Towards a Renewed Definition of the Protoaurignacian

Hin zu einer erneuerten Definition des Protoaurignacien

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Abstract: *The Early Upper Paleolithic marks a turning point in the history of human evolution. Among the technocomplexes that characterize this period, the Aurignacian has received most of the attention because of its direct association with the spread of modern humans into Europe. However, research has often neglected its important synchronic and diachronic variability. Regional studies and accurate re-evaluation of pivotal sites are thus fundamental in deconstructing the notion of the Aurignacian. This paper presents the results of an extensive techno-typological analysis of the lithic assemblages and a re-evaluation of the organic artifacts from five cultural units at Fumane Cave (Veneto, Italy). Furthermore, retouched bladelets from two Protoaurignacian sites, Isturitz (Basque Country, France) and Les Cottés (Vienne, France), are analyzed and compared to the record from Fumane Cave. The main research goals were to reassess the technological signature of the Protoaurignacian and examine the development of the Aurignacian in northern Italy to test whether the so-called "Aquitaine Model" can be applied across Europe. Results of the empirical study and the inter-site comparison confirm that the Protoaurignacian is an industry dominated by bladelet implements, although lamellar production is based on a broad range of reduction strategies that are not related to the dwindling core dimensions as blade production progressed. Although rather homogeneous from a technological standpoint, the variability of retouched bladelets emphasizes the differences that exist between Protoaurignacian regional groups. The study on the diachronic variability of the Aurignacian at Fumane Cave rejects the recurring practice, well established among Paleolithic archaeologists, to transfer a regional model to geographically distant case studies. At Fumane Cave, the techno-typological features of the Protoaurignacian clearly persist throughout the stratigraphic sequence with some gradual variations that are less marked if compared to other sequences. Thus, both the "Aquitaine Model" and the idea according to which the Protoaurignacian vanished at the onset of the Heinrich Event 4 are invalidated when applied to northern Italy. In conclusion, this paper exemplifies how the re-evaluation of pivotal sites and the definition of regional signatures are able to yield new insights into the beginning and development of the European Upper Paleolithic.*

Keywords: *Early Upper Paleolithic, Aurignacian, Fumane Cave, lithic technology, bladelets, human evolution*

Zusammenfassung: Das frühe Jungpaläolithikum stellt einen Wendepunkt in der Geschichte der menschlichen Evolution dar. Unter den Technokomplexen die diese Periode kennzeichnen, hat das Aurignacien wegen seines unmittelbaren Zusammenhangs mit der Ausbreitung moderner Menschen quer durch Europa die größte Aufmerksamkeit erlangt. Oft wurde in der Forschung jedoch seine bedeutende Variabilität sowohl innerhalb ein und desselben Zeithorizontes als auch über längere Zeiträume hinweg missachtet. Regionale Studien sowie sorgfältige Neubewertungen von Schlüsselfundstellen sind daher von grundlegender Bedeutung, um die Vorstellungen zum Aurignacien kritisch zu hinterfragen. Im vorliegenden Beitrag werden die Ergebnisse einer ausführlichen techno-typologischen Analyse der Steinartefaktinventare sowie einer Neubeurteilung der Werkzeuge aus organischen Materialien aus fünf Fundschichten der Fumane-Höhle im Veneto in Italien vorgelegt (Schichten A2, A1, D3base, D3b*alpha* und D3ab). Darüber hinaus werden retuschierte Lamellen von zwei Fundplätzen des Protoaurignacien, nämlich Isturitz (Baskenland, Frankreich) sowie Les Cottés (Vienne, Frankreich), analysiert und mit den Ergebnissen aus der Fumane-Höhle verglichen. Die wichtigsten Forschungsziele bestehen darin, die

technologischen Charakteristika des Protoaurignacien neu zu bewerten und die Entwicklung des Aurignacien in Norditalien zu untersuchen. Hierdurch soll überprüft werden, ob das so genannte ‚Aquitanische Modell' für das Aurignacien tatsächlich auf ganz Europa übertragen werden kann.

Das Aurignacien war ursprünglich aufgrund der Vergesellschaftung von Steinartefakten und organischen Werkzeugen aus einigen wenigen aquitanischen Referenzfundstellen definiert worden, wobei vier aufeinanderfolgende Stufen (I–IV) unterschieden wurden. Eine weitere Stufe, das ‚Aurignacien 0', wurde später hinzugefügt, als man Inventare fand, die dem Aurignacien I (bzw. dem Frühen Aurignacien) vorausgingen. Laplace schlug für diese Inventare den Begriff ‚Protoaurignacien' vor, nachdem er verschiedene Fundplätze in den französischen Pyrenäen sowie in den mediterranen Regionen Spaniens und Italiens analysiert hatte. Nach einer vor allem in der französischen Forschung vertretenen Meinung ist eines der wesentlichen Kennzeichen des Protoaurignacien die Gewinnung von Klingen und Lamellen mittels nur einer einzigen Kernabbausequenz, wobei beide Zielprodukte von denselben Kernen durch fortschreitende Größenabnahme zustande kamen. Klingen wurden dann zur Herstellung von Kratzern, Sticheln und lateral retuschierten Werkzeugen ausgewählt. Schmale Klingen als Zwischenprodukte zwischen Klingen und Lamellen blieben meist unretuschiert. Lamellen waren bei weitem das bevorzugte Zielprodukt der Steinbearbeitung. Sie werden als groß mit geradlinigem Umriss beschrieben und weisen oft konvergierend retuschierte Distalenden auf. Das Frühe Aurignacien ist dagegen nach derselben Forschungsmeinung durch eine klare Trennung zwischen Klingen- und Lamellenproduktion charakterisiert, wobei Klingen von unidirektionalen prismatischen Kernen gewonnen wurden, während man die in der Regel kleinen Lamellen an gekielten Kernen produzierte, die normalerweise als Kielkratzer bezeichnet werden. Letztere seien im Protoaurignacien selten oder fehlten ganz. Retusche sei bei den Lamellen im Frühen Aurignacien wesentlich schwächer ausgeprägt als im Protoaurignacien. Da an denjenigen Fundstellen, an denen sowohl Proto- als auch Frühes Aurignacien vorkommen, Letzteres stratigraphisch immer über Ersterem liegt, wird auch eine chronologische Relevanz dieser Einheiten gesehen. So vertreten einige Forscher die Meinung, das Protoaurignacien sei im Zuge verschlechterter Umweltbedingungen am Anfang des Heinrich 4-Ereignisses gegen etwa 39.900 bis 39.200 vor heute (kalibrierte Daten) verschwunden, während das Frühe Aurignacien sich weiter ausbreitete. Jedoch zeigt sich mit einer deutlich erweiterten Datenbasis, dass das Frühe Aurignacien bereits klar vor dem Einschnitt des Heinrich 4-Ereignisses existierte, es also im westlichen Europa eine zeitliche Überlappung von Protoaurignacien und Frühem Aurignacien gegeben hat.

Die Ergebnisse der empirischen Untersuchungen und des Vergleichs zwischen den Fundstellen, die der Verfasser im Rahmen seiner Dissertation angestellt hat, bestätigen, dass das Protoaurignacien eine Industrie darstellt, die durch an Lamellen gefertigte Werkzeuge dominiert wird, wobei die Lamellenherstellung zwar mit einer großen Variationsbreite bei den Abbaustrategien erfolgte, jedoch nicht mit schwindenden Kerngrößen bei fortschreitender Klingenproduktion in Verbindung steht. Auch Lamellengewinnung an gekielten Kernen kommt im Protoaurignacien in nennenswertem Umfang vor. Obwohl die retuschierten Lamellen vom technologischen Standpunkt her ziemlich einheitlich sind, unterstreicht ihre Variabilität die Unterschiede, die zwischen den regionalen Gruppen des Protoaurignacien bestehen. Die Untersuchungen zur diachronen Variabilität des Aurignacien in der Fumane-Höhle erlauben es, die unter paläolithischen Archäologen gängige Praxis, ein regionales Modell auf geographische entfernte Fallstudien zu übertragen, abzulehnen. In der Fumane-Höhle bestehen die techno-typologischen Charakteristika des Protoaurignacien eindeutig über die gesamte frühjungpaläolithische Sequenz hinweg fort. Dabei gibt es zwar einige graduelle Unterschiede, diese sind aber im Vergleich zu anderen Sequenzen weniger deutlich ausgeprägt. Es wird im Beitrag dafür plädiert, bis zur Erarbeitung einer angemesseneren Nomenklatur die Schichten A2 und A1 der Fumane-Höhle nach wie vor als Protoaurignacien anzusprechen, die darauffolgenden Schichten D3base, D3b*alpha* und D3ab wegen der fortlebenden Traditionen dagegen als *spätes* Protoaurignacien. Das bedeutet, dass sowohl das ‚Aquitanische Modell' als auch die Vorstellung, nach welcher das Protoaurignacien am Beginn des Heinrich 4-Ereignisses verschwand, nicht gelten, wenn sie auf Norditalien angewandt werden. Abschließend ist der Beitrag ein Beispiel dafür, wie die Neubewertung von Schlüsselfundstellen und die Herausarbeitung regionaler Signaturen es möglich machen, neue Einsichten in die Anfänge und die Entwicklung des europäischen Jungpaläolithikums zu gewinnen.

Schlagwörter: frühes Jungpaläolithikum, Aurignacien, Fumane-Höhle, Steintechnologie, Lamellen, menschliche Evolution

Introduction

Background of the research

There are few European technocomplexes that have received the same attention as the Aurignacian. This cultural group represents the best known evidence of the definitive spread of anatomically modern humans (AHMs) across Europe (Conard 2002; Mellars 2006a; Davies 2007; Hublin 2015), to the point that the term Aurignacian is perceived by some as a synonym of peopling of the continent by AMH. In this regard, it is rare to find a paper on the Aurignacian that avoids chronicling the dispersal of AMHs in the very first paragraphs. The attention and effort placed by prehistoric archaeologists in disentangling its complex synchronic and diachronic variability would have been surely undermined if this association were not made. However, some researchers believe that the advent of the Aurignacian might be a second wave of AMHs moving across western Eurasia (Hoffecker 2009). The first wave would be associated with the Bohunician, whose material culture is said to be comparable to the Levantine Initial Upper Paleolithic (Skrdla 2003; Bar-Yosef 2006; Nigst 2012; Tostevin 2013). Similar claims have been made for the Uluzzian after the assignment of two teeth to *Homo sapiens* at Cavallo Cave (Benazzi et al. 2011; Moroni et al. 2018; Zanchetta et al. 2018). The integrity of the Cavallo stratigraphy has, however, been questioned (Zilhão et al. 2015) and further evidence is needed to assess the makers of the Uluzzian in Italy (Benazzi et al. 2014; Peresani et al. 2016, 2019; Villa et al. 2018).

To date, the Aurignacian is the sole, undisputed Early Upper Paleolithic technocomplex associated with AMHs in Europe, as human teeth found in a few stratified sites would suggest (Bailey 2006; Bailey et al. 2009; Benazzi et al. 2015). The issue of the supposed link between the Aurignacian and the Ahmarian of the Near East and/or the Baradostian and the Rostamian of Central Asia (e.g., Otte and Kozłowski 2004; Hoffecker 2009; Tsanova et al. 2012; Tsanova 2013; Ghasidian et al. 2017) is still open to debate, given the current available chronology (Kadowaki et al. 2015; Becerra-Valdivia et al. 2017) and the absence of detailed comparisons between technocomplexes.

The oldest appearances of the Aurignacian are dated roughly between 43–42 ka cal BP and are mainly found along the Mediterranean boundaries and the Danube Basin (Conard and Bolus 2008; Davies and Hedges 2008-2009; Szmidt et al. 2010b; Douka et al. 2012; Higham et al. 2012; Nigst et al. 2014; Wood et al. 2014; Barshay-Szmidt et al. 2018). Criticisms have been raised over the older dates obtained for the Aurignacian of Central Europe (Zilhão and d'Errico 2003; Banks et al. 2013b; Teyssandier and Zilhão 2018), and particular caution is at the moment required when dealing with the site of Willendorf II (described in: Nigst 2012; Nigst and Haesaerts 2012; Nigst et al. 2014).

The Aurignacian was named after the discovery of the eponymous site (abri d'Aurignac) in the Haute-Garonne by Édouard Lartet in 1860 (see a research history in: Bon 2002b; Le Brun-Ricalens and Bordes 2007). Systematic research started only in the 20th century and was mainly conducted in the northern Aquitaine Basin of southwestern France (Breuil 1912; Peyrony 1933, 1935; Garrod 1938; de Sonneville-Bordes 1960; Delporte 1964, 1968; Djindjian 1986, 1993). In the last decades, a constantly growing database has permitted researchers to define the main features of the Aurignacian phenomenon, with various attempts being made to understand its variability (Laplace 1966; Hahn 1977;

Bon 2002a; Bon et al. 2002; Le Brun-Ricalens 2005a; Bar-Yosef and Zilhão 2006). However, given that most of the research has been conducted in the Aquitaine Basin, a region that had a prominent role in the construction of Paleolithic research itself (Groenen 1994), a slightly biased narrative has been constructed (Anderson et al. 2018).

The Aurignacian was initially defined by the association of stone and organic tools discovered in a few Aquitaine reference sequences, which led to the identification of four successive stages (Peyrony 1933, 1935; de Sonneville-Bordes 1960; Demars 1992; Demars and Laurent 1992; Bordes 2006). A further stage, the "Aurignacian 0," was used by Delporte (1968) to label industries prior to Peyrony's Aurignacian I. The most important study on these assemblages was conducted by Laplace (1966). He introduced the term "Protoaurignacian" after the analysis of several sites distributed in the French Pyrenees and the Mediterranean regions of Spain and Italy. Typological definitions of the different Aurignacian stages were only subsequently complemented by technological studies (Le Brun-Ricalens 1993, 2005a; Bon 2002a; Bon and Bodu 2002; Bordes 2002; Chiotti 2005; Bon et al. 2010).

Research has primarily focused on the earliest phases, which are known as Early Aurignacian (EA) and Protoaurignacian (PA) (Bon et al. 2010; Teyssandier et al. 2010). According to some, these two variants have developed in distinct geographic domains and have spread across Europe along different routes. The Danube Basin represented a preferential corridor for the diffusion of EA industries, while the makers of PA industries followed the Mediterranean coastline (Conard and Bolus 2003; Mellars 2004, 2006b; Bertola et al. 2013; Hublin 2015; Chu 2018). To others, they are instead successive technical traditions reflecting different settlement dynamics among AMHs (Bon 2005; Anderson et al. 2015). In Western Europe, the PA is stratigraphically placed below the EA when both industries are documented (Arrizabalaga and Altuna 2000; Bon 2002a; Bordes 2006; Normand et al. 2007; Arrizabalaga et al. 2009). Given this, a recent study has concluded that the adaptive shift that marked the beginning of the EA and the disappearance of the PA over the extension of the European subcontinent was triggered by the deterioration of the environment at the onset of Heinrich Event 4 (H4; Banks et al. 2013a, b; contra: Higham et al. 2013; Ronchitelli et al. 2014). Several scientists have raised criticisms on the validity of this scenario both because of the discard of inconvenient data when running the Bayesian modeling, but also for the strict cultural separation between the two facies (Higham et al. 2013; Ronchitelli et al. 2014; Falcucci et al. 2017). A growing chronological database attests to the beginning of the EA well before the cut-off of ca. 39.9–39.2 ka cal BP and thus a statistical overlap between PA and EA in western Europe (Wood et al. 2014). This is for instance the case at Isturitz (Barshay-Szmidt et al. 2018) and Pataud (Higham et al. 2011).

The previous considerations raise important questions about how these two apparent sister groups relate and if the assumptions that were made are consistent with the available archaeological data (Conard and Bolus 2015). According to the most used reconstructions, PA and EA assemblages can be easily divided according to some technological features that will be briefly summarized. The PA signature is said to lie in the production of blades and bladelets within a single and continuous stone knapping sequence (Bon et al. 2010). Both products are thus obtained from the same core as the result of its progressive reduction (Bon and Bodu 2002). Blades are selected to manufacture endscrapers, burins, and laterally retouched tools. Slender blades, representing the intermediate products between blades and bladelets, are frequently left unretouched. Bladelets are the dominant intention of the lithic production and are described as large with rectilinear profiles that are transformed into Dufour sub-type Dufour (Demars and Laurent 1992). The EA is instead characterized by a clear distinction between laminar and lamellar productions as a result of a stronger anticipation and planning of different needs (Teyssandier 2008; Anderson et al. 2015). Blades are obtained from unidirectional prismatic cores, while curved bladelets are produced from carinated cores, frequently called "carinated endscrapers" (see a research history in Le Brun-Ricalens 2005b). The latter are said to be scarcely found, or even absent, in PA assemblages (Bordes 2006). Blades are robust, have frequently faceted platforms, and are transformed into laterally retouched tools, strangulated blades, and thick endscrapers. These common tools are often modified by the so-called Aurignacian retouch (de Sonneville-Bordes 1960), which is scalar and invasive due to several re-sharpening stages that occur during repeated use and transport over long distances (Bon 2005). Bladelets are instead produced on-site, as needed, and only few were transformed into small sub-type Dufour, mostly by applying an inverse retouch (Le Brun-Ricalens et al. 2009).

Aside from stone tools, the split-based point (SBP) has always been historically considered a type fossil of the EA (Peyrony 1933, 1935; de Sonneville-Bordes 1960), replaced by other types in successive stages of the Aurignacian (but see: Moreau et al. 2015). This type of organic artifact remains important to the definition of the EA today (Teyssandier 2007; Banks et al. 2013a, b; Teyssandier and Zilhão 2018), although Zilhão (2006) emphasized that bone tools, ornaments, and art should not be included in the basic definition of the Aurignacian, which should be based exclusively on lithic artifacts. Only a small percentage of Aurignacian sites contain SBPs and more generally organic points (Liolios 2006; Doyon 2017). Outside of the Aquitaine and the Swabian Jura, finds are scattered (Tafelmaier 2017). Nevertheless, it is not rare that archaeologists ascribe a cultural unit to the EA based solely on the presence of a SBP (de Sonneville-Bordes 1960; Hahn 1977; Banks et al. 2013a; Tejero and Grimaldi 2015; Teyssandier and Zilhão 2018). Recently, the exclusive association of SBPs with EA assemblages has been questioned, and its presence in an archaeological horizon does not in and of itself clarify the cultural attribution (Moreau et al. 2015; Tafelmaier 2017). At Geißenklösterle, for instance, SBPs appear only in the upper Aurignacian horizon (Conard and Bolus 2003; Teyssandier 2007), while at Trou de la Mère Clochette (Szmidt et al. 2010a) and Arbreda (Maroto et al. 1996) SBPs were found in association with lithic assemblages with PA affinities.

Additionally, the EA has produced three-dimensionally formed personal ornaments, figurative representations, occasional finds of mythical imagery, and musical instruments, whereas the PA typically has a more limited range of figurative representations and symbolic artifacts, mostly made from marine shells and teeth (Taborin 1993; Kuhn and Stiner 1998; Conard 2002, 2009; Vanhaeren and d'Errico 2006; Zilhão 2007; Broglio et al. 2009; Higham et al. 2012; White and Normand 2015; Dutkiewicz et al. 2018).

Research outside of southwestern France has often focused on extending the so-called "Aquitaine Model" (Bordes 2006) and its related clear-cut definitions, rather than focusing on achieving refined regional signatures (e.g., Laplace 1966; Hahn 1977; Zilhão and d'Errico 1999; Broglio 2000; Kozlowski and Otte 2000; Otte and Derevianko 2001;

Demidenko et al. 2012; Dinnis et al. 2019). However, the growing number of multi-disciplinary analyses and the re-evaluation of some sites are highlighting a greater technological variability across Europe and revealing several deficiencies in the commonly used chrono-cultural reconstruction (Conard and Bolus 2006, 2015; Sitlivy et al. 2012; Bataille 2013; Falcucci et al. 2017; Tafelmaier 2017; Bataille and Conard 2018; Bataille et al. 2018; Hauck et al. 2018). The main goal of this paper is therefore to contribute to the understanding of the first stages of the Aurignacian by focusing on a pivotal site in northeastern Italy: Fumane Cave (Bartolomei et al. 1994). In agreement with Bon (2002a), I believe in fact that the definition of high-resolution regional signatures will be beneficial in achieving a better understanding of the development of the Aurignacian and, more generally, of the beginning of the Upper Paleolithic with its related anthropological questions.

The Aurignacian in the southern Alpine range and the Italian Peninsula is known from several stratified cave and open-air sites and surface collections. They are distributed in different environmental settings, close to the modern coastlines and up to Alpine and Apennine regions (Palma di Cesnola 2001; Mussi 2002). The Italian research tradition was strongly influenced by the so-called *typologie analytique* developed by G. Laplace in the late sixties and seventies (Laplace 1966, 1977; Plutniak and Tarantini 2016) and detailed technological assessments have been conducted only in a few cases (e.g. D'Angelo and Mussi 2005; Dini et al. 2010, 2012; Bertola et al. 2013). Among those, Fumane Cave is the site that has received the most attention, although research has mainly focused on the earliest manifestations of the PA (Broglio et al. 2005; De Stefani et al. 2012; Bertola et al. 2013). The potential of its long stratigraphic sequence, with evidence of human occupations that both pre- and postdate the occurrence of H4, is far from being exhausted. Besides Fumane Cave, evidence of Aurignacian sites in the Venetian region is poor and difficult to evaluate. At Tagliente Rockshelter, located in the western Monti Lessini, an Aurignacian assemblage was found within a stratigraphic unit that was partially mixed with Mousterian and Epigravettian implements (Bartolomei et al. 1982). At Paina, in the Colli Berici, few Aurignacian lithic implements were found together with a fragmented organic point (Bartolomei et al. 1988).

Generally, it seems that the PA persisted longer in Italy than in other regions (Palma di Cesnola 2001; Mussi 2002; Bon et al. 2010; Anderson et al. 2015). For this reason, Palma di Cesnola (2001) and Mussi (2002) proposed the prefix Proto- be abolished because it gives the impression that assemblages included in this group have an absolute chrono-stratigraphic significance with respect to others, as is the case in western Europe (Bordes 2006; Bon et al. 2010). Fewer "typical" Aurignacian assemblages exist and have been sorted mainly by the presence of SBPs and other organic artifacts (Blanc and Segre 1953; Laplace 1977; Palma di Cesnola 2001; Mussi et al. 2006; Tejero and Grimaldi 2015), although some authors suggested that the two variants be grouped together, given the high resemblance of their main typological features (Gheser et al. 1986). Careful reassessments recently conducted at Bombrini in northwestern Italy (Riel-Salvatore and Negrino 2018a, b) suggest that the PA was a resilient technological system that survived well beyond the H4 and the roughly contemporaneous Campanian Ignimbrite volcanic eruption (see references in: Giaccio et al. 2017). Similar conclusions, even if at a preliminary level, were reached by A. Broglio and the research team of Ferrara University at Fumane Cave (Broglio 1997; Higham et al. 2009).

In this paper, a detailed analysis of the lithic technology from five cultural units (A2, A1, D3base, D3b*alpha*, and D3ab) of Fumane Cave and a reassessment of organic artifacts recovered therein are presented. Fumane Cave has always been considered a key site for understanding the Middle–Upper Paleolithic transition and the complex processes that led to the demise and final extinction of Neanderthal populations and the spread of AMHs across Europe. The systematic and modern excavations conducted for decades, the presence of a high resolution stratigraphic sequence, and the discovery of modern human remains associated with the earliest PA (Benazzi et al. 2015) shed new light on the cultural dynamics that characterized the Aurignacian in the North-Adriatic region and its relationship with contemporaneous industries on a supra-regional scale.

Specifically, I first focus on the lowermost assemblages A2–A1 to test the current technological definition of the PA. An extensive investigation is conducted by using two combined approaches: reduction sequence and attribute analyses. The variability of the PA is then critically discussed across its geographic extent, and comparisons made of our results with the available scientific literature and the empirical data on retouched bladelets obtained at the sites of Isturitz, in the Pyrenean region, and Les Cottés, in northern France. The second main goal of this paper is to investigate the diachronic variability of the Aurignacian at Fumane Cave by comparing A2–A1 to the youngest cultural units D3base, D3b*alpha*, and D3ab. Evidence of cultural change and/or stability is used to support or reject the "Aquitaine Model" and, particularly, to test if the PA is followed by assemblages that can be attributed to the EA. Finally, an alternative scenario on the beginning and development of the Aurignacian is discussed in the larger framework of the European subcontinent.

The site of Fumane Cave and the Aurignacian sequence

Fumane Cave is one of the best known Paleolithic sites of Europe. Besides its undeniable scientific relevance, it is one of the few sites currently excavated that is accessible to visitors of the Lessinia Park and is also part of "Ice Age Europe": a network of the most important prehistoric heritage sites (https://www.ice-age-europe.eu/home.html; last access February 19, 2019). This site is a cave complex excavated in dolomitic limestone located along the Vajo di Roncomerlo in the Fumane Valley, at the foot of the western Monti Lessini, 350 m asl. The Monti Lessini are limestone hills on the southern edge of the Venetian Pre-Alps that rise gradually just north of Verona. Their higher regions form a range of broad plateaus at about 1,600 m asl.

Although the site was first reported in 1884, and part of the stratigraphic section exposed in 1964, systematic excavations began only in 1988 under the direction of the University of Ferrara and the University of Milan (Bartolomei et al. 1994). Excavations have been carried out at different times and at variable extensions beyond the present-day drip-line and in the cave entrance, an area where Middle and Upper Paleolithic levels with well-preserved Mousterian and PA living-floors have been brought to light in a good state of preservation. Nowadays, the site is still being excavated on a regular basis under the direction of Prof. Marco Peresani, from the University of Ferrara.

The current morphology of the site is a result of the combined action of huge collapses, which during the Late Pleistocene affected the massive rock banks and the dismantling phases mostly caused by freezing and thawing. Details about the stratigraphic sequence, paleoclimatic significance, as well as paleontological and cultural content, are available in numerous publications (Bartolomei et al. 1994; Cassoli and Tagliacozzo 1994; Broglio et al. 2003, 2005; Broglio and Dalmeri 2005; Higham et al. 2009; Peresani 2012; Benazzi et al. 2015; López-García et al. 2015; Peresani et al. 2016; Falcucci et al. 2017). A main cave and two associated tunnels preserve a finely-layered sedimentary succession spanning the late Middle Paleolithic and the Early Upper Paleolithic (Fig. 1), with features and dense scatters of remains in units A11, A10, A9, and A6–A5 (Mousterian: Peresani 2012; Peresani et al. 2013), A4 and A3 (Uluzzian: Peresani et al. 2016), A2–A1 (Protoaurignacian: Broglio et al. 2005; Bertola et al. 2013; Cavallo et al. 2017; Falcucci et al. 2017, 2018; Falcucci and Peresani 2018), D6, D3, and D1c (Aurignacian sensu lato: Broglio and Dalmeri 2005), and D1d (Gravettian: Bartolomei et al. 1992). Currently, layers have been extensively excavated at the entrance of the cave and partly excavated in the cave mouth.

Fig. 1: Fumane Cave. The stratigraphic sequence at the entrance of tunnel A with evidence of late Mousterian (A6–A5), Uluzzian (A4–A3) and Protoaurignacian layers (A2–D3). Photo: A. Léone.

Abb. 1: *Fumane-Höhle. Die stratigraphische Abfolge am Eingang von Tunnel A mit Schichten aus dem späten Moustérien (A6–A5), dem Uluzzien (A4–A3) und dem Protoaurignacien (A2-D3). Foto: A. Léone.*

In layers A4 and A3, the Uluzzian occupations date to later than 43.6–43.0 ka cal BP (Higham et al. 2009). The transition from the final Mousterian took place in a relatively short time, as the beginning of the Uluzzian is chronologically indistinguishable from the final Mousterian (Douka et al. 2014). The Uluzzian lithic technology is primarily oriented towards flake production. Technological innovations are rooted in a clear Mousterian cultural context (Peresani et al. 2016). In layer A4, flakes are obtained from centripetal cores, following Levallois concepts. Scrapers of varied morphologies are the prevailing tool type. Layer A3 marks the definitive separation of the Uluzzian from the Mousterian. In this layer, flakes are produced through several methods with bladelet production increasing slightly. The main tool types are scrapers, splintered pieces, and backed flakes.

Unit A2 dates the appearance of the Aurignacian to 41.2–40.4 ka cal BP (Higham et al. 2009; Higham 2011). Its boundary with layer A3 is clearly marked by a dispersion of ocher over a large area (Cavallo et al. 2017, 2018) and by a considerable change in the content of anthropogenic material (Broglio et al. 2009). In the cave entrance, unit A2 is covered by A1, a thin anthropic level with horizontal bedding, which makes it indistinguishable from A2 in the cave mouth. A2 thus extends throughout the whole cave.

Post-depositional processes, due to frost activity, affected layers A3 and A2 in the easternmost part of the cave entrance and allowed PA materials (lithics, bones, and pierced shells) to infiltrate into A3 (Peresani et al. 2016). Stratigraphic deformations have been reported in the inner eastern side of the cave mouth, where layer A2 was tilted and compressed towards the cave wall, forming a pronounced fold. Despite this deformation, during excavations layer A2 appeared to be a clearly discernible sedimentary body preserved at variable thicknesses from a few centimeters to 10 centimeters, indicated through its dark-brownish color, its texture and its high charcoal, bone and stone implement density, as well as the occurrence of features (i.e., hearths, post-holes, and toss-zones) mostly located at the cave entrance (Peretto et al. 2004; Broglio et al. 2006a, b). Some of these hearths were located within shallow basins excavated at the edges of the Uluzzian (Peresani et al. 2016) and final Mousterian layers below, thus producing possible dispersion of a few flaked stones in the A2 and A1 assemblage.

In the front part of the cave, a series of layers from the stratigraphic complex D3 correspond to the youngest Aurignacian phase. From a sedimentological point of view, the macro-unit D is mostly formed of very coarse materials (boulders and stones) collapsed from the cave walls that progressively sealed the cave entrance. These events correspond to a long period of climatic deterioration (Broglio et al. 2003; López-García et al. 2015), where the traces of human presence become less dense than in A2 and A1. Archaeological materials were, however, found in layers embedded in macro-unit D. Because of differences in the composition of the sediments and excavation history, the stratigraphy of the D complex in the cave mouth is different than that of the cave entrance. At the entrance, D3 was divided into several units. At the base of the sequence, D3base was a thin layer that marked the transition with A1. Above D3base, two layers were recognized and then considered as a single accumulation event. They are D3d and D3b*alpha* and, in this paper, they will be grouped together and referred to as D3b*alpha*. Here, human activity is the most evident. D3d stands for *Dallage* and was initially restricted to a deliberate human feature composed of a series of angular, small sized (ca. 10 cm) blocks sub-horizontally arranged to form a regular pavement with a diameter of ca. 120 cm bounded by boulders. In D3b*alpha*, a combustion feature was uncovered together with an accumulation of several lithic artifacts and a split-based bone point (Broglio et al. 2006a). A radiocarbon date produced from a sample taken from the combustion feature suggests that this event took place at about 38.9–37.7 ka cal BP (95,4% of reliability), thus after the H4 (Higham et al. 2009). The top of the D3 complex is divided into two spits: D3a and D3b. These are the most extended deposits, although the archaeological materials are less numerous compared to the lower units. During excavation, D3a was considered almost sterile. Sediments were quickly removed and sieved only for samples from a few square meters. The number of small lithics, such as bladelets, may therefore be slightly underestimated. Here, D3a and D3b are considered as a single unit named D3ab. The consistency of the assemblages is secured by the lack of any evidence supporting massive percolation of stone implements from and to the D3 complex. Clear boundaries between stratigraphic layers, as well as the lack of significant deformations in a large part of the excavated area, suggest that perturbations between the Aurignacian occupations should be excluded.

In the cave mouth the situation looks very different, making any correlation to the previously described units problematic. They are therefore excluded from this study. In this area, due to post-depositional processes that are under examination, the eastern part of the upper sequence appears to be different than that of the western portion. Above a loose stony layer (D6), a thick layer named D3+D6 was described. In the western side, layer D6 was instead covered by a sequence comprising a thin level named D3a+b and the stratigraphic complex D1. The latter was divided in different units, among which D1c was described as Aurignacian, D1d as Gravettian (Bartolomei et al. 1992; Broglio 1997), and D1e as sterile.

Macro- and micro-faunal remains shed light on the Aurignacian ecological context. They show an association between forest fauna and cold and open habitat species typical of the alpine grassland steppe above the tree line (Cassoli and Tagliacozzo 1994; Broglio et al. 2003; Gurioli et al. 2005). This context reflects a clear climatic cooling with relative decreases in woodland formations. Two main phases were detected: the first (A2–A1) was a cold and dry phase probably related with H Event 4, while the second (D3 complex) was a cold and humid phase. The formation of D1d is instead characterized by a warm period. Finally, Heinrich Event 3 was identified in D1e (López-García et al. 2015).

Objectives and expected output of the research

The principal objective of this paper is to assess the variability in lithic technology and behavior during the first manifestations of the Aurignacian. The empirical basis is founded on lithic assemblages from the site of Fumane Cave (Veneto, Italy), which contains evidence of several human occupations during the time span of the European Aurignacian (Broglio et al. 2003; Higham et al. 2009).

Although the available synthesis of the Aurignacian diachronic development (e.g., Bon et al. 2010) is widely accepted and used in a pan-European perspective, some authors question the clear-cut definitions of its earliest manifestations (Proto- and Early Aurignacian) and, more generally, the validity of the "Aquitaine Model" (e.g., Bordes 2006) outside of southwestern France (e.g., Davies 2001; Conard and Bolus 2006; Sitlivy et al. 2014a; Tafelmaier 2017; Bataille and Conard 2018; Bataille et al. 2018). In this regard, the site of Fumane Cave provides a rare opportunity to test the applicability of this model, and the validity of the claims against it, starting from a high-resolution and reliable stratigraphic sequence that contains rich and well-preserved lithic assemblages and organic artifacts. As pointed out by Conard and Bolus (2015): “The fieldwork at Fumane is one of the flagship excavations in the European Paleolithic.”

Previous studies on the lithic assemblages (Bertola 2001; De Stefani 2003; Broglio et al. 2005; De Stefani et al. 2012; Bertola et al. 2013) have the merits of having described the variability of bladelet productions in the PA, even if additional quantitative research was needed to discuss in detail the procedures and the objectives of the stone knapping, but also the diachronic development of the Aurignacian throughout the stratigraphic sequence. The goals and expected output of this paper can be summarized as follows:

1) To give a more comprehensive definition of the PA;
2) To address the techno-typological variability of the PA across its geographic extent;
3) To study the development of the Aurignacian at Fumane Cave and more generally in northern Italy;
4) To investigate the relationships that exist between the PA and its apparent sister group, the EA, and thus test the applicability of the Aquitaine reference model over the extension of the European subcontinent.

Materials

The empirical basis of this research is mainly provided by lithic assemblages of five cultural units from the site of Fumane Cave, northeastern Italy. The study on the variability of retouched bladelets across the geographic extent of the PA was complemented by retouched bladelet datasets from two French sites: Isturitz in the Basque Country (Normand 2002) and Les Cottés in the Vienne region (Roussel and Soressi 2013). General descriptions of these latter assemblages, as well as stratigraphic context and dating, can be found in Falcucci et al. (2018). Concerning Fumane Cave, two different sampling strategies have been used to tackle the research questions previously formulated.

The sample used in the study of the earliest cultural units A2–A1

The purpose of the first research project was to address critically the techno-typological traits of the PA, since its internal variability is frequently neglected in the scientific literature. The empirical base was given by the lithic assemblages recovered in units A2 and A1 at Fumane Cave. Early in the study it became clear that these units did not show significant differences on typological and technological grounds. Thus, given the purpose of the work and the fact that they appear to be chronologically indistinguishable (Higham et al. 2009), I decided to consider them as a single analytical unit.

In order to conduct an extensive technological analysis, all lithic artifacts larger than 1.5 cm in maximal dimension were counted (A2=22,212; A1=4,153 items) and divided according to several technological classes and the sub-square of provenience. The minimal number of flaked products (MNFP), which was calculated by taking into account only blanks with preserved butts, permitted a better estimation of the amount of lithics. This step was judged necessary because no previous quantitative analysis of the lithic assemblage had been undertaken. The data gained during this first phase was used to evaluate the frequency of technological categories and the amount of cortex on artifacts. The sampling procedure was based on the dispersion of lithic materials in the squares and an evaluation of the stratigraphic context, as described in the excavation notebooks. Only the innermost part of the cave, affected by a stratigraphic deformation (see above), was excluded from the analysis. Seven square meters were selected. They are located in different sectors of the cave and are close to the main combustion features. Two adjacent square meters were analyzed in those sectors with the highest concentration of lithics.

A2–A1 is an assemblage dominated by blades and bladelets. For this reason, all blades and bladelets larger than 1.5 cm in maximal dimension, regardless of the degree of fragmentation, were analyzed, while only flakes with preserved butts larger than 2.0 cm in maximal dimension were fully analyzed. Furthermore, the extent of the cave was sampled in order to isolate and include in the database all cores, tools and tool fragments, all complete and almost complete blades and bladelets, and all by-products deemed to have had a significant role in the reduction process. This strategy was considered effective to avoid potential biases in the reconstruction of the knapping system. Therefore, I analyzed a total of 7,866 artifacts.

The sample used to investigate the diachronic variability of the stratigraphic sequence

In this case, the studied sample has been restricted to all materials recovered in the front part of the cave, where the stratigraphy is fine grained and the D3 complex is divided into several units. The cave mouth was excluded given that correlations between the D3 units and the layers described in this area are still under revision. The Aurignacian deposits in the external part of the cave have been excavated since the beginning of fieldwork at the site. Most of the studied materials were recovered from 1988 to 2006 under the supervision of A. Broglio and M. Peresani. I consider five cultural units in this study: A2, A1, D3base, D3b*alpha*, and D3ab. The number of lithic artifacts recovered in the lowermost layers is much higher than that available for the upper layers (Table 1). During the formation of A2 and A1 the occupation of the site was more intense, while the D complex accumulated during a period in which the cave started to collapse, which resulted in a faster formation of the deposit. However, cores, blanks, tools, and by-products of the reduction sequences are available for all units, which allow for an accurate technological comparison. Given that the aim of this study was a diachronic comparison between the different assemblages, units A2 and A1 have been considered here as two different analytical units.

For A2 and A1, the sampling procedure and the recording of data were based on our previous study, but all artifacts belonging to the back of the cave were excluded. Several square meters were selected, most of them located in the vicinity of the combustion features identified during the excavations. Given the smaller sample sizes available for the uppermost units (D3base, D3b*alpha*, and D3ab), the whole extension of the cave entrance was sampled and all recovered artifacts larger than 1.5 cm in maximal dimension were fully analyzed.

	Blank	Tool	Core	Angular debris	Tested nodules	Total
D3ab	382 (73.0%)	70 (13.4%)	17 (3.3%)	54 (10.3%)	-	523
D3b*alpha*	561 (78.2%)	106 (14.8%)	12 (1.7%)	38 (5.3%)	-	717
D3base	830 (79.5%)	144 (13.8%)	5 (0.5%)	65 (6.2%)	-	1044
A1	3235 (78.2%)	648 (15.7%)	34 (0.8%)	219 (5.3%)	1 (-)	4137
A2	8055 (77.2%)	1458 (14.0%)	34 (0.3%)	883 (8.5%)	4 (-)	10434
Total	13063	2426	102	1259	5	16855

Table 1: Fumane Cave. Overview of the studied assemblages used for the second research topic divided according to the main lithic classes. Percentages are given in brackets.

Tabelle 1: *Fumane-Höhle. Übersicht über die untersuchten Inventare, die für die zweite Forschungsfrage verwendet wurden, untergliedert nach den hauptsächlichen Steinartefaktkategorien. Prozentanteile sind in Klammern angegeben.*

Furthermore, a reassessment of the organic tools, painted rocks, and ornamental objects was conducted. This was possible by using the published literature and the datasets compiled by other researchers and made available by the director of the excavations (Marco Peresani). By doing so, it was possible to quantify the number of artifacts within each of the studied units, locate them in the square and sub-square of provenience, and finally evaluate the stratigraphic reliability of the findings with the support of the observations recorded in the excavation notebooks.

Methods

The holistic approach to lithic analyses used in this research project aimed to integrate methods belonging to different research traditions, mainly the French and the North American, often considered as two opposed methodological approaches. Instead, when combined, they become a powerful tool in characterizing the technological system of a given lithic assemblage (e.g., Zwyns 2012a; Conard and Will 2015). These methods are described in detail in the published articles, while a brief summary is presented in the following paragraphs.

The reduction sequence approach (Boëda et al. 1990; Inizan et al. 1995; Conard and Adler 1997; Shott 2003; Soressi and Geneste 2011) identifies the methods of core reduction and the stages of knapping, use, and discard of stone artifacts. The attribute analysis (Andrefsky 1998; Odell 2004; Tostevin 2013) instead provides quantitative data on the numerous discrete and metric features that can be recorded on individual artifacts. The attributes recorded in the database are based on recent studies that have been shown to be valuable for understanding laminar technologies at the onset of the Upper Paleolithic (e.g., Nigst 2012; Zwyns 2012a). Non-extensive refitting analyses (Inizan et al. 1995) were also conducted throughout the study (Fig. 2). They have proven to be particularly valuable to test hypotheses formulated during the analytical process.

Diacritic analyses (Dauvois 1976; Boëda 1994; Roussel 2011; Pastoors et al. 2015) were performed to reconstruct the chronology, the direction of removals, the stages of production on exhausted and initial cores, and short sequences of removals on blanks. By doing this, the detailed biography of artifacts was carefully reconstructed to identify the main reduction processes used by knappers. Details on this method and information about the graphic criteria used to produce schematic drawings of cores and blanks can be found in Falcucci and Peresani (2018).

Fig. 2: Fumane Cave. Examples of refitted artifacts from unit A2. Refitted semi-circumferential blade core (a), small blade refitted to a core tablet (b), and narrow-sided bladelet core with refitted core tablet and plunging technical flake (c). Photo: A. Falcucci.

Abb. 2: *Fumane-Höhle. Beispiele für zusammengesetzte Artefakte aus Einheit A2. Zusammengesetzter halbumlaufender Klingenkern (a), kleine Klinge, die auf eine Kernscheibe gepasst wurde (b) und am Schmalende abgebauter Lamellenkern mit aufgesetzter Kernscheibe und Abbauflächen-Präparationsabschlag (c). Foto: A. Falcucci.*

I use the unified taxonomy by Conard et al. (2004) in order to give a general overview of core categories. Platform cores have been further divided into several reduction strategies according to criteria such as: orientation of the flaking surface, knapping progression, and number of platforms and faces exploited. Carinated cores have been sorted in three sub-categories: core-like, endscrapers, and burin forms.

The typological classification of retouched tools is based on the most frequently used European Upper Paleolithic typologies (de Sonneville-Bordes 1960; Demars and Laurent 1992) that were, however, revised and simplified. This typological approach is particularly valuable in the case of Aurignacian assemblages because it provides comparable data across sites when accurate technological studies are lacking.

In order to assess the curvature of blanks, dorsal scars, and shape, I took into account only complete and almost complete specimens. This is beneficial in that it avoids biases due to the high degree of fragmentation of the assemblage. I quantified profile curvature using the categories defined by Bon (2002a). I excluded retouched tools from the analysis of morphology and distal ends due to the modification of the shape via retouching. The maximum dimensions of each artifact were recorded using a digital caliper. The metric boundary between blades and bladelets was placed at 12.0 mm (Tixier 1963), in agreement with most of the studies conducted on Aurignacian assemblages (Le Brun-Ricalens 2005a) and according to our case study.

The intra- and inter-assemblage differences were statistically tested in IBM SPSS Statistics 24 by using both discreet and metric attributes. Pearson's chi–squared tests were performed to assess the significance of discreet variables while metric differences were assessed by using non-parametric tests (Mann-Whitney and Kruskall-Wallis), given that our samples were not normally distributed according to Shapiro-Wilk and Kolmogorov-Smirnov tests. Finally, I used the Holm-Bonferroni sequential correction test to reduce the probability of performing a type 1 error (Holm 1979).

Results and discussion

The Protoaurignacian lithic technology at Fumane Cave

The aim of this research project was to reassess the lithic technology of units A2–A1 from Fumane Cave and critically discuss the definition of the PA summarized in Bon et al. (2010). Results presented in this section are discussed in detail in Falcucci et al. (2017), Falcucci and Peresani (2018), and Caricola et al. (2018).

The most relevant features of the PA at Fumane Cave are systematic and variable bladelet production and dominance of retouched bladelets among tools (ca. 78%). The quantitative analysis of the knapped assemblage shows that most of the artifacts discarded at the site belong indeed to bladelets and by-products of lamellar reduction strategies. The presence and degree of cortical surfaces among blanks suggest that raw material decortication and core initialization resulted mostly in the production of flakes and blades of variable sizes. Instead, bladelets display cortical surfaces only rarely.

The investigation of core technology allowed the identification of three main core reduction methods: platform, multidirectional, and parallel. Multidirectional and parallel methods played a secondary role and were used to produce flakes of varied morphologies. Multidirectional cores seem to be rather opportunistic and display removals from several faces without well-developed striking platforms. Parallel cores are instead characterized by a removal surface with centripetal negatives that originated from the intersection with the underside. However, this reduction method might be the outcome of marginal post-depositional processes, given the strong resemblance to the centripetal flake cores recovered in the Uluzzian units A4–A3 (Peresani et al. 2016). Knappers employed platform methods to exclusively obtain blades and bladelets. Platform cores have been divided according to five reduction strategies and the main production objectives (Table 2). Blade and bladelet cores represent a relatively homogeneous group. All the identified types share a certain degree of technological overlap, a consequence of a volumetric and unidirectional approach to the knapping. The detailed reduction procedures of each strategy have been described in Falcucci and Peresani (2018). Here, results are combined with the blank analysis to give an overall summary of the technological system.

Core Classification	Blade	Bladelet	Blade–Bladelet	Blade–Flake	Undet.	Total
Narrow-sided	-	23	-	-	-	23 (26%)
Semi-circumferential	4	15	1	-	-	20 (22%)
Wide-faced flat	2	9	1	-	1	13 (15%)
Carinated	-	10	-	-	-	10 (11%)
Multi-platform	-	19	3	1	-	23 (26%)
Total	6 (7%)	76 (85%)	5 (6%)	1 (1%)	1 (1%)	89 (100%)

Table 2: Fumane-Cave. Distribution of platform cores in A2–A1 according to the identified reduction strategy and the objective of the blank production.

Tabelle 2: *Fumane-Höhle. Verteilung der Plattformkerne in den Einheiten A2–A1 im Hinblick auf die erkennbare Abbaustrategie und das Zielprodukt der Grundformgewinnung.*

Note that multi-platform blade-bladelet cores have produced bladelets in independent phases (n=2) or simultaneously with blades, followed by an independent reduction phase (n=1). Initial platform cores (n=26) are not listed. Rounded percentages are given in brackets.

Bladelet production is characterized by a relatively broad range of core reduction strategies. Intact nodules and fragments were brought to the site where the future cores were prepared using simple shaping processes. The orientation of the flaking surface in relation to a flat striking platform depended on the initial volume of the blank and on the intended production goal. A laminar blank, usually cortical, took advantage of a natural steep angle. Non-invasive crests were applied only when the morphology of the blank did not permit the direct extraction of laminar products. According to the volume of the selected raw material nodule, bladelet core initialization could sometimes result in a first series of blade removals. In some cases, the most robust blanks produced in this initial reduction stage were selected to manufacture tools as endscrapers, burins, and laterally retouched blades and flakes.

The optimal production phase took place on cores that were almost completely deprived of cortex and targeted bladelets of variable sizes. Blanks were extracted with direct marginal percussion after an accurate abrasion of the platform edge. According to the wear-traces identified on the macro-tool category (Caricola et al. 2018) and the relatively high frequency of bulbar scars associated with fine ripples in the first millimeters of the ventral face of blanks (Falcucci et al. 2017), it can be said that soft stone cobbles were likely to be used as hammers during the optimal production and maintenance phases. The frequent application of convergent and secondly sub-parallel reduction patterns resulted in the production of bladelets with pointed outlines, as well as bladelets with sub-parallel edges. In the case of convergent patterns, the use of an original procedure permitted narrow and convergent surfaces to be isolated independently from the location of the flaking surface during discontinuous reduction phases (Fig. 3). Each phase allowed the production of a short series of regular bladelets with pointed distal ends following an alternated convergent knapping progression (Falcucci and Peresani 2018). A common operation to isolate the flaking surface consisted of the removal of lateral comma-like blanks at the intersection of core faces and along the longitudinal axis of the core. Lateral comma-like blanks had usually the size of small blades, well recognizable because of the presence of multiple lamellar negatives on their dorsal side. The protracted alternation of primary blanks and by-products required the exploitation of most of the available surfaces by means of a semi-circumferential core progression.

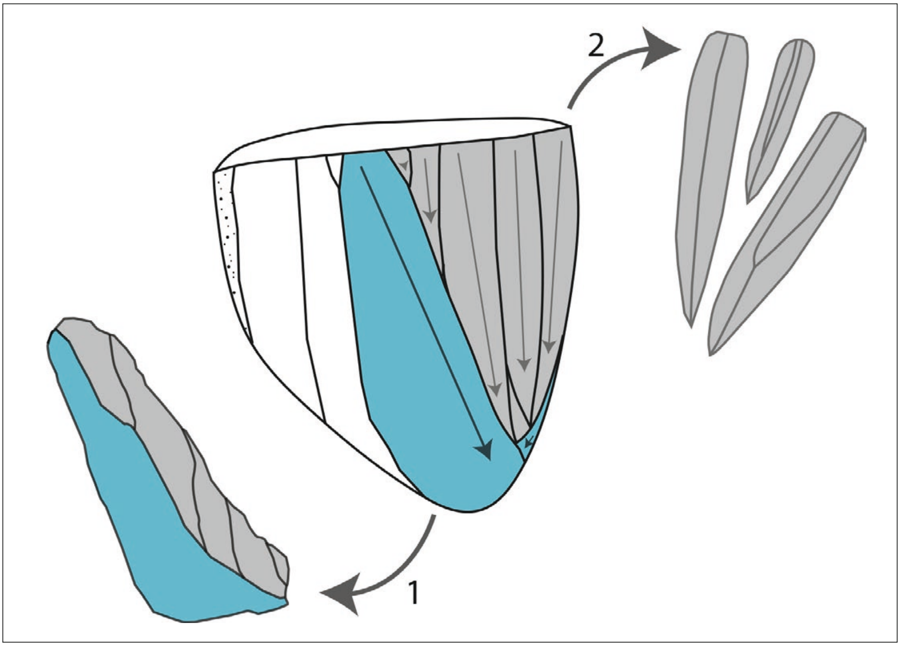

Fig. 3: Schematic drawing of an alternated knapping progression conducted on a semi-circumferential bladelet core. A lateral blade is detached at the intersection of core faces (1) to isolate a narrow and convergent surface where a set of pointed bladelets (2) is removed. Drawing: A. Falcucci.

Abb. 3: *Schematische Darstellung einer alternierenden Abbaufolge an einem halbumlaufenden Lamellenkern. Seitlich ist eine Klinge am Übergang der Abbauflächen des Kerns abgetrennt (1), um eine schmale und konvergierende Abbauläche freizustellen, von der eine Reihe spitzer Lamellen abgehoben wird (2). Zeichnung: A. Falcucci.*

Narrow-sided cores were of major importance and exclusively used to produce bladelets, usually slender and rather straight in profile view. The production usually began with crested bladelets, well-represented in our studied assemblage, detached at the junction of the ventral face of the core blank. The extraction of regular bladelets was then achieved by lateral removals that converged towards the center of the flaking surface. Core recycling was also a frequent strategy used to increase production efficiency. Multi-platform cores and technical blanks related to different operations of re-orientation are in fact numerous. In some cases, bladelet production took advantage of discarded blade cores.

As shown, the flaking surface of bladelet cores was oriented, in most cases, according to the longitudinal axis of the blank, which represents one of the main technological features of the PA. Carinated technology is thus generally less represented if compared to EA industries (Bon 2002a). The technological organization of PA carinated cores from Fumane Cave, however, does not differ from the EA (as described in Le Brun-Ricalens 2005c). Furthermore, it shares several features with the semi-circumferential reduction strategy such as the use of lateral removals to isolate the flaking surface and the discontinuous knapping pattern.

Blades represented the second goal of the PA lithic production system, and their frequency is always lower than that of bladelets. Blades were obtained from independent and, to a lesser extent, simultaneous reduction sequences. The flaked surface of blade cores was framed by at least one perpendicular flank, a feature that permitted the extraction of naturally backed blades and the use of neo-crests to shape the core convexities. Blades were extracted with direct marginal percussion and the striking platform usually remained flat. Faceted platforms are, however, rare. The operational concept used to produce blades was based on the exploitation of a broad area during a linear and consecutive knapping progression that followed a sub-parallel reduction pattern (Falcucci and Peresani 2018). Blades have variable morphometric attributes, but among retouched tools a selection of the bigger blanks, independent of their regularity and the presence of cortical remains, is verified.

Flake production has been observed less often among PA industries and has generally received less attention. At Fumane Cave, this production appears to be marginal and carried out in most cases on informal cores (see above). Most of the flakes recovered were the outcomes of initialization and maintenance operations of blade and bladelet cores. For this reason, flake-tools were mostly made from by-products of the laminar reduction sequences.

Overall, this reassessment shows that the PA is a bladelet-dominated industry. Bladelet production dictates the general organization of stone knapping and is based on a broad range of independent reduction strategies, among which the preference towards the exploitation of the core's longitudinal axis stands out. The role of the so-called single and continuous reduction sequence (Bon et al. 2010; Teyssandier et al. 2010) has been, however, over-emphasized, given that bladelet production is in most cases not related to the reduction of larger blade cores. Blade and bladelet productions are, however, not strictly separated due to the presence of simultaneous reduction sequences, the recycling of some blade cores into bladelet cores, the selection of by-products of the bladelet production as blanks to manufacture common tools, as well as the production of a short sequence of blades on some initial bladelet cores prior to the optimal production phase.

The variability of the Protoaurignacian across its geographic extent

In order to investigate the variability of the PA across its geographic extent, I conducted an extensive inter-site comparison using the available and pertinent literature (Falcucci et al. 2017). The sites that have been carefully compared are Castelcivita (Gambassini 1997), La Fabbrica (Dini et al. 2012), Bombrini (Bietti and Negrino 2008; Bertola et al. 2013), Mochi (Kuhn and Stiner 1998; Grimaldi et al. 2014), Observatoire (Porraz et al. 2010), Esquicho-Grapaou (Sicard 1994; Bazile 2005), Louza (Sicard 1995; Bazile 2005), Mandrin (Slimak et al. 2002, 2006), Arbreda (Ortega Cobos et al. 2005; Tafelmaier 2017; Bataille et al. 2018), Morín (Maíllo Fernández 2003, 2005, 2006), El Castillo (Maíllo Fernández and Bernaldo de Quirós 2010), La Viña (Santamaría Álvarez 2012), Labeko Koba (Arrizabalaga and Altuna 2000; Tafelmaier 2017; Bataille et al. 2018), Isturitz (Normand 2002; Normand and Turq 2005; Normand et al. 2007, 2008), Piage (Bordes 2002, 2006), Les Cottés (Roussel and Soressi 2013), Arcy (Bon and Bodu 2002; Paris 2005), Tincova (Sitlivy et al. 2014a, b), Romaneşti (Sitlivy et al. 2012), Kozarnika (Tsanova 2008), and Siuren I (Demidenko et al. 2012; Zwyns 2012b; Bataille 2013, 2016; Bataille et al. 2018). Additionally, retouched bladelets from two sites, Isturitz and Les Cottés, were analyzed and compared to Fumane Cave with the aim of addressing typological variability in the PA (Falcucci et al. 2018).

The systematic review of lithic assemblages suggests that the PA is technologically consistent across its geographic extent. First of all, it can be emphasized that independent and variable bladelet reduction strategies are the rule, rather than the exception. Although it is not categorically excluded that, in favorable cases, a blade reduction sequence was followed by a bladelet production without going through a substantial reorganization of the core structure, the systematic use of this concept would have not responded to the need of immediate production and consumption of bladelet implements that is the defining features of the PA. Similar conclusions were reached by Tafelmaier (2017) in the course of a reassessment of the lithic technology of Labeko Koba – layer VII, and Bataille (2013) during the analysis of the PA assemblage from Siuren I – units G and H. A detailed critique and revision to the main arguments used by some authors to identify the continuous reduction sequence in PA lithic assemblages can be found in Falcucci et al. (2017).

One of the main features of the PA is the selection of the longitudinal axis of the core to obtain regular and slender bladelets. In many cases, the production was based on the exploitation of narrow flaking surfaces following a convergent reduction pattern to better control the width of the end products. The dichotomy between blade or blade-bladelet productions based on broad surfaces and bladelet productions based on narrow surfaces has been well described at Observatoire (Porraz et al. 2010). The technological strategies used to exploit narrow flaking surfaces in the framework of bladelet production is evident at several PA sites. At Louza, most of the operations conducted on bladelet cores aim to isolate narrow surfaces (Sicard 1995), while at Esquicho-Grapaou the production is sometimes based on a knapping progression that alternates removals at the center of the flaking surface with maintenance products that invade the core flanks (Sicard

1994). At Mandrin, narrow and convergent flaking surfaces are instead isolated by sets of transverse removals detached from an adjacent core face (Slimak et al. 2006). The use of highly diagnostic lateral maintenance products, such as lateral comma-like blanks, has been identified in many PA assemblages (Sicard 1994; Bon and Bodu 2002; Normand and Turq 2005; Tsanova 2008; Bataille 2016; Tafelmaier 2017) and seems to be related to semi-circumferential cores with convex flaking surfaces that are progressively invaded by the progression of knapping. Narrow-sided cores are also numerous. At Arbreda, they have served to produce small blades (Ortega Cobos et al. 2005), while in other sites they are always described as bladelet cores. The initialization and maintenance operations carried out on narrow-sided cores at Observatoire (Porraz et al. 2010) and Arcy (Paris 2005) are comparable to Fumane. Multi-platform cores are frequent at Mochi (40% of cores; Kuhn and Stiner 1998) and are reported at Arcy (Paris 2005), Isturitz (Normand et al. 2008), Arbreda (Ortega Cobos et al. 2005), and Siuren I (Bataille 2016). Carinated cores are represented in most of the PA assemblages. They are rare in Liguria and in southeast France (Bazile 2005; Porraz et al. 2010; Douka et al. 2012; Bertola et al. 2013), are the dominant bladelet production strategy at Arbreda (Ortega Cobos et al. 2005), and are well-represented in northern Spain (Maíllo Fernández 2005; Santamaría Álvarez 2012), the Pyrenean region (Normand et al. 2008; Barshay-Szmidt et al. 2013; Tafelmaier 2017), and eastern Europe (Sitlivy et al. 2012, 2014a; Bataille 2013).

The emphasized variety of lamellar reduction strategies may be a result of the need to manufacture different end-products. Bladelets were used for multiple activities, and some studies have proposed a correlation between size and function (Normand et al. 2008; Porraz et al. 2010; Rios Garaizar 2012), although methodological prudence is required (Anderson et al. 2015). By comparison to the EA, PA bladelets are said to be large and straight (Teyssandier 2007; Le Brun-Ricalens et al. 2009). In the literature and at Fumane, however, large and rather straight bladelets are described along with small and curved bladelets.

The major differences between PA assemblages appear to be more typological in nature. Typological differences are expected and are usually the outcome of factors such as uneven sample sizes, stochastic variation, and possible differences in the function and use of the different sites. The PA seems to be characterized by a slightly higher frequency and variability of burins compared to endscrapers. Laterally retouched tools are frequent and, as expected, have in most cases the size of bladelets. The frequency of retouched bladelets, often typed Dufour bladelets (Demars and Laurent 1992), is the most important typological feature when it comes to identify a PA assemblage. The share of these tools is very high in the PA, although its frequency varies across space and time. At Fumane the richest retouched bladelet assemblage was found, while in other sites percentages can be lower. For instance, PA sites in southern Italy provide fewer retouched bladelets compared to northern Italian assemblages (Accorsi et al. 1979; Gambassini 1997; Palma di Cesnola 2004; Riel-Salvatore 2010).

With the aim of studying the variability of retouched bladelets in the PA, I analyzed the assemblages of Isturitz and Les Cottés and compared the results obtained to Fumane Cave (Falcucci et al. 2018). This direct reassessment was beneficial because a unique database was used to record specific and well distinguishable attributes that are in most cases difficult to identify when looking at published papers. They are often based on highly variable typological approaches and make frequent use of loose terminology. To overcome this problem, I decided to use a simplified and unified classification of retouched bladelets for comparing behavior in between groups distant in space. Two macro-groups were identified: bladelets with convergent retouch and bladelets with lateral retouch. Each group can be further sorted according to the retouch positions (alternate, direct, and inverse). The first group includes all of the bladelets retouched up the apex, with the clear intention to modify and rectify the main tool attribute. The second group includes the rest of the bladelets that, even if naturally convergent in their distal part, are modified only on the lateral edge(s).

Results show several differences between the analyzed bladelet assemblages, even though the selection of elongated blanks with regular edges and slightly curved or straight profiles support the existence of very similar technological concepts and production objectives. First, retouched bladelets at Fumane Cave are often pointed by retouch (59%), while bladelets with convergent retouch are less common at Isturitz (33%) and missing at Les Cottés. Second, differences were found in the incidence of alternate, inverse, and direct retouching. While at Les Cottés most of the bladelets are modified by inverse retouch, at Isturitz the alternate retouch has the same importance of inverse retouch. At Fumane, instead, alternate retouch is the most frequent, followed by direct retouch. Third, an evident link was found between retouch position and the retouching of the distal tip. At Fumane, bladelets with convergent retouch were mostly modified by direct retouch, while at Isturitz the same target was obtained by applying, in most cases, alternate retouch. Our results were compared with the available literature on retouched bladelets. Overall, the main differences can be found in the presence, proportion, and relative retouch position of bladelets with convergent retouch. Bladelets with convergent retouch did not play a significant role in the toolkit of PA foragers settled in northern France. It also seems that the proportion of this tool type decreases in frequency moving from Fumane Cave to the west, as also noticed by Bon et al. (2010). However, we concluded that it is not possible yet to be confident in the limited role, or even absence, of bladelets with convergent retouch in western PA assemblages, because of the approach employed in the study of retouched tools and the inclusion of most of the retouched bladelets in the Dufour family without further characterization.

This assessment proves that the PA fits well within the broad taxonomic group of the Aurignacian. Despite the obvious, and expected, technological overlaps with its sister group, the EA, assemblages assigned to the PA in southern and western Europe can be further divided according to a number of techno-typological features that are undeniable. On typological grounds, the high frequency of retouched bladelets is the most relevant feature, as already noticed five decades ago by Laplace (1966). On technological grounds, it can be now underlined that PA technology is more variable than previously thought and bladelet production is not simply the result of dwindling core dimensions as blade production progresses. As for the terminology to be used, I suggest that it is not advisable to abolish the term PA at this stage of the research, although I agree that the use of the prefix Proto- might be awkward, and its original definition has a problematic research history (Conard and Bolus 2015). Research has, however, advanced, and the accurate analyses conducted at numerous sites have better described the signature of assemblages assigned to the PA. That being said, archaeologists should not passively embrace the use of the term to underestimate the geographic and chronological (see below) variability that characterizes the earliest manifestations of the Aurignacian in this part of the European subcontinent. The present study has the merit of having built additional and high-resolution information for a more dynamic understanding of the Aurignacian, and Fumane Cave should be used as a major site for a more accurate definition of the PA itself and the identification of inter-regional variability. In this perspective, the use of new cultural taxonomic terms borrowed from single case studies, such as Fumanian or Mochian (as suggested in Conard and Bolus 2006), would only result in an over-fragmentation of cultural entities without solving the unanswered questions raised by the scientific community. We can instead discuss variability *within* the PA and talk about particular local features *across* different regions and environmental settings.

The chrono-cultural narrative of the Aurignacian at Fumane Cave

In this section, the comparison of five cultural units (A2, A1, D3base, D3b*alpha*, D3ab) from Fumane Cave is presented and discussed. Lithic assemblage variability and organic artifacts will be investigated to detect evidence of cultural modifications throughout the stratigraphic sequence. Detailed information on this assessment can be found in Falcucci et al. in revision.

The studied sequence shows few diachronic changes and no major discontinuities in lithic technology. All assemblages are characterized by variable and systematic bladelet production and the dominance of retouched bladelets among tools. Blade blanks and cores are less common, while evidence of simultaneous blade-bladelet production is more evident in A2–A1 and D3ab. Bladelets were the first goal of lithic production, and the reduction strategies identified in the oldest cultural units were never abandoned. Cores with bladelet scars are the most common type of core, with frequencies that vary from 86% in A2 to 70% in D3ab. In A2–A1, major emphasis was placed in the selection of the longitudinal axis of the core blank to carry out semi-circumferential and narrow-sided reduction sequences. But in D3base–D3ab, carinated technology gradually increases in frequency, never then used as the sole reduction strategy. Carinated burins were only recovered in A2–D3base, while in D3b*alpha*–D3ab carinated technology was exclusively based on core-like and endscraper forms. The reduction procedures conducted on carinated cores are very similar across the studied units. Multi-platform cores were not found in D3base–D3b*alpha*, while they are common in the D3ab. The strong similarities in the different bladelet productions are also clear when studying the morphometric attributes of lamellar blanks. Bladelets with convergent outlines of varied sizes represented the main production objective. Twisted blanks, which are often said to be obtained from the sides of carinated cores (Le Brun-Ricalens 2005c), are instead represented in low frequencies throughout the sequence.

No significant changes were found in the organization of blade production. Blades were obtained from unidirectional semi-circumferential and wide-faced flat cores by means of linear and consecutive knapping progressions, and only exceptionally from narrow-sided cores. In most cases, striking platforms were flat, while faceted platforms are rare both among cores and blanks. Blanks with sub-parallel edges and similar metrical attributes were the objectives of production. The interdependence between blades and bladelets that characterizes A2–A1 (Falcucci et al. 2017) is still represented in the youngest assemblages. Blades could either be simultaneously produced with bladelets or detached during maintenance operations conducted on bladelet cores. However, blade cores were not systematically reduced into bladelet cores.

The youngest assemblages show a major emphasis in the production of flakes. Flakes increase in frequency in the youngest units (D3base–D3ab), where flake production has in some cases a higher degree of predetermination. Parallel cores and the related by-products were not found in D3base–D3ab, while multidirectional cores are still represented. In D3b*alpha*–D3ab, flakes were also obtained from platform cores. These cores are made from nodules and thick cortical flakes and have flat striking platforms and straight flaked surfaces. Flaking direction is unidirectional and the reduction pattern sub-parallel. The last negatives are frequently hinged. Flakes with unidirectional hinged scars and plain butts are common among blanks and are likely to be the result of this reduction strategy.

The main differences between assemblages can be seen in the typological composition of tools (Fig. 4). Retouched bladelets, although always the most common tool type, gradually decrease in frequency towards the top of the sequence. They are comparable from a morphometric standpoint, although smaller tools were found in D3b*alpha*. There is little variability in the application of alternate, inverse, and direct retouching. Bladelets with convergent retouch are frequent across all the assemblages and usually are modified by direct and alternate retouch. As for common tool category, the lowermost assemblages are characterized by a higher frequency of laterally retouched blades and a major typological variability in burins. Endscrapers, and among those carinated forms,

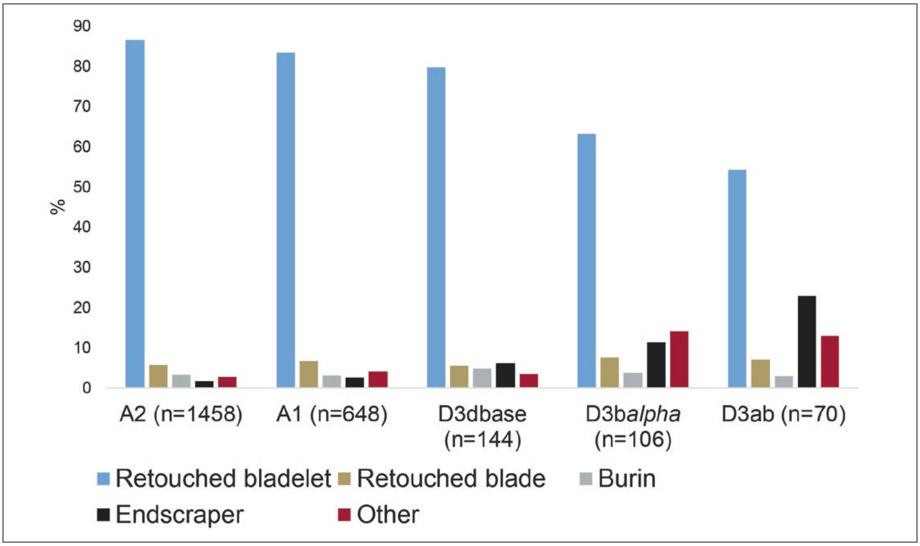

Fig. 4: Fumane Cave. Bar-charts comparing the frequencies of the main tool types identified throughout cultural units A2–D3ab. See the color legend to identify the tool types. Full color version available online: mgfuopenaccess.org.

Abb. 4: *Fumane-Höhle. Balkendiagramme zum Vergleich der Häufigkeiten der wichtigsten Werkzeugtypen in den kulturellen Einheiten A2–D3ab. Für die Kennzeichnung der Werkzeugtypen s. die Farben in der Legende. Die farbige Version ist online verfügbar: mgfuopenaccess.org.*

gradually increase in frequency starting from D3base and represent the main type of tool in D3b*alpha*–D3ab. Aurignacian retouch is rare and no Aurignacian blades were found in D3base and D3b*alpha*. Finally, in A2–A1, common tools are in most cases made on blades, while in D3base–D3ab, tools on flakes are more frequent, in agreement with the general incidence in the number of flakes in the youngest units.

In addition to the lithic artifacts at the site, all the studied units are characterized by ornamental objects manufactured on marine shell. Only one grooved deer incisor was recovered at the top of unit A1. The osseous industry is characterized by a series of common tools such as awls and perforators made from long bone diaphysis, but also by antler points. In few cases, the proximal part is still preserved, allowing for a further classification of some of them as SBPs. Two SBPs were recovered in the D3 complex, while artifacts confidently attributable to this type were not found in the oldest units, although an antler point lacking its proximal part was found at the top of A1.

This study aids us in identifying three main phases within the studied sequence of Fumane Cave: A2–A1, D3base, and D3b*alpha*–D3ab. The main differences were found in the youngest phase (Fig. 5), while the few variations that characterize D3base might be explained both as supporting evidence for a gradual modification of the PA technological system or as possible mixing between A1 and D3b*alpha*. D3base was in fact described as being in direct contact with the under- and overlying units. We might refer to phase D3b*alpha*–D3ab as the *late* PA to emphasize the continuity and the changes in the lithic technological system that occur throughout the stratigraphic sequence, but also to underline the chrono-stratigraphic position of the youngest assemblages. In this framework, the prefix Proto- loses its literal meaning and is only used to refer to assemblages with a similar set of attributes and behavioral features, regardless of their stratigraphic position. We should avoid using archaeological taxonomies in static and dogmatic ways. Taxonomic terms only have meaning in terms of questions that researchers aim to answer, and should be used as conceptual tools to describe and interpret the archaeological record (Brew 1946). The use of the term PA is the most appropriate way to describe the youngest assemblages according to the research objective pursued here, and it additionally calls into question the validity of the Aquitaine Model itself. In fact, the signature of the *late* PA provides a signal that is in contrast to the four stages model developed in the Aquitaine region. In other words, the youngest phase of Fumane Cave cannot be assigned to the EA. If the main features of D3b*alpha*–D3ab are compared to the EA as commonly described (de Sonneville-Bordes 1960; Bon 2002a; Chiotti 2005; Bordes 2006; Bon et al. 2010; Teyssandier et al. 2010), several differences can be highlighted.

In the *late* PA, blades are not more robust and platforms are almost never faceted. Laterally retouched blades only rarely display the so-called Aurignacian retouch (de Sonneville-Bordes 1960). This type of modification, which is said to be virtually absent in the PA and common in the EA (Bordes 2006), is represented in unit A2 and never increases in frequency in the upper sequence. Although the independence of bladelet production is not a viable characteristic with which to define EA (Ortega Cobos et al. 2005; Slimak et al. 2006; Normand et al. 2007; Porraz et al. 2010; Bataille 2016; Falcucci et al. 2017; Tafelmaier 2017; Bataille et al. 2018; Falcucci and Peresani 2018; Riel-Salvatore and Negrino 2018b), carinated cores are said to be the almost exclusive strategy used to obtain bladelets in the EA. Carinated technology is never the sole reduction strategy

Fig. 5: Fumane Cave. Selection of cores and tools from the youngest cultural phase D3b*alpha*–D3ab. Wide-faced flat blade core (a), semi-circumferential bladelet core (b), multi-platform bladelet core with evidence of both carinated and narrow-sided reduction strategies (c), partially refitted initial semi-circumferential blade core (d), unidirectional platform flake core (e), carinated endscraper (f), laterally-retouched blade (g), Aurignacian blade (h), endscrapers on flake (i–j), endscraper on blade (k), bladelets with lateral retouch (l–o), and bladelets with convergent retouch (p–q). D3b*alpha* = d, g, j, l, o–q; D3ab = a–c, e–f, h–i, k, m–n. Photo: A. Falcucci.

Abb. 5: *Fumane-Höhle. Auswahl an Kernen und Werkzeugen aus der jüngsten Kulturphase D3b*alpha*–D3ab. Flacher Klingenkern mit breiter Abbaufläche (a), halbumlaufender Lamellenkern (b), Lamellenkern mit mehreren Schlagflächen, der Hinweise auf Grundformgewinnung sowohl nach der Abbaustrategie an gekielten Stücken als auch Abbau an der Schmalseite des Kernes zeigt (c), teilweise zusammengesetzter halbumlaufender Klingenkern im Anfangsstadium (d), unidirektionaler Plattform-Abschlagkern (e), Kielkratzer (f), lateralretuschierte Klinge (g), Klinge mit Aurignacienretusche (h), Abschlagkratzer (i–j), Klingenkratzer (k), Lamellen mit Lateralretusche (l–o) und Lamellen mit konvergierender Retusche (p–q). D3b*alpha *= d, g, j, l, o–q; D3ab = a–c, e–f, h–i, k, m–n. Foto: A. Falcucci.*

responsible for the production of bladelets in the *late* PA, though carinated pieces are more numerous if compared to the lowermost assemblages. Bladelets in EA assemblages are seldom retouched. In contrast, retouched bladelets are the most common tool type in D3b*alpha*–D3ab. Finally, the simultaneous production of blades and bladelets has been only rarely described in the EA (Chiotti 2005; Teyssandier 2007; Tafelmaier 2017), whereas at Fumane Cave it is a common feature.

Towards a more dynamic interpretation of the Aurignacian phenomenon

Our study challenges the tendency among Paleolithic archaeologists to transfer a regional sequence, although well-defined, to geographically and in some cases chronologically distant case studies. It presents in fact a clear inconsistency between the archaeological data and the interpretative model. For instance, the PA adaptive system cannot be seen as simply a pioneering, short-term phase of modern human dispersal into Europe, as recently suggested (Anderson et al. 2015). Our results are part of the increasing evidence suggesting that the PA was an efficient technological and behavioral adaptation that lasted for several millennia under changing climatic and environmental conditions. Recent studies conducted in northwestern Italy, where long PA sequences are also well represented, are important. At Bombrini, the PA units A2 and A1 accumulated during a period of about five millennia, from ca. 40,710 to ca. 35,640 ka cal BP (Benazzi et al. 2015). The cold phase associated with the onset of H4 took place in the lower unit A2 and did not result in the alteration of its defining characteristics, proving that these foragers had the capacity to adapt to shifting conditions (Riel-Salvatore and Negrino 2018a, b). At Mochi, the recent identification of two PA occupations (Grimaldi et al. 2014) that precede the well-known PA assemblage from unit G (Laplace 1977; Kuhn and Stiner 1998; Bietti and Negrino 2008) and the long chronological span that characterizes the latter (Douka et al. 2012) point towards similar conclusions.

The persistence of the PA in Italy, and thus the contemporaneity with the EA on a supra-regional scale, was considered possible by Bon (2002a, b). However, it is now clear that technological continuity does not imply cultural isolation. This study allows us to identify an internal variability within the sequence of Fumane Cave. The gradual changes that occur attest to common chrono-cultural trends that link Fumane Cave to other southern and western European regions, where a clear cultural break between PA and EA is difficult to detect. Correspondences with the Aquitaine reference sequence is never one-to-one, and differences with the classic EA definition, as well as resilience of PA traits, are frequently emphasized. In the Pyrenean region, the recently excavated site of Isturitz contains several layers that have been attributed to PA and EA occupations (Normand and Turq 2005). The EA from units C 4b1 and C 4b2 is characterized by the presence of SBPs (Normand et al. 2007), bovine teeth, and basket-shaped beads used as personal ornaments (White and Normand 2015). In terms of the lithic assemblages, the increase in the number of endscrapers and carinated cores, and the presence of Aurignacian blades are considered supporting evidence for a shift to an EA phase. However, the researchers also emphasize there are several differences compared to the classic definition, such as the high proportion of retouched bladelets (ca. 23% in C 4b1) and the interdependence of blade and bladelet reduction systems (Normand 2002; Normand et al. 2007;

Barshay-Szmidt et al. 2018). The cultural unit C 4c4 is described as a transitional phase, suggesting a regional development of the EA (Normand 2002; Szmidt et al. 2010b). In Cantabria, the PA unit VII and EA units VI–V of Labeko Koba (Arrizabalaga and Altuna 2000) were recently re-analyzed by Tafelmaier (2017). Tafelmaier shows the strong technological affinities that exist between PA and EA technological systems in terms of bladelet production. As in the previous case, carinated reduction strategies increase in frequency in the EA, while from a typological standpoint retouched bladelets are less common (from ca. 50% to ca. 10%) and endscrapers are more common. It is also interesting to note that flakes are numerous in the EA units, similar to the late PA of Fumane. In northern France, the site of Les Cottés contains PA (US 04inf.) and EA (US 04sup.) units that are chronologically undistinguishable (Talamo et al. 2012). US 04sup. consists of techno-typological traits that are also well represented in the underlying PA (Roussel and Soressi 2013). Research conducted some decades ago in southeastern France shows that sites such as Pêcheurs (Lhomme 1976), Esquicho-Grapaou units B.R. 1 and C.C. 1 (Bazile 1974), Rainaude (Onoratini 1986), and Observatoire unit E (Onoratini et al. 1999), assigned to the EA based on the presence of SBPs and carinated cores, present several features that diverge from the classic definition. For this reason, Slimak et al. (2006) have observed that the use of two static groups such as PA and EA does not allow us to well appreciate the development of the Aurignacian in the Rhone Basin. The authors conclude that a Mediterranean variant of the EA with several PA features is very likely. The duality that seems to exists between the Atlantic and Mediterranean Aurignacian has also been emphasized by other researchers, who have called for new regional assessments to better identify the defining features of the latter variant (Le Brun-Ricalens and Bordes 2007; Anderson et al. 2018).

If we broaden our focus to cover Central Europe, the scenario becomes more complex. In the Swabian Jura, for instance, the Aurignacian seems to begin with assemblages that differ greatly from the PA identified in southern and western Europe and that are rich in carinated cores and almost completely devoid of retouched bladelets (Hahn 1977; Conard and Bolus 2006; Teyssandier 2007). The lithic industries at Geißenklösterle have been described by Teyssandier (2007) as being close to the EA of the Aquitaine Basin, but Conard and Bolus (2006) have also stressed the strong regional signal of the Aurignacian sequence. Distinct chrono-cultural phases have not been identified, but Teyssandier (2008) has suggested a possible change in the organization of the lithic system within the sequence of Geißenklösterle that may not be solely related to the functional variability of the site. Additionally, new data from the ongoing excavations at Hohle Fels suggest that the technological features of the Aurignacian of the Swabian Jura are more diverse than previously thought (Bataille and Conard 2018). The analyses of the assemblages recovered in the oldest horizons will surely better define these components and the development of the Aurignacian in the region.

It is clear that the data and examples presented above demand a new step in research on the genesis and development of the Aurignacian. Archaeologists should be less stuck in terminological and taxonomic problems and more involved in researching the reasons behind the dichotomy between heterogeneity and commonalities that are evident when one focuses on a regional framework. A pertinent example can be considered from Arbreda. In a recent paper, Wood et al. (2014) wrote that the PA unit H may contain EA implements, such as carinated endscrapers and SBPs. Although Zilhão and d'Errico

(1999) have claimed that post-depositional processes have caused this, their arguments have been denied on both stratigraphic (Soler Subils et al. 2008) and archaeological (Ortega Cobos et al. 2005; Tafelmaier 2017) grounds. Wood et al.'s study reveals that an alternative scenario needs to be defined in order to clarify the relationships that existed between the two sister groups. In this regard, we note here that we and other authors have pointed out that the PA shares a common technological background in the scope of lithic technology with the EA and that no features are restricted to one of the two variants (Sitlivy et al. 2012, 2014a; Falcucci et al. 2017; Tafelmaier 2017; Bataille et al. 2018). Although post-depositional and taphonomic processes may distort the archaeological record, mixing cannot be considered the sole explanation for interpreting this cultural variability. As previously shown, variability in the Aurignacian is the rule, rather than the exception.

A thought-provoking reconstruction proposed by Tafelmaier (2017) interprets the PA and EA as two *adaptive facies*. They are distinguishable on the basis of quantitative differences, although being rooted in the same technological repertoire, which is seen as the basal adaptation of an *early stage Aurignacian* that subsumes both variants. Differences would thus be merely functional with no cultural meaning, while specific regional adaptation mechanisms would be reflected in the inter-assemblage variability that can be seen across its geographic extent. In this scenario, PA and EA would not represent two strictly distinct technical traditions, as suggested by Teyssandier et al. (2010). My data partially agree with this interpretation and suggest that the Aurignacian be considered a complex phenomenon where PA and EA represent conceptual tools to help describe a non-linear process with multiple poles of variability (regional, chronological, functional, etc.), and no strict, mutually-excluding features. Nevertheless, if only western and southern Europe are considered, it must be also underlined that assemblages with strong PA affinities are always stratigraphically below assemblages with EA affinities. The common trends towards the decrease of retouched bladelets and the major use of carinated technology to produce bladelets are undeniable. Differences would thus not be exclusively functional, and quantitative variations seem to have a chronological meaning in some regions. They cannot be neglected, otherwise all Aurignacian assemblages would fall in the same macro-group, with little or no possibility to follow processes of temporal development and geographic variability. According to our results, as well as the previous observations on western and southern European assemblages, two main stages can be distinguished. The first coincides with the beginning of the Aurignacian in many stratigraphic sequences. This *early* PA stage has been supposed by us as being technological homogeneous (Falcucci et al. 2017), although variability on a typological ground is expected (Falcucci et al. 2018). During the second stage, gradual modifications and the consolidation of regional components can be detected. They are evident when studying the variability of personal ornaments and technological behaviors. *Late* PA assemblages in northern Italy appear to be contemporaneous with assemblages grouped in the EA. However, I have shown that assemblages that express a high degree of internal variability are frequently classified under this variant, and future research should focus on better isolating particular regional trajectories.

The isolation of general trends in lithic technology that link Fumane Cave to other Aurignacian regions demonstrates the possibility of cultural interactions between foragers. Supporting evidence for this hypothesis is the appearance of SBPs at several sites across Europe (Liolios 2006; Doyon 2017). The manufacture of a SBP requires a highly standardized procedure (Tartar and White 2013) that seems unlikely to have been reinvented in multiple regions without any technological transfer. Its presence in the *late* PA of Fumane Cave thus suggests inter-regional contacts between movable foragers that allowed technological innovations to spread over large areas. For instance, the circulation of marine shells of both Mediterranean and Atlantic origin across Europe testifies of extensive exchange networks from the beginning of the Aurignacian (Taborin 1993; Vanhaeren and d'Errico 2006).

As for the timing of its appearance, the debate is still open. It is often said that when SBPs are found within a clear stratigraphic framework, they are never associated to the lowermost cultural unit (Hahn 1977; Doyon 2017). Also, a chronological comparison of directly or indirectly dated SBPs across Europe suggests that this artifact type does not date to the earliest manifestations of the Aurignacian (Tafelmaier 2017). The ongoing excavations at Hohle Fels attest, however, to the presence of SBPs in the lowermost Aurignacian horizons (Conard and Malina 2009). More data are thus needed to answer this question. In this regard, new findings from some eastern European regions seem promising (Hopkins et al. 2016, 2018), although they still need to be accurately described.

In Europe there were no insurmountable natural barriers at the time of the Aurignacian. In the specific case of Italy, the Ligurian corridor and the exposed land that is today under the northern Adriatic Sea allowed people to move both westwards and eastwards. In this type of favorable situation, the circulation and diffusion of new ideas related to the fabrication of innovative tools is well documented in the ethnographic literature (Kroeber 1940; Murdock 1960; Mulvaney 1976; Wiessner 1983, 1984; Kelly 2013; Tostevin 2013). For instance, research shows that sub-contemporary foragers can be affected by material culture diffusing as far as 1200 km away from the source (Mulvaney 1976). In this framework, multi-lineal and reciprocal transfer of ideas are to be expected (Bataille 2013). The nature of the spread and assimilation of new technologies depends on the degree of social intimacy that occur between foragers, which is triggered by similarities in their respective material culture (Tostevin 2007, 2013). Social intimacy was likely to be very high between groups of PA and EA foragers that, as discussed in this paper, shared a common technological background. Human groups that manifest similar cultural traits are in fact open to and likely to exchange information (Eerkens and Lipo 2007). For these reasons, the presence of SBPs, if not studied in combination with other aspects of an archaeological assemblage, should not be used to infer cultural attributions. In fact, the data from Fumane Cave demonstrate that SBPs are not exclusively related to the EA-like assemblages, as frequently emphasized (Teyssandier 2007; Banks et al. 2013a; Teyssandier and Zilhão 2018). The development and assimilation of organic tools may have followed different paths compared to lithics that require further investigation.

Conclusions

This research paper pursued two principle topics, following the questions that were formalized and revised during the research process: first, a reassessment of the PA to better understand its techno-typological signature and assess its affiliation to the Aurignacian; second, a detailed diachronic study of the Aurignacian sequence at Fumane Cave in order to examine the development of the Aurignacian in northern Italy. To meet these objectives, I have conducted a detailed analysis of the lithic assemblages and have carefully re-evaluated the presence and the stratigraphic reliability of the organic artifacts (pierced shells, teeth, painted fragments, bone tools, and SBPs) recovered in five cultural units (A2, A1, D3base, D3b*alpha*, and D3ab). The outcomes of these research projects were thus combined and compared with other studies to test the veracity of the available models for the development of the Aurignacian.

The choice to focus principally on Fumane Cave is explained by the importance of the site in the context of the Middle–Upper Paleolithic transition and the studies related to the spread of modern humans into Europe. The PA assemblages of Fumane Cave have always received major attention from the research community. Furthermore, excavations have been conducted with modern techniques and have thus the merits of having provided a reliable and detailed stratigraphic sequence. These are important prerequisites for any assessment of the archaeological record that aims to be as meticulous as possible.

The investigation of the lithic technology from units A2–A1, and careful inter-site comparison across Europe, confirms that the PA is part of the broad taxonomic group of the Aurignacian. PA assemblages can be further grouped, as they have in common the need to produce and retouch regular and standardized bladelet implements. This study demonstrates that bladelet production is based on a broad range of reduction strategies that are, in most cases, not related to the reduction of larger blade cores, as previously suggested by Bon et al. (2010). The PA appears to be technologically homogeneous across its geographic extent, although regional signatures are noticeable in the typological variability of retouched bladelets and in the importance given to certain platform reduction strategies, among which the preference towards the exploitation of the core longitudinal axis stands out. The fact that lithic assemblages included in this variant (also named Aurignacian 0 and Archaic Aurignacian; see a research history in Bon 2002b) share a set of qualitative *and* quantitative features points towards the utility of retaining the term PA at this stage of research, as long as archaeologists critically address its historical definition and emphasize its geographic and chronological variability.

The second topic of research explored here aimed to define a chrono-cultural narrative of the Aurignacian at Fumane Cave and to identify possible cultural breaks in the archaeological records of the studied cultural units. Results show that the techno-typological features of units A2–A1 clearly persist throughout the stratigraphic sequence, with few gradual variations that are less marked if compared to other regional sequences. PA assemblages are thus not related to a certain time span and the occurrence of H4 does not coincide with a shift to an EA adaptive system across all of Europe. This study challenges the generalization of the Aquitaine reference sequence and supports the doubts over the eco-cultural niche modeling that builds on it (Banks et al. 2013a). Furthermore, my data strongly discourage using the so-called *fossils directeurs* to infer cultural attributions if information on these artifacts is not combined with the general organization of a given assemblage. For instance, SBPs cannot be used to identify an EA cultural unit. At best, the appearance of SBPs across a large geographic extent suggests the presence of extensive networks that allowed technological innovations to spread across hundreds of kilometers. The identification of a source region for this tool type seems unlikely given that forager territories frequently overlap and the accuracy of our dating methods still leave these issues open to debate.

The Aurignacian can be seen as a landscape of spatial and temporal variability with multiple poles and end points that are difficult to describe if terminological issues prevail over more consciously dynamic research questions. Such research questions will surely be easier to formulate and address when additional regional studies are conducted. The development of the Aurignacian seems in fact to be characterized by a high heterogeneity that cannot be reduced to a static model in which technical traditions and/or adaptive systems are divided by straightforward temporal hiatuses and/or geographic domains. PA and EA should thus be considered as conceptual tools for a preliminary sorting of a given lithic assemblage in the course of the analysis, and not as two clear-cut groups connected by a linear and abrupt change.

The research conducted here has identified an internal variability within the stratigraphic sequence of Fumane Cave that is framed in several chronological trends that are recognizable in south and west European sites. These trends in lithic technology permit us to define two main stages within the early manifestations of the Aurignacian in this part of the subcontinent. The first corresponds to the *early* PA, which appears to be rather homogeneous across its extent, as shown in the first research topic. The second refers to a period of gradual modification and consolidation of regional signatures. At Fumane, and more generally in northern Italy, this phase seems to be in strong cultural continuity with the underlying units, and can be tentatively referred to as *late* PA. The main differences in stone artifacts are the increased proportion of carinated endscrapers and the decrease of retouched bladelets.

When additional evidence in the North-Adriatic region is produced, there might be the possibility to discuss the use of Fumane Cave as a type site for regional variability and to consider the definition of a new variant of the Aurignacian phenomenon, in agreement with evidence from the northern Tyrrhenian coastal belt. In this paper, the use of the existing terminology has helped to critically address the validity of the available pan-European reconstructions. While the definition and concept of the PA have been directly verified with empirical data, the critique of the EA rests exclusively on comparison with published data. Having said that, new taxonomical systems, if retained as necessary, should be discussed by the scientific community involved in Aurignacian studies. These debates would give a necessarily more accurate description of the ever more complex scenario being generated by the increasing number of sites available for comparison and the data obtained from multi-disciplinary studies. This is not the task of one author but the goal of a cooperative research community. This issue therefore remains necessarily open for debate and development within the diverse traditions of the discipline of Paleolithic archaeology.

The present paper represents only the first step towards a more solid definition of the PA at Fumane Cave. Although this technological assessment provides an indispensable prerequisite for any work that interprets human behavior using assemblage variability, future research needs to address questions related to the use of the site through time, and to consider the mobility strategies adopted by foragers. This future research will be important for investigating the impact of functional variables in the formation of the lithic assemblages.

The research presented here is an important step towards a more dynamic understanding of the Aurignacian. The re-evaluation of pivotal sites and the definition of regional signatures are shedding new light on the beginning and development of the Upper Paleolithic in Europe. Several exciting research questions developed over the course of analysis. For instance, it became clear that a great amount of work needs to be done to better understand the Aurignacian south of the Alpine range and the Italian Peninsula. Several sites are waiting for a careful analysis of the lithic assemblages and organic artifacts. One of the main issues here concerns the variability between the northern and the southern Peninsula. Data from the south have a great potential but are still incomplete, sometimes derived from old excavations and surface collections. Further evidence is needed to test the hypothesis of an abrupt end of the PA, triggered by the Campanian Ignimbrite volcanic eruption. Furthermore, research should focus on the possible cultural interactions between the makers of the Aurignacian and Uluzzian technocomplexes, and their related bio-cultural consequences. In this framework, the chronological and archaeological differences that exist between the northern and southern records might be the outcomes of complex adaptation mechanisms, but also might indicate the transfer of ideas between human groups that were settled in adjacent regions. This is an exciting research question that might contribute to support or reject the hypothesis according to which an early wave of AMHs was responsible for the appearance of the Uluzzian in Italy and Greece.

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