Perturbation assessment in archaeological sites as part of the taphonomic study: a review of methods used to document the impact of natural processes on site formation and archaeological interpretations

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PERTURBATION ASSESSMENT IN ARCHAEOLOGICAL SITES AS PART OF THE TAPHONOMIC STUDY: A REVIEW OF METHODS USED TO DOCUMENT THE IMPACT OF NATURAL PROCESSES ON SITE FORMATION AND ARCHAEOLOGICAL INTERPRETATIONS.

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ABSTRACT

In the context of archaeological taphonomy, perturbation assessment aims at characterizing the processes that have affected a set of archaeological remains (lithic pieces, faunal remains, plant material) after their abandonment, and at analysing the consequences of these processes on archaeological interpretations. The processes range from sedimentary to bio-pedological factors and weathering. The main questions that perturbation assessment attempts to answer concern (1) the preservation of the original (anthropogenic) spatial organisation of the remains, (2) the homogeneity and integrity of the assemblage, and (3) the state of preservation of the individual remains. This paper gives an overview of the main processes involved in site formation with an emphasis on the European Palaeolithic, and the most frequent issues archaeologists have to face. Available analytical tools such as fabrics, grain size composition, and refits of lithic and bone material are detailed together with other possible criteria. Overall, we argue that perturbation assessment is a mandatory stage in the archaeological study of any site and that substantial progress in the understanding of site formation processes will arise from further experimental work in active contexts.

RÉSUMÉ

Mise en évidence des perturbations dans les sites archéologiques : revue des méthodes utilisées pour documenter l'impact des processus naturels sur la formation des sites et leur interprétation.

Dans le cadre de l'étude taphonomique des sites archéologiques, l'analyse des perturbations a pour but de déterminer les processus naturels qui ont affecté les ensembles de vestiges (pièces lithiques, faune, matériel d'origine végétale) après leur abandon et d'analyser les conséquences de ces processus sur l'interprétation archéologique. Ils englobent des facteurs sédimentaires, des facteurs bio-pédologiques et l'altération. Les principales questions auxquelles l'analyse tente de répondre concernent (1) la préservation de l'organisation spatiale originelle (anthropique) des vestiges, (2) l'homogénéité et l'intégrité des ensembles de vestiges et (3) l'état de préservation des pièces individuelles. Cet article présente une revue des facteurs impliqués dans la perturbation des sites, avec un focus sur le Paléolithique européen, et les problèmes les plus fréquemment rencontrés. Les outils analytiques disponibles, tels que les fabriques, la composition granulométrique des séries lithiques et les remontages/appariement des pièces lithiques ou osseuses sont détaillés. D'autres critères sont également évoqués. De manière générale, nous soulignons que l'analyse des perturbations est une étape nécessaire dans l'étude archéologique d'un site et que des progrès substantiels dans la compréhension des processus de formation des sites sont à attendre de nouveaux travaux expérimentaux dans des contextes naturels.

MOTS-CLÉS Taphonomie archéologique, analyse des perturbations, processus de formation des sites, Paléolithique.

1 | SITE FORMATION PROCESSES AND ARCHAEOLOGICAL TAPHONOMY: GENERAL PRINCIPLES

The idea that all archaeological sites, and particularly Palaeolithic sites, have undergone transformation by natural processes to varying degrees after their abandonment and that understanding these transformations is of paramount importance has gradually emerged since the 1980s, following a number of geoarchaeological and archaeological works (Bar Yosef and Tchernov 1972; Wood and Johnson 1978; Schiffer 1983, 1987; Bertran and Texier 1997; Texier 2000; Vallin *et al*. 2001; Bordes 2003; Villa 2004). These transformations have obliterated to a certain extent the initial characteristics of the occupation levels, both in terms of the spatial distribution of remains and the integrity and composition of lithic and bone assemblages. In the same way as anthropogenic processes, natural processes are an integral part of the formation mechanisms of a site such as discovered by archaeologists. Therefore, the type of information that the latter can hope to retrieve from the archaeological study of the remains depends largely upon the intensity of transformations, which cannot *a priori* be considered negligible but needs to be analysed in the framework of a critical analysis or "taphonomic analysis".
As defined here, the term "taphonomy", which originally meant" the study of the transition (in all its details) of animal remains from the biosphere into the lithosphere" (Efremov 1940), is used by extension for all the remains regardless of their nature (animal and plant remains but also lithics, etc.), insofar as, to a large extent, the different types of remains are affected by similar burying mechanisms (cf. Whitlam 1982; Hiscock 1985). This analysis attempts to characterize the processes that have affected a set of archaeological remains after their abandonment by past populations and to unravel the consequences of these processes. Since animal and plant remains may have been accumulated by factors other than those involved for lithic material and may have been accidentally mixed with the latter, the analysis also seeks to identify the processes at the origin of the accumulation of remains. Such a use of the term taphonomy is not shared by the community as a whole, as some zooarchaeologists prefer to restrict the term to its original definition (see in particular the debate between Lyman (2010) and Dominguez-Rodrigo *et al.* (2011)). The expression "archaeological taphonomy" proposed by Whitlam (1982) is therefore used here to distinguish this approach from the original discipline. In a broad meaning, it also includes the impact of sampling, treatment and storage during and after excavation.
According to the conception described above, archaeological taphonomy specifically concerns the study of the accumulation and degradation processes of archaeological remains and aims at elucidating the factors involved in their distribution within a site. It helps to isolate groups of remains for which the chrono-cultural consistency has been determined as homogeneous and adapted to the archaeological questions raised. The taphonomic approach does not include all the geological and, more broadly, palaeoenvironmental studies that are usually carried out on archaeological sites, although these constitute an obligatory stage in the analysis of site formation processes and therefore contribute greatly to the understanding of the degradation of archaeological assemblages.

This type of study in archaeological context has given rise to an abundant literature, particularly in journals devoted to the Quaternary, which will only be mentioned marginally here.
This contribution proposes a review of one key component of archaeological taphonomy, here coined "perturbation assessment". It does not encompass the entire scope of archaeological taphonomy but rather focuses on the natural processes frequently involved in the perturbation of Palaeolithic assemblages.
Two main types of perturbations can be distinguished from a geo-archaeological perspective: (1) sedimentary processes, which affect the material at the ground surface or in subsurface, and (2) diagenetic processes, including alteration and soil movements caused by bio-pedological processes, which occur after the burial of the remains. In all cases, physical and chemical transformations may be influenced by biological factors, either because fauna drives the movement of sediment and archaeological remains (typically, bone displacements are largely caused by the activity of carnivores), or because they partly control the dissolution and precipitation of minerals. Although being integral part of archaeological taphonomy, the study of artefact alteration, which raised a large amount of literature, will not be addressed in this paper and we will focus on the perturbations at the assemblage scale.
In the following, we first briefly describe the sedimentary (depositional) and bio-pedological (post-depositional) processes and their consequences, before summarising the analytical tools used to reconstruct them, and providing key examples of their impact on archaeological interpretations.

2 | SEDIMENTARY PROCESSES

The nature and intensity of sedimentary transformations vary greatly, depending on both the type of environmental context and the burial velocity, which gradually removes the archaeological material from the action of superficial geomorphological processes. These transformations can range from simple local readjustments to complete erosion and redistribution of the remains. In most cases, the sites are in an intermediate state of degradation between these two poles (**fig. 1**). As a general rule, two main categories of sedimentary contexts, whose implications on the formation of archaeological levels are fundamentally different, can be distinguished: (1) contexts of pure accumulation, (2) contexts of accumulation - transit of sediments.

2.1 | Pure accumulation sedimentary contexts

Pure accumulation contexts correspond to environments where the successive inputs of sediment are superimposed without reworking the previous deposits, and where sediment accretion occurs without significant truncation. This type of situation, rather uncommon for Palaeolithic sites, mainly concerns low-energy river floodplains, estuary and muddy delta environments, lakes and loess accumulation on flat surfaces. Each archaeological level materialises a palaeosurface buried by sediments and the "chronological resolution" of a level is a function of the relative frequency of occupations and sediment inputs. The frequentation by successive human groups of the same place subjected to little or no sediment accretion leads to the formation of a "palimpsest", a term proposed by archaeologists to designate a level formed by the overlapping of several diachronic occupations (e.g. Dibble *et al*. 1997; Crombé *et al*. 2013). In geology, the corresponding term is "condensed record (or level)". In contexts of pure sedimentary accumulation, the initial pattern, as it can be grasped from artefact and ecofact (e.g., bones) maps, and the integrity of archaeological levels are often well preserved despite the efficiency of some bio-pedological processes (see §3).

2.2 | Accumulation-transit sedimentary contexts

The contexts of accumulation-transit are marked by the redistribution of part of the sediments already deposited, which contribute to sedimentation to varying degrees. These contexts are characterized by reworking processes, with the possibility of truncation of the archaeological record. During each sedimentation event, transient accumulation zones are formed (temporary sediment storage); these deposits are then partially reworked during subsequent events and the progressive accretion of the deposits reflects the overall accumulation/erosion balance. This is the general case on slopes, in aeolian environments where deflation plays an important role (e.g. stone pavements and dune sand in arid or coastal areas), and in alluvial contexts of medium to high energy. In accumulation-transit contexts, archaeological remains, like detrital material, also undergo redistribution and their final organisation results both from the initial pattern of anthropogenic origin and from sedimentary dynamics. The redistribution intensity varies according to the processes involved and the exposure time to these processes.

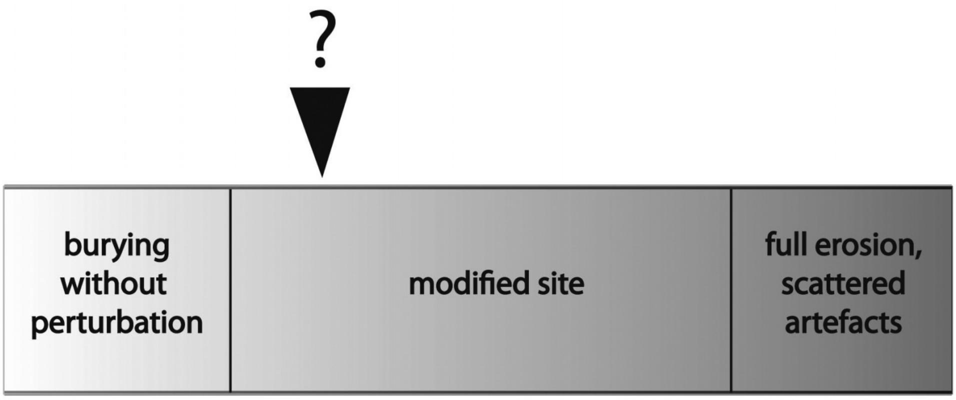


FIGURE 1

One of the main objectives of the taphonomic approach is to determine the degree to which a site has been modified by natural processes after its abandonment by humans.

L'un des principaux objectifs de l'approche taphonomique est de déterminer l'intensité des perturbations provoquées par les processus naturels après l'abandon du site.

Redistribution may be very rapid, for example in connection with fluvial flow (Schick 1986; Hosfield and Chambers 2005) and mass movements (landslides, debris flows), or may result from the repeated addition of small elementary movements or slow soil deformation (creep). On periglacial slopes ≥ 3°, solifluction caused by freeze-thaw cycles can bury occupation levels and efficiently redistribute the remains although movements are slow, most often between 1 and 10 cm.yr-1 (Bowers *et al.* 1983; Texier *et al.* 1998; Hilton 2003; Bertran *et al.* 2015). Overall, the pattern of redistribution is typified by a downstream (downslope) translation of remains to which is generally added a diffusion process. In some cases, secondary concentrations of remains (i.e., after transport) may occur, particularly in fluvial (Schick 1986) or overland flow (Lenoble 2005) contexts.

3 | BIO-PEDOLOGICAL PROCESSES

The existence of movements of the remains caused by bio-pedological factors occurring after burial is a well-established fact in geoarchaeology (Wood and Johnson 1978), and such movements were observed in different contexts, in open air sites (Cahe 1976; Bunn *et al.* 1980; Van Noten *et al.* 1980; Villa 1982; Barton 1987; Vermeersch and Bubel 1997) as well as in caves and rockshelters (Bordes 1972; Petraglia *et al.* 1994). The anthropised palaeosurfaces are degraded to varying degrees depending on the magnitude of transformations linked to mechanisms such as burrowing (Hole 1981; Bocek 1992; Armour-Chelu and Andrews 1994; Balek 2002; Johnson 2002; Araujo and Marcelino 2003; Canti 2003; Mallye 2011), trampling by humans (Villa and Courtin 1983; Nielsen 1991; Benito-Calvo *et al.* 2011) and animals (Thiébaut *et al.* 2010; Eren *et al.* 2010; Asryan *et al.* 2014), tree uprooting (Schaetzl *et al.* 1990; Crombé 1993; Langohr 1993), argiliturbation in soils rich in swelling clays (Cahen and Moeyersons 1977; Delagnes *et al.* 2006), frost jacking and cryoturbation in periglacial environments (Johnson and Hansen 1974; Pissart 1977; Masson 2010; Yamagishi and Matsuoka 2015), or the sieving effect in coarse materials without an interstitial matrix (Bertran *et al.* 2015; Dudill *et al.* 2017). These factors, natural or anthropogenic in origin, are likely to induce not only vertical and horizontal movements, but also artefact reorientation and sorting. The disturbances generally lead to isotropic scattering of the remains in an increasing volume of sediments and to subsequent weakening of remain concentrations. Scattering can combine with vertical sorting according to the size and shape of the remains.

Various examples of Palaeolithic sites affected by argiliturbation are described in detail in the literature. The case of the Nadung'a 4 site, located in a vertic soil in the context of a tropical alluvial plain (Kenya) is striking in this respect (Delagnes *et al.* 2006). The distribution of refits, the fabrics and the large slickensides (shiny and striated clay surfaces caused by the slipping of soil aggregates) show that the significant vertical dispersion of the archaeological material, i.e. over almost one metre in thickness, resulted mostly from movements caused by alternating phases of clay shrinkage in the dry season and swelling in the wet season. Despite significant dispersion, the study confirmed the association of the lithics with the remains of an elephant.

Bioturbation is one of the most important soil-forming factors but also one of the most rapid factor of disturbance, which can occur before, during and after any human occupation, in open air sites as well as in rock shelters and caves. When the sedimentation rate is low, the archaeological record usually corresponds to the mixing to varying degrees of initially distinct archaeological levels (Morin 2006). The gradual burial of artefacts abandoned on the ground as a result of sediment accumulation brought to the surface by biological activity (earthworm droppings, termite mounds, material excavated by burrowing mammal) is a well-documented process that can play a major role in some contexts where sedimentation is low, particularly in tropical contexts. This process can lead to the formation of "pseudo-archaeological levels" at depth, following the concentration of artefacts at the base of the horizon affected by bioturbation. This is the case of stone lines (Johnson 1989, 1990) and associated industries (Williams 1978; Schwartz 1996; Mercader *et al.* 2001).

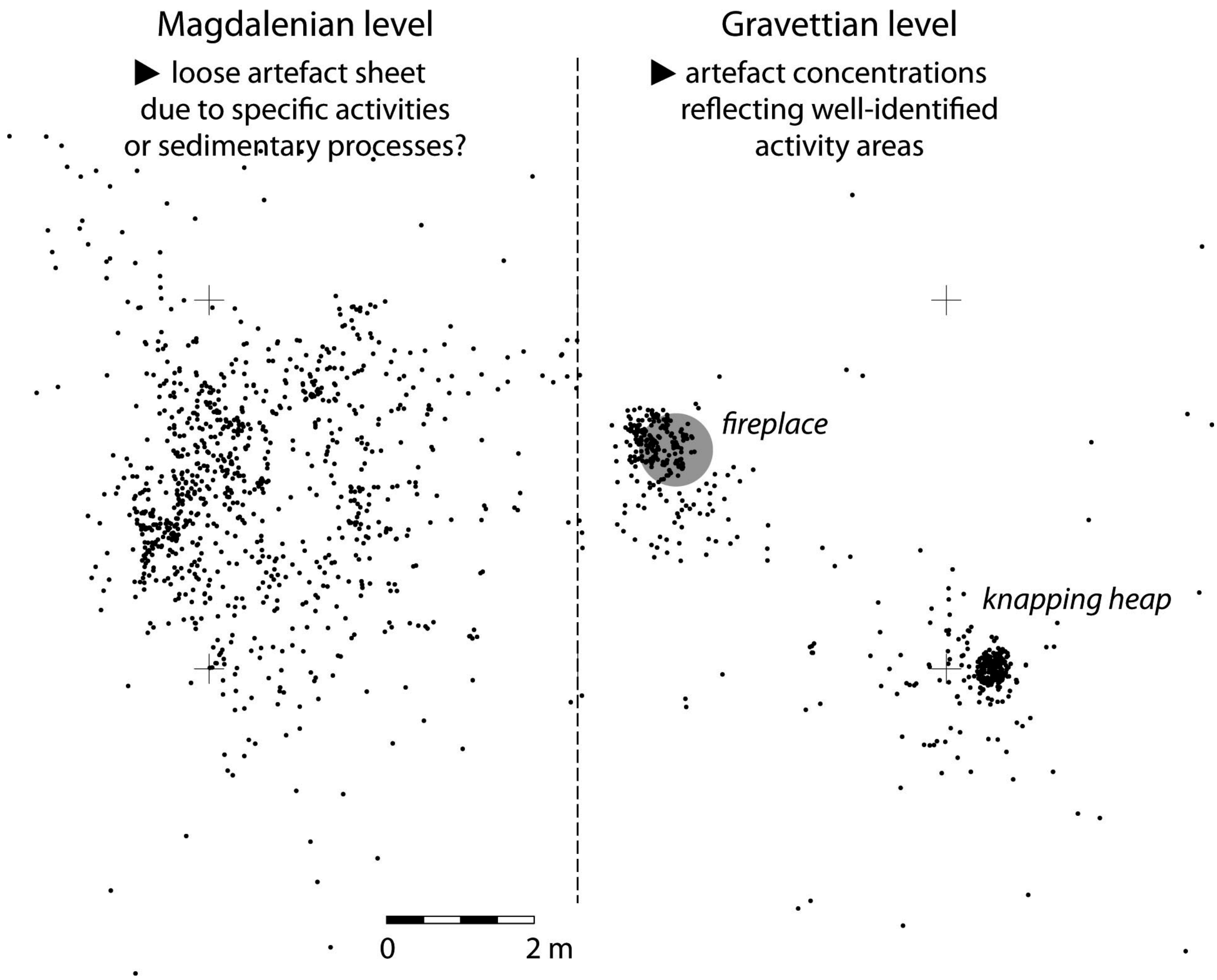
4 | PERTURBATION ASSESSMENT: AIMS, APPROACH AND AVAILABLE TOOLS

4.1 | Aims and relevant questions

The main questions to which the taphonomic study attempts to answer when investigating potential perturbations in a site are the following: (1) to what extent has the original (anthropogenic) spatial organisation of the archaeological material been preserved (**fig. 2**), (2) is the archaeological assemblage homogeneous, i.e. does it possibly result from mixing by sedimentary or bio-pedological processes of initially distinct levels (**fig. 3**), (3) has this assemblage retained its integrity, in other words, is the recovered material a representative sample of the original assemblage (keeping in mind the filter of the excavation method) or does it correspond only to a particular fraction of that assemblage due to sediment sorting (depending on the size or shape of the remains) or differential alteration (depending on the composition and size of the remains), finally, (4) do the artefacts exhibit an individual state of preservation allowing the identification of their manufacturing and use modalities?

Perturbation assessment usually involves several steps (Colcutt et al. 1990; Lenoble 2005).

(1) First, the sedimentary and diagenetic mechanisms involved in the formation of the layers that contain the remains are determined. This step makes it possible to draw assumptions about the transformations that may have affected the archaeological level and to propose appropriate tests to highlight them. On a flat surface, when sedimentation rates are high (i.e. rapid accretion) and flows are of low energy as in alluvial plains and lake environments, this "contextual" analysis may be sufficient to diagnose a good state of preservation of the site. Nevertheless, great caution is needed, as shown by the example of the Middle Palaeolithic site of Shi'Bat Dihya 1 (Yemen) interstratified in silty overbank alluvial deposits (Sitzia *et al.* 2012) where the study showed that, despite the relatively favourable context, the remains had been transported, sorted and reorganised into current ripples (**fig. 4**). It is likely that the heaps of lithic remains have



— FIGURE 2 —

Distribution of lithic remains in the Périgueux-rue Jules Ferry site (Detrain *et al.* unpublished). The Gravettian level, which can be easily interpreted in terms of juxtaposed activity areas, is interstratified in silty sand alluvial deposits. In contrast, the Magdalenian level, which forms an artefact sheet without well-defined concentrations, is in slope deposits. In the latter case, the aim of the taphonomic study is to test the hypothesis of lithic material redistribution by slope dynamics.

Distribution des pièces lithiques dans le site de Périgueux-rue Jules Ferry (Detrain et al., non publié). Le niveau gravettien, qui peut être aisément interprété comme des aires d'activités différentes juxtaposées, est interstratifié dans des dépôts alluviaux sablo-limoneux. Par contraste, le niveau magdalénien, inclus dans des dépôts de pente, forme une nappe d'objets sans concentration bien définie. Dans ce dernier cas, le but de l'analyse tahonomique est de tester l'hypothèse d'une redistribution des vestiges par les processus de versant.

themselves created the hydrodynamic conditions necessary for the development of current ripples, causing a decrease in the thickness of the water sheet and a local increase in current speed.

(2) In a second stage, we try to find, among the different characteristics of the archaeological level, those which must be attributed to natural dynamics. This evaluation uses criteria derived from geomorphology and consists in comparing the organisation and surface state of the remains with those described in natural sedimentary environments. The criteria taken into account are the spatial organisation of the remains ("obvious" sedimentary structures), their surface state (wear, alteration), their orientation and dip (fabric) and their grain size. The diagnosis is of course dependent on the quality of the reference data currently available. The assessment of the "geologically *in situ*" position of the archaeological level, i.e. its location in deposits whose age is compatible with that of the artefacts, may provide additional information. However, this aspect often remains difficult to grasp and concerns mostly sedimentary contexts and periods for which both a detailed chronostratigraphy is available (for example loess in Belgium and northern France) and successive technocomplexes are well dated (as in the case of the European Upper Palaeolithic). Numerical dates (14C, OSL, TL, U/TH, ESR) may help to clarify the contemporaneity of remains and deposits; they may also reveal possible age inversions and, consequently, potential stratigraphic disturbances.

(3) At the same time, data produced by analysis of the archaeological remains themselves (i.e. typo-technological analysis of lithic artefacts, taxonomic identification of faunal remains, observation of the surface state of both lithics and bones, and spatial distribution of refits between pieces) makes it possible to test the consistency of the assemblages. For stone items, it is based on the notion of "chaîne opératoire" (Leroi-Gourhan 1988), and on the identification of technical production systems. Experimental data make it possible to validate the relevance of the criteria used for the technological interpretation of lithic assemblages, while the refits of broken artefacts and of products coming from the same block of raw material

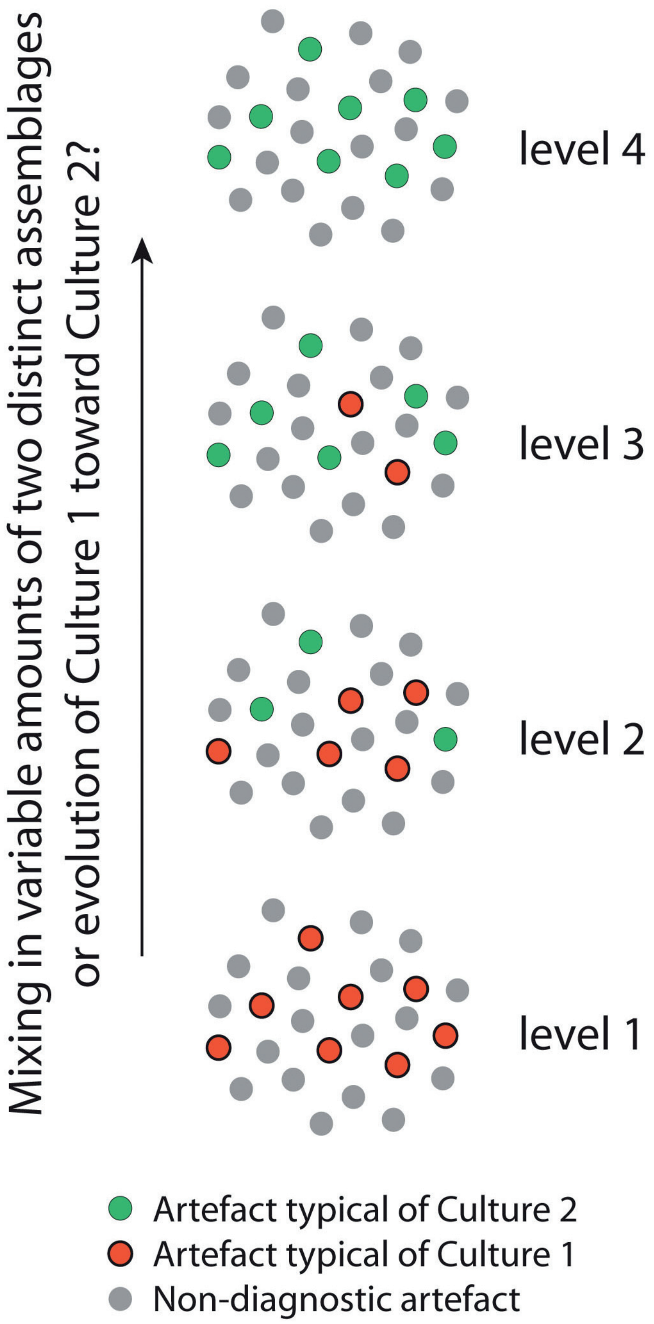


FIGURE 3

A usual problem found in stratified Palaeolithic sites: how to distinguish lithic assemblages reflecting the evolution from one technocomplex to another from assemblages mixed by taphonomic processes.

Un problème habituellement rencontré dans les sites paléolithiques stratifiés: faut-il interpréter les séries successives comme l'évolution progressive d'un technocomplexe vers un autre ou bien comme le mélange par les processus taphonomiques d'occupations appartenant chacune à un technocomplexe différent ?

allow establishing the strict contemporaneity between the remains (Arts and Cieszla 1990). The analysis of the spatial distribution (both horizontal and vertical) of diagnostic artefacts or artefacts belonging to sets of refitted pieces, constitutes the central tool of a robust reconstruction of homogeneous archaeological assemblages (e.g. Bordes 2003; Zilhão *et al.* 2006, 2008; Aubry *et al.* 2012, 2014; Machado *et al.* 2013; Hovers *et al.* 2014; Chacon *et al.* 2015; Anderson *et al.* 2016; Bargalló *et al.* 2016; Deschamps and Zilhão 2018; Gravina *et al.* 2018). Similarly, the data acquired through the study of faunal remains and the search of refits between fragments can provide key information on the homogeneity of an assemblage (e.g. Villa 2004; Morin *et al.* 2005; Mallye 2011; Discamps *et al.* 2012, 2019; Chacon *et al.* 2015; Bargalló *et al.* 2016; Gabucio *et al.* 2017; Pelletier *et al.* 2017). Today, these analyses are greatly facilitated by the digital exploitation of data and systematic remain plotting in modern excavations.

The various disciplines (geoarchaeology, zooarchaeology, stone tool analysis) must contribute to establish, using their own tools, the degree of disturbance of the assemblages they are studying in relation to the questions being asked. All these tools should be used individually with caution, as they provide only limited information that can sometimes be interpreted inconsistently. The comparison of the different approaches enables us to propose a plausible scenario for the formation of the archaeological level, which captures all its characteristics (**fig. 5**). This scenario then allows to answer questions relating to the distribution of the remains, as well as to the homogeneity and integrity of the archaeological level(s). However, perfect consensus is rarely reached, which reflects the difficulty of recognizing all the processes that have affected an archaeological site from its creation to the time of the study.

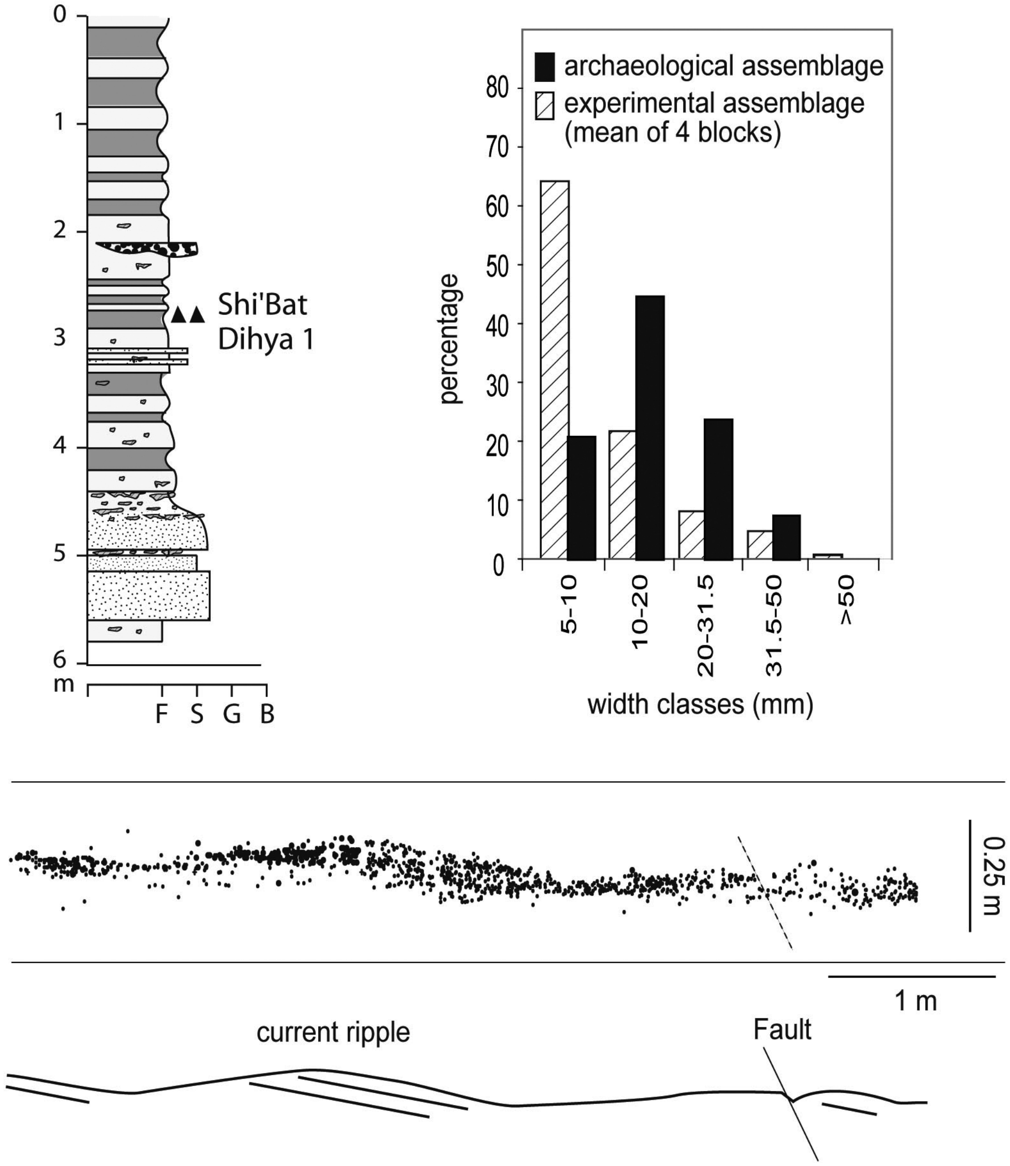


FIGURE 4

Stratigraphy of the Middle Palaeolithic Shi Bat Dihya 1 site (Yemen), grain size composition and vertical projection of artefacts, modified from Sitzia *et al.* (2012). The archaeological level is interstratified in floodplain deposits and has been sorted by flows. The lithic assemblage shows a deficit in both small and large pieces compared to experimental series. The artefacts are organised in current ripples.

Stratigraphie du site paléolithique moyen de Shi Bat Dihya 1 (Yémen), composition granulométrique de la série lithique et projection verticale des pièces, modifié d'après Sitzia et al. (2012). Le niveau archéologique est interstratifié dans des dépôts de plaine alluviale et a été trié par les écoulements. La série présente un déficit à la fois en petits éléments et en grosses pièces lorsqu'on la compare à une série expérimentale. Les pièces sont organisées en rides de courant.

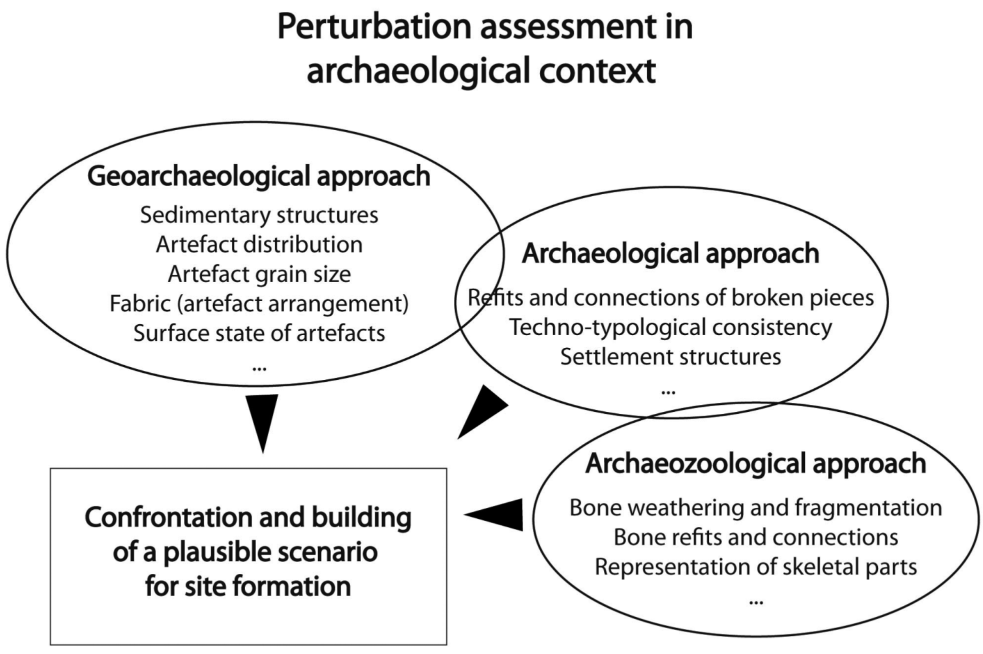


FIGURE 5

The confrontation of different taphonomic approaches in archaeology contributes to the elaboration of a robust scenario for site formation.

La confrontation des différentes approches taphonomiques contribue à élaborer un scenario robuste pour la formation du site.

4.2 | Archaeological material as an anthropogenic signature... or as a sedimentary component: some analytical tools

4.2.1 | Sedimentary structures

Recognition of "obvious" sedimentary structures is an important step in taphonomic analysis. For the open-air European Palaeolithic sites, the most frequently encountered cases are (1) a close association between the archaeological material and lenses or continuous levels of gravel interbedded in finer-grained deposits, corresponding to erosional pavements, (2) a deformation of the archaeological levels by various processes (sliding, creep, flow, cryoturbation...).

A close association between archaeological material and a gravel level is frequently observed in French Palaeolithic sites. These coarse-grained levels correspond most of the time to lag deposits created by unconfined overland flow or channelized flows (rills, gullies) on slopes. The archaeological material is generally sorted by erosion and the coarse-grained elements (cores, large tools...) reach high proportions within the collected lithic assemblages because of the preferential transport of smaller elements. Examples of lag deposits containing rich archaeological assemblages are common outside the North European loess zone, in environments subject to overland flow where the sedimentation/erosion balance is low, particularly in plateau or slope contexts.

This is the general case of open-air Middle Palaeolithic sites in southwest France. The Combebrune 2 site (Frouin *et al.* 2014) located on a karstified plateau near Bergerac (Dordogne) is representative of many sites in the region (**fig. 6**). The archaeological material ranging in age from the early Middle Palaeolithic (dated around 190 ka, MIS 7-6) to the recent Middle Palaeolithic (60-40 ka, MIS 3) is concentrated in a coarse-grained layer composed of flint nodules and sandstone fragments overlying weathering clay. This pavement is covered by aeolian silts deposited during the Late Pleniglacial. In such a context, occupations of different ages are concentrated in the same residual level (condensed record). Since the lag material is most often mobile (reflecting a relative concentration of coarse elements on a surface subject to erosion over a long period; these elements are also affected by creep) and are often deformed by subsequent periglacial processes, the spatial organisation of prehistoric occupations is generally strongly disturbed. This process explains why the archaeological record can be almost continuous (although condensed) even though the sedimentary record is lacunar, because of the lack of deposition during interglacials and interstadials.

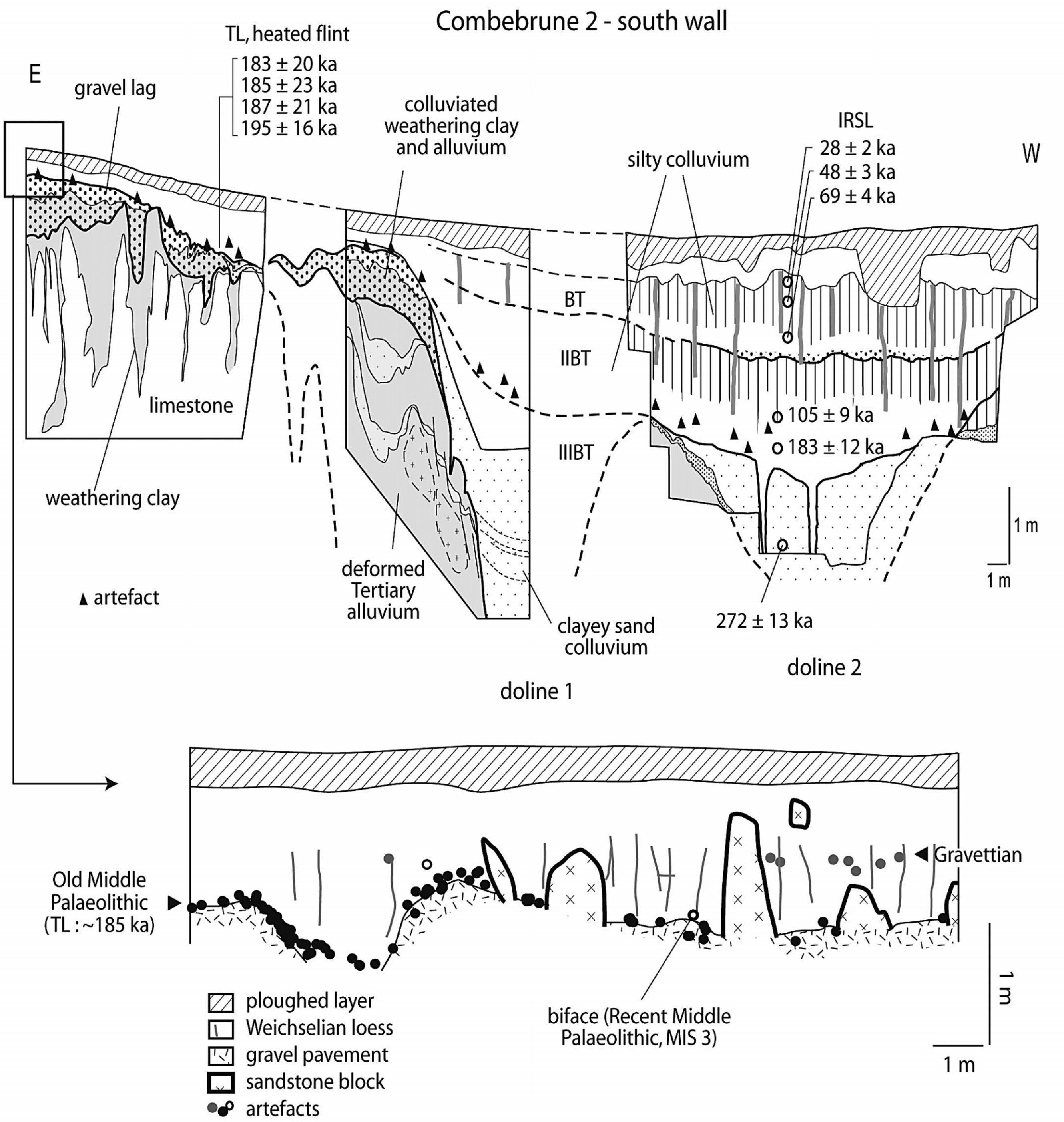
Similar lag deposition also occurs in fluvial and aeolian contexts. Throughout Northern Europe, many Lower Palaeolithic lithic assemblages are buried in sandy gravel alluvium (e.g. Acheulean sites of the Somme terraces). Alluvial pavements are also common in Africa. In fluvial contexts, the coarse material is concentrated at the bottom of the channels where the current is the most rapid. When the coarse load naturally carried by the river is scarce, due to the remoteness of the relief or because the slope dynamics is poorly active (particularly in humid tropical regions), most of the elements that form the pavements correspond to archaeological material coming from bank erosion. Many sites of the African Lower and Middle Palaeolithic fit this model. These sites are typified by artefact sheets mainly composed of large tools (bifaces, cleavers, cores) and pebbles, which often have an imbricated arrangement, or by localised accumulations of material transported and strongly sorted by flows (Schick 1986, 1987). Examples have also been described in Israel (Shea 1999) and Italy (Boschian and Saccà 2010).

In aeolian contexts, the formation of pavements (regs, desert pavements) is a widespread phenomenon (Adelsberger *et al.* 2013; Knight and Zerboni 2018) and the surfaces on which industries of various ages are mixed cover large areas in the Sahara, Chile (Atacama), Arizona and Australia. Allochthonous (or alluvial) regs correspond to alluvial deposits whose coarse elements have been concentrated on the surface by wind winnowing (residualisation). Autochtonous regs are caused by in situ weathering (fragmentation and alteration) of bedrock. Downwards migration by sieving of the fine-grained particles originating from fragmentation and aeolian inputs leads to the formation of a surface pavement that may contain archaeological remains. **Figure 7** shows an example of an archaeological pavement forming in a dune context on the fringe of a glacial lake in Chilean Patagonia.

Deformations affecting the archaeological levels linked to slope processes (landslides, **fig. 8**) or periglacial phenomena (solifluction, cryoturbation...) are commonly observed in the French Palaeolithic. Many sites have been exposed to periglacial climates and have been affected either by solifluction, i.e. a slow downslope soil movement caused by freeze-thaw cycles, or by cryoturbation on flat ground, often associated with sorting (sorted polygons, soil stripes, mud boils). The Solutrean level of Cantalouette 2 located in a doline near Bergerac (southwest France), where a knapping spot of bifacial pieces has given rise to a stone-banked solifluction lobe, is illustrated in **figure 9**. It is likely that the presence of the heap of flint debris, while locally modifying the frost susceptibility of the soil and the creep rate, led to the formation of a lobe instead of a more regular, laminar solifluction.

The Saint-Amand-les-Eaux (northern France) Middle Palaeolithic site and Canaule 2 (southwest France) Châtelperronian site are representative of the many Palaeolithic sites affected by sorted polygons (**fig. 10**) (Bertran *et al.* 2010; Masson et Vallin 2010). The chronocultural distribution of the sites affected by patterned ground, visible either from the artefact distribution maps or from cross-sections, indicates that these processes concern the Middle Palaeolithic as well as a large part of the Upper Palaeolithic. This is the general case for the Gravettian and Solutrean, which are contemporaneous of the Late Pleniglacial. In contrast, the sites of the Final Magdalenian in the Paris Basin, such as Pincevent or Etiolles, which occurred after the coldest periods of the Pleistocene, are comparatively much better preserved.

For many Palaeolithic sites, however, the organisation of the remains is characterized by a more or less dense sheet-like distribution, with no identifiable artefact concentration that can be interpreted in terms of archaeological structure or sedimentary feature. In many cases, this type of pattern seems to result from a diffusion of the remains under the action of geomorphological processes (Bertran *et al.* 2005; Lenoble *et al.* 2008). Different processes can be involved in this diffusion, which can be

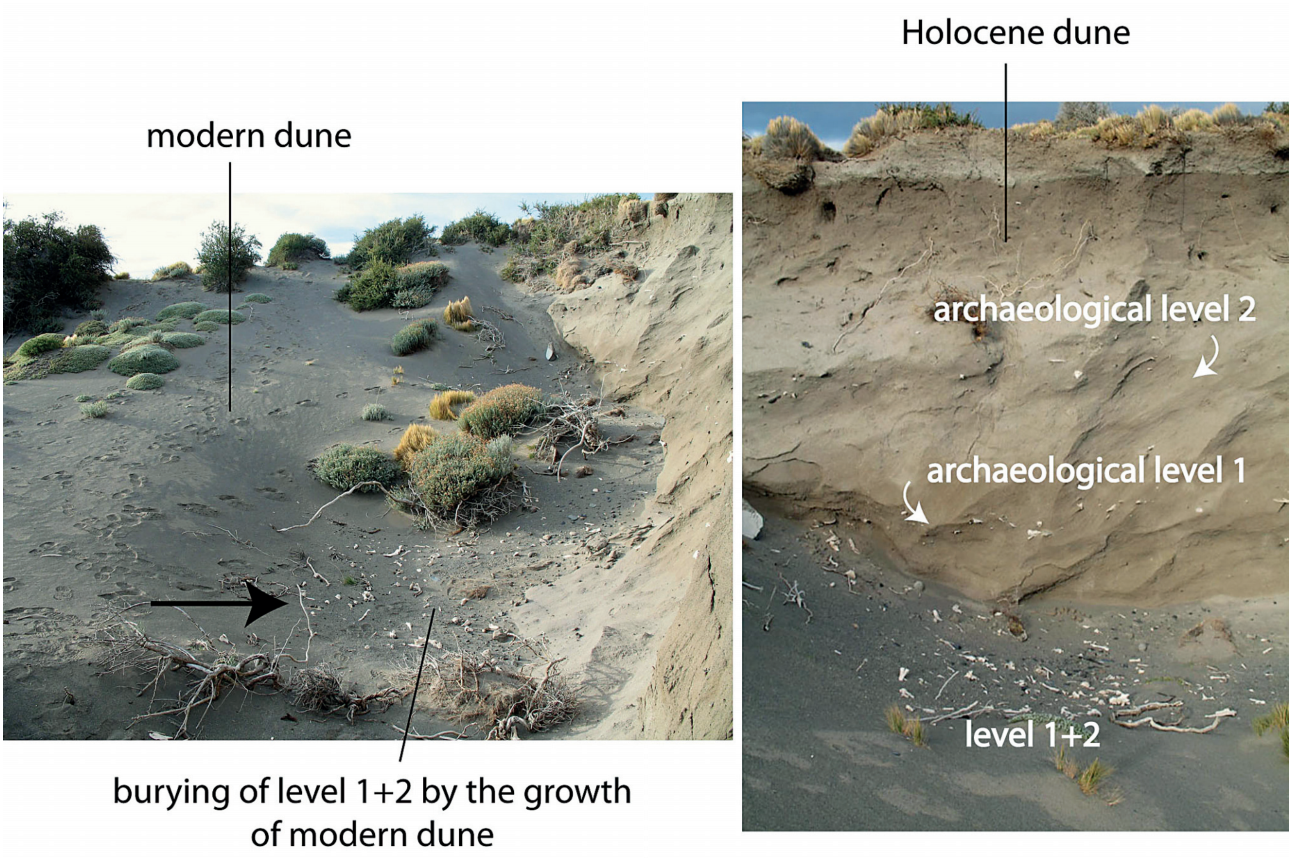


— FIGURE 6 —

Section of the Combebrune 2 site near Bergerac, distribution of archaeological material and chronological data, modified from Frouin *et al.* (2014). On the plateau, the artefacts form a level resting on a residual pavement overlying weathering clay. The archaeological level, which contains both Old Middle Palaeolithic (~190 ka) and Recent Middle Palaeolithic (MTA, 60-40 ka), is buried by Weichselian loess. BT: Holocene (MIS 1) argillic horizon; IIBT: MIS 5 argillic horizon; IIIBT: MIS 7 argillic horizon.

Coupe du site de Combebrune 2 près Bergerac, distribution du matériel archéologique et données chronologiques, modifié d'après Frouin et al. *(2014). Sur le plateau, les vestiges forment un niveau reposant sur un pavage résiduel qui recouvre des argiles d'altération. Le niveau archéologique, qui contient du Paléolithique moyen ancien (~190 ka) et du Paléolithique moyen récent (MTA, 60-40 ka), est enfoui par des lœss weichséliens. BT : horizon argilique holocène (SIM 1) ; IIBT : horizon argilique SIM 5 ; IIIBT : horizon argilique SIM 7.*

accompanied by lateral displacement when the slope exceeds a few degrees. These include biological activity (Hole, 1981), overland flow (Lenoble 2005) and soil creep, particularly in periglacial contexts (Hilton 2003; Lenoble *et al.* 2008; Bertran *et al.* 2015). Two models of downslope displacement and diffusion likely to give rise to sheets of remains are illustrated in **Figure 11**.



— FIGURE 7 —

Paleoindian levels interstratified in a Holocene dune along Lago del Toro (Chilean Patagonia). The dune is being eroded and the archaeological material accumulates at the foot of the escarpment where it forms a pavement. This pavement is gradually buried by the advance of modern dune.

Niveaux paléoindiens interstratifiés dans une dune holocène le long du Lago del Toro (Patagonie chilienne). La dune est en cours d'érosion et le matériel archéologique s'accumule au pied de l'escarpement où il forme un pavage. Ce pavage est progressivement enfoui par l'avancée de la dune moderne.

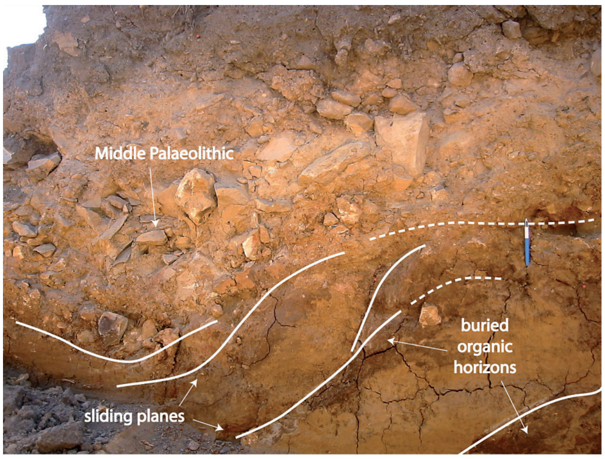


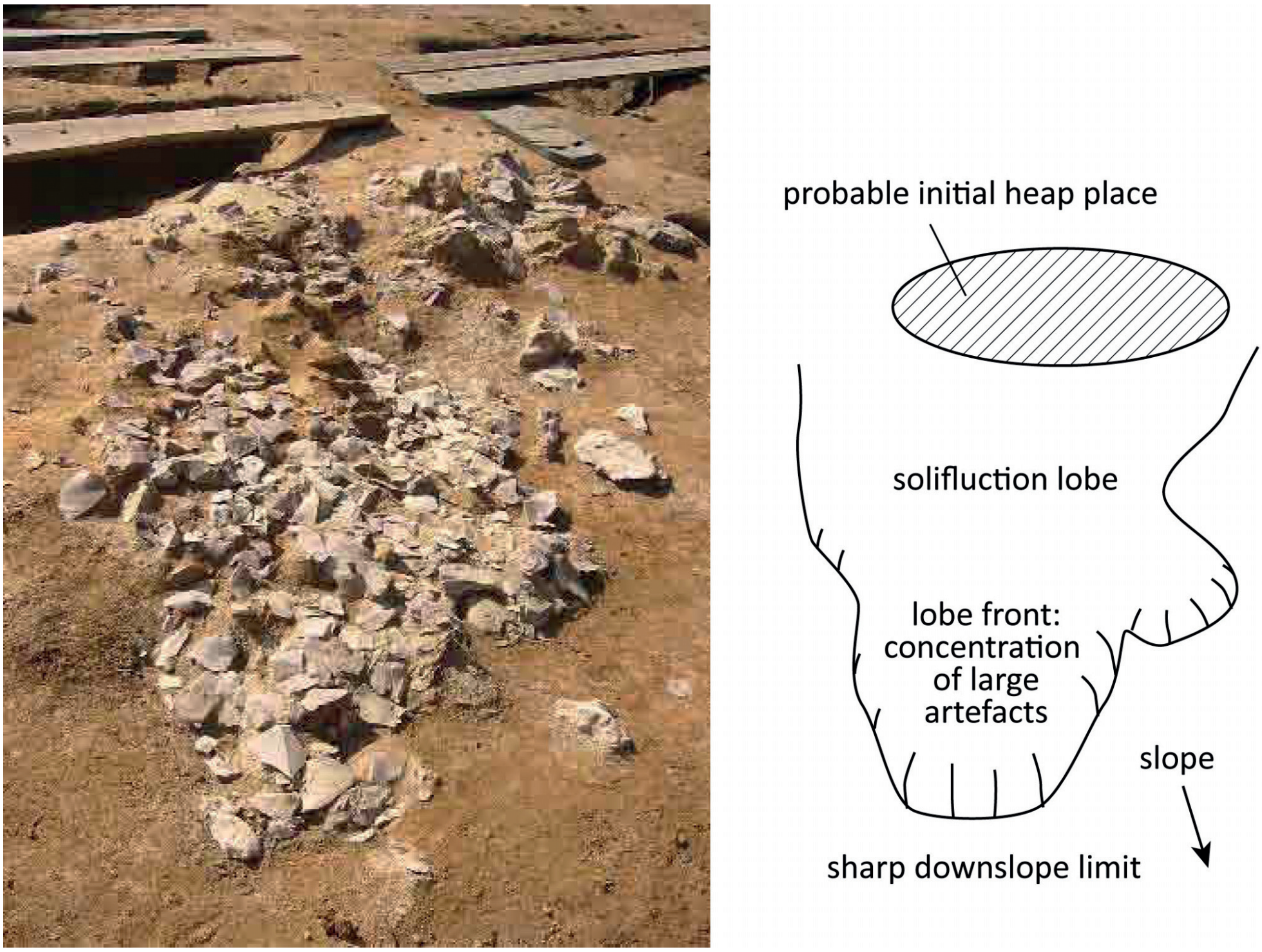
FIGURE 8

Section of the Middle Palaeolithic site of Les Lèches (Dordogne). The archaeological material was displaced by a landslide within the underlying weathering clays.

Coupe du site paléolithique moyen des Lèches (sud-ouest de la France). Le matériel archéologique a été déplacé par un glissement de terrain dans les argiles d'altération sous-jacentes.

4.2.2 | Fabrics

The study of fabrics, i.e. the analysis of the orientation and dip of objects (lithic artefacts or bone fragments) is often informative. This type of analysis was first developed with the aim of understanding the formation of early Palaeolithic sites in alluvial context in Africa and the Near East (Isaac 1967; Bar-Yosef and Tchernov 1972; Schick 1986; Kaufulu 1987). For slope deposits, the application to archaeology is more recent (Bertran and Texier 1995). This tool has been the subject of significant developments in recent decades concerning both the methodology, the types of sites investigated and the establishment of a reference framework in natural and experimental environments (Bertran *et al*. 1997, 2006; Lenoble et Bertran 2004; McPherron 2005, 2018; Benito-Calvo and de la Torre 2011; Benito-Calvo *et al*. 2011; Dominguo-Rodriguez *et al*. 2012, 2014; de la Torre and Benito-Calvo 2013). Generally, only



— FIGURE 9 —

Solutrean knapping spot in Cantalouette site (southwest France), after Lenoble *et al.* (2008), modified. The heap has been stretched on the slope by solifluction.

Amas de débitage solutréen à Cantalouette (sud-ouest de la France), modifié d'après Lenoble et al. (2008). L'amas a été étiré sur la pente par la solifluxion.

the artefact elongation axis (L) (with L > 2l, l being the width) is considered in the analysis. The fabric is quantified by measuring representative samples of forty to fifty elements each and (as far as possible) distributed over a "small" area (i.e. a few square metres). Extensive recording of fabrics within an archaeological layer using a total station, a digital compass/inclinometer or other methods makes it possible to visualize the spatial evolution of artefact orientation and dip (McPherron 2005, 2018). Data processing uses circular statistics (Batschelet 1981; Fisher 1993) and the calculation of parameters to characterize the mean orientation (e.g. mean vector), the intensity of the preferred orientation of the remains (Vector Magnitude) and the type of orientation/dip distribution (Curray 1956; Woodcock 1977). The isotropy and elongation indices (Benn 1994), based on the ratio of standardized eigenvectors, make it possible to plot the fabrics on a triangular diagram where it can be compared with the fabrics of modern sedimentary deposits and experimental sites (Lenoble and Bertran 2004; McPherron 2018).
The fabric type clearly enlightens sedimentary processes and disturbances. Artefacts or bone fragments falling randomly on the ground exhibit a planar fabric, i.e. they lie flat without preferred orientation (Bertran *et al.* 2006; Benito-Calvo *et al.* 2011). Such a pattern is expected to occur in undisturbed sites. Changes in the original arrangement of remains are accompanied either by an increase in isotropy (more disorderly artefact arrangement, especially in the case of bioturbation and argiliturbation), or by a preferred orientation parallel to the slope (typical of mass movements such as solifluction and landslides, but also overland flow on slope gradients greater than ~20°). **Figure 12**, on which the fabrics of a large number of French Palaeolithic sites are plotted according to the isotropy and elongation indices, shows that at least two thirds of the measurements differ significantly from the planar fabric pole, which is characteristic of well-preserved sites and of experiments of random discharge of objects on the ground. This single criterion "fabric" thus clearly indicates the very general character of the taphonomic modifications undergone by Palaeolithic sites. One of the interests of fabric analysis lies in the possibility of working on the orientation of elongated objects measured from archaeological maps or photographs, and thus to enable re-evaluation of ancient excavations (de la Torre and Benito-Calvo 2013).

In some cases, fabric analysis is unable to determine whether some sedimentary processes, such as overland flow on gentle slopes, were involved. In this type of context, the

FIGURE 10

Map of the Châtelperronian site of Canaule 2 (southwest France), after Bordes (1972). The archaeological material draws streaks that correspond to the walls of sorted polygons typical of a periglacial environment.

Carte du site Châtelperronien de Canaule 2 (sud-ouest de la France), d'après Bordes (1972). Le matériel archéologique forme des cordons qui correspondent aux parois de polygones triés typiques d'un environnement périglaciaire.

fabrics are non-diagnostic and not significantly different from those found in unmodified sites. Detailed observation of measurement sets carried out on small surfaces (of the order of one square metre) sometimes makes it possible to highlight a bimodal fabric, similar to patterns typical of fluvial depositional environments. However, this remains uncommon because of the influence of local topographical irregularities on artefact or bone orientation, and because of interactions between archaeological and natural objects (e.g. the "blocking" effect).

4.2.3 | Artefact grain size

The grain size analysis of lithic material is a tool that was initially developed for taphonomic purposes by Schick (1986, 1987), with the aim of understanding the role of alluvial dynamics in the formation of Oldowan sites in East Africa. The analysis consists in separating the different constituents into dimensional classes using screens or sieves. The size range of the fraction studied varies according to the questions asked, the piece width being the main dimension considered. All elements (cores, flakes, chips, tools, debris) are counted in each screen (Stahle and Dunn 1982; Hansen and Madsen 1983; Bertran *et al.* 2012; Brenet *et al.* 2017). In practice, only pieces with a width (w) greater than 7.1 mm (i.e. corresponding to a mesh d = 5 mm) are generally taken into account in the analysis, since this mesh is the smallest routinely used on excavations to recover lithic material. Evidence of sedimentary sorting in the coarser fraction can also have important consequences for the archaeological study. In some sites, however, it may be of interest to study the grain size distribution of smaller pieces (up to w = 2.8 mm / d = 2 mm), particularly for microlithic series.
Several sedimentary processes have the ability to selectively transport particles according to their size. In the case of natural flows (overland flow, rivers), the typical grain-size distribution differs according to whether residualisation, transit or accumulation occurred. Therefore, particle size sorting is a taphonomic signature that can be easily

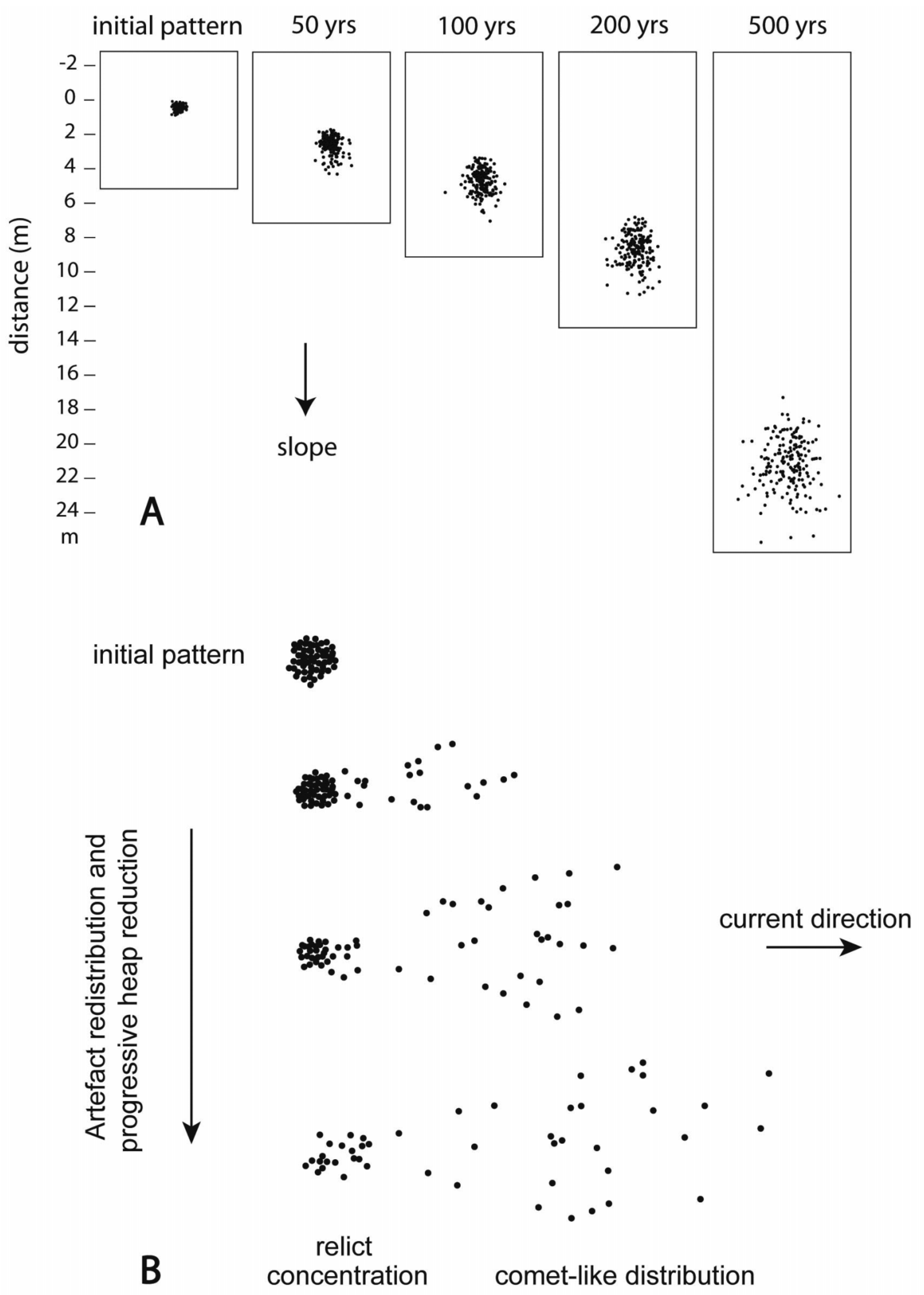


FIGURE 11

Two processes leading to the formation of sheets from artefact concentrations: A – artefact redistribution by solifluction, after Lenoble *et al.* (2008); B – overland flow, after Lenoble (2005).

Deux processus conduisant à la formation de nappes à partir de concentrations initiales de vestiges : A – redistribution des vestiges par solifluxion, d'après Lenoble et al. (2008) ; B – ruissellement, d'après Lenoble (2005).

revealed by the analysis of the composition of a lithic assemblage. The experiments carried out show that products derived from the knapping of flint or other raw materials have a relatively constant grain size composition, the differences in proportions (in number of elements) for each size class being always less than 15 % from one experiment to the other (**fig. 13**). The differences observed, although small, depend on several factors, such as the raw material used, the size of the products desired or the knapper skills. The proportion of fragments decreases rapidly from small to large sizes, i.e. knapping (or shaping) produces a lot of small debris and few large pieces. The distribution roughly follows a decreasing exponential law or a Weibull law.

When the grain size distribution of an archaeological level in which flint knapping activities have taken place deviates in a substantial way from the experimental composition, this implies that grain size sorting of the artefacts has occurred. Sorting can have many causes, either anthropogenic and linked to human activities that governed the formation of the lithic assemblage abandoned on the site, or natural and caused by sedimentary processes that affected the site before it was completely buried. Since the quantification of pieces in number (instead of weight as usually done by geologists) on all artefacts wider than 2.8 or 7.1 mm (meshes of 2 and 5 mm, respectively) minimises the variability of anthropogenic origin (export-import of artefacts), which mainly concerns a few large pieces, the identification of sorting in an assemblage usually suggests modification of the archaeological level by sedimentary

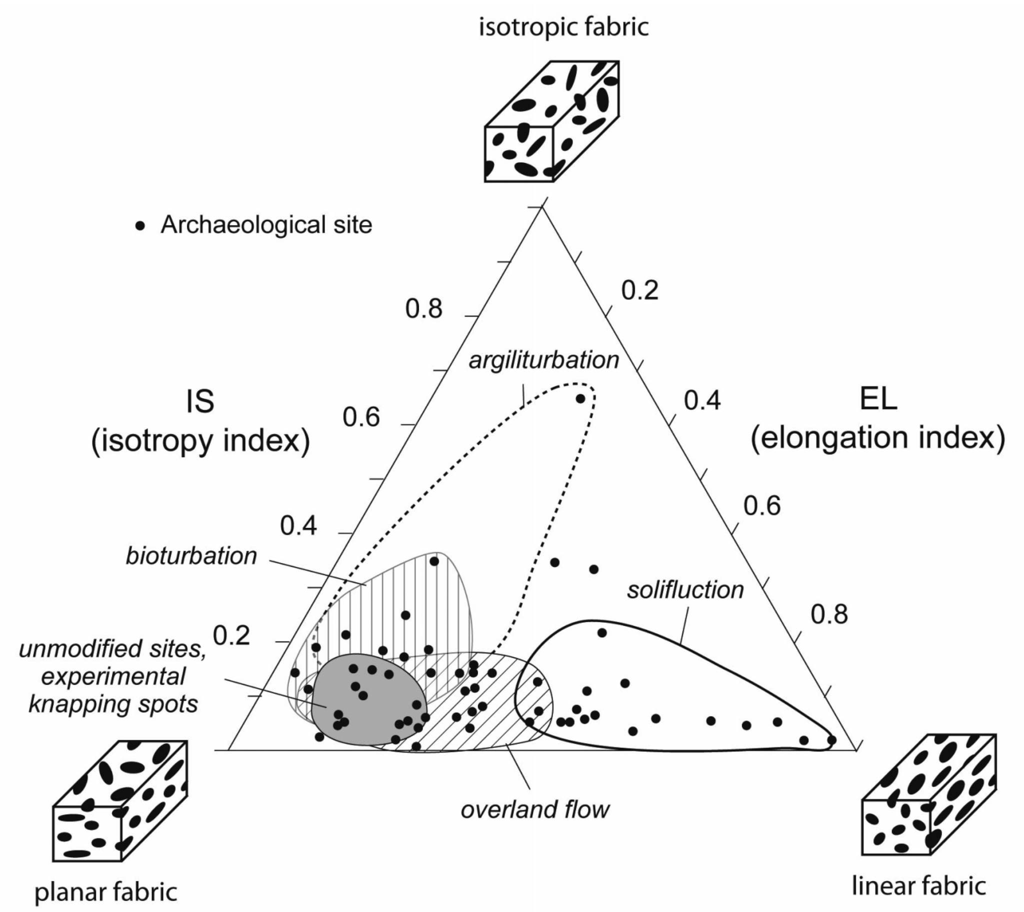


FIGURE 12

Fabric of French Palaeolithic levels and areas corresponding to different processes, after Bertran and Lenoble (2002).

Fabrique de niveaux paléolithiques français et zones correspondant à différents processus, d'après Bertran et Lenoble (2002).

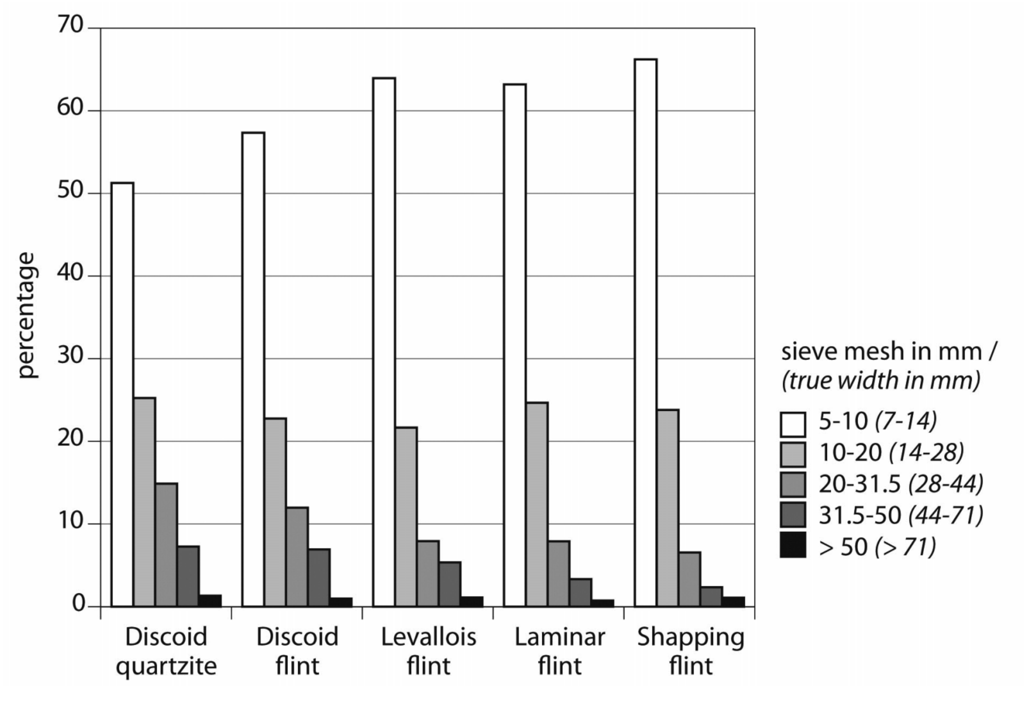


FIGURE 13

Grain size distribution of experimental assemblages produced using different methods and raw material, after Bertran *et al.* (2012), modified.

Distribution granulométrique de séries lithiques expérimentales produites selon différentes méthodes et sur des matières premières variées, d'après Bertran et al. (2012).

processes. Depending on the shear stress applied on the bed and on the duration of exposure to flow, hydraulic sorting usually leads to a bell-shaped size distribution of the transported artefacts with a mode in the medium to coarse pieces, while the upstream (upslope) residual material exhibits a deficit in both fine and medium sized pieces. Because of the protective effect played by the coarse pieces, the finer are never completely missing from the distribution, and depletion affects all sizes in variable proportion. The statement of a sorting then has important implications on the meaning that can be given to the spatial distribution, but also to the techno-economical composition of the lithic assemblage.

Figure 14, supplemented from Bertran *et al.* (2012), illustrates the grain size composition of a number of Lower and Middle Palaeolithic lithic assemblages. While several are located close to the expected area for a site on which flint knapping activities have taken place, others differ significantly and reflect assemblages sorted by flows, either in a fluvial context or on slope (overland flow). These assemblages, therefore, proved to be unfavourable to a reliable techno-economic study, insofar as their integrity has not been preserved. In particular, large tools and cores are noticeably over-represented compared to tools on small flakes. When large areas are excavated, mapping the distribution of artefacts according to their size (grouped into classes) can provide strong arguments in favour of grain size sorting, particularly when downslope gradients are perceptible.

The behaviour of bone pieces in water flows is quite different from that of lithic material and size is not the only parameter controlling hydraulic sorting. According to experiments in laboratory and natural contexts, density and shape are equally significant factors (e.g., Boaz and Behrensmeier 1976; Coard 1999) and lead to modification of skeletal representation in sorted assemblages. Bone groups with similar behaviour in fluvial depositional contexts have been defined by Voorhies (1969). The relevance of these groups for overland flow (where the pieces are usually not fully submerged by water) remains to be investigated. Intense bone breaking in archaeological sites also leads to greater complexity in deciphering the potential sorting of bone material.

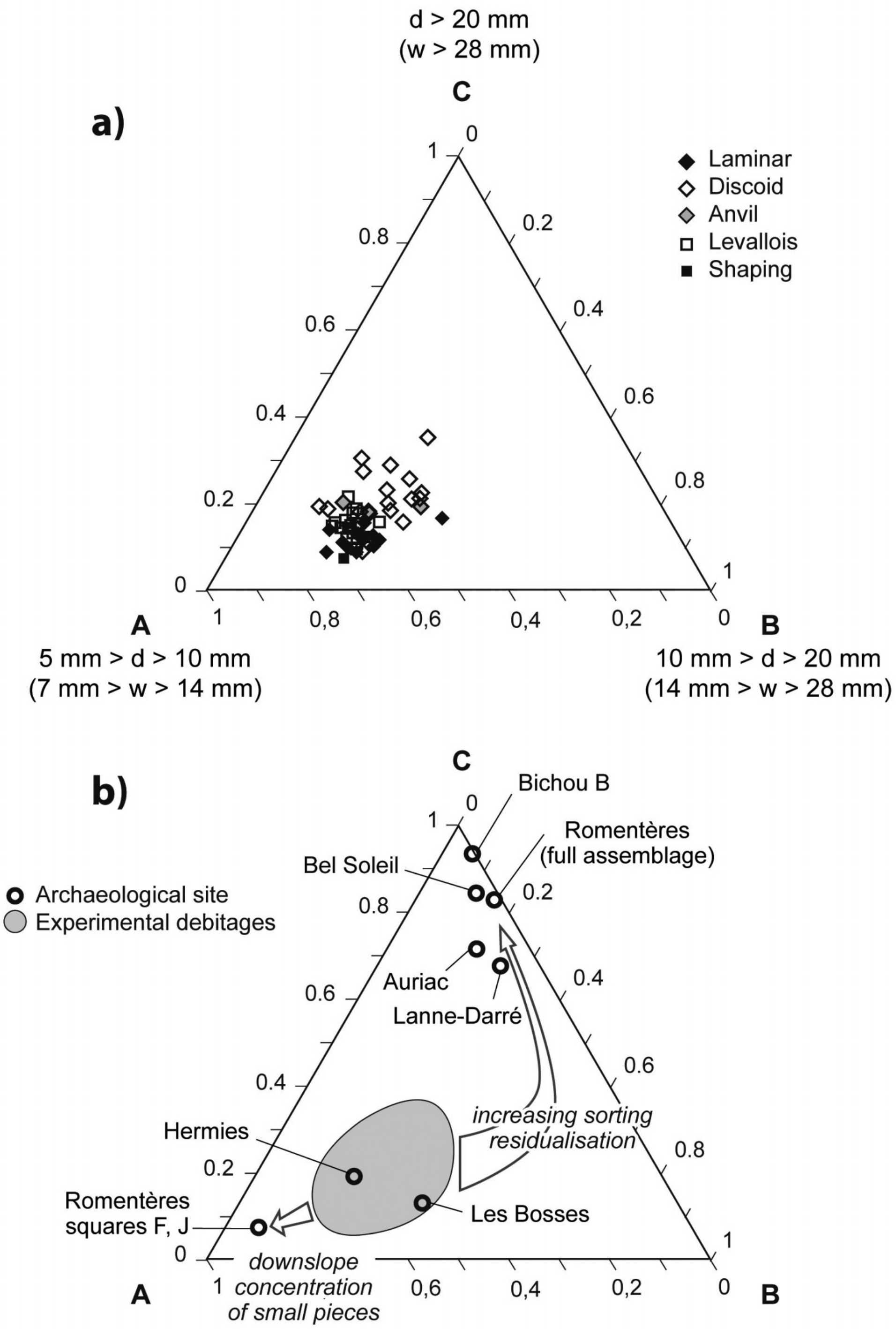


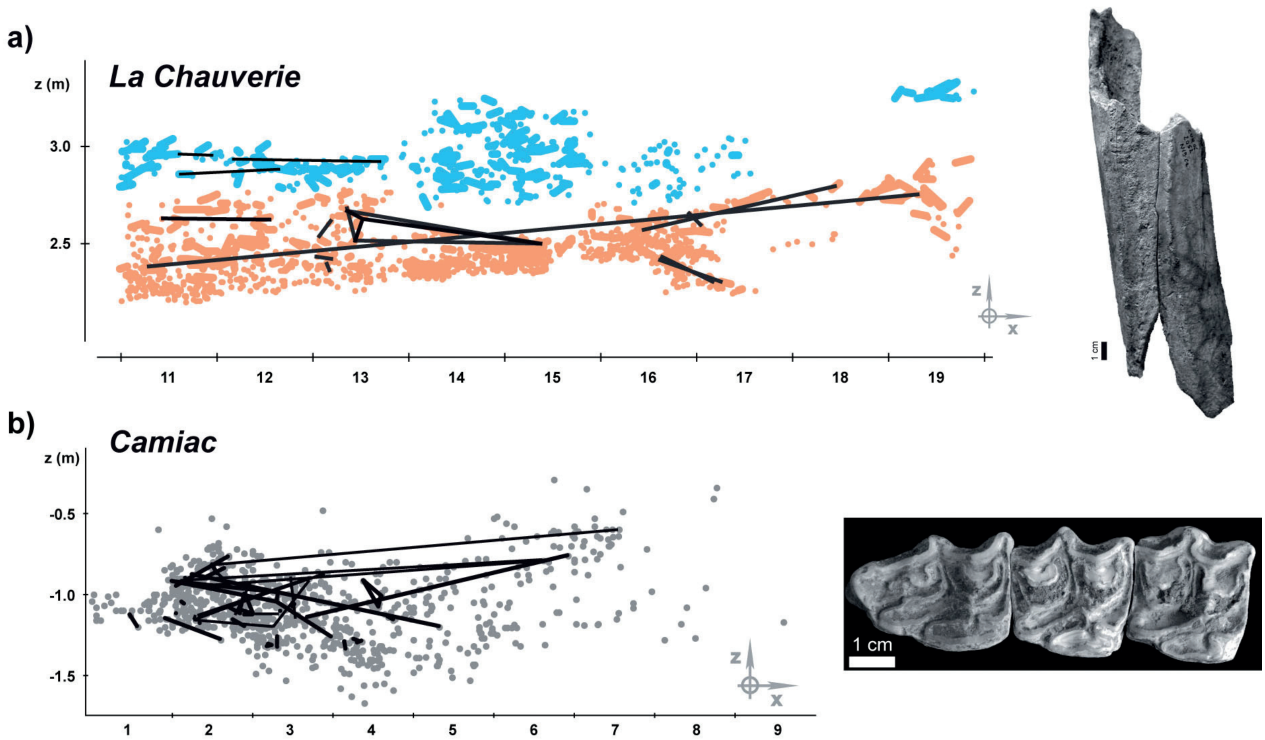
FIGURE 14

Grain size composition of experimental (1) and archaeological assemblages (2, Middle and Lower Palaeolithic), after Bertran *et al.* (2012), modified.

Composition granulométrique de séries expérimentales (1) et archéologiques (2, Paléolithique moyen et ancien), d'après Bertran et al. *(2012).*

4.2.4 | Refits

Refitting lithic pieces coming from the same original matrix (block of raw material) allows reconstruction of the reduction steps of this matrix. This method has been known since the late nineteenth century, but it has long been applied only anecdotally for lithic artefacts and often for technological purposes (Spurrell 1880; Kelley 1954) before being used on other material such as faunal remains (Enloe & David 1992; Morin *et al*. 2005; Mallye 2011; Discamps *et al*. 2012; Bargalló *et al*. 2016). The refits allow the identification of chronological relationships between artefacts, while adding a dynamic dimension to the static view of archaeological levels provided by spatial analyses. The spatial distribution of the relations between the artefacts coming from the same matrix (or skeletal element) reflects the sum of the movements that have affected these remains after their production and discard (Cieszla *et al*. 1990). The movements may be of anthropogenic (voluntary or involuntary) or natural origin. Breakage connections (refits of fragments of the same object) are more difficult to interpret for lithic artefacts from an archaeological point of view because the origin of the fragmentation (knapping fracture, voluntary fracture, accidental shock, frost, etc.) is not always obvious. They nevertheless provide additional evidence of the dynamics that affected the archaeological levels. This problem is less important for faunal remains where breakage origin can often be better discussed (cf. Villa and Mahieu 1991). The interpretation of the distribution of connections, while they establish strong contemporaneity links between the pieces, is not without pitfalls mainly because of the difficulty of assessing the chronological relations between the refitted sets of pieces (see the debate between Bordes 1980a, b, and Cahen *et al*. 1976, 1980a, b). The possibility of "recycling" the lithic remains left by a human group by their successors must also be kept in mind. Such cases are attested in Middle Palaeolithic industries (sometimes indicated by a double patina) but they remain marginal (Turq *et al*. 2013; Gravina and Discamps 2015). However, the analysis of vertical projections remains the most powerful tool to demonstrate the invalidity of an archaeological sequence (Villa 1977; Cahen and Moeyersons 1977; Le Grand 1994; Bordes 2000, 2003; Mallye 2011; Discamps *et al*. 2012), by making it possible to test whether the dispersion of the remains occurs only within each archaeological level or, conversely, whether mixtures between several levels have occurred (**fig. 15**). Their analysis can reveal associations of remains caused by secondary displacements and not by gradual technological changes (or changes in subsistence strategy), and thus makes it possible to re-examine the question of possible cultural transitions (e.g. the Middle /



— FIGURE 15 —

Vertical projections of faunal refits (black lines) at La Chauverie and Camiac sites (Discamps *et al.* 2012). Perturbation seems minimal in case (a), with mostly subhorizontal refits that do not link the two assemblages (plotted in blue and orange), while mixture is more important in case (b), with a large number of vertical refits. The photographs on the right depict examples of a break conjoin (a, large bovid tibia) and articular connections (b, horse upper molars).

Projection verticale des remontages de pièces fauniques (lignes noires) dans les sites de la Chauverie (a) et Camiac (b) (Discamps et al. *2012). Les perturbations semblent minimales dans le cas (a), caractérisé par des liaisons subhorizontales à l'intérieur de chaque ensemble (figurés en bleu et en orange), tandis que le mélange est important dans le cas (b), avec un grand nombre de liaisons verticales. La photographie sur la droite montre un exemple de remontage d'une pièce fracturée (a, grand tibia de bovidé) et un exemple de connexions articulaires (b, molaires supérieures de cheval).*

Late Stone Age transition in Africa (Ivester *et al.* 2010; Staurset and Coulson 2014)) or the interstratification between different technocomplexes (Bordes 2003).

A high refitting rate of lithic artefacts indicates that (1) core reduction or shaping of bifacial pieces has taken place at the site and (2) much of the original archaeological material has been recovered. In contrast, the refitting rate does not bring clear information on whether the assemblage has undergone movements as sometimes claimed, since it depends essentially on the relative proportion of the total assemblage uncovered. However, a low refitting rate (i.e. < 10%) despite a large excavated area (as is usually the case for single-layer open-air sites) in a site where knapping likely took place strongly suggests that the archaeological material has been widely dispersed by geomorphological processes and that its integrity has poorly been preserved. Further experiments and simulations would be necessary to get more information on how to use the refitting rate in a taphonomic perspective.
Anatomical connections between bone elements in archaeological levels are often viewed as testifying to the lack of post-depositional movements (i.e. after their abandonment by humans) and, thus, to evidence for good preservation of the assemblage integrity and patterning. Such a statement is only partially true as tendon breakdown may last months or years, particularly in cold environments (Sutcliffe 1990). Laboratory experiments have demonstrated that articulated bones can be subjected to rapid movement caused by overland or fluvial flow as they have a larger surface area exposed to flow than isolated bones (Coard 1999). Therefore, bone connections themselves do not provide clear indication of potential disturbances that occurred before the complete decay of the organic matter.

4.2.5 | Chrono-cultural and ecological consistency

The analysis of the spatial distribution of lithic and faunal remains provides information on the homogeneity of an assemblage, notably when the vertical (stratigraphic) dimension is considered. Among all variables that can be explored to test the consistency of an assemblage, two are worthy of consideration: (1) the chrono-cultural consistency of artefacts, which allows for the identification of mixed and potentially diachronic chrono-cultural components, and (2) the taxonomic identification of faunal remains, which enable testing the ecological consistency of the faunal assemblage.
The evaluation of the chrono-cultural consistency is mainly based on the techno-typological study of the archaeological assemblages. The diagnosis depends closely on the state of knowledge of the different technocomplexes and the quality of preservation and analysis of the archaeological levels that serve as a reference for the definition of these technocomplexes. This state of knowledge, therefore, continues to evolve with new excavations and the re-evaluation of old series. Thanks to rescue archaeology, the multiplication of discoveries of open-air archaeological levels corresponding to time-limited occupations tends to demonstrate that a significant proportion of the assemblages originally used to define technocomplexes correspond, to some degrees, to condensed records or records with low chronological resolution and which, therefore, group together artefacts and ecofacts spanning a certain period. Furthermore, because of the existence of artefact types or chaînes opératoires with a long chronological distribution, the resolution that can be achieved by assessing chrono-cultural consistency may be low. This is particularly the case for a large part of the Lower and Middle Palaeolithic in Europe. The assessment of the chrono-cultural consistency of the remains that make up an archaeological assemblage is a usual method of analysis, but not without difficulties. The results obtained from this type of analysis must, therefore, be cross-checked with other types of information.

4.2.6 | Numerical dates

Numerical dates can often be used with profit for taphonomic purposes. It is indeed frequent to observe inconsistent radiocarbon ages within an archaeological sequence, either because they do not correspond to the expected age for a given technocomplex, or because the stratigraphic relationships between the dated objects do not conform to the ages obtained (stratigraphic inversion). However, the problem remains complex for radiocarbon, as many cases of inconsistency may be related to problems of pollution of samples by more recent organic matter (Mellars 2006). With the development of methods capable of eliminating most pollution such as ultrafiltration of collagen (Higham *et al.* 2006, 2011), the identification of stratigraphic inversions or outliers becomes more robust and makes it possible to highlight possible phenomena of artefact (ecofact) reworking and mixing in a sequence. The main limitation to this analysis is the need to ensure that the dated material has not behaved differently from the rest of the archaeological material. This can typically be the case for small charcoal fragments that are sensitive to water and wind transport.
For periods beyond the radiocarbon application limit, luminescence dating methods often provide a very valuable insight into the taphonomic history of a site. The combined use of thermoluminescence (TL) on heated flint or quartz and optically stimulated luminescence (OSL) on the sediments from which the archaeological pieces originate makes it possible to evaluate their contemporaneity, within the resolution limits of these methods. This type of analysis was applied to Lower and Middle Palaeolithic sites in loessic colluvium in southwest France (Hernandez *et al.* 2012) and showed unambiguously the association in the same level of pieces of different ages and for some, much older than that of the enclosing sediment (**fig. 16**). This suggests that, in a region where the density of Palaeolithic sites is high and sedimentation remained low during the Pleistocene, the reworking processes and association within erosional pavements of pieces of different age could be widespread.

5 | CONCLUSION

Perturbation assessment in the study of archaeological sites is still poorly developed. Significant progress can, therefore, be expected as research progresses in that direction. The development of additional tools, such as the analysis of refitting rates and the distribution and orientation of connection distances between pieces, should provide interesting information to complement the range of tools already available to understand site forma-

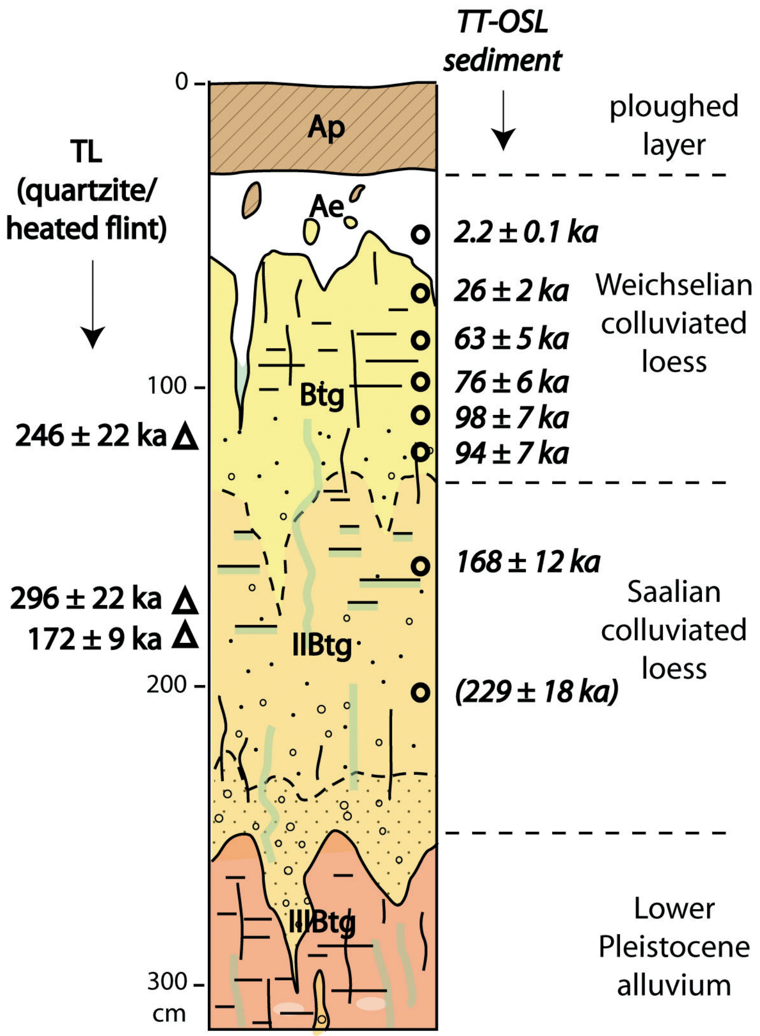


FIGURE 16

Stratigraphy and chronology of the Romentères site (southwest France), after Hernandez *et al.* (2012), modified. Some of the TL-dated pieces are significantly older than the enclosing sediment. The lower archaeological level corresponds to an assemblage of pieces of different ages. BT: Holocene (MIS 1) argillic horizon; IIBT: MIS 5 argillic horizon; IIIBT: polyphased argillic horizon.

Stratigraphie et chronologie du site de Romentères (sud-ouest de la France), d'après Hernandez et al. *(2012). Certaines pièces datées par TL sont significativement plus anciennes que le sédiment dans lequel elles sont incluses. Le niveau archéologique inférieur correspond à un mélange de pièces d'âge différent. BT : horizon argilique holocène (SIM 1) ; IIBT : horizon argilique SIM 5 ; IIIBT : horizon argilique polyphasé.*

tion processes. Similarly, the spatial, and particularly stratigraphic distribution of any variable recorded during the study of lithic, faunal or other material can yield information on the homogeneity and integrity of an assemblage. Nevertheless, one of the most crucial points is to obtain new experimental reference data on the transformations caused by both sedimentary and biological processes. To be truly exploitable, these experiments must use replicas of archaeological material and must make it possible to measure the disturbances suffered by assemblages with an initial pattern close to those known in archaeological sites.

Actually, one of the difficulties in using geomorphological data in archaeology comes from the fact that natural deposits correspond most of the time to accumulations of particles that have been transported over a long period and that have undergone several phases of remobilisation before being buried. A human occupation, on the other hand, results in the addition of new particles in a sedimentary context where specific organisations (grain size sorting, fabric, etc.) may already exist. This occupation will only be recognized as an archaeological site insofar as the redistribution of artefacts has been limited, in other words, if the site has only been exposed to flows (or other geological/biological processes) for a short time and has been rapidly buried. The use of experiments therefore seems the best approach to characterise the early stages of redistribution and obtain data that can be used in archaeology. Another important point is the generally flat morphology of archaeological artefacts (e.g. flakes, blades, fragments of long bones). This morphology has a significant influence on their behaviour towards different processes (frost jacking, flow, etc.), which cannot therefore be directly compared to that of natural gravel of generally rounded shape. In the current state, experimental data dedicated to archaeology are rather limited. This field of investigation is vast and an overview of possible types of disturbance is still far from being available.

Three important points with regard to the interest of taphonomic studies focusing on perturbation assessment in Palaeolithic sites must be underlined:

(1) A critical study of site preservation conditions must be undertaken prior to an in-depth spatial analysis of the remains that aims at reconstructing the settlement pattern. It is likely that many sites, after taphonomic analysis, do not prove to be reliable sources of documentation, because the impact of natural processes in the formation of the archaeological level was underestimated in the past. This point is all the more critical as the periods concerned are old and are associated with hominids whose cognitive abilities remain largely unknown.

(2) Detailed techno-economic and archaeozoological analyses are currently being carried out on Palaeolithic sites, in order to understand the management of lithic raw materials (and animal resources) on a site scale but also on a territorial scale (import - export of artefacts at various stages of production). These analyses only make sense if a taphonomic analysis can demonstrate that the assemblage integrity has been preserved and the lack of sorting by natural processes. Recent developments in particle size analysis of lithic material clearly indicate that this is far from being the general case.

(3) The hypothesis of a "gradual transition" from one culture to another, or between two faunal associations, in a site must rely on a thorough taphonomic study demonstrating that the observed pattern cannot be explained by post-depositional mixing of archaeological material.

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