Oral health and childhood stress during the Final Neolithic in *Grotte de la Faucille* (Sclayn, BE)

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1. Introduction

The Neolithic package first emerged in Anatolia and the Aegean (*ca.* 8000 cal BC) before it spread through Western Europe and Central Europe (Hofmanová *et al.*, 2016; Olalde, 2018; Price, 2000; Whittle, 1996). In Belgium, the Neolithic way of life arrived around 5300 cal BC, with migrating farmer-herders that settled in relatively small regions of Middle Belgium (Crombé *et al.*, 2015; Crombé & Robinson, 2014; Crombé & Vanmontfort, 2007; van Berg & Hauzeur, 2001). The Neolithic gradually expanded over the entire region of current Belgium through further colonisation and contact and exchange with local hunter-gatherers (Crombé, 2010; Messiaen *et al.*, 2018; Teetaert, 2020).

Archaeological and anthropological remains have been recovered from more than 200 karst caves in the Belgian Meuse basin (Toussaint & Pirson, 2007). About a dozen of the caves were used by Mesolithic hunter-gatherers, and more than 120 caves functioned as funerary places for Neolithic agro-pastoralists (Toussaint, 2007). Most cave depositions are dated to the Late (2nd half 4th-millennium cal BC) and Final (3rd-millennium cal BC) Neolithic, but many are known from the Middle Neolithic (*ca.* 4300-3700 cal BC) as well (Toussaint, 2007). Most Neolithic funerary caves contain commingled human remains of five to 15 individuals, although several reached remarkably high minimum numbers of individuals (MNI), including Bois Madame in Burnot (57 individuals, Dumbruch, 2003), Sclaigneaux, near Sclayn (58 individuals, De Paepe & Polet, 2007), and Caverne de la Cave in Maurenne (56 individuals, Vanderveken, 1997). The human remains from cave deposits are the main source of information about early agro-pastoralist in the Belgian Meuse Basin. However, their commingled and fragmented state limits the possibilities of osteological and dental anthropological analyses.

Thousands of human teeth were found in the Neolithic caves of the Belgium Meuse basin. Recent studies of the human teeth from the Neolithic caves in Belgium include the analysis of molar morphology and dental microwear in the populations from the large sites Bois Madame, Sclaigneaux, and Caverne de la Cave (De Paepe & Polet, 2007; Sherrill & Williams, 2019; Williams *et al.*, 2018; Williams & George, 2021; Williams & Polet, 2017). However, no recent detailed studies of stress markers and oral health, or anthropological studies of complete dental samples, are available in the literature. The study of dental wear, calculus, caries, and enamel defects can shed light on childhood stress (Armelagos *et al.*, 2009; Orellana-González *et al.*, 2020; Steckel, 2005), subsistence practices and diet (Bertilsson *et al.*, 2022; Formicola, 1987; Lieverse *et al.*, 2007; Nicklisch *et al.*, 2016, 2022; Smith, 1984) and oral health (Clark *et al.*, 2020; Pilloud & Fancher, 2019; Willis & Oxenham, 2013). This study is part of an ongoing project, which combines molecular archaeological-, osteological-, and dental anthropological analyses to gain insights into the life histories and lifeways of the Neolithic people of Belgium (van Hattum *et al.*, under review, van Hattum *et al.*, in prep.).

1.1. Grotte de la Faucille

The archaeological site *Grotte de la Faucille* is a karstic cave in the valley of the Fond des Vaux in the Province of Namur in Belgium (Fig. 1). Based on a series of new radiocarbon

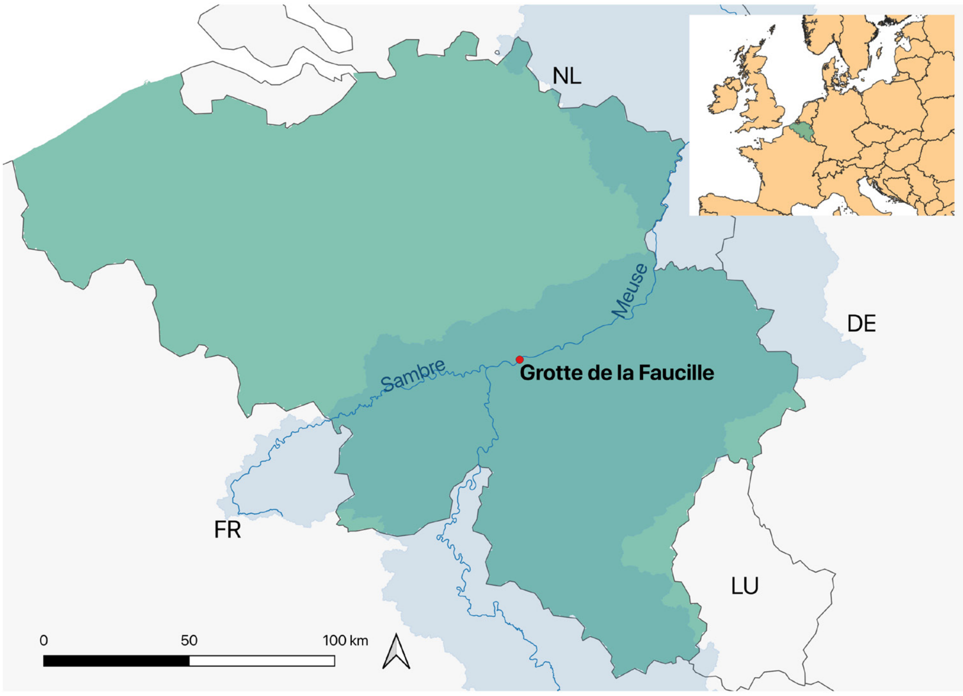

Fig. 1 – Map of Belgium with the location of *Grotte de la Faucille* in the Meuse Basin.

dates on human bone, it appears that the site was in use over a period of 239 and 432 years (2 sigma), with a mean start and end date of 2865 and 2485 cal BC, respectively (De Groote *et al.*, 2022). Despite the small area (less than two cubic meters) thus far excavated inside the cave, the human remains from the site are already one of the largest Neolithic skeletal assemblages recently excavated in Belgium (De Groote *et al.*, 2019, De Groote *et al.*, 2022).

1.2. Oral health

Information about oral health can help answer research questions about subsistence, dietary practices, and general health in populations. This study records four conditions to assess oral health: dental wear, calculus, caries, and periodontal disease. Dental wear is not a pathological condition but is associated with oral health, as severe wear can impact mastication, may cause pain, and can lead to periodontal disease.

1.2.1. Calculus

Calculus is a mineralised dental plaque that accumulates on tooth surfaces. During life, calculus is covered with a film of bacterial plaque, which facilitates periodontal disease and its associated bone responses (Hillson, 1996; Roberts & Manchester, 2007). Calculus occurs most often (and severe) on the lingual part of anterior teeth and the buccal surfaces of molars (Hillson, 1996). Calculus attached to the dental enamel is called supra-gingival calculus. It starts at the cervical area of the crown and can progress upward and outward into a thick layer that covers the crown or can accumulate between adjacent teeth. Calculus can also form on tooth roots. This form is referred to as sub-gingival calculus.

1.2.2. Dental caries

Caries are the most common form of dental pathology. They can affect dental enamel, dentine, and dental cementum, and involve progressive decalcification of these tissues. Caries are caused by bacteria in dental plaque, which convert carbohydrates and sugars in food and drink into acids to slowly destroy the dental tissues (Hillson, 1996). The frequency and severity of caries are related to different factors, including diet, dental shape, and oral hygiene (Powell, 1985: 317).

Carious lesions are often found in tooth crown fissures but can occur on all surfaces, including the root (Hillson, 1996). In enamel, they start as a microscopic smooth white or brown spot, progressing into a spot visible to the naked eye that may develop into a cavity. Carious lesions can also form in the cementum of a tooth root when exposed by periodontal disease. They can form shallow lesions that spread sideways along the circumference of the root and can rapidly penetrate the dentine. When carious lesions progress and remain untreated, they can lead to severe decay, the destruction of entire teeth, infectious dental disease, and antemortem tooth loss (Hillson, 1996).

Compared to canines and incisors, premolars and molars are more prone to caries due to their morphologically complex crowns. Due to this variation in susceptibility, it is important to take tooth type into account when prevalence rates between populations are compared.

1.2.3. Periodontal disease and antemortem *tooth loss*

Periodontal disease refers to the chronic inflammation of the soft tissues and maxillary or mandibular bone supporting the teeth. It starts as an inflammation of the gums (gingivitis), which may progress to the alveolar bone. The inflammation leads to gradual bone resorption, loss of periodontal ligaments, and subsequent tooth loss. Only infection of the alveolar bone (periodontitis) can be recognised in archaeological human remains. The aetiology is multifactorial, but accumulating dental plaque and calculus are known to be primary factors (Roberts & Manchester, 2007). Besides oral hygiene, other important factors that may contribute to the development of periodontal disease are genetics, the immune system, diet, and progressing age (Cochran, 2008; Roberts & Manchester, 2007). When progressed, periodontal disease or severe attrition expose a pulp cavity, and the tooth is prone to bacterial infection. Abscesses may then form in the surrounding alveolar bone due to the accumulation of pus in the tooth's pulp cavity (Roberts & Manchester, 2007).

1.3. Wear patterns

Dental wear is related to subsistence and provides direct evidence for masticatory behaviour (Smith, 1984). Examining the rate, pattern and angle of wear can help assess past diet and food procurement strategies (Hillson, 2014). Over time tooth crowns are worn down by the abrasive properties of food, chewing and the associated tooth-on-tooth contact. Teeth move slightly when used, which leads to tooth-to-tooth attrition and wear at the medial and distal surfaces of adjacent teeth (Scott & Turner, 1988). Most archaeological populations show severe dental wear relative to our modern-day standards.

Studies have revealed that farming populations generally have different patterns of molar use wear than hunter-gatherer groups (Smith, 1984; Walker *et al.*, 1991). Different rates of wear in buccal and lingual cusps result in different angles in the occlusal planes of molars. Agriculturists show more oblique wear planes, while hunter-gatherers are characterised by flatter planes (Smith, 1984). Smith (1984) related the increased wear of the occlusal surface to changes in subsistence and food procurement. The diet associated with agricultural subsistence comprises less tough and less fibrous foods but contains dietary grit from grinding stones, which results in steeper wear planes (Smith, 1984). Watson (2008) also provided evidence that the rate and angle of the wear may reflect changes in food-processing techniques.

1.4. Enamel hypoplasia

Enamel hypoplasia is a disturbance in enamel thickness caused by temporary upsets of ameloblastic activity and reflects episodic disruptions of development (Goodman & Rose, 1990). There are three types of defects: furrow, pit, and plane (Hillson, 1996). The most commonly studied defect is the furrow-type defect linear enamel hypoplasia (LEH). LEH is a non-specific stress marker which can be caused by disease, periods of malnutrition, famine, and temporary metabolic disturbance during tooth formation (Hillson, 2014). Among bioarchaeologists, it is considered a reliable marker of growth disruption and is a common non-specific stress indicator to study general health in past populations (Hillson, 1996). Many studies have looked at the changes in the prevalence of LEH related to subsistence change and diet (Roberts & Manchester, 2007).

LEH is characterised by bands of reduced enamel thickness disrupting the smooth enamel surface of the crown, following the incremental growth lines on the crown (perikymata). Several bands can form above one another on the same tooth at irregular intervals. LEH can occur on both deciduous and permanent teeth but is most prevalent on the latter. It occurs most often on the labial surfaces of the anterior dentition but can be found on the cervical areas of posterior teeth (Hillson, 1996). These defects have been studied more and are better understood than pit- and plane-type defects.

2. Materials

For this study, an inventory was made of all (permanent and deciduous) dental elements, maxillae and mandibles thus far recovered from *Grotte de la Faucille*. This study entails the dental anthropological analysis of 229 teeth, two fragmented maxillae and five partial mandibles recovered during the initial survey in 1999 and excavation seasons in 2016, 2017, 2020, and 2022.

Because of the high number of isolated teeth and commingled state of the remains, data were documented using a count per tooth or alveolar socket rather than by individual. Of the teeth still in their alveolar bone, only erupted teeth are included in the analysis of dental caries, calculus, enamel defects and dental wear. Abbreviations are used to refer to the different permanent teeth of the dental arcades: UI/LI = upper/lower incisor, UC/LC = upper/lower canine, UP/LP = upper/lower premolar, and UM/LM = upper/lower molar. The number following the abbreviation, *i.e.*, in LP2 or UM3, indicates that it is a second premolar or an upper third molar, respectively. The abbreviations for the deciduous teeth are in small caps and start with the letter d. As there are no premolars and third molars in the deciduous dentition, abbreviations are dui1, dui2, duc, dm1, dm2, and dli1, dli2, dlc, dlm1, dlm2.

3. Methods

3.1. Minimum number of individuals and age estimates

To establish a minimum number of individuals (MNI), tooth types and sides were identified for isolated teeth. To avoid an underestimate of the MNI, age, unerupted dentition in mandibles/maxillae, and antimeres (opposite tooth from the same individual) were considered. Antimeres were matched by visual inspection and comparison of all left and right teeth from the same dental element. Age estimations for permanent teeth were established based on the crown and root formation stages using the London Atlas by Al Qahtani *et al.* (2010). For deciduous teeth, age estimations were made on root and crown formation stages or root resorption stages based on the system by (Moorrees *et al.*, 1963) and Al Qahtani *et al.* (2010).

All teeth, except the third molars, are fully developed by the age of 18 years (Al Qahtani *et al.*, 2010), making it difficult to distinguish adults from juveniles once roots have closed apices. The apex of the third molar generally closes between the age of 21 and 23, making it an exception; however, here, we refer to permanent teeth without fully formed roots as 'juvenile' teeth.

Although tooth wear is known to progress with age, it is not possible to determine age for isolated teeth with a closed apex, especially as wear patterns based on isolated teeth are not reliable for ageing. This is especially the case in commingled assemblages where tooth wear has not been associated with skeletal age due to a shortage of dentitions with securely associated skeletal remains for age estimations. In addition, light or moderate wear may also be caused by an absence of contact with opposite maxillary/mandibular teeth due to malocclusion or antemortem tooth loss (AML), but this is impossible to assess in this assemblage.

3.2. Oral Health

3.2.1. Dental Caries

Dental caries were examined macroscopically. A lesion was identified as carious when cavitation was clearly observable. A distinction was made between caries of the crown (coronal caries) and root (root surface/cemento-enamel junction (CEJ) caries) (Hillson, 2001). For each lesion, the location on the crown or root was specified. Large lesions were scored as gross caries if it was no longer possible to discern where in the tooth the lesion originated. Collecting data per tooth or alveolar socket allowed the calculation of caries frequency (number of teeth affected). Caries prevalence, defined as the number of individuals in the population with caries lesions, could not be calculated due to the commingled state of the human remains. Caries prevalence per tooth type was calculated as the percentage of affected erupted teeth per tooth type.

3.2.2. Calculus

Calculus was examined macroscopically and recorded following the scoring system described by Buikstra and Ubelaker (1994) with minor adjustments described below. The presence and severity of calculus was scored per tooth on a four-point scale (0 = absent, T = trace, 1 = small amount, 2 = moderate amount, 3 = large amount, unobservable is scored as 9), noting the location of calculus on the tooth (lingual/labial). The T was added to the scale to document minimal amounts of calculus (*i.e.*, small thin patches that did not form a rim). Also, calculus can easily be detached from teeth. It must be kept in mind that the presence or severity may be underestimated due to detachment related to post-depositional processes. Frequency of occurrence of calculus (per tooth type and the total dental sample), and prevalence per tooth type (percentage of teeth with calculus per tooth type) were calculate.

3.2.3. Periodontal disease

This study applies a simplified version of a scoring system by Kerr (1988) as proposed by Tomczyk *et al.*, (2017). This method distinguishes four stages of alveolar reduction: no reduction, slight reduction, moderate reduction, and considerable reduction.

To assess oral health, the absence or presence of teeth in the alveolar bone was recorded per alveolar socket. Empty sockets were scored as either antemortem tooth loss (AML) or post-mortem tooth loss (PML). Unerupted teeth were documented as unerupted (UE), although this can be difficult to determine for third molars, which erupt around 20 years of age. The alveolar bone was checked for evidence of abscesses that were identified following the criteria described by Lukacs 1989). An abscess is scored as present if a spreading pathological process has destroyed the external bone surfaces of the jaw.

3.2.4. Wear patterns

For anterior teeth, attrition was recorded by scoring the pattern of exposed dentine, following Smith (1984). For molars, severity was scored according to the classification by Brothwell (1981), which provides a 17-step scale per tooth type, ranging from grade 1 to 7. This method is most frequently used in bioarchaeological studies and is recognised as a standard method (Buikstra & Ubelaker, 1994; Hillson, 2005). Occlusal angle and wear planes were recorded in isolated and in situ teeth following the method by Molnar *et al* (1972).

3.2.5. Enamel defects

Enamel defects were studied macroscopically, either with or without the aid of a 10x magnifying glass. A distinction was made between defects confirmed under magnification and those visible without magnification, regardless of the angle of light. The teeth were examined for the following enamel defects: linear enamel hypoplasia (LEH), linear vertical grooves, linear horizontal pits, nonlinear arrays of pits, and single pits.

In the case of LEH, the number of lines was recorded and assigned to the following sections, which each represent one-third of the crown height: occlusal, middle, or CEJ, as advised by Kacki (2016).

4. Results and discussion

4.1. The recovered deciduous and permanent teeth

Of the 229 human teeth, 199 were found in isolation, 24 were in alveolar sockets of five fragmented mandibular bodies, while only six teeth remained in situ in two fragmented maxillae.

Of the total sample, 47 are deciduous and 182 are permanent, of which 51 are identified as 'juvenile' teeth. Based on the developmental stages of the root or crown, 23 unerupted teeth could be identified amongst the juvenile sample. The juvenile dental sample also includes three right third molars from individuals of 15 to 20 years old (yo) and may represent individuals of adult age at death. Thus, at least 95 of 229 teeth (41 % of the sample) came from juveniles.

Tab. 1 and Tab. 2 present an overview of deciduous and permanent teeth, specifying the recovered number per tooth type and side. For the permanent dentition, the number of

	Left				*Right*					
Element	*n left*	*n Ac*	*n Juv*	*n UD*	*n right*	*n Ac*	*n Juv*	*n UD*	*total*	*MNI*
UI1	*8*	8	-	-	*8*	7	1	-	16	9
UI2	*9*	8	1	-	*4*	2	2	-	13	10
UC	*6*	5	1	-	*7*	7	-	-	13	7
UP1	*4*	4	-	-	*4*	4	-	-	8	4
UP2	*7*	6	1	-	*4*	2	-	2	11	7
UM1	*1*	1	-	-	*2*	1	1	-	3	2
UM2	*1*	1	-	-	*2*	2	-	-	3	2
UM3	*7*	3	3	1	*4*	1	2	1	11	7
LI1	*11*	5	5	1	*5*	1	3	1	16	11
LI2	*8*	2	2	4	*5*	2	2	1	13	8
LC	*8*	4	2	2	*9*	4	3	2	17	9
LP1	*6*	3	2	1	*7*	3	3	1	13	7
LP2	*12*	8	4	-	*4*	3	1	-	16	12
LM1	*3*	-	3	-	*7*	2	4	1	10	7
LM2	*4*	3	1	-	*5*	4	1	-	9	5
LM3	*3*	2	1	-	*3*	1	1	1	6	3
Total									178	

Tab. 1 – The number of teeth per dental element and MNI calculated based on the number of teeth per dental element in the sample of *Grotte de la Faucille*.
Ac stands for fully formed teeth with a complete root apex.
Juv stands for juvenile teeth.
UD stands for undeterminable teeth.

recovered 'juvenile' versus fully formed teeth and teeth from adult maxillae or mandibles is reported. Teeth that could not be assigned to an age category due to a damaged root are reported as undeterminable (UD) in the table. Due to extreme wear, it was not possible to side the roots of two permanent upper central incisors and one lower molar. One juvenile lower molar could not be identified as a second or third due to the absence of a root. These four teeth are excluded from table 1 and the calculation of the MNI.

Element	*n left*	*n right*	*n total*
dui1	2	3	5
dui2	2	6	8
duc	3	2	5
dum1	3	1	4
dum2	1	1	2
dLI1	0	2	2
dLI2	2	2	4
dLc	6	2	8
dlm1	1	2	3
dlm2	1	5	6
			47

Tab. 2 – Deciduous teeth per element, specified per side, in the deciduous dental sample from *Grotte de la Faucille*.

4.2. Minimum number of juveniles and age categories

The five mandible fragments belonged to four individuals, one adult and three juveniles (two ± 6-7 years, one ± 4-6 years). One maxilla belonged to a child of ± 5-7 years of age at death. The second maxilla was that of an individual at least of 12 years old at death. Based on the light wear of all teeth in this maxilla (right upper central and lateral incisors, canine, and first premolar), it seems plausible that this individual was an adolescent or young adult.

The total 'juvenile' dental sample (including the maxilla and mandibles) represents at least 13 individuals; two children of ± 2 yo, one of ± 1-3 yo, one ± 4-6 yo, two of ± 5 to 6 yo, two ± 6 to 7 yo, three juveniles of 8- 10 yo, at least one subadult 10-13 yo, and one of ± 13-15 years old at the age of death. Two 'juvenile' upper third molars (left) belonged to individuals 15-20 years old. As these two may have been adults, they are excluded from the minimum number of juveniles.

4.3. Total MNI

The most prominent permanent dental element in the assemblage is the left lower second premolar (n = 12). Eight have a complete root with a closed apex, while four are 'juvenile' teeth. As the apex of the lower second premolar (LP2) closes between 12 and 15 years, the complete LP2s represent eight individuals who were at least 12 years old. The actual age at death could have been any age of adulthood. The four 'juvenile' LP2s could be assigned to individuals of different ages (± 6-9 yo, ± 7-12 yo, ± 8-10 yo, and one 10-12.5 yo). Two out of eight complete left LP2s could have belonged to two juveniles (± 12 to 15 years old) in the sample, as no juvenile LP2s could be assigned to them. One adult individual in the sample is represented by a mandible with AML of the left LP2. The socket of the tooth is almost fully healed, indicating that the tooth was not lost close to death and did not have an LP2 at the time of deposition. With one adult mandible with AML of the left LP2 and six complete LP2s that could not be assigned to one of the 13 juveniles, the MNI of the dental sample is 20.

Skeletal elements of one neonate and an infant approximately 9-12 months old were recovered from *Grotte de la Faucille*. Individuals of these ages are not represented in the dental sample. This brings the MNI for *Grotte de la Faucille* up to 22.

Compared to most Neolithic multiple cave burials, which generally consist of five to 15 individuals (Polet, 2011; Toussaint *et al.*, 2001), the MNI of *Grotte de la Faucille* is relatively high. At least 13 of 20 individuals in the dental sample were juveniles, which is ~65 % of the MNI. Percentages between 40 and 50 % have been reported for the Neolithic human remains from caves in the Belgian Meuse basin (Toussaint *et al.*, 2001).

4.4. Calculus

Out of the 206 erupted (permanent and deciduous) teeth in the sample, 197 teeth could be inspected for the presence of calculus. The crowns of nine teeth were destructed by post-depositional processes. Calculus was observed on 101 out of 197 teeth (~51 %), which falls within the range reported for Neolithic societies in Europe (Lillie, 1996). Lillie (Lillie, 1996) reports percentages of affected teeth between ~47 % to 63 % for five Neolithic populations, and ~35-36 % in Mesolithic groups from Ukraine.

It must be mentioned that in the dental sample of *Grotte de la Faucille*, small amounts of calculus generally consist of a thin rim or patches of calculus at the CEJ or approximal surfaces, while moderate amounts consist of a thicker rim of approximately a 1-2 mm thickness. The largest amounts of calculus consist of several mm thick deposits, covering a large part of the CEJ or crown or circling the tooth. Completely encapsulated crowns or root surfaces do not occur in the sample. Traces of calculus were observed in ~3 % (n = 7), small amounts in ~26 % (n = 51), moderate amount in ± 15 % (n = 28), and a large amount was observed in ~4 % (n = 8). For six teeth (~3 %), the calculus was present, but the severity and location could not be determined due to post-depositional processes. Fig. 2 presents the frequency of caries and its severity per tooth type (grouped by incisors, premolars, etc.).

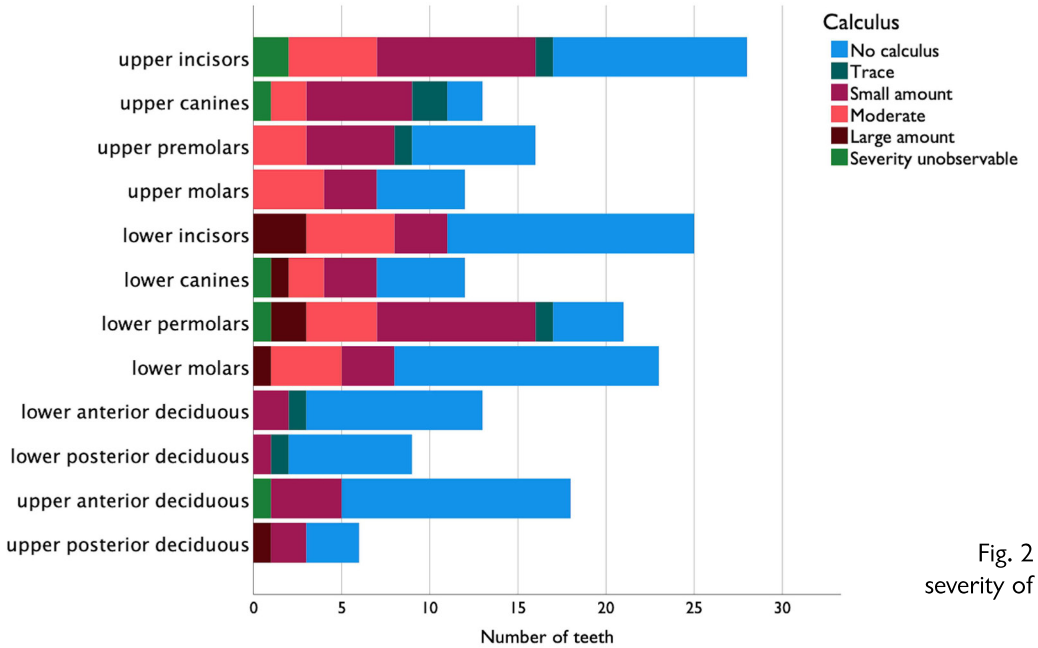

Fig. 2 – Number of teeth and severity of calculus per tooth type.

Tab. 3 reports the prevalence of calculus per tooth type. Calculus is most prevalent in the upper canines and lower premolars, with 85 % and 81 % per tooth type, respectively. In the upper dentition, calculus is more prevalent in the anterior teeth (incisors and canines) than in the posterior teeth (premolars and molars), while in the lower dentition, calculus is most prevalent in the premolars (81 %).

Calculus was observed in ~30 % (n = 14) of the deciduous teeth and is most prevalent in the deciduous upper molars (n = 3) and lower incisors (n = 3). The observed calculus on the deciduous teeth is small, except for one dum1. This tooth, with a moderate to large amount of subgingival calculus, belonged to an individual of ± 7-12 yo. The other deciduous teeth with calculus belonged to at least five other juveniles: one of ± 2-5 yo, one ± 7-12 yo, one ± 6-11 yo, and of ± 4-6 yo. The deciduous teeth generally erupt between 10 months (the incisors) and three years of life (the canines) (Al Qahtani *et al.*, 2010). Thus, calculus in deciduous teeth developed over a period of at least one year and a maximum of 10 after eruption. In the juvenile permanent dentition, calculus was observed in only three teeth: one LP1 (± 10-14 yo), one LP2 (± 12 yo), and one LC (± 13-15 yo), all with a small amount of calculus. As the juvenile LP1 may have belonged to a juvenile of ± 6-11 represented in the deciduous dentition, the minimum number of juveniles with calculus is seven. With a minimum of fifteen juveniles represented in the

	n total	*n calculus*	*prevalence calculus %* [1]
deciduous upper incisors	13	4	31
deciduous upper canines	5	1	20
deciduous upper molars	6	3	50
deciduous lower incisors	6	3	50
deciduous lower canines	8	1	13
deciduous lower molars	9	2	22
upper incisor	28	17	61
upper canine	13	11	85
upper premolars	16	9	56
upper molars	12	7	58
lower incisors	25	11	44
lower canines	12	7	58
lower premolars	21	17	81
lower molars	23	8	35
Total	*197*	*101*	*51*

Tab. 3 – Calculus prevalence (in %) per tooth type in erupted deciduous and permanent teeth.
[1] Calculus prevalence percent is calculated as number of teeth with calculus/ the total number of erupted teeth per tooth type (x 100).

total juvenile sample, the calculus prevalence in the juvenile individuals at *Grotte de la Faucille* is 40 %. LP1 and LC generally fully erupt between the 10 and 12 years of life, while the LP2 erupts around the age of 11. Thus, calculus formed on the juvenile teeth over one to four years after eruption.

Calculus has a multi-causal nature and studies support its relationship to calculus and diet, oral health, oral hygiene, and frailty (Hillson, 2008; Lukacs, 1992; Roberts & Manchester, 2007; White, 1997; Yaussy & De Witte, 2019). In a review of the literature White (1997) states that in populations without regular oral hygiene practices, calculus is expected to develop shortly after or within a decade after tooth eruption. Severity of calculus is in this case expected to increase over time until the approximate age of 30 (White, 1997). In populations with regular oral hygiene practices, calculus is not expected to occur before adolescence and does not increase significantly with age (White, 1997). At *Grotte de la Faucille*, calculus developed on the deciduous and juvenile teeth within one to ten years after eruption. The occurrence of light calculus in the juvenile teeth and the larger amounts of calculus in the complete permanent dentition suggest that calculus did accumulate over time. Thus, calculus rates in the dental sample indicate that regular oral hygiene practices were not a part of daily life for a large part of the population of *Grotte de la Faucille*.

Several studies have used the relationship between calculus and caries within a population to interpret diet (Clarke, 2015; Delgado-Darias *et al*., 2006; Lillie, 1996). The proportion of protein and carbohydrate rich foods are known to influence the formation of calculus (Hillson, 1996; Lieverse, 1999). High calculus rates are associated with protein consumption, while high caries rates are associated with carbohydrate consumption (Hillson, 1996; Lieverse, 1999). Calculus and caries form under different conditions (related to PH values) where calculus frequencies are high, low caries rates are expected (Duckworth & Huntington, 2005). Calculus rates of 88 %, in the absence of caries, have been associated with high protein, low carbohydrate diets (Delgado-Darias *et al*., 2006). However, high calculus rates have been reported for many agricultural populations with high- carbohydrate diets (Lieverse, 1999). The relationship between calculus and caries at *Grotte de la Faucille* will be discussed in the caries section below. Microwear analysis of teeth from Neolithic caves in the Meuse basin provided evidence for a mixed diet farmed and foraged foods, rich in fibrous plants (Sherrill & Williams, 2019). The moderate calculus frequency (51 %), which falls between the rates reported for hunter-gatherers and farmers by Lillie (1996), and the generally low calculus severity at *Grotte de la Faucille* correspond to these findings.

Further studies of commingled dental samples from Neolithic caves are needed to establish whether the rate of ~50 % of the dental sample and low severity of calculus are characteristic of the Belgian Meuse basin.

4.5. Dental caries

Fig. 3 – Example of large root surface caries at the CEJ of an upper third molar from *Grotte de la Faucille*.

Caries lesions were observed in 20 (~9.7 %) of the 205 erupted teeth in the sample. Four out of 20 caries lesions were observed in the 47 deciduous teeth from *Grotte de la Faucille*: in one deciduous canine and three (out of four) deciduous upper first molars. The rare occurrence of caries in deciduous dentition is in accordance with the findings from Brabant and Brabant (1962). The most common type of lesion in the assemblage is root surface caries (Fig. 3), followed by interproximal caries. In total, 172 permanent and deciduous roots could be examined. Root caries were observed in approximately ~9 % of the roots (n = 15). In six permanent teeth, interproximal caries were observed on the crown (~2.9 % of the total sample). The affected teeth belonged to at least four individuals (20 % of the MNI represented in the teeth), of whom two are juveniles (one >12 yo and one 7-12 yo). No lesions were observed in the occlusal surfaces of any teeth. It must be noted that caries in the occlusal surface may become unobservable with progressive dental wear.

Tab. 4 presents the frequency of observed caries lesions in permanent teeth and caries prevalence per permanent tooth type (the percentage of affected erupted teeth). Prevalence is highest in upper premolars and lower third molars. No lesions were observed in the first and second upper molars. As the latter teeth are underrepresented in the sample, it cannot be concluded that these were less affected.

The caries rate of 9.7 % is a relatively high percentage compared to caries reported by Brabant and Brabant (1962) (~5.1 %) for the total dental assemblage of twenty Neolithic caves in the Meuse Basin. In a broader European perspective, similar caries rates as those observed at *Grotte de la Faucille* were reported for several Neolithic European populations (Karsten *et al.*, 2015; Tomczyk *et al.*, 2021). A similar caries frequency (9.5%), as observed in *Grotte de la Faucille*, was reported by Karsten *et al.* (2015) for a population of the Tripolye culture buried in Verteba Cave in Ukraine. Tomczyk *et al.* (2021) report caries rates of 13 % for a Late Neolithic Corded Ware Culture population and 11 % for an agricultural population from the early Bronze age. Tomczyk *et al.* (2021) found in both groups, similar patterns in the location of caries as observed in *Grotte de la Faucille*: caries manifested on the CEJ surfaces and on the interproximal surfaces, while caries on the occlusal surface were rare. Tomczyk *et al.* (2021) state that the percentage of teeth affected by caries and their locations is indicative of agricultural subsistence strategies in their studied groups. Based on the similar rates found in *Grotte de la Faucille* with the Polish groups, the caries rates appear to be indicative of a carbohydrate-rich diet typical for agricultural populations. As mentioned above, high calculus rates have been reported for many agricultural populations with high-carbohydrate diets (Lieverse, 1999). As calculus and caries sometimes occur in the same teeth at *Grotte de la Faucille*, we consider that this study is an example of such a case.

4.6. Dental wear

Dental wear was observed in 106 (~88 %) out of the identifiable 121 erupted permanent teeth with a closed apex and observable crown. Severe wear is most prevalent in the

Element	*n total*	*n caries*	*prevalence caries %**	*caries type*	*lesion location*
UI1	16	1	6	Root surface	Below CEJ
UI2	10		0		
UC	13	1	8	Coronal	Labial side incisal edge
UP1	8	2	25	Coronal	Contact surfaces
UP2	11	4	36	Root surface	Below CEJ
UM1	2		0		
UM2	3		0		
UM3	8	2	25	Root surface	Below mesial CEJ
LI1	13	0	0		
LI2	12	2	17	Coronal and Root surface	Distal contact surface and distal CEJ
LC	13	2	15	Gross and Root surface	At distal CEJ
LP1	10		0		
LP2	12	2	17	Coronal	Contact surfaces
LM1	11	1	10	Root surface	Mesial CEJ
LM2	8	1	13	Root surface	Mesial CEJ
LM3	5	2	33	Root surface	
LM UD**	2	0	0		
Total	*157*	*20*	*14*		

Tab. 4 – Frequency and caries prevalence of caries per tooth type in erupted permanent teeth from *Grotte de la Faucille*.
* Caries prevalence percent is calculated as the number of teeth with caries / the total number of erupted teeth per tooth type (x 100).
** Undetermined lower molars.

molars (Fig. 4), apart from the UM1, which may be explained by an underrepresentation of the tooth in the sample. In 90 % of the total sample, attrition resulted in an angled occlusal surface. Horizontal wear is most common in the lower incisors. The angled occlusal surface and high rates of dental wear in molars are characteristic of Neolithic societies and are associated with chewing of highly abrasive food (Smith, 1984; Toussaint, 2013; Toussaint *et al.*, 2001). The established high rates of severe wear in molars are in accordance with previously established wear patterns for Neolithic Belgium (Toussaint, 2001).

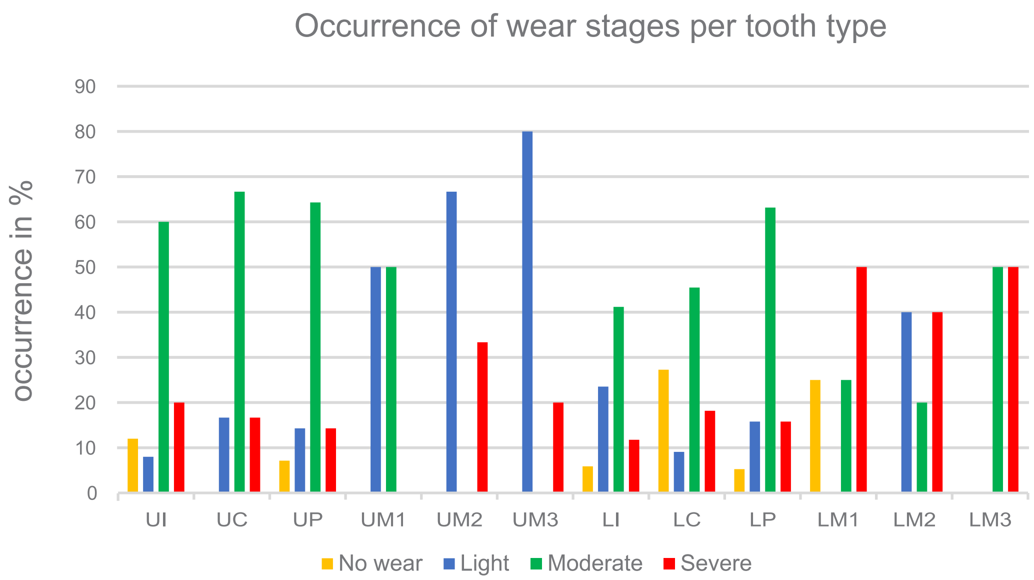

Fig. 4 – The percentage of wear stages per tooth type, calculated as the number of teeth with of each wear stage/total number of teeth per tooth type. First and second incisors and premolars are grouped.

In the juvenile permanent dentition, dentine exposure was observed on the incisor of two individuals of approximately 10-12 *yo*. Light wear developed over a period of at least three years, as the incisors erupt around approximately seven to eight years of life. No dentine exposure was observed in the erupted juvenile premolars and molars. The premolars belonged to two juveniles of 10-14 *yo*, the first and second molars from two juveniles of ± 6-7 *yo*, and two 4-6 *yo*. The third molars belonged to at least two juveniles between the ages of 16 and 20. Light wear is not unexpected as these teeth start erupting around these ages.

In the deciduous dentition, initial dentine exposure is observed in teeth that belonged to two juveniles of ± 2-3 *yo*, one ± 5-6 *yo*, and one ± 8-10 *yo*. Moderate dentine exposure in deciduous teeth occurred in at least five juveniles: two ± 5-6 *yo*, two ± 6-7, and two ± 8-10 *yo*. Severe dentine exposure was observed in deciduous teeth representing at least one ± 8-10 *yo* and one 5-6 *yo*. Light wear developed in a period of at least one year of eruption, moderate wear in at least four years, while heavy wear developed over at least four to six years after tooth eruption. Studies are currently ongoing to make comparisons between dental wear from other Neolithic and Mesolithic dental samples from the Meuse basin. At present, it is difficult to compare wear rates to data in the literature due to the commingled state of the remains.

4.7. Enamel defects

Enamel defects in the form of LEH were observed in 40 (of the 229) erupted or isolated teeth (~18 % of the sample). This might be an overestimation of the prevalence of childhood stress markers, as individuals might have been scored multiple times. Several teeth are (two UI1s) antimeres, and three (lateral incisor, canine, and first premolar) come from the maxilla with permanent teeth (Fig. 5). In three teeth with LEH, nonlinear arrays of pits and/or vertical linear grooves were also observed. The frequency of LEH in the sample of *Grotte de la Faucille* is much higher than reported for other Neolithic assemblages of the Belgian Meuse Basin (Brabant & Brabant, 1962; De Paepe & Polet, 2007; Toussaint *et al.*, 2001). Enamel defects have been reported to be very rare in the Neolithic populations of the Belgian Meuse basin. A study by De Paepe & Polet (2007) reported only two occurrences of LEH in 916 permanent teeth from Sclaigneaux. It was not reported if magnification was used for the identification of LEH in this study. Further study of other Neolithic sites is ongoing and necessary to conclude whether the frequencies of enamel defects in *Grotte de la Faucille* are an exception. Toussaint *et al.* (2001) observed non-specific stress markers in the form of Harris lines in two-thirds of tibiae from the Neolithic cave *Abri du Pape*. Thus, periods of stress seem to have been more prevalent in other Neolithic cave sites.

Fig. 5 – Example of linear enamel hypoplasia in upper anterior teeth in a maxilla from *Grotte de la Faucille*.

In 20 teeth (~9 % of the total sample), LEH is visible regardless of light or angle of inspection. Its presence was confirmed for the other 20 teeth by inspection under magnification (10 x) and by running a fingernail over the crown (if the line could be felt, it was registered as LEH). Fig. 6 reports the frequency of occurrence LEH per tooth type.

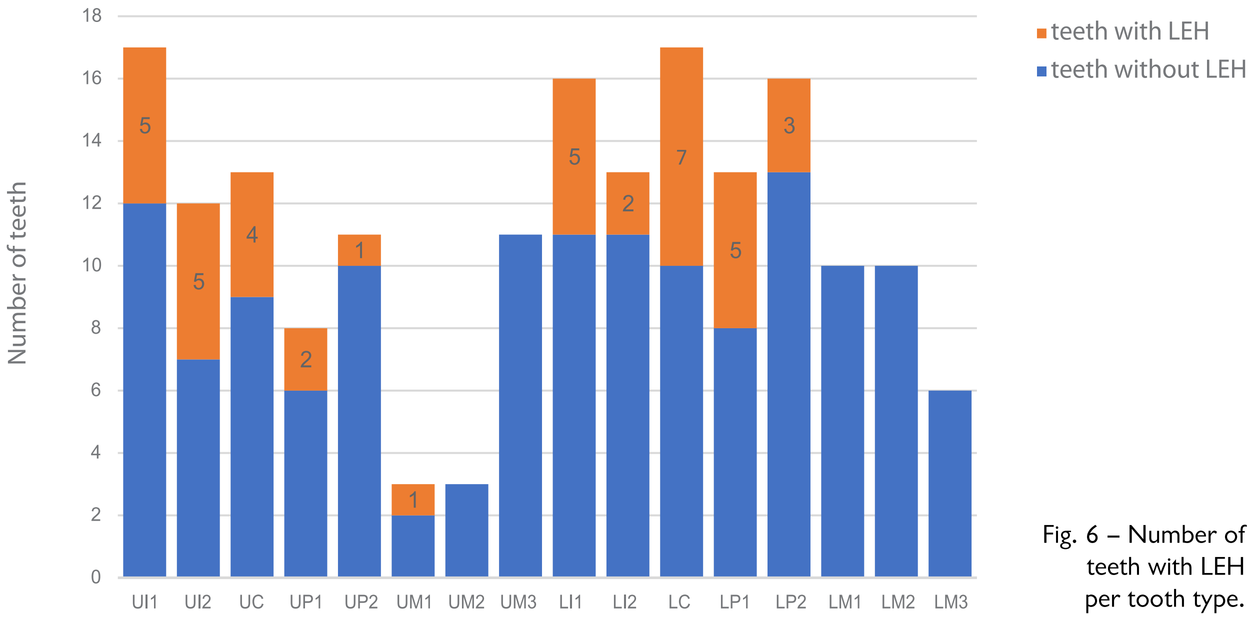

Fig. 6 – Number of teeth with LEH per tooth type.

In most affected teeth, multiple LEH lines were observed (two lines, n = 11; three lines, n = 14; four lines, n = 5; five lines, n = 2). In eight teeth, only one LEH line was observed, which in all cases is located on the lower third of the crown (near CEJ). The presence of multiple LEH lines in the dentition provides evidence that the individuals lived through and survived several periods of stress (such as illness and/or malnutrition) during childhood. The two teeth with five LEH lines (left UC and right LP1) belonged to two juveniles between the ages of 7-11 and 13-15 years old. Of the five teeth with four lines, one is a juvenile tooth. Based on the moderate to heavy crown wear, it seems likely that these individuals were of adult age.

Most LEH occurs in the middle of the crown and the CEJ of canines and incisors, which corresponds with disrupted development between the age of ± 2-5 years in upper incisors, ± 2-4 years in lower incisors, and ± 3-6 years of life in the canines (Hillson, 2008; Reid & Dean, 2006). LEH was only observed twice in the occlusal third of the left UC and right LP1 with five lines, which is probably an underestimate because this part of the crown is often worn down or polished over time by contact with the tongue or lips. However, six out of eight unworn juvenile teeth with LEH do not have LEH in the occlusal third of the crown. All teeth with LEH have at least one line in the lower third of the crown. Thus, in this dental sample, LEH frequencies and the prevalence per tooth type are unlikely to be underestimated due to dental wear. The LEH in the above-mentioned UC and LP1 occur from the tip to the CEJ, corresponding to the period of ± 1.5-5.5 and ± 4-6 years of life (Hillson, 2008; Reid & Dean, 2006). Based on the LEH in the total dental sample, the age at onset of LEH is between 2 and 3 yo at *Grotte de la Faucille*. This is similar to the average ages at onset reported by Ash *et al.* (2016) for five LBK populations across central Europe. The age at the onset of LEH corresponds with the average age of weaning in these Neolithic groups (Ash *et al.*, 2016). Similarly, age at onset at *Grotte de la Faucille* corresponds with stable isotope evidence for weaning around the age of 2 in Belgian Neolithic populations (Bocherens *et al.*, 2007). Weaning might be a stressful time during infancy as the digestive and immune systems need to adjust to the transition from the optimally nutritious mother's milk to solid foods and possible associated contaminants (Dąbrowski *et al.*, 2020; Goodman *et al.*, 1991, and references therein). A Stable isotopic study of *Grotte de la Faucille* is ongoing and may provide direct evidence for the timing of weaning practices (van Hattum *et al.*, in prep.).

4.8. Periodontal disease

With the underrepresentation of adult mandibles and maxillae in the sample, it was not possible to assess the frequency or prevalence of periodontal disease in the population from *Grotte de la Faucille*. The maxilla with permanent dentition did not show any signs of periodontal disease. However, periodontitis does occur in the adult mandible, which represents one out of nine in the sample (Fig. 7 described below). The part of the alveolar process above the chin was damaged by post-depositional processes, and the associated teeth (incisors, canines and left LP1) are missing. Although small portions of several of the alveolar sockets remain, it was not possible to determine if the teeth were lost before or after death. Also, the rami of the mandible are missing due to post-depositional damage, including part of the alveolar socket of the right M3. The right PM1, PM2, M1 and M2 remain in the mandible. The left PM2 and part of the root of the M1 were lost before death. The left M2 and M3, which show heavy dental wear, are present in the mandible. The crown of the left M1 was destructed, likely by severe dental attrition. Wear progressed onto the root to the point that the two roots were no longer connected. The remaining root is completely exposed and has hypercementosis deposits on its lower half and apex. The alveolar sockets of the M1 and PM2 were not fully healed, but the formation of new bone was in a progressed stage. Periodontal disease is the most common cause of AML. And this mandible has several bony changes associated with periodontal disease, which support the diagnosis: slight inflammatory pitting and crest formation in the alveolar process and slight atrophy of the alveolar bone around the remaining premolars and molars. The upper half of the root of the right LP1 is exposed, and there is hypercementosis on the lower part of the root. Also, the teeth in the mandible are all covered with a relatively large amount of calculus, which is known to be a primary factor in the development of periodontal disease (Roberts & Manchester, 2007; Yaussy & De Witte, 2019).

Fig. 7 – Adult mandible with antemortem tooth loss of the LP2 and partial exfoliation of the M1 (root and loose right LP2 are not in the photo). There is alveolar atrophy and crest formation at LM2 and LM3, oblique wear is clearly visible.
The loose right LP1 and root of LM1 not included in the photo.

Six other cases of hypercementosis were observed in the erupted isolated dentition from *Grotte de la Faucille*. Based on the number of teeth affected per tooth type (two left UI1, two left UM3, one left LP1, and one right UP1), hypercementosis occurred in at least two different individuals from *Grotte de la Faucille*. Without inspecting the alveolar bone in which the teeth were lodged during life, it is difficult to determine whether the hypercementosis was a response to periodontitis or excessive force and the associated continued eruption. However, small to large amounts of calculus were present on all six teeth. This supports the hypothesis that these cases of hypercementosis might have been associated with periodontitis.

5. Conclusions

With an MNI of 20 based on the teeth (22 in total), *La Faucille* is one of the larger recently excavated Neolithic sites from the Belgian Meuse Basin. With at least 13 juveniles in the dental sample (59 %), it has a high representation of subadults. In contrast to previous studies of Neolithic cave burials in the Meuse basin, this study found evidence for relatively poor oral health and high frequency of childhood stress at *Grotte de la Faucille*. The LEH in the dental sample provides evidence that a relatively high number of individuals lived through one or multiple periods of stress during childhood. The age at the onset of the stress markers correspond to the age of weaning in Neolithic Belgium. The rates of calculus, frequency of caries and the angled wear patterns correspond with those known from Neolithic societies across Europe and are indicative of a diet rich in carbohydrates.

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References

AL QAHTANI S. J., HECTOR M. P. & LIVERSIDGE H. M., 2010. Brief communication: The London atlas of human tooth development and eruption. *American Journal of Physical Anthropology,* 142(3): 481-490. doi:10.1002/ajpa.21258

ARMELAGOS G. J., GOODMAN A. H., HARPER K. N. & BLAKE M. L., 2009. Enamel hypoplasia and early mortality: Bioarcheological support for the Barker hypothesis. *Evolutionary Anthropology: Issues, News, and Reviews,* 18(6): 261-271. doi:10.1002/evan.20239

ASH A., FRANCKEN M., PAP I., TVRDÝ Z. Z. K., WAHL J. & PINHASI R., 2016. Regional differences in health, diet and weaning patterns amongst the first Neolithic farmers of central Europe. *Scientific Reports,* 6: 1-10. doi:10.1038/srep29458

BERTILSSON C., BORG E., STEN S., HESSMAN E., SJÖBLOM H. & LINGSTRÖM P., 2022. Prevalence of Dental Caries in Past European Populations: A Systematic Review. *Caries Research,* 56(1): 15-28.

BOCHERENS H., POLET C. & TOUSSAINT M., 2007. Palaeodiet of Mesolithic and Neolithic populations of Meuse Basin (Belgium): evidence from stable isotopes. *Journal of Archaeological Science,* 34(1): 10-27.

BRABANT H. & BRABANT H., 1962. *Contribution à l'étude de la paléopathologie des dents et des maxillaires : la denture en Belgique à l'époque néolithique*. *Bulletin* [de l']*Institut royal des Sciences naturelles de Belgique / Koninklijk Belgisch Instituut naturelles de Belgique voor Natuurwetenschappen Mededelingen*, XXXVIII, 6/1962: 32 p.

BROTHWELL D. R., 1981. *Digging up bones: the excavation, treatment, and study of human skeletal remains*. 3rd ed., Cornell University Press, Ithaca (New York): 208 p.

BUIKSTRA J. E. & UBELAKER D. H. (ed.), 1994. *Standards for Data Collection from Human Skeletal Remains: Proceedings of a Seminar at the Field Museum of Natural History*. Arkansas archaeological survey research series, vol. 44, Fayetteville: 272 p.

CLARK A. L., STANTIS C., BUCKLEY H. R. & TAYLES N., 2020. Oral health of the prehistoric Rima Rau cave burials, Atiu, Cook Islands. *Journal of the Royal Society of New Zealand,* 50(1): 158-177.

CLARKE M. R., 2015. *Dental Calculus: Combining Current Methods in the Study of Diet and Mouth Use Activities Among Neolithic and Early Bronze Age Hunter-Gatherers of the Cis-Baikal, Siberia*. Master Thesis, Department of Archaeology and Anthropology, University of Saskatchewan, Saskatoon: 300 p.

COCHRAN D. L., 2008. Inflammation and Bone Loss in Periodontal Disease. *Journal of Periodontology*, 79: 1569-1576 (+ 8 suppl.).

CROMBÉ P., 2010. Contact and interaction between early farmers and late hunter-gatherers in Belgium during the 6th and 5th millennium cal BC. In: Gronenborn D. & Petrasch J. (ed.), *Die Neolithisierung Mitteleuropas. Internationale Tagung, Mainz 24. Bis 26. Juni 2005 / The spread of the Neolithic to Central Europe. Internal Symposium, Mainz 24 June-26 June 2005*, Römisch-Germanischen Zentralmuseums (RGZM - Tagungen, Band 4, 2), Mainz: 551-566.

CROMBÉ P. & VANMONTFORT B., 2007. The neolithisation of the Scheldt basin in western Belgium. *Proceedings of the British Academy*, 144: 261-283.

CROMBÉ P. & ROBINSON E., 2014. ^{14}C dates as demographic proxies in Neolithisation models of northwestern Europe: a critical assessment using Belgium and northeast France as a case-study. *Journal of Archaeological Science*, 52: 558-566. doi:10.1016/j.jas.2014.02.001

CROMBÉ P., SERGANT J., PERDAEN Y., MEYLEMANS E. & DEFORCE K., 2015. Neolithic Pottery Finds at the Wetland Site of Bazel-Kruibeke (prov. Oost-Vlaanderen / B). Evidence of Long-Distance Forager-Farmer Contact during the Late 6th and 5th Millennium Cal BC in the Rhine-Meuse-Scheldt Area. *Archaologisches Korrespondenzblatt*, 45(1): 21-39. doi:10.11588/ak.2015.1.87545

DĄBROWSKI P., KULUS M., GRZELAK J., RADZIKOWSKA M., OZIEMBŁOWSKI M., DOMAGAŁA Z. & KRAJCARZ M. T., 2020. Assessing weaning stress. Relations between enamel hypoplasia, $\delta^{18}O$ and $\delta^{13}C$ values in human teeth obtained from early modern cemeteries in Wroclaw, Poland. *Annals of Anatomy,* 232. doi:10.1016/j.aanat.2020.151546

DE GROOTE I., DI MODICA K., ABRAMS G., IRISH J. D., CROMBÉ P., VANDENDRIESSCHE H. & BONJEAN D., 2019 [2020]. Grotte de La Faucille, Sclayn (Andenne, BE). Preliminary reports on the 2016-2017 excavation of the Neolithic ossuary and terrace. *Notae Praehistoricae*, 39/2019: 143-151.

DE GROOTE I., VAN HATTUM I., HALBRUCKER É., CROMBÉ P., VAN MALDEGEM E., PIRSON S., DI MODICA K., DEFORCE K., TEETAERT D., ABRAMS G., PIRONNEAU C., BONJEAN D., IRISH J.D., DELAUNOIS É. & VANDENDRIESSCHE H., 2022 [2023]. Report on the latest excavation campaigns at *Grotte de la Faucille*, Sclayn (BE). New radiocarbon dates for a better understanding of burial practice during the Final Neolithic. *Notae Praehistoricae*, 42/2022: 161-177.

DELGADO-DARIAS T., VELASCO-VÁZQUEZ J., ARNAY-DE-LA-ROSA M., MARTÍN-RODRÍGUEZ E. & GONZÁLEZ-REIMERS E., 2006. Calculus, periodontal disease and tooth decay among the prehispanic population from Gran Canaria. *Journal of Archaeological Science*, 33(5): 663–670.

DE PAEPE M. & POLET C., 2007. "Numerous and tall": a revision of the Late Neolithic human remains found in a collective burial site at Sclaigneaux (prov. Namur), Belgium. *Notae Praehistoricae,* 27/2017: 163-168.

DUCKWORTH R. M. & HUNTINGTON E., 2005. Evidence for putting the calculus: caries inverse relationship to work. *Community Dentistry and Oral Epidemiology*, 33.5: 349-356.

DUMBRUCH I., 2003. *Étude du site de l'abri-sous-roche du « Bois-Madame », Néolithique, à Arbre, dans la vallée du Burnot (Province de Namur). Étude anthropologique et archéologique*. Bachelor's thesis, Université Libre de Bruxelles, Brussels: 2 vol.

FORMICOLA V., 1987. Neolithic transition and dental changes: the case of an Italian site. *Journal of human evolution,* 16(2): 231-239.

GOODMAN A. H. & ROSE J. C., 1990. Assessment of systemic physiological perturbations from dental enamel hypoplasias and associated histological structures. *American Journal of Physical Anthropology*, 33(S11): 59-110. https://doi.org/10.1002/ajpa.1330330506

GOODMAN A. H., MARTÍNEZ C. & CHAVEZ A., 1991. Nutritional supplementation and the development of linear enamel hypoplasias in children from Tezonteopan, Mexico. *The American Journal of Clinical Nutrition,* 53(3): 773-781.

HILLSON S., 1996. *Dental Anthropology*. Cambridge University Press, Cambridge: 374 p.

HILLSON S., 2001. Recording dental caries in archaeological human remains. *International Journal of Osteoarchaeology,* 11(4): 249-289.

HILLSON S., 2005. *Teeth (Second Edition)*. Cambridge Manuals in Archaeology, Cambridge University Press, Cambridge: 374 p.

HILLSON S., 2008. Dental pathology. In: Katzenberg A. & Saunders S. R. (ed.), *Biological anthropology of the human skeleton*, John Wiley, Hoboken (New Jersey): 301-340.

HILLSON S., 2014. Dental markers of disease and malnutrition. In: Hillson S., *Tooth Development in Human Evolution and Bioarchaeology*, Cambridge University Press, Cambridge: 162-197.

HOFMANOVÀ Z., KREUTZER S., HELLENTHAL G., SELL C., DIEKMANN Y., DÍEZ-DEL-MOLINO D., VAN DORP L., LÓPEZ S., KOUSATHANAS A., LINK V., KIRSANOW K., CASSIDY L. M., MARTINIANO R., STROBEL M., SCHEU A., KOTSAKIS K., HALSTEAD P., TRIANTAPHYLLOU S, KYPARISSI-APOSTOLIKA N., UREM-KOTSOU D., ZIOTA C., ADAKTYLOU F., GOPALAN S., BOBO D. M., WINKELBACH L., BLÖCHER J., UNTERLÄNDER M., LEUENBERGER C., ÇILINGIROĞLU Ç., HOREJS B., GERRITSEN F., SHENNAN S. J., BRADLEY D. G., CURRAT M., VEERAMAH K. R., WEGMANN D., THOMAS M. G., CHRISTINA PAPAGEORGOPOULOU C. & BURGER J., 2016. Early farmers from across Europe directly descended from Neolithic Aegeans. *Proceedings of the National Academy of Sciences*, 113(25), 6886-6891. doi:10.1073/pnas.1523951113

KACKI S., 2016. *Influence de l'état sanitaire des populations anciennes sur la mortalité en temps de peste : contribution à la paléoépidémiologie*. PhD, Anthropologie biologique, Université de Bordeaux, Bordeaux. https://theses.hal.science/tel-01370446

KARSTEN J. K., HEINS S. E., MADDEN G. D. & SOKHATSKYI M. P., 2015. Dental Health and the Transition to Agriculture in Prehistoric Ukraine: A Study of Dental Caries. *European Journal of Archaeology,* 18(4): 562-579.

KERR N. W., 1988. A method of assessing periodontal status in archaeologically derived skeletal material. *Journal of paleopathology,* 2: 67-78.

LIEVERSE A. R. 1999. Diet and the Aetiology of Dental Calculus. *International Journal of Osteoarchaeology,* 9(4): 219-232.

LIEVERSE A. R., LINK D. W., BAZALIISKIY V. I., GORIUNOVA O. I. & WEBER A. W., 2007. Dental health indicators of hunter-gatherer adaptation and cultural change in Siberia's Cis-Baikal. *American Journal of Physical Anthropology,* 134(3): 323-339.

LILLIE M. C., 1996. Mesolithic and Neolithic Populations of Ukraine: Indications of Diet from Dental Pathology. *Current anthropology,* 37(1): 135-142.

LUKACS J. R., 1989. Dental paleopathology: methods for reconstructing dietary patterns. In: Kennedy M. Y. I. & Kennedy K. A. R. (ed.), *Reconstruction of Life from the Skeleton*, Wiley, New York: 261-286.

MESSIAEN L., DE KLOCK T., GOEMAERE É. & CROMBÉ P., 2018. Macrolithic stone artefacts from Swifterbant and Michelsberg Culture sites in the Lower Scheldt valley (NW Belgium) and their significance for understanding interregional contact and exchange during the Mesolithic-Neolithic transition. *Notae Praehistoricae*, 38/2018: 139-148.

MOLNAR S., BARRETT M. J., BRIAN L., BRACE C. L., BROSE D. S., DEWEY J. R., FRISCH J. E., GANGUL P., GEJVALL N.-G. & GREENE D. L., 1972. Tooth wear and culture: a survey of tooth functions among some prehistoric populations [and comments and reply]. *Current anthropology,* 13(5): 511-526.

MOORREES C. F. A., FANNING E. A. & HUNT E. E., 1963. Age Variation of Formation Stages for Ten Permanent Teeth. *Journal of Dental Research,* 42(6): 1490-1502.

NICKLISCH N., GANSLMEIER R., SIEBERT A., FRIEDERICH S., MELLER H. & ALT K. W., 2016. Holes in teeth. Dental caries in Neolithic and Early Bronze Age populations in Central Germany. *Annals of Anatomy,* 203: 90-99. doi:10.1016/j.aanat.2015.02.001

NICKLISCH N., OELZE V. M., SCHIERZ O., MELLER H., & ALT K. W., 2022. A Healthier Smile in the Past? Dental Caries and Diet in Early Neolithic Farming Communities from Central Germany. *Nutrients 2022,* 14(9): 1831. doi:10.3390/NU14091831

OLALDE I., BRACE S., ALLENTOFT M. *et al.*, 2018. The Beaker phenomenon and the genomic transformation of northwest Europe. *Nature*, 555(7695): 190-196.

ORELLANA-GONZÁLEZ E., SPARACELLO V. S., BOCAEGE E., VARALLI A., MOGGI-CECCHI J. & DORI I., 2020. Insights on patterns of developmental disturbances from the analysis of linear enamel hypoplasia in a Neolithic sample from Liguria (northwestern Italy). *International Journal of Paleopathology,* 28(December 2019): 123-136.

PILLOUD M. A. & FANCHER J. P., 2019. Outlining a Definition of Oral Health within the Study of Human Skeletal Remains. *Dental Anthropology Journal,* 32(2): 3-11.

POLET C., 2011. Les squelettes néolithiques découverts dans les grottes du Basin mosan. In: Cauwe N., Hauzeur A., Jadin I., Polet C. & Vanmontfort B., *5200-2000 av. J.-C. Premiers agriculteurs en Belgique*, cat. d'exposition du Musée du Malgré-Tout, « Guides Archéologiques du Malgré-Tout », Treignes: 85-94.

POWELL M. L., 1985. The analysis of dental wear and caries for dietary reconstruction. In: Gilbert R. I. Jr. & Mielke J. H. (ed.), *The Analysis of Prehistoric Diets*, Academic Press, Orlando: 307-338.

PRICE T. D., 2000. Europe's First Farmers. In: Price T. D. (ed.), *Europe's First Farmers*, Cambridge University Press, Cambridge: 1-18.

REID D. J. & DEAN M. C., 2006. Variation in modern human enamel formation times. *Journal of human evolution,* 50(3): 329-346.

ROBERTS C. & MANCHESTER K., 2007. *The Archaeology of Disease*. 3rd ed., Cornell University Press, Ithaca (New York).

SHERRILL K. & WILLIAMS F. L'E., 2019 [2020]. Reconstructing the diet of Late Neolithic farmers of Belgium from dental microwear features. *Notae Praehistoricae,* 39/2019: 113-123.

SMITH B. H., 1984. Patterns of molar wear in hunter-gatherers and agriculturalists. *American Journal of Physical Anthropology*, 63(1): 39-56.

STECKEL R. H., 2005. Young adult mortality following severe physiological stress in childhood: Skeletal evidence. *Economics and Human Biology,* 3(2, Special Issue): 314-328. doi:10.1016/j.ehb.2005.05.006

TEETAERT D., 2020. *Routes of technology: pottery production and mobility during the Mesolithic-Neolithic transition in the Scheldt river valley (Belgium)*. PhD Thesis, Faculteit Letteren en Wijsbegeerte, Ghent University, Ghent.

TOMCZYK J., TURSKA-SZYBKA A., ZALEWSKA M. & OLCZAK-KOWALCZYK D., 2017. Reliability of the Assessment of Periodontal Disease in Historical Populations. *International Journal of Osteoarchaeology,* 27(2): 206-216.

TOMCZYK J., RUSIN P. & ZALEWSKA M., 2021. Prevalence of dental caries in the Late Neolithic and Early Bronze Age populations from Żerniki Górne (Poland). *Anthropological Review,* 84(2): 201-211. doi:10.2478/anre-2021-0016

TOUSSAINT M., 2001. Flémalle/Les Awirs : datations AMS situant au Néolithique le célèbre « crâne d'Engis » découvert par P. -C. Schmerling au Trou Caheur. *Chronique de l'Archéologie Wallonne, 9*/2001: 99.

TOUSSAINT M., 2007. Les sépultures néolithiques du Basin mosan wallon et leurs relations avec les bassins de la Seine et du Rhin. In: Lebrun-Ricalens F., Valotteau F. & Hauzeur A. (ed.), *Relations interrégionales au Néolithique entre Bassin parisien et Bassin rhénan. Actes du 26e colloque interrégional sur le Néolithique. Luxembourg, 8 et 9 novembre 2003*, Archäologie im Saarland, in Lothringen und Luxemburg / Archéologie en Sarre, Lorraine et Luxembourg = *Archaeologia Mosellana*, vol. 7/2007: 507-549.

TOUSSAINT M., 2013. Transitions, ruptures et continuité dans les pratiques sépulcrales préhistoriques du karst mosan belge et de ses abords. In: Jaubert J., Fourment N. & Depaepe P., *Transitions, ruptures et continuité en Préhistoire. Préhistoire. Transitions, rupture and continuity in Prehistory. XXVIIe Congrès Préhistorique de France, Bordeaux - Les Eyzies, 31 mai-5 juin 2010*, Société Préhistorique Française, Paris, vol. 1: 183-200.

TOUSSAINT M., ORBAN R., POLET C., SEMAL P., BOCHERENS H., MASY P. & GARCÍA MARTÍN C., 2001. Apports récents sur l'anthropologie des Mésolithiques et des Néolithiques mosans. In: van Berg P.-L., Hauzeur A. & Cauwe N. (ed.), *Prehistory of Belgium. Special Issue on the occasion of the XIVth Congress of the International Union for Prehistoric and Protohistoric Sciences*, Brussels = *Anthropologica et Præhistorica*, 112/2001: 91-105.

TOUSSAINT M. & PIRSON S., 2007. Aperçu historique des recherches concernant l'homme préhistorique dans le karst belge aux XIX^{e} et XX^{e} siècles : archéologie, géologie, paléoanthropologie, paléontologie, datations. In: Congrès du Centenaire [Thauvin-Boulestin E. & Évin J. (ed.), *Société Préhistoire Française 1904-2004.*] *Un siècle de construction du discours scientifique en Préhistoire. XXVI^{e} Congrès préhistorique de France, Avignon, 21-25 septembre 2004*, Paris, vol. 2 [« Des idées d'hier… »]: 117-142.

VAN BERG P. L. & HAUZEUR A., 2001. Le Néolithique ancien. *Anthropologica et Praehistorica*, 112: 63-76.

VANDERVEKEN S., 1997. Les ossements humains néolithiques de Maurenne et Hastière (province de Namur). *Notae Praehistoricae*, 17/1997: 177-184.

VAN HATTUM I., BODÉ S., BOECKX P., BOUDIN M., CROMBÉ P., VAN MALDEGEM E., DI MODICA K., ABRAMS G., PIRONNEAU C., BONJEAN D., VANDENDRIESSCHE H. & DE GROOTE I., in prep. Stable carbon and nitrogen isotope analysis at *Grotte de la Faucille*: new insights into Late Neolithic diet in the Belgian Meuse Basin.

VAN HATTUM I., COSTAS-RODRÍGUEZ M., CROMBÉ P., VANHAECKE F., HOBIN K., DALED S., PALMER J., VANDENDRIESSCHE H., DHAENENS M., GOFFETTE Q., COLLET H., CATTELAIN P., TOUSSAINT M. & DE GROOTE I., under review. First insights into human mobility in Neolithic Belgium using strontium isotopic analysis and proteomics: a case study of *Grotte de la Faucille* (Sclayn, Province of Namur). *American Journal of Biological Anthropology*.

WALKER P. L., DEAN G. & SHAPIRO P., 1991. Estimating age from tooth wear in archaeological populations. *Advances in Dental Anthropology*, 169: 187.

WATSON J. T., 2008. Changes in food processing and occlusal dental wear during the early agricultural period in northwest Mexico. *American Journal of Physical Anthropology*, 135(1): 92-99.

WHITE D. J., 1997. Dental calculus: Recent insights into occurrence, formation, prevention, removal and oral health effects of supragingival and subgingival deposits. *European Journal of Oral Sciences,* 105(5): 508-522.

WHITTLE A., 1996. *Europe in the Neolithic. The creation of new worlds*. Cambridge World Archaeology, Cambridge University Press, Cambridge: XVI-448 p.

WILLIAM F. L'E. & POLET C., 2017. A secondary mandibular condylar articulation and collateral effects on a Late Neolithic mandible from Bois Madame rockshelter in Arbre, Belgium. *International Journal of Paleopathology,* 16: 44-49.

WILLIAMS F. L'E., GEORGE R. L. & POLET C., 2018. Dental morphology of deciduous molars from late Neolithic Caves of the Meuse River Basin of Belgium. *Dental Anthropology Journal,* 31(2): 18-26.

WILLIAMS F. L'E. & GEORGE R. L., 2021. Permanent molar trait expression in the Late Neolithic cave burials of the Meuse Basin, Belgium. *Dental Anthropology Journal,* 34(1): 35-48.

WILLIS A. & OXENHAM M. F., 2013. The neolithic demographic transition and oral health: The Southeast Asian experience. *American Journal of Physical Anthropology,* 152(2): 197-208.

YAUSSY S. L. & DE WITTE S. N., 2019. Calculus and survivorship in medieval London: The association between dental disease and a demographic measure of general health. *American Journal of Physical Anthropology,* 168(3): 552-565.

Abstract

Grotte de la Faucille is one of many collective cave burials in the Belgian Meuse Basin. This study is an inventory and dental analysis of the ± 300 human teeth recovered from the cave. The aim is to gain further insights into oral health, childhood stress, subsistence, and diet in Neolithic Belgium. *Grotte de la Faucille* is one of a few recently excavated sites and is unique in the detailed study of its chronology. This study found high caries and enamel defect rates compared to other studies of Neolithic teeth from Belgium. However, rates correspond with those from other Neolithic societies in Europe. This study provides valuable new insights into the Neolithic people of Belgium from a dental anthropological perspective and may function as a reference for future intrapopulation studies.

Keywords: Sclayn, *Grotte de La Faucille* (Andenne, Prov. Namur, BE), *La Faucille* cave, dental anthropology, calculus, caries, enamel hypoplasia, periodontal disease.

Résumé

La *Grotte de la Faucille* est l'une des nombreuses sépultures collectives en grotte du bassin de la Meuse. Cette étude présente un inventaire et une analyse dentaire des ± 300 dents humaines découvertes dans la grotte. L'objectif est de mieux comprendre la santé bucco-dentaire, le stress subi pendant l'enfance, la subsistance et l'alimentation dans la Belgique néolithique. La *Grotte de la Faucille* est l'un des rares sites néolithiques récemment fouillés, unique par l'étude détaillée de sa chronologie. Cette étude a révélé des taux élevés de caries et de défauts d'émail par rapport à d'autres études sur les dents néolithiques en Belgique, taux correspondant à d'autres sociétés néolithiques en Europe. Cette étude fournit de nouvelles informations précieuses sur la population néolithique de Belgique du point de vue de l'anthropologie dentaire et peut servir de référence pour de futures études intrapopulationnelles.

Mots-clefs : Sclayn, *Grotte de La Faucille* (Andenne, Prov. de Namur, BE), anthropologie dentaire, tartre, caries, hypoplasie de l'émail, maladie parodontale.

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