Experimental Manufacture of Wooden Implements with Tools of Flaked Stone

Abstract. *Several contemporary archeologists are recapturing an almost-lost art by developing skill at knapping (shaping) stone artifacts by pressure and percussion. However, little is known of how these artifacts could be used. We describe three experiments in the carving of wood implements with stone tools alone, and we outline some of the problems of making and applying a do-it-yourself lithic tool kit.*

In this day of metals and high-speed cutting devices, few people give much thought to the extreme novelty of such materials, or to the hunlreds of thousands of years during which our clever ancestors coped successfully with a harsh world although equipped with only primary tools of rock. How did they do it?

Today there is increasing interest in the many technologies for shaping stone, and several archeologists are becoming competent knappers who use percussion, pressure, and other methods for copying artifacts. But here the inquiry ends. It occurs to us that the time is ripe for asking further questions: What can you do with such equipment? How would you make a lithic tool kit for a particular job on a do-it-yourself basis?

Five hundred years ago, before Europeans brought smallpox and the steel knife to Paleolithic America, marvelous arts were elaborated with stone tools, and a host of household goods were manufactured from wood shaped by cutting with a tool of appropriate stone, suitably designed. Even simple Indians of southern and Baja California made much equipment by this means. including bows, arrows, clubs, rabbit sticks, cradle boards, ceremonial plaques, and boats (*1*).

To gain more insight into how this was done, we have taken a tack opposite to the usual one, considering stone as a means rather than an end and attempting to make from various woods a few objects of aboriginal use, such as Promontory pegs (probably hide stretchers) and pottery paddles. Such paddles were used by women of southern California in moulding their large ceramic jars: an anvil of baked clay was held inside the piece and opposed by a wooden paddle (in much the same way as we beat out crumpled fenders), the clay being patted and drawn into the desired form.

In our experiments these paddles were made of a hard and tough wood—southern California black oak—while the Promontory peg was carved from softer willow, green and fresh. The paddles were shaped in two ways: with stone tools only or with both stone and fire (Fig. 1).

Having set ourselves three simple goals, we experimented freely, not sticking to any set lithic technology as now understood (or mythologized) by archeologists. If a massive unifacial chopper was needed for squaring hard wood, we made one from the stone that proved best adapted (basalt, chalcedony, or flint; Fig. 2a); if a squared scraping edge was required, it was made from chalcedony or metaquartzite with a burin blow (Fig. 2b).

For peeling and trimming soft wood, a freshly struck obsidian blade proved to be superior to the sharpest steel knife. Both of us made tools as they were needed.

New motor habits had to be worked out in connection with our new tool kit. Stone instruments differ from steel ones not so much in sharpness as in brittleness; steel is tougher. We found a distinct need to retrain ourselves not to twist a stone implement or attempt to pry with it as one can with a metal blade. Unless it is used straight in the plane of cut, a stone tool (axe, scraper, or knife) snaps if it is thin, and little damage flakes pop off the flat, riding surface of a thick one.

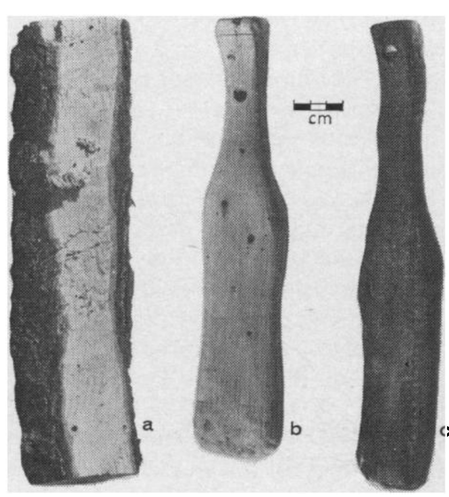

Fig. 1. (a) Oak log dressed on one side with a large chopper. (b) Pottery paddle No. 1, shaped and smoothed without fire. (c) Pottery paddle No. 2, shaped with both stone tools and fire.

Different rake angles of working edges were tried, as well as unifacial and bifacial designs. For either hard or soft wood, a chopper that was unifacial, with a bevel of about 30 to 45 deg, was better than a double bevel on a biface. Bifaces may be better for skinning and fleshing hides or for boning meat, but this possibility remains to be tested.

It must be clearly understood that our experiments did not recapitulate any single aboriginal technology, but constituted a free-wheeling pilot project. Our object was to increase understanding, from an archeologist's point of view, of the serviceability of various items of a diversified lithic tool kit, as well as of the use of supplements such as fire and abrasives; we were also interested in particular skills for getting the best results from stone tools. Obviously one should be trained in these arts from childhood, since body postures and flexibility, as well as relative strengths of muscle groups, would have been critical in the making of an efficient stone-age wood worker (*2*); for example, we are culturally unaccustomed to sitting crosslegged and holding work with our heels as Australian aborigines do.

We describe our program of experiments:

1) Soft wood:

Problem: To make a Promontory peg (Fig. 3a)

Wood: Freshly cut willow (*Salix* sp.)

Procedure: (i) Slice branch from tree with large obsidian flake; (ii) outline top and shoulder cuts of peg with a small obsidian saw, "backed" or blunted on one edge (Fig. 3b); (iii) peel bark with backed obsidian flake (Fig. 3c); (iv) whittle peg to shape with same flaked knife; (v) detach with obsidian saw having teeth "set" or flaked to alternate bevels; (vi) fireharden point.

Time: 30 minutes

2) Hard wood: For working our tough and resistant woods with flaked stone, a number of additional aids had to be used: (i) antler wedge for splitting; (ii) a series of massive (0.5 to 1.0 kg) choppers for roughing-out shape (Fig. 2a); (iii) squared burin edges, which make good scrapers when either pushed or pulled (Fig. 2b); (iv) rounded endscrapers, pulled toward the opera-

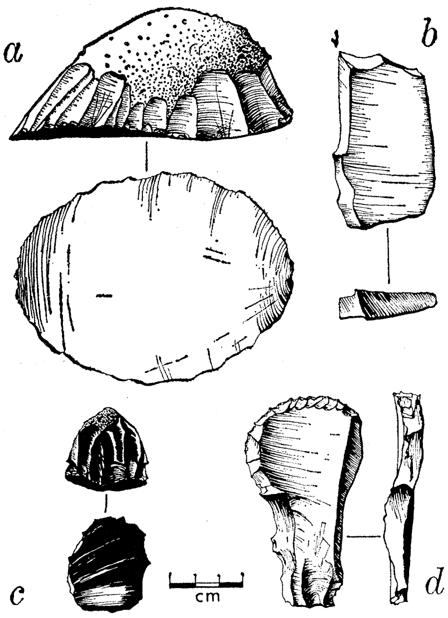

Fig. 2. (a) Heavy unifacial tool, called a chopper and very serviceable as a hatchet. (b) Burin-blow scraper with square edge; ideal for smoothing. (c) Small core plane of obsidian, with which paddle No. 2 (Fig. 1) was finished and burnished. (d) Rounded end-scraper, of flint.

tor with a draw-knife motion (Fig. 2d); (v) the powerful agency of fire (used on one specimen); and (vi) a pump-drill.

Experiment A:

Problem: To make pottery paddle No. 1 without using fire

Wood: southern California mountain oak (*Quercus kelloggii*)

Procedure: (i) Both sides of a small log were faced flat by supporting it on wood and using a medium-bevel (30-deg) chopper as a hatchet, cutting with the grain; (ii) the oak billet was then split parallel to its dressed faces with an antler wedge, the wedge being inserted in a slot made by driving in half of an agate biface; (iii) splitting of the billet produced two small boards, each about 13 by 7 by 2.25 cm; one face of each was smooth while the other was shaggy, covered with fibre and splinters; (iv) the board selected for paddle No. 1 was now dressed on its rough face with a chopper; (v) a self-handle was shaped by chopping, and all surfaces were smoothed with a burin-blow scraper (square edge); (vi) butts of handle and paddle tip were ground on a coarse abrasive stone until rounded; (vii) a hole was drilled through the handle with pump-drill having a fluted bit of chalcedony; the hole was biconical.

Time: 2.5 hours

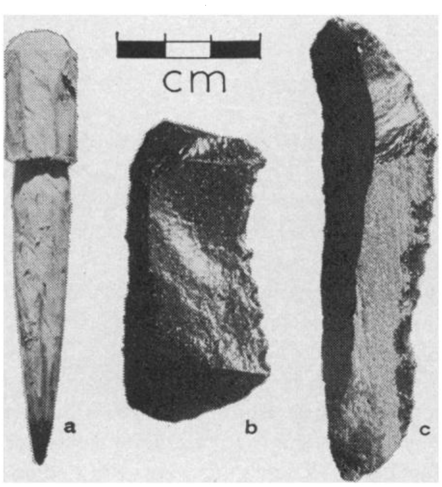

Fig. 3. (a) Promontory peg of willow. (b) Obsidian saw. (c) "Backed" obsidian flake.

Experiment B:

Problem: To make pottery paddle No. 2, using both stone and fire

Wood: As in experiment A

Procedure: (i) The rough surface of this piece was left in its original condition; (ii) sides of handle were roughly shaped with a chopper, as much as possible of the wood shaving being left attached to facilitate burning; (iii) fire of charcoal was kindled in a small hibachi, and controlled fireshaping commenced; (iv) the specimen was quenched in water at frequent intervals, the charcoal was removed with a chalcedony burin-blow scraper, and remaining sound wood was inspected for shape and degree of thinning; (v) this paddle was finished by scraping to hard wood with, first, a chalcedony burin-blow scraper and then a small core plane of obsidian (Fig. 2c) (the flat riding surface of the plane highly burnished the oak); (vi) a biconical hole was drilled through the handle by drilling from both sides with the homemade pump-drill used for paddle No. 1.

Time: about 1.75 hours

Comment: Although faster than the method that used no fire, fire produced a somewhat less shapely and symmetric object than did stone alone.

Some flakes were used as freshly struck; others were modified into burins, saws, and scrapers. Cores were used as choppers when of medium bevel or as planes when the bevel was steep. Many tools were of a chopper-cleaver style. The lithic materials included a wide range of textures from vitreous and glassy to rough and granular: manmade glass; ignimbrite from several sources; basalt from Panamint Valley,

Table 1. Stone used in the experiments.

Stone	Qualities
Manufactured glass	Homogeneous, vitreous, keen, brittle
Obsidian	Homogeneous, vitreous, keen, brittle; some has inclusions
Ignimbrite	Homogeneous, vitreous, keen; subject to crushing
Basalt	Homogeneous, partially vitreous, tough; edges less sharp than glass
Chalcedony (untreated)	Homogeneous, tough, matt surface; sharp but not keen
Chalcedony (heated)	Homogeneous, vitreous, waxy surface; sharp edges; tougher than obsidian
Silt stone	Cleavage planes and weak edges; lacks toughness
Silicified quartzite	Semigranular, tough; irregular edges; well suited to abusive work
Metaquartzite	Very granular and tough; resists percussion; saw-like edges; unsuited to pressure-shaping

California; chalcedony, including varieties that had been artificially altered by thermal treatment (*3*); several kinds of silicified sediments; quartzites formed by deposition of chalcedonies in a matrix of sand grains, and metaquartzites formed by metamorphism, loosely binding particles of quartz, by heat and pressure (Table 1).

For working hard wood, a chopper was made by cleaving a large cobble with a hammerstone and a single direct-percussion blow; the edge created by the first plane of fracture was then flaked. The result was a plano-convex implement resembling an incomplete core (Fig. 2a). The plane face of this chopper was flat along a margin opposite the bulb of percussion, becoming increasingly convex as the bulb was approached. Thus evolved a tool having a diversified cutting edge: flat at the distal end but curved at the bulbar end; which segment of the chopper edge was used depended on the type of cut desired.

When cutting wood, the cortex back of the cobble served as a hand-grip, the plane side or riding surface facing the black-oak stave. Because of the hardness of this oak, a cutting edge of the chopper having a rake angle of approximately 45 deg to the plane face was used. This style of chopper makes a smooth cut, either flat or curved; its working edge withstands considerable abuse when used to shape hard materials. The flat, or riding, side showed no damage nicks until it accidentally struck the supporting anvil; the flat side had then lost a few flakes less than 12 mm in length and terminating in step fractures into the body of the chopper. Generally such use flakes were formed at the bulbar parts of scars of sharpening flakes, but dulling of the tool was often caused by clogging of its edge with crushed wood fiber.

The weight of the implement had to be preserved, so that when resharpening it we could not remove large flakes; renewal of the edge had to be accomplished by removal of thin flakes which, because of their thinness, could not terminate by feathering but were hinge-fractured instead, so that the edge was thickened at their point of termination. Hitherto scars of this sort have been considered results of use; they are really only products of resharpening. When the working edge of a chopper became too obtuse for further sharpening, the chopper was replaced.

True use-flakes on the ventral side of a stone tool are generally accidental, resulting from either improper use of the implement or striking of the support. These flakes are irregular in size and spacing, have diffused bulbs of force, are rapidly expanding, and terminate in a hinge or step fracture; in no way do they resemble scars left by backing (blunting) of an edge or by intentional retouch. When a scraping or planing tool is unhafted and handheld, only small use-flakes are removed, terminating in step fractures but not in the same way as do those removed individually by either pressure or percussion.

A chopper of Calico Hills chalcedony was used for reducing split oak boards to a rough shape but not for finishing. No functional scars were detected on the flat side of the chopper and along the upper margins of its edges; short flakes may have resulted from slight crushing during resharpening by percussion.

A chopper of Panamint Valley basalt was an even more useful tool than the chalcedony chopper because of the toothy edge and tough qualities of basalt. Used improperly, this chopper struck the support and three use-flakes resulted on the flat surface; they were short and rapidly expanding, and terminated in step fractures.

The working edge of a side scraper of flint (Harrison County, Indiana) was made by simultaneous serration and pressure-retouching of a primary flake; it was used to scrape oak paddles by application of pressure and by drawing of the scraper toward the operator. Use-flakes were removed from the ventral to the dorsal side; they were short, small, and terminated in step fractures. When the tool is held improperly, at an angle less than 90 deg, a complete flake is removed. It was determined that no use-flakes are pressed off when leather or hide is scraped.

A backed obsidian knife is used in whittling, like a pocket knife, but the direction of the cut must be kept in line with a stone knife's edge; if the knife is twisted, short, deep flakes are removed from its edge, almost at right angles. When the knife is repeatedly pulled either toward or away from the user, flakes concave to the edge are snapped off. As each concavity forms, it establishes a new platform; thus subsequent strokes pull off additional flakes, damaging the edge and making it useless.

Drilling was done with a chalcedony point fluted on both faces to facilitate hafting to the shaft of the pump drill. The wood was penetrated by alternate drilling of both sides of the paddle handle. Drilling quickly blunted the drill tip because microflakes detached and embedded themselves in the wood, causing double abrasion. A drill had to be resharpened once for penetration of the handles of two pottery paddles. Use-flakes were diminutive and usually terminated in hinge fractures.

Our tests suggest a number of probabilities in archeology:

1) Working of wood quickly consumes stone tools; for this reason, much roughing-out of wooden gear may have been done by aborigines at quarry workshops, near an abundance of material for primary tools (*4*). Much of the quarry litter that archeologists have dismissed as "quarry blanks and rejects"—or just scrap—may be accumulations of rough-and-ready implements; some of our own best tools would be classed as junk or detritus.

2) Unless the craftsman makes a mistake in direction of cut, or misses the mark and hits another stone, his tools show little or no sign of damage except for a gradual smoothing and rounding of the edges that is best perceived tactually; signs of use should also be visible under a binocular microscope (*5*).

3) There are readily discernible differences between three kinds of deceptively similar flake scars: those produced by intentional pressure retouch, those produced by secondary shatter associated with removal of larger flakes, and nicks caused by misuse of the tool. These very different types of scar have probably been confused by archeologists, with resultant loss of information.

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6. We thank Gene Titmus for equipment and help in the drilling operation.

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Acyl Carrier Protein: Effects of Acetylation and Tryptic Hydrolysis on Function in Fatty Acid Synthesis

Abstract. *Acetylation of the four lysine residues and the amino group of the terminal serine residue of* Escherichia coli *acyl carrier protein has no effect on the ability of this protein to function in fatty acid synthesis. Subsequent trypsin hydrolysis resulting in complete inactivation cleaves a single arginyl peptide bond, releasing the amino terminal hexapeptide from the molecule.*

All of the reactions of fatty acid biosynthesis in *Escherichia coli* occur with the substrates bound as thioesters to the acyl carrier protein (ACP) (*1*). This protein functions in fatty acid synthesis in all biological systems tested, including plants, fungi, bacteria, birds, and mammals (*2*). The prosthetic group and substrate binding site of this protein is 4′-phosphopantetheine, which is bound as a phosphodiester to a serine residue of the molecule (*3*). Acyl carrier protein is a heat-stable acid protein which has a molecular weight of