8 Analysing Lithics

The best preserved and most abundant evidence for 95% of the human career consists of stone tools and the debris left from making them. Needless to say, archaeologists have spent considerable time and effort learning how to interpret this evidence.

In this chapter we will consider briefly the technology of stone tool production, the description of lithic artifacts, sourcing lithic raw materials, the replication of simple tools, the determination of tool use, problems posed by post-depositional alteration of lithics, and the questions of economy and style in stone tools. We will concentrate on tools that were shaped by flaking, but will briefly deal with tools made with other reduction techniques, such as grinding. Readers interested in lithics should refer to some of the works listed among the references, especially Andrefsky (1998), Debénath and Dibble (1994), Inizan et al. (1992), and Whittaker (1994).

La Chaîne Opératoire

There are many ways to approach the study of stone tools, including a long-standing typological approach that focusses on the form and retouch of finished tools. Many researchers today use primarily a technological approach, sometimes emphasizing the sequence of activities that were involved in the production of artifacts (e.g., Schiffer 1976). Recently, one such approach for studying lithics and, indeed, any kind of artifact, called the **chaîne opératoire**, has gained prominence. This "operational chain" refers to all the processes involved in people's use of materials, from the discovery, selection, and processing of raw materials, through manufacture, use, and reuse of artifacts, to recycling and eventual discard of the artifacts, their remnants, and the debris from their manufacture. Unlike some similar approaches, it also refers to the strategies that people use in these processes, the decisions they make at each stage, and the "gestures" they have learned through immersion in their culture. For archaeologists, it is a methodological framework for helping to understand variability in lithic and other assemblages or to "read" the signs left by the decisions of the tools' makers and users (Chazan, 1997; Inizan et al., 1992:12-13; Sellet, 1993).

When applied to lithics, the chaîne opératoire approach treats flint-knapping as a subsystem of a larger technological system. It considers the particular characteristics of tools, manufacturing debris, and other debris as the result of physical actions and people's motor abilities, and of skills (*savoir faire* or know-how), knowledge (*connaissance*) and experience, as expressed in ability and performance.

Lithic Raw Material

One of the principal limitations on the manufacture of stone tools is raw material. The makers of stone tools appreciated the differences that raw materials made to ease of flaking, sharpness of edge, tools' ability to hold an edge, and even aesthetic appearance. One indication of this is that tools that appear to have had different functions are often made of different materials, with basalt and quartzite, for example, used for heavy chopping tools, and obsidian for making very sharp knives. Selection and acquisition of raw material were early stages in the *chaîne opératoire*, and prehistoric flintknappers sometimes favored raw materials that could not be found locally, importing highly regarded material over many hundreds of kilometers.

Although many stone and glass materials are useful for making chipped stone tools, the most commonly used material for cutting and scraping tools is flint or chert. This is a microcrystalline (usually 2 to 50 μ) silicate (SiO_2) rock, formed as nodules or layers in limestone, that behaves in many ways like a super-cooled fluid (Hodges, 1964:99), similar to glass. It is formed over millions of years from concentrations of silica in ocean sediments. Broadly defined, any sedimentary rocks composed mainly of microcrystalline quartz can be considered chert, including flint, chalcedony, agate, jasper, and hornstone (Luedtke, 1992).

For many applications that require an extremely sharp edge or great control over fracture mechanics, obsidian is the preferred material. Obsidian is a volcanic glass, and glass is in fact a super-cooled fluid. While obsidian flakes have very sharp edges, they are also brittle.

Quartzite is a hard material that is not as easy to flake as fine-grained flint or obsidian, but can be useful for a variety of heavy tools, such as choppers and hoes.

Quartz is a material that was commonly used in parts of North America and Africa where fine-grained cherts and obsidian were not available. A crystalline silicate, many flaws in the crystal structure of quartz make it much more difficult to flake predictably. Quartz tools are usually small and rather irregular, but still quite functional because quartz does hold a sharp edge.

Basalt is a coarse volcanic rock that can also be flaked, but not with the fine control of flint or obsidian. In spite of its difficulties, Palaeolithic knappers sometimes used basalt for flaked tools. In addition, basalt has often been the prefered material for ground-stone tools.

Even hard, dolomitic limestone and other sedimentary and metamorphic rocks can be flaked, although these rocks are not very suitable for most kinds of cutting tools. More commonly, masons would use flaking techniques to shape them into building stones, or tool makers would use flaking simply to rough out the shape of a tool that they would finish with pecking and grinding.

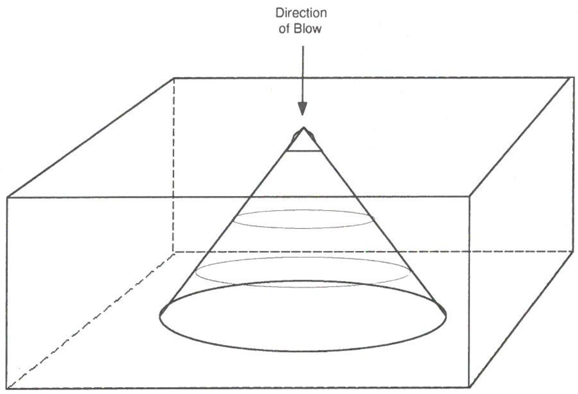

Figure 8.1. Schematic of conchoidal fracture in a block of flint or glass.

Lithic analysts have made some headway both into recognizing prehistoric preferences for particular raw materials and into the identification of their sources. The latter allows us to recognize prehistoric, long-distance exchange or transport (e.g., Dixon et al., 1968).

For many decades, archaeologists tried to identify the sources of raw materials simply by outward appearance, especially color, banding, and graininess. Presumably this was much the way that prehistoric flintknappers also did it, but in the last 30 years archaeologists have increasingly relied on chemical and microscopic attributes for lithic identification and sourcing.

Variation in trace elements in the material can sometimes give it a "signature" that is recognizable. X-ray fluorescence, instrumental neutron activation analysis, and other spectroscopic techniques are commonly used to detect the abundances of these traces in tools or debitage, which can then be compared with samples of raw material from known sources. This sounds very straightforward, but sometimes the sources themselves show considerable internal variability. In addition, until there is sufficient survey of sources to convince skeptics that no sources go unanalysed, there is always the possibility that two or more sources have very similar signa-

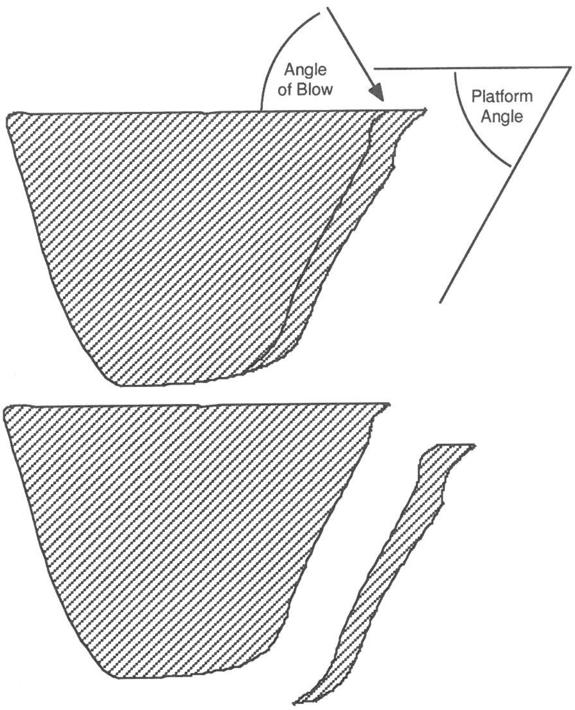

Figure 8.2. Removal of a flake from a core.

tures. Just finding what seems to be a match, then, is not entirely convincing.

In spite of these problems, archaeologists have been quite successful in some regions in identifying the sources of high-quality knapping materials, such as obsidian in Greece, the Near East, western North America, Mesoamerica, and the southern Pacific, and moderately successful at identifying some high-quality chert, such as Rama chert in eastern Canada.

Fracture Mechanics and Stone Tool Manufacture

Lithic manufacture is fundamentally a *reductive* technology. The flintknapper shapes artifacts by *removing* material from a core or flake. In particular, he or she does this by striking the core or flake at a particular angle and location, the idea being to cause **conchoidal fracture**. This kind of fracture involves a shock wave that radiates through the material from the point of impact in a conical fashion (figure 8.1). In flint, the angle between the direction of the impact and the sides of the cone is usually in the range of 120° to 160° (Hodges, 1964: 99), and flintknappers took advantage of this predict-

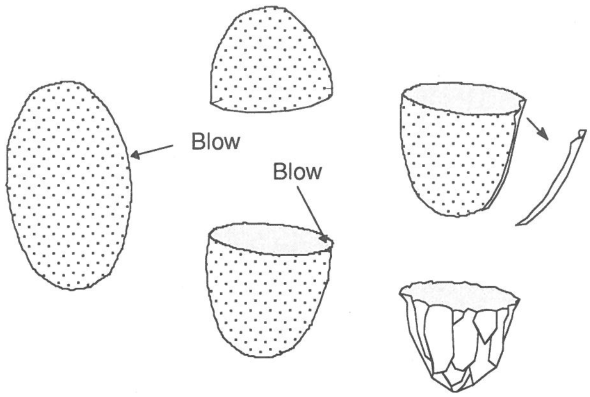

Figure 8.3. Starting a pyramidal core from a cobble.

ability to make thin flakes of flint by directing the blow near an edge with an angle less than 90°. This truncated the cone so that the resulting flake had a surface nearly parallel to one surface of the core (figure 8.2).

To allow this, flintknappers often prepared cores so that they had shapes suitable for producing predictable flakes or blades. To make a simple **pyramidal core** suitable for making big flakes, all that was necessary was to find a good-size, roughly egg-shaped river cobble and break it in half by a sideways blow (figure 8.3). This left a flat area, called a **platform**, on each half that would serve as the surface upon which the flintknapper would direct subsequent blows. Note that the angle of the edge between the platform and the sides of the cobble is around 70° or 80°. Now, striking the platform near this edge at an angle of 70° or 80° in the opposite direction causes the cone of the shock wave to pass though the material at an angle 70° to 80° to the platform (~ 150° - 75°), nearly parallel to the side of the core. When the flint fractures along this wavefront, then, a thin flake will detach. Removing more flakes in a similar fashion around the perimeter of the core will gradually give it the shape of an upside-down pyramid or faceted cone, and eventually the angle between the platform and the sides of the core will become too great, or the core will get too small, for the core to continue to be useful. If the latter, the core will be "exhausted" and discarded; if the former, it could be discarded or, in some cases,

rejuvenated by creation of a new platform or even reused as a tool.

To rejuvenate a core, the flintknapper had to break it in such a way as to create a new platform with the appropriate platform angle, the angle between the platform and the sides of the core. Much as with producing the original platform on the river cobble, this usually involves a strong blow to the side of the core, but at a different angle (figure 8.4).

Sometimes flintknappers maintained more than one platform on the same core, alternately removing flakes first from one, and then another.

The basic techniques of core reduction that flintknappers used were hard-hammer percussion, soft-hammer percussion, indirect percussion, and pressure flaking.

Bipolar reduction is a simple way to produce many flakes, chips, and chunks with little control over their size or shape. It involves placing the core on an anvil and striking it from above with a large hammer to shatter it.

Hard-hammer percussion involves striking the core near the edge of the platform with a stone hammer, such as a rounded pebble.

Soft-hammer percussion involves striking the core with a hammer made of antler, bone, wood, or a material with similar characteristics. This kind of hammer is called a **billet**, **baton**, or **percussor**.

In **indirect percussion**, the flintknapper strikes, not the edge of the platform, but the upper end of a **punch** that has its lower end placed carefully near the platform's edge. This allows the flintknapper to control the location and angle of force very accurately, thus improving the predictability of the resulting flake or blade. The punch can be made of antler, but these wear out quickly, and modern flintknappers tend to use copper-tipped punches. Indirect percussion is commonly used to produce long blades from blade cores.

Pressure flaking works by pressing a flaker perpendicular to the edge of a flake rather than striking it, as you would with hard- or soft-hammer percussion. Although you cannot apply as much force with pressure flaking, accuracy of flake removal is much improved. Pressure flaking is especially useful for **retouching** tools' edges — fine-tuning their shape, sharpening them where you want them to cut, or blunting them where you want to insert them into a haft or bind them with cord.

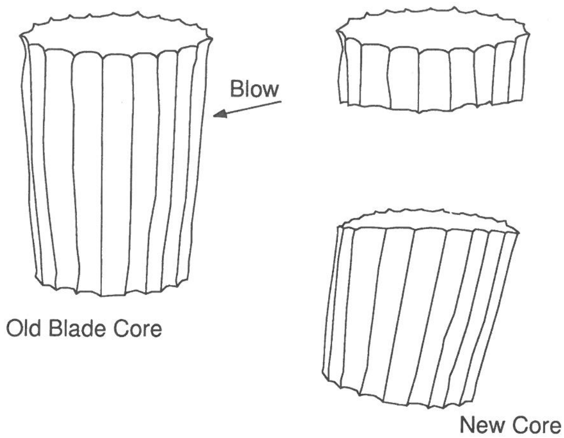

Figure 8.4. Rejuvenating a blade core by an angled blow to the side. Note that the resulting core (lower right) has a more acute platform angle on the right side.

It is important to note that cores were not only used to remove flakes for use as tool blanks, but were often shaped into tools themselves. Such tools are called **core tools**, and include a variety of **bifaces** (core tools flaked on two sides) as well as other types.

The Anatomy of Flakes

Although there remain some differences in terminology, lithic analysts have developed some widely accepted, standard terms for the products of flintknapping and for features on them.

The main products of most kinds of flintknapping are **cores** or core tools and **flakes** that have been removed from cores. Flakes that are at least twice as long as they are wide are conventionally called **blades**. In France, where the term originated, and in the chaîne opératoire approach, **debitage** is the term for all the material removed from a core, including ones that result from shaping the core, flakes that could be used as tools or tool blanks, and unusable flakes

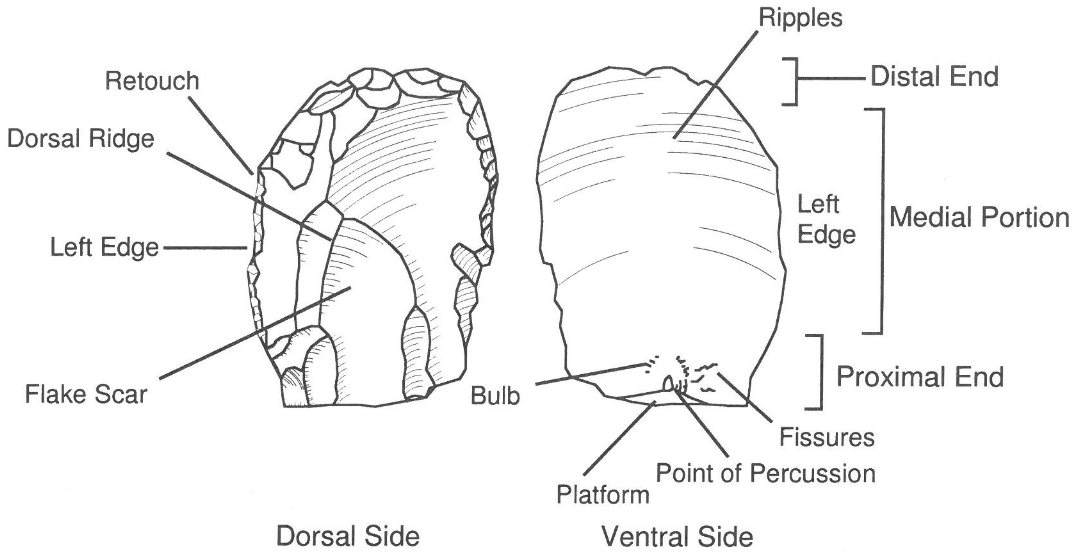

Figure 8.5. Common terms (segmentation rules) for describing the parts of a flake or blade.

and chunks called **debris** (Inizan et al., 1992:84). In North America, many lithic analysts use the term debitage differently, to refer to the waste products of core reduction, including discarded cores. Here we will attempt to avoid confusion by refering to debris and discarded cores as **waste.** Parts of broken flakes and cores are called **fragments**, and sections of snapped blades are called **segments**.

Flakes and cores exhibit some common features. Among these are **cortex**, consisting of the weathered surface that originally covered the raw material, the **platform** (on flakes, of course, you only find a tiny portion of the platform, and only on complete flakes or proximal fragments), and **scars** that resulted from previous flake removals (figure 8.5).

Complete flakes and blades (elongated flakes) that are the products of flintknapping typically show several distinctive features that help us to distinguish them from naturally broken stone or glass. At the **proximal end** we find a small portion of the striking platform. Next to this on the **ventral surface** (the face toward the center of the core) we usually find a small lip, and the **bulb of percussion**, a raised bump that results from compaction under the force of striking, especially by the hard-hammer technique. Sometimes there are several lines on the bulb, radiating away from the point of percussion on the platform, called **radial fissures.** Then we find ripples that extend away from the point of percussion and the bulb like the waves in a still pond. These continue all along the ventral surface to the **distal end** (the end farthest from the point of percussion) and are very distinct in obsidian or fine-grained flints, less distinct in coarser flints and cherts, and nearly invisible in coarse materials. The side of the flake or blade that was on the outer part of the core prior to detachment is called the **dorsal surface**, and shows cortex, if the flake is from the outermost part of the core, or the traces of previous flake removals, called **flake scars**, or both. The sharp ridge that marks the border between flake scares is called an **arris** or **dorsal ridge**. Flakes that show any cortex at all on their dorsal surface are called **cortical flakes** or **primary flakes**. They are quite important because they provide information on some of the first steps in core reduction. Although some naturally broken flakes may show bulbs of percussion, ripples, or radial fissures, this happens relatively rarely. Any assemblage of flakes that shows these features quite consistently is almost certainly the product of artificial flaking. Naturally shattered flint, often produced by weathering, tends instead to have lots of right-angles and flat surfaces that follow the planes of the material's crystalline structure.

Lithic Attributes

Although there is an infinity of attributes that we could measure on any lithic artifact, lithic analysts routinely measure some attributes that they believe are relevant to understanding how tools were made, what they were designed to do, and to what complex or culture an assemblage might belong. They also measure ones that help them to identify the sources and characteristics of raw materials, to discover the way tools were actually used, and to solve other problems that will be discussed in later sections. Some are attributes that occur on all kinds of flakes or blades, others only on certain kinds of tools (e.g., Dibble, 1987), and others are specific to waste (Burton, 1980; Henry et al., 1976). The following is a sample of very basic attributes used to characterize the technology and design of stone tools and the waste products of their manufacture, with emphasis on ones that are fairly straightforward to measure.

Attributes of Cores

Generally speaking, archaeologists find cores that were discarded once they were approaching, or reached, the point where they were no longer useful. The latter are *exhausted cores*. Occasionally we find the flakes that had been removed from these cores and can refit them to find out what the core looked like in earlier stages of reduction, or we find cores that were discarded before exhaustion. Yet even exhausted cores can show us some clues as to the strategy or strategies used to reduce them.

Among the kinds of technological attributes we can observe on cores are the raw material, the type of core preparation, if any, the number of platforms, the means of flake removal, the directions from which flakes were removed, overall core shape, and the intensity with which raw material seems to have been used.

As we have seen, we could use a simple cobble as a core, but some technologies involved intentionally shaping the core so that flake removals would be more predictable. For example, **Levallois** technology involved preparing cores by removing flakes bifacially around the perimeter, so that the "production face" is less convex than the "platform face," and then removing blanks from the production face (Boëda, 1995; Van Peer, 1992). In other cases, only the platform was carefully shaped, to make it easier to control the location of percussion, for example.

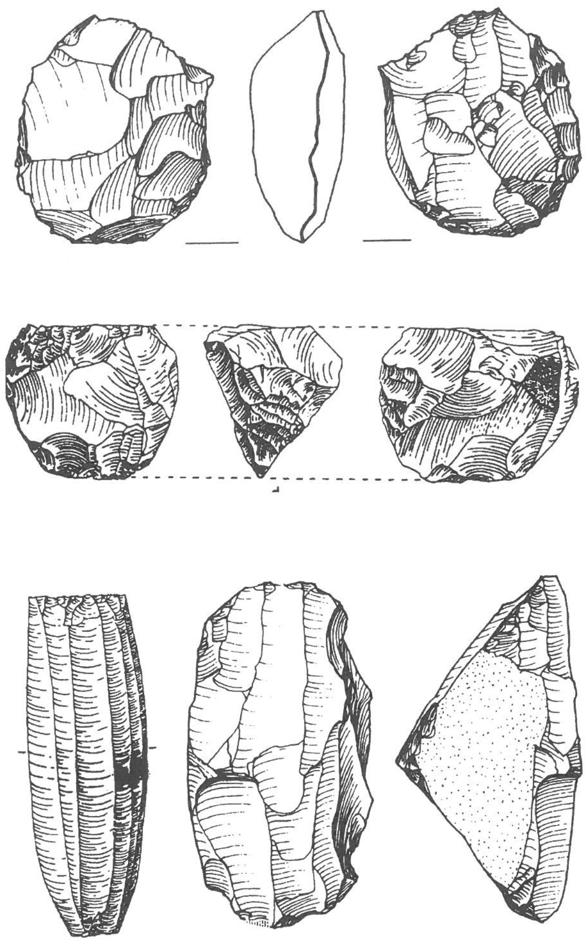

Figure 8.6. Some classes of cores: discoidal (top), amorphous (middle), bullet or pyramidal blade core (lower left), and "naviform" bidirectional blade core.

In addition to single-platform cores, there are bidirectional cores (with a platform at each end), multi-directional cores, and "amorphous" cores (figure 8.6). In the Near Eastern Pre-Pottery Neolithic B, for example, blade blanks were made on narrow, boat-shaped, bidirectional cores that allowed the flintknapper to remove very consistent blades alternately from the two platforms.

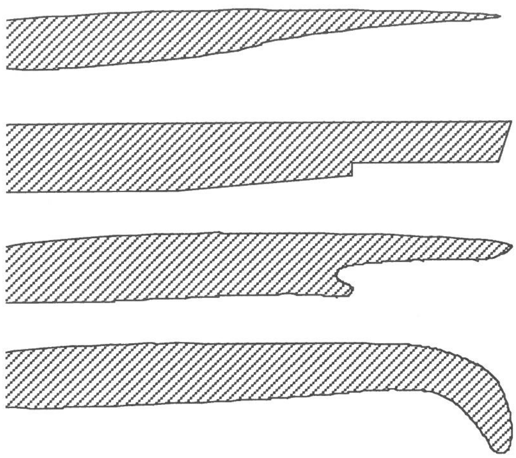

Figure 8.7. Fracture terminations: feather, step, hinge, and plunging.

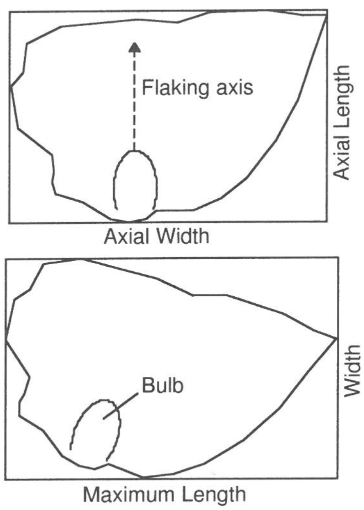

Figure 8.8. Alternative ways to measure a flake's "length" and "width."

By studying the platform angles and negatives of the bulbs of percussion, we attempt to determine whether core reduction was by hard- or soft-hammer or indirect percussion, or by punch.

Attributes of Flakes and Blanks

When a satisfactory flake detaches from a core, the tool maker can discard it, save it for potential use in future, use it as is, or use it as a **blank** for making a retouched tool.

Conventionally, archaeologists use a nominal scale to characterize the forms of flakes. Common categories include blade and triangle. They also use measures on the ratio scale, but researchers vary in how they characterize size and shape (Cullberg et al., 1975; Dibble, 1985; 1987). For example, they use different orientations for the axes of linear measurements. Length can be measured along the longest axis, or along the axis of flaking ("debitage axis") (figure 8.8). Width can be measured perpendicular to the axis of length, or along a different axis, and at the artifact's widest part, or midway along its length. Measurement of thickness can vary substantially in its location. A common practice is to record maximum thickness, but there are alternatives. The most common shape measure is the simple ratio of length/width. It is used, among other things, in the most common definition of blades as any flake with a length/width ratio of 2.0 or greater. Some other shape measures are intended to summarize the "pointedness" of flakes and finished tools (figure 8.12). Because the exact definitions of these measures can vary, it is extremely important to make it clear to your readers how you defined the measures you made.

Some nominal-scale measures are related to the technology of flake production. Platform shape, as viewed from above the proximal end of a flake, may tell us something about core preparation and the blow used in striking. Whether the dorsal flake scars show that previous flake removals were all from the same direction as the current flake (unidirectional), or from two directions but parallel to the flaking axis of the current flake (bidirectional or alternate), or at right angles to the axis of the current flake, or from many directions, will also tell us something about how cores were prepared or used. The nature of the flake termination at the distal end is also conventionally measured on a nominal scale. The flake may show a **feather fracture**, a **hinge fracture**, or a **step fracture**, for example (figure 8.7). In addition, a blade may show that the crack from flaking went too far and curved in towards the core, producing what is called an **overshot** or **plunging termination**. In that case the distal ends's dorsal surface shows the bottom surface of the core and the distal end is often

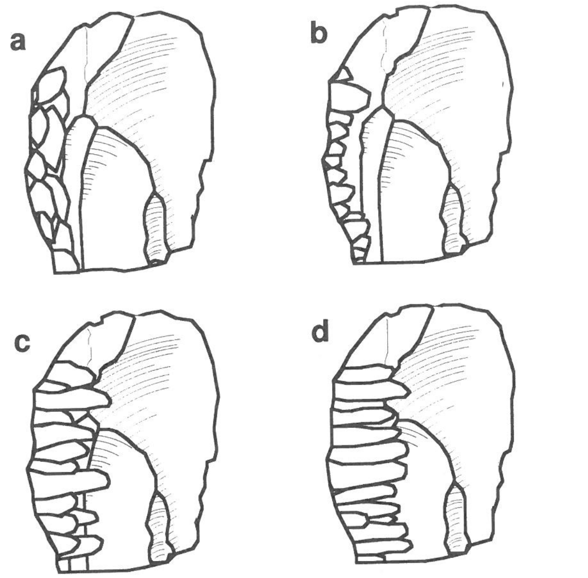

Figure 8.9. Retouch flake scar types: scaled (a), stepped (b), sub-parallel (c), and parallel (d).

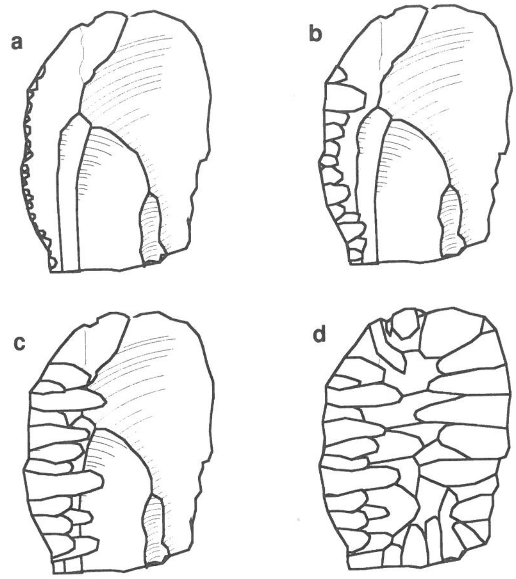

Figure 8.10. Extent of retouch: short (a), long (b), invasive (c), and covering (d).

quite thick. These kinds of information not only help us infer how particular tools were made, and how knappers dealt with flaking errors, but are relevant to the kinds of activities that took place at the site.

Prominence of the bulb of percussion can be measured on an ordinal scale with at least a loose relationship to the force and technique of striking (strong blows with a hard hammer produce more prominent bulbs). However, it is also possible to measure the position and height of the bulb on a ratio scale (Gallet, 1998:35).

Some of the important measures related to flaking technology are angles measured on either ordinal or ratio scales. The exterior platform angle, often simply described as **platform angle,** is the angle between the plane of the platform and the exterior (dorsal) surface of a flake or core (figure 8.2). It will almost always be less than 90°, because it is impossible to create proper flakes with platform angles greater than a right angle. Other angles on the platform may also be important (Gallet, 1998:33).

Attributes of Retouched Tools

Once a blank has been retouched, it is recognizably a tool. Unretouched tools, by contrast, can only be recognized if they show traces of use, such as polish or micro-scratches, or were produced through very controlled core reduction, as with unretouched Levallois points.

Typological approaches to stone tools resulted in many nominal categories for the shapes and retouch characteristics of retouched tools. These include bifaces (made from cores or thick flakes), lunates, and many kinds of points. Lithic analysts often use variations of standardized classifications that were designed for a particular group of lithic complexes, such as the European Paleolithic (Bordes, 1961) or North African Mesolithic (Tixier, 1974). Historically, archaeologists have tended to assume that these morphological types were related to the intended function of the tools, but more recent lithic analysts urge caution in equating form with function. The types are also used to compare assemblages and measure their cultural similarity.

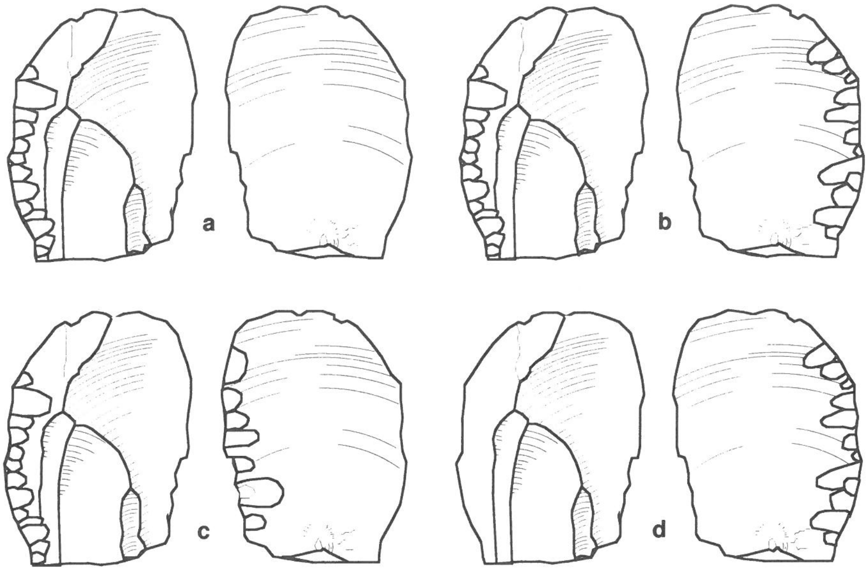

Figure 8.11. Position of Retouch: Direct (a), Bifacial (b), Alternate (c), and Inverse (d).

We can also use a nominal scales for the location and type of retouch (figures 8.9, 8.11). An endscraper, for example, has steep retouch at one end that will hold its shape even under the stress of heavy scraping work. A backed blade has steep retouch, or **backing**, along one of its long edges, presumably to prevent it from cutting into fingers or hafting material. Common categories for retouch are direct, inverse, alternate, and bifacial (figure 8.11). We measure location of retouch relative to the axis of flaking and the point of percussion. Although it is possible to measure the latter in degrees with 0° along the axis of flaking, this is not a ratio-scale measure. You are simply labelling a location with a convenient number that happens to have some common-sense order, just as with compass directions and map coordinates, and it would be nonsense to suggest that a retouch location of, say, 190° is in any sense greater than one of 40°. If, however, you measured *length* of the retouched area in degrees, rather than in millimeters (thus using a length definition based on the radial extent of an arc rather than on a line segment), that would be a ratio-scale measurement. A retouched edge that extends over 80° would be twice as long, relative to the size of the artifact, as one that extends over 40°. Because retouch typically occurs during the final shaping, hafting, and resharpening of tools, these retouch measures tend to be highly relevant to the designed functions and final uses of the tools.

Some of the ordinal-scale measures are related to both flake production and retouch. Steepness and invasiveness of retouch, for example, are often measured on ordinal scales (figure 8.10).

Steepness of retouch is the angle between the flat plane of a flake and a retouched surface. On a unifacial flake this might simply be the angle between the ventral surface and the retouched surface. Note that this retouch angle is likely to vary along a retouched edge, so you should measure it more than once and average the results (with appropriate error estimate) if you are using a ratio scale.

Attributes of Waste and Debris

Waste and debris are becoming increasingly important to our understanding of prehistoric technologies. Because debris consists of chips

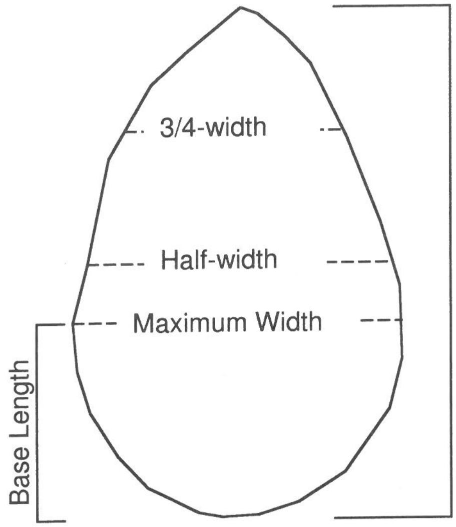

Figure 8.12. Measuring the "pointedness" of a handaxe can be based on the ratios of width measures(after Débenath and Dibble, 1994).

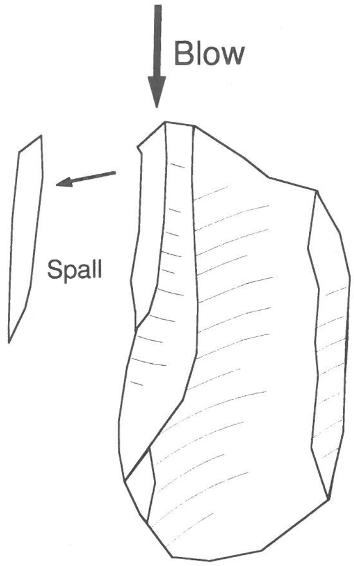

Figure 8.13. Removal of a burin spall.

and chunks for which we cannot identify their manner of fracture (Inizan et al., 1992: 85), we need different ways to analyse them. Often analysis of waste and debris involves use of nominal scales with classification, for example, into proximal and medial-distal fragments (based on presence or lack of platform) and chips and chunks (e.g., Burton, 1980; Henry et al., 1976; Sullivan and Rosen, 1985).

For example, a site with lots of evidence for hard-hammer primary core reduction of a particular kind, but no evidence for finishing tools, might be a place where flintknappers roughed out cores that they would use to make finished tools somewhere else. Another assemblage in which technological evidence indicated a lot of retouch and modification of finished tools, but no primary core reduction, might be a place where hunters repaired their hunting kit while waiting in ambush for their prey. A third might have a technology that suggests extremely economizing behavior in the use of the raw material, indicating, perhaps, that the material was difficult to obtain.