

## CHAPTER XXVIII-1

## THE SCAPULAE

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**Abstract**

*The two partial scapulae found in 1886 in the cave of Spy exhibit patterns closely corresponding to Neandertals; for instance, the dorsal sulcus pattern of the axillary border, the shape and index of the glenoid fossa and the axilloglenoid angle, as well as the distinctive horizontal scapular spine. PCA statistical analysis also groups Spy with other Neandertals, slightly out of the range of most modern humans.*

**INTRODUCTION**

Two adult partial scapulae, one left and one right (Figures 1 and 2), were found in 1886 in the cave of Spy (province of Namur, Belgium), at the occasion of the famous discovery of two incomplete Neandertal skeletons (Fraipont & Lohest, 1887). This was the second discovery of this type, the first being the fragment of right scapula, in 1856, in the Neander Valley. Later, a series of partial Neandertal adult scapulae were discovered. All of these fossils can be grouped in chronological sets, to which older hominin scapulae were added for comparison. As such, the comparative material includes seven samples: *A. afar-ensis* (n = 1), *A. africanus* (n = 2), Early Pleistocene *Homo* (n = 1), Middle Pleistocene early Neandertals (n = 17), MIS 6-5e Neandertals (n = 15), MIS 5-3 Classical Neandertals (n = 18), and MIS 3 Late Neandertals (n = 3) (see SI1 for the list of fossils included in each sample).

Neandertal scapulae have aroused interest since the beginning of the 20th century, when palaeoanthropologists suspected their invaluable potential in taxonomic information or functional interpretation. Three main variations in the shape of the scapular axillary border have been identified and one of them, the dorsal sulcus pattern, used to be seen as more frequently associated with the Neandertal morphology (Boule, 1911, 1912, 1913; Von Eickstedt, 1925;

Stewart, 1962; Trinkaus, 1977); at one time, some scholars considered it as an autapomorphic feature of this taxon (Stringer *et al.*, 1984) but this extreme position is not accepted anymore (Fruyer, 1992a, 1992b; Trinkaus, 2006a, 2006b). For about the last thirty years, additional scapulae have been found (Vandermeersch, 1981, 1991; Carretero *et al.*, 1997) and new studies (Smith, 1976; Heim, 1982; Trinkaus, 1983; Churchill & Trinkaus, 1990; Busby, 2006; Odwak, 2006; Trinkaus, 2006a) have expanded the understanding of axillary borders of fossil remains in relation to their variability, anatomical significance and physiological interpretation.

The relative narrowness of the glenoid fossa in Neandertal scapulae, usually expressed as a glenoid index, has been noted for a long time (Vallois, 1928, 1929, 1932, 1946). Churchill & Trinkaus (1990) stated that it was mainly the variation in glenoid fossa breadth that was responsible for the variation in indices; these authors also proposed a functional interpretation of it, based on the degrees of loading in medial and lateral hyperrotation of the glenohumeral articulation.

The two scapulae from Spy were paid scant regard in all these discussions (see SI2 for a review of earlier mentions of the Spy scapulae in the literature). Moreover, the discoverers of the skeletons gave only a short description of

these bones (Fraipont & Lohest, 1887) and their superficial study 40 years later would bring no additional information (Fraipont, 1927). Afterward, no modern morphological study of these two scapulae, particularly one that would have taken into account the progress of the anatomical knowledge of fossil remains and the increase of samples available for comparisons, has been conducted, even if some morphological and quantitative data derived from them were used as part of Neandertal comparative samples (e.g. Heim,

1982; Churchill & Trinkaus, 1990; Voisin, 2004). The present chapter aims at filling this gap. In addition to this study of the scapulae, it would have been really interesting to be able to study their relationship with the corresponding humeri and clavicles, i.e. analysing the shoulder bones as a whole. Unfortunately, the upper ends of all Spy humeri are missing; the acromial extremities of the clavicles as well as the acromial surfaces for articulations with the clavicles are also broken.

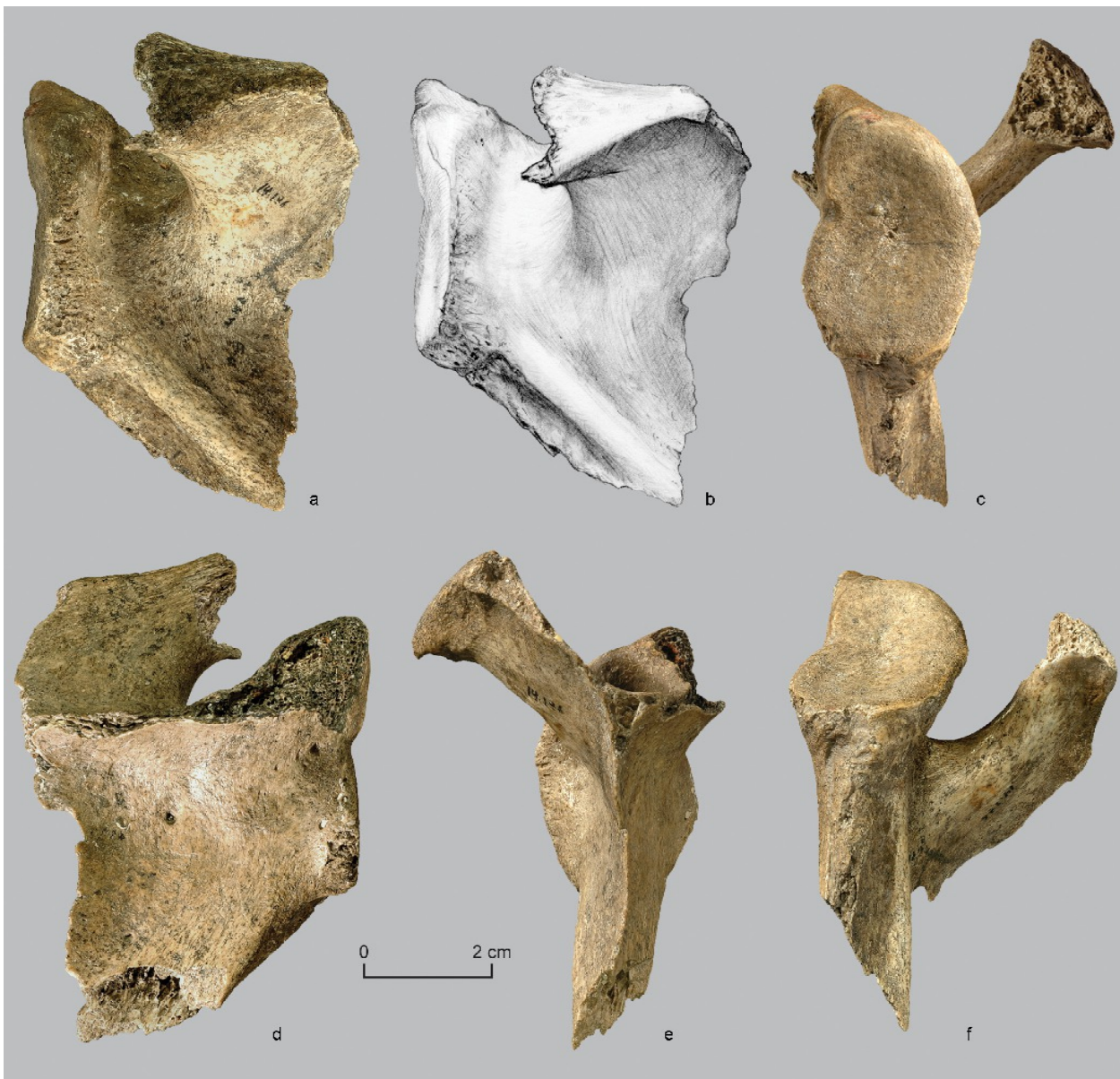


Figure 1. The Spy 573a left scapula.  
a, b: dorsal view; c: latero-cranial view; d: ventral view; e: medial view; f: lateral view.

**MATERIAL**

While the Neandertal remains from Spy are, for the main part, stored at the Section of Anthropology and Prehistory of the Royal Belgian Institute of Natural Sciences, in Brussels, both partial scapulae studied in this paper are from the collections of the *Université de Liège*, like the fragment of sacrum also dug up in 1886.

They are housed at the Department of Geology, Service of Animal and Human Palaeontology where they are both inventoried under no. 14186. Formerly however, the left fragment was listed as no. 14431 and the right as no. 14432. They are attributed numbers 573a and 572a, respectively, in the updated, comprehensive inventory of the Spy collections (Rougier *et al.*, this volume: chapter XIX).

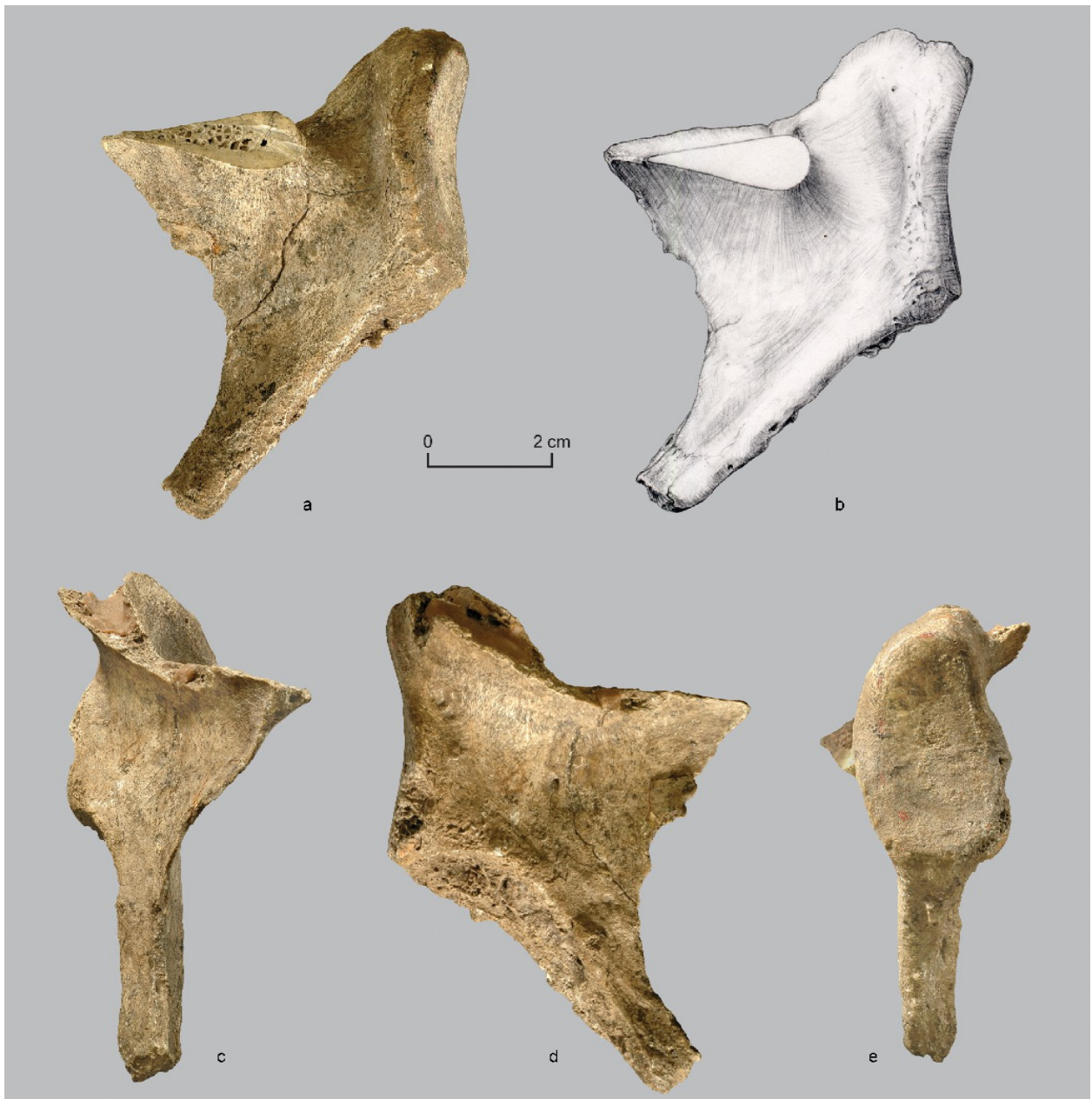


Figure 2. The Spy 572a right scapula.  
a, b: dorsal view; c: medial view; d: ventral view; e: latero-cranial view.



For comparison, a collection of modern human scapulae has been used, mainly series of Mesolithic and Neolithic bones from the Belgian Meuse River Basin as well as from the Belgian Middle Ages and some modern humans (Place Saint-Lambert, Liège). The scapula of the Neandertal type specimen, housed in the *Rheinisches Landesmuseum*, in Bonn, as well as the Krapina scapulae, kept at the Croatian Natural History Museum, Zagreb, were also studied. The other Neandertal scapulae listed in SI1 were also used as comparative material from their respective publications and from casts (Saint-Césaire 1 and nearly all glenoid fossae). A smaller subsample of Neandertal scapular specimens was used for the geometric morphometric analysis: Neandertal 1 and La Ferrassie 1 and 2. A comparative sample of modern humans (recent European- and African-Americans,  $n = 15$ ; Alaskan Inuits,  $n = 13$ ; Egyptians,  $n = 8$ ; and Holocene South Africans,  $n = 12$ ) and one Upper Palaeolithic modern human (Abri Pataud 22) was also used in the analysis. In order to exclude from the analysis the effects of sexual dimorphism in our comparative modern sample, only male specimens were used. With the exception of Spy 573a, only right-sided scapulae were used.

## METHODS

Given the degree of fragmentation of the Spy scapulae, particular attention has been given to the axillary border morphology, the glenoid fossa shape and proportions as well as the angle between the glenoid plane and the axillary border. Other small details have also been noted.

### Axillary border

The diagnostic value of the axillary border has been suggested by numerous experts (Boule, 1911, 1912, 1913; Gorjanović-Kramberger, 1914, 1926; Von Eickstedt, 1925; Vallois, 1932; Stewart, 1962; Trinkaus, 1977). Three main patterns have been identified (see SF1).

In the ventral sulcus pattern, the axillary border (*margo lateralis*) exhibits a ventrally oriented sulcus: it is the *sulcus ventro-axillaris* of Gorjanović-Kramberger (1914), the *sulcus marginis axillaris* of Krause, the *sulcus axillaris subscapularis* of Von Eickstedt (1925) or the *facies*

*ventro-axillaris* of Vallois (1932). This groove is separated from the subscapular fossa (*fossa subscapularis*) by the *crista ventro-axillaris* of Vallois, and is limited laterally by the *crista axillaris* of Gorjanović-Kramberger or the *crista medio-axillaris* of Vallois that joins the base of the infraglenoid tubercle (*tuberculum infraglenoidale*) to the *protuberantia marginis axillaris*. The sulcus enables the insertion of the most external bundles of the *M. subscapularis* which prints in the humerus a movement of internal rotation during adduction.

In the dorsal sulcus pattern, the axillary border exhibits a dorsally oriented, wide and deep sulcus, the *sulcus dorso-axillaris* of Gorjanović-Kramberger, the *facies dorso-axillaris* of Vallois (1932), or *sulcus axillaris teretis* (Von Eickstedt, 1925), which implies a powerful *M. teres minor* whose contraction would allow an ample movement of supination. The dorsal axillary ridge (*crista dorso-axillaris* of Vallois, 1932) is more distant from the *crista medio-axillaris* and more pronounced than in modern humans. The *sulcus ventro-axillaris* is not gutted as in modern humans, which suggests a reduction of the deep bundles of the *M. subscapularis*.

The bisulcate pattern, first described by Testut (1889) on the Chancelade scapula, has two sulci, or *facies axillaris bisulcata* (Von Eickstedt, 1925). Both gutters are laterally, rather than dorsally or ventro-laterally, oriented.

Successive studies, particularly those of Trinkaus, have shown that the frequency distributions of these three sulcus types in Neandertals and recent humans follow a consistent pattern (Von Eickstedt, 1925: 225; Trinkaus, 1977, 2006a; Odwak, 2006): a drastic decrease in the dorsal type and an increase in the ventral pattern from the Middle Palaeolithic to the present. As is well established (Trinkaus, 1977, 2006a, 2006b; Frayer, 1992a), all three axillary sulcus patterns are present in Neandertals, in varying percentages, with the dorsal type predominant at around 60 %, the bisulcate type common in 25-35 % and the ventral condition rare at less than 10 %. On the contrary, modern humans exhibit mainly the ventral sulcus pattern, frequently between 50 % and 75 % according to different populations, as well as up to a third of bisulcate sulci, but very infrequent dorsal sulci: around

15 % in the Early Upper Palaeolithic (Trinkaus, 2006b) and, for example, 11 % in a modern human population from Scotland (Moran & Chamberlain, 1997).

The thickness of the axillary border was also measured 25 mm below the border of the glenoid fossa, as the Spy border is broken below this point.

### Glenoid fossa

The relative narrowness of the glenoid fossa, usually seen as typical of Neandertal scapulae, is expressed as a glenoid index (breadth/height). Numerous discrepancies occur between authors in defining maximum length and breadth of the glenoid fossa, mainly due to the definition of the often rounded borders of the articular surface. In this study, glenoid fossa length (or height) is the maximum craniocaudal distance in a coronal plane between the outermost edges of the line of attachment of the glenoid labrum (similar to Churchill & Trinkaus, 1990; Carretero *et al.*, 1997). The glenoid fossa breadth was taken as the maximum dorsoventral distance between the outermost edges of the attachment for the labrum. The physiological length of the glenoid fossa (glenoid articular height), i.e. the distance between the two most laterally projecting points as stated by Churchill & Trinkaus (1990: 150), was also recorded. The glenoid fossa depth, used to estimate the degree of flattening of the glenoid fossa, was measured with the arms of the coordinate calliper placed at the most laterally projecting points along the line used in determining the glenoid articular length.

The axilloglenoid angle – or glenoaxillary angle – is defined as the angle between the length of the glenoid fossa and the long axis of the axillary border. Usually (Vallois, 1928, 1929, 1932, 1946), this angle is taken using the line connecting the inferior limit of the glenoid fossa and the inferior angle of the scapula as axillary border. As this border is usually incomplete in fossils, as it is on the Spy scapulae, the lateral edge of the preserved part of the axillary border, at 25 mm below the inferior border of the glenoid fossa, was used. The glenoaxillary bar angle of Stern & Susman (1983: 284-285) was also measured, as another variant of this measurement.

### Statistics

Bivariate biometric comparisons used the well-known technique of equiprobable ellipses (Defrise-Gussenhoven, 1955); 95 % confidence ellipses were plotted using the statistical software package PAST (v. 1.77; Hammer *et al.*, 2008).

Additionally, a two dimensional (2-D) geometric morphometric analysis of the glenoid fossa was undertaken, with the purpose of quantifying this morphology and conduct a statistical comparative analysis of its shape. The glenoid fossa shape is considered distinctive in Neandertals, but has only been described up to now with linear measurements and indices, which give only an imperfect representation of its geometric shape. The outline of the glenoid fossa was digitised in 3-D using the portable digitiser Microscribe (Immersion Corporation, 1998).

These semilandmarks were resampled to 25 equally spaced points for each individual specimen. The 3-D coordinates were then projected into two dimensions by a routine written for the SAS statistical software package, v. 8.2 (SAS Institute, 1999-2001). The 2-D outlines of the glenoid fossae were then superimposed using Generalised Procrustes Analysis, which scales the specimen configurations to unit size, translates them to common origin and rotates them according to a least squares criterion. A Fourier Elliptical Analysis (e.g. Rohlf, 1990) was conducted on the fitted outlines in NTSYSpc v. 2.2 (Applied Biostatistics Inc., 1986-2000) and 40 coefficients from the first ten harmonics were used as variables in a Principal Component Analysis.

The shape differences along the principal components axes were visualised by scaling the eigenvector according to the extreme values on the axis and adding / subtracting these values from the average coefficients. These coefficients were then used to estimate the outlines in NTSYSpc. Finally, in order to determine the effects of group membership and size on the PCA results, we conducted an ANOVA using group membership and log centroid size as independent variables. Centroid size is calculated as the square root of the sum of squared distances from each semilandmark to the centroid.

**DESCRIPTION OF THE SPY SCAPULAE**

As far as their state of preservation is concerned, both scapulae from Spy are incomplete but consist of well preserved and fossilised fragments. They belong to an adult. The left scapula (Figure 1) is just composed of the complete glenoid fossa, the upper third of the axillary border, the lateral part of the spine and the acromion, without its extremity and angle (*angulus acromialis*), as well as the upper left part of the subscapular and infraspinatus fossae. This scapula therefore lacks the superior border, the scapular notch, the coracoid process, broken just at its base (like the Neandertal 1 scapula), the tip of the acromion and most of the supraspinatus fossa. The right scapula (Figure 2) is even more damaged. It only consists of a complete glenoid fossa, upper right portions of the subscapular and infraspinatus fossae, a part of the base of the spine and a fragment of the axillary border, i.e. the *crista dorso-axillaris*. The preserved fragment of the spine has been sawed twice, the first time during the first half of the 20th century for an analysis whose results remain unknown, the second a few years ago within the framework of biogeochemical analyses (Bocherens *et al.*, 2001) and attempts at AMS datings (Toussaint & Pirson, 2006). A fissure parallel to the axillary border runs through the infraspinous and infrascapular fossae, then turns around the glenoid basis on the spine.

The axillary border of the Spy scapulae can be observed well only on the left scapula, and only in its upper third. It is obliquely broken at 48.5 mm under the edge of the glenoid fossa on its dorsal side and at 28 mm on its ventral side, with a flake of cortical bone missing on the supero-lateral area of the subscapular fossa. A cross-section through the axillary area, at 25 mm under the glenoid fossa (Figure 3) provides good information about the structure of this region. The dorsal axillary ridge forms a massive pillar. The dorsal sulcus, or *sulcus axillaris teretis* of Von Eickstedt, is large and quite deep (7 mm x 1.2 mm). Both the dorsal axillary ridge and the dorsal sulcus are in a more dorsal position than on the scapula of the Neandertal type specimen. Clearly, Spy belongs to type A.2 of Von Eickstedt's (1925: 228) classification of axillary borders, as do e.g. the scapulae from Saint-Césaire 1 and Krapina 132, while Neandertal 1 is type A.1 (Figure 4). The infraglenoid tubercle, where the long head of the *M. triceps brachialis* attaches itself, is strongly developed – slightly more than on Neandertal 1 – as a well-delimited tuberosity (length: 9 mm) which goes down in a crest running from dorsal to ventral, then is prolonged, becoming the medioaxillary crest. In front of the glenoid tubercle and its prolonging crest, there is a proximal area for the attachment of the *M. subscapularis* similar to that, for instance, of Atapuerca – Sima de Los Huesos AT-1126 and AT-1256 (Carretero *et al.*, 1997). The

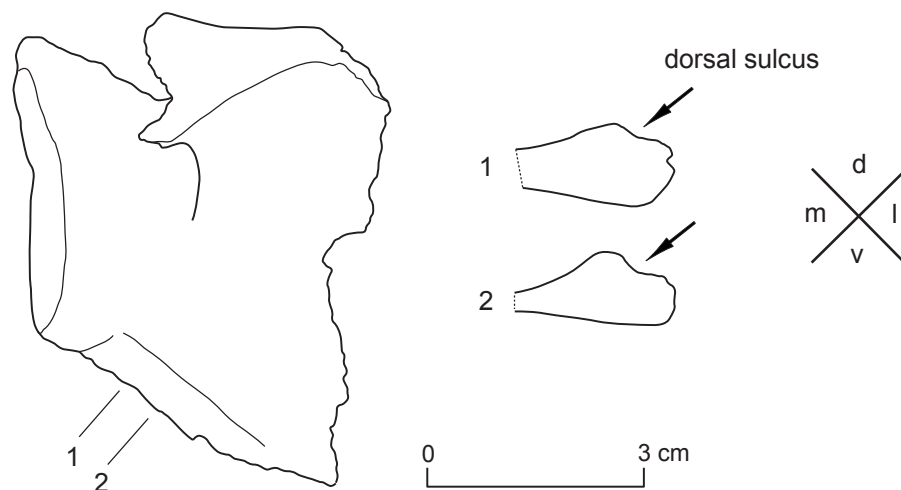


Figure 3. Horizontal cross-sections of the axillary border of the left Spy scapula at two different levels. m: medial; l: lateral; d: dorsal; v: ventral.

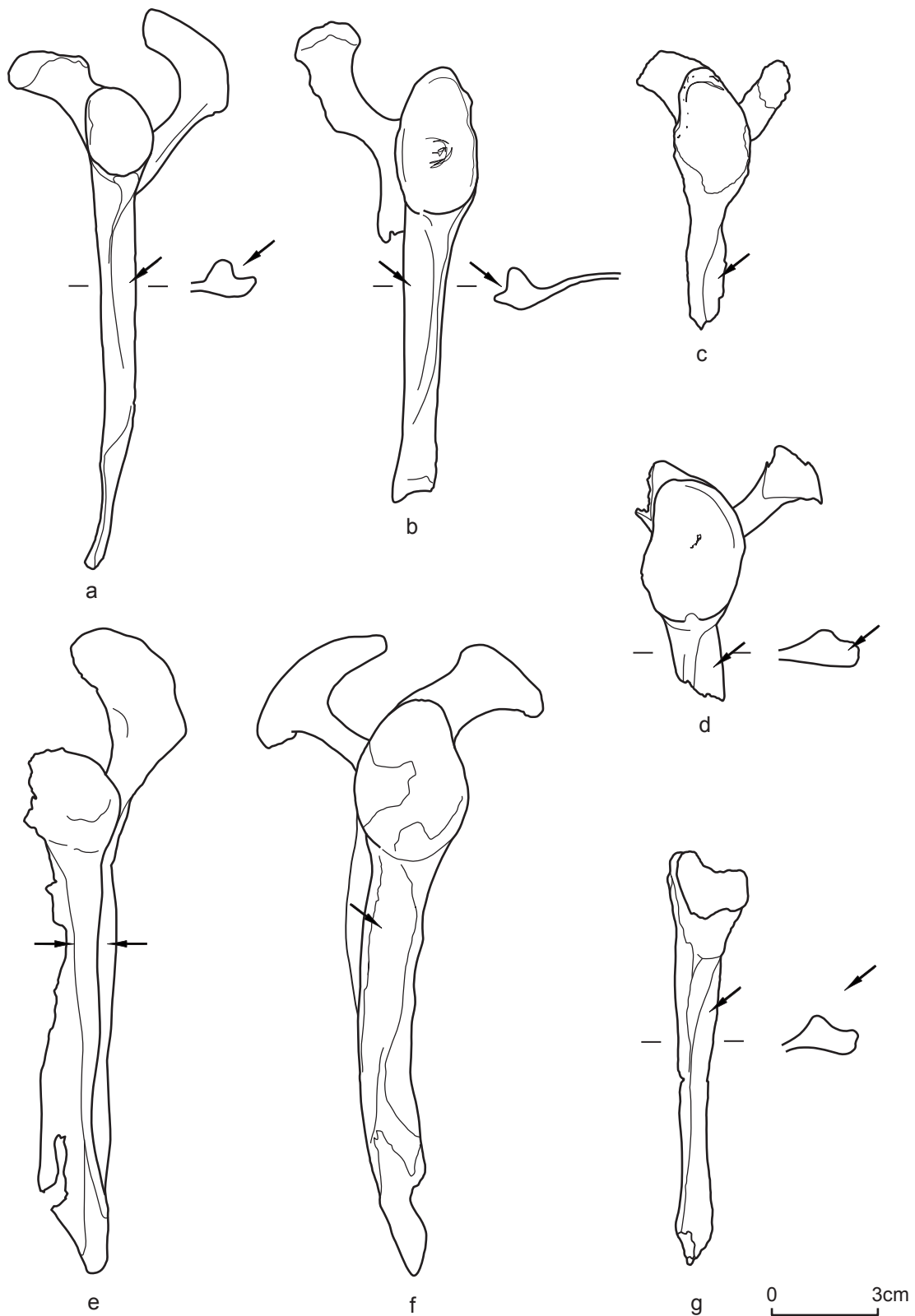


Figure 4. Spy 573a left scapula with different Neandertal scapulae. a: Tabun C1 (after McCown & Keith, 1939); b: Neandertal 1 (after Stewart, 1962 and from cast); c: Atapuerca AT-320 (after Carretero *et al.*, 1997: 362); d: Spy 573a; e: Kebara 2 (after Vandermeersch, 1991); f: La Ferrassie 1 (after Heim, 1982); g: Saint-Césaire 1 (from cast). The arrows show the dorsal sulcus except for Kebara 2 which exhibits the bisulcate pattern.

strong medioaxillary crest runs down obliquely onwards from the strongly marked infraglenoid tubercle. Twenty five millimetres under the edge of the glenoid fossa, the left axillary border is approximately 10.5 mm thick, against 13.3 mm on Neandertal 1 and around 11.0 mm in Tabun C1 as well as 14.4 mm and 16.9 mm on both Kebara 2 scapulae. Although the oblique break amputated the fossil of the other components of the axillary border, it seems clear that the left Spy scapula exhibits the dorsal sulcus pattern. Finally, the scapulae do not have any ventral bar or ventroaxillary pillar.

The anatomical structures of the right axillary border have been even more destroyed than on the left scapula, and this by a longitudinal break slightly ventrally oriented. It is however possible to distinguish a strong pillar, i.e. the *crista dorso-axillaris*, in dorsal position, as on the left bone and on the Neandertal dorsal sulcus pattern. The uppermost part of the *facies dorso-axillaris* is also visible under the infraglenoid tubercle which is well marked. Osteophytes are present below the infraglenoid tubercle.

In the first comprehensive analysis of the functional significance of the three axillary border patterns, Trinkaus (1977) considered the presence of a dorsal axillary sulcus as an indication of the relative increase in the lateral attach-

ment area for the *M. teres minor*, a lateral rotator of the humerus, which therefore is more powerful. The development of that muscle would counteract the medial rotation during strong humeral adduction, helping to gain rotational stability of the gleno-humeral joint and precise manual dexterity. Later, Trinkaus (1989: 334; see also Churchill & Trinkaus, 1990: 158) added that the high frequency of the dorsal sulci in Neandertals may, more probably, reflect a reinforcement of the axillary border in order to resist dorso-ventral bending stresses in response to loading patterns when the humerus is in an abducted position.

**Glenoid fossa**

The glenoid fossae of the two Spy scapulae are piriform. The glenoid notch is particularly well marked on the left bone. The antero-inferior angle of the fossa is eroded on both scapulae, but more so on the left one. The area for attachment of the glenoid labrum, or glenoid ligament (*labrium glenoidale*), is blunt around the left fossa and clearly rounded around the right one, especially on the dorsal border and at the superior extremity. In both specimens, the liplike rim of the glenoid fossa is strongly protrusive posteriorly, slightly more than on the Neandertal type site scapulae. Supero-posteriorly, this rim is thickened into the damaged but

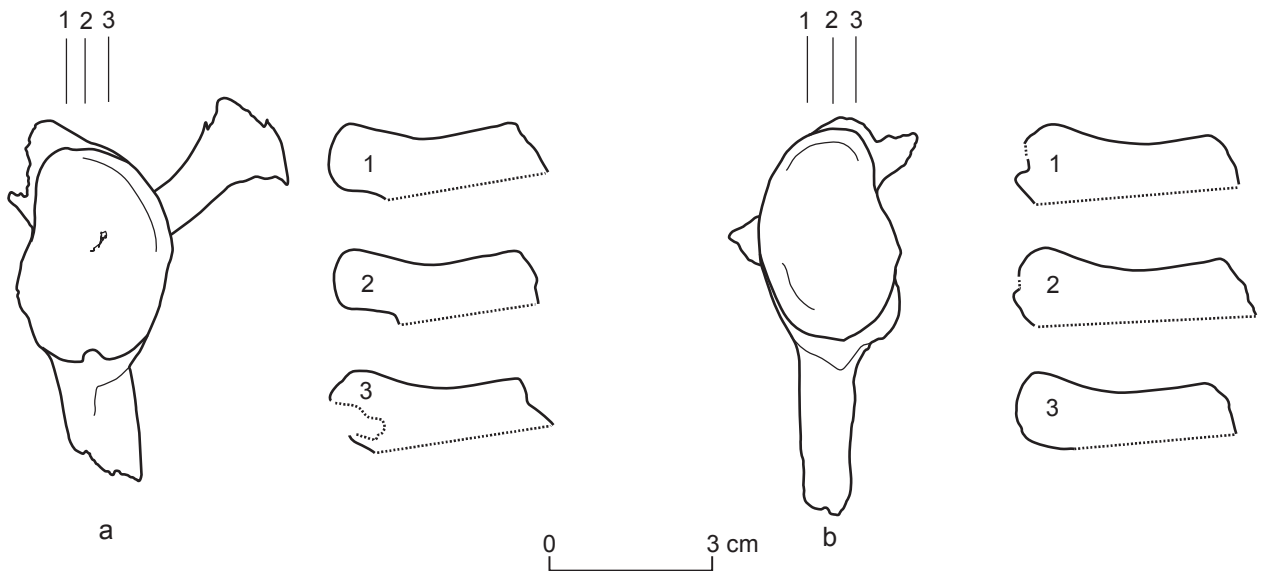


Figure 5. Sections of the glenoid fossae of the Spy scapulae. a: left scapula (Spy 573a); b: right scapula (Spy 572a).



well-expressed supraglenoid tubercle, as in Neandertal 1. Both articular surfaces are slightly concave supero-inferiorly as well as, to a lesser extent, dorso-ventrally (Figure 5). They are shallow, around 3 mm deep. In their centers is a hardly perceptible pit, as on some other Neandertals, but much less pronounced than on the Neandertal type site scapulae (McCown & Keith, 1939: 134); in other words, there is no small tubercle in the centre of the cavity. Neither the shape nor dimensions of both scapulae are exactly the same; there is clearly some asymmetry. For a long time, several scientists (Vallois, 1932: 12; Stewart, 1962: 790; Endo & Kimura, 1970: 237; Vandermeersch, 1981: 203; Churchill & Trinkaus, 1990: 151) stated that Neandertals do have long and narrow glenoid fossae as well as small glenoid indices in comparison with recent humans. However, according to Churchill & Trinkaus (1990), it is mainly the variation in breadth that is responsible for the variation in the glenoid indices. Table 1 gives the measurements of the Spy scapulae as well as comparative data (see ST1 for the raw measurements), while Figure 6 shows that, with the same length, Neandertal scapulae are usually narrower than modern humans, as represented by Mesolithic and recent populations.

The left Spy scapula has an axilloglenoid angle of  $129.5^\circ$  using a point at 25 mm below the inferior border of the glenoid fossa. This Spy angle, as those of most Neandertals measured on the original scapulae of Neandertal and Krapina as well as on some casts, falls within the modern human range of variation, as also do KNM-WT 15000, Dmanisi D4166 and the Atapuerca-SH scapulae (Table 1; ST1; Figure 7). In average however, the axilloglenoid angle is slightly larger in Neandertals than in modern humans. The left glenoaxillary bar angle of Spy is  $134^\circ$ . Only the axilloglenoid bar angle can be estimated for the right scapula: it is around  $134.5^\circ$ .

It is well known that the glenoid fossa of the Neandertal type specimen is directed backwards (Klaatsch, 1901: 151; Vallois, 1928, 1929, 1932, 1946). McCown & Keith (1939: 133) tried to devise a technique for measuring the “angle formed by the intersection of the transverse axis or plane of the glenoid cavity with the infra-spinous plane” but, as noted by Stewart (1962: 792), this measurement is difficult to apply to incomplete scapulae and as such, has been discarded by more recent scientists. Nevertheless, the glenoid fossae of both Spy scapulae do not face as posteriorly as those of the type specimen.

<i>Specimen / Taxon</i>		<i>Glenoid height (M12)</i>	<i>Glenoid breadth (M13)</i>	<i>Glenoid physio. length</i>	<i>Glenoid depth</i>	<i>Glenoid index (M13/M12)</i>	<i>Axillary border thickness, 25 mm under glenoid fossa</i>	<i>Axilloglenoid angle (°) at 2.5 cm</i>	<i>Gleno-axillary bar angle (°)</i>
Spy 573a		(38.0)	26.5	36.35	3.0	69.7	(10.5)	129.5	134.0
Spy 572a		(39.5)	25.5	-	3.0	64.5	-	-	(134.5)
Neandertals	N	18	18	13	10	17	18	20	10
	Mean	37.24	24.02	34.09	2.85	64.96	10.78	129.57	137.85
	Stand. Dev.	4.70	3.45	4.58	0.99	2.90	2.90	6.47	7.25
Modern human -	N	24	25	5	5	24	8	8	-
Mesolithic	Mean	32.93	24.49	28.56	2.54	74.40	11.50	119.75	-
(Belgium, France)	Stand. Dev.	2.38	1.89	2.23	0.54	3.59	1.08	4.75	-
Modern human	N	40	40	40	40	40	40	40	-
(Saint-Lambert,	Mean	38.01	27.35	34.94	4.19	71.97	11.38	121.55	-
Liège)	Stand. Dev.	3.20	2.67	2.98	0.83	4.26	2.20	5.37	-

Table 1. Measurements of the Spy scapulae and statistical parameters (specimen number N, mean, and standard deviation) of the comparative material samples.

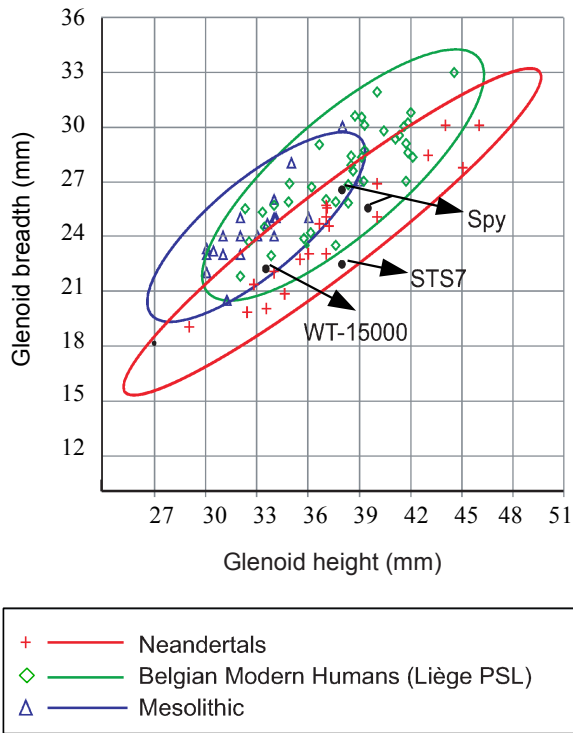


Figure 6. Plot of the glenoid breadth versus glenoid height.

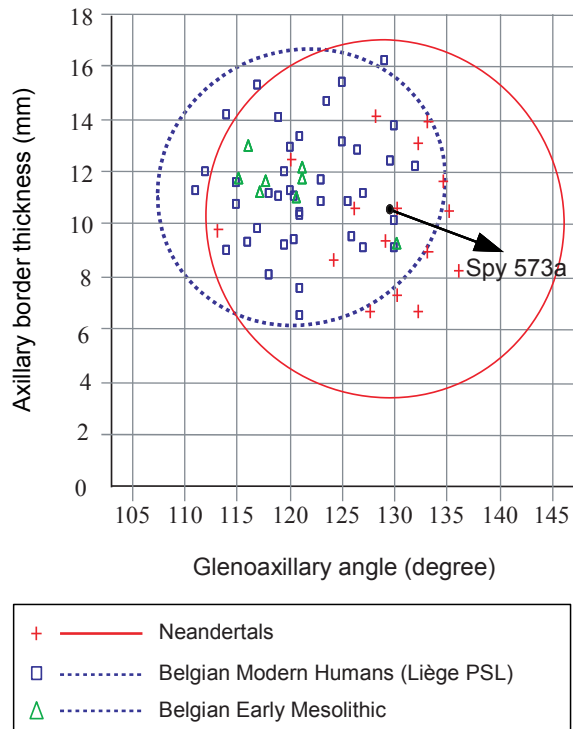


Figure 7. Plot of axillary border thickness versus glenoaxillary angle.

### Ventral and dorsal surfaces

Only small parts of the supraspinatus surface are preserved. On both scapulae, a large – better expressed than on the scapula from the Neandertal type site – vascular hole opening cranially is present in the supraspinatus (or infraspinous) surface, near the spinal base. It is oval on the left side (2.7 x 2.1 mm) and smaller and more circular (2 mm) on the right. The infraspinatus surface does not exhibit any specific detail. The subscapular fossa is deep on the left and right scapulae, at least in its preserved upper lateral part. On both fossils, a vascular hole opens in the middle, c. 25 mm medially from the anterior lip of the glenoid fossae, and a small pit is directly medial to the glenoid notch.

### Acromion, neck and spine

The right acromion is missing. The left one is incomplete, lacking the area of the clavicular facet and the tip. At the point of breakage, the acromion process is c. 20.1 mm wide, but the value before damage was obviously somewhat more important. As can be seen in lateral view, the section of the “root” of the acromion is triangular. The preserved part of that process has a marked dorsal roughness which might indicate a hypertrophied *M. deltoideus*.

Even if taking into account its incompleteness that prevents precise measurements, it seems obvious that the axis of the left spine is quite horizontal, which is consistent with the pattern noted for Neandertals by several authors (Stewart, 1962: 795; Vandermeersch, 1981: 204). As a rough approximation, the angle formed by the spine and the infraspinous plane of McCown & Keith (1939: 134-135) was estimated to be around 135°; by comparison, this angle measures 137° in the Neandertal 1 scapula and 125° in the Tabun C1 one (McCown & Keith, 1939). The height of the spine cannot be measured with McCown & Keith’s (1939: 145) technique but it must be over 30 mm. The thickness of the spine at the glenoid margin (McCown & Keith, 1939: 145) is c. 8.3 mm on the left Spy scapula contra 8.96 on the Neandertal type specimen.

The neck of both scapulae is, as is usual in modern humans as in Neandertals, more distinct behind than in front. The distance between the antero-lateral margin of the spine and the posterior portion of the glenoid fossa is 16.2 mm (taken at the curviest point of the margin). In Neandertal 1, a somewhat similar distance is around 18 mm (personal measurement) but only 13 mm in Amud 1 (Endo & Kimura, 1970: 237).

### GEOMETRIC MORPHOMETRIC ANALYSIS OF THE GLENOID FOSSA SHAPE

Results of the PCA are shown in Figure 8a. Principal component (PC) 1 accounted for 51% of the total variance, and separated

Neandertals from modern humans, while PC 2 partially separated the S. African Holocene sample from the Inuit and European Americans.

Group membership accounted for half of the variation along PC 1 ( $R^2 = 0.50$ ,  $p < 0.0001$ ); Neandertals scored significantly higher than each of the modern human samples with the exception of the Upper Palaeolithic Abri Pataud 22 individual. Among the modern human groups, only the Egyptians and Americans were significantly different from one another along this component. Together with Neandertal 1, the two Spy fossils were the highest scoring specimens, also plotting close to the other Neandertal samples. The two La Ferrassie scapulae just overlapped the modern human distribution on PC 1.

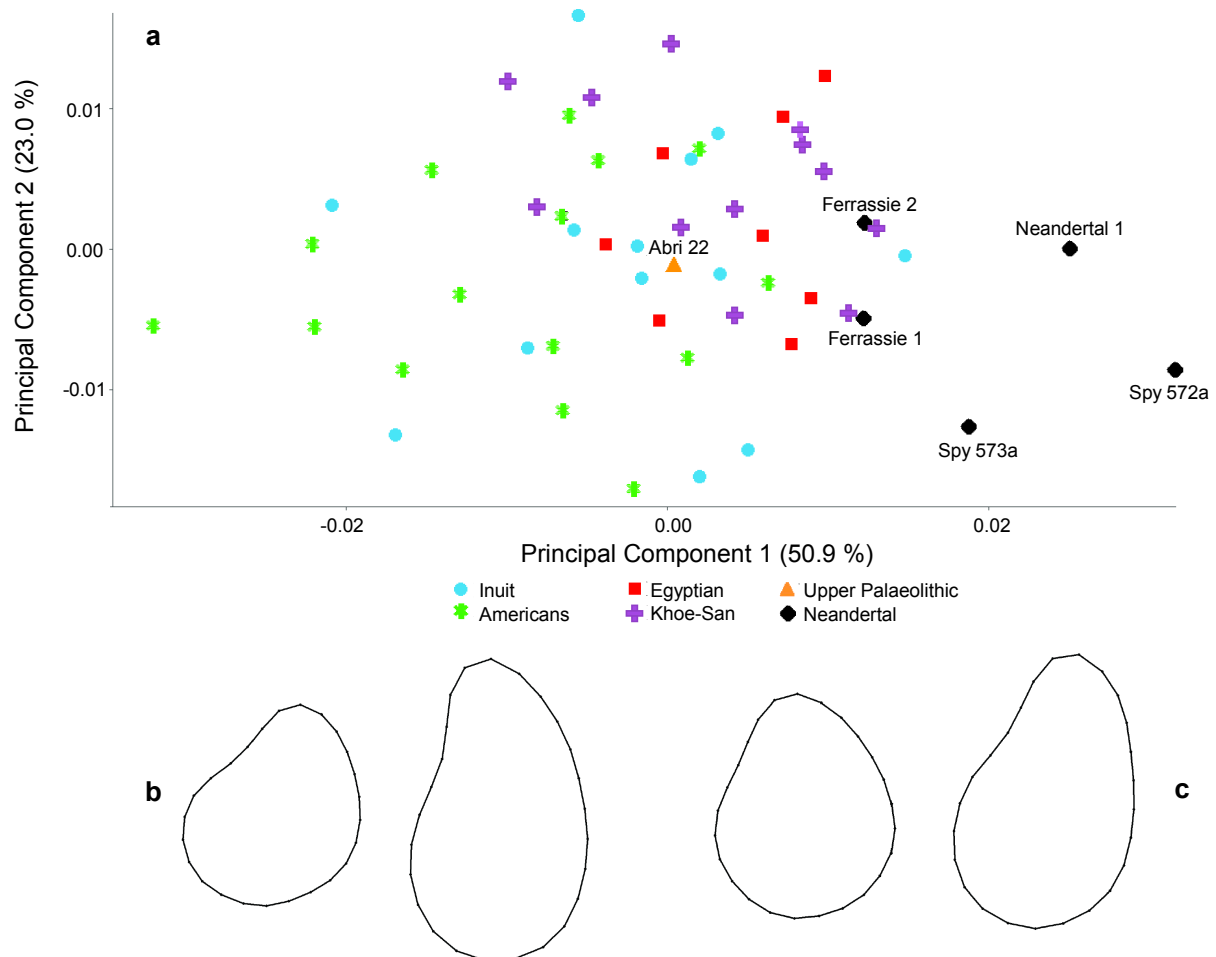


Figure 8. (a) Plot of PC 1 vs. PC 2 of the coefficients from the first ten harmonics of a 2-D Elliptical Fourier Analysis of the glenoid fossa outline. The shape differences associated with the negative (left) and positive (right) ends of (b) PC 1 and (c) PC 2 are shown.

Shape differences along PC 1 are shown in Figure 8b. Neandertals are characterised by high scores, which in turn reflect supero-inferiorly tall and antero-medially narrow glenoid fossae, with a much less pronounced curvature and breadth difference between the superior and inferior parts of the fossae. Although the South African (Khoen-San) sample generally scored higher on PC 2 than other groups, there were no significant differences among groups on this PC. Shape differences are illustrated in Figure 8c. When group membership was taken into account, there was no significant size effect on either PC 1 or PC 2. Neandertals overlapped the modern humans in the overall size of the glenoid fossa. Hence, shape differences cannot be attributed to size differences between the species.

**TAPHONOMY**

At Spy, the left scapula lacks the coracoid process and the tip of the acromion, which is, however, largely preserved; it also has slightly crenulated edges (Figure 9). The axillary border

is obliquely broken and surface exfoliation of a cortical bony flake has occurred on the dorsal surface of the subscapular fossa.

The right scapula also lacks the coracoid process and the tip of the acromion, and has slightly crenulated edges, although less clear than on the left bone. Two concentric cracks are present, affecting both the dorsal and the ventral surfaces. The axillary border is incomplete and has its cortical bone extensively destroyed on its ventral part, but without chewing marks.

Such a set of features substantiates an interpretation of the Spy scapulae as having been damaged by natural processes, with compression in the sediment; no carnivore activity has been observed.

**DISCUSSION**

Both Spy scapulae are so similar in dimensions and morphological details that it seems evident that they belonged to the same adult. J. Frai-

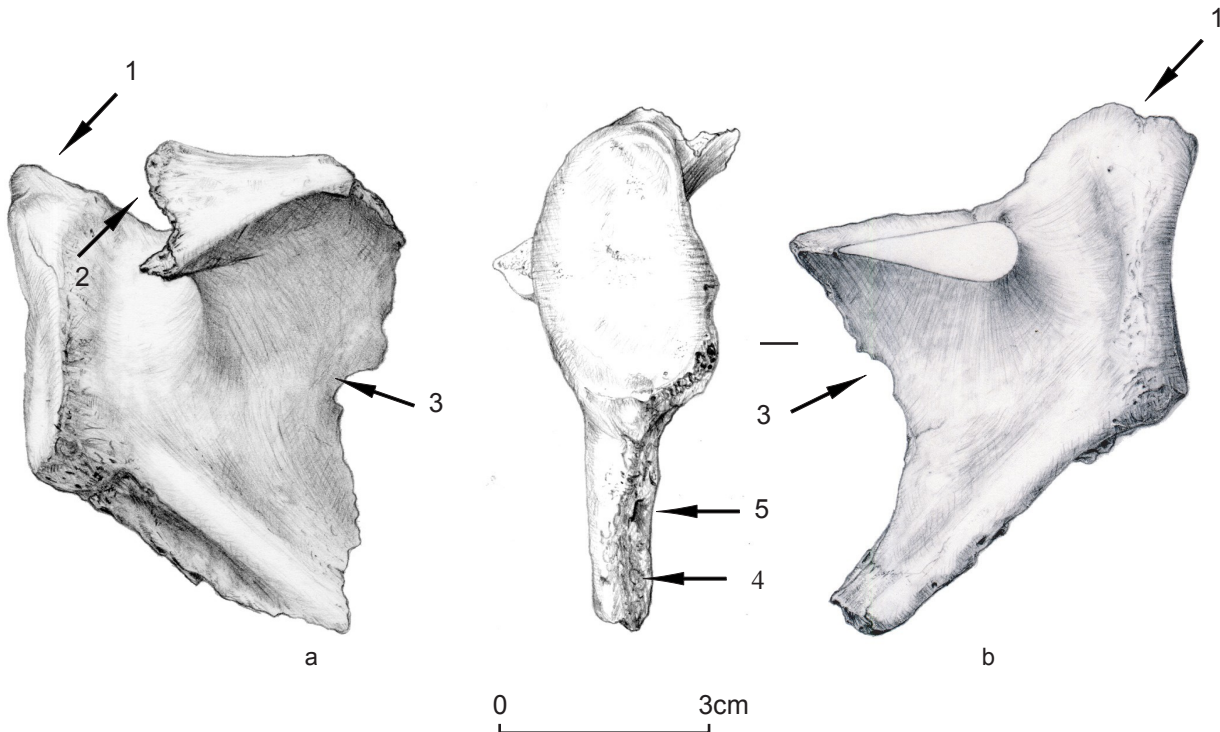


Figure 9. Damage on both Spy scapulae. a: left scapula (Spy 573a); b: right scapula (Spy 572a); 1: missing coracoid process; 2: missing tip of the acromion; 3: crenulated edge of the scapular blade; 4: damaged cortical bone of the axillary border; 5: crack.

pont already attributed them to the same skeleton (Fraipont & Lohest, 1887: 603) and none of the more recent authors who mentioned these bones questioned this observation.

Because most of the human remains of the Spy cave were unearthed more than a century ago, without precise maps of distribution of the bones or fine stratigraphical records, and because, before the present contribution, there was no detailed study of the two scapulae, it is legitimate to wonder if these fossils are really part of the Spy classical Neandertal remains.

As far as morphology is concerned, the axillary border exhibits the dorsal sulcus pattern which is much more frequent in Neandertals than in more recent populations but is not, by no means, exclusive to that taxon. The shape and index of the glenoid fossa and the axilloglenoid angle as well as the distinctive horizontal scapular spine might add some more arguments. PCA statistical analysis also groups Spy with other Neandertals (La Ferrassie 1 and the type site) slightly outside of the range of most modern humans.

Just after the discovery, it was argued that both scapulae belonged to the skeleton referred to as Spy 2 (Fraipont & Lohest, 1887: 603; Hrdlička, 1930), obviously on the grounds of superficial field observations. On the basis of predicted values for glenoid fossa length and breadth, obtained on a least square regression of the humeral distal articular breadth against glenoid fossa dimensions for eight Neandertals, Churchill & Trinkaus (1990: 148) also lean in favour of an attribution to Spy II. As a consequence, if both scapulae really belonged to the Spy II partial skeleton, and since the latter is unquestionably Neandertal (Thoma, 1975), this is another argument that the scapulae also “have” to be Neandertal.

Both AMS  $^{14}\text{C}$  dates obtained from a splinter of the right scapula are too recent to support such an attribution ( $23,880 \pm 240$  BP, OxA-8912 and  $31,810 \pm 250$  BP, GrA-21546; Tous-saint & Pirson, 2006; Semal *et al.*, volume 1: chapter XVI). In our opinion, however, everything indicates contamination by more recent elements, for example varnish, Indian ink or other products used for restoration after the dis-

covery. Yet it is clear that, even contaminated, too recent and very different from laboratories to laboratories, these two dates do allow to discard an attribution of the two scapulae to the series of Neolithic human bones which have also been discovered at Spy, out of any precise context (Rougier *et al.*, 2004; Semal *et al.*, 2009). Furthermore, none of the Neolithic scapulae found in the Belgian Meuse River Basin exhibits the dorsal pattern of the axillary border.

Is it however reasonable to challenge our interpretation on the contention that we overstate the influence of contamination because it would have made the dates of the Spy scapulae younger than we would like them to be and sustain the contrary view that both scapulae really are from the interval between the two dates, therefore suggesting that they did belong to a subject from the Early Upper Palaeolithic? We disagree. Firstly, because of the enormous difference between the two dates obtained from the same fragment of bone, 8,000 years, it does not seem realistic to reject the idea of a pollution by recent elements. Secondly, it would be at least curious that both scapulae might be, as if “by chance”, attributed to the Early Upper Palaeolithic on the grounds of  $^{14}\text{C}$  dating while no other human remain was ever found in the Aurignacian and Gravettian layers at Spy. Thirdly, it has been demonstrated that the scapulae of the Early Upper Palaeolithic exhibit only rarely the dorsal sulcus pattern (Trinkaus, 1983: 219, 2006b: 341; Odwak, 2006). Fourthly, the Spy scapula is not only Neandertal-like as far as its axillary border is concerned, but also in its general pattern, with a “typical” glenoid fossa and a high axilloglenoid angle.

It has been argued that the Neandertal axillary border thickness may be linked to sexual dimorphism (Vandermeersch, 1981: 204; Heim, 1983; Odwak, 2006). Even if such a statement makes sense, it seems risky to use it in sex determination since not enough Neandertal data from skeletons whose sex is known from the pelvis are available. Nevertheless, following Vandermeersch and Heim’s statements, both Spy scapulae – axillary border thickness of 10.5 mm – should be female. And indeed, Tabun C1, usually seen as a female, has a thickness of 11.0 mm, while Neandertal 1 (13.3 mm) and Kebara 2 (left: 14.4 mm, right: 16.9 mm) may be male.



It is also interesting to note that the Spy scapulae fall in the middle of the range of nine adult scapulae from Krapina of which the axillary border thickness at 25 mm below the inferior margin of the glenoid fossa extends from 6.7 mm to 14.1 mm. However, as far as axillary border thickness is concerned and if both scapulae really belong to Spy II, there is a problem as this skeleton is usually seen as a probable male (Thoma, 1975). At least three possibilities allow us to deal with that contradiction. The first one would consist in refuting the attribution of both scapulae to Spy II and re-attribute them to Spy I. The second would be to accept that attribution to Spy II but to question the sexual determination of Spy II as a male and to see it as a female. The third supposes that the variability of the Neandertal axillary border thickness is more important than generally believed.

On the opposite, according to the dimensions of the glenoid fossae and using Heim (1983)'s assessment, the Spy scapulae should be male. Trinkaus & Smith (1995) also determine – cautiously – the Spy scapulae as male based on their size. In our view and considering the present state of research, this question of sex determination of human fossils, especially if the pelvis is absent as it is the case in both Spy skeletons, has to remain hypothetical. At the moment, only DNA, when present and when both X and Y chromosomes are found, like in Vindija 80 (Green *et al.*, 2006), can solve such a problem with certainty.

At one time (Stringer *et al.*, 1984), the dorsal sulcus pattern was regarded as a derived feature of Neandertals, but such a strong claim was dismissed (Frayser, 1992a, 1992b; Trinkaus, 2006a, 2006b). It also seems that none of the other main Neandertal scapulae features can be regarded as autapomorphic. And indeed, other traits of these fossils can be noteworthy, such as the horizontal scapular spine or the tall and narrow glenoid fossa, but they remain in the variation of modern humans, even if they are often near its limit. Moreover, some “typical” features of Neandertal scapulae are also found in Australopiths and Early *Homo*, which distinguishes all these specimens from modern humans; therefore, they might be

regarded as the archaic condition for the hominins (Carretero *et al.*, 1997: 381). Lastly, what really characterised the Neandertal scapula is more its general morphological pattern than some precise morphological features.

Finally, the set of damage features observed on both scapulae (see section Taphonomy) seems to indicate that the Spy scapulae have been damaged by natural processes. Even if, at first, the question of possible carnivore activity was envisaged, detailed observations of both bones as well as taphonomic investigations of the other Spy Neandertal bones leave no doubt.

## CONCLUSION

The two scapulae found in 1886 at Spy together with the illustrious skulls and other postcranial Neandertal remains exhibit patterns closely corresponding to this taxon. The present reassessment aimed to provide more information about these two specimens found thirty years after the Neandertal type site right scapula but nearly unpublished before, and therefore scarcely used as comparative material apart from a few exceptions (Heim, 1982; Churchill & Trinkaus, 1990). The weakness of this study, inherent to the state of preservation of the Spy bones, lies in the absence of physical connection between both scapulae and the corresponding humeri and clavicles, which does not allow for a thorough global study of the shoulder joint.

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