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DIRECT RADIOCARBON DATING AND STABLE ISOTOPES OF THE NEANDERTAL FEMUR FROM LES ROCHERS-DE-VILLENEUVE (LUSSAC-LES-CHÂTEAUX, VIENNE)

DATATION ABSOLUE (^{14}C) ET ISOTOPES STABLES DU FÉMUR NÉANDERTALIEN DES ROCHERS-DE-VILLENEUVE (LUSSAC-LES-CHÂTEAUX, VIENNE)

Cédric BEAUVAL ¹, François LACRAMPE-CUYAUBÈRE ¹, Bruno MAUREILLE ², Erik TRINKAUS ³

ABSTRACT

Direct radiocarbon dating of the Neandertal femoral diaphysis from the Rochers-de-Villeneuve (Lussac-les-Châteaux, Vienne) has yielded an age of $45,200 \pm 1,100$ ^{14}C years B.P. (OxA-15257) [$48,455 \pm 1,878$ cal. years B.P.], and stable isotope values of $\delta^{13}\text{C} = -19.0\text{‰}$ and $\delta^{15}\text{N} = 11.6\text{‰}$. The direct radiocarbon date makes it the oldest directly dated European Neandertal specimen, even though others have securely associated radiocarbon dates in the same time range. The stable isotopes are similar to those for other OIS 3 European Neandertals and indicate a relatively high trophic level for this individual.

Keywords: Neandertal, Mousterian, hyena, dating, isotope, carbon, nitrogen.

RÉSUMÉ

La diaphyse fémorale néandertalienne des Rochers-de-Villeneuve (Lussac-les-Châteaux, Vienne) a été datée à $45\,200 \pm 1\,100$ ^{14}C ans B.P. (OxA-15257) [datation calibrée : $48\,455 \pm 1\,878$ ans cal. B.P.] par la méthode du ^{14}C en SMA. Les valeurs associées des isotopes stables du carbone et de l'azote sont de $-19,0\text{‰}$ pour le $\delta^{13}\text{C}$ et $11,6\text{‰}$ pour le $\delta^{15}\text{N}$. Ce spécimen est ainsi le plus vieux Néandertalien daté directement même si, pour un intervalle d'âge comparable, d'autres dates ^{14}C de fossiles sont connues et acceptées. Les isotopes stables sont similaires à ceux des Néandertaliens européens du stade isotopique 3 et indiquent un niveau trophique relativement élevé pour le Néandertalien des Rochers-de-Villeneuve.

Mots-clés : Néandertal, Moustérien, hyène, datation, isotope, carbone, azote.

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VERSION FRANÇAISE ABRÉGÉE

Durant la campagne de fouilles de l'été 2002, un fragment de diaphyse fémorale néandertalienne était mis au jour dans le gisement des Rochers-de-Villeneuve (Vienne, France). La datation du lithofaciès J livrant la pièce était de $40\,700 \pm 900$ ^{14}C B.P. (Beta-177 765) [$44\,392 \pm 876$ cal. B.P. (CalPal version 1.4, www.calpal.de)] sur la base d'un morceau de radius d'hyène des cavernes, pièce située à proximité du fémur néandertalien (Beauval *et al.* 2005). Ce fémur pouvait donc être classé parmi les Néandertaliens les plus récents d'Europe de l'Ouest (Beauval *et al.* 2005).

Nous avons donc décidé de dater directement le fémur humain. Pour cela, un échantillon de 620 mg a été prélevé au niveau de l'os cortical à proximité de la cavité médullaire sur la moitié latérale de la diaphyse (*fig. 1*). Il a été soumis à l'Oxford Radiocarbon Accelerator Unit (ORAU) pour obtenir une datation au ^{14}C en SMA. Ce laboratoire utilise de plus une technique (l'ultrafiltration) qui permet d'éliminer le collagène dégradé ainsi que les contaminations potentielles (Bronk Ramsey *et al.* 2004 ; Higham *et al.* 2006b). Alors, les dates obtenues sont généralement plus anciennes de quelques millénaires que celles estimées avec d'autres techniques (Jacobi *et al.* 2006). Les détails de l'analyse et les résultats pour le fémur des Rochers-de-Villeneuve 1 sont donnés dans le tableau 1. La datation est de $45\,200 \pm 1100$ ans B.P. (OxA-15257). La valeur calibrée (avec CalPal version 1.4, cf. *supra*) est de $48\,455 \pm 1878$ ans B.P.⁴. C'est donc actuellement le plus ancien néandertalien daté directement (*tabl. II*) et il se rapporte au stade isotopique 3. Si l'âge du fémur est plus ancien que celui obtenu sur le radius d'hyène, c'est probablement en partie la conséquence des techniques de datation utilisées. Rappelons par ailleurs que ce niveau J correspond à un ancien repaire d'hyène et que le fémur des Rochers-de-Villeneuve 1 montre des stigmates liés à l'activité de ces carnivores.

En plus de la datation, l'analyse nous permet de connaître les valeurs des isotopes stables du carbone et de l'azote pour ce fémur. Le $\delta^{13}\text{C}$ est - 19,0 ‰ et le $\delta^{15}\text{N}$ est de 11,6 ‰. Le radius d'hyène du niveau J a un $\delta^{13}\text{C}$ de - 18,6 ‰. À partir de la compilation de données publiées sur les $\delta^{13}\text{C}$ et $\delta^{15}\text{N}$ de différents fossiles du Pléistocène supérieur, nous pouvons comparer la position du fémur des Rochers-de-Villeneuve avec celle d'autres spécimens du stade isotopique 3 (*fig. 2, 3*). Il est maintenant connu (Bocherens *et al.* 1991 ; Richards *et al.* 2000 ; Bocherens *et al.* 2005), que les Néandertaliens ont alors des positions voisines de celles des carnivores des gisements considérés. Le $\delta^{15}\text{N}$ reflète généralement le niveau trophique, augmentant de 3 ‰ à 5 ‰ entre chaque échelon de la chaîne alimentaire (Bocherens *et al.* 2005), bien que des facteurs non alimentaires puissent également interagir (Drucker *et al.* 2003 ; Richards, Hedges 2003 ; Drucker, Bocherens 2004). Le fémur des Rochers-de-Villeneuve 1 a une valeur parmi les plus élevées chez les Néandertaliens, à proximité de deux autres spécimens provenant du gisement des Pradelles (ou Marillac, Charente). Le $\delta^{13}\text{C}$ est négatif. Il est plus faible chez les Néandertaliens que chez les fossiles du Paléolithique supérieur (même si la variabilité des deux groupes se recouvre). Il est probable que le $\delta^{13}\text{C}$ varie à la fois en fonction de l'environnement des proies et des niveaux trophiques des animaux étudiés. La valeur de - 19,0 ‰ de Rochers-de-Villeneuve 1 est proche de celle du radius d'hyène déjà étudié et se place au milieu de la variabilité des Hommes modernes du Paléolithique supérieur et au niveau des plus fortes valeurs des Néandertaliens du stade isotopique 3. Des analyses complémentaires sur les restes de faune de ce gisement sont donc nécessaires pour une interprétation plus fine de ce résultat.

INTRODUCTION

The 2002 discovery of a partial Neandertal femoral diaphysis at the Rochers-de-Villeneuve (Vienne, France) (Beauval *et al.* 2005) has added to our sample of relatively late Neandertal remains in western Europe, reinforcing the morphological pattern of Neandertal (and archaic *Homo* generally) femoral morphology while suggesting a shift in biomechanically relevant parameters among later Neandertal populations. However, the precise age of the specimen has remained uncertain, since it was previously dated by association within Level J within the site.

4 Les dates cal. B.P. présentées ont été calculées avec CalPal version 1.4 (www.calpal.de). Conscients du débat sur la pertinence de ces données « calibrées » (Mellars 2006a, b *contra* Turney *et al.* 2006 ; Van der Plicht *et al.* 2004), nous les indiquons ici pour permettre au lecteur une comparaison plus aisée des données.

Level J is a palimpsest of Middle Paleolithic human activity, indicated by lithic remains and processed herbivore remains, and hyena denning, indicated by gnawed and etched bones, shed deciduous hyaenid teeth, and coprolites. The previous radiometric dating was provided by an AMS (accelerator mass spectrometry) date of $40,700 \pm 900$ ^{14}C B.P. (Beta-177 765) [$44,392 \pm 876$ cal. B.P. (CalPal version 1.4, www.calpal.de)] on a hyena radius from an adjacent square of the same level (Beauval *et al.* 2005).

However, given the possibilities of the mixing of materials in any Pleistocene stratigraphic level, especially one with alternating use of the site by humans and large carnivores, it was decided to directly radiocarbon date the Rochers-de-Villeneuve Neandertal femur. To this purpose, a small piece of cortical bone (*fig. 1*) was removed from the endosteal side of the lateral femoral diaphysis at the proximal postmortem break near midshaft and submitted to the Oxford Radiocarbon Accelerator Unit (ORAU) for AMS dating (for full technical details, see: Bronk Ramsey *et al.* 2004; Higham *et al.* 2006b). In addition to standard AMS dating, ORAU employs a sample preparation technique for bone samples using ultrafiltration, which sorts the derived collagen by molecular weight and thereby removes diagenetically degraded collagen and additional potential contamination (Brown *et al.* 1988;

Bronk Ramsey *et al.* 2004; Higham *et al.* 2006b). When applied to Late Pleistocene samples previously dated by standard pretreatment techniques, this technique usually provides determinations several millennia older (Jacobi *et al.* 2006) than the former results and/or with smaller error factors (Higham *et al.* 2006b), differences attributed to improved pretreatment rigor.

RADIOCARBON DATING RESULT

The 620 mg sample of bone from the Rochers-de-Villeneuve 1 femur yielded 3.6% collagen (*tabl. 1*). This produced a $\delta^{13}\text{C}$ value of -19.0‰ and a carbon: nitrogen (C:N) atomic ratio of 3.25. The $\delta^{13}\text{C}$ value falls in the middle of acceptable ranges for bone, and the C:N ratio is in the middle of the acceptable range of 2.9 to 3.5 for well-preserved bone (De Niro 1985; Bronk Ramsey *et al.* 2004). The resultant date of $45,200 \pm 1,100$ ^{14}C years B.P. (OxA-15257), despite its relatively large standard error, should therefore be an accurate estimate of the age of the Rochers-de-Villeneuve 1 Neandertal individual. When the age is adjusted using CalPal version 1.4, a calendrical equivalent age of $48,455 \pm 1,878$ cal. years B.P.⁵ is attained.

This age for the Rochers-de-Villeneuve 1 femur is older than the previous date on a hyena bone, even at two standard deviations for both of the dates for the uncalibrated dates in radiocarbon years. However, the difference is not markedly greater than the differences of a couple of millennia sometimes encountered when samples are re-dated using ultrafiltration and AMS ^{14}C dating. Moreover, the resultant calendrical equivalent dates are not significantly different from each other at two standard deviations. It is therefore likely that the human femur and the hyena denning activity, as indicated by the hyena damage to the human femur (Beauval *et al.* 2005), were contemporaneous, but that the age of the alternating occupations in Level J at Rochers-de-Villeneuve is slightly older than previously assessed.

This result makes the Rochers-de-Villeneuve 1 femur the oldest directly radiocarbon dated Neandertal

*Fig. 1—Medial view of the Les Rochers-de-Villeneuve 1 femur (proximal extremity at the top) and position of the two samples (A: mtDNA sampling, Beauval *et al.* [2005]; B: ^{14}C datation sampling, this study).*

*Fig. 1 - Les zones des deux prélèvements sur le fémur des Rochers-de-Villeneuve 1 (A : pour l'ADNmt, Beauval *et al.* [2005] et B : pour la datation absolue au ^{14}C).*

5. The cal. B.P. dates presented have been calculated using CalPal version 1.4 (www.calpal.de). Being aware of a debate on the pertinence of the utilization of such calibrated dates (Mellars 2006a, b *contra* Turney *et al.* 2006; Van der Plicht *et al.* 2004), we give them to allow, if interested, more easy comparisons.

specimen. Only the Feldhofer 1 and 2, Vindija 208, and three specimens from Sidrón (*table II*) have provided reliable direct radiocarbon dates for Neandertal specimens; the direct date on the Mezmaiskaya infant (Ovchinnikov *et al.* 2000) is contradicted by the well-dated stratigraphy (Golovanova *et al.* 1998, 1999; Skinner *et al.* 2003).

A variety of relatively late Neandertals, including ones associated with either late Middle Paleolithic or initial Upper Paleolithic technocomplexes, have been dated by association with radiocarbon, thermoluminescence and/or electron spin resonance dates (see Valladas *et al.* 1999). In particular, layer J from which the

Le Moustier 2 burial derives (Peyrony 1930; Maureille 2002) could date to the same time period as the Feldhofer remains [but see contrasts between the TL and ESR determinations (Valladas *et al.* 1986; Mellars, Grün 1991)], and the Saint-Césaire 1 Châtelperronian Neandertal is dated to ca. 36,000 cal. B.P. on the basis of six associated thermoluminescence dates (Mercier *et al.* 1991). However, as with the direct date on Rochers-de-Villeneuve 1 and the previous hyena radius date, given the taphonomic and postdepositional complexities of Pleistocene cave sites, it is preferable to have a direct, confirmatory date on the human remains in question.

	OxA-15257
Radiocarbon age (^{14}C years B.P.)	45,200 $\pm$ 1,100
Calendrical equivalent age (cal. years B.P.)	48,455 $\pm$ 1,878
$\delta^{13}\text{C}$	- 19.0‰
$\delta^{15}\text{N}$	11.6‰
C:N [(2.4397 (mg C)/0.8742 (mg N)) x 1.16618]	3.25
Sample weight	620 mg
Collagen weight (ultrafiltered gelatin yield)	22.3 mg
Burnweight (gelatin combusted for graphitization)	6.2 mg
%C (% carbon on combustion)	39.35%
%N (% nitrogen on combustion)	14.1%

Table I—Results of the dating analysis of the bone sample from the Rochers-de-Villeneuve 1 Neandertal femur diaphysis.

Tabl. I - Données associées à la datation absolue de la diaphyse fémorale néandertalienne des Rochers-de-Villeneuve 1.

	^{14}C B.P.	cal. B.P.*	Lab. number	Reference
Rochers-de-Villeneuve 1	45,200 $\pm$ 1,100	48,455 $\pm$ 1,878	OxA-15257	This study
Feldhofer 1	39,900 $\pm$ 620	43,810 $\pm$ 621	ETH-20981	Schmitz <i>et al.</i> 2002
Feldhofer NN4 (1?)	40,360 $\pm$ 760	44,120 $\pm$ 748	ETH-19661	Schmitz <i>et al.</i> 2002
Feldhofer 2	39,240 $\pm$ 670	43,470 $\pm$ 615	ETH-19660	Schmitz <i>et al.</i> 2002
El Sidrón 500	40,840 $\pm$ 1,200	44,600 $\pm$ 1,099	Beta-192065	Lalueza-Fox <i>et al.</i> 2005
El Sidrón 599a	37,300 $\pm$ 830	42,422 $\pm$ 484	Beta-192066	Lalueza-Fox <i>et al.</i> 2005
El Sidrón 763a	38,240 $\pm$ 890	43,017 $\pm$ 650	Beta-192067	Lalueza-Fox <i>et al.</i> 2005
Vindija 208	32,400 $\pm$ 1,800	38,016 $\pm$ 2,097	OxA-X-2089-06	Higham <i>et al.</i> 2006a

Table II—Comparative direct radiometric dates for OIS 3 European Neandertal remains.

*Calibrated dates based on CalPal version 1.4 (2005).

Tabl. II - Datations absolues directes de Néandertaliens européens du stade isotopique 3.

*Données calibrées basées sur CalPal version 1.4 (2005).

STABLE ISOTOPE COMPARISONS

In addition to providing a radiocarbon date, the ORAU analysis of the Rochers-de-Villeneuve 1 femur provided carbon and nitrogen stable isotopes, with values of -19.0‰ for $\delta^{13}\text{C}$ and 11.6‰ for $\delta^{15}\text{N}$ (table I). As a

result of both stable isotope and chemical analyses associated with AMS dating, there is a growing sample of carbon and nitrogen stable isotopes for Late Pleistocene human remains (*e.g.* Bocherens *et al.* 1991, 2001, 2005; Fizet *et al.* 1995; Smith *et al.* 1999; Richards 2000; Richards *et al.* 2000, 2001; Pettitt *et al.* 2003; Formicola

Fig. 2—Plot of $\delta^{15}\text{N}$ versus $\delta^{13}\text{C}$ values for the Les Rochers-de-Villeneuve 1 (black square), OIS 3 Neandertals (from A: Les Pradelles 10, B: Spy (scapula), C: Vindija 207, D: Vindija 208, E: Les Pradelles M300, F: Les Pradelles M400 et G: Saint-Césaire), and Middle Upper Paleolithic modern humans (from 1: Arene Candide, 2: Barma Grande, 3: Brno 2, 4: Dolní Věstonice, 6: Eel Point, 5: Kostenki, 7: Paviland 1, 8: La Rochette 1, 9: Sunghir 1, 10: Sunghir 2 and 11: Sunghir 11).

Fig. 2 - Graphique bidimensionnel des $\delta^{15}\text{N}$ et $\delta^{13}\text{C}$ pour Les Rochers-de-Villeneuve 1 (carré noir), des Néandertaliens du stade isotopique 3 (A : Les Pradelles 10, B : Spy (scapula), C : Vindija 207, D : Vindija 208, E : Les Pradelles M300, F : Les Pradelles M400 et G : Saint-Césaire) et des fossiles du Paléolithique supérieur moyen (1 : Arène Candide, 2 : Barma Grande, 3 : Brno 2, 4 : Dolní Věstonice, 6 : Eel Point, 5 : Kostenki, 7 : Paviland 1, 8 : La Rochette 1, 9 : Sunghir 1, 10 : Sunghir 2 et 11 : Sunghir 11).

Fig. 3—Comparison of the $\delta^{15}\text{N}$ versus $\delta^{13}\text{C}$ values of Les Rochers-de-Villeneuve 1 to the Middle Paleolithic Neandertals and a dietary range of mammals from the site of Les Pradelles (Marillac-le-Franc, Charente), given the general geographical, cultural and chronological proximity of Les Pradelles. Les Pradelles data from Fizet *et al.* (1995), pooling data points from the different levels, since it is unknown which, if any, of the levels at Les Pradelles provides an appropriate climatic and faunal framework for the Rochers-de-Villeneuve Level J remains. Open symbols—herbivores (triangles: Equus; circles: Rangifer; squares: Bison). Gray symbols—carnivores (triangles: Crocuta; circles: Vulpes; squares: Canis). Solid symbols—Neandertals (triangles: Les Pradelles; square: Rochers-de-Villeneuve 1).

Fig. 3 - Comparaison des valeurs des $\delta^{15}\text{N}$ et $\delta^{13}\text{C}$ du fémur Les Rochers-de-Villeneuve 1 à celles des Néandertaliens et des mammifères du gisement des Pradelles (Marillac-le-Franc, Charente) étant donnée la relative "proximité" géographique, culturelle et chronologique des deux gisements. Les données des Pradelles (Fizet *et al.* 1995) correspondent à l'analyse de vestiges issus des différents niveaux pour lesquels le spectre faunique et le contexte climatique ne sont pas forcément identiques à ceux des Rochers de Villeneuve niveau J. Figurés blancs - herbivores (triangles : Equus ; cercles : Rangifer ; carrés : Bison). Figurés gris - carnivores (triangles : Crocuta ; cercles : Vulpes ; carrés : Canis). Figurés noirs - Néandertaliens (triangles : Les Pradelles ; carré : Rochers-de-Villeneuve 1).

et al. 2004; Schulting *et al.* 2005). As noted elsewhere (Richards *et al.* 2000; Bocherens *et al.* 2005), stable isotope values can be influenced by diagenetic processes, and degraded bone is therefore not ideal for analysis. In addition, stable isotope values of C and N shift temporally and spatially; therefore it is important that human values should be evaluated with respect to a range of mammals from the same level of the same site, or at least a contemporaneous level of a neighboring site. Except for the $\delta^{13}\text{C}$ value of -18.6‰ for the hyena radius from Level J, such comparative data are not yet available for Level J of Rochers-de-Villeneuve; however, values for various large-bodied herbivores for diverse western and central European oxygen isotope stage (OIS) 3 sites exhibit only minor variations in these values, and it is therefore of use, at least for a preliminary assessment, to compare the Rochers-de-Villeneuve 1 values to those of other OIS 3 Neandertal and early modern human values (see *fig. 2* for samples).

Given these considerations, we have plotted the stable isotope values for Les Rochers-de-Villeneuve 1 in two manners. In figure 2 it is compared to values for Neandertals and Gravettian early modern humans from across Europe, and in figure 3 it and two Neandertal specimens from Les Pradelles (Marillac) are compared to a faunal dietary range from the pooled Middle Paleolithic levels of Les Pradelles, Charente.

As previously noted (see especially Richards *et al.* 2000; Bocherens *et al.* 2005), Neandertal $\delta^{15}\text{N}$ values are consistently relatively high, clustering among the slightly more omnivorous of the large carnivores (especially hyenas and wolves). $\delta^{15}\text{N}$ values generally reflect trophic level, increasing with each level of the food chain by 3‰ to 5‰ (Bocherens *et al.* 2005), even if many factors other than dietary intake may have an influence (Drucker *et al.* 2003; Richards, Hedges 2003; Drucker, Bocherens 2004). The Rochers-de-Villeneuve 1 value is among the highest of the Neandertals, clustering with two Neandertal specimens from Les Pradelles and above the carnivores from Les Pradelles. The Middle Upper Paleolithic sample exhibits a higher range of $\delta^{15}\text{N}$ values, with the lower half of the sample exhibiting values similar to those of the Neandertals and half of the $\delta^{15}\text{N}$ values well above the Neandertal range. This has been suggested (Richards *et al.* 2001) to indicate a high consumption of aquatic resources among some of these early modern humans, since aquatic food chains tend to be longer than terrestrial ones.

The $\delta^{13}\text{C}$ distributions provide generally more negative values for the Neandertals, with substantial overlap between the samples. It is likely that these values reflect some combination of the habitats of the prey animals and the trophic levels of the individuals being measured. In any case, the value of -19.0‰ for Rochers-de-Villeneuve 1 falls in the middle of the OIS 3 early modern human distribution, is at the high end of the Neandertal distribution. It is also close to the $\delta^{13}\text{C}$ value for the hyena radius from Rochers-de-Villeneuve and those of the carnivores from Les Pradelles, but marginally above those for the Les Pradelles herbivores. Further analysis of the faunal remains from Les Rochers-de-Villeneuve will be necessary to assess the implications of this $\delta^{13}\text{C}$ value.

CONCLUSION

Direct radiometric dating of the Rochers-de-Villeneuve 1 Neandertal femoral diaphysis to ca. 45,200 ^{14}C B.P. (OxA-15257) [ca. 48,500 cal. B.P.] places it securely within OIS 3 close to the time of the transition to the Upper Paleolithic and early modern humans in Europe, but still well within the preceding Middle Paleolithic. In combination with its stable isotope signature, produced as part of the chemical analysis of the dating sample, it is providing additional data on the high trophic level of these Neandertals prior to their demise in the middle of OIS 3.

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