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PREHISTORIC PROCUREMENT OF SECONDARY SOURCES: THE CASE FOR CHARACTERIZATION

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ABSTRACT

Lithic source identification is a new and exciting subfield of archaeology. Sourcing studies often concentrate on prehistoric quarry areas within primary, or *in situ*, bedrock outcrops. Other important but underrated resources are primary, non-quarry outcrops and secondary, redeposited materials such as glacial till and water-laid gravels. This article discusses the characterization of chert sources by petrographic, or thin section analysis, and assesses the technique's usefulness in identifying specific rock units as the raw material source for prehistoric artifacts. Data from source areas and from archaeological sites in the Delaware and lower Hudson drainages of New Jersey and New York are used to illustrate the need for analysis of non-quarry chert source localities.

Lithic source identification is part of the growing subdiscipline of geoarchaeology. Recent sourcing studies aim to identify the parent source of lithic raw materials used for making artifacts by means of geological and chemical analyses. The two major methods of lithic analysis in use today are geochemical and petrographic. Geochemical or trace element techniques of analysis such as neutron activation, atomic absorption, X-ray diffraction, X-ray fluorescence, and optic emissions spectrometry—to name a few, are intended to provide a chemical signature of each source. Petrographic or thin section analysis documents the textural, mineralogic, and fossil attributes of a rock source through microscopic study of slide samples.

Geochemical and petrographic techniques have been applied with some success to a number of rock types, including obsidian, chert, jasper, steatite, rhyolite, argillite, basalt, and marble. Although the techniques and their success rates may vary, the methods have two things in common: One, they explicitly or implicitly assume that macroscopic, or hand specimen, analysis of rocks is too subjective or too limited a technique for source identification. Two, they seek to distinguish each source objectively and scientifically through the documentation of its chemical, mineralogic, fossil, and/or textural attributes, to identify the geographic location of the stone used in artifact manufacture and better understand the lithic acquisition activities of the cultural group under study. Ultimate goals are the reconstruction of procurement systems and exchange networks to better understand aboriginal settlement systems and intersocietal relationships, and to help promote anthropological/archaeological theory.

Characterization studies often concentrate on prehistoric quarry sites within bedrock outcrops (e.g., Aspinall and Feather, 1972; Sieveking et al., 1972; Blackman, 1974; Butler and May, 1984; Ives, 1975; 1984; Miller, 1982; Luckenbach et al., 1975; Section of Archaeology, n.d.a; n.d.b; Vehik, 1985). This is both a strength and a weakness of sourcing research. It is a strength because the presence of aboriginal quarrying tools, debitage, rejects, and borrow pits at these localities prove that Native Americans really did manufacture tools from these specific outcrops. This being the case, sourcing of prehistoric quarry specimens is a good test of the accuracy of the analytic technique in use. Some artifacts from local archaeological sites should be composed of the quarry material. Their characterization should match those of quarry samples. So the characterization of bedrock outcrops at prehistoric quarries is a good place to begin a sourcing program.

But characterization of quarry areas may become a weakness in the sourcing program if prehistoric quarries are the only outcrops sampled. In some regions, there are extensive chert-bearing bedrock outcrops, but few known aboriginal quarrying areas. This is true of the part of Northeastern North America that is the focus of our research. It includes New York, New Jersey, New England, Delaware, and parts of Pennsylvania and Maryland (Figure 1).

Quantitative analyses of local archaeological assemblages demonstrate that chert materials make up a large percentage of the aboriginal lithic industry (e.g., Lavin, 1983). These data demonstrate that chert was an important lithic resource for aboriginal groups in the area. Interestingly, relatively few prehistoric quarrying sites are identified in the literature, and only for a handful of the known chert types. They include the Pennsylvania Jasper or Hardyston Quartzite quarries in the Lehigh Hills of eastern Pennsylvania (Section of Archaeology, n.d.a); a jasper quarry in the Bald Eagle formation of central Pennsylvania (Miller, 1982), the Newark Jasper quarry at Iron Hill in northern Delaware (Section of Archaeology,

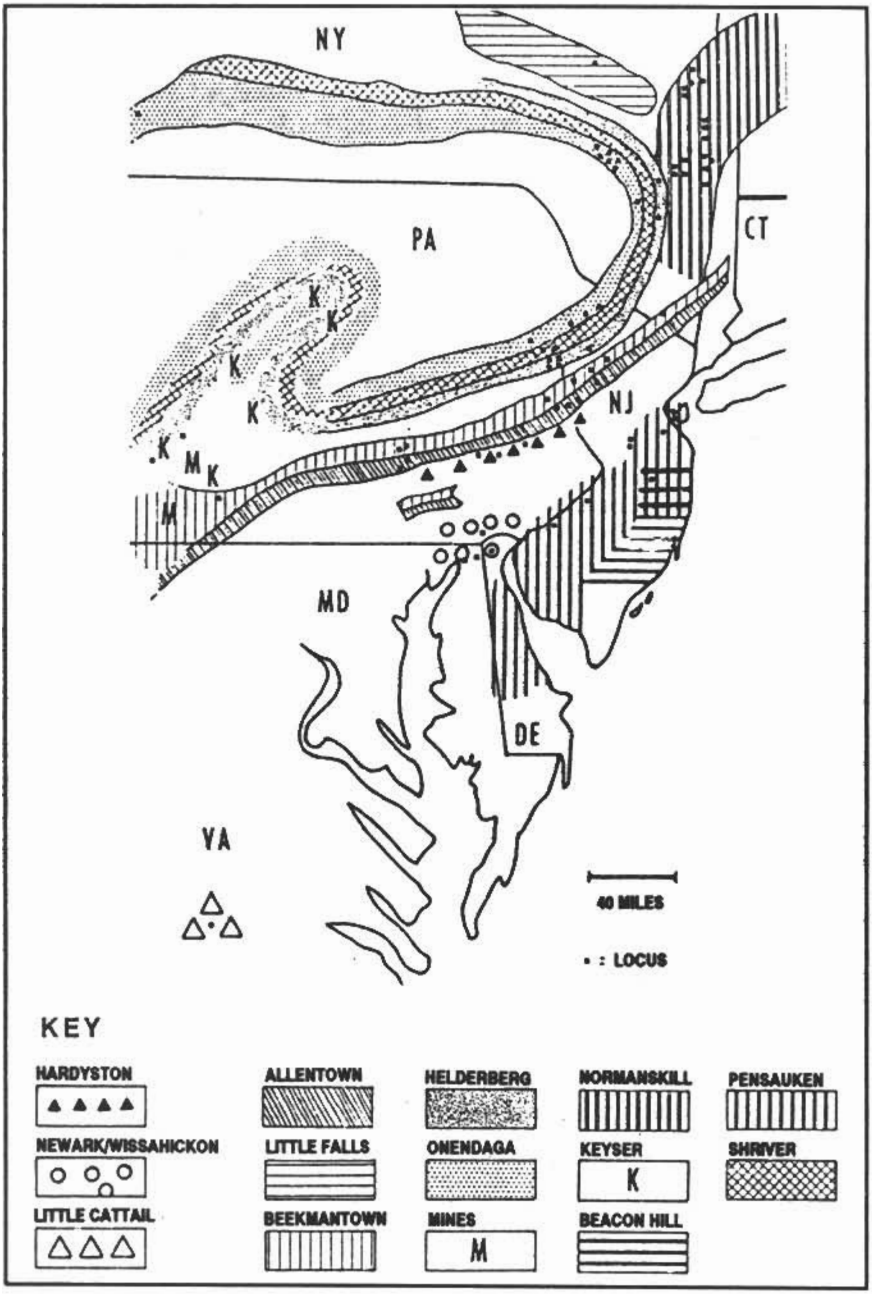

Figure 1. Map of location of major chert-bearing rock units within the study area (Lavin, 1983).

n.d.b); Divers Lake quarry in Onondaga Limestone near Buffalo, New York (Prisch, 1976); the Coxsackie Flint or Normanskill Shale quarrying site at Flint Mine, West Athens, and other hill sections in the Coxsackie-Catskill region of eastern New York (Wray, 1948); and the Munsungun Lake quarry area in northern Maine (Pollock, 1983).

These quarry sites seem to be few and far between, and there is an enormous amount of chert-bearing bedrock cropping out between them. And what about all the other chert types that presently are not represented by a single quarry site?

Obviously, Native Americans were exploiting other bedrock resources in addition to the known prehistoric quarries. The former outcrops may have been destroyed by natural or cultural forces prior to archaeological investigation. Or, the procurement areas may have gone unrecognized due to the absence of borrow pits and the end-products of on-site reduction of cores in biface manufacture.

In addition, a number of archaeological sites from the Delaware and lower Hudson drainages include tools and nonutilized flakes exhibiting a smoothed, water-rounded cobble cortex over much of their surfaces (e.g., Lavin, 1980; 1983; Custer, 1984; Stewart, 1987; Prothero and Lavin, 1990). Such characteristics indicate that the source of raw material for these artifacts were secondary, or redeposited, fluvial gravels.

The preceding information shows that our research designs for source identification projects should include studies of primary outcrops besides prehistoric quarry sites, and studies of secondary sources. We suspect that there are two main reasons that these kinds of lithic resources are often omitted from sourcing projects: One, characterization of chert specimens from outcrops located between prehistoric quarry areas might quash those elegant probability statements distinguishing some quarry materials representing the same rock unit, or chert type.

Geological analyses of some of the more extensive chert-bearing formations in the Northeast, such as the Oriskany Sandstone and Onondaga Limestone, with outcrop ranges from Ontario through New York, New Jersey, Pennsylvania, and into Maryland, demonstrate **gradual** facies changes in matrix over both time and space (Lavin, 1983). It follows logically that chert lenses within the matrix also may exhibit gradual changes in chemistry and texture over time and space. The end result of "between quarry" sampling might be increased overlapping of the two discrete quarry characterizations and a possible blurring of each one's chemical signature.

The second reason for omitting non-quarry source areas stems from the archaeological folklore on secondary source materials. Specifically, it is a common belief that chert cobbles from secondary sources represent low grade materials used only as a last resort by local residents. Recent research by Jeffrey *Kalin (personal communication, 1987)*, a primitive technologist, refutes this statement. Kalin's replicative experiments indicate that some cobble cherts are high quality, easily knappable material.

A second, complementary folk belief is that secondary materials cannot be distinguished from their parent source, and so it is best to ignore them as any analysis will just provide fuel for anti-sourcing people and hurt The Cause. We will never know if these assumptions are true unless we start sampling non-quarry bedrock loci and secondary deposits.

Under grants from the National Science Foundation and the New York State Museum and Science Service, we conducted a pilot study of chert sources in and adjacent to the Delaware and Hudson River Valleys (Lavin and Prothero, 1981; 1987). It was part of a larger study of prehistoric lithic acquisition patterns within the Delaware drainage (Lavin, 1983; Prothero and Lavin, 1990).

Chert samples were collected from over 100 different source localities representing thirty chert-bearing formations. Most of the collecting loci are non-quarry outcrops. Twenty-eight of the formations are primary chert sources. The remaining formations—the Beacon Hill and Pensauken gravels, are secondary fluvial deposits.

ANALYSIS

Macroscopic

Charles Wray's (1948) survey of New York cherts indicated that macroscopic analysis might provide some success in distinguishing chert types. Hand specimen analysis has the advantage of being inexpensive, and not requiring specialized geologic equipment or extensive geochemical knowledge. So, initially for the study, a method of macroscopic, nondestructive analysis was developed by which the possible source of a hand specimen of chert might be located through such characteristics as texture, color, visible inclusions, and reaction to chemical tests such as the application of hydrochloric acid.

Results of the analysis indicated that few chert types could be identified macroscopically. The majority of chert specimens studied are macroscopically homogeneous in texture and of a neutral gray or black—tones found throughout the survey area. Cherts of other hues (such as bluish gray, red, or yellowish brown) do occur within the survey area. But they are not restricted to a specific chert type. This being the case, macroscopic analysis was inadequate for locating the sources of these cherts. Macroscopic analysis is valuable, however, as an **initial** step in chert identification, as it limits the number of possible sources of a specimen, thereby facilitating its identification through other forms of analysis—such as petrography.

Petrographic

Petrographic, or microscopic analysis has a number of advantages that make it very appropriate for a project of this nature:

1. It provides information on texture, mineralogy, and fossil content as well as elemental or chemical composition (Shotton, 1970:48; Lavin, 1983).
2. One thin section covers three to ten times as much area as a geochemical sample, and so local sampling problems may normally be reduced.
3. In petrographic analysis identification procedures do not require sophisticated statistical programs, only a simple comparison of artifact attributes with those of source specimens (Lavin, 1983; Wray, 1948).
4. Compared to geochemical analyses, petrographic analysis is a relatively inexpensive technique, and it is readily available to archaeologists, even those associated with modestly equipped colleges or universities.

Consequently, for our study a lithic method combining both macroscopic and microscopic analyses was developed for identification of chert sources. Reference slides (173) representing thirty chert types were analyzed. They show an amazingly large variation in textures among types, but not within each type. This made discrimination among formations much easier than we originally expected. The reason for the high degree of textural variation among types is that the types are derived from an extremely heterogeneous group of rock units ranging in age from early Cambrian to Devonian. They include quartzite, schists, gabbros, shales, and various carbonates. Since most of these rock types are so fundamentally different, they exhibit distinctive textural and mineralogical traits after silicification into chert.

The petrographic results indicate that all of the primary sources may be distinguished from one another. In a few cases, the chert could be traced to a geographic subarea within the outcrop region of the source. The results are important archaeologically because they indicate that the sources of some of the lithic materials used by Native Americans in the manufacture of artifacts can be identified through petrographic analysis.

To test the applicability of chert petrography to archaeological studies, and to provide valuable data on prehistoric lithic acquisition patterns in the Delaware River Valley, artifacts from thirteen available collections in the New Jersey State Museum at Trenton were macroscopically analyzed. The lithic assemblage from a Late Archaic component in southern New York, excavated and housed at New York University, was also analyzed. Selected artifacts (79) from nine sites containing Late Archaic and Early, Middle, and Late Woodland occupations were petrographically analyzed. Site locations are plotted on Figure 2. Virtually all of the artifact slides were easily identified with one of the chert types under study, some even to a geographic subarea within the type's outcrop area. This fact strongly demonstrates the utility of the petrographic method in chert identification studies (Lavin, 1983; Prothero and Lavin, 1990).

A number of the archaeological specimens were matched to formations containing no known prehistoric quarrying areas. These findings confirm the need to sample non-quarry bedrock outcrops as well as prehistoric quarry sites.

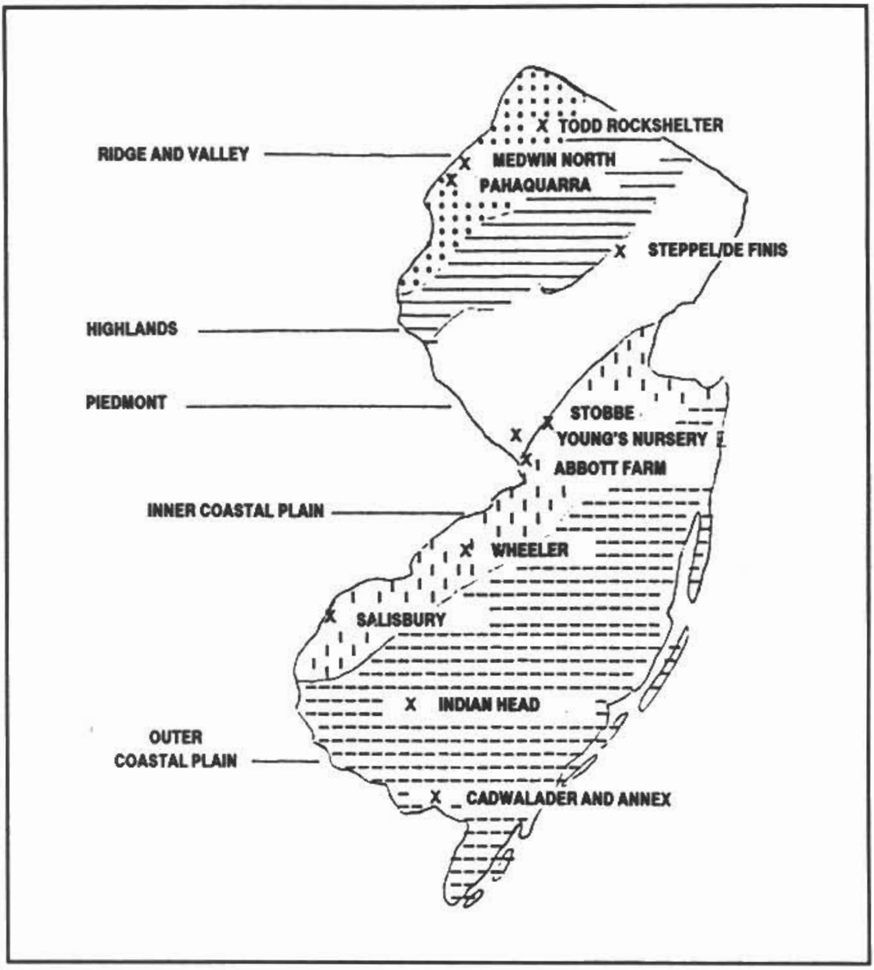

Figure 2. Location of archaeological sites discussed in text (after Lavin, 1983).

Secondary Sources

In regard to secondary sources, the picture is a bit more complicated but also optimistic. Briefly, secondary sources are rock deposits that have been transported from their bedrock parent sources by glaciers, glacial meltwater, rivers and streams, marine action, or other natural forces. They may be divided into two basic groups: glacially transported till, and fluvial or water-laid deposits.

Studies of till deposits indicate that they are decidedly local. Goldthwait's (1971) research showed that 99 percent of all pebble-sized and larger rock

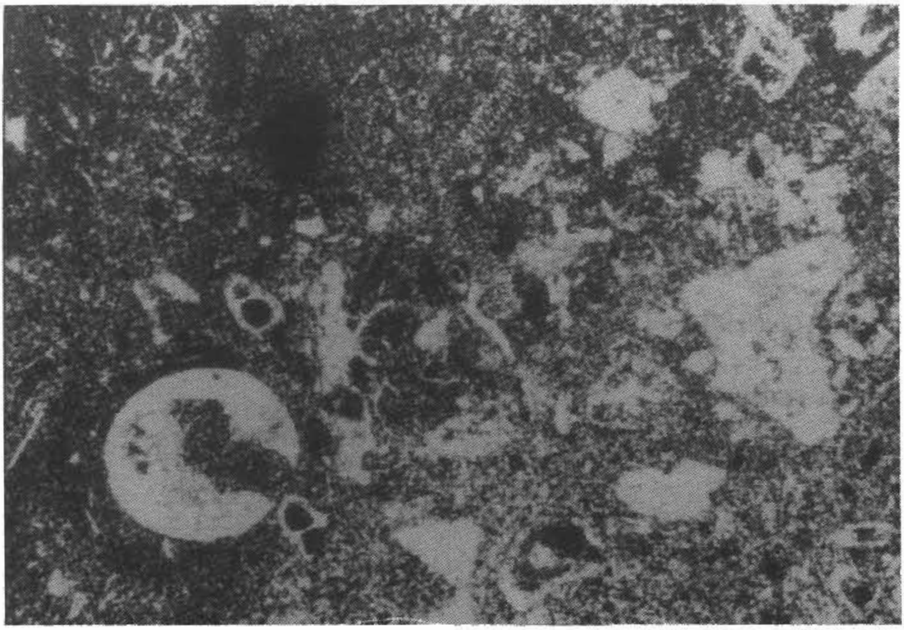

Figure 3. Microscopic thin-section from a jasper cobble of the Beacon Hill formation. The dark area in the left and upper portions of the photo is a heavy iron oxide stain that formed a concentric ring around the cobble due to weathering. Fragments of fossil corals, brachiopods, and fenestrate bryozoans are leached and filled with fine chert, quartz, and opaque minerals (dark areas within the white).

fragments are from bedrock within 21 miles (34 km) of the till deposit. Luedtke (1976; 1985:3) tested this statement empirically with the Bayport chert source in Michigan and discovered it was true. She found that knappable pebbles (i.e., those at least 3 cm or 1 and 1/8 inches long, based on the size of the smallest cores from local archaeological sites) occurred within 25 miles (40 km) of the parent source, close to Goldthwait's 21 mile limit. In our research area, geological studies of till deposits conclude that most of the sediments were derived from the underlying bedrock (Herpers, 1961:15; Lucey, 1969:8; Minard and Rhodehamel, 1969:29,297-301). The Epsteins (1969:173) report that in some sections of northern New Jersey and Pennsylvania over 95 percent of the drift is from underlying bedrock.

The contents of water-laid deposits may travel farther. This is not to say that we should expect to find Ontario cherts in New Jersey gravels. Luedtke (1985:3), citing the geological literature, notes that "secondary deposits of raw materials will be distributed differently for each material, depending on . . . " a number of

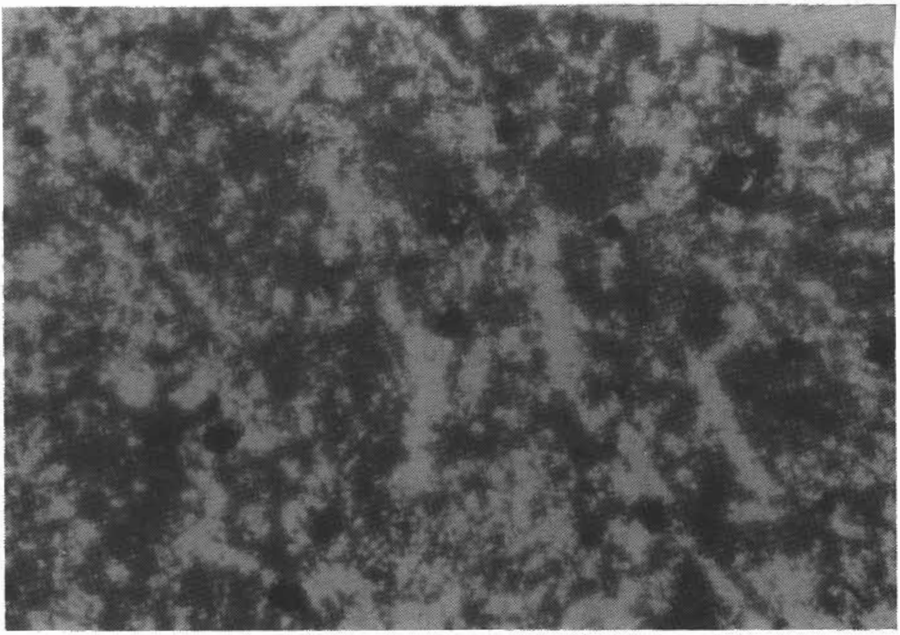

Figure 4. Microscopic thin-section of a jasper cobble from the Pensauken formation. Dark gray areas are iron oxide stains. Small, rhomboidal black and black and white forms are leached dolomite rhombs filled with opaques. The fine-textured chert (light areas) is oriented in a subparallel or "felted" direction that is often obscured by the oxide stain. **Parent source**: Northern New Jersey Onondaga formation.

factors. They include size of the fragments eroded from the parent bed rock, resistance of the rock type to breakage and fracture, relative size of the outcrop area, and resistance of the bedrock to erosion. She concludes that "unless the material occurs in massive deposits it is unlikely that it will occur in usable size fragments or large quantities far from its source."

Chert transported by water action from northern New Jersey sources have been identified in Delaware River deposits at least 80 km from the parent source. This means that artifacts manufactured from fluvial gravels may be misidentified as coming from a nonlocal primary source rather than a local secondary source. This situation may cause dire repercussions in the reconstruction of aboriginal lithic exchange systems, promoting the creation of inter-regional trade networks where none exist.

Fortunately, our project suggests that much of the secondary materials can be identified as such. The two secondary sources in our study—Beacon Hill and Pensauken—are fluvial gravel deposits from central and southern New Jersey.

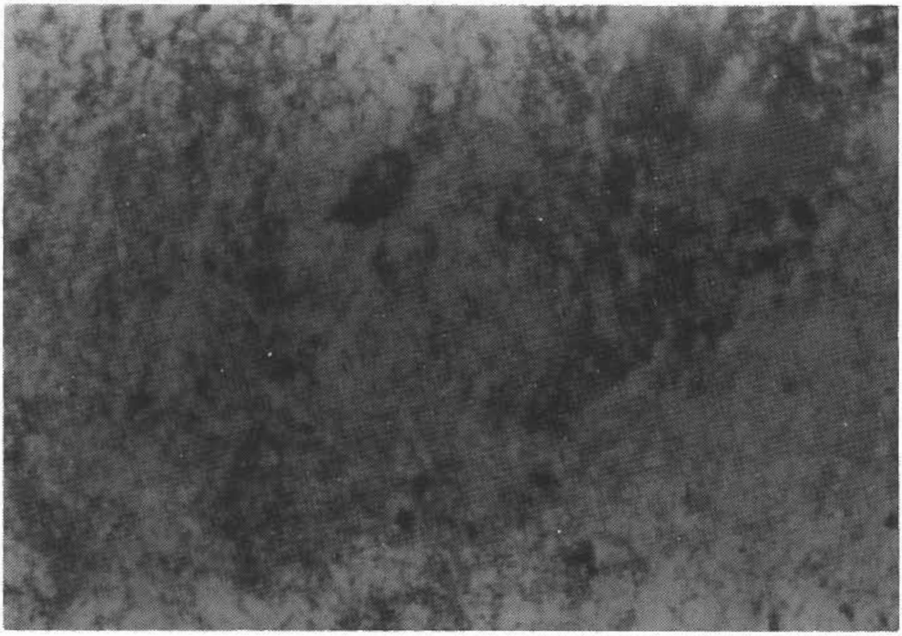

Figure 5. Microscopic thin-section of Onondaga chert from a primary source in northwestern New Jersey. The section exhibits fine-grained chert with a "felted" direction and small, white, unleached dolomite rhombs. Black splotches are pyrites and fine-grained carbonaceous matter.

Both contain cobbles and pebbles of gray and yellowish brown cherts. Since the cherts were derived from a number of bedrock outcrops within the stream drainage, a wide variation of chert types are present. But the cobbles/pebbles are easily identified as water-laid by their smoothed, water-rounded cortex. The cortex, however, is often removed by the knapper during tool manufacture. Fortunately, chert from secondary sources may be distinguished microscopically from chert within a bedrock source through its degree of weathering. Secondary chert cobbles often—but not always—have a strong iron oxide stain that forms one or more concentric rings around the pebble, beginning at the rim and working inward.

Figure 3 is a microscopic thin section from a jasper cobble of the Beacon Hill formation. It exhibits heavy staining and a thick post-depositional ring. Carbonate minerals are almost always leached out, and their voids filled with opaques. Figure 4 is a thin section of a jasper cobble from the Pensauken formation. Besides the oxide stain, there are numerous leached dolomite rhombs filled with opaques. The small rhombs and fine-textured chert with subparallel or felted direction indicate that the original source of the cobble was a bedrock outcrop of Onondaga

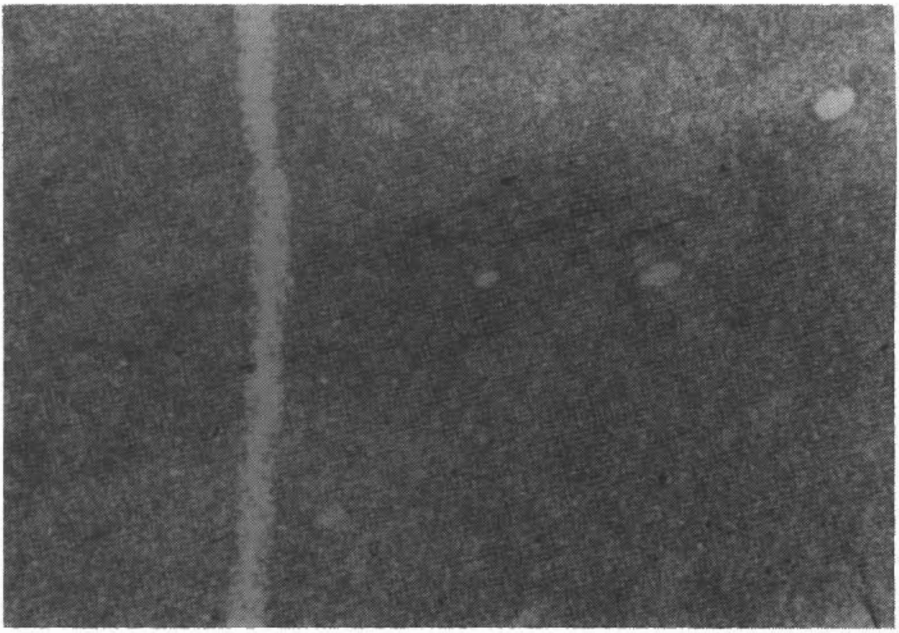

Figure 6. Microscopic thin-section of slightly weathered chert cobble from the Pensauken formation. Ground mass consists of very fine-grained chert (white) and clay (light gray) particles. Light ovoid forms are radiolarian fossils. Opaques are represented by slight stain and by minute inclusions (black). White quartz vein cuts through section. **Parent source**: Normanskill formation.

Limestone from northwestern New Jersey. Figure 5 is a thin section of Onondaga chert from such a primary source. Note the similarity in texture to the Pensauken specimen: the small dolomite rhombs, the felted texture. Only the lack of oxidation and leaching distinguishes the bedrock specimen from the secondary cobble.

Weathering in the form of oxidation of opaques and leaching of carbonates characterize all of the secondary brown, yellow and white cherts included in our analysis—the so-called "pebble jaspers." It characterizes some of the secondary gray and black cherts as well.

Some of the gray and black secondary cherts are unweathered in both hand specimen and in thin section. They cannot be distinguished from "fresh" cherts in their parent source. Figure 6 is a thin section of unweathered gray chert from a Pensauken deposit. Note the absence of oxidation, the unleached carbonates. It is a fine, even-textured chert with fine silt and radiolarian fossils. They indicate that the parent source was the Normanskill Shale, commonly called Coxsackie Flint. The cobble is indistinguishable petrographically from slides of primary

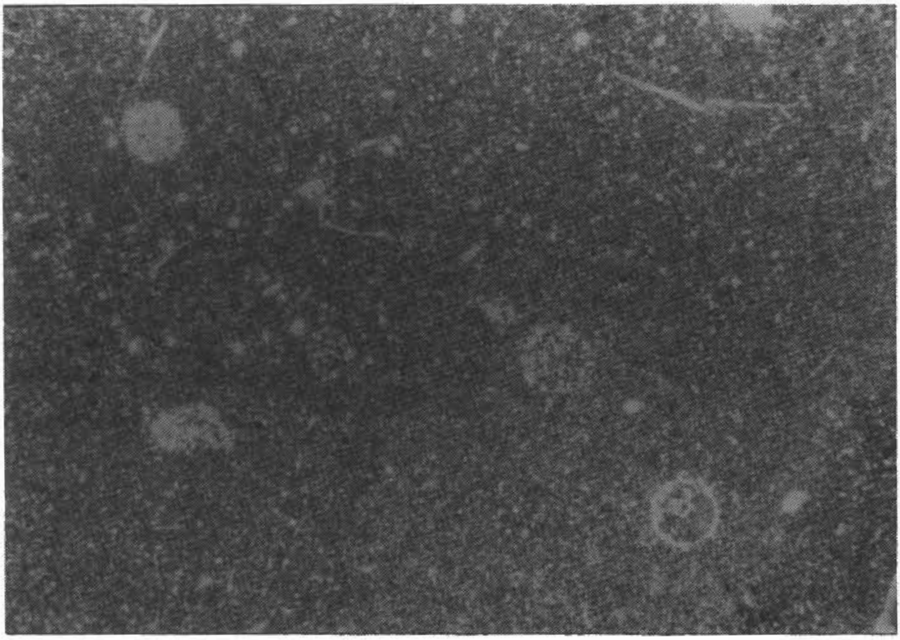

Figure 7. Microscopic thin-section of primary Normanskill chert from Flint Mine Hill, Coxsackie, New York. Groundmass of fine chert (white) and clay-mica particles (light gray). Light spherical-ovoid forms are radiolarian fossils, light needle-like forms are sponge spicules. Black specks are pyrite crystals.

Normanskill chert. Figure 7 is a thin section of primary Normanskill chert from the prehistoric quarrying site of Flint Mine Hill. Notice the similarity in texture, the radiolarian fossils, to the secondary source specimen.

As the foregoing slides illustrate, the parent source of a secondary chert cobble may be identified if the thin section is not completely obscured by weathering in the form of oxidized opaques. This is an important point, because not all water agencies cut through the same rock units. As a result, the gravels deposited by each river or stream may represent different bedrock units. This information may be useful in reconstruction of lithic procurement and exchange systems, as it may be possible to identify the general geographic location of a secondary deposit "quarried" by a prehistoric group.

For example, the Delaware River apparently did not cut through bedrock outcrops of Normanskill Shale, as none of the formation's shale or chert have been identified in its gravels, including the Pensauken and Beacon Hill deposits. In contrast, the Hudson River of eastern New York does cut through extensive shale outcrops, and Normanskill cobbles are found in its gravels. Figure 8 is a thin

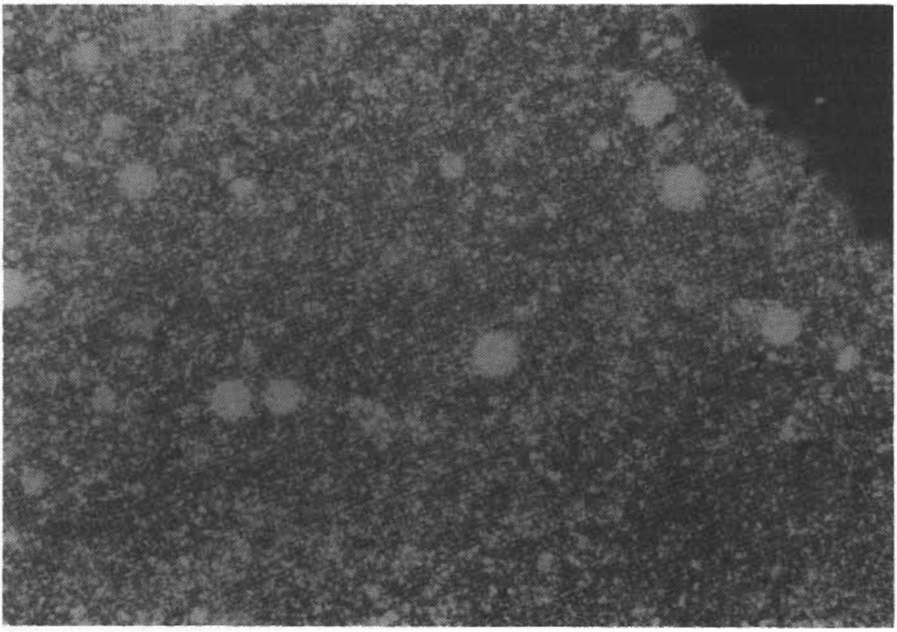

Figure 8. Microscopic thin-section of chert artifiact from Harik's Sandy Ground site, Staten Island, New York. Groundmass contains fine-grained chert (white) and silt (gray) particles. Light, circular forms are radiolarian fossils. Black specks are opaque minerals. **Parent source**: Normanskill formation.

section of an artifact from the Harik's Sandy Ground archaeological site on Staten Island, at the southern tip of New York state and eastern edge of New Jersey (Lavin, 1980). Its silty matrix and fossil radiolarians identify it as Normanskill. Its oxidation and leached carbonates indicate a secondary source. Since Normanskill cobbles have not been identified in the secondary gravels covering New Jersey, the source of raw material for the artifact most probably was a Hudson River gravel deposit—available locally and just north of the site.

Weathered thin sections of stone artifacts often match closely the slides from secondary deposits. Figure 9 is a thin section of an artifact from the Cadwalader site in southern New Jersey. The strong oxide stain and dissolved carbonates readily identify its source as a secondary one. Dolomite rhombs, chalcedony veins, Devonian fossil fragments identify the parent source as eastern Onondaga Limestone. The chert type is found in most of the secondary deposits covering New Jersey, and so the raw material for artifact manufacture was probably procured from a local Pensauken or Beacon Hill gravel deposit.

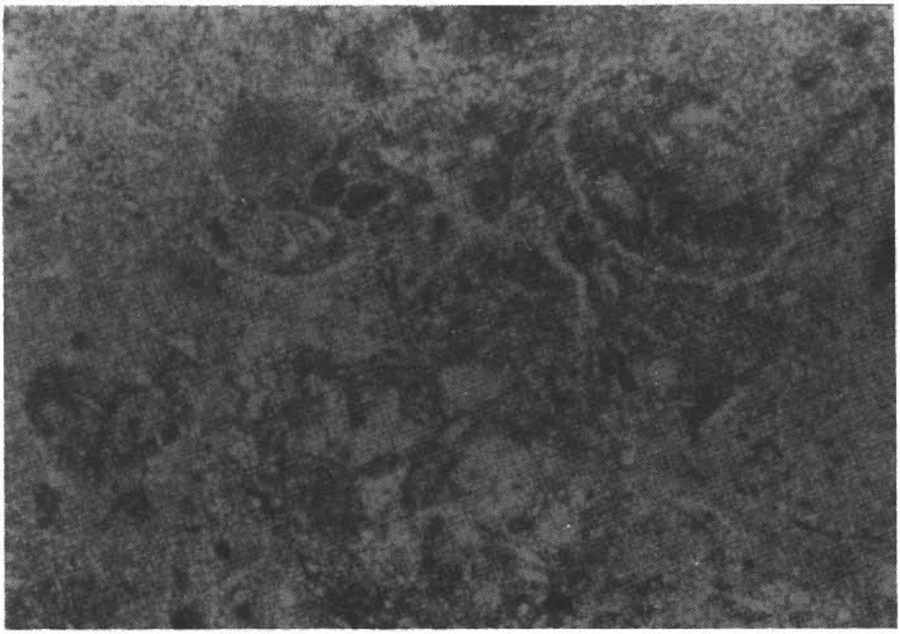

Figure 9. Microscopic thin-section of a chert artifact from the Cadwalader site in southern New Jersey. Dark gray mottling over much of section is iron oxide stain. Light rhomboid forms are chalcedonized dolomite rhombs, white ovoid, and curved outlines are Devonian fossil "ghosts" that are leached and filling with opaques (black). White chalcedony veinlets are present in central area. **Parent source:** Eastern Onondaga Limestone.

CONCLUSIONS

In summary, data from archaeological sites in New Jersey and southern New York indicate that Native American groups were exploiting other lithic sources besides the known prehistoric quarry areas. The information demonstrates that research designs for sourcing projects should include sampling surveys of secondary gravel deposits and of bedrock outcrops of chert types other than those represented at the prehistoric quarrying sites.

Hand specimen analysis alone is inadequate for discriminating among these chert types. It must be used in conjunction with a geochemical and/or petrographic technique. Our study indicates that petrographic analysis may be a powerful tool in the identification of both primary and secondary sources. Weathering in the form of post-depositional oxidized rings, oxidized opaques, and leached carbonates distinguish secondary chert cobbles from their siblings embedded in primary bedrock.

The stumbling blocks in secondary source identification are the nonweathered black and gray cherts that are petrographically indistinguishable from primary specimens of the same chert type. Perhaps trace element analysis will uncover chemical differences caused by the different depositional histories of primary and secondary cherts. Until that time, we must take care to identify the parent sources of secondary rock units in our research area, especially those deposits locally available to the cultural group under study. This will provide us with a listing of the nonlocal bedrock chert types represented in the local gravels, and give us a good idea of which artifacts were made from nonlocal chert and which probably were manufactured from local secondary gravels.

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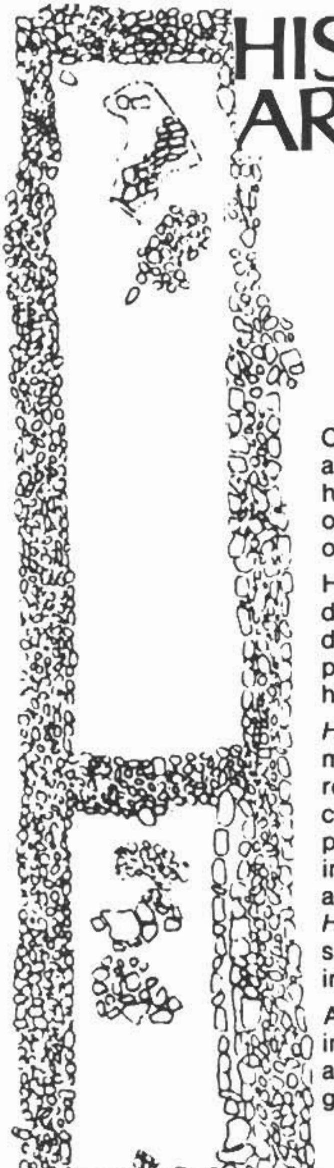

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