<td>cold, dry (stadial extremum)</td>
<td></td>
<td>Iic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5b</td>
<td>“Tayacian” or “Proto-Charentian” flake tool industry</td>
<td>Wooded steppe</td>
<td></td>
<td>cool, humid</td>
<td></td>
<td>IIb</td>
<td>probably Stage 11.3</td>
<td>427</td>
</tr>
<tr>
<td>5c</td>
<td>“Tayacian” or “Proto-Charentian” flake tool industry</td>
<td>Subalpine meadows</td>
<td></td>
<td>very warm, humid (interglacial optimum)</td>
<td>395±27 molluscs 406±15 enamel (LU)</td>
<td>IIIc</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Erosion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>IId</td>
<td>Stage 12?</td>
<td>427-474</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>Dry subtropical woods</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Stage 13?</td>
<td>474-528</td>
</tr>
<tr>
<td>7a</td>
<td>“Tayacian” flake tool industry</td>
<td>High altitude woods; subalpine meadows</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Stage 14?</td>
<td>528-568</td>
</tr>
<tr>
<td>7b</td>
<td></td>
<td>Wooded steppe</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

gray = Lower Paleolithic occupations

1 Based on all data and comparison with OIS curves for MD990963

2 Age comparisons from Aitken & Stokes (1997, Table 1.2)
well as with the later stage (mammalian biozone MNQ 21 after Guérin, 1990) of the Galerian Complex in western Europe. The presence of Canis mosbachensis, Ursus (Spelaearctos) deningeri, Mustela nivalis, Equus altidens, Bison ex gr. priscus-shoetensacki, Stephanorhinus hundsheimensis, Capreolus cf. sassenbornensis among the larger mammals, as well as Arvicola cantiana, Terricola ex gr. major, Chionomys gud, Ochotona transcaucasia ex gr. Vekata, and Sorex sp. among the smaller mammals is especially diagnostic. This fauna includes species which indicate a warm climatic stage (with a very warm and dry conditions for Layer 6). This correlates tentatively with OIS 15 (Baryshnikov, 1993: 42-43). The faunal assemblage from Layers 5a-5d, which is generally similar to that in Layers 6-7b (Table 5), correlates with MNQ 22 (Guérin, 1990). It is also similar to the faunal complex in Layer 5c at Kudaro 1, which is analogous to the Singilien terrestrial faunal complex in eastern Europe (Baryshnikov, 1993: 43).

The large mammal fauna from Layers 4a-4d includes characteristic later Middle Pleistocene taxa, such as Canis mosbachensis, Vulpes vulpes, Ursus (Spelaearctos) deningeri, Capreolus cf. sassenbornensis, Praedama sp., and Bison shoetensacki, but lack some taxa present in the older layers, such as Stephanorhinus hundsheimensis and Equus altidens. This faunal assemblage may be correlated with MNQ 23, and Layer 4a may even correlate with MNQ 24 (Baryshnikov, 1993: 43).

Therefore, the extensive data above (ESR dates, geomorphological, stratigraphical, paleomagnetic, magnetic, floral and faunal data) demonstrates that the Middle Pleistocene sediments preserved at Treugol’naya Cave correlates well with the OIS curve (Table 6):

Layers 6, 7a, and the upper part of 7b all correlate well with the warm phase, OIS 15, which probably corresponds to “interglacial III” in the “Cromerian Complex” (cf. Raebroek and Kolfschoten, 1995, Fig. 2). The lowermost part of Layer 7b, correlates with a colder phase, probably the early part of OIS 15 or late part of OIS 16.

The lower part of Layer 5c tentatively correlates with the warm phase, OIS 13 (“interglacial IV” in “Cromerian Complex”), while the upper part of this layer appears to correspond to a cold stage, probably OIS 12 (“Elsterian” Glaciation), a correlation of Layer 5c with the early part of OIS 11 is also possible.

Layer 5b correlates with the early part of OIS 11 (possibly, the “Hoisteinian” Interglacial optimum). The lower part of Layer 5a correlates best to the middle of OIS 11. Based on ESR, magnetic, and palynological data, the upper part of Layer 5a, the remaining part of Layer 4d, and the lower part of Layer 4c all correlate with a cold phase within OIS 11. According to the palynological and ESR data, the upper part of Layer 4c was deposited in a warmer phase within OIS 11, while Layer 4b also correlates with the later part of OIS 11.

While the exact chronological position of Layer 4a is unclear at present, it was undoubtedly deposited during the upper Middle Pleistocene. From magnetic and palynological data, Layer 4a may correlate with OIS 7, 8, or 9 (Fig. 9) while the correlation with the latest part of OIS 11 is more possible (Table 6). To resolve this, absolute dates for Layer 4a are needed.

Therefore, the Middle Pleistocene deposits at Treugol’naya Cave span the period from before 580 to after 315 ka, and possibly from about 600 to 350 ka. While some breaks occur in the section (i.e., no sediment appears to correspond to OIS 14, which should occur between Layers 6 and 5c, and erosional disturbances exist between Layers 4d and 4c, 4c and 4b, 4b and 4a), otherwise the deposition appears to be almost continuous. Interestingly, the thick deposits for Layers 5b through 4b represent the thickest continuous or nearly continuous deposit from OIS 11 currently known for eastern Europe. In future, this section may prove to be the best candidate for a type section for OIS 11 in Europe.

**PALEOGEOGRAPHY OF THE MIDDLE PLEISTOCENE SEDIMENTATION AT TREUGOL’NAYA CAVE**

According to the geomorphological data (Nesenevyanov, 1999: 309, Fig. 19.4), at the time of the Lower Paleolithic occupations Treugol’naya Cave was located at an elevation near 1,000 m asl, i.e., roughly 500 m lower than today. Consequently, the cave opened about 500 m above the Urup River valley, but the well lit south-facing
cave entrance was only 20 m above the Gamovskaya ravine. Most likely, the roof above the entrance collapsed later.

At present, Treugol'naya Cave occupies the ecotone between the forest and alpine meadow zones. Palynological data indicates that local vegetation experienced significant changes during the Middle Pleistocene (Pospelova et al., 1996: 761). So far, about 35 spora/pollen specimens have been studied from various levels in Layers 8, 7a–b, 5a–c, and 4a–c to build a preliminary spora/pollen diagram for the cave (Fig. 10).

Two major stages in the palaeofloral development have been revealed (see Table 7):

1. The earlier Stage B corresponds to Layers 8–5b, while the later Stage A corresponds to Layers 4c–4a. The Stage B flora includes many trans-regional exotics among the arboreal species, which today are found in habitats very distant from the Caucasus, such as Engelhardia, Eucommia, Taxodiaceae, Taxodium, Weigelia, Alnus, Tsuga, Alnaster, etc.

2. In contrast, the Stage A flora contains none of these exotics. Also, the tree flora in the past was distinguished by the presence of regional exotics (Zelkova, Juglans, Buxus, Castanea, Pistacia, Pterocarya) represented by taxa that now occur in the Caucasus in areas with humid
Dominant and exotic arboreal pollen species at Treugol'nya Cave

<table>
<thead>
<tr>
<th>Layer</th>
<th>Phase</th>
<th>Dominant species</th>
<th>Transregional exotics</th>
<th>Regional exotics</th>
</tr>
</thead>
<tbody>
<tr>
<td>4a</td>
<td></td>
<td><em>Juglans</em> (walnut)</td>
<td></td>
<td><em>Ostrya, Pistacia</em> (pistachio), <em>Juglans, Buxus</em> (boxwood)</td>
</tr>
<tr>
<td>4b</td>
<td></td>
<td></td>
<td></td>
<td><em>Ulmus</em></td>
</tr>
<tr>
<td>4c A</td>
<td></td>
<td><em>Buxus</em> (boxwood)</td>
<td></td>
<td><em>Buxus</em></td>
</tr>
<tr>
<td>4e B</td>
<td></td>
<td><em>Ulmus</em> (elm)</td>
<td></td>
<td><em>Ulmus</em></td>
</tr>
<tr>
<td>4c C</td>
<td></td>
<td><em>Juglans, Carpinus</em> (hornbeam), <em>Alnus</em> (alder), <em>Buxus</em></td>
<td><em>Castanea</em> (chestnut), <em>Ulmus</em>, <em>Carpinus betulus</em>, <em>Juglans</em>, <em>Pterocarya</em></td>
<td></td>
</tr>
<tr>
<td>4c D</td>
<td></td>
<td><em>Ulmus</em> (elm), <em>Castanea</em> (chestnut)</td>
<td></td>
<td><em>Pistacia, Buxus, Juglans</em></td>
</tr>
<tr>
<td>4c E</td>
<td></td>
<td><em>Alnaster</em></td>
<td></td>
<td><em>Pistacia, Buxus, Juglans</em></td>
</tr>
<tr>
<td>4c F</td>
<td></td>
<td><em>Betula</em> (birch), <em>Alnus</em></td>
<td></td>
<td><em>Pistacia, Buxus, Juglans</em></td>
</tr>
<tr>
<td>5a</td>
<td></td>
<td>Dwarf forms of <em>Juglans</em> and <em>Alnus</em></td>
<td><em>Tsuga</em> (hemlock)</td>
<td><em>Castanea, Morus</em> (mulberry), <em>Celtis, Carpinus orientalis</em>, <em>Buxus, Pistacia, Juglans, Juniperus</em> (juniper)</td>
</tr>
<tr>
<td>5c</td>
<td></td>
<td><em>Juglans</em> (walnut), <em>Alnus</em> (alder)</td>
<td><em>Taxodium</em> (cypress), <em>Weigelia</em></td>
<td><em>Pistacia, Ulme, Buxus, Juglans</em></td>
</tr>
<tr>
<td>7a</td>
<td></td>
<td><em>Alnus</em> (alder)</td>
<td></td>
<td>cf. <em>Osmanthus, cf. Pterocarya, Buxus</em></td>
</tr>
<tr>
<td>7b</td>
<td></td>
<td><em>Ostrya, Juglans</em> (walnut)</td>
<td><em>Engelhardia</em></td>
<td><em>Ostrya, Pistacia</em> (pistachio), <em>Juglans</em></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td><em>Engelhardia, Taxodiaceae</em></td>
<td><em>Juglans</em></td>
</tr>
</tbody>
</table>

Subtropical (Colchis-type) or arid climates. Regional exotics even predominate among the arboreal species in Stage A in most samples (Layers 5a–c, 7a–b). The data for Layer 5a points to a stressful phase for the flora between Stages B and A when arboreal and bush species produced dwarf pollen. At this stage, only *Tsuga* occurs among the transregional exotics. This break coincides with a period of intensely continental, cold, dry conditions.

The material from Treugol'nya Cave shows large flora variations during the Middle Pleistocene. In some layers (e.g., the upper level in Layer 7a, mid Layer 5c, lower Layer 4c, and mid Layer 4b), forest vegetation was very reduced in the territory. Unfavorable growing conditions for both arboreal and non-arboreal species, which resulted in dwarf or malformed pollen, occurred when Layer 5a was deposited. In all the samples examined thus far, arboreal species coexisted with various types of meadows. The woods of the past were very different from modern woods in the Caucasus. For most of the deposition, broad-leaved arboreal species and bushes dominated or co-dominated the woods in the modern subalpine zone. Only in some layers the dominant arboreal
species are alder (Layer 7a), alder and birch (Layer 4c, phase f), Alnaster (Layer 4c, phase e), and boxwood (Layer 4c, phase a) (Table 7). Moreover, walnut (Juglans sp.) was the species which dominated most frequently in the past: in layers 7b, 5a–c, 4c (phase c), and 4a. All these dominant arboreal species, except birch (Betula), are exotic to this area.

The Middle Pleistocene avifauna from Treugol’naya Cave comprises species from forest, meadow, steppe, and rocky ectones in the Caucasus Mountains (Baryshnikov and Potapova, 1995: 245). Nine phases reflecting climatic and landscape alterations near the cave can be recognized from the bird fauna (Table 4). Layers 6 and 7b yielded species indicating a warm and dry climate, while Layer 7a formed under somewhat cooler, moister conditions. Layers 6–7 were deposited during a warm stage, OIS 15 (probably equivalent to the “ Cromerian complex”), when a mostly open rocky landscape surrounded the cave.

The bird fossils from Layers 5a–b indicate moister, warmer climates compared with those in Layers 5c and 4b–4c. In Layer 5c, more than 58% of bird bones belong to species characteristic of rocky ectones. Layer 5b experienced an increase in meadow and meadow-steppe elements (63%), while in Layer 5a, meadow species decreased (40%), but forest birds also occur (20%). In Layers 4a–c, too few bird remains survived in each layer for a statistical analysis. As a whole, meadow-steppe species dominate the assemblage from Layers 4a–c, followed by rocky and steppe species, suggesting a primarily open landscape with relatively cool, dry climatic conditions at this time (Baryshnikov and Potapova, 1995: 246).

THE MIDDLE PLEISTOCENE OCCUPATIONS AT TREUGOL’NAYA CAVE

During the Middle Pleistocene, Treugol’naya Cave was repeatedly visited by humans, as shown by lithic materials recovered from Layers 7a, 5c, 5a, 4d–4a (Table 6), as well as carnivores. Taphonomic analysis of the large mammal fauna (Hoffecker et al., 2003) suggests that the large mammal assemblage from the Middle Pleistocene layers at Treugol’naya reflects a complex history of human and non-human occupations, combined with action from some abiotic processes that modified the remains. More than 90% of the identifiable bones are broken or damaged, including all the crania, antlers, mandibles, vertebrae, scapulae, pelves, long bones, and even many isolated teeth. Isolated teeth are particularly common among the identifiable large mammal remains in all layers. The only intact skeletal parts are small short bones, including some tarsals, carpals, and phalanges. No significant variations in fragmentation intensity among layers were evident. Because the large mammal remains displayed little discoloration and geochemical weathering, they displayed a broad array of surficial damage.

In the Middle Pleistocene layers at Treugol’naya Cave, carnivores represent approximately 35% of the total identifiable large mammal assemblage overall, and 40.5% of the total large mammal assemblage from layers with lithic artifacts, if calculated from the minimum numbers of individuals (MNI), or 16% overall, if calculated from the number of identified specimens (NISP) for each taxon (Hoffecker et al., 2003; Table 5). Fossil accumulations by hominids usually have less than 10% carnivores by MNI (Klein and Cruz-Uribe, 1984), whereas assemblages collected by carnivores tend to have much higher percentages of carnivore bones (Stiner, 1994). For example, in hyena dens, carnivore bones typically account for at least 20% of the total large mammal MNI (Cruz-Uribe, 1991). At Treugol’naya, the high overall proportion of carnivores argues for a carnivore collection. Moreover, the pattern of attritional mortality in which old bison and red deer individuals dominate the fossil assemblage is more typical of a carnivore, than a hominid accumulation (Klein and Cruz-Uribe, 1984; Stiner, 1994; Hoffecker et al., 2003).

Most carnivore remains appear to represent animals that died from natural causes while inhabiting the cave (Hoffecker et al., 2003). The Middle Pleistocene cave bear (Ursus deningeri) is the most abundant carnivore (about 50% of the total carnivores by MNI). The assemblage includes isolated teeth (n = 70), of which approximately 45% are deciduous. Among the permanent teeth, a wide range of wear reflects the presence of prime and senescent adults. The high proportion of yearling cubs and presence of old adults coincides
with the expectations of attritional mortality due to old age, disease, and starvation, especially during hibernation (Baryshnikov, 1993: 17; Turk et al., 1995; Nelson et al., 1998). The remains were highly fragmented and dispersed, which occurred when other occupants (medium carnivores and hominids) trampled the bones.

Some bones exhibited damage, including scratches, furrows, gouge marks, pits, and punctures, which are characteristic of carnivores. Among the largest sample of red deer and bison bones from Layer 5 (n = 240), 13% displayed definite or highly probable carnivore damage and another 11% displayed possible carnivore damage. The percentage of bones with clear traces of carnivore gnawing is low compared to large felid and hyena accumulations, which typically contain over 20% and 40% damaged bone respectively (Cruz-UrIBE, 1991). Also, the frequency of short bones (e.g., carpals) is uncharacteristic of hyena accumulations (Cruz-UrIBE, 1991). Bears do not collect large quantities of prey remains. On the other hand, bones accumulated by canids may reveal a lower percentage of chewed specimens (Lyman, 1994), and wolf is the only other large carnivore represented in many layers (Table 5). This data suggests that carnivores probably accumulated and broke most of the artiodactyl remains (red deer, bison, and goat) in Treugol’naya Cave. Among the carnivores identified in the cave, wolf seems most likely culprit (Hofrecker et al., 2003).

Remains from odd-toed ungulate taxa, such as horse and rhinoceroses, appear to have been accumulated primarily by stream action (Baryshnikov, 1993: 23). Concentrated in the fluvial gravel deposit (Layer 6), most of these remains comprise heavily abraded teeth. Roughly 70% of rhinoceroses, and 100% of horse, remains from Layer 6 were heavily abraded suggesting that they have been rolled, but most red deer and bison bones and teeth from this unit were not abraded. Some unabraded rhinoceros remains, mainly tooth fragments, were also recovered from other units. These were evidently accumulated by different means (Hofrecker et al., 2003). Therefore, fluvial processes significantly increasing the representation of taxa that would otherwise be rare in the cave.

Sample sizes are too small for most taxa represented at Treugol’naya Cave to draw conclusions about season of death. Red deer (Cervus elaphus acoronatus), however, comprise about 66% of the total identifiable bones (Baryshnikov, 1993). Frontal bone fragments include specimens with shed antlers, indicating death during winter or early spring, and unshed antlers, indicating death in late summer through late autumn. Several upper and lower first molars exhibit extremely light wear, indicating probable death between November and January (Baryshnikov, 1993: 34). Therefore, red deer mortality was not concentrated in any one season, but spans the year.

Although hominids recurrently occupied Treugol’naya Cave during the Middle Pleistocene, their role in accumulating and modifying the large mammal assemblage seems to have been limited. No compelling evidence exists that hominids brought many bones to the cave as prey remains (Hofrecker et al., 2003). Features characteristic of Middle Paleolithic hominid bone accumulations (i.e., high incidence of tool marks, an age profile dominated by animals in their prime, low carnivore percentage) in the northern Caucasus (Baryshnikov et al., 1996) do not occur. Several bones from Treugol’naya Cave do, however, bear possible traces of human activity (Hofrecker et al., 2003):

1. Three specimens display possible stone tool cut marks related to carcass dismemberment:
   a. A red deer mandible has shallow parallel incisions below the second and third molars on the medial face.
   b. A bison metapodial condyle shows oblique incisions on the lateral surface.
   c. Subparallel incisions occur on the medial shaft of a bison distal tibia.

2. Possible tool percussion marks, in the form of conoidial fractures associated with microstriations, were observed on three red deer long bone shaft fragments, and on one bison long bone shaft fragment.

3. Several red deer bone fragments, primarily recovered from Bed 5, bore traces suggesting that they may have been used as tools:
   a. Seven upper and lower long bone shaft fragments and one distal scapula fragment displayed varying degrees of flaking and polish along one longitudinal fracture edge. All had been broken and damaged in green condition.
   b. Three bones exhibited microstriations,
either parallel or transverse to the damaged edge. Since carnivores can cause similar damage to limb bones, the cause for the damage remains problematic pending more detailed analysis of the microstriaations (Hofecker et al., 2003).

The paleogeographic data for the Treugol’naya Cave deposits indicates that hominids visited the cave mostly during the cooler periods in the Middle Pleistocene (Table 6). The lowest human occupation, Layer 7a, had cooler climatic conditions than those in the archaeologically sterile Layers 7b and 6. Layer 7a dates to OIS 15, while Layers 7b and 6 probably also correlate with OIS 15, and remains to be tested for absolute dates. Layer 5b was deposited under a fully interglacial climate in OIS 11, probably OIS 11.3, but the layer lacks stone artifacts except for two redeposited lithics. Layers 4c, 5a, and 5c, which are all human occupation layers, were deposited under cool to cold climatic periods, with Layers 4c and 5a in OIS 11, and Layer 5c probably in OIS 12. The upper occupational deposits, Layers 4a–b, were deposited under somewhat warmer conditions, but still cool compared to the interglacial climates for Layers 5b or 6.

**TREUGOL’NAYA CAVE: THE LOWER PALEOLITHIC LITHIC INDUSTRIES**

At Treugol’naya Cave, lithic artifacts occurred in almost all layers, including the Holocene Layers 1 and 2, Upper Pleistocene Layers 3a–b, and various erosional lenses. Nevertheless, most artifacts were found in the Middle Pleistocene Layers 4a–d, 5a, 5c, and 7a (Table 6). No artifact concentrations were discovered in any layer. The lithics were dispersed through the excavated area as were the faunal remains. The stratigraphic positions and typological characteristics of the finds allowed them to be divided into four cultural-chronological assemblages (Doronichev, 2000, 2001).

**ASSEMBLAGE IV**

The lowermost lithic industry, Assemblage IV, contained 18 lithics, most found in Layer 7a (Figs. 11, 12a, 12d, 12e, 14) with a few lithics from the reworked sediment in Layer 6 (Figs. 12b, 12f, 13). One tool was located on the top of Layer 7b (Fig. 12c). The industry includes ten flake tools (Figs. 11, 12b, 12f, 13, 14a, 14c, 14d, 14f), five small (less than 5 cm) unretouched flakes with cortical or flat bevelled butts (Figs. 12a, 12c–e, 14b, 14e), and three chips. The artifacts were made using very diverse raw materials: seven were made from chert, six were made on flint, but three were made from quartz and two from limestone. Except the limestone and chert, none of these materials are found near the cave today.

The tools include: a simple straight sidescraper (Fig. 12b); a simple naturally backed concave sidescraper (Fig. 12f); a simple backed concave sidescraper; a transverse sidescraper with bifacially retouched edge made on a flake with massive striking platform (Figs. 11a, 14f); a dentilicate (Fig. 13a); a massive endscraper reworked from a small reused core; a massive endscraper made on a small flake with reduced bulb (Fig. 13b); two composite tools combining sidescraper elements with becs (Figs. 11c, 11d, 14a, 14c); and a composite tool combining dentilicate and endscraper elements (Figs. 11b, 14d).

**ASSEMBLAGE III**

Assemblage III now numbers 27 (see above) artifacts found in Layers 5a (Figs. 15a–c, 17, 18a–c) and 5c (Figs. 15e–g, 16, 18d, 18f), together with two that appear to be redeposited artifacts found in Layer 5b (Figs. 15d, 18e). The finds from Layers 5a and 5c were combined together, because:

1. Layers 5a–c exhibit stratigraphic continuity.
2. Layers 5a–c are separated from the lower artifact bearing Layer 7a by sterile Layer 6.
3. Layers 5a and 5c each yielded very few artifacts, 13 and 12 items respectively.
4. The total lithic assemblage from the layers differs typologically from the lithic industries found in Layers 4a–c or Layer 4d.
5. Compositionally, Layers 5a and 5c are similar in that they both have rare lithic artifacts.
6. Layers 5a and 5c have the highest density of faunal remains, compared to the other human occupation layers.

The assemblage includes six flake tools (Fig. 15a–c, 15g, 18a–c, 18e, 18f), two pebble tools
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[Diagram of archaeological artifacts, labeled as:
- a: bifacially retouched side scraper
- b: knife
- c: small flake
- d: small flake with retouch]

CM
either parallel or transverse to the damaged edge. Since carnivores can cause similar damage to limb bones, the cause for the damage remains problematic pending more detailed analysis of the microstriations (Hoffecker et al., 2003).

The paleogeographic data for the Treugol'naya Cave deposits indicates that hominids visited the cave mostly during the cooler periods in the Middle Pleistocene (Table 6). The lowest human occupation, Layer 7a, had cooler climatic conditions than those in the archaeologically sterile Layers 7b and 6. Layer 7a dates to OIS 15, while Layers 7b and 6 probably also correlate with OIS 15, and remains to be tested for absolute dates. Layer 5b was deposited under a fully interglacial climate in OIS 11, probably OIS 11.3, but the layer lacks stone artifacts except for two redeposited lithics. Layers 4c, 5a, and 5c, which are all human occupation layers, were deposited under cool to cold climatic periods, with Layers 4c and 5a in OIS 11, and Layer 5c probably in OIS 12. The upper occupational deposits, Layers 4a–b, were deposited under somewhat warmer conditions, but still cool compared to the interglacial climates for Layers 5b or 6.

**TREUGOL’NAYA CAVE: THE LOWER PALEOLITHIC LITHIC INDUSTRIES**

At Treugol'naya Cave, lithic artifacts occurred in almost all layers, including the Holocene Layers 1 and 2, Upper Pleistocene Layers 3a–b, and various erosional lenses. Nevertheless, most artifacts were found in the Middle Pleistocene Layers 4a–d, 5a, 5c, and 7a (Table 6). No artifact concentrations were discovered in any layer. The lithics were dispersed throughout the excavated area as were the faunal remains. The stratigraphic positions and typological characteristics of the finds allowed them to be divided into four culturally-chronological assemblages (Doronichev, 2000, 2001).

**ASSEMBLAGE IV**

The lowermost lithic industry, Assemblage IV, contained 18 lithics, most found in Layer 7a (Figs. 11, 12a, 12d, 12e, 14) with a few lithics from the reworked sediment in Layer 6 (Figs. 12b, 12f, 13). One tool was located on the top of Layer 7b (Fig. 12c). The industry includes ten flake tools (Figs. 11, 12b, 12f, 13, 14a, 14c, 14d, 14f), five small (less than 5 cm) unretouched flakes with cortical or flat bevelled butts (Figs. 12a, 12c–e, 14b, 14c), and three chips. The artifacts were made using very diverse raw materials: seven were made from chert, six were made on flint, but three were made from quartz and two from limestone. Except the limestone and chert, none of these materials are found near the cave today.

The tools include: a simple straight sidescraper (Fig. 12b); a simple naturally backed concave sidescraper (Fig. 12f); a simple backed concave sidescraper; a transverse sidescraper with bifacially retouched edge made on a flake with massive striking platform (Figs. 11a, 14f); a denticulate (Fig. 13a); a massive endscraper reworked from a small reused core; a massive endscraper made on a small flake with reduced bulb (Fig. 13b); two composite tools combining sidescraper elements with becs (Figs. 11c, 11d, 14a, 14c); and a composite tool combining denticulate and endscraper elements (Figs. 11b, 14d).

**ASSEMBLAGE III**

Assemblage III now numbers 27 (see above) artifacts found in Layers 5a (Figs. 15a–c, 17, 18a–c) and 5c (Figs. 15e–g, 16, 18d, 18f), together with two that appear to be redeposited artifacts found in Layer 5b (Figs. 15d, 18e). The finds from Layers 5a and 5c were combined together, because:

1. Layers 5a–c exhibit stratigraphic continuity.
2. Layers 5a–c are separated from the lower artifact bearing Layer 7a by sterile Layer 6.
3. Layers 5a and 5c each yielded very few artifacts, 13 and 12 items respectively.
4. The total lithic assemblage from the layers differs typologically from the Lithic industries found in Layers 4a–c or Layer 4d.
5. Compositionally, Layers 5a and 5c are similar in that they both have rare lithic artifacts.
6. Layers 5a and 5c have the highest density of faunal remains, compared to the other human occupation layers.

The assemblage includes six flake tools (Fig. 15a–e, 15g, 18a–c, 18e, 18f), two pebble tools
Fig. 11. Treugol’nya Cave, assemblage IV from layer 7a: a - transverse bifacially retouched sidescraper with massive platform back; b - a composite tool combining denticulate and endscraper elements; c and d - two composite tools combining sidescraper elements with becs
Fig. 12. Treugol’naya Cave, assemblage IV: a – unretouched flake with flat beveled butt, layer 7a; b – simple straight side scraper, layer 6; c – unretouched flake with cortical beveled butt, layer 7b; d – unretouched flake with cortical beveled butt, layer 7a; e – unretouched flake with cortical beveled butt, layer 7a; f – a simple concave naturally backed side scraper, layer 6
Fig. 13. Treugol’naya Cave, assemblage IV: a – a denticulate tool, layer 6; b – massive endscraper made on a small flake with reduced bulb, layer 6

Fig. 14. Treugol’naya Cave, assemblage IV from layer 7a: a and c – two composite tools combining sidescaper elements with becs; b and e – unretouched flakes; d – a composite tool combining denticulate and endscraper elements; f – transverse bifacially retouched sidescaper
Fig. 15. Treugol’naya Cave, assemblage III: a – endscraper made on a flake fragment, layer 5a; b – atypical flat limace, layer 5a; c – double endscraper, layer 5a; d – transverse concave sidescraper combining two endscraper elements on opposite ends, layer 5b; e – composite tool combining endscraper and denticulate elements, layer 5c; f – flake, layer 5c; g – a small massive endscraper, layer 5c
(Figs. 16, 17), seven small flakes with flat bevelled butts (Figs. 15f, 18d), four quartz fragments, five chips, and three core-like pebble fragments. The raw material used for the artifact production varies as does that in Assemblage IV; nine were made from chert, four were made on flint, four were made from quartz, nine from limestone, and one from sandstone. The tools include a small massive endscraper (Fig. 15g), a composite tool combining endscraper and denticulate elements (Figs. 15e, 18f), and a proto-biface made on a flat limestone pebble worked from alternate directions (Fig. 16) from Layer 5c; a transverse concave sidescraper combining two endscraper elements on opposite ends found at the top of Layer 5b (Figs. 15d, 18c); an endscraper made on a flake fragment (Figs. 15a, 18a), a double endscraper made on flake (Figs. 15e, 18c), an atypical flat limace or double sidescraper (Figs. 15b, 18b), and a concave chopper made on limestone pebble (Fig. 17) from Layer 5a.

Relatively few lithics, no chert or flint cores, a high diversity of raw material from predominantly non-local origin, and a high tool percentage, 46% of all lithics in Assemblages IV and III each, all characterize short-term human occupations in the cave for Layers 7a, 5c, and 5a.

ASSEMBLAGE II

In the Assemblage II industry, almost all artifacts are made from local raw material, mainly limestone pebbles and slabs, which occur in large numbers along the slopes of ravines near the cave. At present, the assemblage includes 70 artifacts (Doronichev, 2000, 2001). Careful re-examination of the collection, which originally was thought to number 114 pieces (Doronichev, 1992), led to the rejection of many disputable pieces, mostly found in the colluvial sediment and modern soil (Layer 1) excavated in the open-air area in front of the cave entrance. Thirty lithics in this assemblage were found in a remnant of Layer 4d completely excavated in 1986–1988, but another 15 were found in Lens B, an erosional channel filled with sediment redeposited from Layer 4d. Another 16 pebble tools were found in collapsed sediments from Layer 4d and Lens B, while nine were redeposited pebble pieces found in Layer I.
The débitage includes two small pebble fragments, a small quartz pebble manuport or hammerstone, six amorphous cores made on pebbles or slabs larger than 10 cm, with one or more irregular flake scars, some with irregular retouch (Fig. 19b), two uni-platform cores, a double-platform core (Fig. 20), two three-platforms unifacial cores (Fig. 21), as well as two polyhedrons and a subspheroid, all of which appear to have been used as hammerstones, and 15 mostly small (5 cm) or sometimes large cortical or semi-cortical flakes with cortical or flat distinctly
bevelled butts. Flake tools are very rare. They include a transverse convex sidescraper or possibly a chopper on flake (Fig. 19a), an endscraper-like tool made on flint flake fragment, four retouched flakes, and a small tool fragment. Almost all the tools were made on limestone pebbles and slabs. Pebble tools constitute about 45% of the total assemblage and 81.5% of all tools.

Choppers and chopping tools comprise about 65% of the tools. Over 70% of the choppers are sidechoppers and endchoppers. Almost all the choppers have convex or straight working edges formed by small (1–5 cm) and medium (5–10 cm) flake scars (Figs. 22–29). Chopper bases and lateral faces were either on abrupt pebble surfaces or natural breaks (Figs. 22b, 23, 29, 30) and exhibit waved fractures possible resulting from direct percussion (Figs. 26, 27). Three rather heterogeneous choppers with two working edges (Fig. 29b) included an angled chopper (Fig. 28). Only four chopping tools possess alternatively worked edges (Fig. 30). Among the pebble tools, two heavy duty pebble scrapers differ from choppers in their smaller sizes and the more refined trimming along their working edges, mainly by large retouch (Fig. 31). Among the “heavy duty” tools, two large very heavy pick-like tools are up to 15 cm long. They have unifacially flaked convergent sides, unworked bases, and massive ends (Figs. 32, 33). One of the most expressive and typologically diagnostic tool types in the industry includes four small proto-bifaces made on limestone pebbles. These were partly bifacially worked tools, on which one surface had been flaked much more intensively than the other, which had only two or three flake scars (Figs. 34–36). A unique atypical biface made on a flat, limestone slab (Fig. 37) and a rabot on small pebble (Fig. 27; cf. Debenath and Dibble, 1994, Fig. 9.15) also occur.

The pebble industry in Treugol’nya Cave (Assemblage II) differs from the earlier Assemblages IV and III in that many cores and core-like pieces occur. This appears to reflect the almost exclusive use of the local limestone pebbles and slabs as the raw material for the industry, which were often flaked in the cave. The tool percentage (54% in Assemblage II) is also higher than those in Assemblages IV and III.
Fig. 19. Treugol'naya Cave, assemblage II from layer 4d: a – transverse convex sidescraper or possibly a chopper on flake; b – amorphous core made on pebble with irregular flake scars and irregular retouch.
Fig. 20. Treugol'naya Cave, assemblage II from the collapsed sediment of layer 4d. A double-platform core made on limestone pebble.
Fig. 21. Treugol'naya Cave, assemblage II from the 1986 test pit. Two three-platform cores made on limestone pebbles
Fig. 22. Treugol’nya Cave, assemblage II: a – chopper, Lens β; b – chopper, layer 4d
Fig. 23. Treugol'naya Cave, assemblage II from Lens B: chopper
Fig. 24. Tręugol'naya Cave, assemblage II from Lens B: chopper
Fig. 25. Treugol’nya Cave, assemblage II from the 1986 test pit. chopper
Fig. 26. Treugol’'naya Cave, assemblage II from the 1986 test pit: chopper made on massive limestone pebble fragment
Fig. 27. Treugol’naya Cave, assemblage II from layer 4d: rabot on small pebble
Fig. 28. Treugol‘naya Cave, assemblage II from layer 1: a – chopper, Lens β; b – chopper with two working edges
Fig. 29. Treugol'naya Cave, assemblage II from layer 1: a - chopper, Lens β; b - chopper with two working edges, layer 1
Fig. 30. Treugol'naya Cave, assemblage II from the collapsed sediment of layer 4d: chopping-tool with alternatively flaked edge
Fig. 31. Treugol'naya Cave, assemblage II from the 1986 test pit: Two heavy duty pebble scrapers with retouched working edges
Fig. 32. Treugol'naya Cave, assemblage II from layer 4d: heavy pick-like tool made on massive limestone pebble

Fig. 33. Treugol'naya Cave, assemblage II from Lens 8. A heavy pick-like tool made on massive limestone pebble
Fig. 34. Treugol'naya Cave, assemblage II from layer 4d: proto-biface made on small limestone pebble
Fig. 35. Trengol’naya Cave, assemblage II from the collapsed sediment of layer 4d: proto-biface made on small limestone pebble.
Fig. 36. Treugol'naya Cave, assemblage II from the collapsed sediment of layer 4d: proto-biface made on small limestone pebble
Fig. 37. Treugol’naya Cave, assemblage II from layer 4d: atypical biface made on flat limestone slab
ASSEMBLAGE I

The most distinctive feature of the uppermost industry, Assemblage I, is the predominance of artifacts made from gray flint, for which sources are unknown on the Baramkha Plateau. This assemblage numbers about 280 stone implements. It includes 70 artifacts found in situ in the uppermost Middle Pleistocene Layers 4a–4c (Figs. 38a, 38c–e, 40c, 41c, 41f, 44b) inside the cave, as well as 112 lithic pieces found in situ in Layers 4a–2 and 4b–2 (Figs. 39, 40a, 40b, 40d–i, 41a, 41b, 41d, 41e, 41g, 42) outside the cave, which are extensions of Layers 4a and 4b inside. It also includes 21 and 13 artifacts respectively which were redeposited from Layers 4a–c into Layers 3a–b (Figs. 43, 44a, 44e–h) and Lens R (Figs. 38b, 38f–j) inside the cave. Another two pieces were found in the Holocene Layer 2, 30 in the modern soil, Layer i (Fig. 45), 18 in Lens F1 outside the cave, and 25 in the collapsed sediment from the layers listed above (Fig. 46).

This is a flake industry characterized by predominantly small (3–5 cm), short, massive flakes with mostly flat bevelled butts (Figs. 38b, 38c, 38e, 38h, 39b, 39c, 39e, 39f, 40a, 40b, 40c, 42a, 42d–f, 42h, 43b, 44d, 44f, 46e). The flake backs have mainly irregular flake scars, often combined with cortical areas, while parallel scars also often occur (Figs. 38b, 38e, 38h, 42c, 42f, 43b, 44b–d, 45e, 45j, 45i, 46e, 46g). Only two flakes can be defined as Levallois (Fig. 43a). Cores are represented either by exhausted specimens (Fig. 38a, 43d), or by formless core-like pieces (Fig. 38j).

Secondary working was accomplished chiefly by thin marginal (Figs. 38b–c, 39e, 40f, 40b–i, 42e, 44b, 44d, 44g, 46e), invasive scalar (Figs. 38h, 39c, 40b, 40c, 41f, 42g, 43a, 45c–e, 45j) or non-scalar (Figs. 39b, 41b, 41d–e, 41g, 42a, 42c–d, 42f, 43a, 45f, 45i, 46c–d), and thick, demi-épaisse or épaisse (Figs. 38g, 39a, 40a, 41c, 42b, 45g–h, 46b) retouch, flat (Figs. 40d, 44a, 45b, 46a–b), denticulate (Figs. 40c, 42h, 46f), stepped demi-Quina or Quina (Figs. 40g, 41a, 44a), abrupt (Fig. 38d), and surlevée (Fig. 39f) retouch was much more rarely. Many retouched flakes have irregular and small (Figs. 38f, 44f, 46g), sometimes grignotée (Fig. 38i) retouch, which probably resulted from use.

No retouched Levallois or Mousterian points or limaces are present. There is a unique reversed convergent sidescraper with a tip, formed on a flake base and additionally thinned from the ventral face (Fig. 46b). Among the convergent tool types (Debénath and Dibble, 1994: 65), two Quinson points occurred (Fig. 45b, 46a). Sidescrapers comprise 50% of all the tools. Most are simple convex (Figs. 39a, 39c, 40e, 45i–j), simple straight (Figs. 38c, 39b, 40b, 40d, 40f, 46h, 41a, 45f), transverse convex (Figs. 38g, 40a, 42a, 45a, 45c–d, 46d), and transverse straight (Figs. 40g, 41b, 42f) sidescrapers. Simple concave sidescrapers (Figs. 43a, 45e) and double sidescrapers (Figs. 39d, 42b, 44b) are rare. Canted (déjeté) sidescrapers are presented by two hump-shaped (incurvé) tools (Figs. 38h, 42d), a single déjeté sidescaper (Fig. 46c) and a double déjeté sidescaper. Three sidescrapers are notable for the thickness of the blanks and steep convex edges formed by stepped Quina type retouch; one of them is a scraper with thinning from ventral face back (Fig. 44a).

Among the Upper Paleolithic tool types, endscrapers are well represented. Endscrapers are generally divided in two groups, those made on flakes (Figs. 41d–g, 45h), and massive endscrapers made on fragments (Fig. 42c) or thick flakes (Figs. 39f, 41c). The industry contains also a few retouched porciers or becs (Figs. 40h, 44g, 45g), and a backed knife (Fig. 44f). Several pieces with continuous, delicate, and quite abrupt marginal retouch are defined as raclettes (Figs. 38b, 42e; cf. Debénath and Dibble, 1994: 101). The composite tools include a tool combining a simple convex sidescaper with a nosed endscraper formed on the proximal flake end (Fig. 42g), a tool made on small flake combining a sidescaper having scalar retouch with a denticulate (Fig. 46c), and a tool on small flake combining a retouched point and a nosed endscraper. There are a few denticulates (Figs. 42h, 46f) and notched tools. Also, several pebble tools and cores occurred.

Assemblage I generally resembles other assemblages in the cave in that more than 50% of the assemblage consists of tools. This, in addition to several heavily reduced cores, and a restricted number of artifacts, suggests that, at the time of the Layers 4a–b deposition, the tool makers used Treugol’naya for short occupations.
Fig. 38. Treugol’naya Cave, assemblage I: a – exhausted core, layer 4c; b – raclette made on a small flake, Lens R; c – simple straight sidescraper made on a small flake, layer 4c; d – simple straight sidescraper with abrupt retouch, layer 4b; e – small flake, layer 4b; f – small flake with irregular retouch, Lens R; g – transverse convex sidescraper with épaisse retouch, Lens R; h – incurvé tool (déjeté sidescraper) with invasive scalar retouch, Lens R; i – small flake with flat beveled butt, with grignotée retouch, Lens R; j – formless core-like piece, Lens R
Fig. 39. Treugol’naya Cave, assemblage 1 from layer 4b-2: a – simple convex sidescraper made on thick flake, with épaisse retouch; b – simple straight sidescraper with nonscalar invasive retouch; c – transverse convex sidescraper made on a small flake with invasive scalar retouch; d – double sidescraper made on a small flake; e – simple convex sidescraper made on a small flake with thin marginal retouch; f – massive endscraper made on a small massive flake, with surlevée retouch
Fig. 49. Treugol’nya Cave, assemblage I: a – transverse convex sidescraper made on a small massive flake, with épaisse retouch, layer 4b-2; b – simple straight sidescraper made on a small flake, with invasive scalar retouch, layer 4b-2; c – tool made on small flake combining a sidescraper with scalar retouch and a denticulate with denticulate retouch, layer 4b; d – simple straight sidescraper with flat retouch, layer 4b-2; e – simple convex sidescraper made on a small flake with invasive scalar retouch, layer 4b-2; f – simple straight sidescraper with thin marginal retouch, layer 4b-2; g – transverse straight sidescraper with stepped demi-Quina retouch, layer 4b-2; h – simple straight sidescraper with thin marginal retouch, layer 4b-2; i – perçoir or bec, layer 4b-2
Fig. 41. Treugol'naya Cave, assemblage I: a – simple straight sidescraper with stepped Quina retouch, layer 4b-2; b – transverse straight sidescraper with noncalar invasive retouch, layer 4b-2; c – massive endscrapers made on a thick flake with epaissre retouch, layer 4b; d – endscraper made on a flake with noncalar invasive retouch, layer 4b-2; e – endscraper made on a flake with noncalar invasive retouch, layer 4b-2; f – endscraper made on a flake with invasive scalar retouch, layer 4b; g – endscraper made on a flake with noncalar invasive retouch, layer 4b-2
Fig. 42. Treugol'naya Cave, assemblage I from layer 4a-2: a – transverse convex sidescraper made on a small flake with flat beveled butt and nonscalar invasive retouch; b – double sidescraper with demi-épaisse retouch; c – massive endscraper made on a fragment with nonscalar invasive retouch; d – incurvé tool (déjeté sidescraper) made on a small flake with nonscalar invasive retouch; e – raclette made on a small flake with continuous and delicate retouch; f – transverse straight sidescraper made on a small flake with nonscalar invasive retouch; g – tool combining a simple convex sidescraper with a nosed endscraper formed on the proximal flake end, with invasive scalar retouch; h – denticulate tool with denticulate retouch
Fig. 43. Treugol'naya Cave, assemblage I from layer 3b: a – simple concave sidescraper made on a Levallois flake with invasive scalar retouch; b – small flake with flat, beveled butt, with marginal retouch; c – small flake; d – exhausted core; e – small massive flake
Fig. 44. Treugol'nya Cave, assemblage 1: a – sidescraper made on a thick blank with steep convex edge formed with stepped Quina retouch and with a back thinned with flat ventral retouch, layer 3a; b – double sidescraper with thin marginal retouch, layer 3a; c – flake, layer 3b; d – small massive flake with flat, beveled butt and thin marginal retouch, layer 3a; e – limestone flake, layer 3a on contact with layer 4d; f – backed knife made on a small massive flake with irregular retouch, layer 3a; g – perçoir or bec with thin marginal retouch, layer 3a; h – limestone flake, layer 3a on contact with layer 4d.
Fig. 45. Treugol’naya Cave, assemblage 1 from layer 1: a – a transverse convex sidescraper with nonscalar invasive retouch; b – Quinson point made on a small flake with flat retouch; c – transverse convex sidescraper made on a small flake with invasive scalar retouch; d – transverse convex sidescraper made on a small flake with invasive scalar retouch; e – simple concave sidescraper with invasive scalar retouch; f – simple straight sidescraper with nonscalar invasive retouch; g – perçoir or bee with épaisse retouch; h – endscraper made on a flake with demi-épaisse retouch; i – simple convex sidescraper with nonscalar invasive retouch; j – simple convex sidescraper with invasive scalar retouch.
Fig. 46. Treugol’naya Cave, assemblage I from the collapsed sediment of layers 4a–c: a – Quinson point with flat retouch; b – reversed convergent sidescraper with a tip formed on a flake base and additionally thinned from the ventral face, made on a small massive flake with flat and épaisse retouch; c – déjeté sidescraper made on a small flake with nonscalar invasive retouch; d – transverse convex sidescraper made on a small flake with nonscalar invasive retouch; e – denticulate tool; f – denticulate tool with denticulate retouch; g – flake with irregular retouch; h – small flake
TREUGOL’NAYA CAVE
AND THE LOWER PALEOLITHIC
OCCUPATION IN EASTERN EUROPE

The new data from Treugol’naya Cave, including the absolute dates, paleontological and paleobotanical remains, and lithic industries found in a well preserved stratigraphical context, shows that the assemblages in the cave rank among the oldest Lower Paleolithic industries in Europe. The detailed material from Treugol’naya Cave provides new perspectives on the initial human occupation and the Lower Paleolithic cultural evolution in eastern Europe (Doronichev, 2001).

Although the lower Assemblage IV in Treugol’naya Cave is very sparse, it nonetheless provides good evidence for an initial human occupation in southern eastern Europe as early as 600 ka (Table 8). This indicates that the initial human colonization in southern eastern Europe probably occurred not long after the Don Glaciation (tentatively correlated with OIS 16) left eastern Europe.

During the Middle Pleistocene, the Don glaciers spread much further to the south than did the Oka (= Elsterian = OIS 12?) and Dnieper (= Saalian = OIS 6–8?) glacial advances. Two distinct interglacial intervals and one cold phase separate the Don from the Oka Glaciation (Roebroeks and Kolfschoten, 1995: 298, Fig. 2). This suggests that these two interglacial events correlate with the Cromerian Interglacial IV (= OIS 13?) and III (= OIS 15?), and the cold phase with OIS 14. If so, then the Don Glaciation correlates with OIS 16 (620–660 ka). The maximum Akchagilian and Apsheronian transgressions in the Caspian Sea occurred much earlier in the Lower Pleistocene. Although the period between 600 and 300 ka, which spans OIS 15 through 9, was generally mild in the northern Hemisphere, human settlement in eastern Europe – in contrast with that in western or central Europe – was apparently extremely limited within the southernmost area along the Black Sea coast and Caucasus Mountains.

Assemblages IV and III in Treugol’naya Cave also indicate that roughly between 600 and 400 ka, the Lower Paleolithic in southern eastern Europe comprised flake tool industries lacking in Acheulian bifaces. Likewise, no Acheulian bifaces are known for this time period neither in central and eastern Europe (Bosinski, 1995; Valoch, 1995; Doronichev, 2001) nor in the Caucasus (Doronichev and Golovanova, 2003). One can guess that this is because all these areas lie outside the limits of the territory occupied by Acheulian industries as the “Movius line” demarcates in Europe and western Asia (Kozlowski, 2003, Fig. 7.1).

Unfortunately, the materials documenting the initial human colonization in eastern Europe are currently very scarce and typologically poorly characterized. V. B. Doronichev (2000, 2001) attributed Assemblages IV and III in Treugol’naya to the “Tayacian”, but this term still retains significant typological uncertainty. The similarity of Assemblage III and IV to the industries in the Bilzingsleben-Vértesszőlős group (Doronichev, 2001), as suggested for Pogreby, Dubossary, Khrystschi, also in eastern Europe (Kozlowski, 1998), is also currently poorly documented.

At Treugol’naya Cave, Assemblages IV and III, dating from the early Middle Pleistocene between 600 and 400 ka, contain flaked tool industries similar to those of the southern Caucasus. In Layer 8a at Kudaro III, Liubin (1998) reported that the only possible human occupation discovered so far in the southern Caucasus was a flaked tool industry lacking Acheulian bifaces (Doronichev and Golovanova, 2003: 78). This feature separates the Lower Paleolithic of eastern Europe, and possibly contemporaneous Lower Paleolithic industries in the southern Caucasus, from the Lower Paleolithic of western Asia. In western Asia, mostly Upper Acheulian bifacial industries are known for this time period (Bar-Yosef, 1998).

Therefore, the data available today does not support any hypothesis involving initial human occupations in the northern Caucasus – or possible migrations to the more northerly areas in eastern Europe – from the southern Caucasus or western Asia. No solid data is available at present to confirm a continual human occupation in the southern Caucasus in the early Middle Pleistocene. No well confirmed human occupations are known for this period in the southern Caucasus, because the 11 lithics found in Layer 8a in Kudaro III cave and their single thermoluminescent (TL) date, S60 ± 112 ka (Liubin, 1998), both remain questionable:
### Table 8

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<th>European Glacial &amp; Interglacial Complexes</th>
<th>Oxygen Isotope Stages (OIS)</th>
<th>Ages for OIS (ka)</th>
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<td>11</td>
<td>364–427</td>
<td>&quot;Tayacian&quot; Industry</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>427–474</td>
<td>&quot;Tayacian&quot; Industry</td>
</tr>
<tr>
<td>Elsterian</td>
<td>13</td>
<td>474–528</td>
<td>&quot;Tayacian&quot; Industry</td>
</tr>
<tr>
<td>Crómérion</td>
<td>14</td>
<td>528–568</td>
<td>&quot;Tayacian&quot; Industry</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>568–621</td>
<td>&quot;Tayacian&quot; Industry</td>
</tr>
</tbody>
</table>

1. According to geomorphological data, Kudaro I and III were opened by erosion and available for human occupation no earlier than 300–400 ka (Nesmeyanov, 1999: Table 21.1). More likely, Kudaro III was opened about 200 ka, and Kudaro I, about 250–300 ka (Nesmeyanov, 1999: 336).

2. The single TL date may be incorrect, because applying TL dating to rock fragments present in cave sediment is highly problematic from the methodological point of view. Moreover, the reported age exceeds the maximum age limits for TL, usually 0.5 Ma (Schwarcz and Rink, 2001: 362, 364).

3. None of the artifacts reported from layer 8a in Kudaro III has been illustrated in the literature, despite their obvious importance. In his two most recent books about the Lower Paleolithic in the Caucasus, V. P. Liubin (1998, 2002) simply notes without visual documentation that the pieces result from human manufacture.

In contrast, several human occupations are known from the early Middle Pleistocene in central Europe, for example, in Kärlich G at Miesenhein I, (Bosinski, 1995), Becov I-B at Stránská škála I, Cernovice (Valoch, 1995), and Assemblages VII and VIII at Korošlevo I (Gladičin and Silišić, 1990). Moreover, like Assemblages IV and III at Treugol’naya, only core-chopper or flaked tool assemblages are known for this period in eastern Europe while no Acheulian industries have been found. From the sparse data available today, a central European origin for the Lower Paleolithic in eastern Europe, including the northern Caucasus, seems more likely.

Just after 400 ka, in OIS 11 (not OIS 9 as previously suggested: Doronichev, 2000, 2001), the first core-chopper (or pebble tool) industry, Assemblage II at Treugol’naya, appears in eastern Europe (Table 8). Found in situ in Layer 4d, the pebble tool industry at Treugol’naya has no clear analogues in the Lower Paleolithic within the
Caucasus. It shows general similarities with the industry from Layer VI at Korolevo I (Doronichev, 2000, 2001), which dates to the same time, around 350 ka (Gladilin and Sitlivy, 1990, Fig. 7). Therefore, while this problem requires more detailed analyses, the data are consistent with a central European origin for the pebble tool industries at Treugol'naya (Doronichev, 2000, 2001). Alternatively, one could view the core chopper industry of Assemblage II at Treugol'naya as just a facies within a larger industrial complex. Several pebble tools found in the Lower Paleolithic ("Acheulean") industries in Kudaro I and Azykh in the southern Caucasus (Liubin, 1998: 133) resemble pebble tools in Assemblage II, including proto-bifaces, like those found in the non-Acheulian Buda industry at Vértesszolos (Valoch, 1995). Also, a few pebble artifacts were found in 2000 in the flaked tool industries in Assemblages III and I at Treugol'naya.

One can suggest that in Treugol'naya cave like some Lower Paleolithic occupations in central-eastern Europe and Caucasus the material used for making tools did not favor handaxe production, which may explain the lack (in Treugol'naya) or the extraordinary scarcity (in Kudaro I and Azykh) of Acheulian bifaces. On the contrary, one can note a total absence of the Lower Paleolithic assemblages with numerous typical Acheulian bifaces on a huge territory across central-eastern Europe and the main part of the southern Caucasus while their presence in the nearby areas of western Europe and western Asia (including the southwest part of the Caucasus Doronichev and Golovanova, 2003). This data indicates that the Lower Paleolithic industries of central-eastern Europe and partly in the Caucasus possibly occur outside the distribution range of the Acheulian techno-complex demarcated with the "Movius line" (Kozlowski, 2003, Fig. 7.1).

Assemblage I at Treugol'naya displays some similarities in its flake tools with the Lower Paleolithic industries at Kudaro I and Azykh in the southern Caucasus. Liubin (1984) initially called these industries "Acheulian of Proto-Charentian appearance", but later (1998: 172) has assigned them to the Acheulian sensu stricto, i.e., typical Acheulian with bifaces. Assemblage I differs markedly from these Lower Paleolithic industries, because it totally lacks bifaces, which gives it a non-Acheulian appearance. Consequently, Doronichev (2000, 2001) called it "Proto-Charentien", but more detailed analyses will be necessary to clarify its position among coeval Lower Paleolithic industries in central Europe and western Asia and by that reveal data for more secure definition of this industry type.

Likewise, discussing the origin of the "Proto-Charentien industry" in eastern Europe is difficult, because its relationship with other coeval sites in central Europe, Balkans, and western Asia remains unclear at present. Regarding the southern Caucasus, the available dates (Fig. 47) permits us to guess the origin of "Acheulian of Proto-Charentian appearance" or rather "Proto-Charentian" industries with extremely rare Acheulian bifaces in Kudaro I and III, Tsona, and Azykh from a Proto-Charentian industry type without Acheulian bifaces like Assemblage I at Treugol'naya Cave.

In eastern Europe, three assemblages from Khryashechy and Mikhailovskoe, as well as possibly Pogreby and Dubossary, may be tentatively compared (despite the problems with these materials noted above) with Assemblage I at Treugol'naya (Doronichev, 2001; Table 8). All these other potentially Lower Paleolithic locations yielded flake-tool industries with some pebble tools, but without bifaces. Although generally similar to Assemblage I, the Khryashechy and Mikhailovskoe collections contain less characteristic flaked tool industries ("Proto-Charentian" or "Tayacian")? Tools include typical simple (Praslov, 1968, Fig. 10–2, 11–2) and transverse (Praslov, 1968, Fig. 6–1) sidescrapers with scaled retouch, a sidescraper with Quina retouch (Praslov, 1968: Fig. 10–1), a convergent sidescraper (Praslov, 1968, Fig. 20–2), a retouched perçoir (Praslov, 1968, Fig. 18–1), a possible Quinson point fragment (Praslov, 1968, Fig. 19–1), some pebble tools (Praslov, 1968, Fig. 8–9), and no Acheulian bifaces. The Pogreby and Dubossary materials were assigned to the "Dubossary industry". Due to the industry's typological uncertainty, it resembles the Tayacian (Anisjutkin, 1987: 13), or several other eastern and central European Lower Paleolithic flaked tool industries that have choppers but lack bifaces (Anisjutkin, 1992: 33).

Only at the end of Middle Pleistocene, mostly during the cold phase, OIS 6, which correlates
with the Moscow Glaciation on the Russian Plain, did widely dispersed Lower or early Middle Paleolithic industries (mostly with bifacial leaf points) appear across eastern Europe. Apparently, this reflects the first intensive human occupation in this region. One can propose that the eastern European “Upper Acheulian” represents an easterward continuation of the central European Upper Acheulian (Kolesnik, 1998: 90). Wide variation in bifacial forms, tool inventories, and flaking technologies is noted in the “Upper Acheulian” or “Leaf Point” lithic assemblages in eastern Europe (Golovanova, 2000; Kolesnik, 1998; Stepanchuk, 1998), suggesting significant regional cultural variations, possibly reflecting small, relatively isolated populations, which developed their own distinctive tool industries, each having slightly different origins within the Lower or early Middle Paleolithic “Leaf Point” industries across eastern Europe (Kozlowski, 2003).

**CONCLUSIONS**

The new data from Treugol’naya Cave, including the absolute dates, paleontological and paleobotanical remains, and lithic industries found in a well preserved stratigraphical context, shows that the assemblages found in the cave are among the oldest Lower Paleolithic industries in Europe. The Middle Pleistocene deposits in the cave span the period from before 580 to before 315 ka, and possibly from about 650 to 350 ka. The four lithic assemblages identified in the cave suggest a new view for the initial human occupation in eastern Europe and the evolution of the Lower Paleolithic cultures there (Doronichev, 2001).

The lowermost Assemblage IV in Treugol’naya Cave provides the first evidence for the initial human occupation in southern eastern Europe as early as 600 ka, implying that the first human appearance had probably occurred soon after the eastern European Don Glaciation (probably = OIS 16; Table 8). Assemblages IV and III also indicate that, between roughly 600 and 400 ka, the Lower Paleolithic in southern eastern Europe was represented by flake-tool industries lacking Acheulean bifaces. Likewise, the only Lower Paleolithic industries with no Acheulean bifaces are known in the late Lower through early Middle Pleistocene in the nearby areas of central Europe (Valoch, 1995), Anatolia (Güleç et al. 1999), southern Caucasus (Gabunia 2000), and central Asia (Ranov et al. 1995). All these areas are outside the distribution range of the Acheulean techno-complex demarcated with the “Movius line” (Kozlowski, 2003, Fig. 7.1) to western Europe and western Asia (including the most southern part of the southern Caucasus). Unfortunately, the early Lower Paleolithic artifacts from eastern Europe are currently very scarce and typologically poorly characterized. Assemblages IV and III appear to be closest in classification to “Tayacian” (Doronichev, 2000, 2001).

The data available at present does not support the hypothesis that the initial human occupation of eastern Europe arrived from the southern Caucasus or entire western Asia. No sound evidence is known until today to prove that eastern Europe was inhabited by humans during all of the Lower and most of the Middle Pleistocene. This clearly contrasts with that the first humans had appeared in the southern Caucasus as early as 1.7 Myr in Dmanisi and crossed the Caucasus mountains by 0.6 Myr that is evidenced with the Treugol’naya cave material. The human appearance in the south of Russian plain is probably dated no early than 300 kyr if one suggests Dnieper Glaciation (OIS 8) age of the earliest lithic assemblage from Khryashchya. Nevertheless, a real large scale human colonization of eastern Europe has started just in the end of Middle Pleistocene (OIS 6 or ca. 200 kyr). This wide dispersal of humans appear originates from central Europe while not western Asia.

Somewhat later than 400 ka, a “Core-chopper” (or pebble-tool) industry first appears in eastern Europe, as seen in Assemblage II at Treugol’naya Cave (Table 8). This industry has no clear analogues in the Lower Paleolithic of the Caucasus, while it is generally similar to the industry in Layer VI at Korolevo I (Doronichev, 2000, 2001), which is dated approximately 350 ka (Gladilin and Sitiliviy, 1990, Fig. 7). Therefore, a central European origin for the pebble-tool industry in eastern Europe and at Treugol’naya Cave was proposed (Doronichev, 2000, 2001). However, one can equally suggest west Asian origin of this industry type. Core-chopper industries tentatively dating the Lower Pleistocene are known in Levant in Borj Qinnarat, Kefar Menachem,
<table>
<thead>
<tr>
<th>OES stages</th>
<th>Age of OES stages (Kyr)</th>
<th>Stacked L assemblage</th>
<th>Total Minca</th>
<th>ASS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>109</td>
<td>Tsana,</td>
<td>105</td>
<td>Kusco</td>
</tr>
<tr>
<td>8</td>
<td>344</td>
<td>Kusco</td>
<td>35</td>
<td>Kusco</td>
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<tr>
<td>9</td>
<td>331</td>
<td>Tsana,</td>
<td>30</td>
<td>Kusco</td>
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<tr>
<td></td>
<td></td>
<td>~ 5000 Kusco</td>
<td></td>
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<tr>
<td>10</td>
<td>134</td>
<td>Kusco</td>
<td>18</td>
<td>Kusco</td>
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<td>7</td>
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<td></td>
<td>11</td>
<td>Kusco</td>
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<tr>
<td>11</td>
<td>1690</td>
<td>Azykh,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>564</td>
<td>Treugolina</td>
<td></td>
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<tr>
<td>13</td>
<td>290</td>
<td>Treugolina</td>
<td></td>
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<tr>
<td>14</td>
<td>70</td>
<td>Treugolina</td>
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<td>15</td>
<td>27</td>
<td>Treugolina</td>
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</table>

Fig. 47. Proposed chronology of OES stages.
Sources of data: Baryshnikov, 1

The new data first presented in the paper allows to assume that the specific or separated character of Assemblage II at Treugol'nya Cave and thus interpret it as just a part of a typologically more complex and variable Lower Paleolithic industry type. This data includes a new large series of ESR dates that points to a very close and unexpected (Doronichev, 2001) timing of assemblages III, II, and I within OIS 11 (364–427 kyr); several pebble artifacts were firstly found in 2000 in assemblages III and I.

Assemblage I at Treugol'nya Cave differs markedly from the Acheulean industries in the southern Caucasus in that it completely lacks bifaces. Due to its non-Acheulean appearance, this assemblage has been classified as “Proto-Charentian” (Doronichev, 2000, 2001). Further, more detailed analyses are necessary to clarify the relationship of this assemblage to coeval Lower Paleolithic industries in central Europe, the Balkans, and western Asia, which also makes it difficult to discuss its origin. Nevertheless, the available dating data (Fig. 47) allows to guess the origin of “Acheulean of Proto-Charentian appearance” or rather “Proto-Charentian” with extremely rare Acheulean bifaces in Kudaro I and III, Tsoa, and Azykh from an older “Proto-Charentian” industry type lacking Acheulean bifaces like Assemblage I at Treugol'nya Cave. In eastern Europe, three Lower Paleolithic lithic assemblages from Khrystashche and Mikhailovskoe, as well as possibly Pogreby and Dubossary, appear to be the only locations known so far in eastern Europe that may be comparable to Assemblage I at Treugol'nya Cave (Doronichev, 2001), because each yielded flake-tool industries without bifaces, but with some pebble tools.

Only at the end of the Middle Pleistocene (OIS 6) do widespread Lower or early Middle Paleolithic industries, mostly with bifacial leaf points, occur in eastern Europe. Apparently, this reflects the first fairly intensive human occupation in this region. One can suggest, from the complex nature of this occupation, different origins for the Lower or early Middle Paleolithic “Leaf Point” industries in eastern Europe, and their general relationship with the coeval locations in the central Europe (Kolesnik, 1998; Stepanchuk, 1998; Golovanova, 2000; Kozlowski, 2003).

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