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SPY CAVE

125 years of multidisciplinary research at the Betche aux Rotches (Jemeppe-sur-Sambre, Province of Namur, Belgium)

Edited by Hélène ROUGIER & Patrick SEMAL

Volume 1

2013

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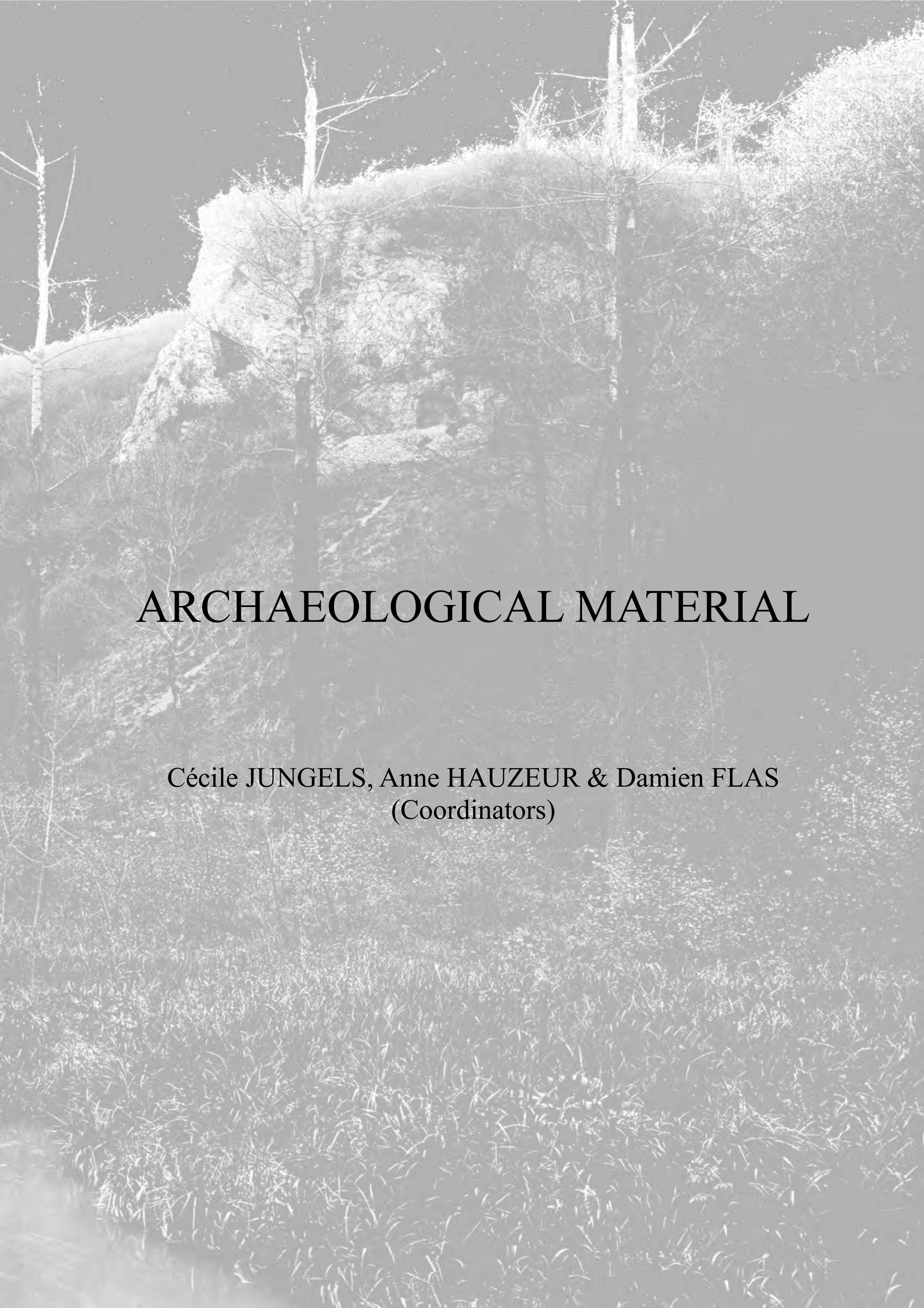

ARCHAEOLOGICAL MATERIAL

Cécile JUNGELS, Anne HAUZEUR & Damien FLAS
(Coordinators)

In: H. ROUGIER & P. SEMAL (ed.), *Spy cave. 125 years of multidisciplinary research at the Betche aux Rotches (Jemeppe-sur-Sambre, Province of Namur, Belgium), Volume 1.* Anthropologica et Præhistorica, **123/2012**. Brussels, Royal Belgian Institute of Natural Sciences, Royal Belgian Society of Anthropology and Praehistory & NESPOS Society.

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CHAPTER VII

NON-FLINT RAW MATERIALS

Anne HAUZEUR, Cécile JUNGELS, Éric GOEMAERE & Stéphane PIRSON

Abstract

This paper presents a macroscopic and mesoscopic characterisation of different non-flint raw materials identified amongst the archaeological material from Spy cave. Already available information for each raw material is discussed before introducing relevant new terminology. Finally, a litho-stratigraphic attribution is proposed alongside a discussion of the geological and geographical origin of each raw material.

More detailed information was recorded for black, finely bedded silicites using Raman spectrometry, and for fluorites by measuring strontium isotopes or LA-ICP-MS of rare-earth elements. In both cases, these analytical approaches allowed macroscopically similar materials to be distinguished and their outcrops identified.

The Orneau Valley has a relatively high lithological diversity (outcrops and fluvial deposits) from which a large part of the raw materials utilised at Spy derive. These materials were complemented by sources found in the Brabant Massif (Ottignies) and the area surrounding Landen.

INTRODUCTION: OBJECTIVES AND LIMITS

Although lithic artefacts from Spy number in the tens of thousands, this paper focuses solely on non-flint raw materials. In addition to their identification, the procurement context, and distance of potential outcrop(s) from the site are also discussed.

An interdisciplinary geo-archaeological study focusing on identifying non-flint raw materials was carried out in the framework of a reanalysis of the Spy archaeological collections. We immediately opted not to employ the standardised petrographic terminology for describing the raw materials (see ST1) as the necessary thin-sections entail the partial destruction of the sampled artefacts. Only macro- and mesoscopic observations were employed in the analysis presented here. While obviously less precise than the more common microscopic analyses, more general raw material determinations are nevertheless instructive for comparing archaeological objects with materials of known geological origin.

Despite siliceous raw materials being the most commonly found objects in archaeological contexts, related terminologies lack consistency and corresponding definitions often remain relatively vague. For example, local terms with historical variations or obsolete stratigraphical units often lead to confusion (see Pirson *et al.*, this volume: chapter V). Furthermore, terms vary not only between geologists and archaeologists, but also from one language to another. In other words, the same term in French or English does not always share a similar definition and, as a consequence, confusion can emerge in translation (e.g. chert). In the present study, French terminology has been privileged in ambiguous cases.

The recent redrawing of Belgian geological maps combined with litho- and bio-stratigraphic syntheses have assisted the linking of artefacts with particular geological units and, in especially favourable circumstances, a more precise location allowing the accessibility of the raw material to be assessed.

Regardless of the period, one of the main goals of this type of study is separating local from exotic or non-regional materials according to the definitions outlined by J.-M. Geneste (1985). A second interpretative question concerns the management of raw materials and the nature of the network (exchange and/or contact) implicated by the presence of exotic materials: imports, transports, exchanges, etc. These aspects of raw material economies are only loosely touched upon in this chapter given the relatively limited sample and possible difficulties concerning it being representative of lithic industry from Spy as a whole. These problems are further compounded by the difficulty, even impossibility, of accurately quantifying the various raw materials by either period or culture.

Bearing this in mind, the sample of raw materials was as extensive as possible, independent of chrono-cultural concerns as contextual uncertainties (see Pirson *et al.*, this volume: chapter V) severely limit certain interpretations. Two-thirds of the analysed sample comprises non-flint artefacts (1 tool, 29 flakes, and 3 cores), with the remainder bearing no signs of human modification. The latter were nonetheless examined given their distinct macroscopic characteristics (see ST2) combined with the fact that they were clearly introduced to the site by its occupants.

The samples considered here come mostly from F. Twiesselmann's excavations of the 19th century backdirt on the slope in front of the cave (37/44; Royal Belgian Institute of Natural Sciences [RBINS] collection, see Pirson *et al.*, this volume: chapter V; Semal *et al.*, this volume: chapter II). The remaining pieces are from A. Rucquoy's excavations (Henricot collection, RBINS) or the Castin and Carpentier collections (RBINS). Two pieces with unique lithological characteristics come from the *Musée Archéologique de Namur*. As mentioned above, the observations employed here are strictly macro- and mesoscopic and need to be complemented by a petrographic study with the aid of a microscope.

PREVIOUS RESEARCH

The raw materials exploited at Spy have been examined macroscopically from the time of the earliest excavations. A. Rucquoy was one of the first to propose an origin for the different siliceous rocks identified by E. Dupont, indicating two potential sources (Rucquoy, 1886-1887: 321): outcrops in the Champagne region ("Vertus-type") as well as a much coarser material from the Meuse region of France ("Vouziers-type"). He also advanced a local provenance for certain siliceous materials (i.e. flint), but excluded the Mons Basin as a potential source (Rucquoy, 1886-1887: 323). The presence of other materials such as Upper Carboniferous *phtanite*, a local, white "Landenian"[1] sandstone, platy limestone from Mazy, manganese oxide, and hematite was also noted (Rucquoy, 1886-1887: 322-323).

In the same year and in the same issue of the *Bulletin de la Société d'Anthropologie de Bruxelles*, M. De Puydt & M. Lohest (1886-1887: 68, note) raised doubts concerning the Champagne hypothesis, proposing the Limburg Cretaceous inliers to be the actual origin of the white chalk flint. These conflicting attributions clearly highlight not only the pitfalls of relying solely on macroscopic observations, but the clear need for new provenance studies supported by a substantial reference collection of lithic raw materials.

Microscopic observations were equally carried out in the 19th century (De Puydt & Lohest, 1886: 36), probably at the behest of Max Lohest who was assistant lecturer in Geology at the *Université de Liège*. He also sought the advice of Professor G. Dewalque for some of the raw material identifications (De Puydt & Lohest, 1887: 220). Black *phtanite*, brown xyloid jasper (De Puydt & Lohest, 1886: 36), different types of sandstones, opal, chalcedony, micaceous sandstones (*psammite*), quartzite, limestone, and hematite are all mentioned as raw materials used by the inhabitants of Spy (De Puydt & Lohest, 1887: 215, 219-221; de Loë & Rahir, 1911).

In the 1980s, M. Goffin-Cabodi undertook a new study of the non-flint raw materials recovered from Spy based on observations with a stereomicroscope and supported by surveys of potential raw material outcrops (Goffin-Cabodi, 1985). These observations were further reinforced by a series of thin-sections of both archae-

[1] Landenian is a now disused term found on 19th century geological maps that today belongs to the Thanetian, i.e. the Upper Paleocene.

ological and lithological samples submitted to the geologist G. Toussaint. While some of the thin-sectioned pieces have been located, the thin-sections themselves were unfortunately lost, and no detailed information concerning these samples was ever recorded or published.

METHODS

The several thousand pieces comprising the Spy collection are today dispersed across various institutions and private collections. Flint is the dominant raw material independent of the period, with other materials comprising less than 5 % of the overall assemblage. Amongst the diverse raw materials, *phtanite* is the most important material after flint, followed by very small quantities (less than 1 %) of sandstones, "*grès-quartzite de Wommersom*" ("Wommersom quartzitic sandstone"), etc.

The widest possible selection of raw materials was examined in order to both evaluate the variety of raw materials exploited during the different occupations, and investigate possible networks of exchange or social interactions. The systematic analysis of the entirety of the non-flint artefacts recovered from the site was not the aim of the present study, especially as we lack sufficient chrono-cultural information for these pieces.

Among forty-nine pieces initially selected, forty-four were examined macroscopically and mesoscopically in order to characterise their lithology (ST2). In addition to describing their colour and possible alterations, a litho-stratigraphical attribution, geological and geographic provenance as well as the likely minimum distance from the site to the potential outcrop have been indicated (see sample list and descriptions in ST2). Finally, a history of the archaeological attributions and interpretations is presented for each lithological group (ST1).

RESULTS

Silicites

Finely bedded silicites, or *phtanites* in French, can be distinguished from nodular silicites, referred to in French as *cherts*. Although flint (*silex*) is also a nodular silicite, in Belgium this term is reserved for siliceous nodules and masses that occur in carbonated Mesozoic deposits, while those from Palaeozoic deposits are referred to as *cherts*.

Bedded silicites or phtanites

History of the archaeological attributions and interpretations

A. Rucquoy attributed the almond-shaped biface he discovered on the floor towards the rear of the cave to the Upper Carboniferous (Rucquoy, 1886-1887: 322 and Pl. XVI – fig. 3). M. De Puydt and M. Lohest defined *phtanite* as a "matte black, opaque stone [which] seems to have a more compact and homogeneous paste than most of our carboniferous phtanites" (De Puydt & Lohest, 1887: 219). These authors mention the presence of two types of *phtanite* in the Spy collections.

The first geologist to genuinely understand the archaeological interest of *phtanite* and first bring attention to A. Rucquoy's discoveries at Spy was G. Cumont (Cumont, 1898, 1904: LV). He only mentions *phtanite* from Ottignies, assuming that all the *phtanites* recovered from the site derived from this source. A. Rutot identified three varieties of *phtanite* with different geological ages: Upper Carboniferous, Carboniferous limestone (simple silica), and Cambrian (Rutot's comment in Cumont, 1898: 270-271). However, according to him, only the latter could have been used in prehistory. Problems surrounding the use of *phtanites* in prehistory were reviewed by J.-P. Caspar (1982) with assistance from analyses carried out by petrographer P. Dumont (*Université Libre de Bruxelles*). Only materials derived from Cambrian deposits were considered by Caspar to be *phtanite*, the other two varieties were grouped under *cherts*.

In an 1897 letter from M. De Puydt to V. Jacques, pieces from Spy were identified as being strictly Cambrian *phtanite* from the Ottignies region (after Cumont, 1898: 272). This notion of a unique origin for all the *phtanite* was subsequently perpetuated from researcher to researcher (e.g. de Loë & Rahir, 1911: XLIX;

Caspar, 1984: fig. 36). Caspar's (1982) petrographic analysis of ten *phtanite* samples from Spy also led him to attribute them to the Cambrian outcrops at Ottignies-Mousty.

Similarly, M. Goffin-Cabodi (1985: 160-165) interpreted all the pieces she analysed as being *phtanite* from Ottignies. Unfortunately, no information concerning the number of sampled

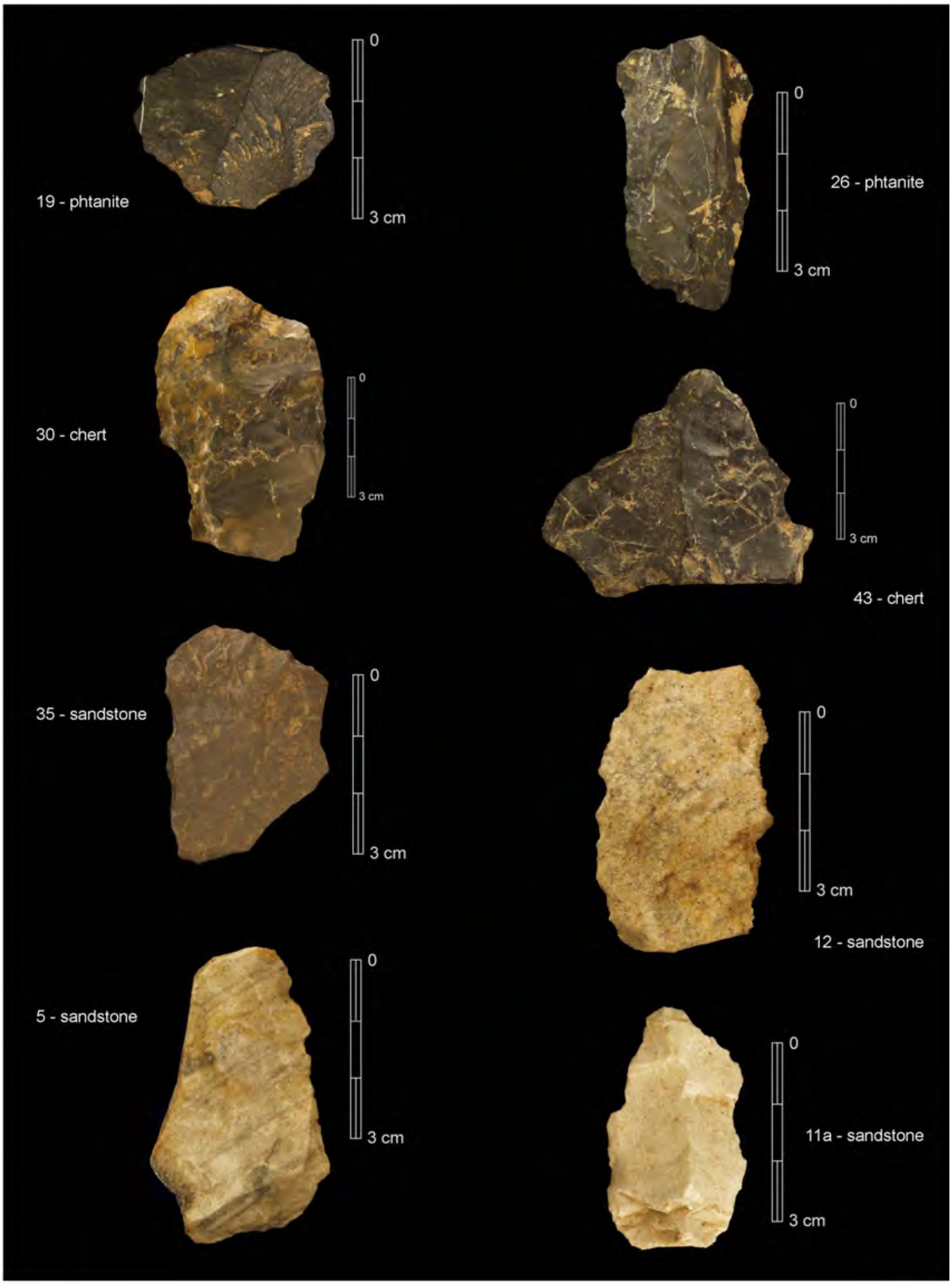

Figure 1. Studied samples of *phtanite*, *chert*, and sandstone.
Numbers refer to the ST2. © RBINS, photos É. Dewamme.

pieces is available, nor any details regarding the petrological results of the thin-sections. Moreover, not all the pieces discussed and illustrated were thin-sectioned, and connecting a particular thin-section with a precise artefact is no longer possible. Finally, several artefacts examined with a stereomicroscope were judged by M. Goffin-Cabodi to be Cambrian *phtanites* from Ottignies-Mousty.

M. Ulrix-Closset (1975: 54, note 1) mentioned the presence of Upper Carboniferous *phtanite* in the vicinity of the cave and commented on its probable use; however, she cautiously grouped all the pieces in one general category of *phtanites* that were nevertheless assigned a unique Cambrian origin (Ulrix-Closset, 1975: 59, note 43). On the other hand, M. Otte (1979: 204) highlighted not only the use of *phtanite* from Ottignies, but also another *phtanite* or *chert* which formed in Visean Carboniferous limestones based on determinations carried out by J.-P. Klercx and H. Pirlet (*Université de Liège*). According to these authors, this material outcrops west of Spy cave at "Vieuswille" (Viesville near Pont-à-Celles)[2]. Finally, only M. Dewez maintained the idea of an exclusively local origin for the *phtanite* artefacts, mentioning a potential outcrop 3 km upstream at Onoz (Dewez, 1980: 37).

These references highlight both the terminological and practical difficulties encountered when attempting to both distinguish different types of bedded silicites and identify their origin.

Use at Spy (based on available literature and personal observations): Mousterian, Aurignacian, and Gravettian.

Selected samples

Four pieces that could fit the macroscopic description of *phtanite* were selected for our study. All are knapped flakes (ST2: nos. 3, 16, 19, and 26; Figure 1) having either an imprecise or unknown context: backdirt excavated by F. Twiesselmann on the slope in front of the cave, or surveys (on the slope?) by Carpentier. One piece (no. 19; Figure 1) with thin, white quartz veins was selected from the Carpentier collection along with a Levallois-like flake attributable to the Middle Palaeolithic (no. 16).

A blade core (ST2: no. 2; Figure 2), typologically similar to Gravettian examples, is in a matte black silicite with white crystalline spots (quartz). This unbedded raw material is very similar to nodular Cambrian *phtanites* which, although deriving from the same outcrop as genuine Cambrian *phtanites*, belong to another facies.

Stratigraphic attribution, geological context, supposed origin, distance to nearest outcrop

Bedded silicites in Belgium can be correlated with two different stratigraphic levels: Cambrian *phtanites* from the Brabant Caledonian Massif and those from the lowest Namurian strata. The Franquenies Member (lower part of the Mousty Formation, Upper Cambrian) contains siliceous beds and lenses of lydite within black shales. Also referred to as *phtanites d'Ottignies*, this raw material outcrops in the disused quarry of Franquenies (Céroux-Mousty) and only rarely in its vicinity.

Pale grey to black, finely bedded silicites (completely silicified beds or *phtanites* and siliceous "radiolarian shales") occur between Dinantian limestones and Namurian siliciclastics (Gottignies Formation, Souvré Formation – age: Visean-Serpukhovian transition). Both formations are geographically restricted: the Gottignies Formation is present in the western part of the Namur Parautochton, while the Souvré Formation outcrops in the Visé-Puth High. The Chokier Formation (Belgian Coal Measure Group, Namurian A) contains beds of silicites alongside calcareous shales and pyrite-rich, aluniferous shales (Delmer *et al*., 2001).

Macroscopically, the two types of *phtanites* are not easily distinguished. Recent tests using Raman spectrometry (non-destructive method) allowed black Cambrian *phtanites* to be separated from Lower Namurian examples based on the degree of evolution evident in the organic matter colouring the raw material (Vanbrabant *et al*., 2010, 2011).

[2] The Viesville Formation (Hoyoux Group, Warnantian Age, Upper Visean) contains centimetric to decimetric beds of dark, algal, fine-grained limestones with *chert* nodules (nodular silicites), argillaceous limestones, and carbonaceous shales. Thin seams of impure coal were mined at the summit of this unit. A coal seam outcrops immediately south of Spy cave.

Two additional samples from the Rucquoy collection (Spy-AR5608/1 and 5608/2) were also considered. One sample was assigned to Namurian *phtanite*, most likely found in the immediate vicinity of the site, and the other to Cambrian *phtanite*, found uniquely in the area around Céroux-Mousty. The same Raman examination of the biface from Rucquoy's excav-

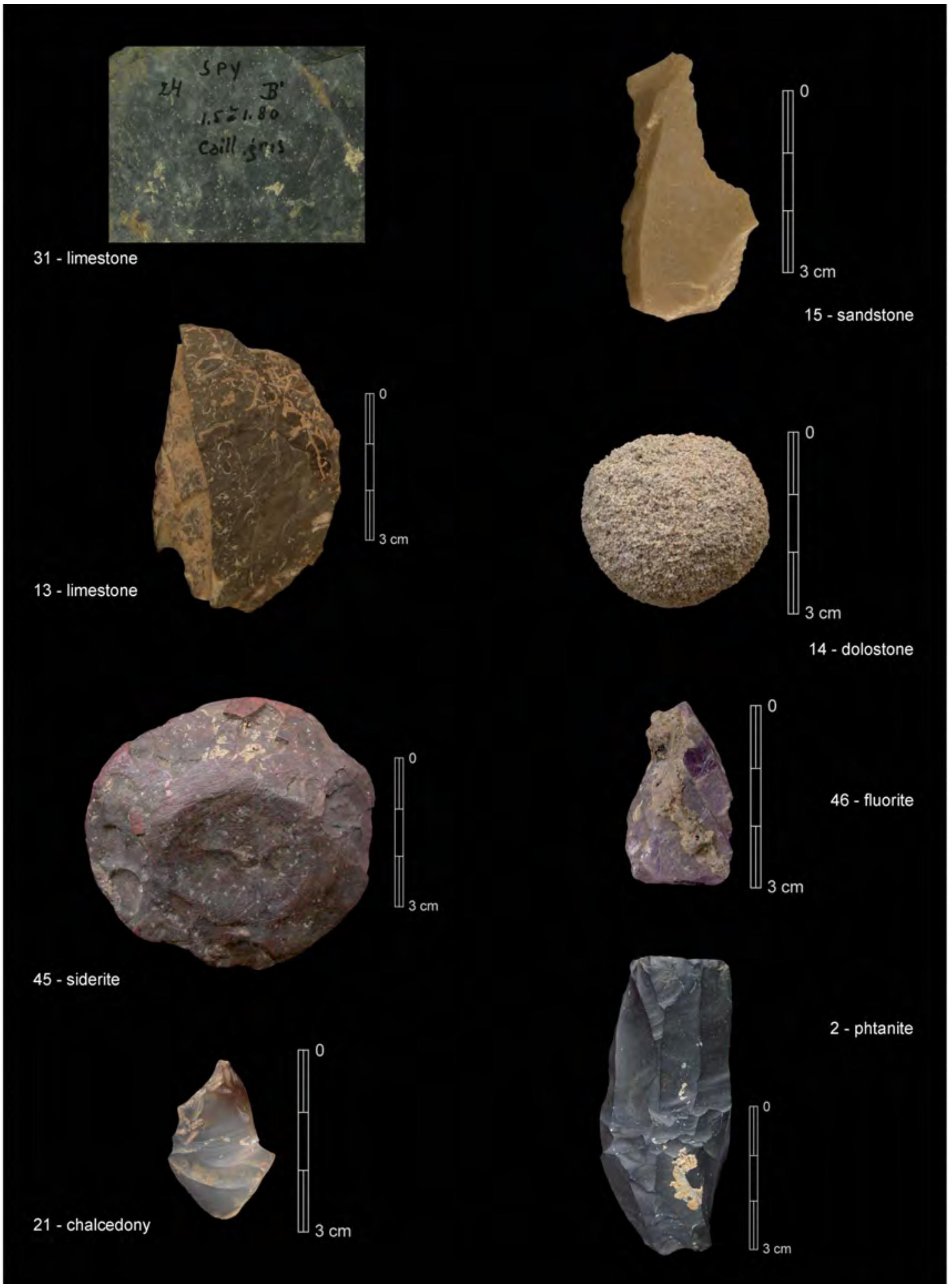

Figure 2. Studied samples of carbonate rocks, sandstone, siderite, fluorite, chalcedony, and *phtanite*. Numbers refer to the ST2. © RBINS, photos É. Dewamme.

ations (Spy-AR5608) also pointed to a Cambrian origin.

Samples of bedded silicites (*phtanites* from the Chokier Formation) can be collected as debris on the eastern slopes of the Orneau Valley, south of the last outcrops of Visean limestones near the cave (Delcambre & Pingot, 2008). Outcrops containing these low-quality materials, although very restricted (only several metres wide), are extremely long. They consist of two sub-parallel strips, roughly oriented east-west, that correspond to the two sides of the Namur Parautochton (mostly Hainaut Trough that extends eastwards from Namur). To the east of Namur, these strips outcrop north of the Meuse, on both banks of the Sambre River to the west, and in valleys cutting these series. Their fracturing along the stratification plane and fine lithology allows them to be easily extracted.

Probable ages: 1) Lower Namurian (Upper Carboniferous); probable minimal distance from the site: < 1 km; 2) Cambrian (Franquenies Member, Mousty Formation); distance from the site: ca. 23 km.

Nodular silicites or cherts

History of the archaeological attributions and interpretations

The presence of black *cherts* is rarely mentioned in discussions concerning the Spy collections. Furthermore, clearly knapped, black *chert* pieces are rare and have obviously been confused with or included in the *phtanite* category. M. Goffin-Cabodi described a local, black Visean *chert* (Goffin-Cabodi, 1985: 170) into which she classed a small retouched flake. In her opinion, this material was rarely used during the Middle Palaeolithic and only as a substitute material (Goffin-Cabodi, 1985: 171). Although M. Dewez (1980: 37) mentioned the possibility of local *chert* being procured 100 m west of the cave, this material is most likely Upper Carboniferous *phtanite.* This idea was also advanced by M. Ulrix-Closset (1975: 59, note 43) amongst others.

These examples once again demonstrate the confusion between *chert* and *phtanite*. Chrono-culturally attributable *chert* pieces are rare and mainly Middle Palaeolithic. Finally, K. Di Modica mentioned the presence of *chert*, in the sense employed here, from six other Middle Palaeolithic sites in Belgium (Di Modica, 2010: 155).

Selected samples

Six *chert* samples were selected (ST2: nos. 4, 9, 28, 29, 30, 43; Figure 1) of which five bear traces of human modification (4 flakes and 1 core). One example is a Middle Palaeolithic pseudo-Levallois point. An un-modified block was selected from the Rucquoy's excavation, while the other artefacts recovered from the backdirt on the slope in front of the cave by F. Twiesselmann must be considered "without context".

Colour and texture vary from one nodular silicite to another according to stratigraphic position, geographic origin, and the freshness of the material. These silicites show evidence for a more or less pronounced devitrification, generally beginning at the border and progressing towards the core of the nodule or, more rarely, as widespread or coalescent spherules.

Stratigraphic attribution, geological context, supposed origin, distance to nearest outcrop

Cherts occur in several Tournaisian and Visean formations (secondary dolomites and limestones, respectively). These series can mainly be observed in two large structural units; the Namur Parautochton in which Spy cave is found, and the Ardenne Allochton, both in its northern (previously referred to as the Dinant Basin or Dinant Synclinorium) and eastern expression (the Visé-Puth High, previously referred to as the Verviers Synclinorium). Their broad distribution spreads north and south of the Meuse and Sambre Rivers, extending from the French border to those with Germany and the Netherlands. In the Orneau Valley, only two formations contain *cherts*: the calcareous Viesville Formation (Warnantian, Upper Visean), close to the limestone cliff where Spy cave is located (Lives Formation, Livian, Visean), and the dolomitic Namur Formation (Ivorian-Upper Tournaisian and Lower Moliniacien-Lower Visean) that outcrops more than 1.5 km from the cave. Two nearby sources are therefore possible. Extracting *chert* from unweathered massive limestone is very difficult, with unweathered dolomites being only slightly easier. Their procurement is simpler in weathered rocks; however, this is offset by a more substantial devitrification. An intermediate case is found with screes. In addition to the classic "black *cherts*", a brown-black, jasper-like *chert* flake (ST2: no. 30; Figure 1) likely has a different origin.

Probable age: Tournaisian or Visean. Minimal distance from the site for black *cherts*: < 1 or more than 1.5 km, perhaps *in situ* in the Orneau Valley.

The terrigenous rocks

Terrigenous rocks mostly concern sedimentary arenites (sandstones and quartzites) as gravelly sandstones and slate were not encountered in the Spy collection.

History of the archaeological attributions and interpretations

"Bruxellian"[3] sandstones (ST2: nos. 12, 42; Figure 1)

A. Rucquoy had already noted the presence of a few rare artefacts made in a local, white "Landenian" sandstone during his excavations (Rucquoy, 1886-1887: 322) that he referred to as "*grès lustré bruxellien*" ("lustred Bruxellian sandstone") without specifying its exact provenance (de Loë & Rahir, 1911; Ulrix-Closset, 1975; Goffin-Cabodi, 1985). On the other hand, Marcel De Puydt and Max Lohest tentatively attributed this sandstone to the "Bruxellian" stage, making clear that it did not derive from the cave's immediate environment (De Puydt & Lohest, 1887: 220).

Only M. Otte attributed several sandstone artefacts to the local "Fayat sandstone". Petrographic analysis of a thin-section from one of the artefacts by J.-P. Klercx and H. Pirlet (*Université de Liège*) confirmed the geographical origin of this raw material (Otte, 1979: 204, note 15). Although sometimes interpreted as being "Landenian" (Rutot, 1887, 1888), the "Fayat sandstone" is of "Bruxellian" age. Moreover, when A. Rucquoy made reference to "Landenian" sandstone, it is quite possible that he also included "Fayat sandstone".

Use at Spy: rare.

[3] Bruxellian is a now disused term found on 19th century geological maps that today belongs to the Lutetian, i.e. the Middle Eocene.

"Landenian" quartzites (ST2: nos. 8, 23, 40)

A. de Loë and E. Rahir were the first to recognise a fine-grained "Landenian" quartzite known as "*grès-quartzite de Wommersom*" or GQW ("Wommersom quartzitic sandstone"). Although they mentioned only one piece (de Loë & Rahir, 1911: LVI) from the "third fauna-bearing level" in the gallery, subsequent researchers continuously mentioned the presence of GQW pieces from both Middle (Ulrix-Closset, 1975: 59; a single piece) or Early Upper Palaeolithic contexts (Otte, 1979: 204). In her study of non-flint raw materials, M. Goffin-Cabodi readdressed the question of the GQW, introducing yet another geologically and geographically similar material – "*grès-quartzite de Rommersom*" ("Rommersom quartzitic sandstone"; Goffin-Cabodi, 1985: 165-167). Even if some authors continue to separate these two types of raw materials (Crombé, 1998), this is unjustified from a geological perspective.

Use at Spy: occasionally in the Middle and Upper Palaeolithic.

Other sandstones and quartzites (ST2: nos. 5, 10, 11a, 15, 20, 22, 25, 32, 33, 35-39, 41; Figure 1 and Figure 2)

M. De Puydt and M. Lohest mention the presence of flat, Upper Carboniferous sandstones in the hearths of the "second fauna-bearing level", "some of which still bear traces of fire" (De Puydt & Lohest, 1887: 214).

A. de Loë and E. Rahir also discovered "two fragments of sandstone slabs (Famennian "stratoid psammite"), one slightly stained red on one side" (de Loë & Rahir, 1911: XLVI). They also mentioned the presence in the "first fauna-bearing level" of two large river cobbles of weathered siliceous sandstone "which were used as hammer- or grinding stones" (de Loë & Rahir, 1911: LIV). They also reported a "Coblencian"[4] sandstone "ball" and three flat slabs in the same material from the "second faunal-bearing level" (de Loë & Rahir, 1911: XLIX). Several "Coblencian" sandstone river pebbles are also mentioned by M. Ulrix-Closset (1975: 59), not-

[4] Coblencian is a now disused term found on 19th century geological maps that today corresponds to the Pragian *pro parte*, i.e. the Middle Lower Devonian.

ing that these objects, generally considered as hammer- or grinding stones, very rarely show traces of crushing.

The use of sandstone and quartzite as "hearth stones" or as hammer/grinding stones in the Early Upper Palaeolithic at Spy is also mentioned by M. Otte (1979: 308).

Use at Spy: most likely during the Upper Palaeolithic.

Selected samples

Twenty pieces were examined, 11 of which fit the description of lustred sandstone. These 11 macroscopically homogeneous pieces comprise 10 flakes or flake fragments and 1 tool. None of the studied pieces are diagnostic of a particular techno-complex as they come from Rucquoy's excavations, Twiesselmann's investigation of the slope deposits, or private collections lacking any precise stratigraphic context.

The nine other pieces portray a wider variety of detrital rocks (siltstone, sandstone, and sedimentary quartzite). Two artefacts were obviously knapped, amongst them a flake from a quartzitic pebble from a conglomerate (ST2: no. 23), and another in a fine-grained sandstone with a weakly developed quartzitic structure (ST2: no. 32). The other selected pieces all come from Twiesselmann's excavations and comprise river pebbles (sometimes broken), a small slab, and a concretion. In addition to the fact that they are non-diagnostic or non-anthropogenic, these pieces cannot be attributed to a specific "fauna-bearing level".

Stratigraphic attribution, geological context, supposed origin, distance to nearest outcrop

While Tertiary series normally contain loose sediments (sands, silts, clays), in particular local contexts and several stratigraphic levels ("Bruxellian", "Landenian") a variable silicification has generated hard rocks referred to as "sandstones", "sandstone-quartzites" or "quartzites"[5]. These rocks outcrop as denudation blocks (Pirson *et al.*, 2001) that can be collected as raw material. The degree of silicification, as well as the sand granulometry, vary locally, inducing slight differences with locally specific names connected to either a stratigraphic reference ("Landenian" or "Bruxellian" sandstone) or a geographic origin ("*grès-quartzite de Wommersom*", "*grès-quartzite de Rommersom*", "Landen sandstone", "Tienen quartzite", "Bray sandstone", etc.). Both the original morphology of the quartzite grains (63 µm to 2 mm) and silica cement are observable when the thin edges of knapped pieces are viewed mesoscopically under bright light.

"Bruxellian" and "Landenian" sandstones

In Belgium, the Tertiary cover is largely present north of the Sambre-Meuse axis. Substantial in the north, it reduces progressively towards the south, appearing only as strips immediately north of the Sambre-Meuse axis or as accumulations in karstic pockets that developed within Dinantian limestones in the *Entre-Sambre-et-Meuse* region.

Silicified sands are contained in different stratigraphic levels of the Upper Palaeocene (Landen group of the Thanetian stage, previously referred to as "Landenian" on geological maps, several different levels of marine or fluviatile sands) and Middle Eocene (Senne Group of the Lutetian stage, Bruxelles Formation, formerly referred to as "Bruxellian" on geological maps). "Landenian" and "Bruxellian" are disused terms describing regional Palaeogene stages in Belgium (De Geyter *et al.*, 2006).

"Landenian" sandstones outcrop both in Hainaut ("Bray sandstones", "Binche sand-

[5] The terms "sandstone" and "sedimentary quartzite" (orthoquartzites) are defined in the geological literature. Orthoquartzite is a clastic sedimentary rock composed of silica-cemented quartz sand whose cement is commonly deposited in crystallographic continuity with the quartz of the worn grains. The term "sandstone with quartzitic structure" is used to describe a diagenetic continuum linked to increasing constraints on the material (pressure, temperature, etc.). These types of quartzites are found in Lower Palaeozoic and Devonian deposits in Belgium, while sandstones occur in younger series (Carboniferous and Jurassic). The sandstone cement can be composed of different components (carbonates, clays, silica), alone or combined in variable proportions. However, in some cases without pressure constraints, substantial silicification of Tertiary sands (e.g. in phreatic or pedogenic conditions) can also lead to the formation of genuine quartzites. Metaquartzite is a metamorphosed sandstone in which silica grains fuse together to form a hard, massive rock. Metaquartzite contains more than 90 percent quartz, giving it a pale, sugar-like appearance.

stones", etc.) and in the eastern part of Hesbaye (Dupuis *et al*., 1997; Pirson *et al*., 2001). The Bruxelles Formation mainly contains coarse sands, but also quartzitic calcareous sands and sandstones. Silicified "Bruxellian" sandstones seem to be scarcer, outcropping a little more than 1 km north-west of Spy where they are known as "Fayat sandstones" (Rutot, 1887, 1888). Due to their resistance to alteration and abrasion, these silicified sands appear as a light tabular relief in the landscape. Their age has been determined by the presence of Nummulites (Rutot, 1887, 1888).

The macro- and mesoscopic examination presented here was inconclusive, rendering the petrographic analysis of sandstone artefacts containing silica cement necessary in order to establish their specific geological age and geographic origin. Despite relevant lithofacies showing strong lateral and vertical granulometric variations, secondary cements and accessory minerals remain the best way to differentiate different types of sandstones.

Other sandstones

Red sandstones attributed to the Middle Devonian and brown-green (weathered colour) or grey-beige (weathered colour) quartzitic sandstones attributed to the Lower Devonian or Lower Palaeozoic have been identified. Corresponding geological sources are dispersed along the northern limits of the Ardenne Allochton (former Synclinorium of Dinant). As far as the Devonian sandstones and quartzites are concerned, they may originate immediately south of the Meuse, although the closer "Mazy sandstones" of uncertain age (possibly Lower Frasnian or older) would also be good candidates for some artefacts. Some of the quartzites may also derive from the Caledonian Massif of Brabant that outcrops locally at the bottom of several Brabant valleys (Thyle, Dyle, Senne, Orneau, etc.). However, as all the pieces from this category consist of river pebbles, a closer, probably local origin is most likely.

The following quartzite and sandstone pieces from Spy were sampled:

- A quartzite flake (ST2: no. 23) from a weathered Lower Devonian pebble. Probable origin: nearby valleys; minimum distance from the site: 0-5 km.
- A fine-grained sandstone flake with a light quartzitic structure (ST2: no. 32) that probably comes from the Upper Famennian (amaranth sandstone from Huy), the ante-Frasnian detrital formations of the northern limits of the Namur Parautochton, or the Lower Devonian (northern limits of the Dinant Synclinorium).
- Probable origin: nearby valleys; minimum distance from the site: < 10 km.
- The other pieces are river pebbles (sometimes broken), slabs, and a concretion; all are of local origin (5 km from the cave at most).

Carbonate rocks

Limestones

History of the archaeological attributions and interpretations

A. de Loë and E. Rahir (1911: XLIX), as well as M. Ulrix-Closset (1975: 59), mention the presence of limestone *sensu lato* and silicified crinoidic limestone. A "silicified crinoidic limestone flake (Carboniferous limestone) of unknown geological provenance" from the "third fauna-bearing level" and fragments covered by hematite powder (oolithic ironstone) in the "second fauna-bearing level" were collected by A. de Loë and E. Rahir (de Loë & Rahir, 1911: LVI).

Use at Spy: rare, probably during both the Middle Palaeolithic and Early Upper Palaeolithic.

Selected samples

Pieces of silicified crinoidic limestone kept at the Royal Museums of Art and History and the *Grand Curtius* Museum were not examined in this study. The rarity of such artefacts poses questions as to their being intentionally knapped. Three grey limestone flakes from the backdirt of the 19th century excavations and a fourth from the Castin collection were selected (ST2: nos. 1, 13, 27, and 31; Figure 2). These micritic limestone objects lack any visible macrofauna. In the absence of thin-sections, three are non-diagnostic and cannot be assigned to a particular chrono-stratigraphic unit. That being the case, thin-sections are only useful if the material contains specific microfauna. Micritic limestones are generally not favourable for this kind of analysis.

Stratigraphic attribution, geological context, supposed origin, distance to nearest outcrop

The samples of grey-blue micritic limestone can be connected to Upper Visean outcrops not far from the site in the Orneau Valley. The distribution of these outcrops is potentially as large as that described for the Dinantian *cherts*. Attributing samples to a specific formation requires petrographic analysis coupled with an evaluation of their micro-palaeontological content. Sample 31 (ST2; Figure 2) is a micrite rich in infra-millimetre globular Foraminifera (*Saccaminopsis carteri*?) that is partially cemented by white calcite, although a thin-section is required to confirm this determination. This Foraminifera, if confirmed in thin-section, would indicate an Uppermost Visean age and a probable local source.

An outcrop of the Rhisnes Formation (Frasnian) in the Orneau Valley, 3 km north of the cave, could also be a potential source of carbonate rocks. Interestingly, silicified crinoidic “limestones” (dolostones?) also outcrop in the Tournaisian dolostones (Namur Formation) in front of Mielmont castle.

Probable minimum distance from the site: 0 to 3 km within the Orneau Valley.

Dolostones

History of the archaeological attributions and interpretations

Up until now, no dolostones have been cited in the archaeological literature pertaining to Spy.

Selected sample

A “bowl” of coarse-grained, light buff coloured, secondary dolostone from Twiesselmann’s excavations was examined (ST2: no. 14; Figure 2). The most noticeable aspect of the sample is the unusual, but not uncommon size of the dolomite grains. No fossil traces were recognised. Given that the material is not heavily cemented, the “bowl” shape may result from post-excavation handling.

Stratigraphic attribution, geological context, supposed origin, distance to nearest outcrop

Several levels of Tournaisian and Lower Visean limestones, both in the Namur Parautochton or the Ardenne Allochton (forming part of Dinant Synclinorium), are dolomitised. The Dinantian dolostones (Namur Formation, thickness: 200 m, Upper Tournaisian to Lower Visean) are cut by the Orneau Valley, no less than 1.5 km to the north.

Minimum potential distance from the site: 0 to 3 km in the Orneau Valley.

Siderite

History of the archaeological attributions and interpretations

This material has not been mentioned in previous studies.

Selected samples

Two sub-nodular pieces (inventory no. A.5627) of unknown archaeological context and housed at the *Musée Archéologique de Namur* (ST2: nos. 44 and 45; Figure 2) were selected as they probably represent the only examples of this type of material in the entire Spy collection. One (no. 45) shows traces of scraping referable to human action, while the antiquity of the sawing traces on the second piece is questionable.

Stratigraphic attribution, geological context, supposed origin, distance to nearest outcrop

Spherical siderite concretions frequently appear at the top of the Namurian and Westphalian Formations (Upper Carboniferous, Upper Palaeozoic). Their nodular shape is, however, more characteristic of the Namurian-Westphalian transition, where it is more often associated with marine levels.

Discoid carbonated concretions, whose flatter shape suggests more continental levels affected by pedogenesis are more often associated with the Westphalian (Upper Carboniferous, Upper Palaeozoic). However, carbonate levels also appear in these levels as centimetric and occasionally discontinuous strips.

Spy cave is located directly on the limit between Visean limestones to the north and Namurian-Westphalian siliciclastic rocks immediately to the south. Upper Carboniferous rocks consist of silty shales with subordinate sandstones and coal seams. Their lithologies are more weathered and outcrops are infrequent, restricted to deeply incised valleys. Numerous brownish centimetre-sized siderite concretions were easily collected during field surveys from the dark shale host which sporadically outcrops 50 to 100 metres south of the cave on the east bank of the Orneau River. Siderite nodules found in the Spy deposits were therefore probably procured immediately south of the cave. The local geological structure and topography exclude the possible introduction of this material into the cave by natural processes.

Fluorite

History of the archaeological attributions and interpretations

One of the fluorite fragments discovered during A. de Loë's excavations was suggested by M. Otte (1979) to be associated with the few Late Upper Palaeolithic artefacts (a perforated ivory disk, eyed needle fragment, backed bladelets) given the scarcity of this raw material in the older assemblages (Jungels & Goemaere, 2007).

Selected samples

Three fragments of a translucent, light mauve, intentionally fractured fluorite, whose crystal faces follow the cleavage plans, were identified in the RBINS collections (ST2: nos. 46 to 48; Figure 2). Recovered by Twiesselmann, these objects are not connected to a specific layer and therefore lack any reliable context.

Stratigraphic attribution, geological context, supposed origin, distance to nearest outcrop

The strontium isotope ratio and LA-ICP-MS measurements of rare-earth elements were obtained for a fluorite sample from Spy in addition to several archaeological samples from other Belgian Palaeolithic sites (the cave of Chaleux, Trou Magrite). These values were compared with fluorites from known geological outcrops in Belgium and abroad, including fluorite from the Visean limestones close to Spy cave. The fluorite from Spy was collected from silicified Fromelennes limestones (Givetian, Middle Devonian) in the area surrounding Givet (Jungels & Goemaere, 2007). Mineralisations found at Foiches show very similar features to the fluorite from Spy. The two Magdalenian fluorites from Chaleux cave and an Upper Palaeolithic fluorite from Trou Magrite display identical geochemical and radiochemical signatures.

Chalcedonies

History of the archaeological attributions and interpretations

M. De Puydt and M. Lohest indicated a dozen artefacts from the "second fauna-bearing level" in addition to a single example from the overlying level to have been made from a grey, veined chalcedony (De Puydt & Lohest, 1887: 220 and note 1, respectively). M. Otte counted at least 20 chalcedony flakes which he attributed to the Early Upper Palaeolithic (Otte, 1979: 210-280), suggesting this particular raw material to have been used more often at the beginning of the Upper Palaeolithic. M. Goffin-Cabodi has suggested that patination (surface discolouring by weathering) could make identifying this specific raw material difficult (Goffin-Cabodi, 1985: 170-171), most likely rendering it underrepresented in the Spy collections.

Use at Spy: Early Upper Palaeolithic.

Selected samples

Two pieces of chalcedony were sampled; a flake from a river pebble with black cortex (ST2: no. 18) and a small non-cortical flake (ST2: no. 21; Figure 2), neither of which could be attributed to a specific cultural level.

Stratigraphic attribution, geological context, supposed origin, distance to nearest outcrop

The lack of information concerning this particular raw material has made it impossible to determine its geological age. With that said, they probably derive from the Meuse Valley and its terraces, especially the piece with alluvial cortex. Chalcedony can be found in consolidated rocks of undetermined age and lithology near Barchon, Berneau, Bioul, Chokier, Dalhem, Heure-le-Romain, Maredret, Montignies-les-Lens, Richelle, and Seilles (data compiled by Hatert *et al.*, 2002); however, an exhaustive analysis of its distribution is currently unavailable.

Probable minimum distance from the site: < 1 km.

Raw materials with an unknown provenance

A river pebble in the form of a greenish, metamorphic rock (ST2: no. 7) of unknown origin with minute mica flakes and small white veins of quartz was sampled. Lithologically, the material appears exotic as no such rocks exist in Belgium; however, it could have been collected from the local fossil terraces of the Meuse River or on the alluvial plain. The original archaeological context of this item is unknown.

Other previously cited raw materials not considered in the present study

M. De Puydt and M. Lohest mentioned the presence of **lignite** fragments (De Puydt & Lohest, 1887: 227), but did not specify any stratigraphic origin, and A. Rucquoy (1886-1887: 323) recorded **manganese peroxide** (pyrolusite or manganite?) which could have been used as a colorant in the same way as hematite. Lignite (often referred to as "brown coal") has characteristics placing it somewhere between coal and peat. Geologically younger than higher-grade coals, lignite can primarily be found in Tertiary deposits. Occurrences of lignite are well known in the Andenne region where they are associated with white plastic clays; however, this combustible material is widely distributed across numerous continental Tertiary deposits. Pyrolusite (MnO_2) is a dehydrated product of manganite ($MnO(OH)$), which according to Malaise (1913, reported by Hatert *et al.*, 2002), is found in Andenne, Angleur, Bodrange, and Moresnet, but also in Fe-Mn ores in the Lienne River valley (Stavelot-Venn inlier). Pyrolusite is frequently found as dendritic crusts developed on stratifications planes and fractures in siliciclastic rocks, and especially in the weathering front of outcrops.

Pyrolusite also appears as fibrous, dense, or earthy aggregates with limonite (iron oxi-hydroxide) in Devonian rocks of Beaufays, Hertogenwald (Membach), and Marchin, in Carboniferous seams at Andenne, Aywaille, Boignée, Ligny, Masta, Priomboeuf, Sprimont, and Tilff, as coatings on quartz veins at Fraiture (Bihain), in the Lienne Valley, and at Salmchâteau, Sart-lez-Spa, and Vielsalm (Hatert *et al.*, 2002). No occurrences have been documented in the area around Spy, but pyrolusite (or manganite) may occur in Dinantian rocks found near the site. In the end, interpreting the presence of Mn-compounds at Spy is difficult without accurately identifying this material.

According to M. De Puydt & M. Lohest (1886: 36), **brown xyloid jasper** could have been used during the Upper Palaeolithic based on their discovery of a core in this material. Although this material could come from the centre of the Paris Basin (Otte, 1979: 204), the description provided by M. Otte could fit with the more local, brown silicite described here (see section "Nodular silicites or *cherts*").

M. Goffin-Cabodi described a Levallois flake made from a quartzite containing garnets (Goffin-Cabodi, 1985: 168-170); however, neither the thin-section nor the piece itself could be located. Rocks with (Mn-)garnets inclusions are present in two metamorphic zones of the Ardenne (the Lower Palaeozoic at the southern margins of the Stavelot inlier and from the Lower Devonian of the Ardenne Anticlinorium) as well as in the Mousty Formation (Upper Cambrian; Brabant Massif). The latter outcrops only along the Dyle Valley in the same area as the Cambrian *phtanite* from Ottignies (Franquenies Member forming part of the Mousty Formation). These two types of material thus share similar geological and geographic characteristics.

CONCLUSION AND PERSPECTIVES

The conclusions presented here are severely hampered by difficulties connected to the lack of archaeological contexts for the majority of the pieces examined. Nevertheless, several types of raw materials have been identified at Spy. The most abundant raw materials besides flint are Palaeozoic rocks that likely have a very local origin (within a 5 km radius of the site). These include oolithic hematite (see Goemaere *et al.*, this volume: chapter VIII), limestones, *cherts*, dolomites, and siderite nodules. This large variety of materials seem to have only been sporadically exploited and do not appear to have especially good knapping qualities. Consequently, artefacts are rare and not culturally representative. Lustred sandstones also potentially have a local origin, much like the "Fayat sandstones"; however, "Landenian" sandstones outcrop both in Hainaut ("Bray sandstones", "Binche sandstones", etc.) and in the eastern part of Hesbaye.

Additional raw materials found in secondary geological contexts also probably derive from nearby sources. This is the case with chalcedonies, jasper-like silicites, a "green stone", and various intensively exploited flints found as river cobbles (see Di Modica *et al.*, this volume: chapter IX, for more detail). The Meuse pebbles exemplify the lithological diversity in terms of rock type and age cut by river valleys.

The Brabant Massif supplied raw materials such as garnet quartzite alongside several bedded silicites including "Ottignies-Mousty *phtanite*". This Cambrian bedded silicite is regionally available – according to archaeological standards (i.e. 20-50 km) – and was clearly the most frequently exploited raw material after flint. Its favourable knapping qualities made it an attractive alternative, a fact made evident by its continual use by the cave's inhabitants (e.g. bifaces, Mousterian points, Upper Palaeolithic *débitage* and tools, etc.). Finally, identifiable fluorites were procured from outcrops of Givetian limestones near Givet, while other silicified sands most likely have more distant origins (e.g. Hainaut to the west, and Hesbaye to the east).

Petrographic analyses are a fundamental tool for recognising specific raw materials and, in more favourable cases, establishing their lithostratigraphic age, and hence areas where corresponding outcrops can be identified. Confronted with such an overwhelming number of pieces, the lack of sound archaeological contexts, and an incomplete inventory of the site's collections, this study represents a first attempt at describing all possible sources of non-flint raw materials, independent of the cultural context, that were procured directly or by exchange. This study forms part of a larger scale project currently in progress concerning several other Belgian sites. The necessary petrographic analysis of the Spy materials will be conducted only once a more global macroscopic assessment can be carried out, especially as archaeological pieces are partly destroyed during this kind of analysis. Finally, this contribution highlights the necessity of a close collaboration between archaeologists and geologists when discussing the finer points of sourcing raw materials and related provisioning networks.

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