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## **BREAKING BAD?**

### **DISCARDING THE SOLUTREAN NORMS: CHRONOLOGY, EVOLUTION AND GEOGRAPHICAL EXTENT OF THE BADEGOULIAN PHENOMENON IN WESTERN EUROPE**

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**ABSTRACT:** The Badegoulian technocomplex holds a special place among the West European Upper Paleolithic (UP) cultural traditions. Often understated or even bypassed by the main prehistorical overviews, caught between the fascinating Solutrean and the “classic” Magdalenian technocomplexes, it nonetheless probably marks a turning point in the evolving trajectory of hunter-gatherers in present-day France. The deep typo-technological changes, traditionally noted through lithic equipment, have recently been examined in the framework of interdisciplinary programs centered on several key-stratigraphic sequences located in south-west France. The combined analyses of flint, bone and antler assemblages, ornaments and faunal remains, together with the implementation of systematic archaeostratigraphic reassessment and radiometric dating, serve to confirm the speed and the strength of these changes ca. 23 cal ka BP. Without going into detail into the Solutrean-Badegoulian transition issue, the present paper provides a synthetic overview of the main Badegoulian characteristics—and their known variability—on the basis of the lithic and osseous equipment that guided the original identification. Following a three-step structure successively exploring the “when”, the “what” and the “where” questions, we will look at the current challenges in LGM chronocultural research, between (false) consensus and (true) sticking points.

**KEYWORDS:** Western Europe, France, Badegoulian, radiometric chronology, lithic and osseous industries, cultural geography

## **1. INTRODUCTION**

From the very first descriptions by Capitan and Breuil (1902) to current research, the so-called Badegoulian technocomplex has raised several questions and sub-questions that still remain unsolved. Appearing to be the odd man out in the highly specific and codified universe of the West European Upper Paleolithic, the “unable” Badegoulian flintknapper (Breuil, 1937) broke the prehistorian codes when he broke the Solutrean ones. While the issue of the integration of the Badegoulian assemblages into the Magdalenian phylogeny has given rise to stronger debate (as notably shown through an endless terminological dispute; see for a summary Cretin, 2007 or Ducasse, 2010: 8-14), a fairly broad consensus quickly emerged concerning the strong break existing between the Upper Solutrean and the Badegoulian (e.g. Breuil, 1937; Cheynier, 1939; Allain and Fritsch, 1967; Allain, 1983).

Emphasized by the sudden disappearance of the main Solutrean typo-technological *lithic* markers—laurel-leaf and shouldered points as well as flat and invasive retouch—this shift was interpreted in several ways depending on the evolution of paradigms and the scientific “school of thought” within which studies took place. Thus, while the answer to the “why” has long been sought only in the effects of ancient migrations, sometimes giving rise to disruptive analogies (Cheynier, 1939, p. 395) or very questionable scenarios (Stanford and Bradley, 2002; O’Brien et al., 2014), the impact of past climatic and environmental variability is now preferred and is currently deeply explored, both to clarify its conjunction with—and possible role in—the “cultural” evolving processes and to discuss its effect on human dispersal and population dynamics (e.g. Banks et al., 2008; 2009; 2011; Burke et al., 2014; 2017). At the

same time, the “where”, sometimes strongly connected to the “when” and corresponding for decades to a major point of contention (e.g. Bosselin and Djindjian, 1999; 2000; Straus and Clark, 2000), still remains little understood, drastically limiting the viability of large-scale models. Similarly to the recognition of Badegoulian industries across the area of present-day France which was slow and progressive (Daniel, 1937; 1952; Cheynier, 1939; Sonnevile-Bordes, 1966; Sacchi, 1967; Clottes, 1989), resulting from various—and sometimes combined—factors (old excavations conducted with obsolete methods, unrecognized taphonomic issues, paradigmatic resistance, etc.: see below), discussions are still ongoing about the existence—and, if so, about the chronology—of the Badegoulian typo-techno-economic norms outside the classic “French core”, leading to deep interpretative divergences (this being notably the case in the Iberian Peninsula where the Final Solutrean hypothesis still challenges the Badegoulian one: e.g. Rios Garaizar et al., 2013; Zilhão, 2013; Straus, 2018; Rasilla Vives et al., 2019). These divergences, partly rooted in existing gaps in the archaeological record as well as in chronological uncertainties, are currently blurring a broad understanding of the Badegoulian issue, often making it difficult to discuss the crucial question of cultural geography objectively, since “regionalization” *versus* “globalization” phenomena (*sensu* Valentin, 2008, p. 72) are sometimes based on prehistorian rather than prehistoric “frontiers” (e.g. Cazals et al., 2007).

Rooted in recent and ongoing research conducted in the framework of several interdisciplinary programs (*SaM* project: S. Ducasse and C. Renard dir.; *LA\_BA* project: S. Ducasse and D. Sacchi dir), monograph projects (Clottes et al., 2012; *Cassegras* project: S. Ducasse and J.-M. Le Tensorer dir.; *Casserole* project: A. Lenoble and L. Detrain dir.; *Chatenet* project: S. Ducasse and Q. Villeneuve dir.), PhDs (Renard, 2010; Ducasse, 2010; Baumann, 2014; Peschaux, 2017) or standalone studies that have highlighted the general trend of techno- and socio-economic evolution from the Upper Solutrean to the Badegoulian in SW France (Ducasse et al., 2019b; Renard and Ducasse, 2015), this brief paper aims at refocusing on the Badegoulian technocomplex to perform an updated chronological, typo-techno-economical and geographical state of the art. Results from archaeozoological and adornment studies will be set aside, and the following synthesis will be based only on lithic and osseous equipment from the “French core” area, following a three-step presentation: (1) the “when” will be explored first through the presentation of a renewed radiometric framework of the Badegoulian-type industries, (2) the “what” will then be recalled through a synthetic—and critical—view of the typo-technological and techno-economic characteristics and transformations of the flint, bone and antler industries and, from there, (3) the “where” and its implications will be challenged in the light of most recent research, especially regarding the current Solutrean-Magdalenian framework in Cantabrian Spain (e.g. Straus and Langlais, 2020), the relationship between Badegoulian and Salpétrian near the Rhône valley (Boccaccio and Bazile, 2008; Boccaccio, this volume) and the so-called Swiss Badegoulian (Le Tensorer, 1996; Sedlmeier, 2010; Leesch et al., 2012; Reade et al., 2020).

## 2. MATERIAL AND METHODS

The following overview is based on a total of 17 archaeological sites located from the north of the Aquitaine Basin to the Basque Country and the Languedoc region (figure 1 and table 1). Such a corpus, composed of assemblages encompassing the main part of the currently known Badegoulian typo-technological variability, together with a bibliographic review, provide an important and solid basis for discussing the above issues. While two-thirds of this corpus correspond to multi-layered deposits from caves (N=6) and rockshelters (N=5), the last third is composed of single-layered open-air sites (N=6); Twelve of the seventeen sites yielded well-preserved osseous component. Given that it includes sites that were excavated in very

different time periods, ranging from the 1910s to the 2010s (table 1), we had to adapt our methodological approaches on a case-by-case basis to ensure that each studied sample was representative. To avoid repetitions and unnecessary developments, we refer to the detailed information and explanations of these adaptations given in princeps studies (see the references listed in table 1). While the analysis of lithic and osseous assemblages was carried out according to the well-known, classic typo-technological and techno-economic approaches (e.g. Geneste, 1991; Inizan et al., 1995; Pelegrin, 1995; 2000; Averbouh, 2010; Tixier, 2012), we have taken systematic steps to control the chronocultural homogeneity of each assemblage, including—when feasible and relevant— intra- and inter-layer refittings, as recommended in lithic taphonomy studies (Villa, 1982; Bordes, 2000; Klaric, 2003; Bertran et al., 2017), and extended to the bone and antler assemblages (Pétillon, 2006).

In order to further test the intra-site coherence as well as to optimize the inter-site and inter-regional comparisons, careful attention was also paid to the renewing of the radiometric framework. Thus, as detailed in previous publications (Ducasse et al., 2019b), the archaeostratigraphic reassessment of each site systematically included a chapter dedicated to the radiometric framework, whether it was to revise, update (e.g. Cuzoul de Vers rockshelter, Lot: Ducasse et al., 2014; Pégourié Cave, Lot: Ducasse et al., 2019a; Casserole rockshelter, Dordogne: Ducasse et al., 2020 or Lassac open air site, Aude: Pétillon and Ducasse, 2012) or create ex-nihilo solid chronological data (e.g. Cassegros rockshelter, Lot-et-Garonne: dataset of fourteen AMS ages for the Upper Paleolithic sequence, soon to be published). Depending on the specificities of each context, direct dating of 3D coordinated osseous manufactured artifacts was favored (i.e. bone and antler manufacturing technical wastes or finished tools and points: see e.g. Brou, 2006; Ducasse et al., 2014 for a detailed description of the sampling method), and completed—or substituted when direct dating of the osseous industry was not possible—by 3D coordinated faunal remains. In contrast, note that in the case of presumed unreliable (e.g. Pégourié Cave, Lot) or even lacking stratigraphic information (e.g. Les Harpons rockshelter, Haute-Garonne: Ducasse et al., 2017), faunal remains were generally excluded from the dating program which, in consequence, was quasi exclusively supplied by manufactured artifacts considered to be chronoculturally specific. In such contexts, only rare or non-usual species have been directly dated. In general, to ensure the inter-comparability of results, notably by reducing the impact of inter-laboratory variability in pretreatment processes, the samples to be dated were entrusted to a limited number of labs (i.e. ORAU lab of Oxford; Lyon-CDRC/Saclay-CEA in the framework of the ARTEMIS program: Billard, 2008; Lyon-CDRC/Groningen-CIO) and inter-laboratory blind-tests were—successfully—held several years apart (2011–2017; ORAU versus Lyon/Saclay). All in all, such a strategy led to results that serve at different scales, shedding light on various aspects of the archaeological record, whether purely chronological (i.e. timing of the different stages of the Badegoulian technocomplex, from its first expressions to the very early manifestations of the Magdalenian features), typo-technological (i.e. charting the (micro-)evolution of the bone and antler equipment), environmental (i.e. reassessing the faunal species associations and their evolution) or taphonomical (i.e. by highlighting the potential chronocultural heterogeneity of the analyzed assemblages).

Finally, as shown in figure 1b, the studied sites can be divided into four main groups according to the level of reliability of each previously characterized Badegoulian assemblage and chronocultural attribution certainty: (1) sites with well-defined and well-preserved Badegoulian components (e.g. Cuzoul de Vers and Casserole rockshelters, Cabannes open-air site); (2) sites with well-defined Badegoulian components underlying previously unrecognized Magdalenian ones, leading to several typo-technological reattributions with respect to initial publication (e.g. Cassegros Cave); (3) mixed sites combining Badegoulian and other Upper Paleolithic components from which Badegoulian markers were separated,

sometimes through direct dating in the specific case of osseous artifacts (e.g. Pégourié Cave, Le Piage and Les Harpons rockshelter), and (4) undatable, uncommon Badegoulian-like lithic assemblages (e.g. *Bertonne* core-yielding assemblages like the Seyresse open-air site: [figure 1c](#)). While dynamic restitutions of the Badegoulian lithic and osseous technical system, as well as the radiometric framework, were obviously based mainly on the two first categories, the third one allowed (or theoretically may allow) us to complement specific aspects of the Badegoulian typo-techno-economic features through the study of decontextualized lithic markers (i.e. petrographic analysis searching for long-distance raw material/toolkit diffusion; techno-functional analysis) and directly dated bone and antler artifacts (i.e. typo-technology of hunting equipment; specific decorations). As indicated above and developed below, the latter also served to discuss and complement the evolution trends of several typo-technological specificities. The cultural, chronological and possible functional statuses of the fourth and last group—corresponding in our study to the single case of Seyresse ([table 1](#)) but theoretically extendable to similar regional and extra-regional open-air sites (e.g. Lenoir, 1987; Ducasse and Langlais, 2008; Chehmana et al., 2010; Lafarge, 2014)—were examined through typo-techno-economic comparisons with assemblages from the two first groups (Ducasse, 2010: 395-403) and discussed in the present paper in the light of most recent advances (e.g. Primault et al., 2020).

### 3. RESULTS AND DISCUSSION

#### 3.1. Searching for the tipping points: recent reassessment of the <sup>14</sup>C chronology

The timing of the several “tipping points” punctuating the development of the Badegoulian technocomplex—mainly if not exclusively classically defined through the lithic equipment (i.e. Early and Late stages: Bordes, 1958; Trotignon et al., 1984; Morala, 1993; Fourloubey, 1998; Cretin et al., 2007; see below)—has undergone several profound changes over the past twenty years. These changes, stemming from new findings and research and from methodological improvements in dating processes (i.e. AMS dating, pretreatment process developments, etc.), sampling strategies (see above) and result interpretations (Ducasse et al., 2014; Banks et al., 2019), are mainly reflected in a global ageing and a chronological tightening, as first documented at Le Cuzoul de Vers rockshelter (Oberlin and Valladas, 2012). This dual phenomenon has affected our understanding of local/regional issues as well as inter-regional and inter-cultural comparisons (see below, [section 3.3](#)).

A reassessed radiometric framework is presented in [figure 2](#) and [table 2](#), based on a non-exhaustive but representative dataset of 45 <sup>14</sup>C AMS ages from the available corpus collected in the framework of the above-mentioned projects conducted in SW France ([table 2, #1-27, 41-45](#); see above), supplemented by a selection of recently published ages from (1) reliable Badegoulian sequences or sites located in Dordogne, Poitou, Bourgogne and Massif Central, and (2) a series of compatible Badegoulian ages from disturbed assemblages yielding clear Badegoulian component (“Badegoulian-like” tagged ages: [table 2, #37-40, 44-45](#)). Note that this selection does not include compatible ages from sites for which the cultural attribution is still pending (e.g. Montoya et al., 2019) or any beta counting ages, since it has been demonstrated that a number of problems exist regarding their comparability with recent AMS ages (i.e. bulk samples giving average results, high standard-deviations, etc.: Ducasse et al., 2020; Banks et al., 2019).

Finally, the results of this reassessment have led to a switch from the 22,8-19 cal ka BP interval that was documented at the end of the 1990s through the combination of several beta-counting dated key-sites from the Paris Basin to the Languedoc region (e.g. Cuzoul de Vers, layer 24: 18,400 ± 200 BP, 22,8–21,9 cal ka BP, Gif-6798; Lassac, locus 1: 16,750 ± 250,

20,8–19,6 cal ka BP, Gif-2981; Cuzoul de Vers, layer 5c:  $15,980 \pm 150$ , 19,6–18,9 cal ka BP, Gif-6638), to a 2,000-year interval approximately comprised between 23,5/23 cal ka BP—overlapping with the most recent Upper Solutrean ages—and 21/20,5 cal ka BP (figure 2). These results, obtained from the same geographical area or even the same sites, show that contrary to the prevailing general view (Bosselin and Djindjian, 1997; Djindjian, 2000), the chronological gap hypothesis is unable to explain the deep and sharp break documented between the Upper Solutrean and the Early and Late Badegoulian assemblages (e.g. Renard and Ducasse, 2015). As we can see, these changes, the possible causes of which are beyond the scope of this paper, took place during a relatively short-term phase characterized by high climatic instability (GI2.2-GS2.2-GI2.1: Rasmussen et al., 2014, pp. 17, 22). From there, the Badegoulian covers the first part of the Last Glacial Maximum (LGM, sensu Mix et al., 2001; MARGO Project members, 2009) corresponding to cold and humid conditions (GS2.1c). At the opposite chronological milestone, the Badegoulian-to-Magdalenian transition timespan, i.e. 21,5–20,5 cal ka BP (not illustrated in figure 2), is currently being much discussed through the ongoing characterization of the so-called LDDM industries (named after the presence of specific marginally retouched bladelets called “*Lamelles à Dos Dextre Marginal*”: Langlais et al., 2010; Ducasse et al., 2011) in the framework of the DEX\_TER project (S. Ducasse and M. Langlais dir.; see below). Finally, between these two limits, the issue of the classic two-fold division between Early and Late Badegoulian—quite well-established in term of archaeostratigraphic sequence—appears to be chronologically blurred by the strong overlap visible within the 23,5–22,5 cal ka BP timespan, corresponding to the entire development of the Early stage, as documented at Le Cuzoul de Vers (layers 27 to 22: Ducasse, 2010; Clottes et al., 2012) and Casserole rockshelters (layer NA6: Ducasse et al., 2020; Morala, 1993).

However, besides this general and paradigm-dependent framework, and despite a too low radiometric resolution for these clearly fast phenomena, we will see that detailed archaeostratigraphic examinations of the timing and co-evolution of several techno-technological proxies reveal a very complex but exciting panorama.

### 3.2. Refining the core definition of the Badegoulian: characteristics and evolution of its technical equipment

#### 3.2.1. “Punk rocks”: an overview of Badegoulian flint technology

The triumph of technical mediocrity never happened: research carried out for more than twenty-five years in present-day France has unequivocally demonstrated that the Badegoulian lithic technical system, by breaking the Upper Solutrean rigid norms, paved the way to a no-less innovative cycle. The apparent simplicity of these flake-dominated industries is in some ways what makes them so complex to fix in a single picture, since simplicity gives way to versatility, adaptability and then variability. While previous syntheses, aiming at discussing the general framework of the Solutrean-to-Badegoulian transition in SW France, took the side of an average—and thus necessary simplified—presentation (Ducasse et al., 2019b; Renard and Ducasse, 2015), the following lines will focus on specific and sometimes exceptional points in order to serve subsequent diachronic views. Pending the results of an ongoing PhD work focusing on the technical exploitation of “non-flint” components from Upper Solutrean and Badegoulian lithic assemblages (Q. Villeneuve; University of Bordeaux), only the flint component will be considered.

#### The Early Badegoulian (ca. 23 cal ka BP): nothing will be the same again

Although the classic Early Badegoulian (EB) features (e.g. Allain and Fritsch, 1967; Gausсен, 1980; Trotignon et al., 1984; Clottes and Giraud, 1989; Morala, 1993) were sometimes seen—rightly in certain cases—as the result of non-chronological but functional variability or issues in the representativeness of the considered archaeological record (e.g. Bodu et al., 2007), it has finally been firmly demonstrated from recently excavated archaeological sequences that specific *raclette*-less Badegoulian-like assemblages systematically pre-date the well-known *raclette*-yielding assemblages (i.e. no evidence of Early Badegoulian/Late Badegoulian-like assemblage interstratification). However, a critical review of the so-called Early Badegoulian suggests that extremely few known assemblages can safely be attributed to this first chronocultural stage (see Ducasse, 2010, pp. 376–382 for a detailed reassessment). To date, there are between four and five taphonomically-reliable sites that could fit with such an attribution, from the strongest stratified evidence (Le Cuzoul de Vers, Lot, layer 27 to 22; Casserole NA6, Dordogne) to the undated but fully compatible ones (Fritsch rockshelter, Indre, layer 6 to 8b: Trotignon et al., 1984; Aubry et al., 2007; Le Péhau, Gironde: Monin, 2014; Pasquini et al., 2014). While a clear EB component is documented at Cassegros Cave, Lot-et-Garonne (Le Tensorer, 1981 and obs. pers.), it remains extremely difficult to distinguish from the Late Badegoulian one, according to recent work to be published in the framework of the ongoing monograph project (Ducasse and Le Tensorer dir.). Despite the numerous recognized layers mostly based on sedimentary variations, the EB sequence of Le Cuzoul de Vers, on which the information below is essentially based, must be taken as a two-phase (if not one-phase) sequence, since inter-layer refittings were clearly documented between layers 27 and 24 (e.g. figure 3, #5, figure 4a, #3 and figure 4b, #2) and suspected for layers 23 and 22. For its part, Casserole NA6 is demonstrated to be a single and highly coherent assemblage (Morala, 1993 and obs. pers.).

Taken alone, the main typo-technological lithic features of the EB illustrate, more than any “average” view of Badegoulian flint technology (Renard and Ducasse, 2015), the very strong disruption occurring after the Upper Solutrean (US) in France. Thus, while the toolkits are mainly composed of “domestic” tools, among which thin and sometimes short ones bearing semi-abrupt retouches should be noted (figure 3, #6-7; i.e. *proto-raclettes* sensu Le Tensorer, 1981), they are lacking in undisputed evidence of lithic tips and inserts potentially involved in hunting activities. Few unretouched (micro-)bladelets are documented and come essentially from flake-edge cores (i.e. part of the so-called “notched burins”: figure 4a, #3) while “carinated” reduction sequences are extremely rare, if not absent, within the studied EB assemblages (note that such reduction sequences were described as part of the AMS-undated lowermost Badegoulian EB? assemblages from the Fritsch rockshelter, together with a unique marginally-retouched microbladelet: Aubry et al., 2007). This absence of backed or retouched specimens cannot be viewed in relation to a representativeness bias since the fine-fraction lithic material (i.e. retouch flakes, chips, micro-debris: Ducasse, 2010, p. 194) is well documented, notably at Le Cuzoul de Vers thanks to the implementation of quasi systematic water sifting (Clottes et al., 2012). Lastly, the possible role of the numerous sharp blanks obtained from flint bipolar reduction in the manufacturing and use of hunting equipment remains difficult to state in the absence of use-wear analysis (Ducasse, 2010, pp. 221–224).

That being said and besides the versatile role and status of the well-documented bipolar percussion, the main techno-economic aspects of the studied EB assemblages can be summarized and simplified as follows: (1) a marked exploitation of the local lithic resources together with the limited but systematic contribution of regional and extra-regional raw material through (2) the introduction of blade tools (with evidence of soft organic percussion) or robust blanks, the latter to be used as “domestic” tools or edge core-blanks, (3) the in situ and marginal implementation of blade production, simplified and adapted to local raw materials (figure 4a, #1), together with (4) the massive implementation of flake production to

obtain a wide range of blanks, from thick flakes to thin and/or elongated ones; for the most part these flakes are from integrative/multi-objective productions, sometimes organized in distinct and successive short sequences.

Further ongoing and subsequent collective analyses of Le Cuzoul de Vers EB assemblages, including archaeostratigraphic and technological analyses of the numerous available refittings, a study of the “non-flint” component (PhD work of Q. Villeneuve, see above) as well as a renewed petrographic approach and the implementation of use-wear analyses will, in the medium term, increase our understanding of these very rare pieces of evidence of one of the major tipping points in the evolution of West European Upper Paleolithic traditions.

#### “One shot”: the Badegoulian shouldered points (ca. 23-22,5 cal ka BP)

Apart from the demonstrated cases of cultural admixtures with Solutrean components (e.g. Pégourié Cave, Lot: Ducasse et al., 2019a; Le Piage, Lot: Champagne and Espitalié, 1981; Bordes et al., 2006), assemblages from Le Cuzoul de Vers, layers 16 to 21 are the only demonstrated example to date of a *raclette*-yielding industry containing shouldered points (figure 5a and 5b). Contrary to what is suggested by the multi-layered distribution of these specific artifacts, archaeostratigraphic analyses and inter-layers refittings have shown that this typo-technological combination probably corresponds to a “one-shot” phenomenon (Ducasse, 2010; Ducasse et al., 2014). Since the main typological and techno-economic features of these assemblages are quite comparable to the ones from uppermost levels, we will not repeat here what was previously published in the same journal (see Ducasse, 2012).

The corpus of 37 specimens, found in association with several invasive-backed bladelets (figure 5a, #11-14), is characterized by a large number of fragmented pieces showing diagnostic impact fractures and scars. Besides the use of local alluvial flints, this typological group documents the use of a wide variety of raw materials among which non-determined allochthonous flints are frequent: with a single exception (figure 5a, #7 and 10), each point comes from distinct exploited volumes. This high degree of spatial-temporal techno-economic fragmentation makes it difficult to accurately characterize the implemented *schema opératoire*. Moreover, the high morphometric variety of the blanks used could suggest—at least partly—distinct technological origins. A technological assessment of the industries from layers 16 to 20 has notably shown evidence of (1) in situ unipolar production of small, thin and narrow rectilinear blades (figure 5a, #9; soft mineral percussion) compatible with the low-retouched shouldered points, and (2) spatially and temporally segmented blade reduction sequences from opposite platform cores, potentially partially implemented in situ (figure 5a, #8) but essentially visible through imported artifacts. Beyond the implementation of systematic direct or crossed abrupt retouch, this technological diversity is coupled with strong typological variability. However, a subgroup distinguishes itself despite a non-systematic lateralization (figure 5a, #1 and 2): opposing a generally long and narrow tang to a short limb, these artifacts bear an indirect and short retouch at the proximal end (probably used to reduce the convexity of the butt) which shapes a specific “coma-like” extremity recalling the Salpétrian shouldered points (Bazile and Boccaccio, 2008 and Boccaccio, this volume) and thus fueling an inter-regional and inter-cultural connection hypothesis that will be discussed later in this paper.

Although the techno-economic features of these hunting weapons’ production (i.e. on-site production together with imported cores and/or finished points) theoretically suggest links with regional/extra-regional *raclette*-yielding occupations, a careful consideration of reliable southwestern assemblages reveals an almost complete absence of similar typo-technological evidence. Beside the undatable Late Badegoulian open-air site of Cabanne, Landes, which yields evidence of compatible imported thin rectilinear blades, together with a single possible



backed point (interpretation to be confirmed through use-wear analysis; Ducasse, 2010: 318), the isolation of the assemblages from Le Cuzoul de Vers, layers 16 to 21, may also reflect the under-representation of the archaeological records for the 23-22,5 cal ka BP timespan (see below).

#### On the edge: the issue of *raclette*-yielding Badegoulian (micro-)bladelet production

Contrary to the shouldered point-yielding assemblages, the Late Badegoulian bladelet productions are essentially linked to ramified *chaînes opératoires* through the exploitation of thick flakes and, occasionally, robust blades. Three distinct *schemas opératoires* are currently recognized to be part of the Badegoulian technical palette: (1) flake-edge cores aka “notched burins” producing bladelets, microbladelets and robust lamellar flakes (Bodu et al., 2007; Bodu and Chehmana, 2008; Ducasse, 2010; 2012); (2) “*sur front dorsal*” cores, aka “carinated enscrapers” producing microbladelets (see Ducasse and Langlais, 2007 for terminological information), and (3) “*Orville/Bertonne*” cores mainly producing specific bladelets with a “fluted-facet” (Ducasse and Langlais, 2008; Chehmana et al., 2010; Ducasse, 2010; Chehmana, 2011). While flake-edge cores *sensu lato* are almost systematically part of the Late Badegoulian assemblages, whatever the considered space of time and geographical area, the chronological distribution of the two other technical modalities are currently fueling specific issues that deserve further developments.

Regarding the “*sur front dorsal*” cores—which were classically considered to be among the markers of the Badegoulian, partly justifying the comparison with Aurignacian features—research carried out in recent years have shown their great scarcity, if not absence, within taphonomically-controlled assemblages from caves and rockshelters (e.g. Le Cuzoul de Vers: Ducasse, 2010; Casserole rockshelter and Cassegros Cave: obs. pers.), as well as their questionable association with Badegoulian components within disturbed archaeological records (e.g. Pégourié Cave: Ducasse et al., 2019a, Le Petit Cloup Barrat, Lot) or collections from surface surveys. In the latter case, note that a recurring association between *raclettes* and very specific Aurignacian-like “nosed” cores is documented in the Gironde region—notably seen at Birac III and Le Pourquoi open-air sites (Crochet, 1967; Sireix, 1988; pers. obs.)—and is the object of ongoing critical reassessment. Finally, until this problem is resolved, the only reliable Badegoulian cases where the implementation of microbladelet production through “*sur front dorsal*” cores is clearly developed correspond to (1) undatable open-air sites (e.g. Mirande 2, Tarn-et-Garonne: Langlais et al., 2016) and (2) assemblages that can be chronologically assigned to the end of the Badegoulian, ca. 22-21 cal ka BP (e.g. Lassac locus 1, Aude: Ducasse, 2010; Oisy-Mont Saint Aubin, Nièvre: Bodu et al., 2007), both associated with direct and/or inverse backed microbladelets (figure 6).

From the seminal work of Lenoir (1976) and Perlès (1982) to the systematic revisions from old collections and the recently published evidence from Le Taillis-des-Coteaux, Vienne (Primault et al., 2020), the chronocultural issue of the “*Orville/Bertonne*”-type productions seems close to a resolution. While the technological status of Bertonne pieces as bladelet cores was firmly established through convergent research (Ducasse and Langlais, 2008; Chehmana et al., 2010), their chronological distribution and cultural attribution is still pending (see Ducasse, 2010, pp. 396–403 for an extended overview). Although the authors remain cautious regarding the reliability of the documented association of *raclette* and *Orville/Bertonne* cores within Le Taillis-des-Coteaux assemblages from levels AGIII<sub>f</sub> and AGIII<sub>g</sub> (Primault et al., 2020), this exceptional stratified and dated evidence (21,8-20,9 cal ka BP) places *Orville*-dominated industries within the Badegoulian-to-Magdalenian transition phase. This, combined with (1) the associated Badegoulian-like antler technology (i.e. use of the knapping technique; Pétilion and Ducasse, 2012), (2) the undisputable association of

*Bertonne* cores with Badegoulian-type components from recently excavated open-air sites and highly reliable *raclette*-yielding assemblages (e.g. Cabannes, Landes: Gellibert and Merlet, 2001; Ducasse, 2010; Les Sablons, Gironde: Ortega et al., 2005; Cretin et al., 2007), and (3) the more questionable but similar association from Lassac (Ducasse, 2010, pp. 400), appears to be consistent with a development (if not an emergence) at the very end of the Late Badegoulian.

### 3.2.2. *Badegoulian to the bone: a revised typo-technological framework for the osseous industries*

Despite the precocity of the work of Allain and Rigaud at the Fritsch rockshelter, Indre (Allain et al., 1974; Rigaud, 2004), and the significant role of antlerworking in the individualization of the Badegoulian technocomplex (e.g. Rigaud, 1989, p. 215), little was known about the technological aspects of the Badegoulian osseous equipment, notably in the Aquitaine basin, despite the fact that sites yielding manufactured bone and antler artifacts are abundant in this region (e.g. Laugerie-Haute and Lachaud rockshelters, Dordogne: Bordes, 1958 and Cheynier, 1965; Cassegros Cave, Lot-et-Garonne: Le Tensorer, 1981). Apart from the unpublished work of P. Bidart at Casserole rockshelter, Dordogne (Detrain et al., 1992), it was only at the end of the 2000s and the work of J.-M. Pétillon and A. Averbouh at Le Cuzoul de Vers rockshelter, Lot (Averbouh and Pétillon, 2011; Pétillon and Averbouh, 2012) that this part of the archaeological record was finally systematically reconsidered, on a large-scale basis (table 1) and in a consistent manner. Regarding technology, this work confirmed and supplemented the proposal of Allain and Rigaud: while the use of the groove and splinter technique (GST) to produce antler blanks has since been suggested based on evidence from Pégourié Cave, Lot (Séronie-Vivien, 1995), and from the open-air site of Lassac, Aude (Sacchi, 2003; artifacts from surface surveys and poorly documented sectors of the site), a critical analysis coupled with direct <sup>14</sup>C dating has shown that the knapping technique was the only method used to produce antler splinters during the Badegoulian (figure 7a and b; Ducasse et al., 2019a; in press; Pétillon and Ducasse, 2012; Pétillon and Chauvière, 2017). As can be seen in figure 2 (“K”-tagged ages), directly-dated flakes—similar to those represented in figure 7a, #1—or other specific knapping waste products are distributed all along the Badegoulian timespan, from 23,6 to 20,7 cal ka BP (table 2, #9 and #41; note that the only known counterexample comes from the Lascaux Cave and has recently been discussed in the framework of a new dating program: Ducasse and Langlais, 2019).

Considering the taphonomically-controlled assemblages, the so-called “domestic” component of the osseous toolkits is not very diversified and is mainly composed of tools involved in the working of organic materials (the only significant exception being bone retouchers, which correspond to ubiquitous Paleolithic tool types that are well represented in Badegoulian assemblages as well). Specifically, besides bone awls, the Badegoulian assemblages are marked by the significant presence of bone-eyed needles (figure 7c, #3 and 4). As previously noted, while the appearance of bone-eyed needles during the Upper Solutrean in SW France still needs clarification, the early stages of the Badegoulian witnessed their first clear development and generalization in Western Europe, indicating the deployment of new dressmaking techniques (Pétillon and Chauvière in Ducasse et al., 2019b; Pétillon and Chauvière, 2017). It is worth stating that no evidence of the use of GST for the exploitation of bones has been documented to date and the implementation of alternative methods consisting in the scraping, abrasion and polishing of cortical fragments from medium-size ungulate diaphysis has been suggested based on Le Cuzoul de Vers assemblages and unpublished experimental tests (Le Guillou, 2012, p. 352). Antler beveled tools (i.e., chisel/wedge types) are rare, except at Cuzoul de Vers where they are represented by a number of highly curated,

fully shaped artifacts (figure 7c, #5). Antler perforated batons (*bâtons percés*) are absent and bone spatulas (*lissoirs*) are very scarce.

Compared to Middle and Upper Magdalenian standards (Langley et al., 2016) and contrary to the stereotype of the poorly-dated and probably mixed assemblages of the Placard Cave, the Badegoulian projectile points from recently excavated and/or reliable sites appear to be relatively rare, and mostly non-decorated. This scarcity is coupled with a marked diversity that seems to be, at least in part, chronologically ordered according to the results of direct <sup>14</sup>C dating and archaeosequence comparisons (figure 2 and 8; see below). Right after the extremely small and poorly characterized Early Badegoulian assemblages ca. 23,5-23 cal ka BP (Le Guillou, 2012; Pétilion and Averbouh, 2012), self-barded antler points (figure 7c, #2; Le Cuzoul de Vers, ca. 22,5 cal ka BP) are documented and may have continued until the end of the period, while single-beveled points with round or oval cross-sections, including striated beveled points (figure 7c, #6 and 7; “SsBP” and “Pe”-tagged ages in figure 2; e.g. Pégourié Cave, 22,5–21,5 cal ka BP), are only documented at a later stage after ca. 22.5 cal ka BP. The three parallel longitudinal and curvilinear lines motif, carved with the so-called “pseudo-excise” technique (Barandiarán, 1973; Utrilla, 1986), is currently the only decoration undeniably specific to the Badegoulian in SW France, as firmly demonstrated through the direct dating of the specimen from Pégourié (figure 7c, #6 and “Pe”-tagged age in figure 2; Ducasse et al., 2019a). Note that the issue of the possible Badegoulian attribution of the famous but enigmatic “arciform artifacts” from the Placard Cave (Chauvière et al., 2017)—some of them bearing Lascaux-like motifs (e.g. Feruglio and Leroy-Prost, 2001)—needs to be further discussed in the light of ongoing research; indeed, attribution to the LDDM-yielding industries (see above) cannot be ruled out.

### 3.2.3. Challenging the classic two-fold chronocultural division? A first essay

While much is yet to be done and published, results achieved over the past twenty years already allow for a refinement, if not a reconsideration, of the low-significant and single-proxy framework, mostly based on a few typological lithic markers. While this is not to say that the classic two-fold division based on the emergence of *raclette*-yielding assemblages remains meaningless, the multiplication and combination of elements from both lithic and osseous equipment show subtle and sometimes differentiated developments, justifying new proposals. As presented in figure 8, the chronological distribution of weaponry items (i.e. backed bladelets, lithic and osseous points) as well as some of their related technological aspects (i.e. blank production modalities) give us a glimpse of potential typo-technological (micro-)evolutions to be further tested through subsequent analysis. From a short, indivisible and currently little-represented Early Badegoulian stage (see above), the variability of the *raclette*-yielding assemblages, aka Late Badegoulian, shows several specificities that, along its whole timespan (23-21 cal ka BP), emerged and developed in an arrhythmic way. Inequivalent in length and occurrences, non-dependent on functional and regional variability (Ducasse, 2012; Ducasse et al., 2019b) and sometimes chronologically overlapped despite a well-differentiated stratigraphic position (Ducasse et al., 2014), this possible evidence of internal evolutions can be summarized as follows:

- (1) *Early Badegoulian* (EB; 23,5–23 cal ka BP): unchanged classic first stage, quite rare at the currently known Badegoulian distribution area (see above); EB is marked by very poor bone and antler assemblages within which the typology of the—scarce—hunting equipment remains unclear; apart from extremely rare and sometimes doubtful (micro-)bladelet cores (“sur front dorsal” and core-edge modalities) together with possible, but a not clearly demonstrated production of edged debris from flint bipolar

reduction (Ducasse, 2010), retouched lithic toolkits are only composed of a wide variety of “domestic” tools (see above);

- (2) *Late Badegoulian, aka raclette-yielding industries* (LB; 23–20,5 cal ka BP): if it is premature to speak of real sub-stages within the LB timespan, the fact remains that a general trend has appeared through the combination of archaeostratigraphic and radiometric data from several French assemblages (e.g. Le Cuzoul de Vers, Casserole, Le Taillis-des-Coteaux, Lassac, Oisy), as well as evidence from directly-dated artifacts. Thus, the following proposition, comprising three empirical clusters, should only be considered as a future line of work.

☒ The oldest currently known LB assemblages, previously only documented at Le Cuzoul de Vers rockshelter (layers 21-16), are marked from around 23 cal ka BP by the technologically coherent but currently unique association between a classic Badegoulian “domestic” component—including numerous typical *raclettes*—and abruptly-retouched shouldered points, together with backed bladelets (invasive back) sometimes obtained from the same reduction sequences (see above); both categories show diagnostic features of use as projectile elements. As in the EB case, almost no bone or antler points are documented. Although this assemblage may theoretically correspond to a specific expression of the synchronic variability of *raclette*-yielding assemblages, it is factual to point out its specific chronological position in terms of both stratigraphic and radiometric evidence.

☒ While the 23–22 cal ka BP interval is currently little-documented through dated sequences (see [figure 2](#)) and, once again, essentially known at Le Cuzoul de Vers (layers 15-6 at least), the lithic equipment shows marked similarities with numerous undated SW France assemblages, since it corresponds to very “classic” Badegoulian ones (i.e. flake tools including *raclettes*, blade tool-kit, (micro-)bladelet production on edge cores; unretouched bladelets); opposite the underlying shouldered point assemblages, unequivocal hunting points are this time made of antler, as essentially seen through the development of thin bipoints, among which laterally-beveled pieces can be considered as self-barbed points.

☒ The last part of the LB (22-20,5 cal ka BP) is both the best radiometrically-documented ([figure 2 and table 2](#)) and probably the most complex timespan. Thus, while the so-called “Final Badegoulian” stage, traditionally marked by the development of Magdalenian-like typo-technological components (e.g. Séronie-Vivien, 1995; Le Tensorer, 1996), is no longer considered relevant as initially defined (Pétillon and Ducasse, 2012; Ducasse et al., 2019b), the 22-20,5 time range nevertheless shows an increasing diversification of lithic and osseous hunting equipment. Whereas *raclette* and backed microbladelet-yielding assemblages are clearly documented (e.g. Oisy, Nièvre, layers 3 and 4: Bodu et al., 2007; Bodu and Chehmana, 2008; Debout et al., 2012; Lassac, Aude, locus 1: Ducasse, 2010), direct dating of specific antler artifacts from disturbed assemblages yielding Late Badegoulian components suggests that single and striated beveled points—aka Placard-type points sensu Aura et al., 2012; Utrilla Miranda et al., 2020—emerged from about 22,5 cal ka BP and may have developed at least until 21,5 ka cal BP together with the famous “pseudo-excised” decorations (Ducasse et al., 2019a) and the persistence of self-barbed points (e.g. in Pégourié). To date, the end of the LB—and thus the Badegoulian-to-Magdalenian transition—remains highly unclear and archaeostratigraphic records often contradict inter-site radiometric comparisons. This is notably the case considering the timing of the emergence of marginally right side-retouched bladelets in the context of *Bertonne/Orville pieces*-yielding assemblages and LDDM industries, both still pending clear chronocultural attribution.

This arrhythmic typo-technologic chronology should be complemented and challenged in the short and long term, not only through an increase in radiometric data from taphonomically-controlled sequences (e.g. Fritsch rockshelter, Indre) and/or directly dated characteristic artifacts (e.g. the famous “Lower Magdalenian” antler tools and points from Le Placard Cave, Charente, or Lachaud rockshelter, Dordogne), but also in light of more detailed techno-economic data (e.g. evolution of the spatio-temporal management of lithic tool-kits), ornament variability and faunal dynamics, in order to better weigh the reality and significance of these evolution and, subsequently, to turn this simple timeline into an animated panorama. Above all, we have to keep in mind that these phenomena could have had distinct chronological and geographical realities, leading us to the final question to be addressed in this paper: to what extent do the “what” and the “when” detailed above, essentially based on the classic “French core” assemblages, dissolve when the “where” is examined?

### 3.3. A purely “French” phenomenon?

From this chronocultural model, the never-ending question of the “where” must be addressed through a multiscale approach, not only outside the present-day France, but also closer to the classic “Badegoulian core”, by reassessing its margins on a step-by-step basis and with an open mind. While the current geographical distribution of the French Badegoulian is now very similar to the previous Upper Solutrean one, going far beyond the initial Perigord area (figure 1a), recent discoveries and studies in northern France (e.g. Le Chemin de l’Evangile 3, Yonne: Connet et al., 2004, 2019; Le Colombier, Aisne: Montoya et al., 2019) suggest a possible greater “cultural” complexity—unless it reflects undocumented techno-economic complementarities—showing that a binary presence-absence test is far from relevant here. Furthermore, it is likely that considering the chronological variability highlighted above, the Badegoulian margins should rather be seen as shifting boundaries. That being said and pending further extra-regional data, results obtained in SW France can be used to complement and discuss, if not challenge a part of the established frameworks. From the strongest evidence to that pending, the following and last sections will briefly consider the issue of “cultural geography” in three different directions, corresponding, as we will see, to three distinct phases.

#### 3.3.1. *The Vasco-Cantabrian connection: tracking “pseudo-excised” artifacts*

The alleged scarcity, if not absence, of Badegoulian industries in the French Pyrenees has long been considered the result of an anthropological phenomenon: the specific concave-based points-yielding Upper Solutrean assemblages, unknown to the north, were in direct cultural and chronological continuity with the Vasco-Cantabrian ones, which, according to some, developed until the emergence of Magdalenian societies around 20,5 cal ka BP. This model must be reconsidered in depth, since it has recently been demonstrated that this absence on the north side of the Pyrenees is due to a strong bias in the available archaeological collections (i.e. extremely old excavations essentially by R. de Saint-Périer from the 1910s to the 1930s) that in fact yield clear but unnoticed Late Badegoulian lithic and osseous elements mixed with Upper Solutrean (US) components (Ducasse et al., 2017). In view of these elements and considering the proposed *terminus ante quem* of 23 cal ka BP for the Pyrenean US (*op. cit.*), it seems reasonable to call into question the chronology of the concave-based points-yielding US assemblages in Vasco-Cantabrian Spain—mostly based on old beta-counting ages—and, in doing so, the absence of Badegoulian in this area. Following the seminal work of Utrilla (1986) and the discoveries made fifteen years ago by Fortea at Llonín,

Asturias (Fortea Pérez et al., 1995; Duarte et al., 2014; Rasilla Vives et al., 2019), recent research has been conducted on two successive and interdependent fronts to look further into the issue of the Cantabrian Badegoulian: (1) to confirm through undisputed evidence the Badegoulian attribution of the French so-called “pseudo-excised” antler artifacts since all of them derive from old-excavated and/or taphonomically-questionable sequences (Ducasse, 2010, p. 360) and, subsequently (2) to track this potential Badegoulian “signal” by reviewing the “pseudo-excised” piece-yielding assemblages from present-day Spain. While the first objective has been successfully completed, as shown earlier (see [section 3.2.2](#)), through the reassessment of the Pégourié Cave sequence and the direct dating of the unique specimen of “pseudo-excite” decorated antler point (see [section 3.2.2](#); Ducasse et al., 2019a), the second one was addressed through the typo-technological and archaeostratigraphical reassessment of the Solutrean-Magdalenian sequence of Aitzbitarte IV, Basque Country. This work, conducted in 2018 and 2019, allowed us to obtain a final confirmation of the Utrilla hypothesis through the identification of unequivocal Badegoulian lithic markers ([figure 9](#)) whose relative stratigraphic distribution, compared to the Upper Solutrean and Middle/Upper Magdalenian components, is still being addressed.

While the details of this latter evidence and its implication will be discussed in depth in a dedicated paper (Ducasse and Ruiz-Redondo, in prep), it is important to stress here that, coming on top of the Llonín and Pégourié radiometric data (22,5-20,5 cal ka BP), it adds significant fuel to the hypothesis of the existence of a cultural network that extended from the north of the Aquitaine Basin to Asturias, at least during the second part of the Late Badegoulian stage (Ducasse et al., 2019a). This is at least what is suggested by the archaeostratigraphic, chronological and typo-technological evidence from Llonin, level III ([figure 8](#); Ducasse et al., 2019a): overlying a 23,5-23 cal ka-dated concave-base point-yielding Upper Solutrean industry ([table 3, #7-9](#)), this well-dated assemblage (22,4-20,9 cal ka BP; [table 3, #1-6](#)) bears highly characteristic *raclettes* together with several single and striated beveled antler points (i.e. Placard-type points) and evidence of the use of the “pseudo-excite” technique to engrave antler artifacts (Rasilla Vives et al., 2019; Duarte et al., 2014).

### 3.3.2. What about the Badegoulian-Salpetrian relationship?

The hypothesis of a partial synchrony between Badegoulian and Salpetrian (Bazile and Boccaccio, 2008; Boccaccio, this volume), implying the existence of a marked cultural geography independent of any obvious physical/environmental barrier, currently rests on (1) the alleged “post-Upper Solutrean” position of the Salpetrian (op. cit.); (2) the existence of abruptly-retouched shouldered lithic points—a Salpetrian marker (see Boccaccio, this volume)—within classic *raclette*-yielding Badegoulian assemblages from Le Cuzoul de Vers, Lot (see above, layers 21–16); and (3) recent <sup>14</sup>C AMS ages for the eponymous site of La Salpêtrière, Gard (Bazile, 2014, p. 12). Although this assumption is theoretically relevant, several elements, including big weaknesses in the available archaeological record, require a cautious approach. Thus, without invalidating the above model, we can theoretically discuss or challenge it as follows:

- *There is no reliable archaeological sequence documenting the transition between the Upper Solutrean and the Salpetrian*: Upper Solutrean is lacking at La Salpêtrière (Bazile, 1990; Boccaccio, 1999) and other Salpetrian assemblages are from undatable single-layered open-air sites (Boccaccio, 2006a; 2006b; Bazile and Boccaccio, 2008);
- *Upper Solutrean is poorly documented in the Rhône valley, both typo-technologically and chronologically*: Baume d’Oullins (Bazile and Bazile-Robert, 1979) is the only known evidence, yielding Salpetrian-type shouldered points together with “pointes à

face plane” (Bazile and Boccaccio, 2007) suggesting a possible mix between Early Solutrean and Salpétrian components;

- *Evidence of Salpétrian-type shouldered points within Upper Solutrean assemblages is documented and vice versa*: as pointed out by G. Boccaccio (2005, p. 458), scarce but clear evidence from Le Fourneau-du-Diable, Dordogne, shows high typotechnological similarities with Salpétrian standards; similarly, the Salpétrian assemblage of the La Rouvière open-air site, Ardèche, gave a typical Atlantic-type Upper Solutrean shouldered point manufactured with flat and invasive retouch applied on a non-Salpétrian blank (Boccaccio, 2005, p. 231); note that the raw material used to produce the latter artifact was potentially acquired from the Turonian outcrops of the Cher valley (Delvigne et al., 2017);
- *The archaeological succession between Salpétrian and raclette-yielding Badegoulian is known at the Petite Grotte de Bize, Aude*: despite the limitation of these old excavations (see [table 1](#)), Bize provides a unique relative chronology confirming this succession; the challenge is now to give an age to this transition in order to know if it occurred prior to the emergence of Lassac-type assemblages ca. 21,5 cal ka BP ([figure 2 and 6b](#); ongoing research in the framework of the LA\_BA project, Ducasse and Sacchi dir.);
- *The Badegoulian shouldered points show very distinct—and variable—typotechnological standards compared to the strict Salpétrian ones* (see above, section 3.2.1): besides the strong typological divergences, opposite technological choices were selected: while in the Salpétrian a strong technical investment concerned the production of very morphometrically calibrated blanks that were then marginally transformed, the Badegoulian strategy follows the opposite logic consisting in producing less standardized blanks that were finally very shaped;
- *The initial beta counting radiometric framework highlighted two distinct chronological phases*: a 1,000-year gap between the shouldered point-yielding Badegoulian (layer 20; Gif-6797:  $17,050 \pm 170$  BP, i.e. 20,971–20,186 cal ka BP) and the Salpétrian (layer d; MC-2084:  $18,500 \pm 240$  BP, i.e. 22,966–21,990 cal ka BP) was recorded;
- *Finally, despite the obtaining of new  $^{14}\text{C}$  AMS ages, the strong radiometric overlaps seen in [figure 2](#) between undisputable successive chronocultural phases in SW France (i.e. Upper Solutrean/Early Badegoulian/Lower Late Badegoulian) urge caution when it comes to dealing with long-distance radiometric comparisons.*

All in all, and to take the discussion one step further, one could provocatively ask whether the Languedocian Salpétrian would not in fact correspond to one of the numerous regional and specific expressions of the Upper Solutrean. Such a hypothesis, which might sound extreme, does not contradict the possibility that a partial cultural overlap could have occurred from the Aquitaine to the Rhone valley during the timespan corresponding to the very beginning of the (Early) Badegoulian. In any event, we must accept the current limitation of the archaeological record, which is unable to provide definitive conclusions: significant advances can never be made without refreshed fieldwork data.

### 3.3.3. Were there raclettes in Switzerland?

The most easterly Badegoulian-like evidence in present-day France remains poorly documented and known only through compatible radiometric ages, generally deriving from anciently excavated sites (Cupillard et al., 2015; Béreiziat, 2020; [figure 1a](#)). This evidence likely corresponds to Late Badegoulian components, as is probably the case at Solutré (Saône-

et-Loire) in the Upper Solutrean layer 3 of sector I11, where tools bearing abrupt retouches “similar to that observed on the Ancient Magdalenian [=Badegoulian] *raclettes*” (Comber and Montet-White, 2002, p. 77) are documented, together with several 21 cal ka BP-centered beta-counting ages inconsistent with the Upper Solutrean component (see Ducasse et al., 2017, pp. 264–265). While the existence of discrete *Bertonne/Orville* bladelet productions at La Roncière, Côte-d’Or (Soriano and Lechenet, 2000) and Rigney, Doubs (Malgarini et al., 2017) cannot be sufficiently conclusive, recent AMS ages from La Baume-Noire-Fretigney, level M5, provide interesting evidence of human occupations around 23,5–23 cal ka BP (Béreziat, 2020): despite an uncharacterized assemblage to date, this timespan not only corresponds to the Solutrean-to-Badegoulian transition phase in SW France (see above and Ducasse et al., 2019b), but also to the recently refined chronological framework of the middle archaeological layer from Kastelhöhle Nord cave (Switzerland; [table 3, #10-12](#)), for which a Badegoulian attribution has long been proposed (Le Tensorer, 1996; Street and Terberger, 1999; Sedlmeier, 2010; Leesch et al., 2012). Long—and still—considered as the Badegoulian entrance gate in present-day France from Central Europe according to older ages compared to the now obsolete beta-counting chronology of Le Cuzoul de Vers (e.g. Terberger, 2013, pp. 437–439), this industry actually shows strong similarities with the extremely rare Early Badegoulian assemblages documented in the Quercy and Dordogne regions (Morala, 1993; Ducasse, 2010; see above, [figure 3, 4 and 8](#)). While the lithic and osseous hunting tips or inserts are completely lacking, the “domestic” toolkits appear to be essentially composed of heavily retouched massive flakes and laminar flakes (end-scrapers, side-scrapers, etc.), together with semi-abruptly retouched thin flakes and numerous splintered pieces showing a (long and) complex use-life (i.e. “recycled” tools) (Sedlmeier, 2010). Pending a necessary direct and deeper comparison of these specific industries, the newly reassessed AMS radiometric frameworks of Le Cuzoul de Vers (Ducasse et al., 2014), Casserole NA6 (Ducasse et al., 2020) and Kastelhöhle Nord (Reade et al., 2020; [table 3](#)) allow one to propose a *synchronic* emergence and development from about 23,5 cal ka BP, thus complicating the relevant but still debated “Central Europe” hypothesis (i.e. population moves from East to West) initially based on a supposed “time-lag” (inferred from beta-counting and AMS ages comparisons) and an average typo-technological view of the Badegoulian typo-technological features. From this chronological readjustment and in parallel with the current chronocultural reassessment of Central and Eastern LGM assemblages (e.g. Neugebauer-Maresch et al., 2016; Škrdla et al., 2016; Demidenko et al., 2019), new typo-technological bases for such a discussion are currently being established and we consider that mid-term research efforts will probably be crucial.

#### 4. CONCLUSIONS

Though non-exhaustive, this short overview serves not only to highlight the main evolutionary trends of LGM hunter-gatherer equipment from SW France, but also to point out, between the lines, all the gaps, deficiencies and other blind spots that punctuate our dataset and thus imbue our models. Setting aside the emergence and disappearance issues, the above synthetic chronocultural view restates, if necessary, that there is not a single “Badegoulian”, but several ones, far beyond the classic EB/LB dichotomy. Although it might seem a risky enterprise given the missing data and radiometric inaccuracies for certain periods of time and/or some specific types of industries, this unprecedented chronological panorama provides typo-technological outlines to be further tested within and outside the classic French core area.

Taking advantage of recent and ongoing dynamic research on several key French LGM sequences, the combined “taphonomic”/typo-technological/radiometric approach developed



here serves to define clear and exclusive chronological associations, as well as to identify blind spots for which further information is needed in order to strengthen the proposed framework. While the well-known—but not always fully understood—variability of Badegoulian equipment could partly be explained through (1) the specific techno-economic structuration of its lithic technical system (see Ducasse, 2010; 2012) and (2) (micro-)evolving dynamics as defined above, the remaining part of this variability is theoretically still to be discussed with an open mind through the lens of potential functional/regional/inter-cultural dynamics and/or currently undemonstrated/unspecified taphonomic issues. Among these blind spots and besides the burning issues of long-distance inter-regional—inter-cultural?—relations (see above, section 3.3), the end of the Late Badegoulian (21,5-20,5 cal ka BP), including the Badegoulian-to-Magdalenian transition phase, deserves detailed investigation. In spite of (or perhaps because of) a dense archaeological record, it now appears to be a highly diverse and arrhythmic phase, where the “what” and the “when” issues are both difficult to precisely determine, most notably because the available archaeostratigraphic and radiometric resolutions remain problematic. While ongoing projects serve to reassess a significant portion of key anciently-excavated sites from SW France (e.g. DEX\_TER and LA\_BA projects, see above), the complementary contribution of ongoing and recent excavations (e.g. Primault et al., 2020) remains essential to weigh up the obtained results, exceed the methodological and paradigmatic limits of ancient collections, and open new perspectives.

Moreover, in parallel with the necessary acquisition of new fieldwork data to illuminate the particularly poorly understood chronological and/or geographical expressions of the Badegoulian (e.g. *Bertonne*-yielding assemblages; relationship between Salpétrian and Badegoulian in Languedoc; Solutrean-to-Badegoulian transition in the Pyrenees), efforts will have to be made, when possible, to adopt a *systematic* combined petrographic/typo-technological/functional approach to the lithic components, in parallel with detailed use-wear analyses of the antler and bone “domestic” equipment. Only such an approach will avoid the interpretative traps of the complex issue of synchronic versus diachronic variabilities and achieve more dynamic knowledge of the anthropologic phenomena studied.

All in all, the “whys” of the changes we observed in this paper remain the crucial issue, so future research should first conscientiously try to fill all these gaps in order to reduce, as far as possible, the background noise. Let’s get to work!

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## Captions

**Figure 1.** A: Location of the main Badegoulian sites, together with the Badegoulian, Badegoulian-like, Upper Solutrean and Salpétrian sites mentioned in the text (written in full; white circles, lozenges and triangles: caves and rockshelters; black ones: open-air sites; CdV: Cuzoul de Vers; FdD: Fourneau-du-Diable; LH: Laugerie-Haute; PCB: Petit Cloup Barrat; RdB: Rond-du-Barry; TdC: Taillis-des-Coteaux); #1: La Chapelle Saint-Mesmin; #2: Trocadero; #3: Le Poron des Cuèches; #4: La Pyramide; #5: Le Silo; #6: La Pluche and Saint-Fiacre; #7: La Malignière; #8: La Faye-Godet; #9: André Ragout rockshelter; #10: Chez-Fiacre; #11: La Bertonne, Croûte Charlus and Mauran 1; #12: Les Sablons; #13: Le Gouillard; #14: Houleau rockshelter and Casevert; #15: La Pibole and Pellegrue; #16: Bordeneuve; #17: Solvieux; #18: La Croix-de-Fer; #19: Guillassou and La Station du Burin; #20: Chancelade;

#21: Badegoule; #22: Les Jamblancs; #23: Les Braugnes; #24: La Roche à Tavernat; #25: Camparnaud and La Rouquette; #26: La Rivière; #27: L'église-nord; #28: Le Réservoir; B: Details of the confidence level assigned to each studied assemblage (see table 1 and material and methods section); C: Chronocultural attribution and indication of preserved osseous equipment within each studied assemblage. CAD S. Ducasse; background map IGN 2012-Open Source; LGM coastlines and glacier extents from Ehlers et al., 2011 and Zickel et al., 2016.

**Figure 2.** The Badegoulian radiometric framework based on a selection of AMS  $^{14}\text{C}$  ages from several French key sequences (see Table 2 and section 3 for details about the nature of each dated artifact and the selection criteria). “Badegoulian-like” tagged dates correspond to compatible ages obtained from (or strongly suspected to be) mixed archaeological contexts including a Badegoulian component.

**Figure 3.** Main Early Badegoulian lithic features from Le Cuzoul de Vers (layers 27 to 22). 1-4: end-scrapers; 5: composite-tool (end-scrapers/burin) made on an imported and massive crested blade with possible intentional breakage (note the transformation of the proximal non-lamellar “notched-burin” into a dihedral burin); 6: semi-abruptly/scaled-retouched large and thin flakes (aka so-called “proto-raclettes”: Le Tensorer, 1981; example of dedicated productions linked to this type of tools is notably documented in Casserole NA6 through several refittings: Morala, 1993 and obs. pers.). All the artifacts are from layer 24, except #2 (layer 22) and #5 which show inter-layer refitting between layers 24-25-26. Pictures and CAD S. Ducasse, drawing #2 G. Peyre.

**Figure 4.** Main Early Badegoulian lithic features from Le Cuzoul de Vers (layers 27 to 22). A: examples of “notched-burins” and related artifacts; note that while #3 unequivocally corresponds to a flake-edge core, some of the other illustrated artifacts should be interpreted as tools (#1; extensive techno-functional analysis is needed); B: blade and thin-flakes cores from local alluvial flints. Drawings M. Jarry, pictures S. Ducasse, CAD S. Ducasse and M. Jarry.

**Figure 5.** The shouldered point-yielding Badegoulian (Le Cuzoul de Vers, layers 21 to 16). A: examples of shouldered points (#1-8; #10), associated backed-bladelets (#8, #11-14) and thin-blade core; note the refitting #8 that evidences the combined production of shouldered point and backed-bladelets blanks; B: flake-edge cores (#1 and 2) and refitted *raclettes* from shouldered point-yielding assemblages (layers 16 and 20). Drawings S. Ducasse and M. Jarry, pictures S. Ducasse, CAD S. Ducasse and M. Jarry.

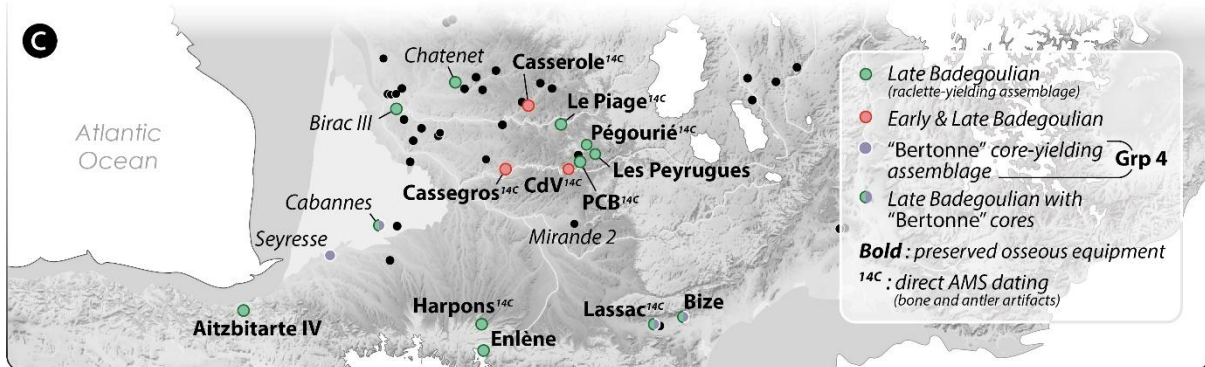
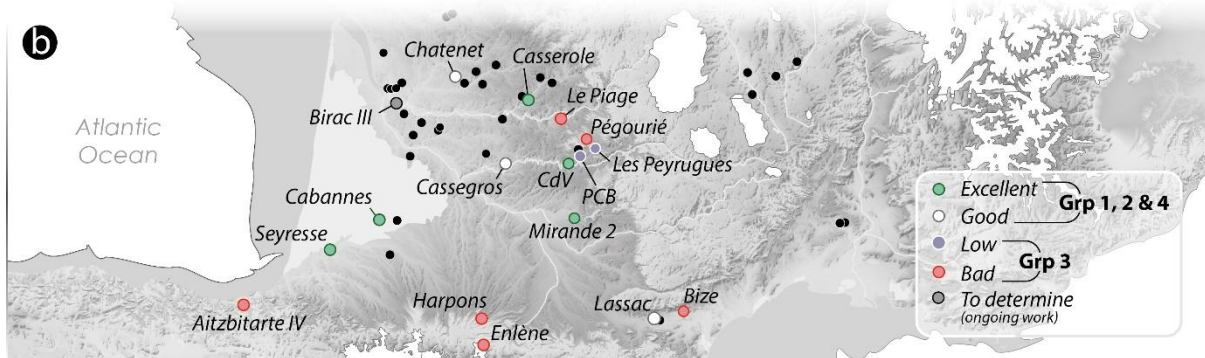
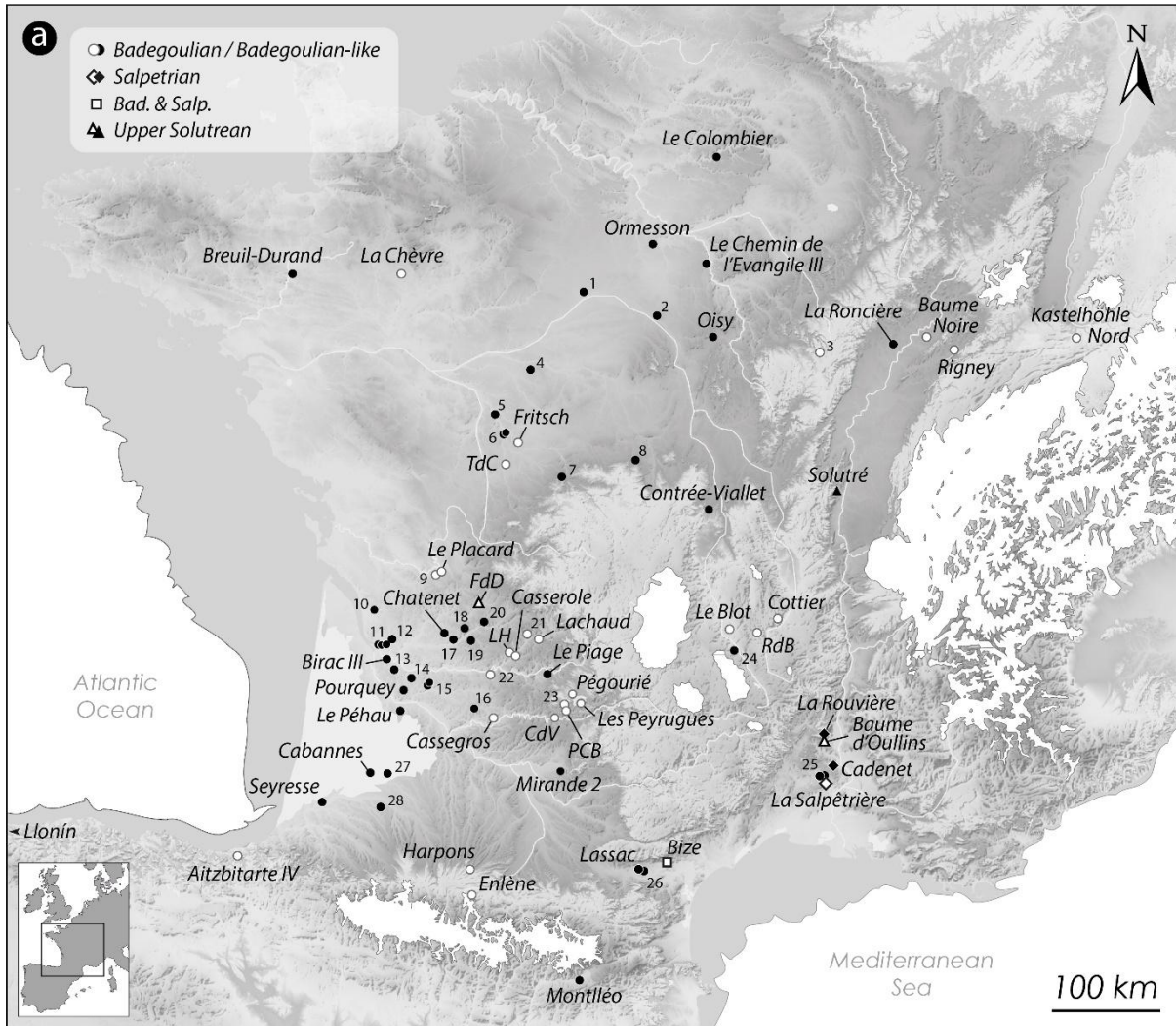
**Figure 6.** Examples of bladelet and microbladelet productions from Late Badegoulian assemblages (A: Mirande 2, Tarn-et-Garonne; B: Lassac locus 1, Aude). Pictures S. Ducasse, drawings S. Ducasse, Célia Fat-Cheung; CAD S. Ducasse.

**Figure 7.** Main typo-technological features of the Badegoulian bone and antler equipment; A: examples of knapping technique manufacturing wastes (#1: refitted flake removal sequence from Le Cuzoul de Vers, layer 6; black arrows and numbering indicate the percussion points and their chronological ordering, respectively; #2: example of desired blank from Le Cuzoul de Vers, layer 12); B: synthetic knapping *schéma opératoire* consisting in “shaping” the beam of large antlers in order to obtain a cortical “rod” that will then be worked by scraping); C: examples of “domestic” tools and hunting tips (#1 and 2: long and thin point and self-barbed point from Le Cuzoul de Vers, layers 10 and 10, respectively; #3 and 4: bone-eyed needle

from Le Cuzoul de Vers, layers 25 and 11; #5: antler wedge from Le Cuzoul de Vers, layer 11; #6: directly dated striated single-beveled point from Pégourié, layer 8c, bearing a “pseudo-excised” decoration; #7: directly dated recycled striated single-beveled point from Pégourié, layer 8a. Indicated time ranges for each typological group correspond to  $2\sigma$  calibrated ages from directly dated artifacts or associated dated antler technical wastes and/or faunal remains (pictures and schemas: J.-M. Pétillon and J.-F. Peiré, after Pétillon and Averbouh, 2012; Le Guillou, 2012 and Ducasse et al., 2019a).

**Figure 8.** Challenging the classic Badegoulian chronocultural subdivisions? Comparative evolution of lithic and osseous hunting equipment from 23,5 to 21 cal ka BP in France (Pictures, graphics and drawings S. Ducasse, M. Jarry, J.-M. Pétillon, J.-F. Peiré) and chronostratigraphic correlations with LGM assemblages from Spain (Llonin Cave, level III; radiometric data, drawing and pictures from Rasilla Vives et al., 2019) and Switzerland (Kastelhöhle Nord, layer 4; drawing from Sedlmeier, 2010; radiometric data from Reade et al., 2020). Note that, unlike in figure 7, time ranges were weighted on the basis of archaeostratigraphic successions. US=Upper Solutrean; EB=Early Badegoulian; LM=Lower Magdalenian; CdV: Cuzoul de Vers; Cass<sup>re</sup>: Casserole; Peg: Pégourié; TdC: Taillis-des-Coteaux ; LDDM: *Lamelle à dos dextre marginal*.

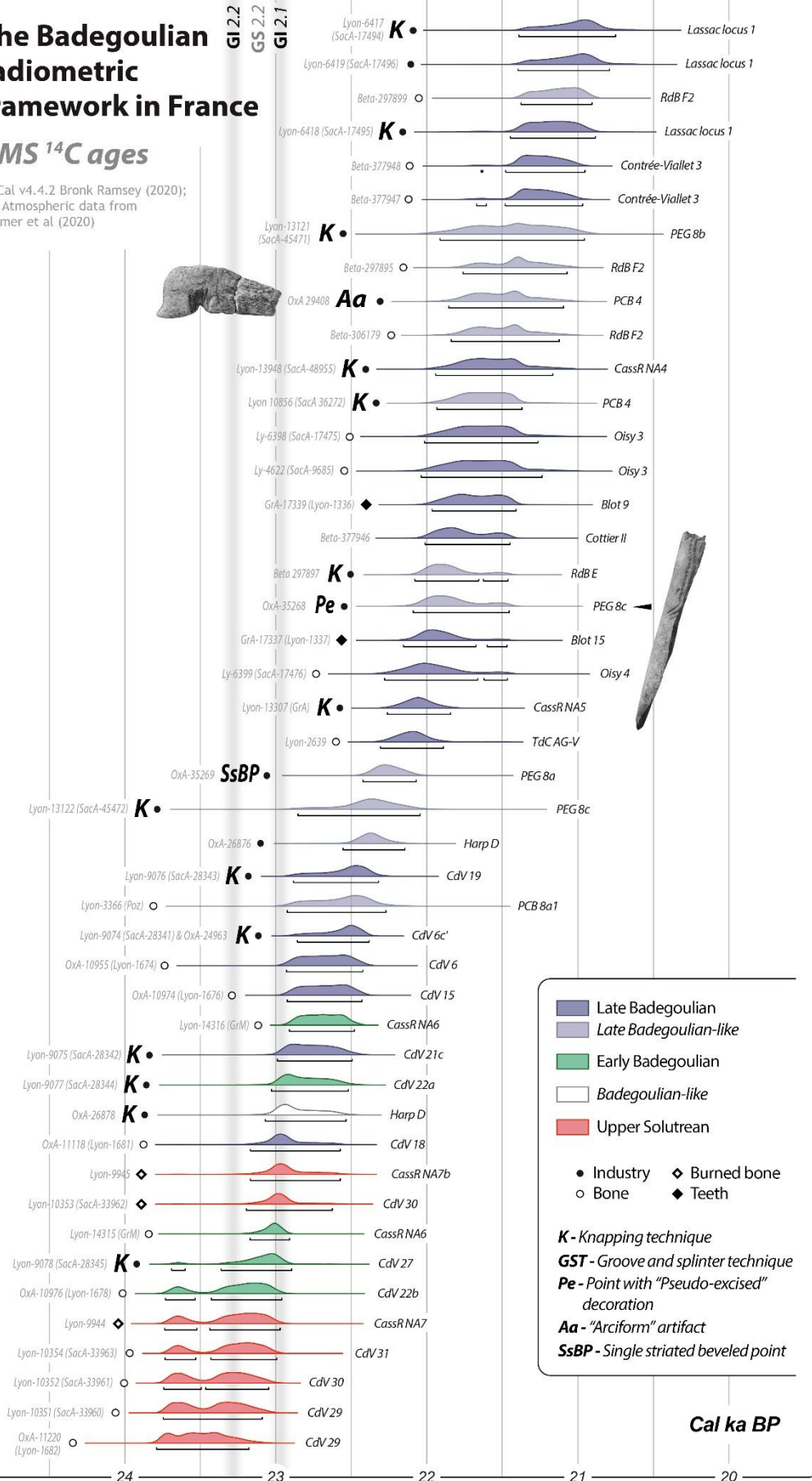
**Figure 9.** Examples of typical Badegoulian *raclettes* from the Magdalenian (#1) and Upper Solutrean (#2-3) assemblages of Aitzbitarte IV Cave, Basque Country. Pictures and CAD S. Ducasse.



# The Badegoulian radiometric framework in France

## AMS <sup>14</sup>C ages

OxCal v4.4.2 Bronk Ramsey (2020);  
r:5 Atmospheric data from  
Reimer et al (2020)



EARLY BADEGOULIAN

**Le Cuzoul de Vers (I. 27-22)**  
ca. 23 cal ka BP



①

1



①

→



②



③



1



①



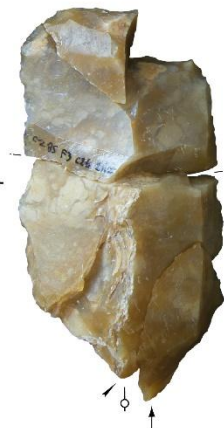
④



3cm



⑤



G3  
c.25

F3  
c.26

E3  
c.25

G4  
24b''



⑥



⑥

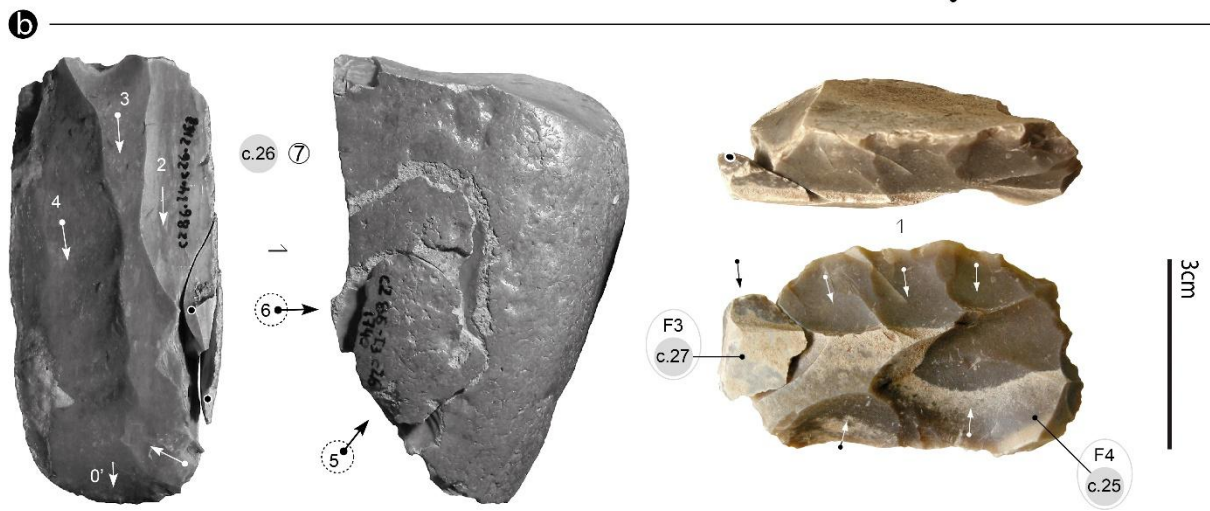
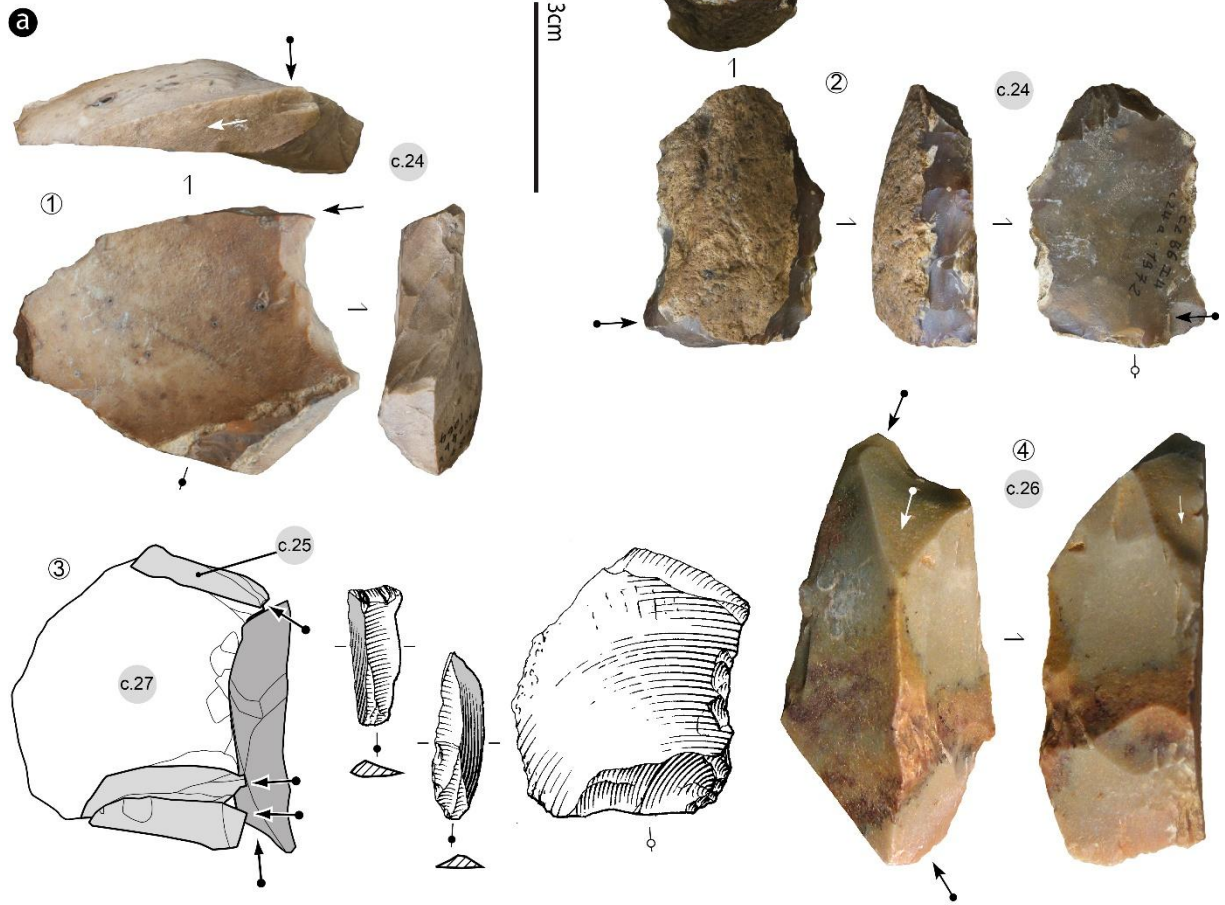


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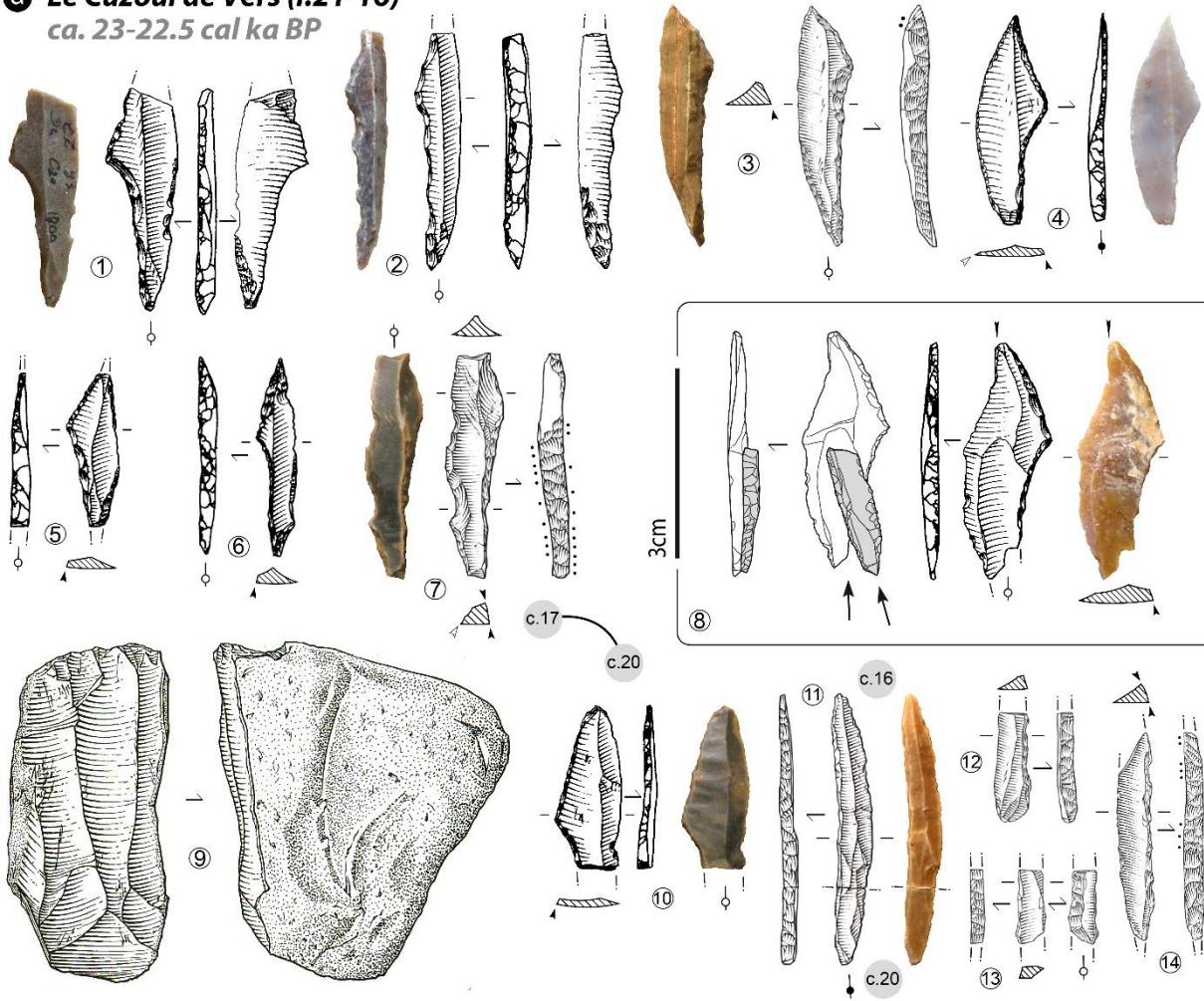


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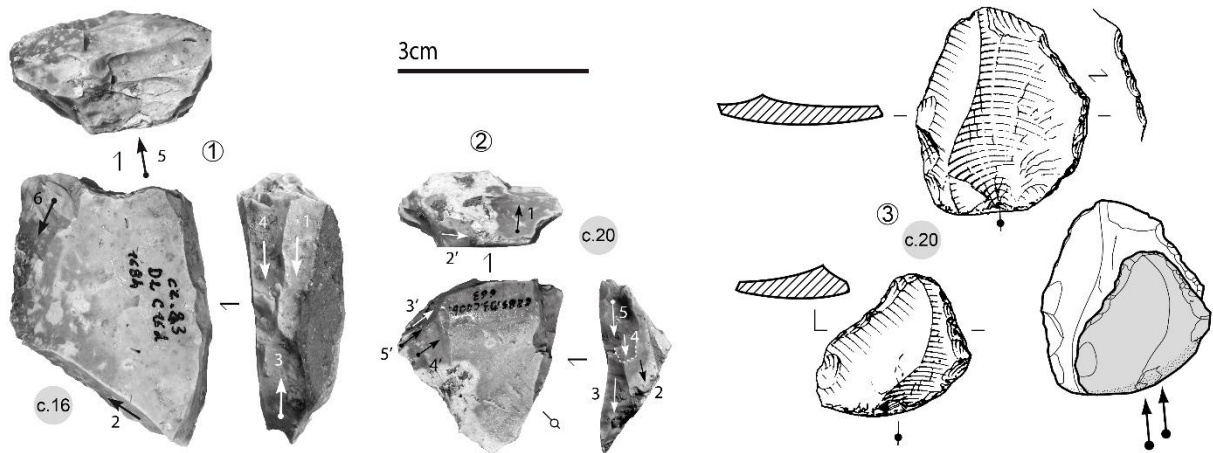
**Le Cuzoul de Vers (l. 27-22)**  
ca. 23 cal ka BP



**a** Le Cuzoul de Vers (I.21-16)  
ca. 23-22.5 cal ka BP

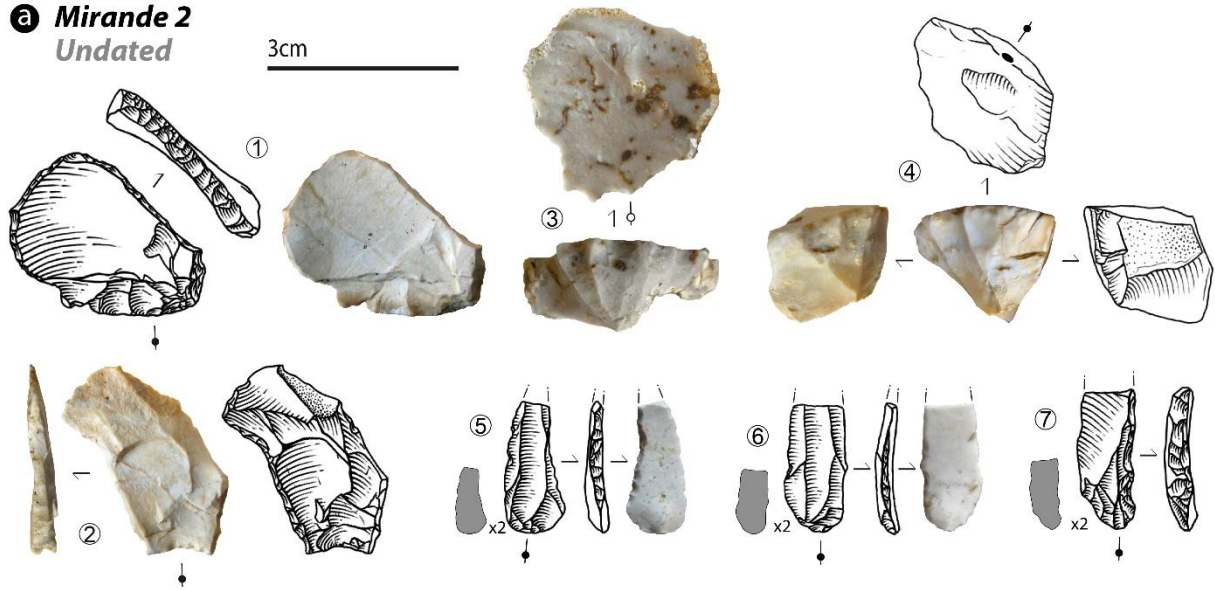


**b**

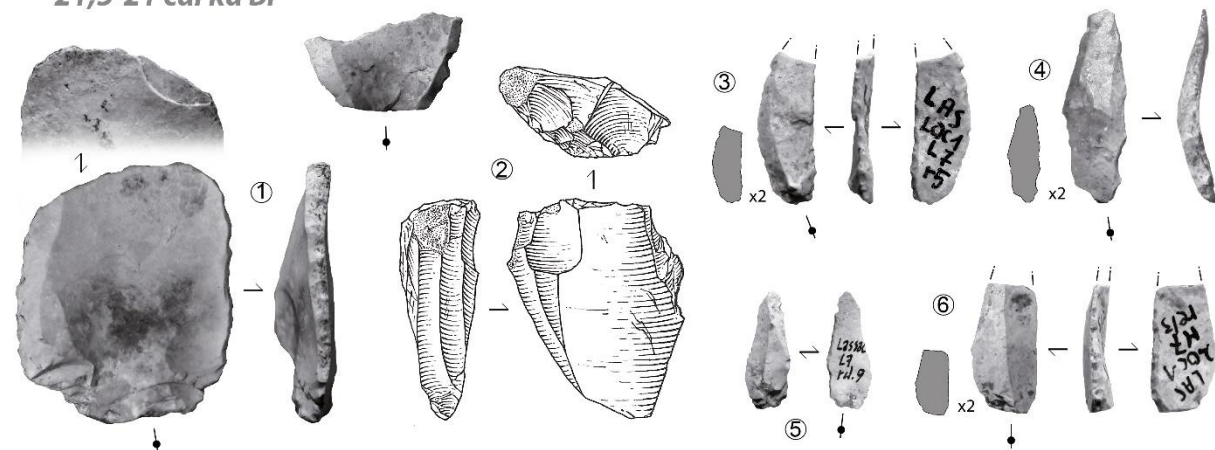


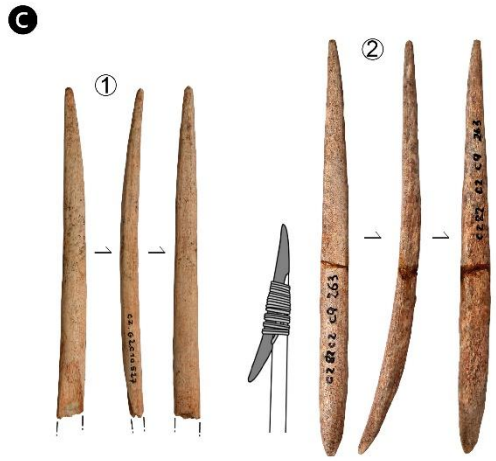
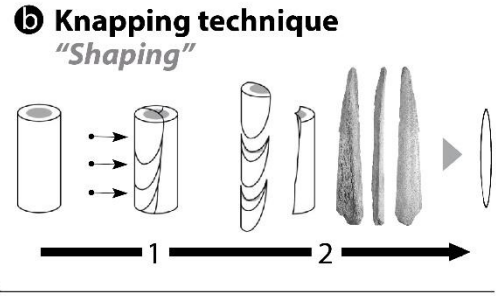
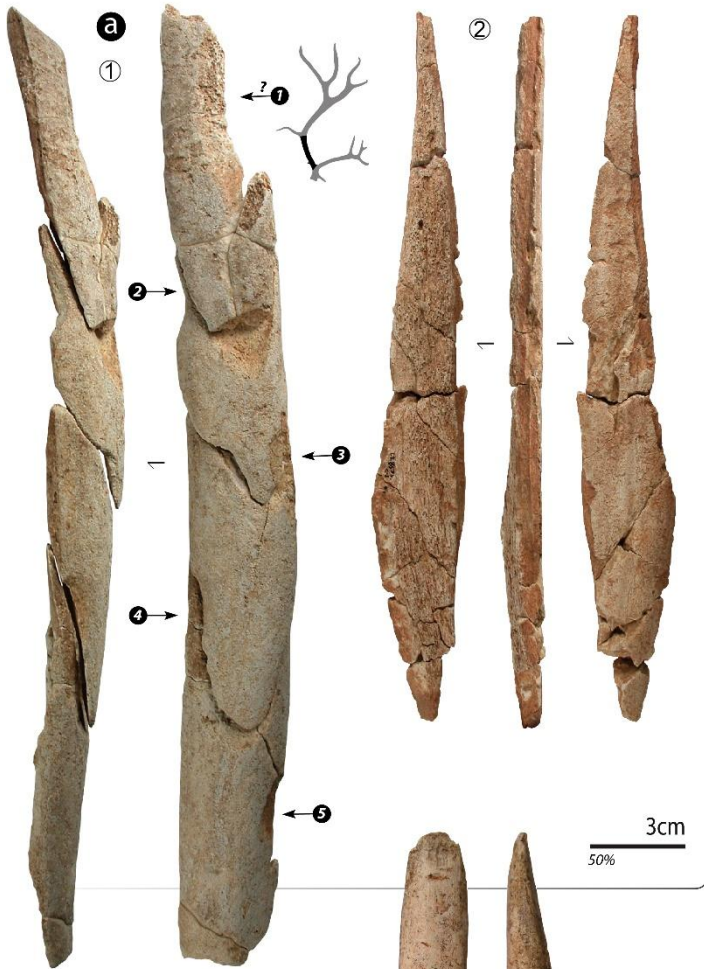


**a** *Mirande 2*  
*Undated*



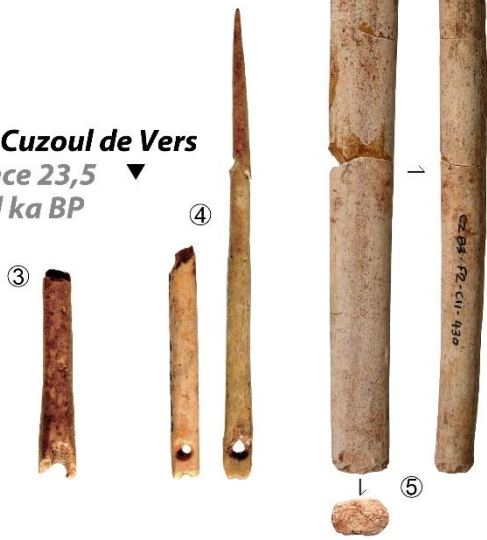
**b** *Lassac, locus 1*  
*21,5-21 cal ka BP*





**Le Cuzoul de Vers**  
ca. 23-22,5 cal ka BP

**Le Cuzoul de Vers**  
since 23,5 cal ka BP



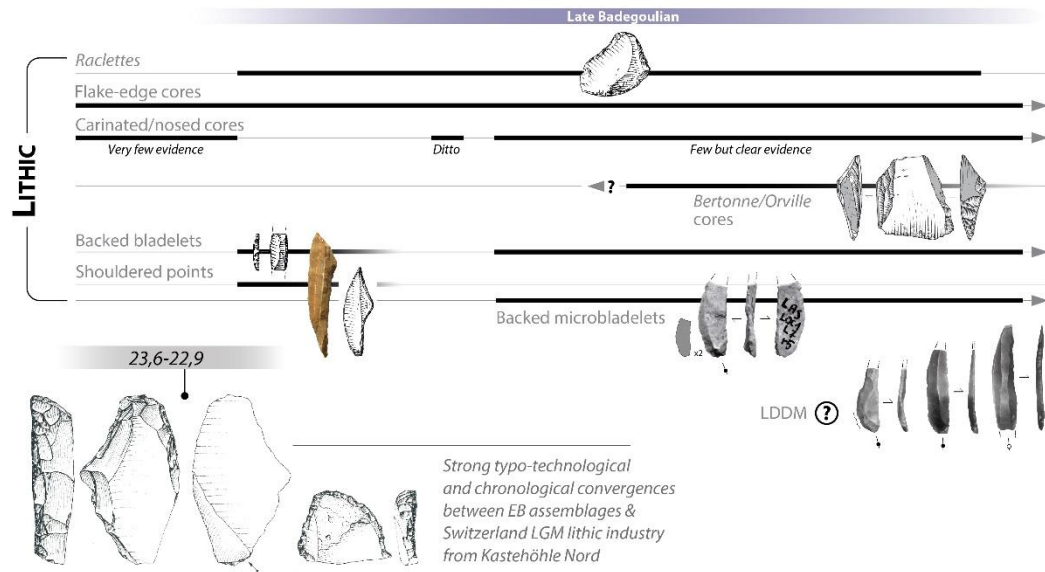
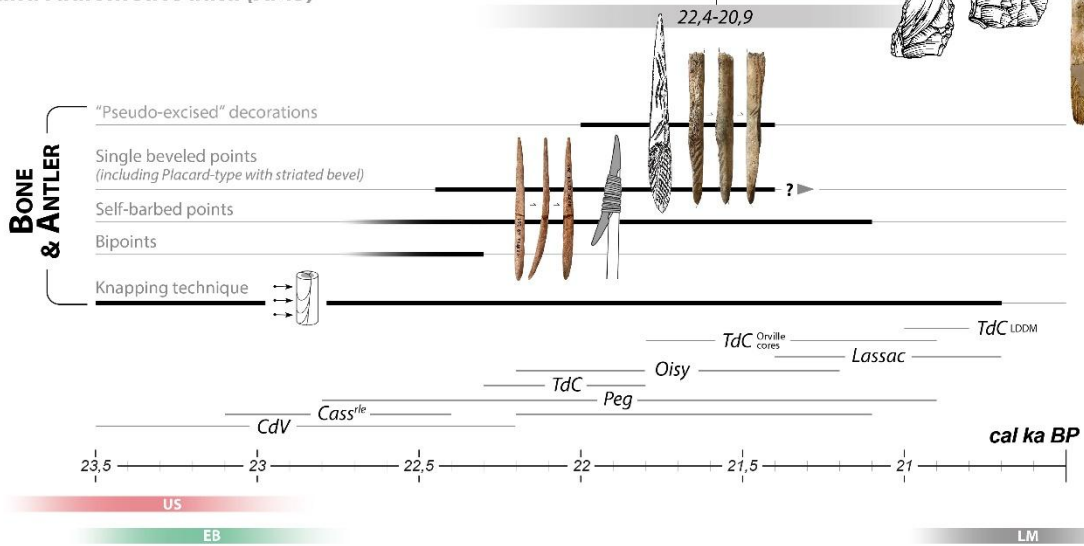
**▼ Pégourié Cave**  
ca. 22,5-21,5 cal ka BP



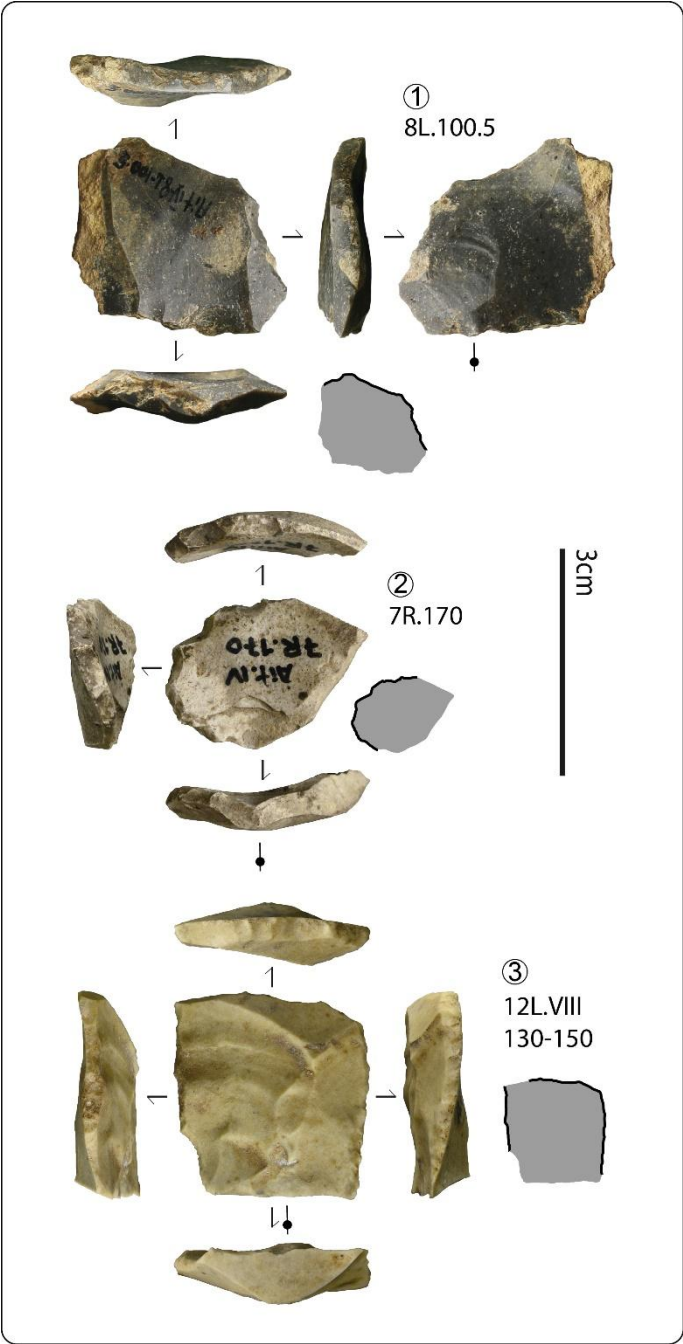
# Comparative evolution of the French Badegoulian lithic and osseous hunting equipment

Combination of archaeostratigraphic and radiometric data (AMS)

Very consistent typo-technological and chronological comparison with Spanish Badegoulian-like industries from Llonín, level III, bearing raclettes, "Placard-type" points and pseudo-excised decorations



Strong typo-technological and chronological convergences between EB assemblages & Switzerland LGM lithic industry from Kastehöhle Nord



Town	Site type	Years of excavation	Layer/Sector	Documented Badegoulian stages	Bone and antler assemblages	AMS dating*	Confidence level	References	Location information	
<b>Quercy</b>										
Le Cuzoul de Vers	Vers	Rockshelter	1982-1986	1–27	EB and LB	Y	Yes (N=19)	E	Clottes et al., 2012; Ducasse, 2010	SRA Occitanie, excavations storage depot, Toulouse (France)
Pégourié	Caniac-du-Causse	Cave	1967-1988	8 and 9	LB	Y	Yes (N=10)	B - intrusive Az/M/S/G components	Séronie-Vivien dir., 1995; Ducasse et al., 2019a	Pech Merle Museum, Cabrerets (France)
Le Petit Cloup Barrat	Cabrerets	Cave	2004-2016	8a1 and evidence from I.4	LB	Y	Yes (N=2)	L - ongoing archaeostratigraphic analysis	Castel et al., 2006; Ducasse et al., 2011	Pech Merle Museum, Cabrerets (France)
Le Piage	Fajoles	Rockshelter	1958-1968/2003-2019	CDE, BST, g/h, alpha	LB	Y	Yes (N=17; ongoing publication)	B - intrusive M/S/Au components	Bordes et al., 2008; OMP	MAN, Saint-Germain-en-Laye (France)
Les Peyrugues	Orniac	Rockshelter	1986-2002	5–9	LB	Y	Yes (N=8)	L - intrusive M/S components	Allard, 1992; Ducasse, 2010; Jaubert, 2013	MNP, Les Eyzies-de-Tayac (France)
Mirande 2	Nègrepelisse	Open-air	2014	.	LB	N	none	E	Langlais et al., 2016	PACEA laboratory, Bordeaux (France) - temporary depot
<b>Agenais</b>										
Cassegras	Trentels	Cave	1973-1985	9 and 10	EB? and LB	Y	Yes (N=14; ongoing publication)	G - marginal intrusive M component (top of layer 9)	Le Tensorer, 1981; OMP	MNP, Les Eyzies-de-Tayac (France)
<b>Perigord</b>										
Chatenet	St-Front-de-Pradoux	Open-air	1988	.	LB	N	none	G - marginal intrusive Mousterian evidence	Gausson and Moissat, 1990; Fourloubey, 1996, 1998; OMP	MNP, Les Eyzies-de-Tayac (France)
Casserole	Les Eyzies-de-Tayac	Rockshelter	1991-1993	NA4–NA6	EB and LB	Y	Yes (N=4)	E	Detrain et al., 1991; Morala, 1993; Ducasse et al., 2020; OMP	MNP, Les Eyzies-de-Tayac (France)
<b>Gironde</b>										
Birac III	St-Sulpice-et-Cameyrac	Open-air	1960	.	LB	N	none	To determine - possible Au component	Crochet, 1967; Lenoir, 1983	PACEA laboratory, Bordeaux (France)
<b>Landes</b>										
Cabannes	Brocas-les-Forges	Open-air	1998-1999	.	LB	N	none	E	Gellibert and Merlet, 2001; Ducasse, 2010	PACEA laboratory, Bordeaux (France) - temporary depot
Seyresse	Seyresse	Open-air	1970	.	LB?	N	none	E	Ducasse and Langlais, 2008; Ducasse, 2010	SRA Nouvelle Aquitaine, excavations storage depot, Hasparren (France)

<b>Languedoc-Pyrenees</b>											
Lassac	Sallèles-Cabardès	Open-air	1973	locus 1	LB	Y	Yes (N=3 + ongoing analysis)	G	Sacchi, 1986, 2003; Ducasse, 2010; OMP	Carcassonne (France), excavation storage depot	
Petite grotte de Bize	Bize-Minervois	Cave	1927-1933	1 (Helena) and 5 (Genson)	LB	Y	none	B - ancient and recent admixtures (excavation and storage issues)	Sacchi, 1969, 1986	Béziers Museum and Palais des Archevêques of Narbonne (France)	
Les Harpons	Lespugue	Rockshelter	1912-1930	D	LB	Y	Yes	B - intrusive M/S/G components	Ducasse et al., 2017	MAN, Saint-Germain-en-Laye; Lespugue and Montmaurin Museums (France)	
Enlène	Montesquieu-Avantès	Cave	1984-1990	EDG, layer 4	LB	Y	Yes	B - intrusive M/S/G components	Clottes, 1989; Bégouën et al., 2019	Pujol laboratory, Montesquieu-Avantès (France)	
<b>Basque Country</b>											
Aitzbitarte IV	Errenteria	Cave	1960-1964	.	LB	Y	none	B - intrusive M/S component	Utrilla, 1986, 1989; Ducasse and Ruiz-Redondo, in prep	Centro de Patrimonio Cultural Mueble de Gipuzkoa (Irún, Spain)	

**Table 1.** Detail of the studied sites, outlining the documented Badegoulian stages (EB: Early Badegoulian; LB: Late Badegoulian), the presence of bone and antler assemblages, the availability of <sup>14</sup>C AMS ages (\*=report limited to the Badegoulian levels), the confidence level assigned to each industry (E: excellent; G: good; L: low; B: bad; Technocomplexe acronym correspondence: Az=Azilian; M=Magdalenian; S=Solutrean; G=Gravettian; Au=Aurignacian) and the main location information (SRA: Service régional de l'archéologie; MAN: Musée d'Archéologie nationale; MNP: Musée national de Préhistoire). OMP: ongoing monograph publication.

	Level/Sector	Cultural attribution	Labelling	Material	Nature of sample	Uncalibrated age (BP)	Calibrated age (BP, 2σ)	Lab Code	Reference
<b>Quercy</b>									
1	Cuzoul de Vers	6c'	Late Badegoulian	CZ84 K4 c6c' #289 non coordinated ("vrac")	Antler	Flaked antler	18,640 ± 71	Lyon-9074 (SacA-28341) & OxA-24963	Ducasse et al. 2014
2	Cuzoul de Vers	6	Late Badegoulian		Bone	MSU diaphysis	18,730 ± 110	OxA-10955 (Lyon-1674)	Oberlin and Valladas 2012
3	Cuzoul de Vers	15	Late Badegoulian	B2 or B3 square	Bone	MSU diaphysis	18,730 ± 100	OxA-10974 (Lyon-1676)	Oberlin and Valladas 2012
4	Cuzoul de Vers	18	Late Badegoulian	E5	Bone	MSU diaphysis	19,020 ± 110	OxA-11118 (Lyon-1681)	Oberlin and Valladas 2012
5	Cuzoul de Vers	19	Late Badegoulian	CZ83 D4 c19 #1772	Antler	Flake	18,590 ± 110	Lyon-9076 (SacA-28343)	Ducasse et al. 2014
6	Cuzoul de Vers	21c	Late Badegoulian	CZ85 J4 c21c #1555	Antler	Flake	18,860 ± 110	Lyon-9075 (SacA-28342)	Ducasse et al. 2014
7	Cuzoul de Vers	22b	Early Badegoulian	D2 to D5	Bone	MSU diaphysis	19,280 ± 120	23,733–23,534 (19,2%) 23,428–22,960 (76,2%)	OxA-10976 (Lyon-1678) Oberlin and Valladas 2012
8	Cuzoul de Vers	22a	Early Badegoulian	CZ86 I5 c22a #636	Antler	Knapped splinter	18,920 ± 110	Lyon-9077 (SacA-28344)	Ducasse et al. 2014
9	Cuzoul de Vers	27	Early Badegoulian	CZ86 D5 c27 #1192	Antler	Flake	19,150 ± 110	23,691–23,602 (4,0%) 23,364–22,895 (91,4%)	Lyon-9078 (SacA-28345) Ducasse et al. 2014
10	Cuzoul de Vers	29	Upper Solutrean	B5	Bone	MSU diaphysis	19,510 ± 110	OxA-11220 (Lyon-1682)	Oberlin and Valladas 2012
11	Cuzoul de Vers	29	Upper Solutrean	CZ86 E5 c29a #1649	Bone	Reindeer Metatarsal	19,410 ± 100	Lyon-10351 (SacA-33960)	Ducasse et al. 2014
12	Cuzoul de Vers	30	Upper Solutrean	CZ86 I4 c30 #2472	Bone	MSU diaphysis	19,380 ± 100	23,743–23,495 (33,1%) 23,465–23,048 (62,4%)	Lyon-10352 (SacA-33961) Ducasse et al. 2014
13	Cuzoul de Vers	30	Upper Solutrean	CZ85 B4 c30 #1291	Burned bone	Reindeer Tibia	19,050 ± 100	Lyon-10353 (SacA-33962)	Ducasse et al. 2014
14	Cuzoul de Vers	31	Upper Solutrean	CZ86 J4 c31 #2049	Bone	MSU diaphysis	19,320 ± 100	23,735–23,531 (22,6%) 23,430–22,994 (72,8%)	Lyon-10354 (SacA-33963) Ducasse et al. 2014
15	Pégourié	8b	Late Badegoulian-like	Peg 257 c8b K5 #3764	Antler	Flake	17,680 ± 150	Lyon-13121 (SacA-45471)	Ducasse et al. 2019
16	Pégourié	8c	Late Badegoulian-like	Peg 283 c8c K6 #3475	Antler	Flake	18,440 ± 170	Lyon-13122 (SacA-45472)	Ducasse et al. 2019
17	Pégourié	8c	Late Badegoulian-like	Peg 341 K6 #4312	Antler	Decorated single beveled point using the "pseudo-excise" technique	17,960 ± 90	OxA-35268	Ducasse et al. 2019

18	Pégourié	8a	Late Badegoulian-like	Peg 395 K7 #6070	Antler	Recycled single and striated-beveled point	18,310 ± 90	22,424–22,070	OxA-35269	Ducasse et al. 2019
19	Petit Cloup Barrat	8a1	Late Badegoulian-like	PCB05 U72 d25 #608	Bone	MSU diaphysis	18,595 ± 150	22,925–22,271	Lyon-3366 (Poz)	Ducasse et al. 2011
20	Petit Cloup Barrat	4	Late Badegoulian-like	PCB08 R70D d3 #91	Antler	Flake	17,800 ± 80	21,933–21,370	Lyon 10856 (SacA 36272)	Chauvière et al. 2017
21	Petit Cloup Barrat	4	Late Badegoulian-like	PCB08 P72A d20 #680	Antler	"Arciform" artifact rough-out	17,720 ± 90	21,855–21,094	OxA 29408	Chauvière et al. 2017
<b><i>Dordogne-Poitou</i></b>										
22	Casserole	NA4	Late Badegoulian	O14b #1	Antler	Flake	17,760 ± 100	21,942–21,165	Lyon-13948 (SacA-48955)	Ducasse et al. 2020
23	Casserole	NA5	Late Badegoulian	N15d #34	Antler	Flake	18,100 ± 80	22,262–21,842	Lyon-13307 (GrA)	Ducasse et al. 2020
24	Casserole	NA6	Early Badegoulian	Q12d	Bone	Unworked humerus (diaphysis; horse size)	18,755 ± 50	22,911–22,480	Lyon-14316 (GrM)	Ducasse et al. 2020
25	Casserole	NA6	Early Badegoulian	R14b (Z=93,2)	Bone	Unworked reindeer cotyloid cavity	19,110 ± 70	23,171–22,909	Lyon-14315 (GrM)	Ducasse et al. 2020
26	Casserole	NA7	Upper Solutrean	K10 a #52	Burned bone	Coxal (horse size)	19,300 ± 120	23,737–23,524 (21,9%) 23,438–22,973 (73,5%)	Lyon-9944	Ducasse et al. 2020
27	Casserole	NA7b	Upper Solutrean	K10 b #55	Burned bone	.	19,020 ± 110	23,169–22,574	Lyon-9945	Ducasse et al. 2020
28	Taillis-des-Coteaux	AG-V	Late Badegoulian	.	Bone	.	18,140 ± 85	22,307–21,891	Lyon-2639	Primault et al. 2010
<b><i>Bourgogne-Massif Central</i></b>										
29	Oisy-Mont St. Aubin	3	Late Badegoulian	.	Bone	.	17,810 ± 110	22,016–21,264	Ly-6398 (SacA-17475)	Debout et al. 2012
30	Oisy-Mont St. Aubin	3	Late Badegoulian	.	Bone	.	17,820 ± 120	22,038–21,236	Ly-4622 (SacA-9685)	Debout et al. 2012
31	Oisy-Mont St. Aubin	4	Late Badegoulian	.	Bone	.	18,050 ± 120	22,280–21,662 (89,1%) 21,621–21,467 (6,4%)	Ly-6399 (SacA-17476)	Debout et al. 2012
32	Contrée-Viallet	3	Late Badegoulian	.	Bone	Horse	17,610 ± 70	21,670–21,605 (1,7%) 21,481–20,968 (93,7%)	Beta-377947	Lafarge 2014
33	Contrée-Viallet	3	Late Badegoulian	.	Bone	Horse	17,600 ± 70	21,640–21,630 (0,2%) 21,478–20,953 (95,3%)	Beta-377948	Lafarge 2014



34	Blot	15	Late Badegoulian	J8 15-41	Teeth	.	18,000 ± 80	22,155–21,675 (90,2%) 21,600–21,468 (5,2%)	GrA-17337 (Lyon-1337)	BANADORA; Banks et al. 2019
35	Blot	9	Late Badegoulian	K4 9-11	Teeth	.	17,850 ± 80	21,965–21,409	GrA-17339 (Lyon-1336)	BANADORA; Banks et al. 2019
36	Cottier	II	Late Badegoulian	.	unknown	.	17,910 ± 70	22,012–21,449	Beta-377946	Lafarge 2014
37	Rond du Barry	F2	Late Badegoulian-like	3C #539	Antler	Fragment	17,490 ± 80	21,377–20,905	Beta-297899	Raynal et al. 2014
38	Rond du Barry	F2	Late Badegoulian-like	F14	Antler	Fragment	17,680 ± 70	21,760–21,071	Beta-297895	Raynal et al. 2014
39	Rond du Barry	F2	Late Badegoulian-like	E13 #77	Antler	Fragment	17,720 ± 80	21,839–21,123	Beta-306179	Raynal et al. 2014
40	Rond du Barry	E	Late Badegoulian-like	J13 #1	Antler	Flake	17,960 ± 70	22,080–21,656 (85,4%) 21,625–21,462 (10,1%)	Beta-297897	Rémy, 2013
<b>Languedoc-Pyrenees</b>										
41	Lassac	locus 1	Late Badegoulian	M6 CX rel.6	Antler	Flake	17,400 ± 110	21,390–20,750	Lyon-6417 (SacA-17494)	Pétilion and Ducasse 2012
42	Lassac	locus 1	Late Badegoulian	W section	Antler	Flake	17,530 ± 100	21,447–20,883	Lyon-6418 (SacA-17495)	Pétilion and Ducasse 2012
43	Lassac	locus 1	Late Badegoulian	L6 rel8	Antler	Wedge Sectioned base of shed antler	17,420 ± 110	21,396–20,790	Lyon-6419 (SacA-17496)	This paper
44	Les Harpons	D	Late Badegoulian-like	HARP-1	Antler	(chopping)	18,450 ± 100	22,556–22,145	OxA-26876	Ducasse et al. 2017
45	Les Harpons	D	Early/Late Badegoulian-like	HARP-3	Antler	Flake	18,960 ± 110	23,070–22,535	OxA-26878	Ducasse et al. 2017

**Table 2.** AMS <sup>14</sup>C dates used in Figure 2 and covering the entire time span of the French Badegoulian, including the Solutrean-to-Badegoulian transition (MSU: medium-sized ungulate). Calibration was carried out with the OxCal program (v4.4.2: Bronk Ramsey, 2020) using the IntCal20 calibration curve (Reimer et al., 2020).

	Country	Site	Level/Sector	Cultural attribution	Labelling	Material	Nature of sample	Uncalibrated age (BP)	Calibrated age (BP, 2σ)	Lab Code	Reference
1	Spain	Llonin	Level III (gallery)	Late Badegoulian	LLO-71	Charcoal	<i>Ericacea</i>	17,480 ± 75	21,366–20,902	OxA-26042	Rasilla Vives et al., 2019
2	Spain	Llonin	Level III (gallery)	Late Badegoulian	LLO-70	Charcoal	<i>Ericacea</i>	17,610 ± 90	21,712–20,955	OxA-26041	Rasilla Vives et al., 2019
3	Spain	Llonin	Level III (gallery)	Late Badegoulian	LLO-68	Charcoal	<i>Juniperus</i>	17,650 ± 130	21,829–20,950	OxA-26338	Rasilla Vives et al., 2019
4	Spain	Llonin	Level III (gallery)	Late Badegoulian	LLO-71	Charcoal	<i>Juniperus</i>	17,920 ± 80	22,033–21,445	OxA-26340	Rasilla Vives et al., 2019
5	Spain	Llonin	Level III (gallery)	Late Badegoulian	LLO-31	Bone	.	18,100 ± 90	22,286–21,814	OxA-X-2559-11	Rasilla Vives et al., 2019
6	Spain	Llonin	Level III (gallery)	Late Badegoulian	LLO-69	Charcoal	<i>Fabacea</i>	18,345 ± 75	22,435–22,123 23,734–23,532	OxA-26339	Rasilla Vives et al., 2019
7	Spain	Llonin	Level IV (gallery)	Upper Solutrean	LLO-28	Bone	.	19,300 ± 110	(20.7%) 23,429–22,976 (74.7%) 23,737–23,526	OxA-22700	Rasilla Vives et al., 2019
8	Spain	Llonin	Level IV (gallery)	Upper Solutrean	LLO-27	Bone	.	19,330 ± 100	(24.3%) 23,436–23,001 (71.2%)	OxA-22699	Rasilla Vives et al., 2019
9	Spain	Llonin	Level IV (gallery)	Upper Solutrean	LLO-26	Bone	.	19,480 ± 110	23,779–23,145	OxA-22698	Rasilla Vives et al., 2019
10	Switzerland	Kastelhöhle-Nord	middle level	Early Badegoulian-like	UPN-221	Bone	Reindeer metatarsal, cut-marked	19,140 ± 80	23,263–22,910 23,683–23,610	OxA-V-2793-57C	Reade et al., 2020
11	Switzerland	Kastelhöhle-Nord	middle level	Early Badegoulian-like	UPN-222	Bone	Reindeer tibia, cut-marked	19,200 ± 90	(4.3%) 23,355–22,936 (91.2%)	OxA-V-2797-20C	Reade et al., 2020
12	Switzerland	Kastelhöhle-Nord	middle level	Early Badegoulian-like	UPN-223	Bone	Reindeer phalanx 1, cut-marked	19,110 ± 90	23,280–22,880	OxA-V-2804-43C	Reade et al., 2020
								19,130 ± 80	23,246–22,905	OxA-V-3002-12C	Reade et al., 2020

**Table 3.** Available AMS <sup>14</sup>C ages for the Late Badegoulian assemblages from Llonin Cave, level III (Spain) and the Early Badegoulian-like assemblages from Kastelhöhle-Nord, middle archaeological layer (Switzerland). Calibration was carried out with the OxCal program (v4.4.2: Bronk Ramsey, 2020) using the IntCal20 calibration curve (Reimer et al., 2020).