Chapter 21

THE SCLADINA I-4A JUVENILE NEANDERTAL: A SYNTHESIS

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1. Introduction

A total of 19 Neandertal remains — bones and teeth — have been discovered at Scladina Cave. They consist of the mandible and a fragment of the maxilla of an eight-year-old child (Figure 1). Most of these fossils (11 teeth and the fragment of the right maxilla) were discovered between 1990 and 1992 but not identified until after the discovery of Scla 4A-1, the right hemimandible, in July 1993 (Bonjean et al., 2009).

Many papers have been devoted to these remains. Some are just preliminary presentations (e.g. Otte et al., 1993; Toussaint et al., 1998), while others are detailed studies of specific subjects (e.g. Smith et al., 2007). Various contributions, often derived from PhD theses or post-doctoral research, include the Scladina fossils in aspects of general Neandertal studies, for example the enamel-dentine junction (Skinner et al., 2010) or tooth root size (Le Cabec et al., 2013). Although of great interest, these works divide the information into a large number of contributions, with only little confrontation between all involved disciplines and subdisciplines.

Figure 1: The Scladina I-4A juvenile Neandertal remains.

Conversaly, this monograph combines most of the information obtained for the juvenile Neandertal remains from Scladina, in topics ranging from their stratigraphic position, their chronology, their taphonomy, their age at death, their morphology, their DNA, and their isotopes of carbon and nitrogen. In this context, this chapter summarizes key aspects of this monograph from a multidisciplinary perspective and discusses the future of Neandertal research in the region.

2. Main interdisciplinary results of the research at Scladina

2.1. Context

2.1.1. Stratigraphic position of the Neandertal remains

In the years following the discovery of the Scladina Child, the stratigraphy related to these remains was understood as the following sequence, from bottom to top: Layer 4B, Layer 4A, Stalagmitic Floor CC4, and Layer 3. A few years later, the identification of a stalagmitic floor inside Layer 4A, called CC14, led to the definition of a new stratigraphic succession: Layer 4B, Layer 4A (lower), lower Stalagmitic Floor CC14, Layer 4A (upper), upper Stalagmitic Floor CC4, and Layer 3. Most of the remains were attributed to the upper part of Layer 4A at that time, situated between stalagmitic floors CC14 and CC4 (Bonjean et al., 1996; Bonjean, 1998), while some teeth, originally attributed to Layer 3, were reattributed to Layer 4A.

In the context of a PhD thesis (Pirson, 2007), detailed stratigraphic observations took place of almost all the available sedimentary profiles within Scladina, allowing about 120 layers to be defined and grouped into 30 distinct stratigraphic units. Following this stratigraphic reappraisal, former Layer 4A became 'Sedimentary Complex 4A', including about 20 layers grouped into 4 units (Chapter 3). These include, from bottom to top:

- Unit 4A-AP, the lowermost unit, including the layers within the complex that are older than Stalagmitic Floor CC4 (i.e. pre-floor layers);
- Unit 4A-IP, including stalagmitic floor CC4 (which is in fact an equivalent of CC14) and the layers that are contemporaneous with the formation of CC4 (i.e. syn-floor layers);
- Unit 4A-CHE, which includes the layers that developed inside a large gully structure that eroded underlying layers, including CC4 (i.e. post-floor and syn-gully layers);
- Unit 4A-POC, the uppermost unit, superimposing both units 4A-IP and 4A-CHE (i.e. post-gully layers).

For this monograph, all available arguments were re-examined in order to refine the stratigraphic position of the Neandertal remains discovered in former Layer 4A (Chapter 5). These arguments include the 3-dimensional coordinates, the analysis of sedimentary profiles, the projection of the remains onto the nearest profiles, the analysis of field notes, the analysis of pictures, etc.

Based on this, out of the 19 juvenile Neandertal remains unearthed to date, seven were accurately and precisely repositioned inside the new stratigraphic record (see Chapters 3 & 5). Each of these seven fossils is either from the gully in Unit 4A-CHE or from the directly superimposing deposits (Unit 4A-POC). Three of these seven fossils were repositioned with a high degree of certainty into a specific layer:

- the right half of the mandible (Scla 4A-1) is from the top of Unit 4A-CHE, and more specifically from the uppermost 4A-GX lithofacies;
- two teeth are from Unit 4A-POC, including Scla 4A-4 from Layer 4A-BO and Scla 4A-13 from Layer 4A-LEG.

The stratigraphic provenance of the 12 other remains is still uncertain, as several units are possible candidates (4A-IP, 4A-CHE, 4A-POC, 3-INF, and, less likely, 3-SUP). However, an attribution to Unit 4A-POC is most probable when considering the results of the taphonomic study (Chapter 7) as well as the palaeoanthropological analysis, which indicates that the remains are from a single individual.

Given the sedimentary depositional dynamics of Unit 4A-CHE, all remains unearthed from there are at least in secondary spatial position. Some remains were subsequently reworked into at least one superimposing unit (Unit 4A-POC). These reworked remains are therefore in tertiary spatial position. The spatial distribution of the fossils along the longitudinal axis of the cave is logical within this framework. In the present state of research, the primary spatial position of the child is still unknown.

Because the Neandertal remains were redeposited through an episode of gully formation, questioning the relationship between the age of the remains and this structure is important: were the remains reworked from a much older unit, or are they contemporaneous with the gully's formation? This issue is addressed in the next section.

2.1.2. Chronostratigraphy: integrating the disciplines

Several observations made during the taphonomical study of the Neandertal remains (Chapter 7) led to the conclusion that the Neandertal remains are contemporaneous with the gully of Unit 4A-CHE. They include:

- when combining all of the physical taphonomic attributes, animal bones and teeth from units 4A-CHE and 4A-POC have the strongest correlation to the Neandertal child, which suggests that the remains were deposited during the gully event;
- the mandible was a 'green bone' when it was broken into two parts;
- the two halves of the mandible differ in colour and have different taphonomical properties, indicating that they were embedded in different sediment before the majority of their taphonomic alteration began. This suggests that the Neandertal remains were not (at least not completely) fossilized when they were incorporated into different layers within Unit 4A-CHE.

These are fully compatible with the following stratigraphic arguments:

- the oldest stratigraphic unit that has yielded Neandertal remains is Unit 4A-CHE;
- all of the Neandertal remains assigned to 4A-CHE are from the top of the unit, suggesting that these objects were incorporated during the last stages of the gully's formation;
- their spatial distribution, restricted to the course of the 4A-CHE gully, suggests they are strictly associated with this structure, even if they were later reworked from the top of Unit 4A-CHE into the low energy Unit 4A-POC, probably through run-off.

Along with the reappraisal of the stratigraphic sequence, the palaeoenvironmental data and chronostratigraphy of the Scladina sequence were also re-examined (Pirson, 2007; see Chapter 4). The new palaeoenvironmental framework is mainly based on new results from palynology, anthracology, as well as climatic signals recorded in the sediments themselves through the observation of sedimentary dynamics and post-depositional processes. These results correlate with the data from literature that was based on the former stratigraphic record (e.g., Cordy & Bastin, 1992). Overall, the palaeoenvironment results from all the available disciplines are in agreement. The data for Unit 4A-CHE indicates cold conditions, which is logical considering that the gully is interpreted as a result of the degradation of a deep frozen soil (melting structure).

The chronostratigraphic framework of the entire Scladina sequence was also reconsidered, based on all the available data sets: numerical dates (luminescence, radiocarbon), biostratigraphy, archaeostratigraphy, comparison with the loess reference sequence from Middle Belgium (heavy mineralogy, lithological, and pedological markers), and climatostratigraphy. This reappraisal concludes that most of the Scladina deposits can confidently be positioned in the Upper Pleistocene. However, the chronostratigraphic framework of Scladina is still quite imprecise. Several situations still need more attention, such as the location of the beginning and end of MIS 5 in the sequence. Interpreting the age of the Unit 4A-CHE gully relies on the integration of climatostratigraphy and heavy mineralogy, especially the green amphibole contents when compared with the data from the loess reference sequence (see Chapter 4). The main arguments are:

— in the lower half of the sequence, from units 7A to 2B, strong green amphibole values (ca. 20%) were recorded, suggesting the reworking of either MIS 6 loess or MIS 4-2 loess;

— between units 7A to 2B, two units (Unit 6B, former Layer 6; Unit 4A-IP, former Layer 4A) indicate temperate forest conditions, compatible with an interglacial or an early glacial interstadial, notably through palynological and macrofaunal data as well as the presence of major stalagmitic floors;

— combining the first two arguments allows the reworking of MIS 4-2 loess to be discarded as a hypothesis and supports the reworking of MIS 6 loess during MIS 5, in the sequence from Unit 6B to Unit 4A-IP. The available U/Th and TL dates obtained on speleothem CC4 (Unit 4A-IP) are in agreement with the MIS 5 interpretation. With a strong climatic improvement evidenced in MIS 5 (Unit 6B), Unit 4A-IP (and Speleothem CC4) must be positioned in either MIS 5c and/or MIS 5a;

— higher up in the sequence, Unit 2A is interpreted as the first allochthonous loess input of MIS 4, and Unit 2B is best interpreted as representing the end of MIS 5a (see Chapter 4).

Following these arguments, and combining them with the complexity of the Scladina sequence, there are several possible interpretations for the chronostratigraphic positioning of the cold episode represented by Unit 4A-CHE and the associated Neandertal remains, the most probable being the following:

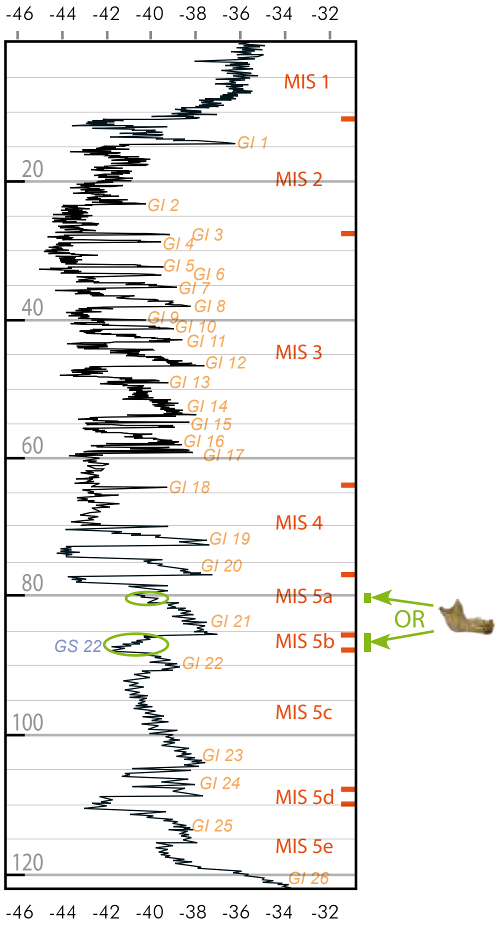

Figure 2: The two best hypotheses attributing the Scladina I-4A juvenile Neandertal remains in either GS 22 (MIS 5b) or GI 21 (MIS 5a), in the NorthGRIP sequence (modified after NorthGRIP-Members, 2004; Andersen et al., 2007).
GI = Greenland interstadial; GS = Greenland stadial.

- if CC4 corresponds to MIS 5c temperate conditions, 4A-CHE would be part of MIS 5b colder conditions (GS 22 of the Greenland record, between GI 22 and GI 21, around 87,000 BP; NorthGRIP-Members, 2004); in this case, the Scladina Child would be contemporaneous with the Remicourt lithic assemblage (Bosquet et al., 2011; Pirson & Di Modica, 2011);
- if CC4 corresponds to the 'warmer' first half of MIS 5a, 4A-CHE would belong to the intra-MIS 5a cooling (intra-GI 21, ~80,000 BP);

The best hypothesis attributes the whole sequence from Unit 6B to Unit 2B to part of MIS 5; the gully from Unit 4A-CHE is placed in either MIS 5b or MIS 5a. Therefore, the Scladina Child would have lived either ~87,000 years ago, or ~80,000 years ago (Figure 2). This chronostratigraphic hypothesis is consistent with the morphometrical and the diet studies of the fossils (see below, § 2.2.2. & 2.2.5).

2.2. Palaeoanthropology

2.2.1. Morphology

The morphology of the Scladina juvenile mandible exhibits a general pattern that is quite characteristic of Neandertals. Indeed, the fossil shows a typical association of some characters either derived Neandertal or, without being derived, frequent on this taxon; all of these characters fit well with the collection of Neandertal mandibles of similar ages (Chapter 10). Statistically, comparative analysis of the shape of the mandible in the context of ontogenetic and adult variation of Neandertals and modern humans (Chapters 10 & 11) shows that the fossil has features that distinguish Neandertals from modern humans.

The Scla 4A-2 maxilla is a small fragment of the right midfacial region that is comprised of part of the alveolar and palatine processes, as well as a small part of the body (Chapter 12). The fossil is consistent with Neandertal maxillae with regards to the bilevel configuration of its internal nasal floor and its rather high estimated subnasal height. The anterior part of its dental arcade does not seem very large and the location of its zygoalveolar crest is not as posterior when compared to other similarly aged Neandertals.

The crowns of the 24 teeth from the mandible and maxilla have been examined from anatomical and statistical perspectives (Chapter 13). Regarding the taxonomic allocation, the teeth fit very well in the characteristic Neandertal pattern, even if, as for the teeth from similar sites, they do not exhibit characteristics that are exclusively Neandertal. Mesiodistal and buccolingual diameters of all crowns were compared to samples of Early and Late Neandertals (EN and LN), Middle Palaeolithic Modern Humans (MPMH), Upper Palaeolithic Modern Humans (UPMH), and Modern *Homo sapiens sapiens* (MHSS) using univariate methods, i.e. probabilistic distances (DP), *écart centré réduit ajusté* (ECRA), as well as bivariate equiprobable ellipses. Regardless of the method, significant differences between Scladina and MHSS are present. Slight differences exist for the UPMH comparison sample. By contrast, the Scladina teeth crowns are never different from those of Late Neandertals and rarely from Early Neandertals and MPMH.

The analysis of the Scladina teeth enamel thickness (Chapter 14) confirms, using 3D μCT data, that Neandertals have lower average enamel thickness and relative enamel thickness indices than *Homo sapiens*, and that molars, premolars, canines, and possibly also incisors, have a different trend, with premolars having generally larger relative enamel thickness index than molars, while the canines have the lowest values. Tooth root morphology has been shown to taxonomically differentiate Neandertals from modern humans, for both anterior (incisors and canines) and posterior (molars) teeth (Chapter 16). Compared to MIS 5 Neandertals, Scladina I-4A has the shortest root dimensions relative to its crown sizes. Scladina has also an anterior tooth root shape similar to other Neandertals. Moreover, the molar roots are lacking any degree of taurodontism.

2.2.2. Scladina, Early or Classic Neandertal?

Following the accretion model, the Neandertal evolution comprises four Neandertal 'stages' (Dean et al., 1998; Hublin, 1998): stage 1 or "Early-Pre-Neandertals", before and during MIS 12, with fossils such as Arago and Mauer; stage 2 or "Pre-Neandertals" from MIS 11 to 9 with Atapuerca (Sima de los Huesos) or Steinheim (no specimens are placed in MIS 8 according to the accretion model; Dean et al., 1998); stage 3 or "Early Neandertals" during MIS 7-5 with, for instance, Ehringsdorf, La Chaise, or Lazaret; stage 4 or "Classic Neandertals", during MIS 4 and 3 with Feldhofer, Spy, La Chapelle-aux-Saints, La Ferrassie, Le Moustier, La Quina, etc. The morphological division between stage 4 and stage 3 of the evolution of Neandertals is the least clear, as some late 'Early Neandertals' of MIS 5, such as Saccopastore or La Chaise, Abri Bourgeois-Delaunay, exhibit intermediate conditions between Early and Classic Neandertals (Dean et al, 1998).

Condemi (2000)'s views are not so different, especially regarding MIS 5 to 3: "Proto-Neandertals" during stage 5, which correspond to the "intermediate condition" of the accretion model, and "Classic Neandertals" dating back to stage 4 and stage 3 (see also Condemi, 2005).

For Serangeli & Bolus (2008), "Early Neandertals" are younger than 200,000 BP but pre-Weichselian, while "Classic Neandertals" appear in the largest number during the Weichselian, ca. 115,000 years ago, which is near the beginning of MIS 5.

In the context of these models, what is the place of the Scladina I-4A juvenile specimen in Neandertal evolution? The morphology of the incisors and canines, as well as the occlusal surface of the premolars and molars, present some combinations of features that give them a general Neandertal appearance (Chapter 13). Metrically, MD and BL diameters of the Scladina teeth correspond quite well to Early and Classic/Late Neandertals of the accretion model. For some attributes, they are not closely related to Early Neandertals but correspond well to Late Neandertals instead. Intraspecific temporal variation in enamel-dentine junction (EDJ) morphology confirms the intraspecific taxonomic position of Scladina, which is closer to that of the Classic Neandertals than to the Early Neandertal sample (Chapter 15). In addition, the tooth root size is most comparable with the Neandertals of MIS 5, with the exception of MIS 5e (Chapter 16). In addition, using ECRA, the mandible seems closer to EN than LN. Therefore, the best hypothesis is to consider Scladina as a "Classic Neandertal", but with subdividing a continuum, these fossils can be considered an "old Classic Neandertal" — "Proto-Neandertal" from Condemi's perspective and "intermediate condition" of Dean et al.'s view — particularly when compared to Late Neandertals, such as Spy. The morphology of the Scladina teeth seems consistent with the best chronostratigraphic hypothesis for the fossils, i.e. MIS 5b or 5a.

2.2.3. Age at death

The final estimation of the dental age of the Scladina Juvenile, proposed in Chapter 8 (see also Smith et al., 2007), was performed using a histological method that potentially offers the most reliable and accurate results. Based on this, the Scladina Child appears to have died at 8 years old.

However, summarizing the estimation of the age at death previously obtained at Scladina by conventional anthropological methods — the study of tooth maturation, mainly the beginning of calcification; calcification scoring dental; tooth emergence; growth of the roots; and root completion — and then comparing these results to those of histology is very useful.

Based on this, a preliminary report concluded that "[i]f the criteria of age linked to dental eruption and to the formation of molar roots observed in modern humans are applied to Neandertals, the Child of Sclayn [...] would have been at least 12-13 years old. The persistence of deciduous molars could however indicate a younger age, probably not more than about ten years" (Toussaint et al., 1998: 740). More recently another perspective was used: "[d]ental age determination compared with cutting teeth and molar root formation in modern humans suggest that the child died at age 12, yet the persistence of deciduous molars is consistent with a younger age, but probably not less than 10" (Toussaint & Pirson, 2006: 382-383).

In two methodological studies, Granat & Heim (2001, 2003) developed a new model for dental maturation that estimates the age at death of Neandertals without referring to the classic modern populations dental growth tables. Several postulates forced the authors to mention a 'suspected age', i.e. an age relative to the onset of maturation that is considered identical in both Neandertals and modern humans, rather than an absolute age. Among these postulates is the age of only the central deciduous incisors as estimated from modern populations' dental growth tables, as well as the notion that the deciduous teeth, incisors, canines, and first molars of Neandertals begin calcifying at the same time. They proposed two methods, one using two mathematical formulas and the second using a graph; both of them yield the age of a Neandertal from the degree of maturation of his/her deciduous and permanent teeth, but the graphical approach is clearly more approximate. Although it has been nearly 15 years since it was established, the palaeoanthropological community only minimally uses this new approach. Comparing results from these methods with results obtained by histological determination of the individual's age offers a valid test of their applicability. Individually, the teeth of Scladina provide an age range from 7 years 8 months to 10 years 6 months, with most of them ranging between 8 years 3 months and 8 years 9 months. The average is therefore 8 years and almost 6 months. Histological techniques and Granat and Heim's method yield similar results for the Scladina Child: only 6% older for Granat's technique compared to 25% older when the minimal average age of 10 obtained through traditional methods are taken into account. Despite its lack of acceptance in the anthropological community, Granat and Heim's technique provides an interesting perspective, although it slightly overestimates the age.

2.2.4. Sex

Numerous sex determination techniques, based either on morphological traits or on metric differences, have been developed for adult bones, but they were mainly developed from modern human skeletons of known age and sex. Regarding juveniles, there are no really precise sex diagnosis techniques.

At Scladina, these problems exist: the remains belonged to an 8-year-old child, traits commonly used for sexing modern humans are not accurate enough for Neandertals, and mandibles and maxillae are not the most accurate bones to use for determining sex.

The dental technique developed by Oxnard (1987) avoids the pitfall of applying modern human measurements to other taxa by using the bimodal appearance of some dimensions of the crowns of teeth, as it is largely acknowledged that the size distribution of some teeth, particularly the canines, show the greatest differences between males and females. On this basis, the Scladina Juvenile may have been female (Chapter 9).

Other evidence from the histological study and the study of tooth roots align with the same interpretation. Based on the Scladina teeth, perikymata numbers fall either near the low end or below the values reported for other Neandertals, which, based on comparisons with other fossils, may provide another argument for the determination of Scladina as a female (Chapter 9). The Scladina tooth roots are very short and fall within the lower end of the Neandertal variation. In addition, the pulp cavities are very large. Both arguments support the hypothesis that the Scladina Child is female (Chapter 16).

The dimensions of the mandibular body are relatively small when compared with other Neandertal mandibles of similar ages at death. Even if this is body size dependent, it could tentatively support the hypothesis that the fossil is female (Chapter 9).

Although none of these indices are determinant, and even if it is extremely difficult to estimate the sex of the Scladina Juvenile, the conjunction of the various analyses presented in this monograph suggests a female trend.

2.2.5. Diet and environment

At Scladina, both techniques used for the reconstruction of the child's diet, carbon/nitrogen isotopic signatures (Chapter 17) and tooth microwear patterns (Chapter 18), indicate that the child mainly ate meat. However, the microwear data also reveals that the diet of the child most likely included small amounts of abrasive plant foods.

In this regard, and throughout Europe, it seems that the Neandertal diet may significantly differ in response to the changes in palaeoecological context, with increased consumption of plant foods with the expansion of tree cover and the use of meat in cold, open, steppic conditions (El Zaatari et al., 2011; see also Chapter 18). Scladina microwear texture is within the range of Neandertals who lived in both open and wooded habitats, but appears closer to the former group, which is somewhat expected in the context of a cold episode from the second half of Weichselian Early Glacial. To complete this information, studying starch grains and phytoliths in calculus on teeth could confirm the consumption of a variety of plant foods, such as with the Spy I and II specimens (Henry et al., 2011). However, the Scladina teeth are not clearly encrusted with visible deposits of calculus, possibly because of the individual's young age.

3. Some perspectives for the Neandertal research in the Belgian Meuse River Basin

3.1. Scladina

At Scladina, the study of Neandertal remains still offers interesting prospects, both in the field and laboratory.

In the cave, Sedimentary Complex 4A, which yielded the Neandertal remains, is far from being completely excavated (see Chapter 7). In addition, the Middle Palaeolithic context situated near the top of the cave in former Layer 1B is not all excavated and has already yielded some human remains. Their analyses have not yet been completed.

The origin of the Neandertal remains and how they became interred in Sedimentary Complex 4A is also unknown, so excavation will undoubtedly continue.

The re-examination of the available sedimentary profiles at the cave entrance is also promising in terms of providing new results.

During the final stages of preparing this monograph, the remains of the child were shown to date from the end of Weichselian Early Glacial (most probably MIS 5b or 5a). This is a significant improvement over the previously assumed age, which ranged from MIS 6 to MIS 4. However, new palaeoenvironmental research to be undertaken in parallel with the ongoing excavations will confirm or deny the new MIS 5b-5a interpretation.

Analysis of the fossils will undoubtedly continue. Ongoing research on the potential use of strontium as a marker of Neandertal movement between different ecological niches is a good example (Verna et al., 2014). Hopefully the current edition of the monograph will inspire researchers to continue analysing the Scladina remains, incorporating them in different aspects of Neandertal research.

3.2. Other sites

The chronology of Neandertals in the Meuse River Basin, although relatively well established, still lacks precision (Chapter 20). This will likely be improved in the future by using new radiocarbon dates, especially when these methods better control the effects of pollutants (glue, varnish), which have made some dates, such as Engis 2, appear too young. Improvements in ^{14}C dating methods may eventually allow the acquisition of dates for fossils that are older than what can be currently dated.

New discoveries of Neandertal remains are likely to continue, even from museums and private collections as recently demonstrated with the examples of Spy and Goyet. At Spy Cave, the careful analyses of many skeletal remains collected by François Twiesselmann's team in the 1950s from the debris accumulated on the slope between the cave and the Orneau River (Rougier et al., 2004), as well as the purchase of a private collection of material from the site (Semal et al., 2009), led to the discovery of various previously unidentified Neandertal remains. These findings have also triggered a new comprehensive analysis of anthropological and archaeological material discovered at Spy since 1886, which led to the publication of a large monograph (Rougier & Semal (eds.), 2013, 2014 in press). In the caves of Goyet, the excavations of 1998 on the terrace and in the main cave did not yield palaeolithic human remains (Toussaint et al., 1999); most of the sediments were removed by E. Dupont in the 1870s and his many successors without the use of detailed stratigraphic records. In contrast, since 2004 numerous human remains from the Upper and Middle Palaeolithic were discovered in the collections of the Royal Belgian Institute of Natural Sciences. Although retrieved by Dupont nearly a century and a half ago, they had never been analysed in detail (Rougier et al., 2014).

Most of the caves where Neandertal remains have been discovered no longer have any significant amount of in situ sediments, making new anthropological discoveries and the acquisition of geological and palaeoenvironmental data next to impossible. This is the case at Engis and Spy, where only the sieving of debris from old excavations on the slope in front of the cave at Spy and at the bottom of a small quarry dug adjacent to the cave at Engis may yield finds. At Fonds de Forêt, the excavations completed ten years ago (before the installation of fences to protect bats) yielded only contaminated or sterile sediment (Toussaint & Pirson, 2004). At Couvin, after the 1984 excavations (Cattelain & Otte, 1985), research undertaken between 2009 and 2012 discovered in situ sediment, including some Middle Palaeolithic artefacts, although the area was quite limited and no new humans remains were discovered (Miller et al., 2014). In Walou Cave, most of the sediment was excavated during two excavation campaigns: 1985 to 1990 (Dewez dir, 2008) and 1996 to 2004 (Draily, 2011; Draily et al. (dir.), 2011: Pirson et al. (dir.), 2011). In Goyet, as the terrace and the third cave were carefully excavated by E. Dupont and his successors, secondary sites on a nearby cliff, including an intact entrance recently found below the upper rock shelter, provide the best possibility.

Except Scladina, La Naulette provides the best opportunity for new in situ anthropological discoveries out of the sites that have already yielded Neandertal remains, even if the dating of the fossils is very imprecise. The human remains from La Naulette could be the oldest from the Meuse Basin. During some short field campaigns that have been conducted since 1999 (Toussaint et al., 2000), backfill obstructing the cave was removed. In situ sections left by E. Dupont in 1866–67 were partially recovered. The continuation of this field program aims to excavate the in situ sediment, study palaeoenvironmental deposits, and hopefully find new human remains.

At Montignies-le-Tilleul and Le Tiène des Maulins, two other karstic sites which supposedly have already yielded Neandertal remains (Otte, 1986; Groenen, 2005), numerous analysis have to be carried out before deciding whether or not to add them to the list of Neandertal sites in Belgium (see Chapter 20).

Due to the limited number of opportunities for new anthropological discoveries in the currently available karst sites, new multidisciplinary excavations are absolutely necessary for finding well-contextualized fossils, ideally in unexcavated sites or in caves where human remains have not yet been found. Ongoing research at Trou Al'Wesse, in Petit-Modave in the Hoyoux Valley, could become particularly interesting; excavations undertaken in the 21st century at the site (Miller et al., 2007), which was only partially excavated during the 19th century, provided Mesolithic, Aurignacian and Middle Palaeolithic layers.

However, due to the relatively limited palaeoanthropological potential of the ongoing excavations in Middle Palaeolithic karstic sites an intensive survey program is needed to expand our knowledge of regional Neandertals. Such a program would require a lot of work before providing results, as, so far, all the regional Neandertal remains were discovered in large sites, and most of these sites, such as Engis, Spy, Goyet, or Fonds de Forêt, are highly visible on the landscape and were identified long ago, especially because speleology was very extensive in the region. In this context, finding intact sites like Walou and Scladina in the 20th century is extremely rare. Their discovery shows the extreme importance of developing contacts with speleologists.

When a new cave or rock shelter is discovered with archaeological and anthropological potential, research there must be undertaken from a multidisciplinary perspective. A Quaternary geologist should be present from the beginning of excavations, together with palaeontologists, prehistorians, palaeoanthropologists, and experts in many other disciplines. The importance of understanding the stratigraphic details and the sedimentary depositional phenomena is critical to any palaeoenvironmental, palaeontological, or archaeological interpretation of a karstic site.

In laboratories, the prospect of regional Neandertal anthropology remains large, as well as throughout all of Eurasia, especially with the constant development of new investigation techniques, such as 3D reconstruction with computer tomography, isotopic biogeochemistry ($^{13}C/^{15}N$, Sr, Ba, etc.), histology, and DNA extraction (especially nuclear DNA). Scladina will be very important for developing these future methods due to the relatively large number of fossils discovered at the site and the opportunity for future geological and palaeoenvironmental studies to be done.

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