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MICROSCOPIC ANALYSIS OF CHERTS WITHIN AND ADJACENT TO THE DELAWARE RIVER WATERSHED

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Abstract

A regional sampling survey of chert-bearing formations in the New York and Middle Atlantic region was conducted as part of a study of prehistoric lithic procurement systems within the lower and middle Delaware River Valley. Chert samples were collected from over 80 localities, representing 21 of the archeologically relevant formations within the research universe. Laboratory analysis indicates that the sources of virtually all of the chert types can be identified. There is evidence that thin-section analysis can distinguish specimens from various loci within the outcrop area of a single formation, as well as from loci representing different formations.

Under grants from the National Science Foundation and the New York State Museum and Science Service, a regional sampling survey of chert-bearing formations in the New York and Middle Atlantic region is being conducted as part of a larger study of prehistoric lithic procurement systems within the lower and middle Delaware River watershed. To date, chert samples have been collected from over 80 localities, representing 21 of the archeologically relevant chert-bearing formations within the research universe. Nineteen of the formations are primary chert sources; *i.e.*, *in situ* bedrock deposits. The remaining two formations are secondary fluvial deposits. The formations are the Hardyston

Quartzite; Newark Gabbro; Wissahickon Schist; Little Cattail Creek; Allentown Dolomite; Little Falls Dolomite; Mines Dolomite; Beekmantown Group (including the Rickenback Dolomite, Epler Limestone and Dolomite, Halcyon Lake Dolomite, Rockdale Run Limestone, and Stonehenge Limestone); Normanskill Shale; Keyser Limestone; Helderberg Group (including the Coeymans Limestone, Kalkberg Limestone, New Scotland Limestone, and Alsen Limestone); Onondaga Limestone; Shriver Chert; Beacon Hill Gravel; and Pensauken Sand and Gravel. Figure 1 illustrates the geographic distribution of the chert-bearing outcrops of each lithic unit. Cherts derived from a specific formation are herein referred to as a "type."

Initially, a method of macroscopic, nondestructive analysis was developed, by which the source of a hand specimen of chert might be distinguished through megascopic attributes such as color, texture, reaction to simple chemical tests (such as application of HCl), and presence of visible inclusions. The Mines chert, for example, is identified by its coarse oolitic texture; the chert is literally packed with ooids. Greenish Normanskill chert can be identified by its distinctive color, shaley texture, and lack of reaction to HCl.

It was found, however, that the majority of chert types within the research universe are macroscopically homogeneous in texture and of a neutral gray or black - tones ubiquitous throughout the six-state survey area. Cherts of various hues (*e.g.*, bluish gray, brownish yellow, yellowish brown, *etc.*) do occur, but they are not diagnostic of a single formation. Consequently, the application of macroscopic analysis in itself is inadequate for pinpointing the sources of these cherts. The technique does have value as an initial stage in the identification process by delineating the number of possible chert types represented by a specimen and facilitating identification through microscopic analysis.

A large number of petrographic traits have been utilized to differentiate the various chert types under study. Although Wray's (1948) thin-section analysis of New York cherts provided a baseline for our research, we have not limited ourselves to researching each slide for characteristics considered diagnostic by him. Rather, we are documenting the entire contents of each slide in order to (1) test Wray's conclusions, and (2) uncover additional features that may prove characteristic of a certain chert type. Distinctions in texture, fabric and structure as well as mineralogy and chemistry are being sought.

To date, 130 thin-sections representing 14 primary sources and two secondary sources, have been analyzed. To test the degree of intra-formational variation, samples were collected from several discrete localities within the outcrop area of each formation whenever possible. So far, the results of the analysis indicate that chert types from all of the primary sources can be distinguished from one another. Identification of secondary source materials, however, does pose some problems.

Some geologists have expressed doubt that cherts can be diagnosed by textural and mineralogical petrographic characters, since these are

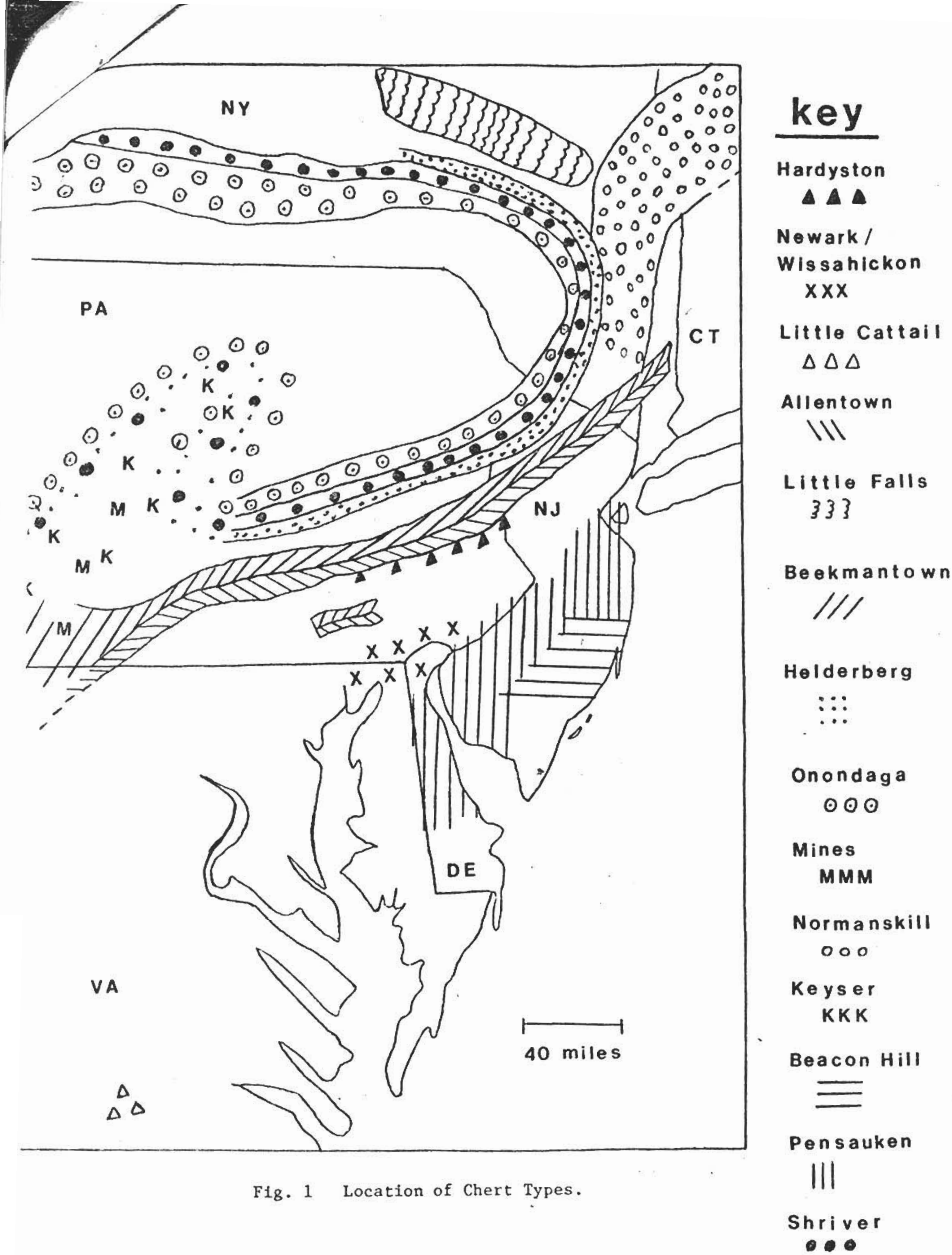


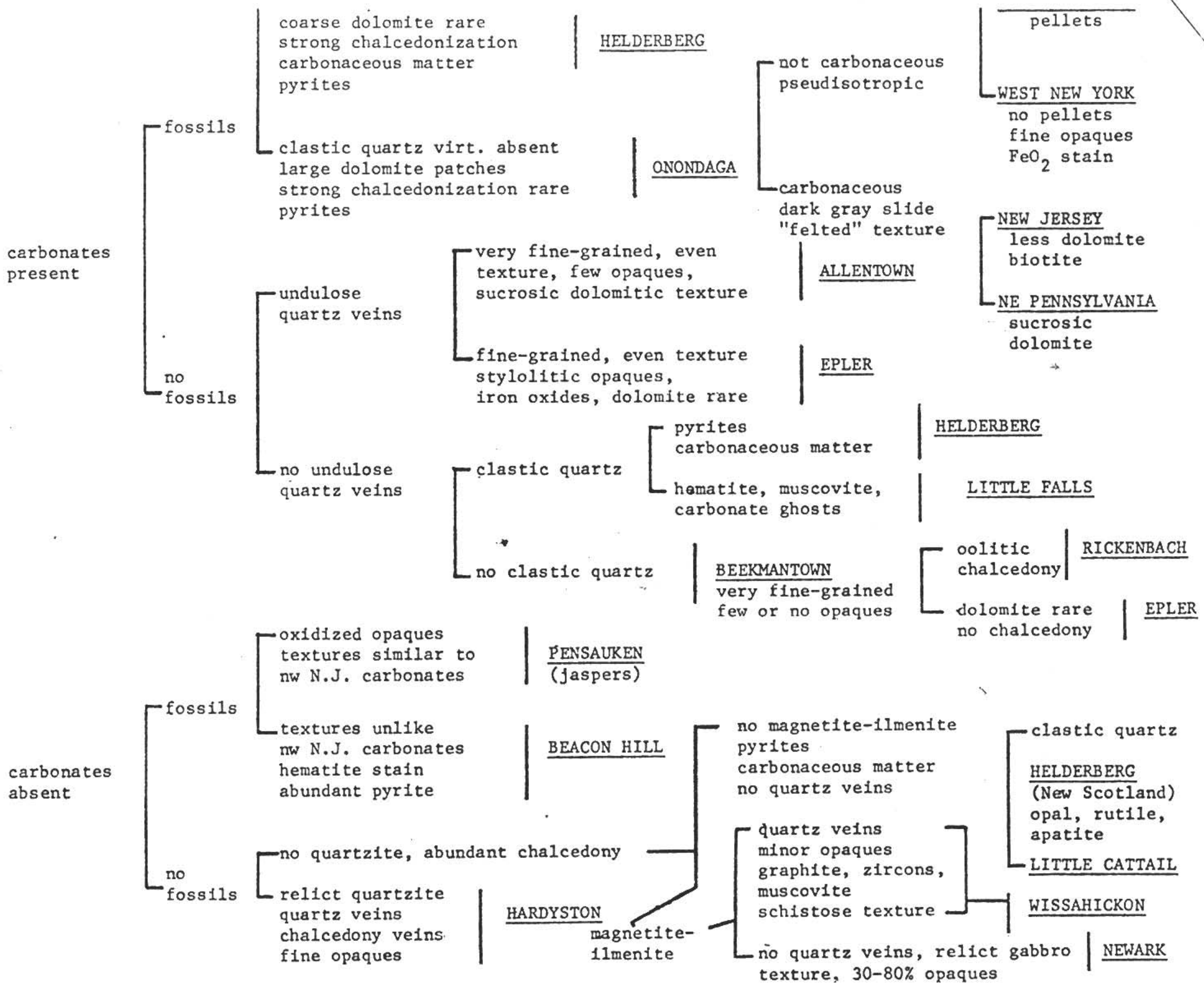
Fig. 1 Location of Chert Types.

seldom unique features and are often a function of local depositional or diagenetic conditions. In regions where all the cherts are derived from similar sources, such as the platform carbonates of the midwest, this may be the case. In these regions, our methods may not prove useful. However, in our area, the cherts are derived from an extremely heterogeneous variety of sources: schists, gabbros, quartzites, shales, and a variety of carbonates. We have little or no difficulty distinguishing cherts derived from the noncarbonate sources, since these are so fundamentally different and give strikingly different textures after silicification. Among carbonate-derived cherts, distinctions are not as easy, but we have been surprised to see how different many of these units look in thin-section, and how homogeneous the textures are intraformationally. Where there are doubts in our minds about assignment to carbonate units (especially between Helderberg and Onondaga) we have clearly stated this in our discussion.

The petrography of each chert type is briefly summarized below. Figure 2 is a dichotomous key of chert attributes that differentiate the various chert types under study. The cherts easily divide into a suite of carbonate-derived and noncarbonate-derived cherts. Each half of this dichotomy can be subdivided into fossiliferous and nonfossiliferous cherts. The cherts can be further subdivided according to various textural and mineralogical attributes. Some of these attributes are only present in a single chert type, and are therefore diagnostic of that particular type. Other chert types have no single diagnostic characteristic, but each one does contain a combination of traits specific to that type, and so may be identified through its *diagnostic combination* of attributes.

1. Hardyston Quartzite (11 specimens representing 3 localities).

The Hardyston Quartzite is a Lower Cambrian rock unit that often contains yellow, brown and orange cherts commonly called "Pennsylvania Jasper." Virtually all chert-bearing outcrops are located in east-central Pennsylvania (Drake 1969; Section of Archaeology n.d.; Witthoft n.d.). A distinguishing characteristic of the chert is alteration of a strained fine-grained quartzite to microcrystalline quartz and chalcedony. Alteration begins with patches and pods, leaving large isolated undulose quartz grains outlined by stylolitic seams in streaks and patches. Completely chertified specimens contain relict quartz grains outlined by opaques, including microcline and plagioclase, indicating a primary arkosic source. The opaques frequently pseudomorph a granular texture in the chert. Secondary growths of quartz and chalcedony veins are often present. Abundant fine opaques are either scattered throughout the chert and/or occur in clots and streaks. The opaques, which are mostly hematite (although limonite is also sometimes present), usually represent 10-30% of each slide. The one exception is a sample consisting of only 2% opaques. Opaques occur only in the chert; they are excluded from the quartzite and secondary veinlets. Occasional stylolitic seams of limonite and hematite are formed along grain boundaries or margins of veinlets. Traces of fine-grained biotite peppered with hematite occur in some specimens. Both inter-outcrop and intra-outcrop variability is evident.



Dichotomous Key to Chert Identification

They are mainly due to the differential degree of quartzite replacement.

2. Newark Gabbro (9 specimens representing at least 3 localities).

The Newark Gabbro is a lower Paleozoic unit. Outcrops in eastern Maryland, northern Delaware and southeastern Pennsylvania contain yellowish brown and black fine-grained chert known as "Newark Jasper" and "Cecil Black Flint," respectively (Wilkins 1967). The cherts can be identified by the abundant presence of magnetite, ilmenite and/or chromite in streaks, clots and euhedral crystals; they comprise 30-80% of each slide. Relict gabbro texture is often represented by chert-filled opaque-rimmed pseudomorphs of olivine, plagioclase and pyroxene. The chert is often stained with limonite in gels. Opaques are generally strongly aligned in streaks. Veins of fibrous chalcedony are developed and virtually always present. The veins are rimmed by stylolitic concentrations of iron oxides; they occasionally crosscut one another. Intra-outcrop variation is minimal. There is slight inter-outcrop variation between the Delaware and eastern Maryland loci. The former contains a much higher percentage of opaques (80% of each slide) and much smaller amounts of chalcedony veins and chert; slides are heavily stained with iron oxides.

The brown and black cherts are petrographically very similar; differences are minimal. Limonite in gels is more often found in the brown specimens while relict gabbroic texture is more often found in the black chert.

3. Little Cattail Creek Formation (6 specimens representing 1 locality).

We are using the term "formation" rather broadly here, as the Little Cattail Creek unit consists of residual chert cobbles that, as far as we have been able to determine, no one has attempted (or been able) to associate with any known geological unit. Consequently, there is a possibility that they do belong to a previously named unit (albeit not one that we have analyzed). Until this possibility has been investigated, we shall refer to the unit as the Little Cattail Creek Formation.

The Little Cattail Creek chert is commonly known as Dinwiddie or Williamson Chert. The chert is derived from a residual deposit located along Little Cattail Creek in Dinwiddie County, northeastern Virginia (McCary 1975). The chert was formed on Precambrian rock, and so the formation may be as old as Precambrian or Cambrian.

The chert is heavily altered to chalcedony and opal, with numerous patches of radially fibrous chalcedony. Strong undulose extinction is common. All specimens contain carbonaceous matter (less than 1% to 20% of each slide) and pyrites; rutile needles and apatites are very often present. Some slides also contain limonite gels, muscovite grains, chalcedony veins, possible pseudomorphs of sponge spicules, and anhedral quartz and stylolites filled with iron oxides or fibrous chalcedony.

4. Allentown Dolomite (8 specimens representing 2 localities).

The Allentown Formation extends from northwestern New Jersey through eastern and southern Pennsylvania into western Maryland. Outcrops east of the Schuylkill River have traditionally been called Allentown; those west of the Schuylkill are called Concocheague (Gray *et. al.*, 1960).

Analysis demonstrates a very fine-grained, even-textured chert replacing sucrosic-textured dolomite (grains 0.02-0.05 mm. in diameter). The chert frequently surrounds isolated euhedral dolomite rhombs as large as 0.1 mm. in diameter. All slides contain well-developed veins and patches of coarse-grained, anhedral, highly sutured and undulose quartz, often with considerable stretching of the grains parallel to the vein direction. Opaques are rare (less than 1%) to non-existent; they are restricted to finely disseminated carbonaceous matter. Patches of radiating chalcedony, stylolites of iron oxide and opal are present in one slide each. Large patches of medium coarse-grained quartzite occur in two slides, suggesting that there may have been localized quartz sand in the carbonate environment. Inter-outcrop, intra-outcrop and intra-nodular variation is negligible.

5. Little Falls Dolomite (3 specimens representing 1 locality).

The Little Falls Dolomite is an Upper Cambrian rock unit cropping out in eastern and east central New York (Hammer 1976:52). Petrographic analysis indicates a very fine-grained, even textured chert with abundant well-rounded clastic quartz grains (10-15% of each slide) sometimes showing undulose extinction. Muscovite flakes (5-10% of each slide) and small amounts of opaques - usually hematite (2-5% of each slide) are present. Large euhedral dolomite rhombs (0.1-0.4 mm. in diameter) and their pseudomorphs, and ghosts of ooids and fossils are often present; all are commonly rimmed with hematite. Hematite also occurs in beds. Small patches of chalcedony (sometimes consisting of radiating fibrous chalcedony) are often present. Well-defined relict bedding is visible in some specimens. Intra-outcrop variation is minimal.

6. Beekmantown Carbonate Group (10 specimens representing 2 formations and 4 localities).

A. Rickenbach Formation (4 specimens representing 2 localities).

Large dolomite rhombs (0.1-1.0 mm.) and patches of sparry carbonates are scattered throughout the chert. Interstices and vugs are filled with fine chalcedony or quartz. Opaques are rare (0 to less than 1%), although one slide does contain 5% pyrites and 5% submicroscopic opaque dust. The slides show some inter-outcrop variation in texture. Three of the slides (representing 1 locus) exhibit a relict oolitic carbonate texture replaced by fine chalcedony. The fourth slide (representing a second locus) consists of a fairly uniform fine-grained chert with a mottled texture that may represent ghosts of a carbonate sand or fossils 0.03 mm. in diameter.

B. Epler Formation (6 specimens representing 2 localities).

The Epler Formation is characterized by a fine-grained, even textured chert. Dolomite rhombs are absent or restricted to a few patches (0-9% of each slide). Unlike other dolomite-free cherts, chalcedony is absent. Well-developed quartz or quartzite veins and patches are often present; they are occasionally undulose and sutured. Opaques are present but scarce (less than 1% to 2%) and usually concentrated in stylolites. They appear to consist of iron oxides, especially hematite. Intranodular variation and intra-outcrop variation are negligible. Inter-outcrop variation is indicated by the presence of undulose, sutured quartzite patches and 20-28% less chert per slide at one of the loci.

The variability normally expected from a group with several formations is reflected in the Beekmantown slide collection. Some of the cherts are clean, fine-grained, uniform chert as in the Epler specimens. Others are slightly altered, as in the oolitic or mottled textured Rickenbach cherts.

There are, however, a few generalizations we can make about the Beekmantown Group as a whole: The chert is fine-grained with few or no opaques. Fossils and clastic quartz are also absent. Carbonates are present, except for some of the Epler specimens; the presence of stylolitic concentrations in those specimens, however, indicate a carbonate origin for the chert.

7. Wissahickon Schist (3 specimens representing 2 localities).

The Wissahickon Schist is a lower Paleozoic unit; chert-bearing outcrops are located in eastern Maryland, northern Delaware and southeastern Pennsylvania. The chert is commonly known as Broad Run Chalcedony (Section of Archaeology n.d.a.). The basic texture of the Wissahickon chert is that of an altered mica schist, as shown by the presence of patches and streaks of graphite (5-15% of each slide), fine flakes of muscovite, purple zircons (at one locality) and the schistose texture. Abundant clots and veins of quartz and chalcedony are also present. Limonite gels and iron oxides are often present. The iron oxides and graphite frequently show preferred orientation; occasionally stylolites are formed by the oxides along chalcedony veins. A strong alignment fabric of chalcedony veins also occurs. The presence of the purple zircons at one locality suggests (very tentatively, due to the small sample) that intraformational variation may allow us to distinguish a source location or locations within the general Wissahickon outcrop area.

8. Helderberg Group (19 specimens representing 4 formations and 5 localities).

The Helderberg Group extends in a narrow band from central and eastern New York through northwestern New Jersey and eastern and central Pennsylvania into western Maryland. The Group consists of at least 8 lower Devonian formations; most are chert-bearing (Fisher *et. al.*, 1970;

Gray *et. al.*, 1960; Johnson 1950).

A. Alsen Formation (3 specimens representing 1 locality).

Alsen chert is characterized by numerous (10-15% of each slide) well-preserved Lower Devonian fossils of corals, bryozoans and brachiopods, usually showing replacement to chalcedony. Dolomite is present, usually as numerous small rhombs, but few to numerous large rhombs (up to 3.0 mm. in diameter) may also occur. Pyrites and small amounts of carbonaceous matter (1% or less of each slide) are also present. In one specimen the chert is strongly chalcedonized (*ca.* 65% of the slide), and fracture planes are recrystallized with calcite. Another specimen contains subhedral, subequant grains of clastic quartz. Intra-outcrop variation is minimal. Intra-nodular samples are very similar, differing only in the presence of minor clastic quartz in one slide.

B. Coeymans Formation (3 specimens representing 1 locality).

Coeymans chert is characterized by abundant patches and large rhombs of dolomite, carbonaceous matter and pyrites. It is often strongly chalcedonized (*ca.* 55-75% of each slide). Fossils (including corals and brachiopods), clastic quartz, iron oxides, fracture planes recrystallized with calcite, carbonaceous ghosts and segregated zones of clean chalcedonized chert and opaque-laden stained carbonate-rich chert may sometimes occur.

C. New Scotland Formation (8 specimens representing 2 localities).

New Scotland chert is a strongly chalcedonized (*ca.* 55-80% of each slide) carbonaceous chert. Large (0.05-0.1 mm.), angular, anhedral grains of clastic quartz occur; they are restricted to the New Scotland Formation. Ghosts of carbonate clasts, dolomite rhombs, pyrites and abundant fossils (including trilobites, brachiopods, and corals) are often present. Iron oxides, chalcedony spherules, opal and segregated zones of clean chalcedony and opaque-laden carbonate-rich chert may sometimes occur.

D. Kalkberg and/or Port Ewen Formation (5 specimens representing 1 locality. Chert from the two formations were inadvertently given the same catalog number. Consequently, the slides may represent either or both of the rock units).

The chert is very fine-grained and uniform in texture. It is predominantly a silicified limestone with carbonates composing 30-55% of each slide. Dolomite rhombs, when developed, are usually small (less than 0.1 mm.). Pyrites and carbonaceous matter are present. The latter clouds calcite and forms ghosts, stylolitic seams, and pelletoids. Anhedral, angular clastic quartz is often present; it is much finer-grained than quartz in the New Scotland specimens. Fossils (trilobites, brachiopods), fracture planes recrystallized with calcite, sparry calcite pseudomorphs of fossils, dusty calcareous aggregates and opaques (including iron oxides) may sometimes occur. There is only a minor development of fibrous chalcedony; strongly chalcedonized chert and chalcedony veins are uncommon.

As might be expected from a group with numerous formations, the Helderberg slides are highly variable, and generalizations are difficult. Even slides from a single formation show inter-outcrop and intra-outcrop variation (*e.g.*, Coeymans and New Scotland Formations). With this reservation in mind, the following generalizations on the Helderberg Group as a whole still appears valid: Carbonaceous matter is always present. Pyrites and carbonates, especially fine carbonates and small dispersed dolomite rhombs, are virtually always present (17 of our specimens). The chert is often highly recrystallized to fine patches of fibrous chalcedony (12 of the specimens); veins of chalcedony, however, are uncommon. Clastic quartz commonly occurs (12 of the specimens). Eleven of the specimens contain well-preserved fossils. They include brachiopods, trilobites, corals and bryozoans. Seven of the specimens contain iron oxides and other opaques. The following traits infrequently occur (1-7 of the specimens): fracture planes recrystallized with calcite, segregated patches of clear chalcedony and opaque-laden carbonate chert, carbonaceous ghosts, chalcedony spherules, dusty calcareous aggregates, opal and sparry calcite.

9. Onondaga Limestone (25 specimens representing 9 localities).

The Onondaga Formation is a lower Middle Devonian unit. It extends from Ontario and New York through northwestern New Jersey and eastern Pennsylvania into western Maryland (Fisher *et. al.*, 1970; Gray *et. al.*, 1960; Johnson 1950). The chert is generally fine-grained. Dolomite is numerous as fine patches and/or rhombs. Both large (0.1-2.0 mm.) and small (less than 0.1 mm.) rhombs commonly occur. Pyrites are always present. Middle Devonian fossils of brachiopods, corals, crinoids and bryozoans are often well-preserved. Unlike the Helderberg specimens, chert is not strongly chalcedonized. But fibrous chalcedony frequently occurs as veinlets, seams, patches and spherules.

Petrographic analysis indicates that intra-formational variability is distinctive enough to allow us to distinguish chert subtypes from geographic areas within the Onondaga outcrop region. Chert from the following areas can be differentiated: western New York (Divers Lake Quarry); the Albany-Catskill region of eastern New York; northern and western Sussex County, New Jersey; northeastern Monroe County, Pennsylvania.

A. Western New York (5 specimens from Divers Lake prehistoric quarry).

The chert is a fine-grained pseudisotropic chert with pervasive small dolomite rhombs (0.01-0.03 mm.) and fairly abundant pyrites. There are few large dolomite rhombs and spherules of chalcedony. Fossils are present, representing corals (including *Halysites*), brachiopods and bryozoans. The slides often contain finely disseminated opaques, and slight brown iron oxide stains. The following traits infrequently occur (1-2 specimens): a few patches or seams of fibrous chalcedony, patches of fine dolomite, patches of sucrosic dolomite surrounding pseudisotropic chert, anhedral quartz grains 0.2 mm. in diameter, quart crystallization of fossils. One slide contains a few possible biotite grains (0.02 mm. long), but the identification is equivocal. No pelletoids or "felted" texture occurred.

B. Albany-Catskill (12 specimens representing 5 localities).

The chert is so finely divided that it appears almost isotropic. It contains numerous dolomite rhombs, usually large and small (0.005-5.0 mm. long), but also in large patches. Chalcedony is also present in patches, spherules or veins. Ooids and pelletoids rimmed by chalcedony are common, also with an apparently isotropic fabric. Many of the fossils and pelletoids are replaced by coarsely fibrous chalcedony. Middle Devonian fossils occur, often abundantly; they consist mainly of brachiopods, crimoids, trilobites and corals. Carbonaceous matter, iron oxides and "felted" texture are absent.

C. Northwestern New Jersey (3 specimens representing 2 localities).

The chert invades limestone in a patchy fashion, leaving many fine unaltered carbonate inclusions. Chert and carbonate both have a strongly "felted" texture emphasized by streaks of abundant finely disseminated carbonaceous matter, which also occurs in clots 0.05 mm. in diameter. Except for a few fragments of brachiopods and trilobites, texture is remarkably uniform, with few grains, spherules or veinlets. A few euhedral dolomite rhombs may occur, but they are generally small. Stylolites of euhedral carbonate infrequently occur. Chalcedony veinlets are present but few in number; they are very long and thin (0.01 mm. wide) and cross-cutting. Very fine (0.02 mm. in diameter) biotite flakes occur, along with abundant patches of pyrite. Megascopically, the slides are a distinctive dark gray color. Iron oxide stains and pelletoids are absent.

D. Northeastern Pennsylvania (5 specimens representing 1 locality).

The chert is a fine-grained material containing fine dolomite rhombs and patches of fine sucrosic dolomitic carbonate. Euhedral dolomite is less common, but occasionally developed into thick (0.3 mm. wide) veins. Pyrites are present. Carbonaceous matter is also present, mainly in the carbonates. Due to the latter, the slides have the same dark gray color found in the New Jersey specimens. Fossils often occur (4 of the 5 specimens); brachiopods are most often represented, although one slide contains "spherical" fossils, possibly gastropods. The "felted" texture characteristic of the New Jersey specimens occurs in two of the slides. The following traits infrequently occur (1-2 specimens): Large dolomite rhombs (up to 0.2 mm. wide); veins of sparry calcite, stylolitic seams of opaques or chalcedony, hematite, chalcedony spherules. One slide contains patches of carbonaceous matter, some of which have a vaguely pellet-like shape.

10. Beacon Hill Gravel (6 specimens representing 1 locality).

The Beacon Hill Formation is an Upper Pliocene gravel that crops out in central New Jersey (Richards 1953:340-343). It is one of the two secondary chert sources included in this study.

The chert is heavily laden with opaques, mainly oxidized pyrites and large patches of hematite. Patches of iron oxide stains are present; sometimes the entire slide has an orange iron oxide stain. Five of the specimens have rims of iron oxides, indicating that much of the stain is post-depositional. A well-preserved fossil hash of brachiopods, corals, bryozoans and spicule-like rods is often present (5 of the 6 specimens), completely altered to fine chert, chalcedony and/or quartz vein filling. Carbonates are absent. One of the slides contains a single pelletoid.

Some intra-outcrop variation is present. This is to be expected, since the Beacon Hill Gravel is a secondary chert source.

11. Pensauken Gravel (25 specimens representing 7 localities).

The Pensauken Formation is a Pleistocene fluvial deposit that crops out in central and southern New Jersey and extreme southeastern Pennsylvania (Gray *et. al.*, 1960; Johnson 1950). It is the second of two secondary chert sources included in this study.

The Pensauken deposits contain yellow, brown and tan "jaspers," whitish cherts with brown weathered exteriors, and black to light gray cherts. As might be expected from a Pleistocene fluvial deposit derived from multiple sources, there are no diagnostic elements for the Pensauken chert *per se*. The "jaspers" and whitish cherts (12 specimens), however, may be distinguished from their parent formations by a highly weathered condition. Weathering has destroyed and replaced virtually all carbonates in the specimens, and oxidized the opaques. The parent rocks of some specimens are difficult to identify because texture is almost completely obscured by opaques. Most of the specimens, however, can be assigned to their primary sources. With the exception of one probable Helderberg specimen, all derive from the Onondaga Formation.

The gray and black cherts (13 specimens) pose the only identification problem incurred in this study. Nine of the specimens show no signs of weathering; there appears to be no microscopic way of distinguishing them from their primary sources. The majority (9 of the 13 specimens) are derived from Beekmantown formations; the Onondaga Formation and possibly the Helderberg Group are represented by one specimen each.

Conclusions

In conclusion, inter-formational variability is quite high among the chert types so far examined. Except for the unweathered chert from one secondary source, the distinctions are so clear that it is possible to make a dichotomous key for identification that works for the vast majority of the specimens. The degree of intra-formational variability differs according to chert type. Some types, such as the Allentown and Epler, are extremely uniform in texture and mineralogy. Other types, such as the Onondaga and Helderberg cherts, may demonstrate marked differences in one or more traits. Intra-outcrop variation is lower than inter-outcrop variation, and intra-nodular variation is lowest of all. In every case, however, the variability is never considerable enough to inhibit accurate formational identification.

Complete confidence in our assertions, of course, depends upon the results of examination of further samples of these and other chert-bearing formations. But if the experience so far is any indication, the cherts available in and adjacent to the Delaware watershed are all easily identifiable to their formation and, in several cases, to their geographic origin within the outcrop area of the formation as well. These findings are archeologically important in that they indicate that the sources of the raw materials comprising lithic artifacts may be delineated through petrographic analysis. Data derived from the analysis could then be used to elucidate problems of prehistoric procurement and exchange.

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Glossary

ALIGNMENT FABRIC (=PREFERRED ORIENTATION): tendency of elements in a rock (crystals, grains, *etc.*) to be aligned in a parallel or subparallel ("preferred") direction.

ANHEDRAL: a crystal with no crystal faces.

CLASTIC: sedimentary particle derived from fragmentation of original material. Shorthand for "sand, silt and clay," as opposed to "chemical" sedimentary rocks--carbonates and evaporites.

DIAGENETIC: refers to textures caused by secondary alteration of rock after deposition, *e.g.*, compaction, cementation, recrystallization, dissolution, replacement, dolomitization.

EUHEDRAL: a crystal completely bounded by crystal faces.

FELTED: (strictly speaking, an igneous term) texture of numerous small elongate grains in a subparallel alignment.

OOLITE: spherical particle, 0.25-2.0 mm in diameter, originally calcareous, with a nucleus and concentric ring structure; in cherts, it is silicified and has a radial structure.

OPAQUES: minerals which do not transmit light, *e.g.*, magnetite, hematite, ilmenite, chromite.

PSEUDISOTROPIC: appears to become totally extinct under crossed nicols (as in isotropic minerals), due to finely subdivided, cryptocrystalline material.

PSEUDOMORPH: a grain having the apparent form of another grain, due to replacement of the latter by the former.

RELICT TEXTURE: preservation of original texture during replacement.

SPARRY: in carbonate rocks, a coarsely crystalline calcite cement.

STYLOLITE: a jagged, irregular seam filled with insoluble residue of opaques, usually due to dissolution.

SUBEQUANT: less equidimensional than "equant," but not "elongate."

SUBHEDRAL: a crystal partly bounded by crystal faces.

SUCROSIC DOLOMITE: dolomite having a "sugary" texture, usually due to a porous, equigranular framework of dolomite euhedra.

UNDULOSE (=UNDULATORY) EXTINCTION: irregular, "wavy" extinction of a crystal when stage is rotated under crossed nicols, due to distortions of crystal lattice.

VUG: a cavity in a rock, often lined with crystals.

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