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Taphonomy of the fossil hominid bones from the Acheulean site of Castel di Guido near Rome, Italy

Castel di Guido near Rome is one of the few open air Middle Pleistocene European sites that has yielded hominid skeletal remains associated with fossil fauna and Acheulean implements. The fossil hominid bones include two femoral shafts, respectively designated Castel di Guido-1 (CdG-1) and CdG-2, an occipital fragment (CdG-3), a right maxilla lacking teeth (CdG-4), a portion of right parietal (CdG-5), a right temporal (CdG-6), and a fragment of left parietal vault (CdG-7). CdG-1 through CdG-4 were collected in 1979–1982 on the surface, together with fossil fauna, where ploughing incised fossiliferous tuffaceous sands. Excavations conducted in the same area from 1980 to 1990 led to the discovery of CdG-5, CdG-6 and CdG-7 within the tuffaceous sands, which were shown to overlay a bone-bearing paleosurface, with abundant evidence of hominid activities. The Castel di Guido hominid assemblage poses intriguing taphonomic questions. The analysis of the physical evidence offered by the bone surfaces, reported in the present study, indicates that the hominid skeletal remains were heavily fragmented before fossilization and exposed to carnivores and rodents, as well as to trampling and/or friction in abrasive sediment. Although definitive conclusions cannot be reached on the basis of the available evidence, it is possible that clusters of incisions localized on specific regions of the Castel di Guido fossil hominid bones might reflect deliberate human manipulations.

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Received 1 December 2000
Revision received
18 May 2001 and
accepted 25 May 2001

Keywords: hominid, fossil,
taphonomy, Middle
Pleistocene, Castel di
Guido, Italy, surface marks,
cannibalism.

Journal of Human Evolution (2001) **41**, 211–225
doi:10.1006/jhev.2001.0492

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Introduction

The Castel di Guido site

To the immediate west and north-west of Rome, the Aurelian Way runs through a low plateau, incised by shallow erosion valleys that expose an impressive sequence of littoral, fluvio-deltaic, and lacustrine Middle

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Pleistocene formations, deposited in environments associated with the lowermost course and paleoestuary of the river Tiber (Blanc, 1957; Ambrosetti, 1967; Ambrosetti *et al.*, 1972; Jacobacci, 1978; Malatesta, 1978a,b; Conato *et al.*, 1980). In the second half of the 20th century, surface investigations, inspired by the example of the late A. C. Blanc, led to the identification of a number of archaeological and palaeontological sites along the Aurelian Way, most

notably including Torre in Pietra, at the 26th km, Malagrotta, at the 14th km, La Polledrara di Cecanibbio, at the 19th km, and Castel di Guido, at the 20th km (Blanc, 1954, 1957; Radmilli *et al.*, 1980; Cassoli *et al.*, 1982; Mallegni *et al.*, 1983; Anzidei *et al.*, 1989; Radmilli & Boschian, 1996a). Castel di Guido is one of the few open air Middle Pleistocene European sites that yielded hominid remains associated with fossil fauna and Acheulean implements (Radmilli *et al.*, 1980; Mallegni *et al.*, 1981, 1983; Mallegni & Radmilli, 1988).

The Castel di Guido site, located on a low hill, was discovered in July 1976 by one of the authors (RM-C), as a result of surveys of the Pleistocene outcrops between kilometres 13 and 21 of the Aurelian way, undertaken since 1970 with E. Alleva and E. T. Longo (Mariani & Radmilli, 1984; Radmilli & Boschian, 1996a). Systematic excavations, conducted from 1980 to 1990 by A. M. Radmilli and colleagues from the University of Pisa, led to the discovery of a well-preserved bone-bearing paleosurface showing abundant evidence of hominid activities, that was excavated for about 1100 m² (Radmilli & Boschian, 1996b). The paleosurface formed on a paleochannel, interpreted as the bed of a brook or as a marginal loop of a small lacustrine basin, that was covered with a thin layer of eolic sand, upon which implements and fossil bones were deposited, directly overlaid by the tuffaceous sands exposed on the agricultural surface (Pitti & Radmilli, 1982; Radmilli & Boschian, 1996b). The deposition of the tuffaceous sands that sealed the paleosurface most probably followed an overflow of the ancient water basin that filled the channel with slow-moving mud admixed with volcanic products (Pitti & Radmilli, 1982; Radmilli & Boschian, 1996b). Such deposits of tuffaceous sands occur frequently in the Pleistocene formations along the Aurelian Way, as a consequence of obstructions of ancient drainage basins by pyroclastic debris

from the Sabatian Volcan (Bertini *et al.*, 1971; Malatesta, 1978b).

The vertebrate fauna recovered *in situ* on the Castel di Guido paleosurface and in the overlying tuffaceous sands includes, in order of frequencies, aurochs (*Bos primigenius* Bojanus, 1827), elephant (*Elephas antiquus* Falconer & Cautley, 1845), a large horse (*Equus caballus* Linneus, 1758), and a red deer typical of the Italian Middle Pleistocene (*Capreolus cf. rianensis* Leonardi & Petronio, 1974). Other species, represented by scarce skeletal elements, include hare (*Lepus cf. europaeus* Pallas, 1778), hippopotamus (*Hippopotamus cf. major* Owen, 1843), wild boar (*Sus scrofa ferus* Linneus, 1758), rhinoceros (*Stephanorhinus cf. hundsheimensis* Toulou, 1902), lion (*Panthera leo* Linneus, 1758), an early form of wolf (*Canis lupus* Linneus, 1758), and a smaller canid, possibly *Canis mosbachensis* Soergel, 1914 or *Cuon* sp. (Sala & Barbi, 1996). Fragmentary bones attributable to these species and to other vertebrate genera, including *Emys*, *Dama*, *Capreolus*, *Crocota*, and *Castor*, were also collected loose on the ploughed agricultural soil (Mallegni *et al.*, 1983). The ungulates are mainly represented by skulls or skull parts and by limb bones, that show repetitive transverse or spiral breaks, suggestive of intentional fracturing (Sala & Barbi, 1996; Radmilli & Boschian, 1996c). The artefact assemblage made from a wide variety of materials, including flint, limestone, lava, calcareous silt, sandstone, quartz, pumice and compact bone of large mammals, is composed of bifaces, choppers, chopping tools and flakes of clactonian tradition, associated with microlithic pebble and flake tools (Radmilli & Boschian, 1996c; Radmilli & Boschian, 1996d). Overall, the archaeological evidence suggests that Castel di Guido might represent a hunting site, dedicated to the accumulation and butchering of animal carcasses (Radmilli & Boschian, 1996c).

The Pleistocene archaeological sites identified along the Aurelian way near Rome are all posterior to the pyroclastic fall and flow deposit of the Sabatian Volcan (i.e., Bracciano), dated at $431,000 \pm 40,000$ BP and $438,000 \pm 40,000$ BP by K/Ar on sanidine crystals from ignimbritic outcrops at Torre in Pietra (Evernden & Curtis, 1965; Ambrosetti *et al.*, 1972; Anzidei *et al.*, 1989). On the basis of the stratigraphic position, of the faunal association, referred to the late Middle Pleistocene, and of the artefact assemblage, Castel di Guido can be correlated with the nearby archaeological sites of La Polledrara di Cecanibbio and Malagrotta and with the Acheulean levels of Torre in Pietra (Caloi & Palombo, 1978; Cassoli *et al.*, 1982; Anzidei *et al.*, 1989; Radmilli & Boschian, 1996*b,c*; Sala & Barbi, 1996; Caloi *et al.*, 1998). All these sites belong to the sedimentary cycle named Aurelia Formation, which is related to oxygen isotope stage 9 (Caloi *et al.*, 1998).

The hominid remains

A total of seven fragmentary postcranial and cranial fossil hominid bones was recovered at Castel di Guido in the years from 1979 to 1990 (Radmilli *et al.*, 1980; Mallegni *et al.*, 1981, 1983; Mallegni & Radmilli, 1988). The post-cranial bones are represented by portions of two femora, Castel di Guido-1 (CdG-1), a distal segment of shaft from a robust right femur, reconstructed from three recently broken pieces, reconnected through good joins, and CdG-2, a proximal half of shaft from a more gracile left femur (Mallegni *et al.*, 1983). The cranial remains include CdG-3, a fragment from the superior region of a right occipital, including part of the *torus occipitalis*; CdG-4, a portion of right maxilla, lacking tooth crowns and including the region from the intermaxillary suture to the mesial walls of the 16 buccal and 17 lingual alveoli; CdG-5, a posterior-inferior fragment of right parietal, including a length of occipital margin with the mastoid

angle; CdG-6, a right temporal, including most of the squamous portion and the mastoid portion, except the apex of the mastoid process, the auditory process and the glenoid fossa; CdG-7, a fragment of the superior region of a left parietal, measuring 3.6 cm in antero-posterior length by 3.2 cm in width and 1.0 cm in thickness (detailed descriptions and measures of specimens CdG-1 through CdG-6 were previously published, see Mallegni *et al.*, 1983, and Mallegni & Radmilli, 1988).

The Castel di Guido hominid assemblage might derive from a minimum of two to a maximum of six adult individuals, based on the size differences between the two femoral shafts and on a joining surface connecting CdG-6 and CdG-5 at the parieto-mastoid suture (Mallegni *et al.*, 1983; Mallegni & Radmilli, 1988). Four of the fossil hominid bone fragments (i.e., CdG-1, CdG-2, CdG-3 and CdG-4) were identified in the years 1979–1982 by E. T. Longo, A. M. Radmilli and two of the authors (FM and RM-C), among the fragmentary faunal specimens collected on the loose soil, where ploughing had deeply incised the tuffaceous sands, exposing the paleosurface (Radmilli *et al.*, 1980). CdG-5, CdG-6 and CdG-7 were found, separately, within the tuffaceous sands removed during the archaeological excavations conducted to expose the paleosurface. Unfortunately, the precise position of the hominid bones relative to the paleosurface could not be recorded. Bone preservation and chemistry of the hominid and nonhominid fossil bones collected loose on the ploughed surface were similar to those of the specimens collected within the tuffaceous sands or on the paleosurface (Mallegni *et al.*, 1983). The fossil bones found loose on the agricultural surface could have derived from the paleosurface, or from the overlying tuffaceous sands. Based on geoarchaeological data, it appears that the fossil bones found within the tuffaceous sands had been transported for

only a short distance by the volcanic mud and thus might have originated from the area of the paleosurface or from a nearby land surface (Radmilli & Boschian, 1996*b,c*).

The Castel di Guido hominid bones show a mixture of archaic (*erectus* like) and progressive (Neanderthal like) features, and are morphologically well known (Mallegni *et al.*, 1983; Mallegni & Radmilli, 1988), but still pose intriguing taphonomic questions. In fact, at least in part, their fragmentation must have occurred prior to deposition in the sediment, as indicated by the refit of CdG-5 and CdG-6, found separately within the tuffaceous sands (Mallegni *et al.*, 1983; Mallegni & Radmilli, 1988). In this respect, the analysis of the physical evidence offered by the bone surfaces, which is reported in the present study, should contribute to an understanding of the taphonomic agencies that affected the preservation of the hominid skeletal remains at this important Italian late Middle Pleistocene archaeological site.

Methods

The Castel di Guido fossil hominid bones were examined macroscopically under a strong light. Break surfaces were analysed for differences in colour, matrix cover, and texture compared to the rest of the bone. Breaks were scored as ancient when matching the rest of the specimen, if not, modern, while breaks that remained ambiguous were scored as indeterminate (White, 1992; Degusta, 1999). Weathering was scored according to Behrensmeyer (1978). Surface abrasion was graded according to Shipman (1981). To document surface detail, the seven cranial and postcranial hominid specimens were examined under incident optic fibre light at magnifications ranging from $\times 3$ to $\times 21$, using a stereoscopic light microscope equipped with a videocamera. To compare the exocranic and endocranic surfaces, each of the five hominid skull

fragments (i.e., CdG-3, CdG-4, CdG-5, CdG-6 and CdG-7) was positioned in a sand-filled box, in such a way as to expose the outer and then the inner cortical tables. The box was overlaid with a 1.0 cm² copper wire grid. Each bone-containing square of the grid was numbered and photographed at the same microscopic magnification. Photographs were used to reconstruct a composed magnified image of the bone surfaces. Using a code of colours and referring to the magnified photographic map for orientation, well-defined ancient surface incisions and tooth marks were reported on schematic drawings of the surfaces of each specimen. The drawings in turn were used to trace the position of the ancient surface marks on plaster casts of the Castel di Guido hominid bones, using the same code of colours. Shallow, thin striations, attributable to friction in sandy sediment (Haynes, 1991; Giacobini, 1995), and scratches lacking the surface patina of ancient marks (Potts & Shipman, 1981; Shipman, 1981), probably produced with metal tools during agricultural works, excavation, preparation, or casting, were not recorded graphically on the casts. The Castel di Guido skull fragments were also analysed using a scanning electron microscope. High-resolution replicas were made using silicon materials (XANTOPREN VL plus, Bayer). Positive replicas were then made using an epoxy resin (Nural-23). These replicas were coated with 200 Å of gold-palladium and analysed using a Philips 515 scanning electron microscope at a standard acceleration voltage of 150 kV.

Results

The Castel di Guido hominid bones, shown in Figures 1–3, are highly fossilized, tan to whitish in colour, with localized black manganese oxides staining, and do not show evidence of weathering beyond Behrensmeyer's stage 1 (Behrensmeyer, 1978). The posterior–inferior fragment of right parietal

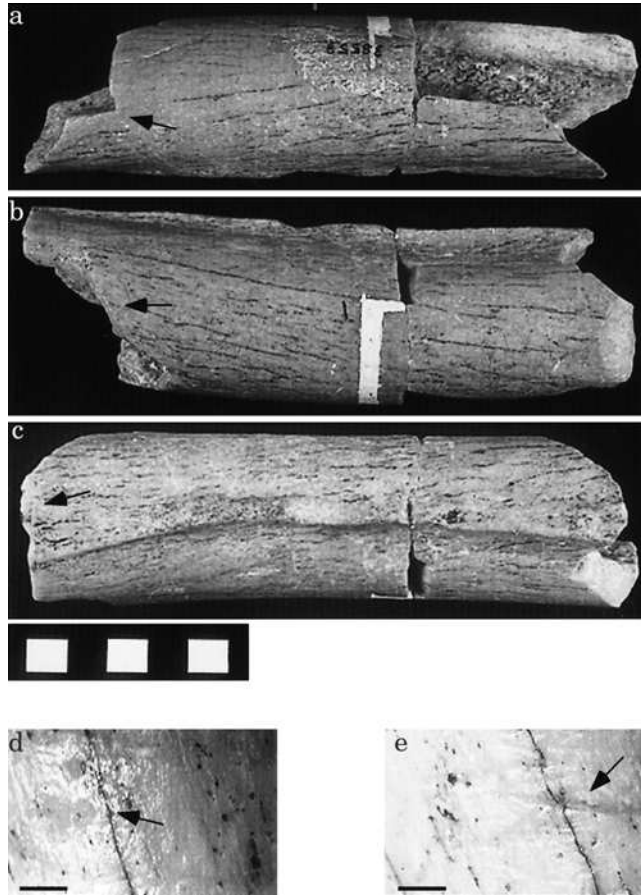


Figure 1. Views of the CdG-1 right femoral shaft fragment [(a)–(c) squares: 1 cm; D–E, bars: 1 mm]. (a) Medial view. (b) Lateral view (the area restored with plaster was originally removed for microscopic studies). (c) Posterior view. The arrows point to the distal, ancient notched break. (d) Detail of the CdG-1 bone surface, showing two superficial tooth punctures (arrow), attributable to a small carnivore. (e) Incision (arrow) on the medial aspect of the CdG-1 bone surface.

CdG-5 (Figure 3) is unweathered: its exocranic surface is finely pitted by minute vascular foramina, while the endocranic surface displays previously described well-preserved depressions and reliefs, corresponding to the convolitional pattern of the brain, and vascular furrows for the posterior ramification of the middle meningeal artery (Mallegni *et al.*, 1983). The fragment of right femoral shaft CdG-1 [Figure 1(a)–(c)], the fragmentary right maxilla CdG-4 (Figure 3), the right temporal CdG-6 (Figure 3) and the left parietal vault

fragment CdG-7 (Figure 3) show focal whitish areas of superficial etching, probably reflecting chemical erosion from the sediment or from plant roots (Shipman, 1981; Giacobini, 1995), their bone surfaces being otherwise relatively well preserved. The femoral shaft fragment CdG-2 (Figure 2) and the occipital fragment CdG-3 (Figure 3) respectively show severe and moderate surface abrasion. In particular, the outer bone surface of CdG-2 has been entirely lost, exposing the underlying vascular channels, which results in a

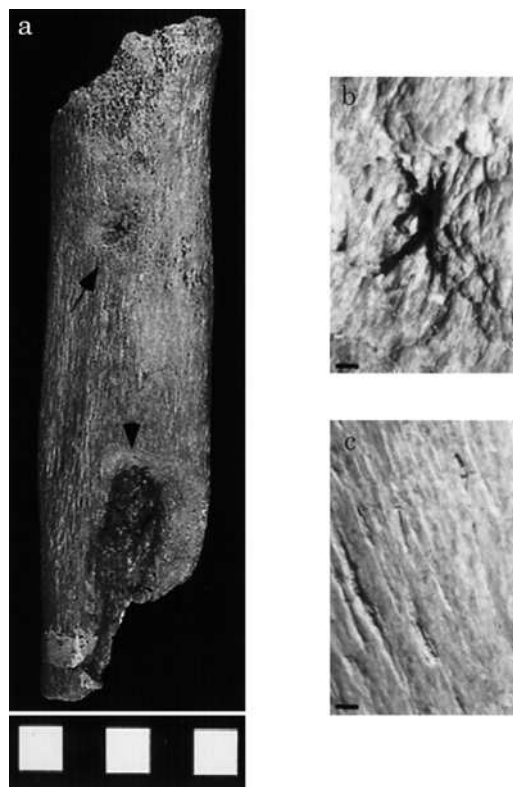


Figure 2. (a) Posterior view of the CdG-2 left femoral shaft fragment [(a) squares: 1 cm; (b), (c) bars: 1 mm]. The arrow points to a roughly circular tooth puncture on the upper posterior surface of the bone fragment, attributable to a medium to large size carnivore. The arrow-head points to the distal ancient helical break. (b) Detail of the tooth puncture on the upper posterior surface of CdG-2, showing a fragment of bone cortex crushed inwards. (c) Detail of the CdG-2 surface, showing longitudinal grooves due to the exposure of vascular channels, following the abrasion of the outer cortical bone.

longitudinally striated, roughly textured surface (Figure 2). Table 1 summarizes the weathering stages and the categories of abrasion of the Castel di Guido hominid bone fragments.

The cranial fragments CdG-5, CdG-6, and CdG-7 were separately recovered in the tuffaceous sands overlying the paleosurface, and the break surfaces of these bones are ancient, as shown by the absence of

differences in colour, matrix cover, and texture compared to the endocranic and exocranic surfaces. CdG-5 and CdG-6 can be joined toward the mastoid angle and appear to derive from a single calvarium (Mallegni & Radmilli, 1988). The analysis of the break surfaces of the CdG-1 and CdG-2 femoral fragments, both collected loose on the soil, indicates that for these specimens also some fragmentation occurred before fossilization. The proximal linear break of CdG-1 is recent and most probably related to damage following agricultural works, while the distal notched break, in the area where the shaft is beginning to expand for the condyls, appears to be ancient [Figure 1(a)–(c)]. With regard to CdG-2 [Figure 2(a)], the proximal break at the anatomical neck appears to be recent, while the distal break, at about midshaft, can be classified as ancient, based on a helical break front, characteristic of spirally broken fresh bone (Shipman, 1981; Haynes, 1991), and on the presence of a thin matrix cover. The occipital fragment CdG-3 and the portion of right maxilla CdG-4 were also surface finds and may have been exposed for a length of time to the elements and to damage following agricultural works. The original upper break margin of CdG-3 was sawn off for microscopic studies at the time of discovery, while the antiquity of the remaining break surfaces, although weathered, cannot be determined. This is also the case for the break surfaces of CdG-4. With regard to the teeth, the incisors and 16 appear to have been lost with their roots *post mortem* before fossilization, while the canine and premolar roots are *in situ* and their break surfaces appear to be recent.

By optical and scanning electron microscopy several ancient marks are readily detectable on the surface of the Castel di Guido hominid bones (Figures 4 and 5). These ancient surface marks include: (1) tooth marks; (2) thin, superficial striations, and (3) deeper, wider incisions, often with a

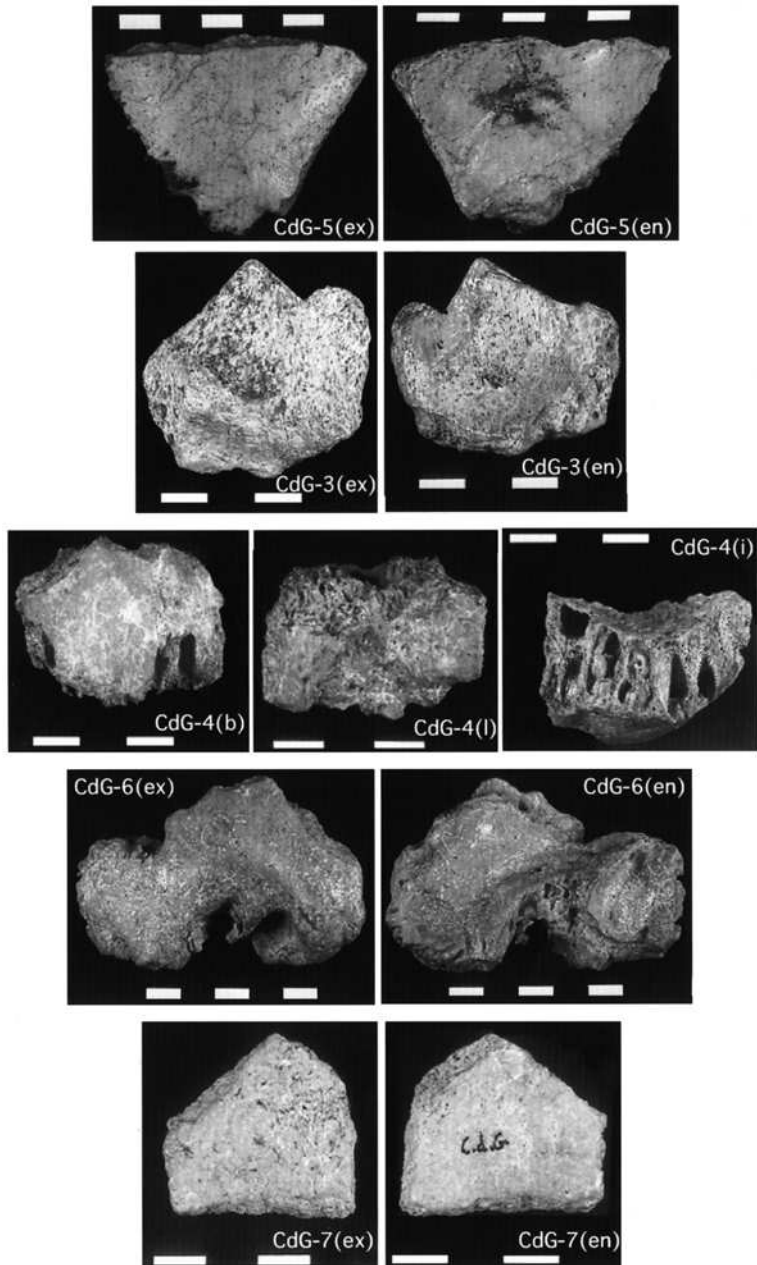


Figure 3. Views of the Castel di Guido hominid skull fragments CdG-5 (right parietal fragment), CdG-3 (occipital fragment), CdG-4 (right maxillary fragment), CdG-6 (right temporal) and CdG-7 (left parietal vault fragment). Squares: 1 cm; views: (ex), exocranic; (en), endocranic; (b) buccal; (l), lingual; (i), inferior.

Table 1 Weathering stages (Behrensmeyer, 1978) and categories of abrasion (Shipman, 1981) observed on the Castel di Guido hominid bones

CdG hominid no.	Weathering	Abrasion
CdG-1	Stage 1	None or little
CdG-2	Stage 1	Heavy
CdG-3	Stage 1	Moderate
CdG-4	Stage 1	None or little
CdG-5	None	None or little
CdG-6	Stage 1	None or little
CdG-7	Stage 1	Moderate

V-shaped cross-section. These ancient marks are readily distinguishable from sharply incised recent scratches [Figure 4(g)] probably accidentally produced with metal tools, which are occasionally present and clearly lack the surface patina of ancient marks (Potts & Shipman, 1981; Blumenschine *et al.*, 1996).

The tooth marks are represented by isolated grooves with U-shaped cross-sections, probably due to the canine teeth of small carnivores [Figure 4(a) and Figure 5(a)], by adjacent shallow grooves with flat bottoms, consistent with the marks left by the incisors of small rodents [Figure 4(b)], and by roughly circular, superficial or deep cortical indentations [Figure 1(d) and Figure 2(b)], consistent with punctures left by tooth cusps of carnivores (Potts and Shipman, 1981; Shipman, 1981; White, 1992; Giacobini, 1995; Blumenschine *et al.*, 1996; Fernández-Jalvo *et al.*, 1999). Overall, most of the tooth marks measure less than 5 mm in width, and are in the size range of those left by modern small carnivores, such as foxes, or by modern small rodents, such as mice or voles. The only surface mark preserved on the CdG-2 femoral shaft fragment is a roughly circular hole on the upper posterior surface, measuring 1.4 cm × 1.0 cm in maximal diameters and revealing a fragment of cortical bone crushed inwards. This hole appears to represent a tooth puncture attributable to a wolf- to

hyena-sized carnivore (Potts & Shipman, 1981; Shipman, 1981).

The superficial striations, which are particularly widespread on the exocranic and endocranic surfaces of the occipital fragment CdG-3, measure on average 15–30 µm in width by hundred(s) of micrometres in length and are characterized by a flat bottom, with internal parallel microstriations, resulting in a “railway track” appearance [Figure 5(a), (b)]. These striations are clearly identifiable as marks produced by trampling in sediment containing volcanic phenocrysts (Behrensmayer *et al.*, 1986; Olsen & Shipman, 1988; Haynes, 1991; White, 1992; Giacobini, 1995).

The well defined incisions measure 0.1–0.4 mm in width by centimetres or fractions of centimetres in length and often show V-shaped cross-sections and internal striations [Figure 1(e), Figure 4(c)–(f), and Figure 5(c)–(f)]. Some incisions are relatively wide and short [Figure 5(c), (d)]. In most cases, the incisions are not isolated, but rather arranged in clusters, concentrated on specific regions of bone surface and more evident on the bones showing better surface preservation, such as CdG-5 and CdG-6, while no incisions are detectable on the severely abraded CdG-2 femoral shaft. Overall, these marks resemble stone tool induced scraping marks and cutmarks (Bunn, 1981; Potts & Shipman, 1981; Olsen & Shipman, 1988; White, 1992; Giacobini, 1995; Blumenschine *et al.*, 1996; Degusta, 1999; Fernández-Jalvo *et al.*, 1999).

In some cases, trampling marks may mimic tool-induced marks (Behrensmayer *et al.*, 1986; Olsen & Shipman, 1988; Haynes, 1991). The distribution of the surface incisions and of the tooth marks may yield further clues regarding the taphonomic agencies that affected the preservation of the Castel di Guido hominid remains (Blumenschine *et al.*, 1996). Incisions and tooth marks, often superimposed, are

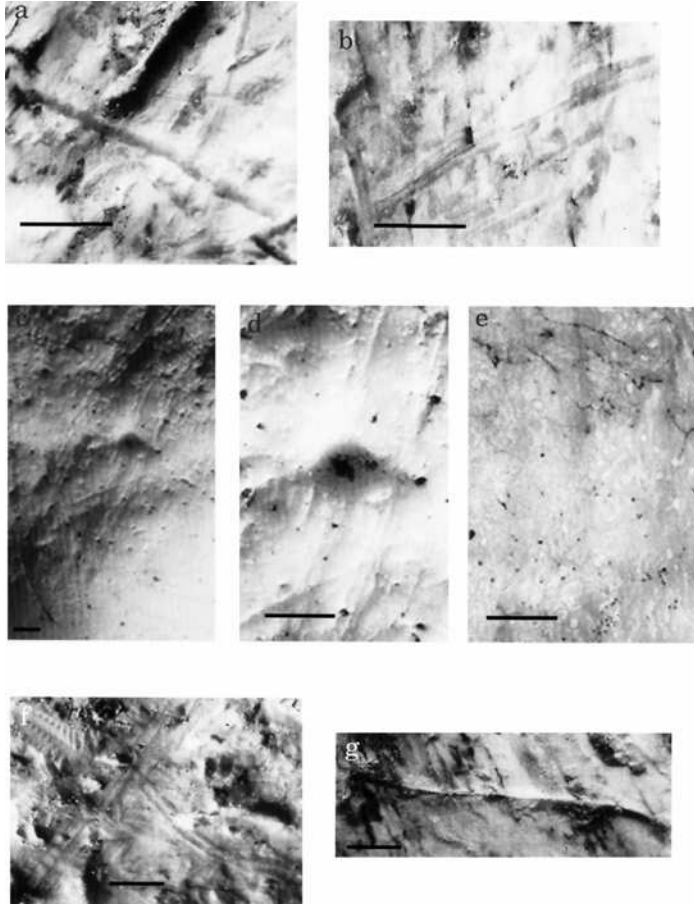


Figure 4. (a) Scratch with U-shaped cross-section on the endocranic surface of the CdG-3 occipital fragment, attributable to a tooth of small carnivore. (b) Gnawing marks on the endocranic surface of CdG-3, attributable to the incisors of a small rodent. (c), (d) Details of clusters of parallel incisions on the exocranic surface of the CdG-5 right parietal fragment. (e) View of the endocranic surface of CdG-5, which does not show surface modifications. (f) Clusters of parallel incisions on the endocranic surface of CdG-3. (g) Recent scratch, probably determined by a metal tool, on the CdG-3 exocranic surface [(a)–(g) bars: 0.5 mm].

evident throughout the cortical surface of the CdG-1 femoral shaft fragment [Figure 1(d), (e)]. Figure 6 shows casts of the Castel di Guido hominid skull fragments, reporting the localization of the incisions (outlined in red) and of the tooth marks (outlined in blue). Incisions running in parallel, antero-posterior orientation are present on the exocranic, but not on the endocranic, surface of the right parietal fragment CdG-5. A few carnivore tooth marks are found on both

the exocranic and the endocranic surface of CdG-5 (Figure 6). Notwithstanding the surface erosion, incisions and tooth marks are detectable on the spared exocranic and the endocranic surface of the CdG-3 occipital fragment. The incisions are concentrated above and at the level of the occipital protuberance on the exocranic surface and toward the base of the right cerebral fossa and the groove for the transverse sinus on the endocranic surface.

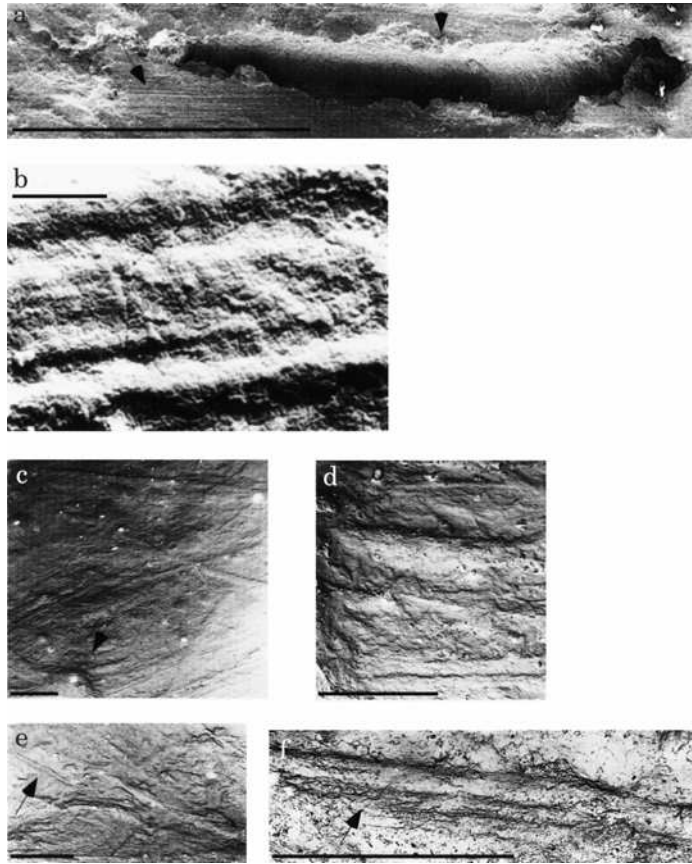


Figure 5. Scanning electron microscopic views of surface marks on the Castel di Guido hominid bones. (a) Exocranic surface of the CdG-3 occipital fragment. The arrow points to a tooth scratch, attributable to a small carnivore, the arrow-heads to widespread, thin superficial striations (bar: 250 μ m). (b) Detail of a superficial striation with flat cross-section and internal "railway track" microstriations, from the surface of CdG-3 (bar: 10 μ m). (c)–(f) Clusters of incisions on the exocranic surface of the CdG-6 right temporal. The arrows on (c) and (e) point to details, respectively shown at higher magnification in (d) and (f). Bars: (c) 1 mm; (d) 250 μ m; (e) 1 mm; (f) 1 mm.

Various tooth marks are also found in these areas (Figure 6). A few incisions, running parallel to the plane of the alveolar process, and a tooth mark crossing their tracks, are detectable above the 11 alveolus on the buccal surface of the CdG-4 right maxillary fragment. Only carnivore tooth marks are visible on the CdG-4 lingual surface (Figure 6). Clusters of incisions with variable orientations, concentrated in areas above the glenoid fossa and the auditory process, are also present on the exocranic, but not on the endocranic, surface of the

CdG-6 right temporal. No carnivore tooth marks are detected on CdG-6 (Figure 6). Incisions, running in roughly parallel antero-posterior orientation, are also detectable on the exocranic, but not on the endocranic, surface of the CdG-7 parietal vault fragment. Carnivore tooth marks, in various orientations, occur on both the exocranic and endocranic surfaces of the bone fragment (Figure 6). In conclusion, with the exception of the CdG-3 occipital fragment, the incisions found on the Castel di Guido hominid cranial fragments appear

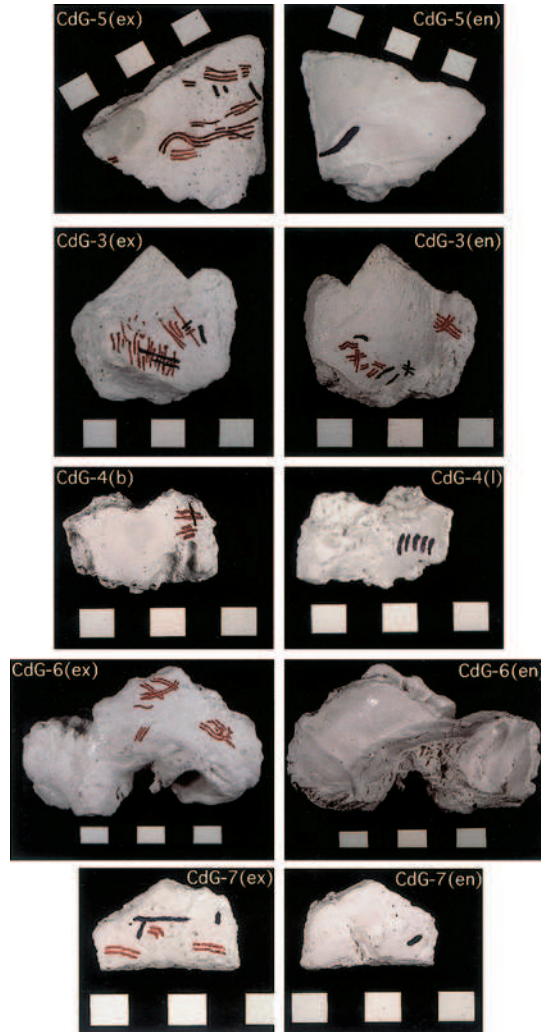


Figure 6. Views of casts of the Castel di Guido hominid skull fragments, reporting the prevalent positions and orientations of the tooth marks (blue) and of the ancient incisions (red), excluding superficial striations. Squares: 1 cm; views: (ex), exocranic; (en), endocranic; (b), buccal; (l), lingual.

to be selectively distributed on the outer relative to the inner bone surfaces. This indicates that most of the incisions were produced prior to breakage of the calvarium or calvaria.

Discussion

Excavations conducted at the late Middle Pleistocene Italian site of Castel di Guido

led to the discovery of a paleosurface showing abundant evidence of hominid activities (Radmilli & Boschian, 1996b). This paleosurface, which rested on a paleochannel, was sealed under tuffaceous sands, most probably deposited after an overflow of the ancient water basin (Pitti & Radmilli, 1982; Radmilli & Boschian, 1996b). Castel di Guido yielded seven fragmentary hominid bones, representing at least two

adult individuals, associated with a variety of implements and with fossil fauna (Mallegni *et al.*, 1983; Mallegni & Radmilli, 1988; Radmilli & Boschian, 1996c). Four of the fossil hominid bone fragments (i.e., CdG-1, CdG-2, CdG-3 and CdG-4) were collected loose on the agricultural soil, where ploughing had deeply incised the tuffaceous sands, exposing the paleosurface (Radmilli *et al.*, 1980). The other hominid bone fragments (i.e., CdG-5, CdG-6 and CdG-7) were found within the tuffaceous sands removed to expose the paleosurface, but their precise position could not be recorded at the time of the excavations (Radmilli & Boschian, 1996b,c). Thus, the taphonomic interpretation of the Castel di Guido hominid bones is hampered by the lack of spatial distribution data, critical to the assessment of paleoenvironmental events (Villa *et al.*, 1986; Defleur *et al.*, 1999). However, based on the overall geoarchaeological framework, the fossil bones found loose on the Castel di Guido agricultural surface could have derived only from the paleosurface or from the overlying tuffaceous sands, while the bones found within the tuffaceous sands appear to have been originally transported for only a short distance by the volcanic mud, and thus might have been eroded from the paleosurface itself, or from a nearby land surface (Radmilli & Boschian, 1996b,c).

Predepositional modifications of fossil bone surfaces may reflect several agencies, including weathering, abrasion by windborne or waterborne sedimentary particles, gnawing or chewing by a variety of bone-eating mammals, trampling, and hominid activities (Potts & Shipman, 1981; Shipman, 1981; Behrensmeyer *et al.*, 1986; Olsen & Shipman, 1988; Haynes, 1991; Giacobini, 1995). The absence of significant weathering suggests that the Castel di Guido hominid bones were not exposed to wet-dry cycles and to strong sunlight (Behrensmeyer, 1978; Shipman, 1981). However, the presence of cortical abrasion,

evident on CdG-2, CdG-3, and CdG-7, suggests that at least these hominid bones were exposed to windborne or waterborne erosion (Shipman, 1981).

Overall, the pattern of bone fragmentation of the Castel di Guido hominid assemblage could be consistent with a variety of pre-depositional damaging agents, including trampling, intentional fracturing by humans, and intervention of carnivores (Haynes, 1991). Even in the case of the hominid bones collected loose on the agricultural surface, ancient break surfaces indicate that much breakage occurred before deposition in the sediment. The temporal CdG-6 and the parietal fragment CdG-5, most probably belonging to the same calvarium, were separately found within the tuffaceous sands, which points to a high degree of predepositional fragmentation of at least one hominid skull. However, the CdG-1 and CdG-2 femoral shafts do not show longitudinal breaks, typical of long bones processed by hominids for marrow extraction (Villa *et al.*, 1986; White, 1992; Turner, 1993; Defleur *et al.*, 1999; Degusta, 1999).

The geoarchaeological evidence indicates that at the Castel di Guido site animal carcasses and bone scatters, mostly related to butchering activities, were left on a sandy surface, probably adjacent to a small lacustrine basin (Radmilli & Boschian, 1996b,c). The proximity of water and the bone scatters should have attracted a variety of mammals, including large herbivores and carnivores, potential agents of bone breakage and of trampling damage (Haynes, 1991). Modern bones trampled in sandy sediments show striations that correspond in size and morphology to the thin, superficial striations with internal, parallel micro-striations present on the Castel di Guido hominid bones (Haynes, 1991; Giacobini, 1995). The presence of tooth marks due to carnivores and small rodents also points to non-human agents of damage and indicates that the hominid skeletal remains were

available to scavengers before deposition in the sediment (Shipman, 1981). The majority of the tooth marks detected on the Castel di Guido hominid bone assemblage are in the size range of those left by fox-sized carnivores and by small rodents (Blumenschine *et al.*, 1996; Díez *et al.*, 1999). However, the intervention of a medium to large size carnivore is attested by a tooth puncture on the CdG-2 femoral fragment. Several carnivores, potentially capable of breaking hominid bones, are recorded at Castel di Guido (Sala & Barbi, 1996; Mallegni *et al.*, 1983).

In addition to the shallow, thin striations, clearly attributable to trampling, the Castel di Guido fossil hominid bones, except the severely abraded CdG-2 femoral fragment, present wider, deeper incisions, often with V-shaped cross-sections. These incisions, more evident on the cranial bone fragments showing better surface preservation, tend to be concentrated in clusters on the exocranic rather than on the endocranic surface, and are localized in regions serving for the attachment of muscles and ligaments, most notably including the temporal and the parietal in the area covered by the temporalis muscle. This pattern of distribution indicates that most incisions were produced before breakage of the calvarium, and might suggest that these incisions could represent hominid-induced modifications, resulting from manipulations having as objective the removal of soft tissues. Morphologically, the incisions resemble scraping marks, that manifest as parallel scratches on relatively broad areas of bone surface, and cutmarks, particularly those obtained with limestone tools, that often result in closely associated incisions, reflecting difficulties experienced in cutting (Bunn, 1981; Potts & Shipman, 1981; Olsen & Shipman, 1988; White, 1992; Giacobini, 1995; Degusta, 1999; Fernández-Jalvo *et al.*, 1999). This is relevant to the case of the Castel di Guido site, where implements were made of a wide

variety of materials, including limestone and other soft stones (Radmilli & Boschian, 1996*c,d*). However, as demonstrated by the analysis of modern bone assemblages, trampled skeletal elements may also show sharply incised linear striations, that closely mimic hominid-induced cut marks (Behrensmaier *et al.*, 1986; Haynes, 1991). Therefore, it cannot be entirely excluded that the incisions on the Castel di Guido hominid bones might have resulted from frictions or impacts of hominid skeletal elements, including unbroken hominid skull(s), against abrasive sediment, possibly in connection with the activities of scavengers.

Recently, well-documented proofs of human cannibalism, provided by archaeological sites of various ages in North America, Europe, Africa, and the Pacific region, sparked off a renewed interest in the taphonomy of fossil hominid remains (Villa *et al.*, 1986; Phillips, 1987; White, 1987, 1992; Defleur *et al.*, 1993, 1999; Turner, 1993; Fernández-Jalvo *et al.*, 1996, 1999; Gibbons, 1997; Culotta, 1999; Degusta, 1999). The taphonomic analysis of bone assemblages from different sites and different periods may, in perspective, clarify the controversial questions concerning the nature of the agents responsible for fragmentation and surface modification of fossil hominid skeletal remains. In Europe, heavy fragmentation of the skulls and sets of incisions on cranial and facial bones overlaid by musculature are documented for the cannibalized human bone assemblages from the Lower Pleistocene site of Gran Dolina in the Sierra de Atapuerca, from the Neanderthal site of Baume Moula-Guercy and from the Neolithic site of Fontbrégoua Cave (Villa *et al.*, 1986; Defleur *et al.*, 1993, 1999; Fernández-Jalvo *et al.*, 1996, 1999). At the Italian late Middle Pleistocene hunting site of Castel di Guido, fossil hominid bones were fragmented before deposition in the sediment and were exposed to scavengers

and to trampling. Although definitive conclusions cannot be reached on the sole basis of the osteological evidence, it is possible that the skull fragmentation and the surface incisions on the Castel di Guido fossil hominid bones might reflect deliberate human manipulations.

Acknowledgements

This study was supported by the *Consiglio Nazionale delle Ricerche*, Finalized Project *Beni Culturali-Archivio Biologico*, contract #96.01152.PF36, and by the *Soprintendenza Archeologica dell'Abruzzo*. The article is dedicated to the memory of Ernesto Tarquinio Longo, Attilio Barbattini, and Antonio Mario Radmilli, who contributed to the investigation of the Pleistocene fossil-bearing deposits along the Aurelian Way in the years from 1970 to 1981. RMC wishes to thank Aldo G. Segre and Eugenia Segre-Naldini, of the Italian Institute of Human Palaeontology, Piazza Mincio 28, 00198 Rome, for their helpful and friendly comments on the dating of the Castel di Guido site.

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