PART ONE

Introduction

Chapter 1

Toward the analysis of lithic production systems

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This chapter serves as an introduction to the volume. Its objective is to open discussion on the importance of prehistoric quarries and lithic production in the contexts of procurement, exchange, technology, and social organization.

The concept of lithic production systems is defined and discussed. These systems can be reconstructed by adapting the strategies and techniques developed for exchange systems. The analysis of the quarry, debitage analysis at sites within the study region, the use of production indices and spatial analysis, chemical characterization and chronometric dating of artifacts and debitage will play roles in reconstructing lithic production systems.

The quarry is the most important site and component of these systems. A complete analysis of the quarry will allow the researcher to reconstruct the processes of extraction, selection, knapping, and on-site activity of the average knapper, as well as documenting the reduction sequences, changes in technology and rates of production over time. The quarry remains the logical site to begin the study of a stone-tool-using culture.

It is important to understand the nature of different lithic production systems and the variables which affect their structure and morphology. The paper opens discussion on a number of variables for consideration. It is expected that the regional lithic resource base, the modes of procurement, social distance between knappers and consumers, labor investment, modes of transportation and social organization will be important although not an exclusive list of variables.

Introduction

Among the subjects of a topical approach to archaeology, production—in particular lithic production among stone-tool-using peoples – requires critical and systematic attention. The results of studying lithic production in a systematic manner will provide new insights into the behaviors of many prehistoric societies.

The primary objectives of this chapter are: to open discussion on the importance of lithic production in the context of procurement exchange, technology, and social organization; to introduce the concept of lithic production system; and to formulate a multidisciplinary strategy integrating a number of techniques presented in this anthology.

Recent research on prehistoric exchange systems has indicated the fundamental importance of understanding lithic production in the context of exchange of obsidian and other lithic materials (Ammerman & Andrefsky 1982; Ericson 1981, 1982; Spence 1982). Although natural unmodified lithic materials do pass through exchange systems, there is a tendency for the material to be modified at one or more points along the system beginning at the source. This process of material modification can be termed lithic production. Production at the quarry and workshops both controls and is controlled by the 'demand' for lithic materials through a series of poorly understood feedback mechanisms (Wright & Zeder 1977). It is critical that we understand these mechanisms in the context of regional exchange. In a diachronic perspective the production of lithic exchange items has been shown to be a sensitive indicator of major changes within regional exchange systems (Frederickson 1969; Ericson 1981; Findlow & Bolognese 1982) and lithic technology (Ammerman & Andrefsky 1982; Ericson 1982; Leach ch. 10; Singer & Ericson 1977). The systemic relationships among technology, production, and exchange need to be more fully investigated.

Despite the long-standing interest in stone-tool production, such research has not culminated in a standardized and systematic approach. Sophisticated advances in lithic technology have been made in the areas of replication and forensic examination of use-wear (Tringham *et al.* 1974; Hayden 1979; Keely 1980) and definition of the stages of lithic reduction (Semenov 1964; Swanson 1975; Hayden 1979; Callahan 1979; Newcomer 1971). However, this important body of information has not been utilized to study lithic production until very recently (Ammerman & Andrefsky 1982; Singer & Ericson 1977). Debitage analysis is critical in this research, yet a review of the literature indicates that very few studies have been directed toward this form of analysis (Brauner 1972; Crabtree 1972; Draper 1982; Flenniken 1978; Flenniken & Stanfill 1980; Osbourne 1965). In fact, it appears that debitage is seldom analyzed and reported. As a consequence, a vital part of the archaeological record has been inadvertently lost.

A quarry site or lithic production workshop would seem the logical place to begin the study of a stone-tool-using culture, as pointed out by Gramly (ch. 2). Yet, a review of the literature indicates that these sites have been neglected relative to other types of sites (cf. Hestor & Heizer 1973). This trend most likely is the result of technical and methodological limitations imposed by a shattered, overlapping, sometimes shallow, nondiagnostic, undatable, unattractive, redundant, and at times voluminous material record. The chapters in this book address many of the methodological problems common to quarries and workshops and demonstrate new strategies for dealing with these sites.

Note on quarries

The following notes are drawn from a lengthy discussion by Purdy (1981b). For the archaeologist who is concerned with all phases of lithic technology, particularly production, the ethnographic documentation is very incomplete. When we consider the wealth of information available on the varieties of human experience, the information on the activities associated with quarries and workshops have to be ranked among the most abysmal. Early explorers apparently took little notice of lithic procurement and production practices. Generally, observations were restricted to village life or observations made along the route of travel. Lithic quarries were infrequently visited. The ethnographic record is far from complete, yet data are available. For example, perhaps the most complete investigation of flintknapping was made of the gunflint industry at Brandon, England (Clarke 1935; and his cited references). Clarke speaks of geographic and geologic availability of the flint, mining techniques, implements employed, selection for quality, historic continuity, and supply and demand. He observed that flintknapping was restricted to a few families among whom intermarriage was 'more than common' (Clarke 1935, 44). He noted that 'knappers die before the age of 40 from consumption caused by inhalation of flint particles' (Clarke 1935, 52).

Observations by Holmes (1894:129–36) and other investigations about quarries pertain to: the procedures involved in quarrying; the quantity of rejected material; and quarry ownership.

Procedures involved in quarrying

Holmes (1919) states that the procedures involved in quarrying were as varied as the geographic and geologic locations. Development of pits, vertical shafts, and horizontal tunneling depend on the outcrop; firesetting, stone, and antler picks, mauls, sledges, and hammerstones were used to break up and remove the stone.

The account of Brandon flintknappers furnishes a valuable description of quarrying procedures. Their metal picks, hammers, spades, and crowbars are probably similar to those used by prehistoric stoneworkers, differing only in the material of which they were made. Some early stoneworkers, however, did not have to dig shafts 10 or more meters deep to reach quality stone, nor did they use exclusively the sophisticated blade technique necessary in the gunflint industry.

Quantity of rejected material

All accounts describing the appearance of quarry areas mention the amount of waste material found there. As many as 1,000 gunflints a day were produced by an expert Brandon knapper. Extrapolating on these figures, it is no wonder that hundreds of thousands of stone tools and inestimable amounts of debitage have accumulated at quarry sites throughout millennia of use. Fowke says that 'probably nine-tenths of the flint carried from the pits . . . was rejected' (Holmes 1919, 178). Bryan states that 'in the study of the great flint quarries one should expect to find large quantities of waste rock' (Bryan 1950, 33). Gould *et al.* (1971) observe that a man can leave behind as many as two hundred waste flakes for each flake he actually chooses and says that this accounts for the tremendous quantities of unused stone which one finds on the surface of aboriginal quarries (Gould *et al.* 1971, 160–1).

However, not all quarry material is rejected debitage. Bryan argues that quarry sites did not exist solely for the production of exportable material. He asserts that many quarries were industrial sites where a variety of articles were made (Bryan 1950, 20–1). Bryan's observation has been substantiated in that a full range of stone implements was found at several Florida quarry sites (Purdy 1981).

Quarry 'access'

Ancient ownership or control of quarries and trading of the raw materials are mentioned by several authors. As previously noted, the practice of mining among the Brandon flintworkers is restricted to a few families (Clarke 1935, 44). In some areas of California, the control of the quarries was 'tribal but related and nearby groups had the right to quarry either freely or on the payment of small gifts. Wars resulted from attempts by distant tribes to use a quarry without payment. On the other hand, the Clear Lake obsidian quarries were neutral ground' (Bryan 1950, 34). The famous red pipestone quarry in Minnesota, according to George Catlin, 'was held and owned in common, and as a neutral group' (Holmes 1919, 262). Flint Ridge, Ohio is thought to have been neutral ground from which the raw material was carried away or traded because it is found at sites throughout a wide area. Gould *et al.* (1971) give no indication of any concept of quarry-site ownership on the part of the Australian aborigines. In fact, they mention that the chipping of stone tools is regarded as an art of little importance. It is of interest, however, that different colors are preferred by certain groups, not because of chipping quality but because of the close totemic ties each man has to the particular region in which he was born and from which he claims totemic descent. 'A man may have a sense of kinship with some of the localities, and he will value the stone material from them as part of his own being. Stone materials thus acquired are not sacred in any strict sense but are nevertheless valued highly enough to be transported over long distances by the owners' (Gould *et al.* 1971, 160–3). Again, a different level of analysis is needed 'to understand how materials are found occurring on sites many miles from the localities where they were quarried or collected' (Gould *et al.* 1971, 160–3).

Ethnographic data supports the concept of nonprivate ownership of property among hunting-gathering groups. A clue to quarry rights comes from the Senator Edwards site in Florida, where at least eight different varieties of Preceramic Archaic stemmed projectile points were recovered (Purdy 1975). Since some of the varieties exist in a single time period, it is possible to deduce that autonomous but related groups had access to the same raw material, i.e., neutral ground. It is not likely, however, that ownership rights changed much when a higher socioeconomic level was reached about 2,000 years ago in Florida. There was no production of large ceremonial blades like those associated with cultures in other parts of North America (California, Tennessee, Meso America, Ohio Valley), which necessitated specialized crafts and, possibly, central control of quarries.

Archaeologists must devise a methodological framework to reconstruct lithic production activities; this anthology is the logical first step (Purdy 1975).

Analysis of lithic production systems

A lithic production system can be defined for purposes of discussion as the total of synchronous activities and locations involved in the utilization and modification of a single source-specific lithic material for stone-tool manufacture and use in a larger social system (Ericson 1982). Production is seen as a process of material modification with intent to form a particular object. During the course of the many stages of production of the material, debitage will be created at the sites of production, which will be indicative of the stages of production (Crabtree 1972). Debitage analysis is a basic technique used in the reconstruction of a lithic production system. Spatial analysis, temporal control, and perhaps chemical characterization (Harbottle 1982) of the debitage have to be incorporated into the research strategy (cf. Sappington ch. 3). For purposes of analysis we must concentrate on the dominant patterns for any given region.

In the context of this volume, the reconstruction of lithic production systems is fully justified from a phenomenological point of view. The structure of a lithic production system will reveal a great deal about the investment of human energy involved in production and decision-making, having economic import. The nature and internal organization of these systems are important to further our understanding of production and resource utilization in the context of procurement, exchange, technology, and social organization.

Reconstruction of a lithic production system can be achieved by adopting the techniques used in reconstructing exchange systems. Production indices are calculated and used like an exchange index to reconstruct a synchronous lithic production system in space (Ericson 1982). A number of different indices based on data from archaeological sites have been formulated as presented in table 1.1. Each index has a

Table 1.1 *Site and material-specific indices for lithic production analysis.*

	Variable (numerator)	Normalizer (denominator)	Units of analysis	Relevance
Exchange index	single source	total material in chipped-stone-tool-category	pieces or wt. ratio %	after Renfrew, Dixon, & Cann 1968
Debitage index	debitage*	total tools and debitage	pieces or wt. or size ratio %	general production index *excluding retouch/sharpening flakes
Cortex index	primary and secondary decortication flakes	total debitage†	pieces ratio %	indicative of the import of raw materials on site †excluding retouch/sharpening flakes
Core index	spent cores	total cores and tools	pieces ratio %	important index if cores are transported, and a medium of exchange
Biface index	Biface thinning flakes	total debitage	pieces ratio %	biface production

particular function in reconstructing the amount and location of different stages of production of a specific lithic material. The Debitage Index is the most generalized index. The Cortex Index is indicative of the extent of exportation of raw materials in the system. The Core Index is important if prepared cores are the medium of exchange. The Biface Index is indicative of biface manufacture. Other indices can be created ad hoc to serve as indicators of different stages of lithic production. The spatial patterns of these indices describe components of a lithic production system.

It is expected that the morphology and internal structure of these systems will vary a great deal. Some types of systems are immediately apparent. In some cases, all stages of production will be restricted to a particular zone; this is termed terminal production. More frequently, reduction is taken to a particular stage in one area and then completed in other areas of the system where the final production is completed at or near the site of consumption and use; this is termed sequential production. Production can also be quite irregular and dispersed throughout a region; this is termed irregular production. The zone of production can also vary. Some production systems will be centered and restricted to the source, a quarry-based lithic production system. Other systems will extend out into the local area surrounding the source, a local lithic production system. These differences are probably related to quarry ownership and the supply of labor involved in production. Production will frequently occur throughout the entire region, a regional lithic production system. The types of production form a continuum, from terminal to sequential to irregular. Each require different energy budgets and varying numbers of producers. The sites of production can occur at the quarry, within the local area, or within the region. Some of the possible systems are presented in table 1.2.

The quarry and its workshops are perhaps the most important components of a lithic production system. Most of the chapters in this book demonstrate the importance of the quarry in understanding prehistoric lithic production. A number of important activities and behavior patterns can be studied directly on the quarry site.

The processes of extraction and selection are really dependent on the geological setting of the resource (Holmes 1919). Often the source is a surface deposit which requires only sorting and testing of cobbles and blocks (Sappington ch. 3; Singer ch. 4; Torrence ch. 5; Gibson ch. 13). In some settings, the extraction process is subsurface (Stocker and Cobean ch. 8) and in hard rock (Gramly ch. 2; Turnbaugh *et al.* ch. 12).

The process of knapping and the stages of the reduction technology can be reconstructed. Singer (ch. 4) uses a reconstruction technique to reconstruct the reduction technology on two quarry workshops in California. Leach (ch. 10) focuses on reduction sequences at a blade-making quarry site in New Zealand in order to understand adze manufacture. She notes that adze manufacture requires the same technological steps used to produce blades. She uses a three-dimensional jigsaw to determine the actual details of manufacture at the quarry. Although this reconstruction technique has been used in the past, Leach demonstrates its potential in reconstructing actual steps of the lithic reduction. She reconstructs the actual patterns of behaviour on the quarry that can be ascribed to chipping, including some motor habits, numbers of people involved, location on the site, and so on. Leach has been able to show the actual *event* of production, using the three-dimensional recovery with the jigsaw technique. This is an important methodological advance in quarry-site analysis: indeed, to be able to 'see' the individual knapper and his comrades at work.

Table 1.2 *Stages, zones of production, and products.*

	Stages of production		
Zone of production	Terminal	Sequential	Irregular
Quarry	final product produced here, then conveyed to region	partially completed products to region	some production at quarry
Local	final products produced here, then conveyed to region	partially completed products to region	final and incomplete natural materials are supplied from quarry
Regional	n/a	production completed at or near site of consumption and use	natural material supplied from quarry and local production zone

The changes in lithic technology on the quarry workshop can also be studied. Singer and Ericson (1977), studying the Bodie Hills quarry in eastern California, have been able to link changes in production rates with changes in reduction technology. These changes in production and technology also occur simultaneously at other quarry workshops in central and eastern California (Ericson 1981, 1982). Leach observes a transfer of technology from one tool form to another in her New Zealand study.

The rate of production can be determined with quarry workshop data. Luedtke (ch. 6) uses ethnographic data to evaluate the lithic production rate of lithic materials at Flint Ridge, Ohio. She observes common patterns in the amount of material used at a given point in time, and concludes that flint procurement was a rather casual, mundane, and low-labor-intensive activity. She formulates a lithic-demand equation using as a model the observations of Gould and other researchers.

Torrence (ch. 5) examines the Melos quarry in the Mediterranean. She comes to terms with production rates of regional exchange during the time period 12,000–3,000 B.P. The obsidian was distributed over the whole of the Aegean peninsula and the Greek islands. Torrence observes a low-intensity production rate in keeping with Luedtke (ch. 6) and Singer and Ericson (1977).

The analysis of the quarry and its workshops provides primary data for determining extraction technology, raw material selection processes, knapping behavior, reduction technology, material products, production rates, changes in technology, and the dynamic stability of production, exchange, and technology over time.

Discussion

The morphology and structure of lithic production systems will vary, depending on a number of underlying factors. The structure of the regional lithic resource base, the modes of procurement, social distance between producers and consumers, labor investment, the modes of transport, and social organization are among the important factors to consider – not an exclusive list by any means.

The regional lithic resource base

An important step in understanding procurement and production is to understand the regional lithic resource base. Generally, researchers are only interested in the dominant lithics, particularly those traveling long distances as exchange items. For a stone-tool-using society it is important to understand the structure of the lithic resource base. Preliminary work by Wright (1974) indicated the need to consider alternative lithic materials in reconstructing prehistoric exchange systems. The location of and distance to alternative lithic resources tend to affect the morphological characteristics of obsidian exchange systems (Ericson 1977, 1981). Reconstruction of the regional lithic resource base will allow the researcher to account for this type of interaction and other processes.

Such a reconstruction can be achieved through a series of steps. Archaeological museum collections can provide sufficient samples to assemble a list of rocks and to tabulate their frequency of occurrence in the archaeological record. Subsequently, a geologist can assemble a list of potential locations of different rock types using geological maps, and literature on the regional geology. Then, petrographic analysis of selected artifacts and samples from geological museum collections can be compared to identify specific sources. For certain rocks, it will be necessary to characterize chemically different sources. Once a preliminary picture of the resource base is constructed, the sources should be verified in the field, surveyed, and sampled. It should be mentioned that this suggested procedure is time-consuming and not always conclusive. However, a lithic resource base map which locates quarries and the frequency or range of occurrence of specific resources in the archaeological record provides important baseline data for comparison and interpretation of regional procurement and production strategies.

The continuation of this line of research opens up some interesting possibilities. Findlow and Bolognese (ch. 7) illustrate the usefulness of reconstructing the regional resource base to understand the decision-making and economics of lithic procurement and production strategies. They locate the regional sources and quantify the frequency of use of a number of different lithic materials in the Animas Valley of the American southwest. They test a model of observed frequency and elevation-corrected distance (cf. Ericson & Goldstein 1980) for optimality of use. The principle of optimality appears to be operating on decisions to procure lithic materials on a regional scale. This is an important finding; their methodology should be applied to other study regions.

Future studies of optimality should also include variables related to technology and function. For example, different materials often appear in different categories of function and tool typology. This is particularly the case in regions where there is a great diversity of rock type. Since the physical properties of rocks are quite variable, these properties most likely play an important role in the processes of selectivity and function. Although the importance of physical properties on selection of stone-tool material has been discussed (Goodman 1944; Ericson & Singer 1977), these relationships have not been adequately demonstrated. Future optimality studies will be even more fruitful in understanding decision-making of prehistoric stone-tool-using peoples if a full range of variables is included. We do not yet have a fundamental understanding of processes of selection of lithic resources.

Procurement strategies

Lithic production systems will vary in structure depending on the procurement strategies used to acquire the material. These, in turn, appear to be linked to territoriality within a region (Gibson 1981; Bettinger 1982). For example, direct access and regional exchanges are different procurement strategies which tend to result in different lithic production systems (cf. Alden 1982). Direct acquisition of a resource by the people of a region can be termed regional direct access if members acquire the raw material at its source. The production, transportation, and consumption of the material are related to the activities of a knapper and his group. Within a region there will be many individuals who visit the source to obtain raw material. Production often will be completed at the source/quarry in order to reduce transport of waste flakes. Since there is little to regulate the actual behavior of a great number of individuals involved in production, it is expected that the resultant lithic production systems will be quite irregular and heterogeneous in internal organization in terms of reduction technology and products (but cf. Gibson ch. 13). Even so there will be discernible patterns within a particular range of variability for a particular time period and socio-economic level. On the other hand, lithic production systems linked to regional exchange are expected to have greater regularity due to certain regularities in production of specific items. In regional exchange the resource can be procured as a product from local producers through a network of trade partners or other forms of exchange.

In a quarry-based or local lithic production system, the number of producers is small compared to the number of individuals involved in transportation/distribution, final production, and consumption. As a consequence, redundancy and a degree of regularity are built into these geographically restricted production systems. A sequential production strategy will often be employed to produce utilitarian exchange items, whereas there is a tendency for luxury exchange items to be completed at the quarry or in the local region (Ericson 1981).

The archaeological criteria which distinguish these two types of lithic procurement strategies are not clearly defined. In direct access, the falloff tends to be rapid (Bettinger 1982) and possibly linear with distance (Findlow & Bolognese 1982). These procurement systems tend to be smaller in size (Ericson 1981). These criteria clearly have limited utility. Data derived from the analysis of quarries and workshops in this book may shed light on the problem.

Gramly (ch. 2) infers on several lines of evidence that the people who used the Mount Jasper rhyolite source used direct access to obtain their rock. He noticed that spent tools from regionally diverse sources were frequently discarded at the quarry or workshop. He also observed multiple technological components over the history of the workshop. Purdy (1975; ch. 11) verifies this pattern in that diverse and overlapping lithic traditions are observed at the Florida chert quarries and workshops. Sappington (ch. 3) suggests that obsidian was acquired by direct access during the seasonal mobilization of people to fish salmon along the Snake River. Most of the lithic production here occurred away from the obsidian sources in the surrounding region.

Social distance and production

Social distance may play an important role in influencing lithic production. If the knapper is related to or in contact with the intended tool-users, he can respond directly to the needs of the consumer. In such cases, the knapper may tend to produce finished items from the raw material. However, as the social distance increases between the knapper and intended tool-user, he may tend to produce less specific forms or use a mixed strategy of finished items and blanks. The cross-cultural occurrence of blanks and preforms as exchange items can be interpreted to demonstrate the operation of this principle – i.e., these products represent the response of a knapper to the anonymous consumer. As pointed out by Spence (1982), trade partners are notoriously slow to respond to changes in the needs of the 'consumers' within the exchange systems (Harding 1967; Rappaport 1968). If social distance within a lithic production system governs the amount of production of particular items and the completeness of production, this relationship opens up some interesting possibilities for interpretation. For example, it would follow that the final stages of lithic production will become more extensive in space as the social distance is increased between knapper and consumer. The production of esoteric items for luxury use in simple societies and mass-produced tools for anonymous consumers in complex societies (Spence, Kimberlin & Harbottle ch. 9) are special cases.

Labor investment

The labor investment will play a role in the structure of a lithic production system. In direct access the labor requirements are ad hoc and occasional, depending on the needs of the groups using the source. Gould *et al.* (1971) present a good example of this case. However with many knappers and groups visiting the source, the carrying capacity of the catchment of the quarry may become a limiting factor. It is not surprising to learn of compensatory rules and customs to avoid these ecological impacts. For example, round-trip fasting was practiced by the Wintun groups in California when traveling to obsidian sources (Dubois 1935). As a region grows in population, however, population may be an autocatalytic factor which promotes and is promoted by the development of regional exchange systems. Sedentism, which changes people–land relationships, requires increased scheduling and dependability of resources. Sedentism, population growth, and a growing dependency of the population on regional resources as well as the establishment of territoriality within the region favor the growth of a regional exchange system. An immediate advantage in the change of procurement strategy is reduction in travel. Regional exchange is far more cost effective than direct access in regard to regional travel costs (Ericson 1981; Alden 1982).

There are problems in switching procurement strategies with regard to labor investment even if the processes of change are slow and gradual. The people of the source begin to have new roles as suppliers, and eventually as producers in order for the system to develop and continue. If the requirements of a region are small, the impact on the local people is most likely negligible. However, if the source has utilitarian function to the region as a whole, the labor investment will have to be underwritten by increased specialization and support of the specialists. This support will have ramifications on the subsistence economy of the population and on the lithic production system. I have argued for such a case in California where the lithic production systems change as a response to technology and resource function in prehistoric California societies (Ericson 1982).

The labor investment will play a role in the structure of lithic production systems, whether there are many producers scattered throughout a region as in direct access, or whether the producers are concentrated at the quarry or local area near the quarry, as in production for exchange. The changes and fluctuation in lithic production systems may reflect responses to changes in internal organization of labor supply and the consumer demands in the region (cf. Wright & Zeder 1977).

Modes of transportation

Notwithstanding the above arguments, we do not yet understand the mechanisms of production by others and reasons why it occurs in primitive societies. The act of production at least sets values, reduces transport weight, or both. The production of finished items minimizes transportation of waste yet fixes forms. Gould *et al.* (1971) mention that nearly 200 flakes are produced for each flake retained; Newcomer (1971) reports that debitage forms 92 per cent of the product weight. Most likely there is a balance struck between production and transportation costs. The production system is thus tied to transportation. As transport costs are reduced, say with the introduction of water transport or domesticated animal transport, raw materials or products tend to be transported longer distances. Ammerman and Andrefsky (1982) studied the effects of water transport on obsidian production in Calabria, Italy. They observe that the obsidian is further reduced when it arrives on land, at the juncture between the water and land transportation systems. Production for exchange or consumption in direct access is considered to be a waste reduction process to reduce transport cost. It will be interesting to learn whether the principle of optimality is adhered to in the relationship between production and transportation in addition to resource selectivity (Findlow & Bolognese ch. 7).

Social organization

Several patterns of lithic production systems appear to emerge relative to social organization and socioeconomic complexity. Generally, lithic production becomes more organized in structure, increases in size, volume, and efficiency in response to larger and more complex stone-tool-using populations (cf. Torrence ch. 5).

In simple societies direct access, ad hoc production by the occasional knapper and, at times, the creation of a no-man's land around the quarry appear to be recurrent patterns in many region for many millennia. Among tribal and more sedentary people, direct access is not particularly abandoned since it is highly interactive to meet the demands of the consumers. If for any reason that access to a quarry is restricted to the people of a region, this change can lead to conflict and sets up the pre-conditions for stimulating production for exchange. It is possible that both forms of procurement operate simultaneously for long periods of time. However, as patterns of territoriality become fixed and land tenure is proscribed, it is suspected that direct access procurement is abandoned or limited to the people of the local region. The above changes produce fundamental changes in the structure and morphology of lithic production systems. We will need many more case studies to fully understand all of these interrelationships.

In complex societies, the form and degree of regional administration will determine the system. Even within the political domains of a centralized administration, it is possible that the production systems involving secondary sources of similar material are not affected. It will be interesting to know more about the effects of administration on production systems and if there exists a cross-cultural development sequence related to levels of social organization.

Spence (1982) was able to trace the influence of the Teotihuacán administration on the lithic craft specialists through time. He notes that 'although the Teotihuacan administration eventually played a larger role in the industry, particularly in the regional sector, the well-developed social identities of the craft groups and their history of self-sufficiency protected them from being absorbed or replaced by the state.'

More often the primary producers lose their self-sufficiency and identity when supported by other members of their society. Often there will be many divisions of labor involved in extracting and exporting the raw material, knapping the stone, and transporting the product. Frequently raw materials will travel to centers of production, often highly populated areas. This pattern of displaced off-quarry production appears to be a recurrent trend and most likely is cost effective.

Spence, Kimberlin and Harbottle (ch. 9) examine the movement of Sierra de las Navajas obsidian through the Teotihuacán state system. They use neutron activation analysis to differentiate intrasource areas. This demonstration is an important methodological finding in its own right. They are able to define a prehistoric warehouse that stored material from specific points in the quarry, which were then produced into items, and distributed within Teotihuacán. Although specific quarry areas can be defined chemically within this source, the Teotihuacán obsidian warehouse indicates that the materials from the different quarries were stored and removed in a random manner. Earlier, specific flows of this source were used by specific groups or regions. The obsidian moved along kinship lines and/or lines of political affiliation.

Another aspect of social organization and lithic production is the stability of the systems and patterns of procurement. We might expect that production systems are going to fluctuate a great deal in time. As a result, diachronic rates of production will be indicators of other changes in the region, as argued by Wright and Zeder (1977). Preliminary evidence from California suggests that the production of lithic materials, observed at the lithic quarries, is regular and quite conservative over many millennia (Ericson 1981, 1982). In contrast, Findlow and Bolognese (1982) have indicated that there are extreme fluctuations in lithic procurement strategies in the American southwest. The sensitivity of production systems to other systemic variables makes the study of lithic production important for prehistoric research.

Conclusions

When we consider the wealth of information on the varieties of human experience, our information on the activities at quarries and workshops ranks among the most abysmal. This trend can be traced to existing technological and methodological limitations. The chapters of this book demonstrate the value of studying lithic production of quarries and workshops. If we are to advance our understanding of regional patterns of procurement, exchange, and technology, we must know what events have occurred at the quarries. This is fundamental information vital to our understanding of stone-tool-using cultures. The concept of a lithic production system is introduced to provide a construct for systemic analysis. The quarry and its nearby workshops are the most important components of such a system.

This chapter suggests that there are tremendous advantages of extending the study of production to the entire region using procedures developed for studying regional exchange. If we look at production on a regional scale, we can begin to understand more about the investment of human energy involved in production and decision-making, having economic import. The nature and variability among different systems will further our understanding of production and resource utilization relative to other variables. It is expected that the structure and morphology of a given lithic production system will be controlled in part by a number of complex, interacting variables. The structure of the regional lithic resource base, the mode of procurement, social distance between knappers and consumers, labor investment, modes of transport, and social organization, as well as technology, and other variables, are expected to affect the development and maintenance of any given system.

Finally, we must begin to focus our attention on the quarry, the workshops, and other sites of production if we are to understand production in the contexts of exchange and technology in the years to come.

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PART TWO

Procurement, production, and exchange

Chapter 2

Mount Jasper: a direct-access lithic source area in the White Mountains of New Hampshire

R. M. Gramly

Archaeological excavations at Mount Jasper, a rhyolite source in northern New England, reveal that it was exploited at a slow rate over 7,000 years. Although stone from the mountain was transported over a broad region, its movement was in the hands of miners rather than traders or other intermediaries. An unexpected benefit of the work at Mount Jasper was the discovery that workshops may yield three classes of artifacts. One of these classes, exhausted tools of exotic stones, holds valuable information about subsistence activities, the range of seasonal movements, and general culture history. Archaeologists can no longer afford to overlook this rich source of data in their studies of stone-tool-using groups.

The object of this discussion is to present the fruits of archaeological research at a small-scale lithic source area located in the White Mountains of New Hampshire, a region that was as thinly populated in prehistory as it is today. Mount Jasper is an example of a lithic resource that was consumed at a slow rate over a long period. The stone that was quarried there for flaked tools was not transported very far from the site. As we shall argue, the most economical explanation for the distribution of Mount Jasper stone is that users satisfied only personal needs. Since there is no evidence of exchange networks at any period in the region, there was no surplus production. The appearance of Mount Jasper stone at distant habitation sites reflects actual movements of quarrymen in pursuit of game, fish, and other necessities of life.

Excavations since 1976 at Mount Jasper have laid bare prehistoric industry spanning 7,000 years. The stone sought by