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Lower Palaeolithic Core Technology and the Origins of the Levallois Method in North-Western Europe

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The appearance of Levallois technology ca. 300,000–250,000 years ago (oxygen isotope stage 8) is commonly used to define the Lower-to-Middle Palaeolithic boundary in Europe (see Ronen 1982) and arguably represents the only major innovation in lithic practices during the entire Middle Pleistocene of that continent (White and Pettitt 1995, Gamble 1999). Given the 300,000 years of stasis that precede it, this example of culture change is an event of singular importance that goes beyond lithic technology and may herald the emergence of more profound changes in hominid social, behavioural, and cognitive structures. Despite this, the origins of Levallois technology have of late been a remarkably neglected area of research.

Most recently published accounts of the origins of Levallois technology in Europe have tended to emphasize an *in situ* evolution from handaxe technology (Tuffreau 1995, Rolland 1995, White and Pettitt 1995; see also Debono and Goran-Inbar 2001 for the Near East). For Rolland (1995), the presence of finely made handaxes would have led almost inevitably to the accidental discovery of the Levallois method via large axial thinning flakes. Examples of such detachments (what Callow [1976] termed "pseudo-Levallois") can be observed in numerous Acheulean contexts, perhaps the best-known of which is at Cagny La Garenne, France (late oxygen isotope stage 12), where on occasion what appear to be preferential Levallois cores have been formed from handaxes broken during manufacture or sometimes from very thick complete handaxes (Tuffreau 1995). If such an emergence is accepted, then the development of Levallois technology in Europe would appear to have been a disjointed, multiphase affair involving the precocious but unstable mutation of handaxes (probably from the earliest European Acheulean) followed by the much later sedimentation and elaboration of the technique sometime around stage 8 (Rolland 1995). By stage 7 Levallois technology was widespread and all the currently documented variation was in place, suggesting rapid development, diversification, and dispersal (Tuffreau 1995). A completely different and quite separate evolution is described for Africa, where the Levallois method is suggested to have emerged gradually from simpler core-working strategies through a series of proto-stages (Rolland 1995).

While the timing of these events, especially in Africa, is still to be fully worked out, the picture of continuity in Africa combined with discontinuity and the apparent lack of any proto-stage in Europe ostensibly lends support to Foley and Lahr's (1997) "Mode 3" hypothesis. This advocates an exclusively African genesis for prepared-core technologies, with their subsequent introduction to Europe ca. 250,000 years ago as part of a major dispersal event by *Homo helmei*, proposed as the most recent common ancestor for Neanderthals and anatomically modern *Homo sapiens*. With this model Foley and Lahr explain the common use of Levallois technology by these two species in the Levant ca. 100,000 years ago but in doing so also implicate the Neanderthals more closely in the origins of anatomically modern humans, "modern" behaviour, and the African Middle Stone Age. In light of recent work on the Middle Stone Age (McBrearty and Brooks 2000), such a connection would demand a radical reevaluation of the way we look at the

European archaeological record from 250,000 years ago onwards.

This paper presents some observations on the technological origins of Levallois using the lithic assemblage from Botany Pit at Purfleet, augmented by some observations on the small collection of cores and refitting flakes from Frindsbury, England. It suggests that the core technology from these sites is a relatively simple and unrefined form of prepared-core technology geared towards attaining greater control over cores and their products; given their age and character it may be justifiable to call this "proto-Levallois" technology (Wymer 1968). (For present purposes we will adopt the slightly less loaded term "simple prepared-core" technology.) These conclusions carry implications for the origins of Levallois technology and the origins of the Neanderthals.

THE PURFLEET SITE

Purfleet is located in the Lower Thames Valley, 20 km east of central London. Since the 1960s a complex sequence of Pleistocene deposits has been exposed in a series of commercial pits (fig. 1). The deposits are interpreted to belong to an abandoned meander loop of the main River Thames and to form part of the Lynch Hill/Corbets Tey Formation (Bridgland 1994), which on lithological and biostratigraphical correlation spans oxygen isotope stages terminal 10 to early 8 (Bridgland 1994, Schreve et al. 2002). The sediments at Botany Pit consist of some 3.4 m of sand and gravel banked up against a Chalk river-cliff and are interpreted as the upper part of the complete Purfleet sequence seen in Bluelands and Greenlands Pits, dating to late stage 9/early stage 8 (i.e., > 300,000 years). Equivalent deposits in the neighbouring Greenlands Pit have provided an averaged age of 324,000 years by optically stimulated luminescence (Eddie Rhodes, personal communication).

The slightly rolled flint assemblage, recovered by Snelling in 1961 (Wymer 1968, 1985), is essentially a core-and-flake industry with few formal tools. Wymer (1968) described some of the cores from Botany Pit as proto-Levallois, and Roe (1981:228) too detected a much higher level of controlled flaking and considered some to represent a "reduced" Levallois method. Included in the Botany material are a small number of handaxes, recorded by Snelling as coming from the base of the Botany sequence and reportedly resting directly on Chalk. They probably predate the core-and-flake assemblage, and it seems likely that they are the final occurrence of the Acheulean industry represented in the Middle Gravel (the Bluelands Gravel of Schreve et al. 2002) in other pits from the area.

CORE TECHNOLOGY AT BOTANY PIT

The study of Lower and Middle Palaeolithic cores has undergone a dramatic shift in emphasis in the past 20 years (Boëda 1986, 1995; Chazan 1997; Ashton 1992, 1998), moving from an essentially typological approach (study of final form) to an explicit concern with technology (study of process). This is especially evident in the study of the Levallois method. Advocates and opponents of the two approaches are equally divided over several issues (cf. Boëda 1988, 1995; Dibble 1989; Van Peer 1992, 1995; Schlanger 1996), but the technological school has nevertheless succeeded in identifying a set of clear and replicable criteria for recognizing the Levallois concept that potentially avoids the major interanalyst variation and ambiguity that plague the typological approach (see Perpère 1986). It has also extended the boundaries of Levallois technology to subsume far greater variation than previously recognized (see Boëda 1986, 1995; Boëda, Geneste, and Meignen 1990; Chazan 1997). A technological approach is adopted here.

A total of 268 cores from Botany Pit from the Snelling Collection at the British Museum were examined during the present study. The cores can be classified into three basic operational schemas, although there is undoubtedly a continuum of variation in the approach to each of them.

The largest category (49%) can be described as migrating-platform cores of the kind that typify Lower Palaeolithic technology in Europe. The working of these cores consists of one or more sequences of flaking (core episodes), each episode involving single, parallel, or, most often, alternate flaking (Ashton 1998). Knapping generally proceeds in a varied and organic fashion, with the evolving morphology of the core strongly influencing the location and character of each core episode. The resulting cores vary enormously in morphology and the degree of working, have a diverse range of platforms, and are frequently quite chunky. The intention behind this type of working appears to be the removal of medium-sized flakes, which, because of the predominant use of alternate flaking techniques (cf. Ashton 1992, 1998; Ashton and McNabb 1996), tends to operate in an invasive fashion by removing material from the body or volume of the core.

The second category (43%) consists of cores previously described as proto- or reduced Levallois and clearly differs from the above in both concept and form (figs. 2 and 3). Flaking has been directed at the removal of large flakes, mainly in parallel sequences from single or adjacent platforms but sometimes in multiple or opposed directions. Rather than migrating around the core in pursuit of appropriate angles wherever they emerge, flaking is more controlled and is organized around a plane of intersection that defines a striking-platform surface and a flaking surface. Flakes are detached more or less parallel to this plane and remove material from the *surface* of the nodule rather than from its volume. Typically these cores show almost no preparation of either the flaking surface or the striking-platform surface. The striking platform was often simply created using one or more bold removals and then a series of flakes was removed from that platform, often along the long axis of the nodule. The resultant cores are generally flat, and the negative scars testify to the production of elongated flakes. Where more than one platform has been exploited, the same methods are repeated on other parts of

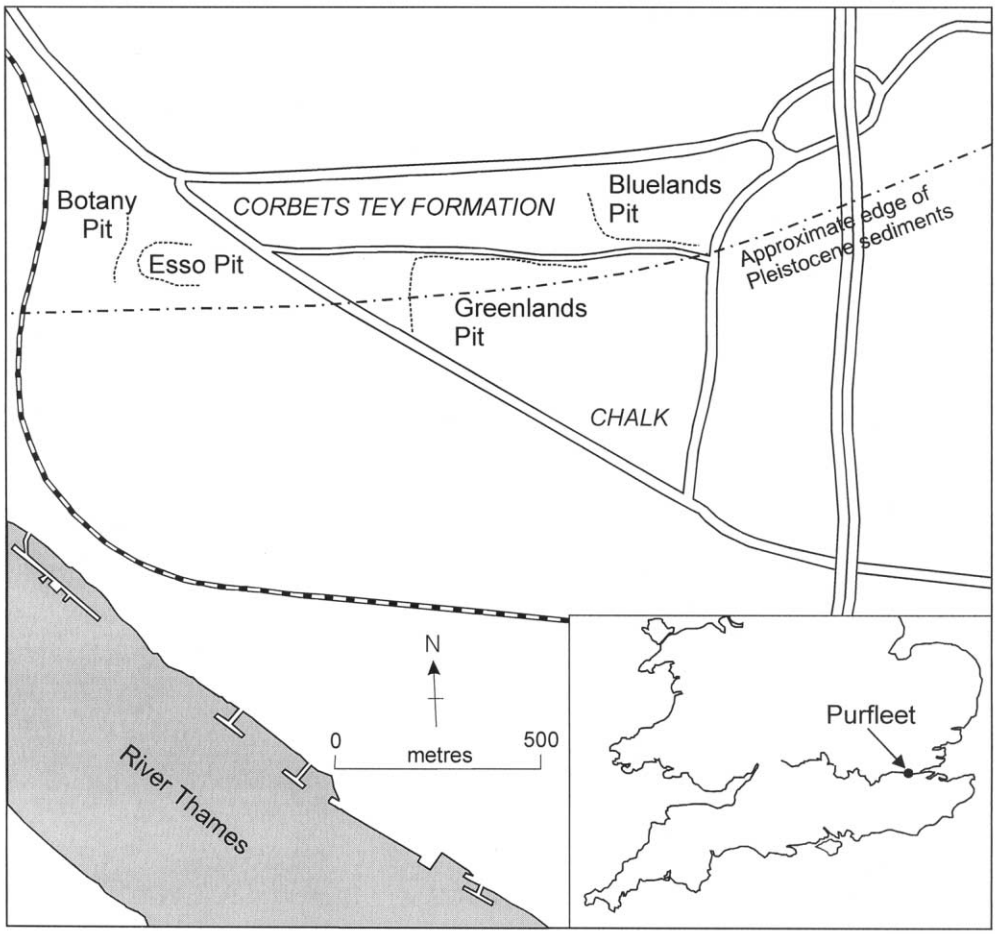

FIG. 1. *Location map.*

the core, and the relationship between flaking surface and striking-platform surface is preserved. In these cases, flaking from one platform dominates, but this is not necessarily the last platform created. The number of removals from each platform is difficult to gauge, although the evidence from the cores shows that two or three flakes per platform can be considered a minimum. As part of this group, 8% of the assemblage mimic classic Levallois by showing a final preferential removal. In most cases the final configuration of the core depends entirely on the removal of a large final flake from an otherwise non-Levallois core. However, two cores do display the features of classic tortoise-cores and may be quite deliberate.

The third category of core (8%) would generally be described as discoidal (Boëda 1995). Reduction was aimed at the removal of a series of flakes detached centripetally from two flaking surfaces situated above and below a plane of intersection. The surfaces are nonhierarchically organized, acting as both a flaking surface and a striking-platform surface, and the plane of intersection defines a hinge that extends around the perimeter of the core and around which knapping takes place. While these differ from both the other core types in form and conception (see Boëda 1995), the distinction is not always technologically or typologically clear, and in some cases the final form may be a fortuitous result of another reduction strategy.

Although three methods of core reduction have been identified, it has proved difficult to distinguish characteristic flakes that result from each flaking method. There are more than 3,500 flakes from Botany Pit, and most of them display between two and four dorsal flake scars that tend to originate from a proximal or sometimes lateral direction. The butts are usually plain, occasionally dihedral, and never faceted. One would expect flakes resulting from the simple prepared cores to be slightly larger and slightly longer than those produced by other techniques, and large laminar flakes do exist within the collection. In practice, however, and in the absence of refits, it would be unwise to identify all of these as coming from such cores, especially given the probable mixed nature of the assemblage. As few diagnostic flake types seem to emerge from this type of core reduction, we

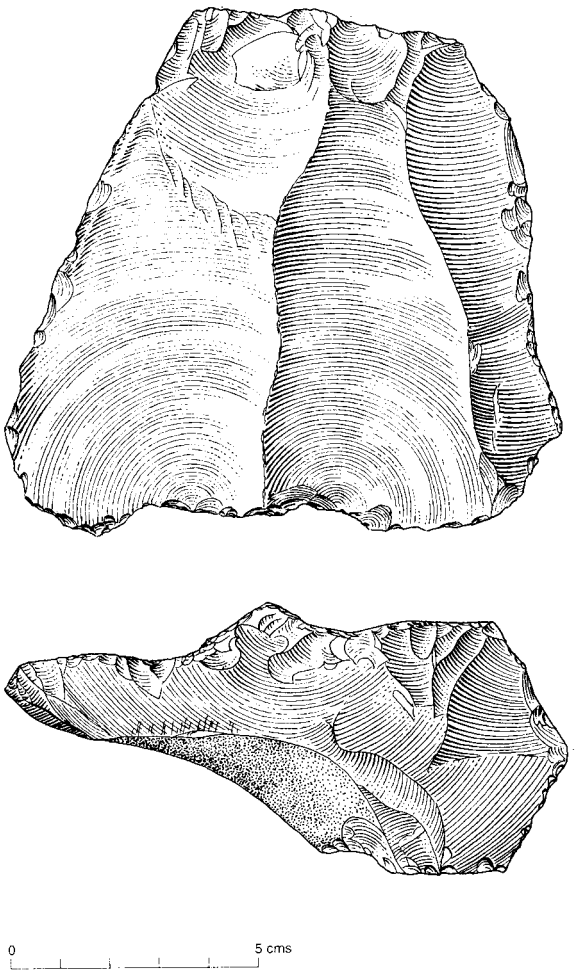

FIG. 2. *Simple prepared core (proto-Levallois) from Purfleet.*

suspect that the purpose of this technique was not so much to determine the precise form of the flakes as to control the volume and thereby the productivity of the core, producing a greater number of larger flakes from each nodule.

An indication of the type of flake that results purely from simple prepared cores can be found at the site of Frindsbury, Kent (Cook and Killick 1924). This poorly dated site produced an assemblage in fresh condition from a hollow within chalky drift directly above Chalk. Here, 14 of the 16 cores are of the simple prepared type, and they are associated with 478 flakes and 2 handaxes. The cores are identical to those from Purfleet, with the clear intention of flaking across surfaces, again from one or more platforms. As this is the dominant reduction method, the flakes clearly result from this type of flaking and, while falling into the range of variation seen within the amassed Purfleet sample, are distinguished by their comparative elongation and the predominance of a unilinear flake scar pattern. This is illustrated by a group of five refitting flakes (fig. 4), all knapped from the single, plain platform and presenting no evidence of preparation on the flaking surface. This type of flake certainly occurs as part of the Purfleet assemblage.

The refitting, fresh condition, and context (Cook and Killick 1924) suggest that the Frindsbury assemblage represents a relatively short phase of activity and reveals a narrowly defined set of core reduction practices. In contrast, the more complex stratigraphic situation at Purfleet, together with the greater and more variable condition of the artefacts, suggests the intermixture of several assemblages, which may explain the wider variety of core reduction strategies evident.

IS THERE LEVALLOIS TECHNOLOGY AT BOTANY PIT?

Previous descriptions of the Purfleet simple prepared cores have emphasized their similarities to Levallois cores (Wymer 1968, Roe 1981). The key question here is whether they can be considered to conform technologically to the Levallois concept *sensu* Boëda (1986, 1995; cf. Chazan 1997). Boëda has identified a limited number

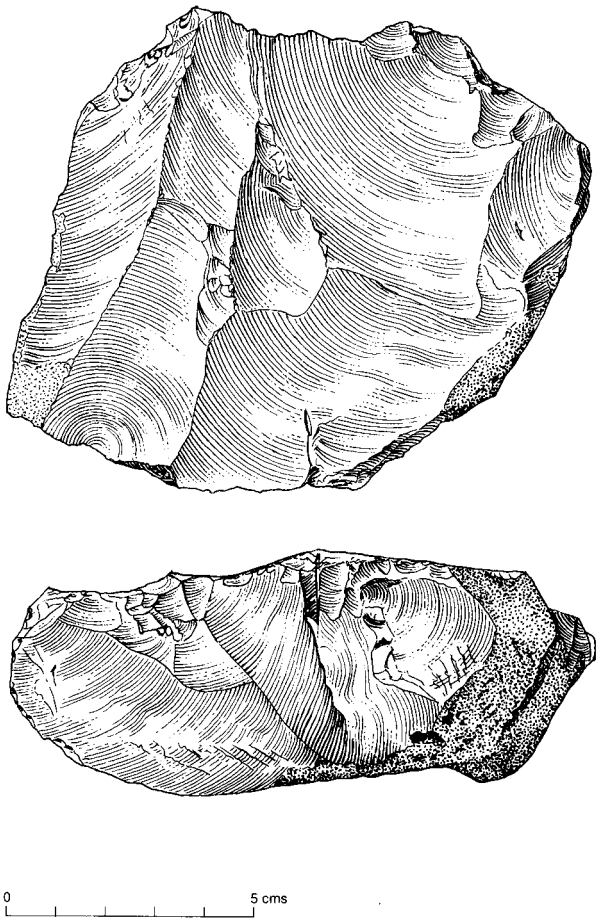

FIG. 3. *Simple prepared core (proto-Levallois) from Purfleet.*

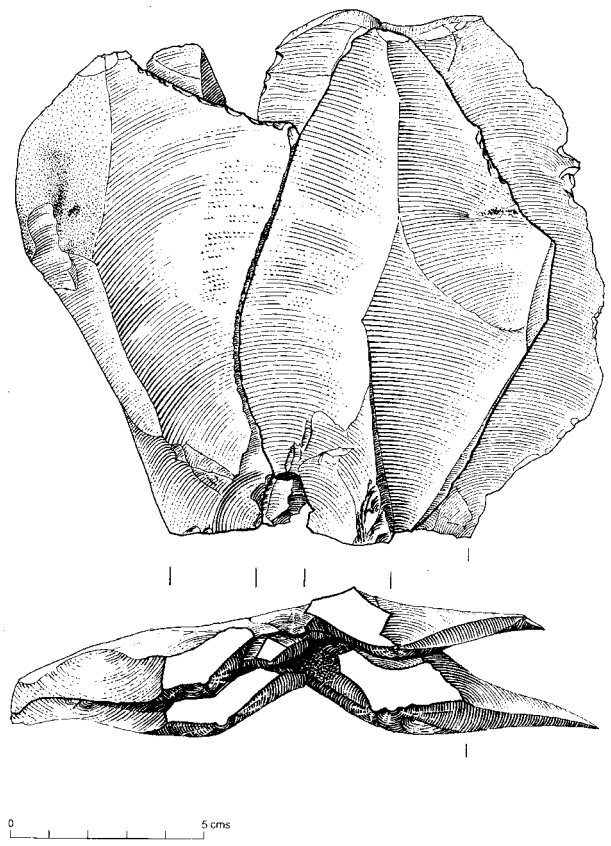

FIG. 4. *Group of refitting flakes from a "proto-Levallois" core from Frindsbury, Kent.*

of technical and geometric principles that underwrite all Levallois production (fig. 5). These principles *are absolutely constant*, but the manner in which they are executed and the initialization phase may vary, thus producing the range of variation now evident within Levallois technology. The simple prepared cores from Purfleet certainly conform to the Levallois concept in a number of important respects. The volume of the piece is conceived as two surfaces separated by a plane of intersection (criterion 1), and these surfaces are hierarchically related, one being a striking platform surface and the other a flaking surface (criterion 2). The fracture plane for the removal is broadly parallel to the plane of intersection (criterion 4), and the junction between the flaking surface and the striking platform (the hinge) is perpendicular to the axis of percussion and oriented to allow the removal of flakes from the flaking surface (criterion 5). Flaking is also exclusively done with a hard hammer (criterion 6). However, the Purfleet conception also differs from the strict Levallois concept in several respects. Most important, the flaking surface does not show the maintenance of distal and lateral convexities (criterion 3), and the preparation of either surface is minimal. Overall, the cores appear technologically underdeveloped and procedurally truncated, especially when compared with classic Levallois cores. The core and its products are certainly under some control, and reduction is clearly geared towards removing large flakes from a surface rather than a volume (Boëda 1995), controlling the size of the product and the productivity of the core. Still, they do *not* appear to conform strictly to the Levallois concept.

If one or more of the underwriting principles is absent, can the technology still be considered Levallois? The same question was asked by Kuhn (1995) in his analyses of Pontinian Middle Palaeolithic assemblages from the Latium coast of Italy. Kuhn provided details of "prepared platform cores" that fulfilled some criteria of the Levallois concept but not others; like the Purfleet simple prepared cores they did not maintain distal and lateral convexities of the flaking surface (criterion 3) and had only limited core preparation and weak predetermination. Kuhn suggested that this might be a Levallois strategy stripped down to its essentials (i.e., two hierarchically related surfaces separated by a plane of intersection) to exploit the natural convexities of diminutive pebble blanks. This may be similar to the case of the stage 5/4 site of Saint-Vaast-la-Hougue, France (Guette 2002) where, using poor-quality beach pebbles, the convexities of the cores were minimally maintained but flakes were removed with clear platform alteration and preparation.

In contrast, Chazan (1997:732) suggests that because criterion 3 requires only that the two faces be organized in terms of convexities, not that they be shaped into such, then Kuhn's material, perhaps that of Saint-Vaast-la-Hougue, and by implication the Botany material are Levallois products. However, as far as we can see, organizing two convexities is tantamount to shaping.

It is shaping that immediately leads into the issue of predetermination or intentionality. Although this concept is popularly perceived to be inherent in the Levallois strategy, it has been disputed by some writers, particularly in questioning the Levallois method as a means of producing "privileged flakes." Davidson (2002) uses Van Peer's refitting work, which showed that many preparatory flakes were absent from knapping floors at several sites in Egypt, suggesting that Levallois flakes were not necessarily the desired end product. By contrast, many "final flakes" were simply abandoned at the knapping site. However, Van Peer (1992:114) provides several reasons that the Levallois strategy is an intentional act designed to produce large flakes (not necessarily of uniform shape and size). The strongest arguments are the abandonment of perfectly good cores after the production of a "last" large flake and, conversely, the repetition in flaking arrangement in instances where cores are reprepared to provide more than one such flake. He also cites examples from Nazlet Safaha 1 in Upper Egypt which contain a number of preparatory elements but no Levallois cores and flakes, the inference being that the preparatory and final stages have occurred in different parts of the site or elsewhere. He also warns against uncritically equating missing elements with human agency rather than excavation or refitting biases. In essence, the pro-

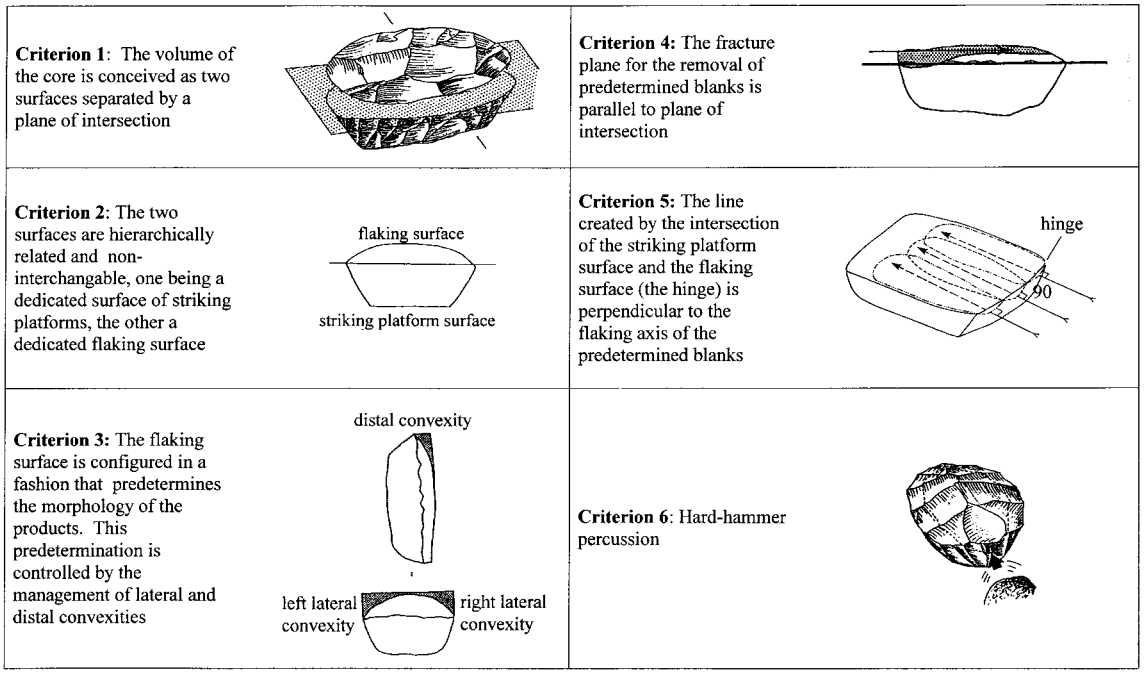

FIG. 5. *Boëda's technological criteria for identifying the Levallois method (drawings modified after Boëda 1995).*

duction of a large flake does not automatically reduce all other flakes to unwanted waste, and, while we might expect Neanderthals to have selected a range of flakes for future use, depending on need and context, this does not mean that the final large flake was unintended and unwanted.

Dibble (1989) takes a slightly different line, using a technological analysis of flakes from five sites in southern France to cast doubt on the degree of predetermination present in Levallois products. His data demonstrate that Levallois products are just as variable in terms of shape and size as non-Levallois flakes and handaxe thinning flakes, leading him to conclude that the Levallois method is a reductive strategy designed to extract many serviceable flakes from a single core rather than a single desired end product.

Chazan (1997:727) provides a neat précis of the current situation, suggesting that we do not know what the expectations of the knapper were in terms of predetermined flakes and by-products but we can surmise that the entire project of knapping was carried out with a specific plan of action and some knowledge of the end product. Our analysis and, we would suggest, that of Van Peer and Boëda are consistent with this conclusion.

In the case of Purfleet, then, there is a degree of intentionality in the sense of a specific plan of action designed to produce a series of large flakes but not predetermination through the shaping of the surface of cores (criterion 3) to produce one or more privileged or standardized flakes. We are therefore left with a number of options. We could insist that the Purfleet simple prepared cores are merely stripped-down Levallois cores (as with the Pontinian?) stimulated by particular ecological, economic, or other local social factors. In this case what we see at Purfleet is stripped-down variations on lineal Levallois as well as unidirectional and bidirectional recurrent Levallois. While this conclusion might be acceptable within the limits of the already expanding Levallois concept, it would really only serve to defy attempts to study the Lower-to-Middle Palaeolithic transition and render the identification of a proto-stage impossible. Furthermore, in contrast to the Pontinian example, there are no obvious reasons here for a stripped-down Levallois technology to have been used. Raw material was probably abundant at the site, as the river was actively eroding the Chalk river cliff, and there are no obvious differences in raw materials between the core types described above. From residual cortex on the cores it would seem that the original nodules were medium-sized to large (20–25 cm) and not particularly flat, so this cannot be the reason simple prepared-core technology was used. Equally, the cores were rarely used to exhaustion, so shortage of raw material would not appear to have contributed to reduction strategy; on the contrary, Wymer (1985) described the use of flint at Purfleet as extravagant, a factor which in itself might have elicited a less rigid approach in some cases but surely cannot explain the frequency of these cores in a single assemblage and their absence from equally flint-rich horizons elsewhere in the local area.

The age, position, and technological parsimony of the Purfleet simple prepared cores favour an alternative. The Purfleet cores can be seen to represent a proto-Levallois technology stemming from two very simple conceptual innovations in core reduction: the plane of intersection and hierarchically organized surfaces. These two factors dictate the configuration of the core, and it is from them that the level of control apparently exercised over the method of flaking, the core and its products, and the associated technological complex all emerge, without necessarily being fully developed Levallois technology (see Kuhn 1995).

A selection of other western European sites (far from exhaustive) broadly contemporary with or slightly younger than Purfleet displays a similar approach to core reduction and supports such a conclusion. The Drenthian (stage 8) site of Markkleeberg, Germany (Baumann and Mania 1983, Svoboda 1989), contains a number of cores showing similar technology alongside a number of other Levallois methods. As at Purfleet, the poor stratigraphic resolution at this site may be responsible for such a mixture. Early prepared-core technology has also come from the site of Mesvin IV, associated with a cool, steppic fauna and attributed to the early Saalian (stage 8) (Cahen and Michel 1986), while at Argoeuves (Lower Terrace Complex of the Somme, stage 8) unidirectional and bidirectional techniques have been used to produce series of laminar blanks (Tuffreau 1982, 1995) similar to those from Purfleet and Frindsbury. Rolland (1995) has summarized a wealth of literature that hints at a proto-Levallois phase in La Micoque levels 3 and 4; electron spin resonance dates for the higher level 5 have provided minimum age estimates for levels 3 and 4 ranging from 241,000 to 288,000 years. Further claims have been made for the site of Korolevo, Ukraine, where proto-Levallois cores have been identified as coming from levels that have been thermoluminescence-dated earlier than 360,000 ± 50,000 ago (Adamenko and Gladiline 1988).

The best example, however, comes from Orgnac 3, France, which is dated to 350,000–300,000 years ago (Moncel and Combier 1992). Here the basal levels (7–6) show a variety of non-Levallois methods, including a hierarchically organized centripetal technique, with prepared-core technology first appearing as a numerically low "complementary method" in level 5b. In its earliest manifestation it is generally unipolar or bipolar, its overall configuration suggesting to the primary workers a method that was controlled but whose rules were "*not fully standardized* " (our emphasis). By levels 4a and 4b fully fledged and formalized Levallois technology is seen, with diversification in the method to include most of the variants identified by Boëda. What we seem to have at Orgnac 3, then, is the gradual emergence, diversification, and standardization of an evolving technological practice *in Europe* as an elaboration of methods already in place.

Taken together these show a persistent and distinct change in approach to core reduction in which, in contrast to much Lower Palaeolithic flaking, consideration is given to core surfaces and volume. Although the resulting flakes are only weakly predetermined, there is a clear element of control over the evolving core and its products. From the sites listed above this key change seems to occur across Europe from about 300,000 years ago, with the full suite of variation visible by ca. 250,000–200,000 years ago. The technology at these very early sites, then, suggests that the emergence of the Levallois method in Europe was gradual, involving the initial reorganization and recombination of core technology to establish a basic level of controlled flaking, followed by refinement, elaboration, and diversification towards a full Levallois concept.

DISCUSSION

Stone tool technology can be divided into two overarching operational systems: systems of flaking (*debitage*), in which the aim of the action is primarily to divide a volume of material into smaller usable units (i.e., flakes), and systems of shaping (*façonnage*), in which reduction is primarily geared towards reducing a mass of material using a complex of interrelated flake scars so that the remaining volume takes a desired form (see Boëda, Geneste, and Meignen 1990; Baumler 1995). In the first system the core—the nucleus of the nodule—is essentially waste and flakes are the desired result, while in the second system the situation is reversed.

In the Lower Palaeolithic, these two systems are essentially separate, operating according to different conceptual principles and for different purposes. The ambiguous "chopper-cores" notwithstanding, *façonnage* is predominantly manifest as bifaces, based around a plane of intersection separating two interdependent surfaces that may be hierarchical or non-hierarchical, biconvex or plano-convex, depending on the precise operational chain and blank type used (Boëda, Geneste, and Meignen 1990). There is no distinction between predetermining and predetermined flake removals, but the important point is that the two surfaces are organized in relation to each other. Reduction is oriented towards the removal of flakes from the surface of the piece so as to thin and shape an inner volume. Some question remains about the status of handaxes made on flakes, which for Boëda et al. represent examples of *débitage*. In contrast, we see the initial act of *débitage* (i.e., striking the flake blank) as being followed by the shaping of an internal volume to fulfil a mental construct, indicating to us that the last phase in the production and end result of action is actually *façonnage*. Whether or not this is conceptually correct, the most important issue here is that the two procedures are separate sequential steps in the biography of the object; the technology is non-reflexive.

Similarly, Lower Palaeolithic *débitage*, prior to oxygen isotope stage 9/8 (in Britain at least), is most often operationalized according to the migrating-platform concept. This is the simplest way of working a core, showing many varied and interchangeable platforms, no fixed plane of intersection, no hierarchically organized surfaces, little control over flake dimensions, and the working of a volume rather than a surface. Only the much

rarer discoidal or centripetal cores deviate from this general pattern, having a plane of intersection separating flaking and striking surfaces, although to what extent these are fortuitous rather than a product of blank shape is debatable (see, e.g., Orgnac 3, where centripetal cores are common but are produced on flint plaquettes—a case of blanks' dictating a technique or blanks' being selected to facilitate a technique?).

The differences evident in the Purfleet and other simple prepared cores can be described in these terms: as an elaboration of *débitage* brought about by the systematic application of concepts (i.e., plane of intersection and hierarchical interdependent surfaces) that had previously been most common, if not quite unique, to *façonnage* (White and Pettitt 1995). Rather than evolving directly from handaxes (Rolland 1995, Tuffreau 1995) or arriving fully formed courtesy of immigrant African hominids (Foley and Lahr 1997), both of which would demand no proto-phase, prepared core technologies originated *in situ* within north-western Europe (at least) through a gradual transformation of existing core technologies and a fusion of elements of both *façonnage* and *débitage*. In short, the development of the full Levallois concept represents for us the erosion of boundaries between and the integration of two existing systems, the practical fusion of *façonnage* and *débitage* into a new dynamic. While the final purpose was undoubtedly the production of select flakes, in our view it cannot be considered exclusively in terms of *débitage*, as it contains an elaborate shaping phase clearly aimed at controlling the form of an inner volume. But neither is it a system of *façonnage*, as the shaping of the core is only a means to producing desired flake blanks. In the Levallois method the core is involved in a reflexive interplay of these two concepts, constantly morphing from structured shaping phases to production phases; the rigid distinction between operational schemas seen earlier collapses and constructs that had been conceptually separate merge into one unified and highly flexible concept. That the products of early Levallois technology were used unmodified and to produce both scrapers and handaxes (with minimal modification) and that, in the wake of its emergence, handaxes tended to phase out in some regions serves to demonstrate the nature of this fusion and fundamental restructuring of technology. However, standard systems of *façonnage* and *débitage* do not disappear as redundant technologies but continue to exist alongside Levallois technology at various temporal and spatial scales.

If our reading of the Purfleet materials and its implications are valid, then there is an *in situ* evolution of Levallois technology in Europe via at least one proto-stage. This evolution parallels but is unrelated to the trajectories documented for Africa (Rolland 1995), where stochastically occurring examples of prepared-core technologies may extend back into the Lower Pleistocene, although Vermeersch's (1995) survey of the Northern African evidence failed to find any Levallois technology older than or even as old as that found in Europe. Given that a small and fairly simple mutation of technologies that had existed since the beginning of the Acheulean/Developed Oldowan is required for prepared-core technologies to emerge, we must entertain the notion of many unrelated, polyphyletic "origins" of the Levallois method at different times in different places and in different ways (see Bordes 1971, Rolland 1995). In other words, Levallois is immanent within the Acheulean.

The Near East is a case in point, for here cores falling into categories of "proto-Levallois" and "flat debitage" are evident perhaps as early as 560,000 years ago (Copeland and Hours 1993), with a few of the latter somewhat resembling the Purfleet cores. By the Late Acheulean, non-Levallois flat-debitage cores identical to the Purfleet materials are found at sites such as Azraq C-Spring, Jordan, tentatively dated to ca. 225,000 years ago (Copeland 1989, 1991, 1995). Equally, though, an emergence from handaxes has been proposed at Tabūn (Debono and Goran-Inbar 2001). This brings us back to the precocious European Levallois reported at Cagny La Garenne (Tuffreau 1995), where broken handaxes were exapted into cores that because of their origins of course possess some of the characteristics of handaxes. Although they may therefore fortuitously resemble Levallois products, they still serve to reinforce the technical fluidity of *débitage* and *façonnage* within prepared-core technology. India provides a further example of its pedigree and diversity. At the Isampur Quarry in the Hunsgi Valley, Petraglia, Schuldenrein, and Korisettar (n.d.) describe "prepared" cores made on large boulders worked around their perimeters, designed, they argue, to produce a large flake suitable for supporting a side-struck cleaver. Moreover, in the Malaprabha Valley these researchers have described "transitional" assemblages that show an unbroken flow from Lower Palaeolithic to Middle Palaeolithic technology. The shift is gradual, indicating that prepared cores have their roots in the local late Acheulean and that the transition from the Lower Palaeolithic to the Middle Palaeolithic is a gradual one.

Like most transitions, then, the emergence of prepared-core technologies was probably a matter of short bursts of frenzied innovation and variation with frequent "failures" and the eventual sedimentation and stasis of a successful form (Gould 1989, Goren-Inbar and Belfer-Cohen 1998). While the above examples nicely demonstrate that Levallois technology is immanent in Acheulean knapping practices, they also call into question the idea that it always emerged directly from handaxe manufacture as is widely presumed. The link lies in the principles and concepts underlying tool manufacture, not necessarily in the tools themselves; it is perhaps no surprise, then, that in areas that largely lacked these concepts (and by default show a paucity of the characteristic tools of the Acheulean, e.g., China [see Schick 1994]) Levallois technology never fully developed (Gao and Norton 2002).

The emergence of Levallois technology in Europe is not simply a restructuring of core technology. The transition may also be marked by other (diachronous) changes in technological practices. Although handaxes seem to be phased out in many areas as flake and flake

tool production increase (see Goren-Inbar and Belfer-Cohen 1998), in some areas they are retained at some level while in others (such as Germany) they actually increase dramatically. Moreover, those areas and phases that see the continued production of handaxes also seem to witness changes in their basic functions. The growing evidence from use-wear and site association suggests that handaxes in the Lower Palaeolithic are predominantly butchery tools (Keeley 1980, Villa 1990, Mitchell 1995, Austin et al. 1999). The overall aim seems to be the production of sharp-edged, symmetrical cutting tools, where the edge and the volume of the piece form a unified whole (Ashton and White 2001). In contrast, it has been suggested by Boëda, Geneste, and Meignen (1990) and J. Gouédo (personal communication) that Middle Palaeolithic bifaces should be understood through the distinct concepts of volumetric shape (encompassing the prehensile qualities of the tool) and the specific functional edges of the tool. They argue that in some industries (e.g., the Micoquian) bifaces had become the support for other tools, contained different functional areas on different edges of the same piece, and were the subject of resharpening. This flexibility in function has also been noted by Turq (2000:207–11) and Soressi and Hays (2001) on Middle Palaeolithic bifaces from France, where edges that serve as scrapers and notches are imposed on bifaces or bifaces are converted into cores. As with the Levallois method, there seems to be a breakdown of the distinctions between *façonnage* and *debitage*, with tools once produced from *debitage* now being produced as part of *façonnage*. As a result, technology becomes more flexible.

The changes in lithic technology are accompanied by a suite of wider changes related to the overall process of Neanderthalization. The lithic *chaîne opératoire* is arguably extended in time and space, involving greater mobility and higher levels of curation, with Levallois products being notably "mobile" (Geneste 1985, 1989; Féblot-Augustins 1999). Geneste (1985, 1989) had demonstrated that in south-western France Levallois products often occur on raw materials showing longer transport distances, testifying to a greater degree of curation for this technology. This has led White and Pettitt (1995) to argue that the Levallois was specifically a technology geared towards greater mobility. These patterns are partly reflected in the overall distances of lithic transfers in the Middle Palaeolithic (Roebroeks, Kolen, and Rensink 1988), with distances of up to 120 km in western Europe and up to 300 km in eastern Europe. While the general distribution and patterns of lithic transport in the Lower Palaeolithic and the early Middle Palaeolithic are comparable, suggesting behavioural continuity (with greater differences existing between the early and late Middle Palaeolithic), they nevertheless show some evidence for a greater variety of movement and curation (Féblot-Augustins 1999). At the same time, from oxygen isotope stage 8/7 there seems to be progressive adaptation of humans to more open and at times cooler conditions, in particular the rich semi-arid environments of the mammoth steppe (Ashton and Lewis 2002, Ashton n.d.; cf. Guthrie 1990). One effect may have been a shift in settlement patterns, with human populations surviving better on the mammoth steppes of the east in warmer phases, tracking the westward expansion of the steppic biomes as climate cooled, and retreating to southern refugia during glacial extremes. Furthermore, the distribution and movement of herds in the more open landscapes would have required greater mobility of human populations and new strategies for dealing with the exploitation of such resources. This is reflected in the faunal record, with specialization in hunting noted increasingly from stage 7 onward (Gaudzinski 1995, 1996, 1999; Scott 1986; Jaubert et al. 1990; Stiner 2002).

These shifts in hunting specialization, mobility, and settlement pattern were probably accompanied by changes in group organization and size (Ashton and Lewis 2002). Other than from the faunal record, changes in group size might also be recognizable at early Levallois sites. The richest sites tend to concentrate around sources of very abundant raw materials, and the very dense concentrations suggest either very frequent visits to key resources or exceptionally large gatherings. If the latter, then the origins of Levallois technology might be underwritten by changes in the way in which systems of flake production were used in the social sphere, perhaps becoming more critical to the construction of social life—a role some believe was previously dominated by handaxes (Kohn and Mithen 1999; cf. Gamble 1999). Such an explanation might well help explain the elaboration of simple prepared cores into full Levallois products and the eventual sidelining of the handaxe. Given the previous hundreds of thousands of years of stasis, in which innovation is muted and rarely sedimented, all of this must be underwritten by changes in the mechanisms of social transmission (see Mithen 1994) and the power of agents to bring about lasting change in cultural structures (Hopkinson and White n.d.). Taken together, these show that the emergence of Levallois technology does not signal a simple technical shift to be explained in a monocausal fashion but is the lithic incarnation of a multifaceted transformation in human societies and their organization at this time that may herald the evolution of the Neanderthals and their modes of action.

CONCLUSION

The simple prepared cores from Purfleet represent a proto-Levallois technology dating to oxygen isotope stage 9/8. The cores demonstrate the employment of hierarchically organized surfaces separated by a plane of intersection and a volumetric core concept. This represents an innovative conceptual leap whereby principles previously limited to systems of *façonnage* are exapted to systems of *debitage*, presaging the development of the more sophisticated and finely controlled Levallois methods of the later Middle Palaeolithic. For us it is this *incorporation of difference* (Hopkinson 2001), the fusion of principles taken from two distinct operational systems, that characterizes the Middle Palaeolithic technology, leading to far greater variation and flexibility in

both core reduction and tool production than that witnessed in the Lower Palaeolithic. This is not necessarily the only route to Levallois technology, but it is one that may have had many different expressions before finally becoming integrated into the variety of techniques now recognized. Most important, the examples cited give a strong impression of continuity rather than abrupt change in technical practices in Europe and a suite of associated changes that are progressive rather than abrupt. This does not, of course, refute Foley and Lahr's suggestion of an exclusive African origin, but it leads us to question the arrival in Europe of a fully developed system in the hands of a group of dispersing hominids equipped with the skill and knowledge to practice it. It is, however, interesting to note that when it finally takes hold the Levallois method appears to occur almost simultaneously across Europe, the Near East, and Africa. This may well be a problem with the resolution of our dating, which through time averaging often contemporarizes events that are in reality separated by tens of thousands of years, but if real it shows that even if hominids were not moving, ideas and techniques were being transmitted through extensive social networks of the supposedly small and isolated human populations. The origins of Levallois technology and the changes that accompanied it have remained a neglected area of research that has cognitive, behavioural, and social implications and clearly warrants a global program of multidisciplinary investigation.

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