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Published in:
American Journal of Physical Anthropology

DOI:
10.1002/ajpa.20954

IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

Document Version
Publisher's PDF, also known as Version of record

Publication date:
2009

Link to publication in University of Groningen/UMCG research database

Citation for published version (APA):
Semal, P., Rougier, H., Crevecoeur, I., Jungels, C., Flas, D., Hauzeur, A., Maureille, B., Germonpre, M., Bocherens, H., Pirson, S., Cammaert, L., De Clerck, N., Hambucken, A., Higham, T., Toussaint, M., & van der Plicht, J. (2009). New Data on the Late Neandertals: Direct Dating of the Belgian Spy Fossils. *American Journal of Physical Anthropology*, *138*(4), 421-428. https://doi.org/10.1002/ajpa.20954

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New Data on the Late Neandertals: Direct Dating of the Belgian Spy Fossils

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KEY WORDS northwest Europe; Middle to Upper Paleolithic transition; acculturation

ABSTRACT In Eurasia, the period between 40,000 and 30,000 BP saw the replacement of Neandertals by anatomically modern humans (AMH) during and after the Middle to Upper Paleolithic transition. The human fossil record for this period is very poorly defined with no overlap between Neandertals and AMH on the basis of direct dates. Four new ^{14}C dates were obtained on the two adult Neandertals from Spy (Belgium). The results show that Neandertals survived to at least ≈36,000 BP in Belgium and that the Spy fossils may be associated to the Lincombian–Ranisian–Jerzmanowician, a transitional techno-complex defined in northwest Europe and recognized in the Spy collections. The new data suggest that hypotheses other than Neandertal acculturation by AMH may be considered in this part of Europe. Am J Phys Anthropol 138:421–428, 2009. ©2008 Wiley-Liss, Inc.

The replacement of Neandertals by anatomically modern humans (AMH) in Eurasia is one of the major issues in paleoanthropology (Gravina et al., 2005; Orlando et al., 2006; Trinkaus, 2007). This population process corresponds to the period between 40,000 and 30,000 ^{14}C BP, during which the transition from the Middle to Upper Paleolithic took place. Different scenarios have been proposed for explaining these two major events, from a certain degree of both biological and cultural continuity (e.g. Wolpoff et al., 1994) to complete replacement of Neandertals by modern humans together with either acculturation or independent technical evolution of the last Neandertals (Mellars et al., 2007; Zilhão et al., 2008a).

Understanding the biological and/or cultural relationships of the two groups has been limited by the dearth of well-dated and diagnostic human remains associated to a secure archeological context. Numerous Neandertal remains come from old excavations that yielded incomplete or no stratigraphic data or for which the dating and/or associated archeological context have not been revaluated by current methods. Between 40,000 and 30,000 BP, techno-complexes described as transitional have been documented across Eurasia. Identifying the manufacturers of these industries is one of the main keys for answering the question of the biocultural relationships between Neandertals and AMH. The only transitional techno-complex to which diagnostic human remains have been associated is the Châtelperronian of southwestern France and northern Spain. The Neandertal specimens discovered at Saint-Césaire and Arcy-

The first three authors contributed equally to this work.

Grant sponsor: FRS-FNRS; Grant number: 2005-2006/1.5.287; Grant sponsor: NERC; Grant number: NE/D014077/1.

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Received 23 July 2008; accepted 12 September 2008

DOI 10.1002/ajpa.20954
Published online 10 November 2008 in Wiley InterScience (www.interscience.wiley.com).

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Renne (France) suggest that at least some of the transitional industries are related to Neandertals. Bordes (2002) invalidated the Châtelperronian/Aurignacian interstratification at the two sites where it was proposed, but this matter is debated again (Mellars et al., 2007, 2008; Zilhão et al., 2008a,b).

In the northwest of Europe, the Châtelperronian is not recognized, but sites located between Wales and southern Poland have provided another transitional technocomplex, the Lincombian–Ranisian–Jerzmanowician (LRJ; Flas, 2006; Jacobi, 2007).

Neandertals from only a handful of sites have been directly dated using AMS radiocarbon techniques. Among them, those from Engis, El Sidrón, Feldhofer, Okladnikov, Spy, and Vindija may be attributed to the period under examination (Schmitz et al., 2002; Higham et al., 2006a; Rosas et al., 2006; Toussaint and Pirson, 2006; Krause et al., 2007). Besides dating methodology problems (Smith et al., 1999; Higham et al., 2006a; Rosas et al., 2006; Krause et al., 2007), inconsistencies with the archeological context (Skinner et al., 2005; Toussaint and Pirson, 2006) may also invalidate the youngest dates. Finally, the most reliable results for northwest Europe point to ≈40–39,000 BP for the youngest directly dated Neandertal remains (Schmitz et al., 2002). The oldest occurrence of European AMH (Peştera cu Oase, Romania), at ≈35,000 BP (Trinkaus et al., 2003), indicates that there is no clear overlap between Neandertals and modern humans based on the direct AMS dating of human fossils.

It is therefore essential to obtain new dates on human fossils using rigorous protocols to evaluate the various hypotheses regarding the replacement of Neandertals by AMH in Europe. In this context, we have directly dated several human bones and teeth from the Spy Cave collections hosted at the Royal Belgian Institute of Natural Sciences.

SPY CAVE

The discoveries of Spy Cave and their importance in Paleoanthropology

Spy Cave is one of the richest prehistoric sites in Belgium. The first human remains were discovered in 1885 during excavations by M. De Puydt and M. Lohest. They hired a miner, A. Orban, who dug a gallery to reach the lower levels. Orban worked by candlelight, and his finds were inventoried outside (Lohest et al., 1925). The miner was often alone in the field, and the few preserved archives mention quick excavations. The goal of De Puydt and Lohest was to prove the contemporaneity of human specimens with layers yielding remains of extinct species. In early July 1886, a statement was recorded in a hurry (because of the risk of collapse for the gallery) to testify to the discovery of *in situ* human fossils. This was presented in the first ever published monograph on Neandertal remains, and their study was entrusted to the paleontologist J. Fraipont (Fraipont and Lohest, 1887). Since then, many excavations (whether official or not) have been carried out at Spy (Rougier et al., 2004). The most extensive one, by F. Twiesselmann (Royal Belgian Institute of Natural Sciences) between 1948 and 1956, encountered only archeologically rich sediments from disturbed layers. Most of the material coming from the various excavations has been only partially studied and remains unpublished.

Reassessment of Spy Cave and its contents

The work of De Puydt and Lohest (1887) allows us to reconstruct partially the context of the human remains. The first skeleton discovered (Spy I) was quite incomplete and its position is difficult to assess, since the bones were not in anatomical connection; the second skeleton (Spy II) was also incomplete, but lying on the right side, with one hand against the mandible. A. Hrdlička, who had the opportunity to study the Spy human remains in the 1910s and 1920s, noted that "A repeated critical examination of the specimens leaves a serious doubt as to the accuracy of [Fraipont's] distribution. No photographs or sketches were made on the spot; the bones were not marked, and have evidently become mixed up, their distribution being decided upon later. The specimens indicate very strongly different relations." (Hrdlička, 1930, p 188).

Recent reassessment of all the collections from Spy has allowed us to discover numerous unpublished human remains from Neandertals and AMH mainly among the unsorted fauna (Rougier et al., 2004). The number of human remains from Spy has increased from 89 numbered bones and teeth to 1,816 (including at least 24 new Neandertal remains), representing all skeletal elements. The minimum number of individuals (MNI) is 26, the great majority of which probably derives from a collective Neolithic burial. The large number of recent remains questions the homogeneity of the original Spy collection. Beside the two Neandertal individuals recognized in 1886, only one additional immature individual had been mentioned (Twiesselmann, 1971), and Trinkaus (1978) suggested the existence of at least three adult Neandertal individuals based on the foot bones.

The morphometrical analysis of the newly recognized human remains has allowed us to compare these new specimens with the two adult Neandertals to further consider issues of attribution. The following results have emerged: 1) the original collection includes mature and juvenile anatomically modern bones; 2) the attribution of the remains to each adult Neandertal skeleton has been reassessed; 3) among the numerous human remains recognized within the faunal collections, some show characteristics that bring them closer to the range of Neandertal variability. For instance, only five of the thirteen hand bones from the original human collection can be attributed to Neandertals. IC discovered ten more Neandertal hand bones, which can be associated with the five from the original collection based on morphometry and anatomical connections. The new human remains that refit with the original collection are of particular interest, since they were discovered among unwashed fauna, which makes them available for isotopic analyses, unlike the original, consolidated, and varnished specimens.

Stratigraphical and archeological context of the Neandertal skeletons

The discoverers identified only three fauna-bearing levels. The two Neandertal individuals were found in the deepest level, above brown clay lying on the bedrock and below thin yellow clay (Fraipont and Lohest, 1887; De Puydt and Lohest, 1887). The hard reddish breccia of the intermediate fauna-bearing level lying just above the skeletons was an argument for unmixed deposits. The possibility of a burial was rejected by the discoverers but commonly inferred later (Rutot, 1909; Maureille and

Vandermeersch, 2007). Although the primary and/or intentional character of the anthropological deposit at Spy may never be proved, the coherence of the identified Neandertal hand bones gives credence to the description by the discoverers (De Puydt and Lohest, 1887) of the position of the now most complete skeleton.

A few lithic pieces were found near the human fossils. The only characteristic tool is a phtanite Mousterian point purportedly found beside Spy I, which is similar to the Mousterian points of the intermediate fauna-bearing level (Jungels et al., 2006).

The original stratigraphy was replaced by a "cultural stratigraphy" based on typology when Breuil (1912) recognized four cultural levels by dividing the Middle Paleolithic assemblage into two different Mousterian industries. He considered that the burial was associated with the upper Mousterian cultural level. This stratigraphy, with four cultural levels, has introduced an additional source of inconsistency and material mixing. Bordes (1959) recognized a Quina-type Charentian industry based on the presence of some Quina-type tools in the collections. He suggested that the human fossils may be related to this industry based only on the comparison with other Neandertal burial sites. Subsequently, Ulrix-Closset (1975) recognized three Middle Paleolithic industries at Spy: a Mousterian of Acheulian tradition, a Charentian-type industry, and a late Mousterian ("Moustérien évolué"). The last was found in the intermediate fauna-bearing level. Recent studies (Jungels, 2006; Jungels et al., 2006) have shown that a Quina-type Mousterian as defined by Bourguignon (1997) is, however, not represented at Spy. The association of the human fossils with such an industry is thus no longer tenable.

A transitional industry, the LRJ (Campbell, 1980; Flas, 2006), and an important Aurignacian industry (Otte, 1979) have also been identified in the intermediate fauna-bearing level. The LRJ is a relatively unknown and rarely discussed industry that is characterized by the presence of leaf-points ("Jerzmanowice points") made on blades using bifacial retouch. At Spy, the LRJ is represented by 22 Jerzmanowice points (of which nine are complete), as well as by two burins and one splintered piece made on Jerzmanowice point fragments, a reuse behavior commonly found in LRJ sites (Flas, 2006).

The imprecision of the field data and the mixing of material prevent us from defining precisely all of the techno-complexes present at Spy. In the same way, no reliable information is available regarding the archeological context of the human fossils.

PREVIOUS DIRECT DATING ATTEMPTS OF HUMAN REMAINS FROM THE SPY COLLECTIONS

Direct dating of a couple of human remains from the Spy collections was carried out by MT (Toussaint and Pirson, 2006) (Table 1). A first direct dating attempt was done on a sample from one of the two human scapulae housed at the University of Liège. These fragmentary scapulae, attributed to Spy II since their discovery in 1886 (Fraipont and Lohest, 1887), present a dorsal sulcus along the axillary border identified as a derived Neandertal trait relative to earlier humans (Trinkaus, 2006). Nevertheless, their presence in a minority of Gravettian humans is also attested (Trinkaus, 2007). The reassessment of the Spy collections shows that their attribution to one or the other of the adult Neandertals

TABLE 1. Direct radiocarbon ages and sample information for human remains from Spy (Belgium)

Lab number	^{14}C age (years BP)	Sample name	Sample description	Material	Sample (mg)	Collagen (mg)	Yield (%)	$\delta^{13}C$ (‰)	%C	%N	C/N
Previous dates[a]											
OxA-8912[d]	23,880 ± 240	Spy 572a	Right scapula fragment	Bone	300	25.6	8.5	−19.0	33.4	11.5	3.4
OxA-8913[g]	24,730 ± 240				300	12.3	4.1	−19.4	35.3	12.9	3.3
GrA-21546[d]	31,810 ± 250						12.4	−19.8 (−19.8)[e]	(41.5)	(14.4)	(3.4)[e]
OxA-10560 (UF)[d]	36,250 ± 500	Spy 737a	Vertebra fragment	Bone	560	24.5	4.4	−22.9[d], −18.8[f]	40.4	15.0	3.1
Neolithics[b]											
GrA-32621	4,350 ± 35	Spy 425k	Right fibula, diaphysis fragment	Bone	887	29.0	3.3	−21.4 (−21.6)	(45.2)	(16.1)	(3.3)
GrA-32628	4,800 ± 40	Spy 398l	Right third metacarpal	Bone	305	25.5	8.4	−20.5 (−21.2)	(45.9)	(16.0)	(3.3)
GrA-32632	4,835 ± 35	Spy 425n	Right proximal hallucal phalanx	Bone	304	30.0	9.9	−21.4 (−21.1)	(45.6)	(16.1)	(3.3)
OxA-20981 (UF)[g]	3,896 ± 31	Spy 7A	Left ulna, proximal fragment	Bone	537	13.5	2.5	−21.1	46.1	15.9	(3.4)
Neandertal adults[c]											
GrA-32623	35,810 + 260, −240	Spy 94a	Right M3, maxilla fragment attached	Bone	739	57.3	7.8	−19.3 (−19.4)	(43.7)	(15.2)	(3.4)
GrA-32626	36,350 + 310, −280	Spy 92b	Left I1	Dentine	176	15.9	9.0	−19.7 (−19.8)	(47.1)	(16.7)	(3.3)
GrA-32630	33,940 + 220, −210	Spy 430a	Right middle third manual phalanx	Bone	162	11.9	7.4	−20.1 (−20.3)	(46.8)	(15.8)	(3.5)
OxA-17916 (UF)	32,550 ± 400			Bone	414	10.1	2.4	−21.6	43.6	13.5	3.8

Measurements in parentheses are after Hervé Bocherens.
UF, extraction protocol using ultrafiltration; %C, percent carbon in the pretreated gelatine on combustion; C/N, atomic ratios.
[a] Previous results: dating of Paleolithic human remains.
[b] Present study: dating of human remains that were suspected Neolithic by their morphometrical study.
[c] Present study: dating of Spy I and Spy II individuals.
[d] Toussaint and Pirson, 2006.
[e] Bocherens et al., 2001.
[f] Thomas Higham, personal communication.
[g] Application of a solvent extraction prior to bone pretreatment due to suspected glue-based/resin contamination.

Fig. 1. Human remains from Spy directly dated to the Neolithic in the present study. Upper left: Spy 398l-604a and 22B (right third and second metacarpals, with Spy 604a being the distal epiphysis of MTC Spy 398l) in palmar and proximal views; upper right: Spy 425n and 25G (right and left first proximal foot phalanges) in plantar and proximal views; bottom: Spy 26A and 425k (right fibula diaphysis fragments) in anterior view. Specimens from the original collection are indicated in italics; newly discovered ones are in plain font.

Fig. 2. Neandertal remains attributed to Spy I and II and directly dated in the present study. Left: Spy 94a, an upper right third molar with a small alveolar fragment attached that refits with maxilla fragment Spy 11A; right: Spy 92b, an upper left central incisor that articulates with the lower incisors on mandible Spy 3. Font code as in Figure 1.

is ambiguous. The first date obtained on the Spy 572a scapula at the Oxford Radiocarbon Accelerator Unit (ORAU) is much younger than the one provided by the Center for Isotope Research (CIO) at the University of Groningen using a sample extracted by HB (Table 1). The pretreatment method applied in Oxford at that time was essentially the same as that used in Groningen; so, it is difficult to determine the reason for the divergent results; it may relate to differential consolidation and decontamination. The contamination of the scapula through 19th century consolidation is attested by historical sources and is further supported by the slightly older age of the second date obtained in Oxford (OxA-8913) after application of a solvent extraction prior to bone pretreatment. Subsequently, an unpublished, fragmentary human vertebra (Spy 737a), discovered on the slope below Spy Cave, was directly dated to 36,250 ± 500 ^{14}C BP (OxA-10560; Table 1; Toussaint and Pirson, 2006). Given this date, it may belong to one of the Neandertals, but it cannot be clearly associated to either of the two adult Neandertals.

NEW ^{14}C DATING RESULTS ON THE SPY COLLECTIONS

Materials and methods

Samples selection and preparation. The sampled specimens are bones and teeth that were recognized during the recent reassessment of the Spy collections. The human specimens are numbered following the new numbering system we have adopted (see Rougier et al., 2004), i.e., with "Arabic" numbers followed by a lower-case letter. The specimens housed at the University of Liège were not previously labeled, and we did it according to the new system. The human remains were scanned or microscanned (Semal et al., 2005) and molded using DC-3481 silicone elastomer before their sampling for radiocarbon dating. Pictures were taken before and after sampling.

Radiocarbon dating protocols. At the CIO, extraction of the collagen samples followed the procedure developed by Longin (1970), and the samples' chemical pretreatment used standard procedures (Mook and Streurman, 1983). Samples dated at the ORAU using ultrafiltration were prepared following the protocol described by Higham et al. (2006b).

Neolithic human material among the Spy original collection

Four human remains from the Spy collection are dated to the Neolithic (Table 1, Fig. 1). The first one, Spy 425k, is a fragment of right fibula diaphysis that matches Spy 26A from the original collection, attributed to Spy II by Hrdlička (1930). The second one, Spy 398l, is a right third metacarpal (MTC) that articulates with MTC2 Spy 22B from the 1886 collection. Spy 22B presumably belongs to a set of MTCs that Fraipont and Lohest (1887) attributed to Spy I/II. However, its distal end corresponds to a metaphyseal surface. The two MTCs thus represent an immature individual that cannot be either Spy I or Spy II, and the direct dating of Spy 398l shows that they do not represent an additional Neandertal. We also discovered among the fauna the symmetrical phalanx (Spy 425n) to the proximal hallucal phalanx Spy 25G, attributed to one of the two adult Neandertals by Twiesselmann (1971). The resultant date shows that the two pedal phalanges do not belong to Neandertals. Finally, we dated the Spy 7A left ulna fragment from the original collection, despite the risk of contamination through glue and varnish, because its morphological restudy raised doubts about its Neandertal affinities. The direct dating of Spy 7A shows that it is Neolithic. The mixture of the Neolithic bones with those of the Neandertals is most probably the result of a postexcavation mishandling of the specimens. The position of the Neolithic bones in the site is not precisely known, but the preliminary report of 1885 excavation mentioned the presence of a human bone and ceramic in the upper layer. Some other Neolithic human remains were also discovered by de Loé and Rahir in the beginning of the 20th Century (archives and inventories of the Royal Museum of Art and History).

Direct dating of the Spy adult Neandertals

Two sets of teeth represent the Spy adult Neandertals. Both individuals were directly dated in the present study, since one extra tooth belonging to each of the dental sets has been discovered among the faunal remains from the site (see Fig. 2). These two samples Spy 94a

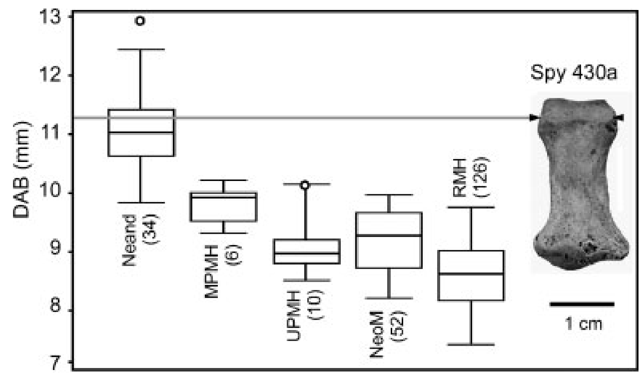

Fig. 3. Box plots of Spy 430a (a right middle third manual phalanx directly dated in the present study) and comparative sample distal articular breadth (DAB) of the pooled middle second, third, and fourth manual phalanges. Spy 430a is figured in palmar view. Comparative samples: Neandertals (Neand), Middle Paleolithic modern humans from the Near East (MPMH), Upper Paleolithic modern humans from Europe and North Africa (UPMH), Belgian Neolithic modern humans (NeoM), French Recent modern humans from the "Jacques Brel" Gallo-Roman cemetery, Charente (RMH). Box plots display the median, 25th, and 75th percentiles of each group. Numbers of individuals are indicated in parentheses.

(upper right M3 with associated dated alveolar bone) and Spy 92b (upper left I1) yielded dates that are very close to each other (Table 1), at ≈36,000 ^{14}C BP.

The last dated human specimen is a hand third middle phalanx (Spy 430a), recognized within the Spy faunal collection. In total, ten new Neandertal hand bones have been discovered. Most of them belong to the same individual, which helped in the determination of Spy 430a as a MP 3 of Spy II. Its morphometrical characteristics are fully Neandertal. The length of Neandertal phalanges is within the modern range of variation, but several authors have noted the difference in proportions between the breadth of their distal and proximal extremities and their maximal length (Musgrave, 1973; Heim, 1982; Villemeur, 1994). In absolute value, the distal articular breadth of Neandertal middle phalanges is significantly greater than modern humans, whatever is their rank. This is illustrated on Figure 3, where Spy 430a lies out of the fossil and extant modern human ranges.

Radiocarbon dates on the fauna and archeological remains from Spy

There have been twelve attempts at dating fauna remains and an archeological bone artifact from Spy. All selected bones and teeth were unconsolidated and unvarnished. Four of the obtained radiocarbon dates were rejected, since their C/N ratios were outside the accepted range of 2.9–3.5. The eight remaining radiocarbon results allow us to give chronological reference points (Table 2) for the three fauna-bearing levels identified by the discoverers (Fraipont and Lohest, 1887).

Two of the dated specimens were excavated in 1886 and their stratigraphical origin was recorded at that time (Table 2). The first one (GrA-37936) comes from the upper fauna-bearing level, and its age is 25,670 +130, −120 ^{14}C BP. Another sample from a metatarsal fragment of *Rangifer tarandus* with cutmarks and ochre traces but of unknown position gave a similar date

TABLE 2. Results of the dating of Paleolithic fauna remains and a bone artifact from Spy, Belgium

Lab number	^{14}C age (years BP)	Sample name	Sample description	Material	Taxon	Observations	Stratigraphical position	Sample (mg)	Collagen (mg)	Yield (%)	δ^{13}C (‰)	%C	%N	C/N
Archeological sample														
GrA-32619	32,830 + 200, −190	Spy SP2 Spy 1954	Flat and triangular spearpoint	Bone	–	–	–	598	57.3	9.6	−20.3 (−21.1)	(47.6)	(15.4)	(3.6)
Fauna samples														
GrA-37936	25,670 + 130, −120	Spy 16637 Ulg	P3 or P4	Dentine	*Coelodonta antiquitatis*	–	Upper level	1,517	12.1	0.8	−20.8	43.3	14.2	3.6
GrA-37931	26,390 + 140, −130	Spy 10640 Ulg	Metatarsal fragment	Bone	*Rangifer tarandus*	Cutmarks, Ochre	–	802	11.3	1.4	−21.3	39.2	14.9	3.1
GrA-37934	29,040 + 180, −160	Spy 13071 Ulg	First Phalanx	Bone	*Rangifer tarandus*	–	Intermediate level	616	16.3	2.6	−19.8	43.4	14.4	3.5
GrA-32612	34,410 + 230, −210	Spy D4 19B 121 1480	Metatarsal fragment	Bone	*Rangifer tarandus*	Ochre	–	1,300	70.2	5.5	−18.5	39.3	17.4	2.6
GrA-32615	34,640 + 240, −220	Spy D1 227 9D-E	Incisor	Dentine	*Ursus arctos*	Ochre	–	743	44.9	6.0	−18.4	40.6	14.4	3.3
GrA-32616	42,330 + 550, −450	Spy D3 19B 121 1474	Milk molar	Dentine	*Mammuthus primigenius*	–	–	9,925	315.8	3.2	−21.1	35.1	12.5	3.3
GrA-32613	44,350 + 650, −500	Spy D2 Pal Plate 4	Milk molar	Dentine	*Coelodonta antiquitatis*	–	–	3,342	137.9	4.1	−20.1	40.4	14.4	3.3

Radiocarbon ages and sample information are given. Codes as in Table 1.

(26,390 +140, −130 ^{14}C BP; GrA-37931). This corresponds to the time period of the Gravettian in Belgium (Straus et al., 2000).

The second dated faunal remain for which the stratigraphical position is known is a first phalanx of *R. tarandus* from the intermediate level. It is dated to 29,040 +180, −160 ^{14}C BP (GrA-37934). A flat and triangular spearpoint fragment (most likely split-base point) was recently identified among the fauna from the site. Such spearpoints are recognized as being markers of the Aurignacian (Otte, 1990). The direct date of the piece (32,830 +200, −190 ^{14}C BP; GrA-32619) corresponds to what we know about the appearance of the Aurignacian in the region (Flas, 2004).

Two fauna remains with ochre (GrA-32612 and GrA-32615) provided similar ages, around 34,500 ^{14}C BP. We believe that these samples may belong to the reddish breccia of the intermediate fauna-bearing level situated above the Neandertal remains.

Finally, two deciduous teeth of *Mammuthus primigenius* (GrA-32616) and *Coelodonta antiquitatis* (GrA-32613) have been dated >42,000 ^{14}C BP. They may belong to the lower fauna-bearing level described by the discoverers (Fraipont and Lohest, 1887).

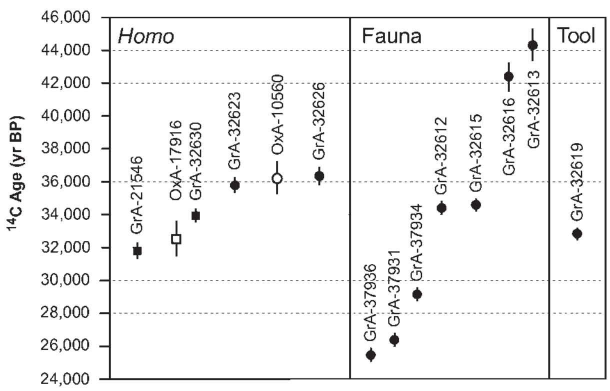

Fig. 4. Ages on Paleolithic human remains, fauna, and a bone tool from Spy Cave obtained in the present study. ^{14}C direct dates and associated 2σ ranges are represented. For sample numbering, see Tables 1 and 2. Black circles = AMS without utrafiltration, white circles = AMS with extraction protocol using ultrafiltration. Squares indicate dates for which contamination is suspected (see text).

DISCUSSION

The Neandertal collection

The dating to the Neolithic of four of the human remains from the original Spy collection has reinforced the hypothesis, raised by the morphological study, of the mixed nature of the collection. The Neandertal remains from the original collection provide a MNI of two adults: Spy I and II. New hand bones and teeth identified among the faunal collection add to the corpus of material. The direct dating of Spy I and II (GrA-32623 and GrA-32626; Table 1, Fig. 4) shows that both individuals date to ≈36,000 ^{14}C BP. These new dates fit well with the previous result on the human vertebra Spy 737a (Toussaint and Pirson, 2006; Table 1), which may belong to either Spy I or Spy II. It is important to note that these congruent results dating the Spy adult Neandertals to ≈36,000 BP were obtained in two different laboratories on bone (both with and without using ultrafiltration) or on dentine without using ultrafiltration.

The dating of the Spy 430a manual phalanx at the CIO (GrA-32630) yielded a young age outside of the 2σ range of the dates on the samples representing Spy I and II. The determination obtained by ORAU using ultrafiltration (OxA-17916) is ≈1,500 years younger than the age obtained by Groningen. The C/N ratio (3.8) is outside the accepted range of 2.9–3.5; therefore, there are grounds for considering this age to be in error. Finally, the new dates confirm that the age previously obtained for the Spy 572a scapula belonging after Fraipont and Lohest (1887) to Spy I or II is too young when compared with other dates (Toussaint and Pirson, 2006; Table 1). In this case, a contamination could be due to the consolidation of the bone in the 19th century. This is the most parsimonious interpretation, but we cannot exclude that Spy 572a belongs to a third younger adult Neandertal or even to a AMH exhibiting the dorsal sulcus pattern as do some Gravettian specimens (Trinkaus, 2007).

Our interpretation of the dating of the Spy adult Neandertals is not contradicted by the other radiocarbon dates obtained on fauna remains and a bone artifact from different levels of the stratigraphical sequence of the site (Table 2).

Chronology and cultural context

The available chronological data for the end of the Mousterian in the Mosan Basin are rare, as is the case for north-

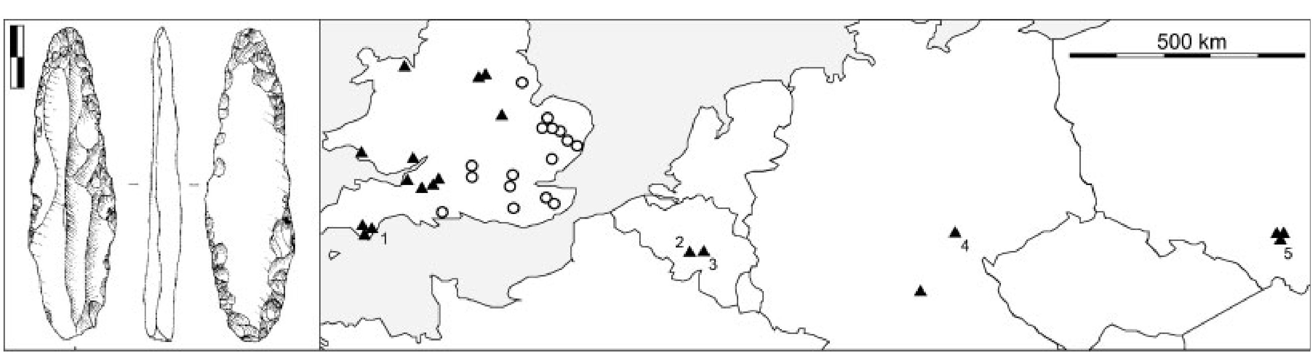

Fig. 5. Geographic distribution of LRJ sites (after Flas, 2006). Triangles = cave sites; circles = open air sites. Sites mentioned in the text: 1, Kent's Cavern; 2, Spy; 3, Goyet; 4, Ranis 2; 5, Nietoperzowa Cave. Left: Jerzmanowice point from Spy Cave (Royal Museums of Art and History collections).

ern Europe as a whole. No assemblage younger than ≈38-37,000 BP has been clearly attested so far (Vrielynk, 1999; Jacobi et al., 2006; Toussaint and Pirson, 2006), while the first traces of the Aurignacian are dated in the region at 33,000 BP (Flas, 2004; Grünberg, 2006; Jacobi, 2007). In northern Europe, the LRJ transitional complex has been recognized in more than thirty sites from Wales to southern Poland (Fig. 5; Kozlowski and Kozlowski, 1979; Campbell, 1980; Flas, 2006; Jacobi, 2007). No dating or precise stratigraphical information are available in Belgium for this techno-complex. At Ranis (Thuringia, Germany), the LRJ industry is wedged between a late Middle Paleolithic layer and an Aurignacian layer (Hülle, 1977). In the Nietoperzowa Cave sequence (Jerzmanowice, Poland), the dates of the oldest LRJ assemblage (layer 6) are ≈38,000 BP (Chmielewski, 1961). In Great Britain, the most reliable ^{14}C dates for the LRJ are ≈37–36,000 BP (Jacobi, 2007). Diagnostic artifacts belonging to this industry have been recognized in the collections from Spy Cave, one of the richest LRJ sites (Flas, 2006).

The dates obtained on the Spy Neandertals are closer to the chronological range of the LRJ (Flas, 2006; Jacobi, 2007) than to the known late Mousterian from northern Europe, even if this latter attribution might not be excluded. Because of the uncertainties surrounding their discovery and context, the hypothesis that the Neandertal remains from Spy may be associated with the LRJ assemblage is unverifiable. However, it has often been proposed that the LRJ industry was made by the last Neandertals of northern Europe on the basis of its cultural roots in the local late Middle Paleolithic (e.g. Otte, 1990). The new radiocarbon dates from the Spy Neandertal remains are in agreement with this hypothesis.

CONCLUSIONS

The debate regarding the population history of western Europe during the transition between the Middle and Upper Paleolithic is often limited to a restricted part of the territory (i.e. France and northern Spain), given the proposed association of Neandertals with the Châtelperronian. The dates obtained for the Spy Neandertals from Belgium provide an age of ≈36,000 BP. On the basis of the radiocarbon chronology, they are contemporary with the LRJ culture, the only one recognized so far in northwest Europe during this time period and represented at Spy. In this region, only the maxillary fragment Kent's Cavern 4 (southwest England) may be of a comparable age (Jacobi et al., 2006). The maxilla was referred to as an AMH (Keith, 1927), but its fragmentary state and the heavy wear of its teeth leaves doubts regarding its taxonomic attribution. Artifacts attributable to the LRJ were discovered at Kent's Cavern, but they come from a different area of the cave (Jacobi, 2007).

Taken together, the new dating results suggest that the two Spy individuals are the youngest Neandertals identified thus far in northwest Europe. They are contemporary with a transitional culture (the LRJ) present in the collections from Spy Cave, whereas the contemporaneity of two biologically distinct populations has not yet been documented in this territory (Flas, 2004; Jacobi, 2007). Moreover, the origin of the LRJ has most often been interpreted as a local evolution not linked to an acculturation process (Otte, 1990; Flas, 2006). This suggests that the biological and cultural changes that took place during the transition between the Middle and Upper Paleolithic were more complex than that previously thought. In this case, whether the LRJ is the result of an acculturation process will raise new questions. However, if such a process could be proposed for a small territory like southwest France in the 1980s, it would be more difficult to consider it for an area as large as the northern European plains, especially since no contemporaneous early Aurignacian occupation has been discovered on the LRJ distribution area (Flas, 2006). Moreover, the hypothesis of a large biological and cultural Aurignacian wave sweeping away the European Mousterian populations has been widely abandoned (Teyssandier, 2006). Different scenarios for the disappearance of the Neandertals have then to be tested and the model proposed and already debated since the end of the 1990s (D'Errico et al., 1998) for southwest France cannot be simply generalized and used for northwest Europe.

ACKNOWLEDGMENTS

We are grateful to the institutions that funded the TNT (The Neanderthal Tools, IST 6th framework), the Spy Action 1 (Research project MO/36/012, Belgian Science Policy) and MARS (IST project I2/2F/212, Belgian Science Policy) projects that gave the opportunity to perform a multidisciplinary research on the Spy Cave collections to appreciate and highlight their potential and importance. BM thanks the "*Transitions d'une société à l'autre: processus d'adaptation et de peuplements*" program (Région Aquitaine, convention 20051403003AB). We are very grateful to E. Trinkaus, the AJPA editor and two anonymous reviewers who provided helpful comments.

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