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CHAPEL FARM ESTATE

RIVERDALE. BRONX COUNTY, NEW YORK

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FIELD INVESTIGATION AND GEOLOGICAL RECONNAISSANCE

Prepared For:

Robert Kahn
82 Pine Crest Drive
Hastings-on-Hudson, New York 10601

Prepared By:

LaPorta Associates
The Old Grist Mill
Glenwood, New Jersey 07418

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FIELD INVESTIGATION
OF THE CHAPEL FARM ESTATE SITE
AND SURROUNDING AREA

I. Introduction

As the result of a series of visits to the *Chapel Farm Estate* site and the area surrounding it between November 1992 and January 1993, combined with extensive library research, the researcher has concluded that the *Chapel Farm Estate* site contains a previously unreported prehistoric quartz quarry, and that the lithic reduction area identified in the Stage 2 investigation carried out by CITY/SCAPE: Cultural Resource Consultants, Hartgen Archeological Associates, Inc., and Historical Perspectives, Inc. is part of that quarrying operation. Further, the library research indicates that the presence of extensive quartz veins in the Fordham gneiss located on and in the vicinity of the project area has not been previously noted in the literature, nor has the potential of these veins as primary lithic resources for prehistoric peoples been explored. The research leading to the conclusions above is described in the body of this report, but, first, it may be helpful to identify the basic elements of a prehistoric quarry:

<u>The Typical Quarry Site</u>

1. **the quarry**, containing the material being extracted, i.e. chert beds, nodules, or pods, or, as in the case of *Chapel Farm Estate*, veins of quartz;
2. **the tailings pile**, located just below the quarry face, containing blocks of quarried material;
3. **the ore dressing area**, also located below and within approximately 50 meters of the quarry face, where large blocks are broken down into smaller blocks for transportation to the lithic reduction site - also referred to as the milling area or transition area;
4. **the lithic reduction site**, usually located above the quarry face or on a level terrace adjacent to the quarry face, where the reduced blocks are further broken down into sizes that can be transported off-site for manufacture into projectile points and other tools.

In general, chert quarries contain numerous hammerstones and other pounding tools of various weights, varying from a few ounces to several hundred pounds, whereas, previously reported quartz quarries have appeared to lack hammerstones. In contrast to reported quartz quarries, *Chapel Farm Estate* appears unusual in that hammerstones of various weights and materials, including quartzite and diabase, are abundant. It is interesting to speculate whether the reported paucity of hammerstones at previously identified quartz quarries is real, or whether it is a case of hammerstones and other quarrying tools being overlooked. Previous investigations of quarry sites have indicated that many tools other than hammerstones exist in quarry areas, including modified flakes that may have been used as chisels, etc. Although tools are abundant, it should be noted that, in general, diagnostic tools, such as projectile points, are not found at quarry sites. Our research indicates that the types of activities carried out and the types of tools employed in the quarrying operation are the same whether the material being quarried is chert, as is the case in the Wallkill Valley, or quartz, as is the case at quarries in southern New England and at the *Chapel Farm Estates* site.

II. Field Observations and Evidence at Chapel Farm

The source of the quartz debitage discovered during the Stage 2 excavations at Chapel Farm occurs approximately 100 meters east of the excavation. The precise location of the quarry is not clearly understood, but surface indications suggest that the location consists of at least two intersecting conjugate veins of solution hydrothermal quartz. Surface textures found on excavated blocks indicate that the quartz veins were emplaced after the primary phases of deformation in the schist had already occurred. Cold emplacement of the quartz veins permits the outer surface of the quartz to mimic the fabric and texture of the mica grains in the surrounding country rock. The occurrence of large blocks of quartz to the east of the Stage 2 excavation possibly represents the location of the point of extraction of the ore.

Further to the east occur several east-west trending veins of white quartz which have been weathered to the surface. Field observations suggest that all the quartz veins are a part of one geological event which occurred very late in the deformational history of the region. To the north, near the estate house, occurs yet another north-south trending vein of quartz which crops out on the surface. Hammerstone fragments were found near all outcrops of quartz veins.

The megascopic characteristics of the quartz recovered during the Stage 2 excavation matches those characteristics of the quartz occurring in scattered outcrops throughout the hillside. Clearly, the lithic reduction site is genetically related to the quartz quarries located on the site.

III. Evidence from the Furman Estate and Outcrops in the Vicinity of Chapel Farm Estate

The quartz veins exploited at *Chapel Farm Estate* are representative of a greater sequence of prehistoric mining activity which occurred throughout coastal New York during the Late Archaic and Transitional periods (5,000 to 3,000 BP.) (Ritchie, 1959). Quartz veins are reported to have been a focal point of prehistoric mining activity during this time period (Skinner, 1917, 1919). Shell middens excavated at Throgs Neck and Whitestone usually feature a predominance of largely unmodified quartz flakes as well as diagnostic tools fashioned from quartz (Solecki, personal communication, 1983). Despite the work of Skinner, the source of this lithic material has never been well understood, and recent investigators have assumed it was derived from glacial gravels. (Claassen, 1992; Ritchie, 1959; Smith 1950)

Field reconnaissance has revealed the presence of a great number of large and small intersecting veins of quartz that crop out at *Chapel Farm Estate* and in the immediate vicinity. The quarry and associated reduction site at *Chapel Farm Estate* represents a portion of the plexus of prehistoric mining activities recently discovered in Riverdale. The presence of quartz veins on the *Chapel Farm Estate* site was unexpected, because it had been assumed that quartz veins and associated pegmatites do not occur west of Cameron's Line in New York City. If this assumption were correct, quartz veins should be abundant east of Van Cortlandt Park and rare west of the park. (Fig. 1 & 2) Recent investigations have shown that the quartz veins and pegmatites are typical features within the tightly folded schists and gneisses of the Bronx, and should have been common elements of the prehistoric lithic landscape. (Fig. 3 & 4) The writer is not certain why their occurrence has not been reported. The veins may have been considered geologically insignificant and not worthy of further mapping or investigation.

The Furman Estate

During the field reconnaissance of the area surrounding the *Chapel Farm Estate* site, the investigator discovered a substantial outcrop of quartz on a property identified as the Furman Estate located north and east of the project area. At the time of the construction of the Furman house in the 1960s, the equilibrium profile of the soil readjusted to compensate for the exaggerated relief created by the construction. The newly-created severe slopes of more than 60^{o} rapidly weathered to their present 45^{o} profile, thereby unearthing bedrock that had been covered by several meters of soil over the centuries. The newly exposed rock surfaces revealed the presence of a nearly vertical vein of quartz that the prehistoric miners had missed. The vein is approximately 5 feet high, 12 feet long, and up to 1 foot in thickness. (Photo 1) It bears a glaciated surface and stands out in high relief in contrast to the softer, darker-colored schists. The color is bone white, the luster is highly vitreous, and the entire vein is intersected by a series of closely-spaced horizontal joints. The presence of joints within the vein suggests that it intruded the schist during the later stages of deformation or thrust faulting, probably along cold joint surfaces. Other quartz veins also occur as infillings within conjugate joints, both in and beyond the immediate study area. This vein exposure is extremely important as an example of what the prehistoric landscape looked like during the Late Archaic and Transitional periods; such exposures were probably very common and easily recognizable in the field by prehistoric peoples.

To the left, or south, of this exposure, on shallower slopes, occurs yet another vein of quartz that was actively quarried during prehistoric times. Evidence for quarry activity includes the presence of an uneven, hacked upper surface of the vein (where the outer glaciated surface has been removed); the presence of much quartz debitage in the form of unmodified flakes; quartzite hammerstones; and a small, chipped flake chisel-like object. (Photo 2) The exploited vein and the undisturbed vein rest side by side at the Furman Estate. Occurring above the exploited vein surface are exposures of folded schist whose joint surfaces were once filled with vein quartz. (Photo 3 & 4) The veins were completely evacuated during the mining activity; only hammerstone fragments and quartz debitage remain.

The Russian Embassy Site

At a second location, contiguous with the study area and near the Russian Embassy compound, there are a number of outstanding examples of exploited quartz veins. (Photo 5 & 6) The veins range in thickness from 2 inches to more than 1 foot, and pinch and swell according to their orientation within folds. Abundant quartzite hammerstones and quartz debitage lie on a nearby slope. Large quartz slabs invariably bear the evidence of the horizontal joint surfaces, which are also very common on much of the reduction debitage found in the Stage 2 excavation at *Chapel Farm Estate*. (Photo 7) Yet another location north of the Russian Embassy exhibited a large vein of quartz more than 50 feet in length and greater than a foot in width. It occurs in association with a great number of thin, less well developed stringers and pods of quartz. (Photo 8)

It must be understood that the joint surfaces within the quartz veins are essentially horizontal at *Chapel Farm Estate* and elsewhere in the surrounding area. A second generation of joint surfaces intersects the horizontal joints, creating blocks with 120^{0} and 60^{0} angles. (See Photo 1) These orthogonal blocks, once extracted from the vein, represent quarry blanks or preforms, which are common at the *Chapel Farm Estate* Stage 2 excavations. The next stage of lithic reduction usually preserves some faces of the original intersecting joint surfaces. Because of the orientation of the joint surfaces, in order to extract the quartz, percussion or impact had to be perpendicular to the horizontal joint surfaces; simply stated, the force of impact between the hammerstone and the quartz surface would have to occur at 90^{0} to the plane of the joint. Very rarely, however, are the planes of these joint surfaces oriented parallel to the proposed impact direction. Therefore, large quartzite pounding instruments were probably necessary to crush the quartz and separate it along joint surfaces.

Somewhere between the approximate location of the quarry at *Chapel Farm Estate*, the large tailing pile (Photo 9), and the Stage 2 reduction site, there probably occurs a milling station, or area where quartz was concentrated into a more workable ore. Evidence for a milling station or area of ore refinement (ore dressing) probably occurs within a 50 meter radius of the proposed point of extraction. At this point there would be angular fragments of quartz bearing joint surfaces and thin slabs of schist representing the country rock (or gangue) which surrounds the ore.

The quarries at *Chapel Farm Estates* were archaeologically important because they represented the intersection of large veins of minable quartz. The presence of diabase hammers and anvils as well as quartzite hammerstones is testimony to the fact that extraction was extremely difficult, because the quartz veins are embedded between layers of tightly-folded gneiss. The quartz veins exposed along the eastern slopes of *Chapel Farm Estate* represent abandoned operations or potential prospect pits and areas of exploration and testing, which are related to the exploited quartz veins both within and outside the study area. (Photo 10) All of these exploited veins are related to a large-scale prehistoric exploitation of lithic resources in coastal New York. The presence of quartzite hammerstones, diabase pounding and anvil objects, and small dense purple quartzite hammerstones at the *Chapel Farm Estate* site are all evidence for a common mining practice involving a well-understood technology.

The preponderance of quartz flakes at nearby coastal shell middens (including shell middens in Riverdale Park) suggests an intimate relationship between the quarries, exploration pits, outlier exploited quartz veins, and the coastal middens. All are part of a continuum representing the subtle aspects of prehistoric subsistence, which has previously gone either unrecorded or misinterpreted.

IV. Comparison with Other Quarry Locations

Quartz Quarries in Southern New England

Quartz quarries are prehistoric quarries developed within quartz veins and are less frequently cited than other types of quarries (Dunn, 1945; Powell, 1965; Zern, personal communication). The preponderance of quartz debitage in Coastal-Late Archaic-Woodland shell middens suggests that quartz was a preferred lithic type, especially in the Lower Hudson River Valley, where chert occurs predominately as secondary sources of glacial origin. Although few quartz quarries have been reported, those that have been reported possess some characteristics common to the quarries at *Chapel Farm Estate* and other characteristics which render them unique. First, the quartz quarries of southern New England have been reported to contain very few hammerstones or pounding instruments employed to extract the quartz. This is not the case at *Chapel Farm Estate*, where hammerstones are fairly abundant. In several cases quartzite disks found at prehistoric quarry sites have been misinterpreted as blanks or early stage bifaces (Fowler, 1959). The writer feels that in most cases, pounding instruments and hammerstones, as well as many other elements that could be assigned to the prehistoric quarry extraction and reduction process, have gone unnoticed or misinterpreted in the literature. An argument has been put forward (Powell, 1965) that hammerstones are not present on quartz quarry sites because prehistoric miners exploited naturally-occurring fractures enclosed within the quartz veins. These fractures are said to expedite the mining process and enhance the workability of thick veins of quartz embedded within metamorphic and igneous rocks. Although naturally occurring, closely-spaced joints do occur within the quartz veins, they only aid in the extraction process to a minor degree. Certainly, the planes of weakness, or joints, are a principal focus of the quarry worker during the initial stages of extraction, but the extraction process still involves the employment of heavy pounding instruments. Remnant surfaces of close-spaced joints are visible on many early stage bifaces and they do serve to control the size of the extracted pieces of ore. Second, the quartz quarries at *Chapel Farm Estate* possess a unique assemblage of quarry instruments which have not to date been reported from other quartz quarry locations. These include possible anvil instruments of very dense basalt. The lithic preference for basalt being largely due to the preponderance of basalt boulders and cobbles in the glacial till.

Chert Quarries in the Wallkill Valley and associated tool assemblages

Prehistoric quarries in the Wallkill River Valley occur along chert-bearing strata, where chert occurs as closely-spaced nodules, pods, and rarely beds. Therefore, in some ways they are reminiscent in outline to the trend of quartz veins visible at *Chapel Farm Estate* in that their strike is a linear element. Large pieces of ore initially extracted from beds are found in the tailings pile located below the quarry face. Only rarely do they ever occur anywhere other than in a downslope position. Reduction sites occur either directly above the quarry face or on level terraces adjacent to the quarry face and along the strike of the beds. A similar situation exists at *Chapel Farm Estate*. Usually, non-portable anvils are associated with these reduction sites. (Photo 11) These may occur as large glacial erratics embedded in the soil, masses of loosened bedrock, or bedrock in place. Evidence for use of these non-portable objects as anvils comes in the form of an apron of fine flaking debris. Intermediary between the downslope location for extracted ore and the upslope position of reduction sites there will occasionally be a transitional area where the ore is processed into smaller chunks. In the case of chert in the Wallkill Valley, several generations of intersecting close-spaced fractures are generally exploited in processing the ore into smaller and smaller workable chunks. At this point poor quality chert and gangue, or country rock, is winnowed away, leaving behind fist-sized pieces of a higher quality concentrate. The mill product from this form of concentration usually occurs as piles of irregular masses of chert attached to dolomite.

Such may be the case at *Chapel Farm Estate*, where large pieces of quartz have been found just to the north of one of the proposed points of extraction. These large masses (up to 50 pounds each) represent the downslope position, or the first stop, in the reduction sequence. (See Photo 9) The transitional stage and finer reduction may have both been carried out near to where the Stage 2 excavations took place. If not, then the transition step lies somewhere between the downslope position of the quartz fragments below the point of extraction and the location of the Stage 2 excavations.

Examination of the quartz debitage from the Stage 2 excavation suggests that the transition phase of exploiting close-spaced joints had been performed because most large pieces of quartz contained at least one smooth joint surface. Therefore, the idea of processing or milling a concentrate is a transition step in the reduction of the quartz at *Chapel Farm Estate*. Surface finds of fist-sized and larger pieces of quartz near the Stage 2 excavation always bear at least one smooth flat joint surface.

Hammerstones

Chert quarries within the Wallkill River Valley bear evidence for division of labor, or task subdivision, in the form of varying size weights or class weights of quartzite hammerstones. Pounding instruments up to several hundred pounds are found along the quarry face. (Photo 12 & 13) Mechanically crushed and broken spalls of these large hammers are found in the tailings piles just below the quarry face. Intermediate between the tailings pile below the face of the quarry and the fine scale reduction sites is the ore dressing station or milling area. A number of different hammerstones are associated with these areas. At the grossest scale are large pounding objects that are spalled and broken by use. (Photo 14) Wedge-shaped quartzites weighing up to 15 to 20 pounds are another class of instrument often associated with milling areas. These objects usually exhibit a characteristic projection or beak. (Photo 15 & 16) These beaks are the result of repeated sharpening or flaking and serve as a diagnostic quarry instrument. Also found in milling areas are groups of small blunt and spalled stones of decreasing size that are interpreted by the writer as chisels used to focus blows from large pounding instruments. (Photo 17) Reduction sites similar to the one at *Chapel Farm Estate* contain quartzite hammerstones in various weight classes, some as large as 8 to 10 pounds and others as small as 4 ounces, many of which exhibit evidence of heat treatment. (Photo 18-20)

At *Chapel Farm Estate*, several large hammerstones or hammerstone fragments were found lying between blocks of quartz tailings downslope from the presumed point of extraction. Small veins of quartz, possibly prospect pits, along the eastern perimeter of the hill contain intermediate size hammerstones, of which one was characteristically beaked. (See Photo 10) Small hammerstones, from 5 pounds to as little as a few ounces, are very common on the surface of the Stage 2 excavation. (See Photo 20) Therefore the weight classes of hammerstones and diagnostic form serve to demarcate or delineate the subdivision of tasks at *Chapel Farm Estate*.

What is not so apparent at *Chapel Farm Estate* is the location of the transitional milling site where concentrate would have been produced for further reduction at the Stage 2 site. (See Photo 20) It is possible that it has so far been overlooked or, alternatively, that it was destroyed by the gardening activities that have taken place on the site. As noted above, a special characteristic of the *Chapel Farm Estate* quarry site was the discovery of hammerstones and anvil stones fashioned from a very dense variety of basalt known as diabase. The presence of this preferred lithic type at the site infers a need for an extremely dense, durable substance for the extraction of the quartz, or points to the paucity of available glacially-derived quartzite in the immediate vicinity of the quarry.

GEOLOGICAL RECONNAISSANCE OF THE CHAPEL FARM ESTATE SITE AND SURROUNDING AREA

I. Introduction

In November 1992, the researchers discovered a plexus of quartz veins within the Fordham Gneiss that had not previously been recorded or described. The veins are many in number and are of particular importance because they have been exploited as prehistoric lithic resources or quarries. Due to the uniqueness of the discovery and the potential for the existence of a great number of quarries in a heavily populated region; the researcher undertook library research and a field reconnaissance of the project area and its environs. The purpose of the library research and field investigation was to better understand the geographic distribution of quartz veins occurring within the Fordham Gneiss, their small-scale outcrop patterns within the *Chapel Farm Estate* study area and immediate vicinity, and, to a lesser degree, to investigate the question of the timing of the formation of the quartz veins. These goals will warrant more investigation in the future because a clear understanding of the timing of formation of quartz veins, their genesis and spatial distribution will aid in the elucidation of the full plexus of quartz veins and possibly point to other potential prehistoric quarry sources. The present study sought to survey the literature for specific references to the occurrence of quartz veins within the Fordham Gneiss in and around the *Chapel Farm Estate* study area, as well as to understand the geographic distribution of quartz veins in any neighboring lithologies. In addition, the researcher sought to understand why it is that, with the possible exception of Balk (1936), the presence of quartz veins, their proper classification, stratigraphic position and structural orientation has escaped geological maps and section notes.

II. Statement of the Problem

Differing viewpoints on the importance of various geological features such as quartz veins is reflected in the general lack of written documentation of these veins in the New York City area. Some researchers who have published detailed descriptions of the geology and structure of the New York City area apparently thought the occurrence of quartz veins in the local formations was only incidental and not worthy of further research. Complicating the issue is the fact that most quartz vein occurrences are thought to be pegmatites, and are therefore lumped into the nomenclature with these coarse-grained granites. (Photo 21) In fact, the quartz veins are only roughly similar to pegmatites in external outline, but close inspection, and even simple hand-sample analysis, will distinguish pegmatite occurrences from quartz veins. The three general types (granite pegmatites, aplites or micropegmatites and quartz veins) are found intimately associated within the research area. (Photo 22) Furthermore, within the Fordham Gneiss there also occurs thick and thin bands of micropegmatite, or aplite; these sugary, rather saccharoidal rocks appear quartz-like both in outcrop and hand sample. Close inspection reveals their largely feldspar and mica composition. Thick layers of aplite in association with quartz veins are abundant at *Chapel Farm Estate* and the immediate vicinity. (See Photo 5)

Another example of incomplete documentation in the literature concerns the occurrence of numerous quartz veins within the Hartland Formation at South Twin Island, Orchard Beach in the Pelham section of the Bronx. The Hartland Formation is well exposed as glaciated surfaces which can be studied at low tide throughout the Pelham Bay region and northward to Connecticut, yet the published accounts describing detailed stratigraphic and structure sections for the immediate vicinity of North and South Twin Islands do not describe the quartz veins; only a general description of quartz occurring as layers and veins, along with other mineral assemblages, is mentioned. Interestingly enough, quartz veins are abundant within the Hartland Formation and were mapped by LaPorta (1987, unpublished field notes and maps). The quartz occurs as highly transparent, gray to white veins up to 9 inches thick and as much as 75 to 100 feet in length. They trend NW-SE, much as those described by Balk, and may aid in defining a zone of shearing within the Hartland. Flat-lying conjugate joints are also present within these quartz veins, but their similarity in both orientation/composition and structural style had not been previously recorded. Worth noting here is that during the 1987 mapping season (LaPorta, 1987), several prehistoric sites were located within the vicinity of Orchard Beach. The sites contained numerous shell middens and lithic debitage comprised of almost entirely unmodified quartz flakes.

The same is true of the Fordham Gneiss: quartz veins are ubiquitous, yet their occurrence has not been noted by any researcher.

The presence of these veins suggests that quartz occurs in most of the formations of the New York City Group, from well east of Cameron's Line westward to the Hudson River, west of Cameron's Line. (See Fig. 3) As one moves north of the *Chapel Farm Estate* site into Westchester, Putnam and Dutchess counties, the researcher has found that quartz veins become increasingly abundant. These quartz veins may define a zone of thrusting that may be of Alleghenian age.

As stated above, Balk (1936) is the only researcher to note the occurrence of quartz veins within schists and slated occurring along the Hudson River Valley in Putnam and Dutchess counties. His account represents the finest and most detailed documentation of the occurrence of quartz within the metropolitan area. The researcher has, therefore, decided to include this description and employ it as a guide or model for the classification of quartz veins within the Chapel study area. Comparisons made between Balk and this researcher will aid in the classification of the suite of quartz veins present at *Chapel Farm Estate*. This will allow us to consider the question of their genesis or mode of formation, which will, in turn, allow us to predict the possible location of other quartz veins, and the possible location of prehistoric quarry sites occurring within this very heavily urbanized area. It should be noted that the citations that mention quartz have been highlighted. According to Balk:

> ***The Hudson River Slate, as far as the shores of the Hudson, and the Poughquag Quartzite in the entire area, are traversed by thousands of quartz veins.*** *Many layers and grit lenses are so replete with quartz veins that the volume of the introduced quartz exceeds that of the lens. The conditions illustrate well a principal elaborated by O. Anderson that a maximum of veins will form in those rocks that develop numerous fractures during the stage of vein formation while the surrounding rocks were in either the plastic stage of deformation or in a viscous condition, if magmas. The veins differ in age; possibly some of the oldest ones on the schist phases are recrystallized chert layers, isoclinally folded with the surrounding schist or recrystallized cleavage bands. Others are themselves slightly folded, although some of them cut the isoclinal folds of the schist. A third generation follows fracture cleavage planes, and even they may be bent or fractured.* (Fig. 5 & 6)
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> *Quartz veins along thrust fault zones:* ***Several of the more important thrust faults are accompanied by quartz veins that differ from others in being unusually long and straight and intensely foliated and streaked, just as are the surrounding rocks of the thrust fault zones.*** *South of the Hudson Gneiss block, they are joined by fine-grained granite dikes and pegmatites.*
>
> *Quartz veins on tension joints and cross joints:* ***Some of the latest quartz veins have fixed the position of prominent fractures that opened during the late stage of regional deformation.*** *The strain by movements obliquely upward to the west or northwest has not only caused the development of thrust faults in this direction, but has given rise to fracture systems dipping west or northwest at angles between 35 and 85 degrees, depending on the pitch angle of the linear structure to which these tension cracks are complementary.* ***Hundreds of these fractures have been filled with quartz, and in several outcrops the linear structure of the country rock with cross fractures and quartz veins is well exposed.*** *Other quartz veins of random strike and dip are themselves crossed by westward or northwestward dipping joints that probably originated from the same stresses and were so well reproduced because the quartz veins had not been jointed before and because they are exceptionally brittle rocks.* ***The quartz veins that follow thrust faults are cross-jointed in regular manner so that the veins commonly fall asunder as rectangular slabs, each bounded by the foliation planes and cross joints.*** (See Photo 1)

Due to the lack of detailed published geological literature relating to the *Chapel Farm Estate* study area and the immediate surroundings, it was also decided to include the following stratigraphic column of Hall (1963, A and B). (Fig. 7 & 8)

The sillimanite grade Precambrian and Paleozoic rocks that were mapped by Hall (1963, A and B) occur in southeastern New York and southwestern Connecticut and occur within the White Plains-Glenville area. They have been interpreted as a Precambrian basement gneiss complex that is unconformably overlain by a Cambro-Ordovician miogeosyncline sequence, that is in turn tectonically overlain by a Cambro-Ordovician eugeosynclinal sequence. (See Fig. 7 & 8) The thrust surface separating the two lithotectonic packages is defined as Cameron's line, which is in essence, a suture which separates rocks *in situ* from those that have been thrust upon it. The following stratigraphic column is widely accepted by geologists working in the metropolitan area and can be safely employed for correlation studies a few kilometers to the south, at the *Chapel Farm Estate* site.

Please note that within the descriptions of the following lithologies, there is an occasional mention of the occurrence of quartz, within both schists and gneisses. It should be emphasized that Hall's stratigraphy encapsulates more than 30 years of research within the metropolitan area; yet, although most geologists working in the area, including Hall, were well aware of the field associations and occurrences of quartz veins within the Fordham and Yonkers Gneiss units, the occurrence of quartz is barely mentioned.

The field work and geochemical analysis of Langer (1966) clearly elucidates the problem concerning the documentation of the presence of quartz veins and, for this reason, a series of passages are included here from his work in the Botanical Gardens, which is in close proximity to the *Chapel Farm Estate* area. (See Fig. 2) This research involved the geochemical analysis of several pegmatites and pegmatite suites occurring in a linear belt which Langer described as the trace of a shear zone. Prior to the geochemical analysis, Langer was compelled to classify the quartz veins and pegmatites into a series of groups. This exercise aided in creating the first classification of mineral vein occurrences within close proximity of the study area. The classification includes compositional bands, quartz veins, coarse grained pegmatites, as well as micropegmatites or aplites. It is worthy of mention that all three vein occurrences can be found at the *Chapel Farm Estate* site. Langer suggested that veins of quartz were often misclassified under the misnomer of pegmatites. Langer wrote:

> *Kurt E. Lowe of City College (1963) stated that the southern units of the Manhattan lithologies exposed in the Botanical Garden are so gneissic, so highly contrasted and so unlike the type lithology of the Manhattan Schist that they likely constitute another phase of the Fordham Gneiss. These outcrops occur just east of Cameron's Line.*
>
> *In the Botanical Garden area, the metamorphic lithologies represent a southwesterly plunging tight isoclinally folded series of metasedimentary units with near vertical axial planes striking N 20 E. The southwest plunge of the structure ranges between the limits of 8 degrees and 38 degrees measured on foliation crenulations and mineral elongation characteristic of each lithology.* ***The pegmatites occurring within the mixed gneisses and schists of the Garden are thought to be the result of replacement, metasomatic and granitization processes from within a metamorphic host rock.***
>
> *Gneisses and schists: represent the most abundant lithologies constituting the metasediments in the Botanical Garden. They are generally gradational at a single outcrop and may be defined on the basis of width of compositional banding, porphyroblast development and relative amounts of foliate and non-foliate minerals present. Gneissic development is so marked locally that it is difficult to distinguish such units from units considered characteristic of the Fordham Gneiss. Manhattan and Fordham units are often indistinguishable in isolated outcrops in the Pound Ridge area* (Scotford, 1956*). Many outcrops in the Garden area are mapped as gneiss/schist because of their marked gradational and intercalated nature. Nomenclature on these rock types was derived from petrographic thin sections wherever megascopic examination proved inadequate.*

Ubiquitous throughout the schist and gneiss units are many varieties of vein materials. These range in size and composition, but for the most part they consist of ***local concentrations of quartz,*** *feldspar and muscovite, separately or in combination. Structurally, they range from concordant to discordant bodies, although they tend to occupy the foliation planes of the gneisses and schists. Veins, especially those composed of quartz, have often been described under the misnomer "pegmatites." Vein material is notably absent from the granulite units. Modes of vein materials are given in Table 2 as compositional bands.*

Origin of the compositional gneissic banding

The gneisses of the Garden area are of sedimentary origin, and a reconnaissance study of zircons from the gneisses in the area found that these minerals tend to be rounded and to have developed overgrowths. This indicates a sedimentary origin for the pre-crystallization materials (Poldervaart, 1955a). *The mineral compositions of the vein material is very similar to the hos . . .which suggests a common origin. The gneissic banding probably results from a combination of sedimentary and metamorphic processes. Change in the character of sedimentation may be easily envisaged to account for layers and lenses of materials of different composition, or of materials of similar composition but different physical qualities. Metamorphic segregation may also effectively produce banding during the metamorphic cycle. The lithological units in the Botanical Garden area crystallize under conditions of the kyanite-muscovite-almandine subfacies of the almandine-amphibolite facies in response to temperatures on the order of 500-600 degrees C, and 4000-8000 bars pressure.*

Fordham Gneiss

Merrill and colleagues (1902) describe ***the Fordham Gneiss as a banded unit consisting of alternating lenses of quartz rows and biotitic minerals averaging two inches in thickness****. The mineralogy was described as chiefly composed of quartz, feldspar (microcline more abundant than plagioclase of oligoclase composition) and biotite as a chief mafic mineral. Minor and accessory minerals include hornblende, garnet, sphene, zircon and apatite. Abundant amphibolite, granulite and pegmatite units were noted, but* ***the presence of quartz veins is rarely noted in the literature.*** *The type locality was given inadequately as Bronx Borough.*

Berkey (1907), who compared the gneisses of the Hudson Highlands with those of New York City and Westchester County pointed out that the major differences between these units lay in structural aspects and not in their mineralogical makeup. He stated that the gneisses of the New York-Westchester area maintain their foliation planes for greater distances as compared to the gneisses of the Highlands. Deformation of the Highlands was apparently more plastic. Prucha (1956) described the gneisses of Westchester County as possessing banding on the order of several feet in thickness. Mineralogically they consist of granoblastic quartz and feldspar (predominantly plagioclase), with hornblende as the principal mafic mineral. Biotite was reported as an accessory, and microcline as sporadic.

The gneisses within the New York City area are remarkably dissimilar. The Fordham Gneiss making up the ridge opposite Highbridge Park in the Bronx Borough is a coarsely banded gray gneiss with intercalated conformable bands of felsic material several centimeters to a meter in thickness. The gneiss composing the Riverdale Hill is composed of several smaller gray and light pink units with the color varying from outcrop to outcrop. There is also a marked deformation lineation in the foliation plane which can be measured on slickensides and mineral elongations.

The gneiss outcropping in Van Cortlandt Park in the Bronx Borough is again different, possessing foliation layers meters to centimeters in thickness. Kurt Lowe (1963) considers the lithologic and stratigraphic complexity of the Fordham Gneiss such as to warrant its redefinition as a group. The Fordham Gneiss within the type area is a lithologically and mineralogically diverse unit.

Structural evidence suggesting replacement

Merrill's original geological map of New York City (Harlem Quadrangle, 1903) showed a linear outcrop distribution of "granitic injections" parallel to the Bronx River. This line of granitic injections strikes northeastward into the Harrison Granodiorite and southwestward into the Ravenswood Granodiorite. The pegmatites in the Botanical Garden area are part of this linear belt. The presence of slickensides, brecciation of country rock and offsets attest to the post-recrystallization faulting in the Manhattan Formation. It is in this locality that the course of the Bronx River changes abruptly, following the zone of shearing which lies parallel to the planes of schistosity within the formation. ***It appears that the pegmatites formed within the center of the shear complex, the material constituting the conformable pegmatites was introduced after the recrystallization of the Manhattan sediments, probably at the close of the metamorphic cycle.*** *Following metamorphic recrystallization of the Manhattan Formation sediments, shearing occurred parallel to pre-existing schistosity. During this last phase, fluids rich in silica and potash migrated through these zones, causing progressive replacement of the pre-existing crystalline units.*

Stratigraphy

It is possible to describe a stratigraphic column for the White Plains-Glenville area by assuming that the rocks are progressively younger with increasing distance across strike and upward from the basement gneiss complex. This rather simple approach to the stratigraphy is complicated by the presence of at least one, and possibly two, major faults in the region. One of these faults involves thrusting of the Cambro-Ordovician eugeosynclinal sequence onto the miogeosynclinal sequence. This allochthonous eugeosynclinal sequence also appears to decrease in age across strike away from the gneiss complex. The other fault is within the eugeosynclinal sequence and is of uncertain nature. For purposes of description, the units that make up the stratigraphic column are presented in order of increasing distance from the gneiss complex. [See Appendix C for details of stratigraphic column]

Summary of the Stratigraphic Column

The stratigraphic sequence above the Precambrian Fordham and Yonkers Gneisses is assumed to be continuously younger upward from that gneiss complex. It is approximately 5800 meters thick, and consists of a clean clastic carbonate sequence at the base, overlain by a volcanic and clastic sequence that contains some granitic intrusive rocks. In light of the regional stratigraphic column, the sequence is best described as a Cambrian-Ordovician miogeosynclinal sequence with a eugeosynclinal sequence thrust on top of it (Hall, 1968a). (Fig. 9; see also Fig. 3 & 4) *On the basis of his 1980 mapping, Baskerville further clarifies the location of Cameron's Line. This feature has been adjusted to what appears to be a closer alignment with the known locations of Hartland rocks to the east and Prucha's New York City rocks to the west. Cameron's Line is hypothesized to be a Taconian thrust surface separating the western Proterozoic (Fordham Gneiss of New York City) and miogeosynclinal Cambro-Ordovician (Prucha's New York City Group) rocks from the eastern Cambrian and Ordovician eugeosynclinal rocks (Hartland Formation* *and Harrison Gneiss). The allochthonous eastern units are thought to be thrust westward over Prucha's miogeosynclinal New York City Group* (Hall, 1968b; Rodgers 1970, 1971).

Most recently, Merguerian (1985), has allowed for a summary statement of the tectonic history of the New York City-metropolitan area, which includes a generation of quartz veins during the development of thrust faulting. This most recent study, both in its description and style clearly rings out and points backwards more than 50 years to the description of Balk (1936). It is apparent from this last study that there may be some renewed interest in the work of Robert Balk. Merguerian wrote:

The three schist units and underlying rocks have shared a complex structural history which involve three superposed phases of deep-seated deformation. The base of the middle schist unit is truncated by a ductile shear zone, here informally named the St. Nicholas Thrust. The upper schist unit is in probable ductile fault contact with the middle schist unit along Cameron's Line in the Bronx and in Manhattan. Development of the St. Nicholas Thrust occurred during two progressive phases of ductile deformation accompanied by isoclinal folding. A reduction of grain size occurs at the thrust zone with the formation of mylonitic layering, ***ribboned and polygonized quartz, lit-par-lit granitization, and quartz veins developed parallel to the axial surface of the folds.*** *During deformation, metamorphic growth of layers and lenses of quartz and sillimanite, quartz and magnetite up to 10 cm thick formed in the folds, which deformed further to create a recumbent structure that strikes N 50 W and dips 25 SW.*

Miogeosynclinal Sequence: (the zone of shallow marine water carbonate clastic deposition)

The section from the Lowerre Quartzite through Member A of the Manhattan Schist makes up the miogeosynclinal part of the stratigraphic column that correlates with similar rocks to the north in eastern New York and the western parts of Connecticut, Massachusetts and Vermont (Hall, 1968a). The miogeosynclinal part of the stratigraphic column in the White Plains-Glenville area is also interpreted to be equivalent in age to most of the eugeosynclinal sequence in this area, which is described below.

Eugeosynclinal Sequence: (the zone of deeper marine water clastic and volcanic sedimentation)

Consideration of the eugeosynclinal part of the stratigraphic column, Members B and C of the Manhattan Schist, and the amphibolite member of the Hartland Formation through the Harrison Gneiss suggests correlation to the north in western Connecticut and Massachusetts. The contact between Members B and C of the Manhattan Schist and Member A of the Manhattan is a thrust fault, and is related to Taconic thrusting. The rocks were complexly folded after thrusting; however, some deformation and metamorphism can be attributed to the Acadian orogeny, and the Allegheny may have had a direct effect on rocks in this area. Another fault, Cameron's Line (Rodgers, 1970*) disrupts the section along the contact between Member C of the Manhattan and the Hartland Formation. The nature of this fault remains uncertain, but its regional extent and significance hints of an Alleghenian timing for this thrusting event.*

The proper assimilation of the above quotes and descriptions can only lead to the conclusion that the quartz veins occurring at the *Chapel Farm Estate* study area may delineate portions of the tectonically obscured pattern of a zone of thrusting. The research direction of Balk and Langer represents the most logical line of reasoning in that the former provides outstanding field descriptions of the occurrence of quartz in the Hudson River Valley, while the later, Arthur Langer, provides the first genetic classification for the veins. It is only through these two directions that the geographical districts of quartz veins that are of potential prehistoric importance can be elucidated. The spacial distribution of the various types of quartz will eventually delineate a zone of thrusting within the Fordham gneiss.

III. Observations of the occurrence of quartz veins in the Fordham Gneiss

On the south side of Tuckahoe Road in Yonkers, between Route 100 (Central Park Avenue) and the Bronx River Parkway, an extensive quartz vein occurs within a very schistose variety of the Fordham Gneiss. (Photo 23) The vein, which is approximately a meter wide in places, is oriented NE-SW and projects onto Tuckahoe Road. The quartz itself is translucent white, extremely glassy, and grades to a pale pink in a scattered few places. Widely disseminated grains of muscovite mica occur in the quartz, and the translucency as well as the glassiness of the quartz fades near its contact with the gneiss into a duller white, less translucent milky quartz. There is some evidence for lineations or striations along the contact with the gneiss. Close inspection has revealed that the quartz vein is rather conformable, if not parallel to the hinge of the fold, to the predominant foliation. This suggests that the quartz segregated from the original metamorphic gneiss during folding, and is wrapped or enveloped into the architecture of the fold. Langer (1966) describes these veins as compositional quartz veins in the Botanical Gardens, and suggests that their chemistry matches the parent chemistry of the accompanying schist or gneiss. This recently discovered quartz vein and associated prehistoric workshop (Sohl, personal communication 1993) is approximately 5 miles north of the study area, also within the Fordham Gneiss. The field relations suggest the possibility that the quartz vein is the result of a metamorphic replacement process or metasomatism, and not an intrusion or dike filling. The NE-SW orientation is more consistent with compositional bands (Langer 1966) and somewhat similar to quartz veins described by Balk (1936). The presence of cross joints within the quartz vein represents the only field evidence which may suggest that the quartz has filled in along a thrust fault. (Balk 1936) Although the cross joints are weakly developed, the resulting outcrop exposures are blocky, relinquishing small slabs bounded by joint surfaces and foliation surfaces, very similar to those that have been described on the Furman Estate, which is contiguous with *Chapel Farm Estate*. (See Photo 1) While the field evidence suggests the presence of the compositional bands described by Langer, because the vein is somewhat conformable to the hinge or the foliation of the fold, the presence of cross joints, the blockiness of the outcrop, the width and great volume of quartz present, as well as the presence of foliation along the contact between the quartz and the gneiss, all suggest intrusion along a thrust fault surface.

IV. Quartz veins present at the Chapel Farm Estate

Quartz veins in place or visible to outcrop inspection occur at several localities on *Chapel Farm Estate*. (See Field Reconnaissance Map) Most of these quartz veins have a NW-SE trend, possess cross joints, striations and foliations along the contact with the gneiss, and have a slabby or blocky outcrop appearance. (Photo 24) The color of the quartz ranges from clear white to gray-white to opaque white to pale pink. Field reconnaissance and outcrop inspection suggest that most of the occurrences of quartz at *Chapel Farm Estate* support the fracture-filling hypothesis of Balk and not the compositional band hypothesis of Langer. Great numbers of thick bands of granite micropegmatite, micropegmatite or aplite, also occur at the *Chapel Farm Estate*; these light-colored lithologies are usually composed of quartz, plagioclase and minor amounts of muscovite mica, and may be easily confused with quartz veins and pegmatites. (See Photo 21 & 5) The presence of several varieties of gneiss at this location, including a schistose variety and a magnetite-rich variety, indicate that the rocks may not be in their normal stratigraphic succession; instead, the heterogeneous character of the gneiss within the closely spaced outcrops at *Chapel Farm Estate* suggest that the lithologies may be intercalated and in a thrust relationship. The occurrence of the quartz veins may further highlight the general trend of the thrust surface. It is possible, therefore, that the presence of the heterogeneous gneisses and their accompanying quartz veins may delineate a thrust fault zone.

V. The occurrence of quartz veins in the vicinity of Chapel Farm Estate

As previously noted, quartz veins are present along Fieldston Road in the Riverdale section of the Bronx, just north of the Henry Hudson Parkway. Behind a small delicatessen and restaurant, a thick quartz vein (up to 10 cm) occurs in association with an aplite dike within the schistose gneiss. (See Photo 5) The orientation is nearly east-west, and the quartz vein appears to be nonconformable to the principal foliation of the fold. The quartz is granular, highly translucent and gray, yet the contact with the surrounding gneiss is sharp and crisp, showing no signs of compositional gradation. This occurrence may be that of an early fracture-filling quartz which was subsequently refolded during metamorphism, since the quartz vein is within an open fold but not conformable to the principal schistosity. This occurrence represents a second variety of quartz vein infilling and is remotely similar to some of those mentioned by Balk (1936) as having occurred along the Hudson Highlands within the Manhattan Schist.

<u>The Furman Estate</u>

Probably the most revealing outcrops occur west of Broadway in the Riverdale section of the Bronx on the Furman Estate. As previously noted, the construction of new house has caused slope instability and soil erosion or accelerated creep on the east-facing hillside. The erosion has revealed both joint-filling quartz veins, as well as compositional quartz bands, that were quarried in prehistoric times. The fracture-filling quartz vein is approximately 20 cm in diameter and projects out into the open air 6 to 8 feet. (See Photo 1) The contact with the surrounding gneiss is crisp and non-gradational. Foliation surfaces occur along the contact of this NW-SE trending vein. The color of the quartz is ivory white; it is extremely translucent and is intersected by a series of flat-lying cross joints, very similar to those described by Balk (1936). The field relationships indicate that this occurrence of quartz is identical to that described by Balk as being a thrust fault-filling quartz vein; the NW-SE orientation is also very similar to the orientations of quartz veins recorded by Balk above the Hudson Highland gneiss block in Putnam and Dutchess Counties. The only difference between the Riverdale location and the Putnam and Dutchess County locations is that the quartz veins located by Balk are reported to occur in a schist rather than a gneiss.

The compositional band occurring on the Furman Estate represents a second occurrence with a nearly north-south orientation and seems to show a gradational contact with the surrounding gneiss. (See Photo 3) The quartz vein pinches and swells and shows some indication of having undergone boudinage or deformation. The quartz of the compositional band is highly translucent, gray-white and possesses grain of muscovite mica and occasional scattered grains of feldspar. The slabbiness or blockiness present in the NW-SE striking quartz veins mentioned above are absent in this compositional vein.

VI. Summary

Field work and library studies undertaken by this researcher indicate that quartz veins, whatever their origin, are abundant, not only within the Hutchinson River Group east of Cameron's Line, but within the Fordham Gneiss, Manhattan Schist and Hudson River Slates west of Cameron's Line as well The only clear reference to the quartz veins and the timing of their development is from Balk (1936). This research was conducted above the Hudson Gneiss block in Dutchess County, New York. In the New York City area, to the south of the area where Balk conducted his investigations, Arthur Langer provides the only genetic classification of quartz veins and pegmatites. Although correlations between Balk's study area and those of Langer, Hall, Merguerian and others working in the New York City area are possible, contrasts in styles of note taking, emphasis on what is important versus what is unimportant, and focus upon specific details of stratigraphy and structure result in an incomplete overall picture of the geology of the area. In essence, what is important to one researcher, such as the presence and orientation of quartz veins noted by Balk, is reduced to an incidental observation by other researchers whose interests do not include the genesis of the quartz veins.

Based on the research outlined in the body of this report, it is obvious that although quartz veins are ubiquitous to Precambrian, Cambrian and Ordovician lithologies throughout the New York City area, the timing of their emplacement, their mode or modes of genesis, and their relationship to the plate tectonic history of the region has never been addressed. Indeed, their occurrence appears only as disparate observations in section notes and detailed stratigraphic columns. In addition, the occurrence of quartz veins has oftentimes been confused with the occurrence of pegmatites, which are basically coarse-grained rocks of granitic composition that can occur as joint in-fillings as well as compositional bands within the host lithology. Vein-filling pegmatites, as well as those that are conformable to relict bedding, are more common at *Chapel Farm Estate* than are quartz-filled veins. Close inspection of the pegmatites reveals their saccharoidal texture and the presence of abundant feldspars and various micas. Their grain size is generally smaller than in most pegmatites, and, therefore, the pegmatites themselves can be further subdivided into coarse-grained pegmatites and fine-grained aplites, or micropegmatites.

Only Balk attempted to relate the northwest-trending quartz veins to a series of thrust fault slices, whose age were at one time thought to be Taconic, but may now be considered as late as Alleghenian. If this is true, we may then take the research one step further. According to Balk, some quartz veins, especially those oriented east-west and northeast-southwest, lie within the principle direction of foliation near-parallel to the axial plane of the fold. These may be the compositional quartz veins studied by Langer at the Bronx Botanical Garden. Their occurrence (Balk, 1936) and modal chemistry (Langer, 1966) suggest segregation of silica during metamorphism, and, therefore, suggest a possible Taconic origin. A second and much later generation of quartz veins occurs as in-fillings in conjugate joint systems, as well as in zones of extension outlining possible thrust faults (Balk, 1936). This latter generation of quartz veins may be tectonically late in their origin and possibly Alleghenian in age. The lack of the presence of boudinage in the quartz veins is also suggestive of a late emplacement.

We have now outlined at least two generations of quartz veins: one in-folded into the schists and gneisses and bearing a distinct foliation; the other emplaced along joints and fault sets bearing a beautifully developed cross-joint pattern, seen and described at the Furman Estate. (See Photo 1) This generation of quartz veins, primarily oriented northwest-southeast, occurs as a very homogeneous quartz lacking the feldspars and micas which typify the thrust-faulted quartz veins of possible Alleghenian age. Balk (1936) beautifully describes the cross joint patterns, the northwest-southeast preferred orientation, the homogeneous nature of the quartz, and its regional extent. A series of northwest-southeast trending quartz veins of the later, intrusive type was mapped by LaPorta (1987). These highly vitreous, clear white quartz veins, similar to those seen at the Furman Estate, intrude the Hutchinson River Group at Orchard Beach in the Pelhams on both South Twin and North Twin Islands. The spacial distribution of the quartz veins appears to lie in a generally north-south alignment along the eastern side of the Hudson River Valley. Besides the quartz veins identified on the Chapel Farm Estate site, the Furman Estate, in the vicinity of the Russian Embassy compound on Fieldston Road and at Tuckahoe Road, quartz veins associated with prehistoric quarrying activity have been observed by the researcher and CITY/SCAPE: Cultural Resource Consultants in the Town of North Castle (Village of Armonk) and the Town of Somers (hamlet of Somers) in northern Westchester County, the Town of Patterson in Putnam County, and in the Town of Fishkill in Dutchess County. In all cases, the general orientation of the quartz veins has been similar to that described by Balk (1936). This geographical distribution outlines a primary lithic resource for prehistoric cultures.

As noted in the report, there are several varieties of vein filling minerals that are similar in outward appearance that occur within and around the study area. Of the several varieties - compositional quartz bands, aplites or micropegmatites, granite pegmatites and quartz veins - it is the quartz veins that are archaeologically relevant, for it is the quartz vein that would have been the primary target for prehistoric quarry operations, with the compositional bands of secondary interest. The presence of quartzite hammerstones, diabase pounding instruments, possible anvil objects, and small dense purple quartzite hammerstones at *Chapel Farm Estate* are evidence that quartz veins were exploited. Comparison between the types of mining instruments associated with the quartz quarries at *Chapel Farm Estate* and those found at the chert quarries in the Wallkill Valley indicate that the prehistoric peoples that exploited these quarries were using a common mining practice involving a well-understood and widely disseminated technology.

This slightly more detailed geological picture of *Chapel Farm Estate* and the surrounding area may make it possible to suggest other potential target areas in Bronx County for the occurrence of extensive quartz veins that may have been quarried in prehistoric times. The proper synthesis of the regional geology and a close inspection of the stratigraphy and structure, with a discerning eye for the notation of the presence of quartz veins, will create a regional picture of the geographic distribution of this plexus of late-stage quartz in-filling that may define a prehistoric quarry district. These prehistoric quartz quarries are related not only to the Late Archaic and Coastal Transitional cultures of New York (e.g., Susquehanna-Orient, 3500-3000 BP), but may have also been exploited by Beekmantown and Sylvan Lake cultures of the Middle and Late Archaic period (6000-5000 BP).

In light of the recent discoveries, it may be necessary to reconsider our assumptions concerning the source of the lithic materials utilized by Coastal Archaic peoples, along with the supposition that the lithic industry in coastal New York has been one of bi-polar crushing of randomly gathered glacially imported quartz cobbles, since it now appears that primary resources in the form of quartz veins were regularly visited by coastal groups. Further, the preponderance of quartz flakes at nearby coastal shell middens (including shell middens in Riverdale Park) suggests an intimate relationship between the quarries, exploration pits, outlier exploited quartz veins and the coastal middens. All are part of a continuum representing the subtle aspects of prehistoric subsistence, which has previously gone either unrecorded or misinterpreted.

From the foregoing discussion it can be seen that the *Chapel Farm Estate* site has provided important new information concerning the lithic resources utilized by Coastal Archaic peoples in the New York City area; however, it should be emphasized that the *Chapel Farm Estate* site does not represent a unique resource. The investigations of this researcher have shown that prehistoric sites similar to those located on the *Chapel Farm Estate* site have been found nearby, i.e. to the north and east on the Furman Estate, to the west near the Russian Embassy compound, and to the north and west in Yonkers, New York, as well as at a number of more distant locations in Westchester, Putnam and Dutchess counties. It is the opinion of the researcher that additional investigations should be undertaken at the *Chapel Farm Estate* site, including mapping the quartz veins and outcrops located on the property, a systematic collection of quarrying instruments from the site, the production of a catalogue of these artifacts and those collected in the course of the Stage 2 investigation, a comparison of these artifacts with others from collections that have been made in the area (most notably from the sites in Riverdale Park), and the development and execution of a testing strategy that will clarify the types of quarrying activities that took place on the site.

APPENDICES

APPENDIX A

FIGURES

FIGURE LIST

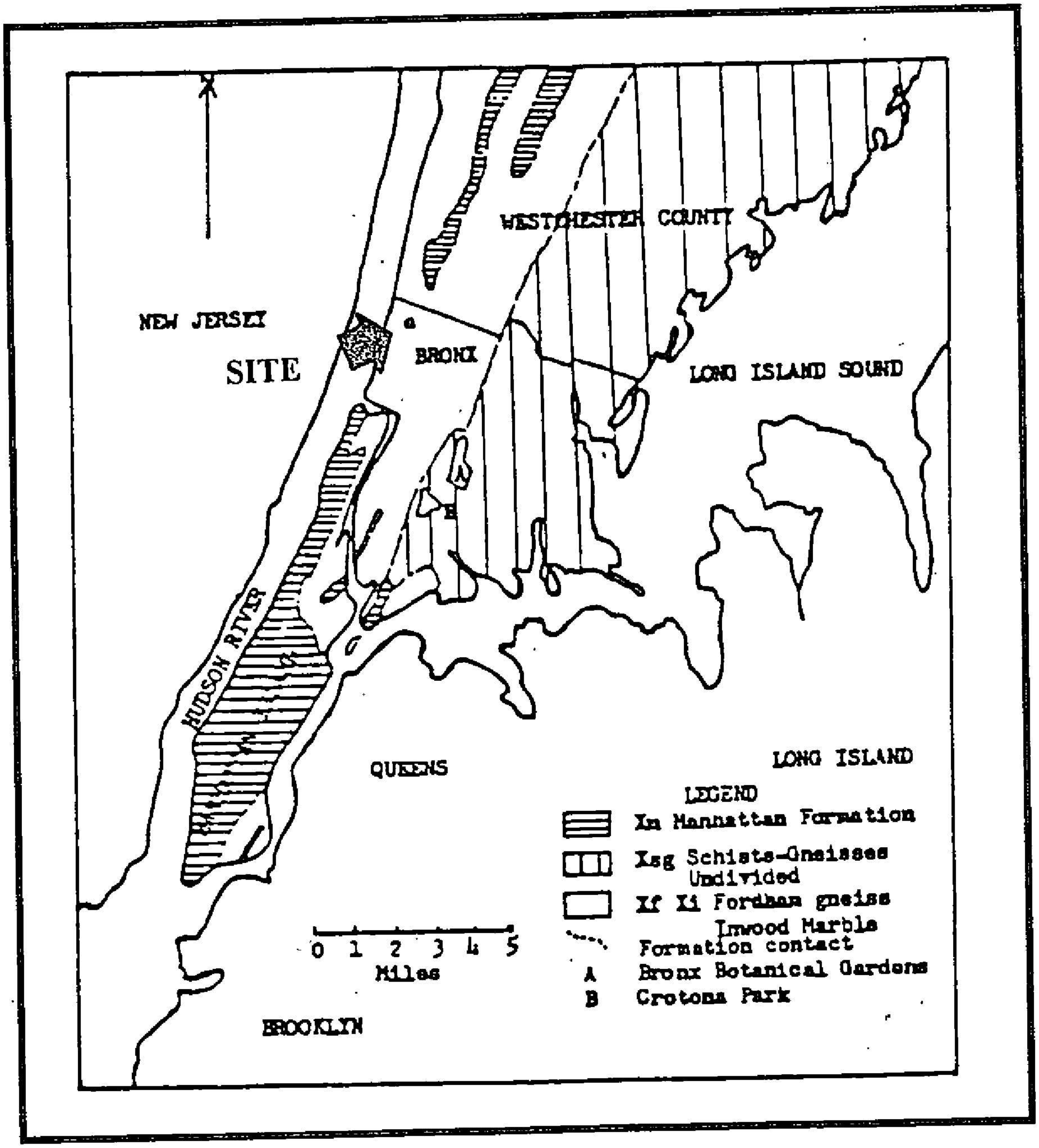

Figure 1: Bedrock geology of the Manhattan Prong in New York City (1961). (From Langer 1966)

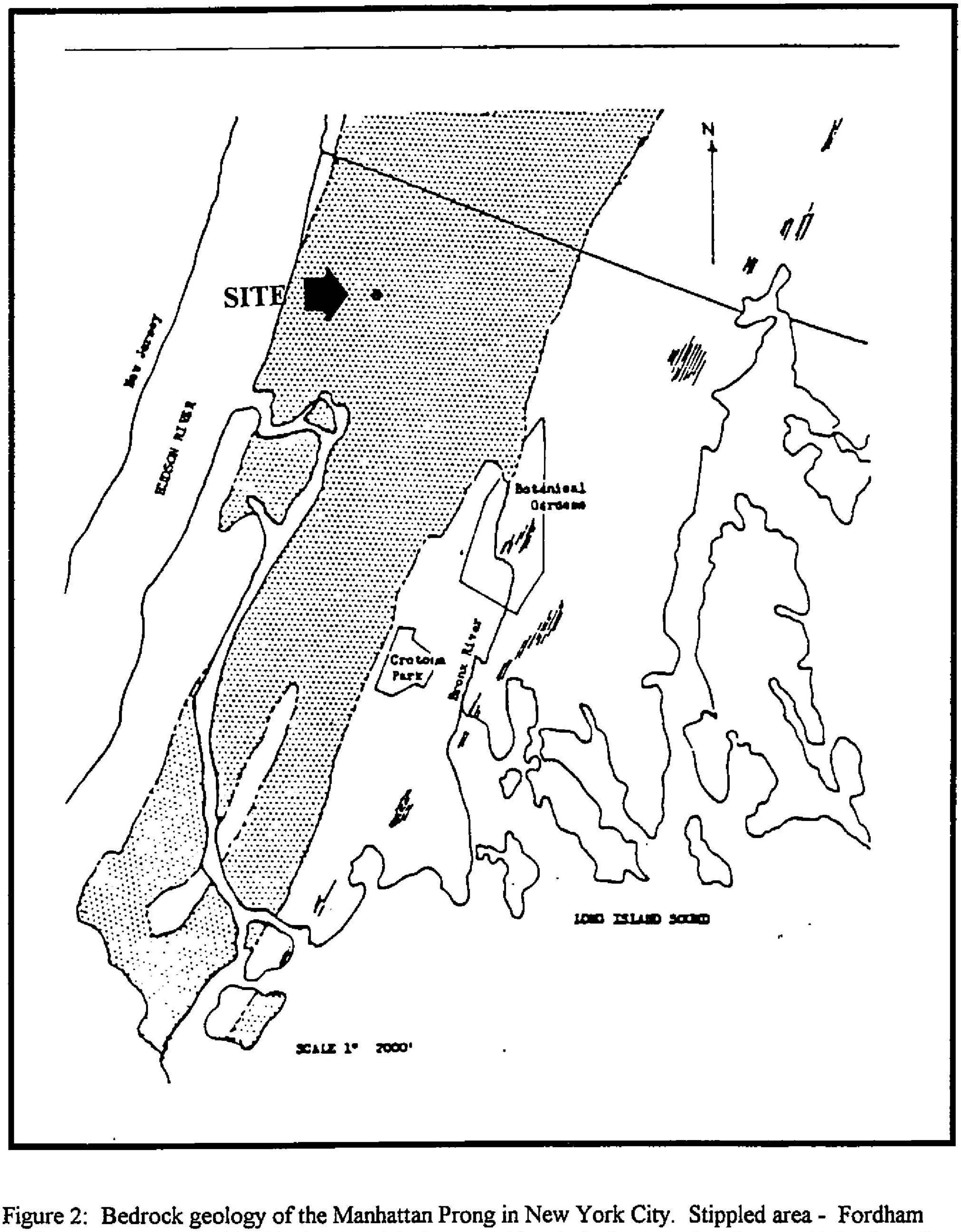

Figure 2: Bedrock geology of the Manhattan Prong in New York City. Stippled area - Fordham gneiss and Inwood marble; blank area - Manhattan schist; dashed area - closed-spaced injection of granite in schist. (From Langer 1966)

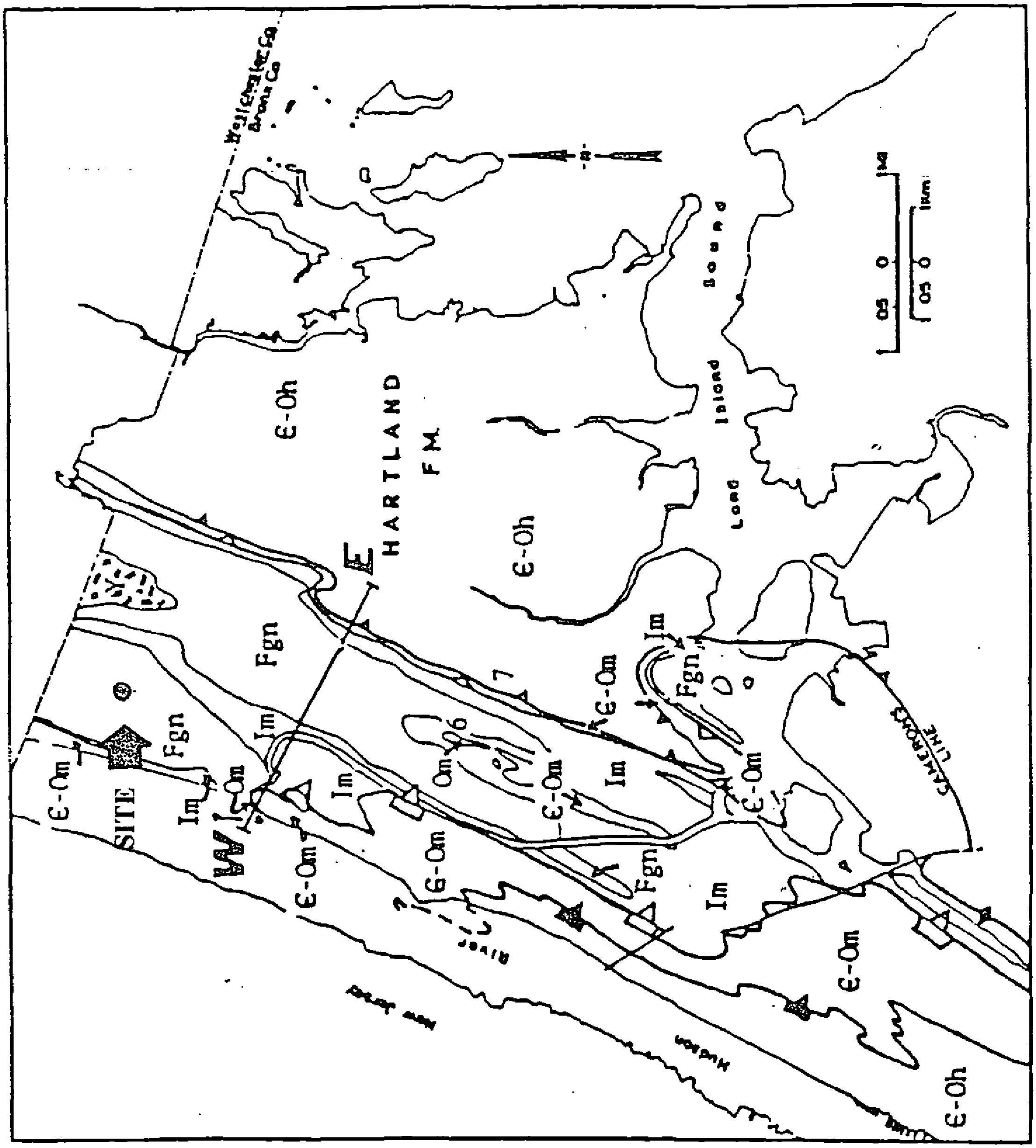

Figure 3: Geological base map for New York City area. Cameron's Line is indicated. Approximate location of Chapel Farm Estate is shown. (From Merguerian 1985)

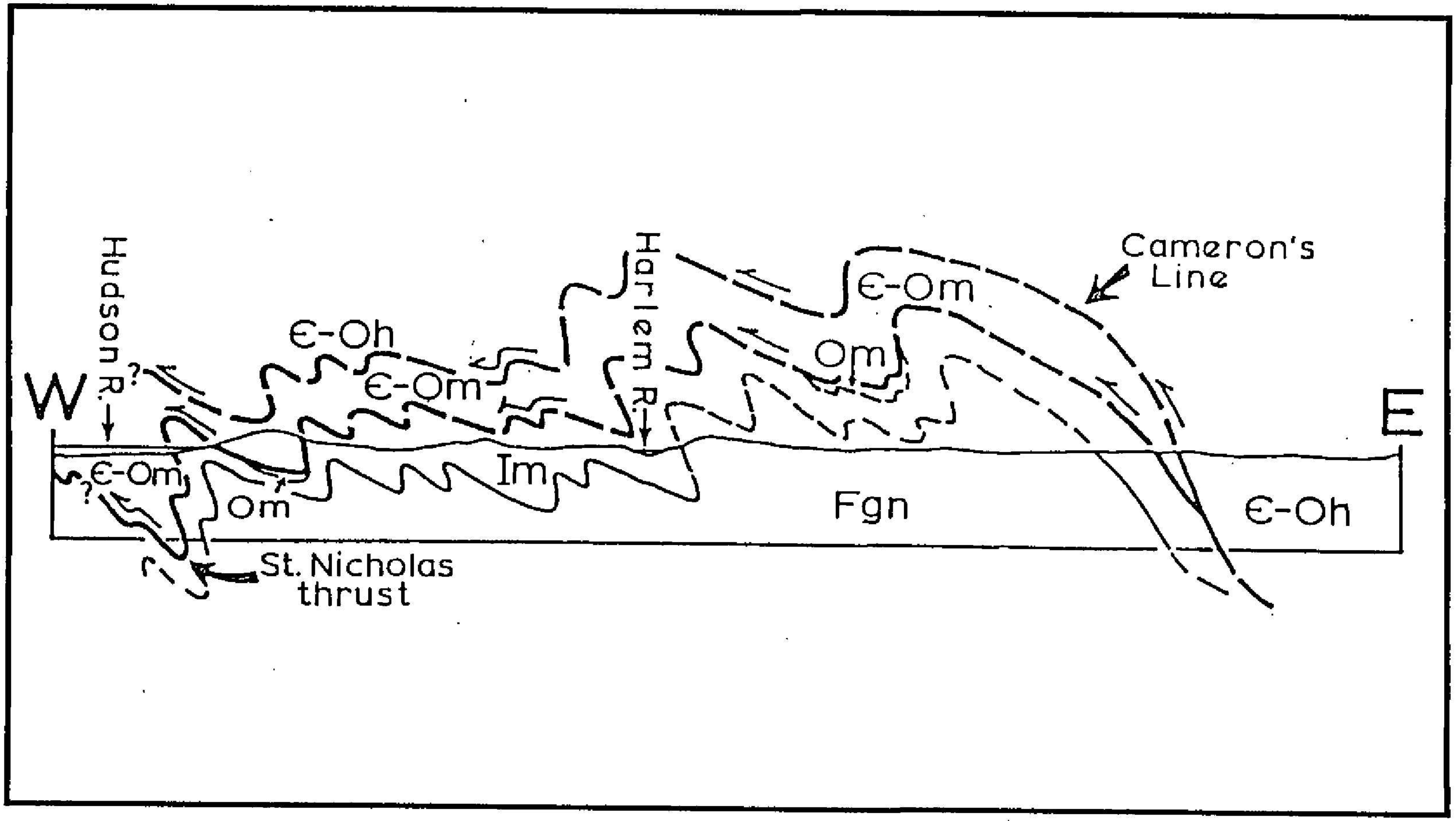

Figure 4: Interpretation of the cross-section of structural geology seen in Figure 1. East-west structure section across northern Manhattan and the Bronx. (From Merguerian 1985)

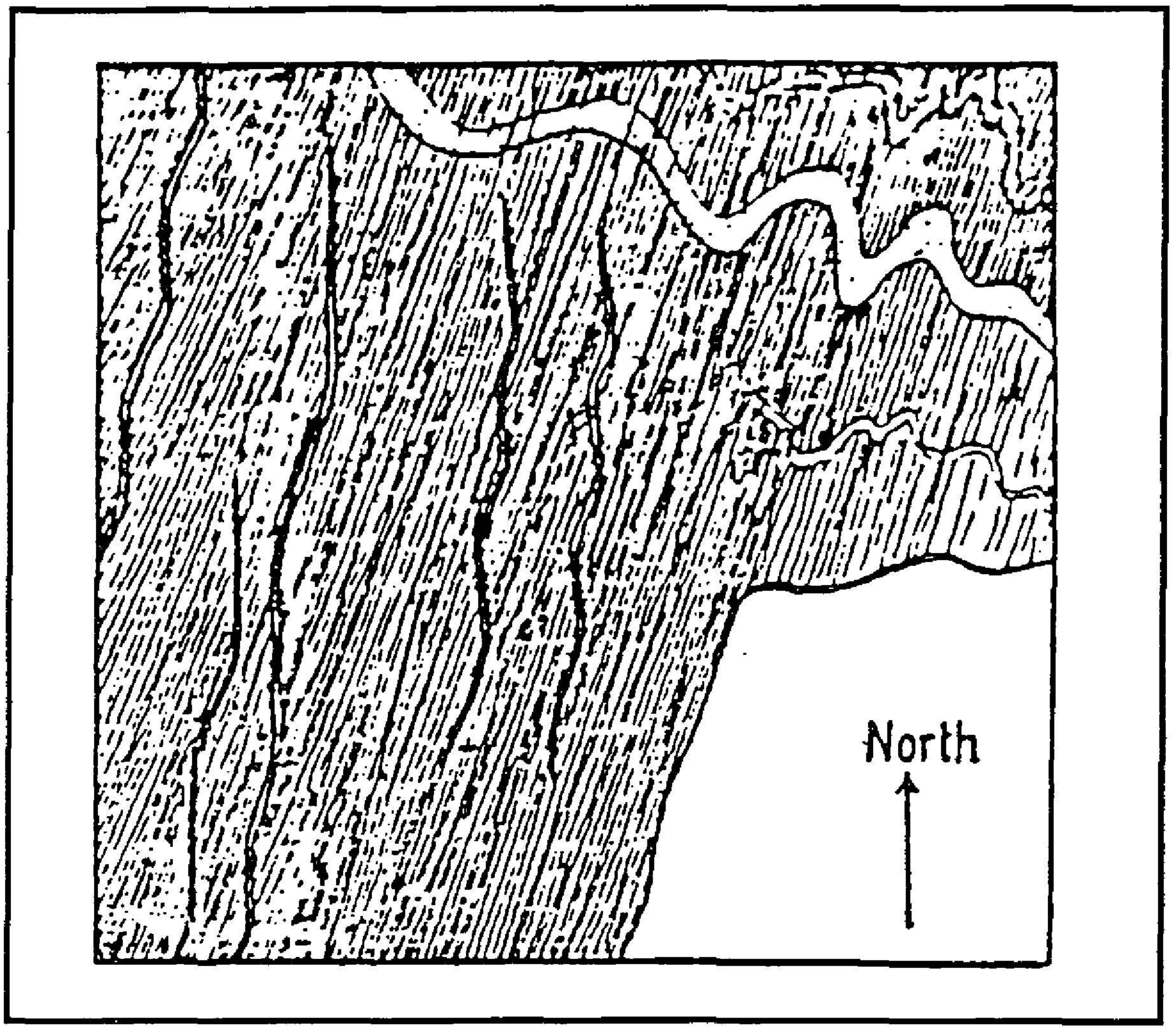

Figure 5: Quartz veins subparallel to fracture cleavage in phyllite. Flat surface, 4 by 3 feet, east of top of hill 1120, a mile southeast of Chestnut Ridge settlement. Siliceous beds trend east-southwest - west-northwest; fracture cleavage dips 72°.E-SE. Quartz veins oscillate between cleavage planes and connecting fractures (From Balk 1936)

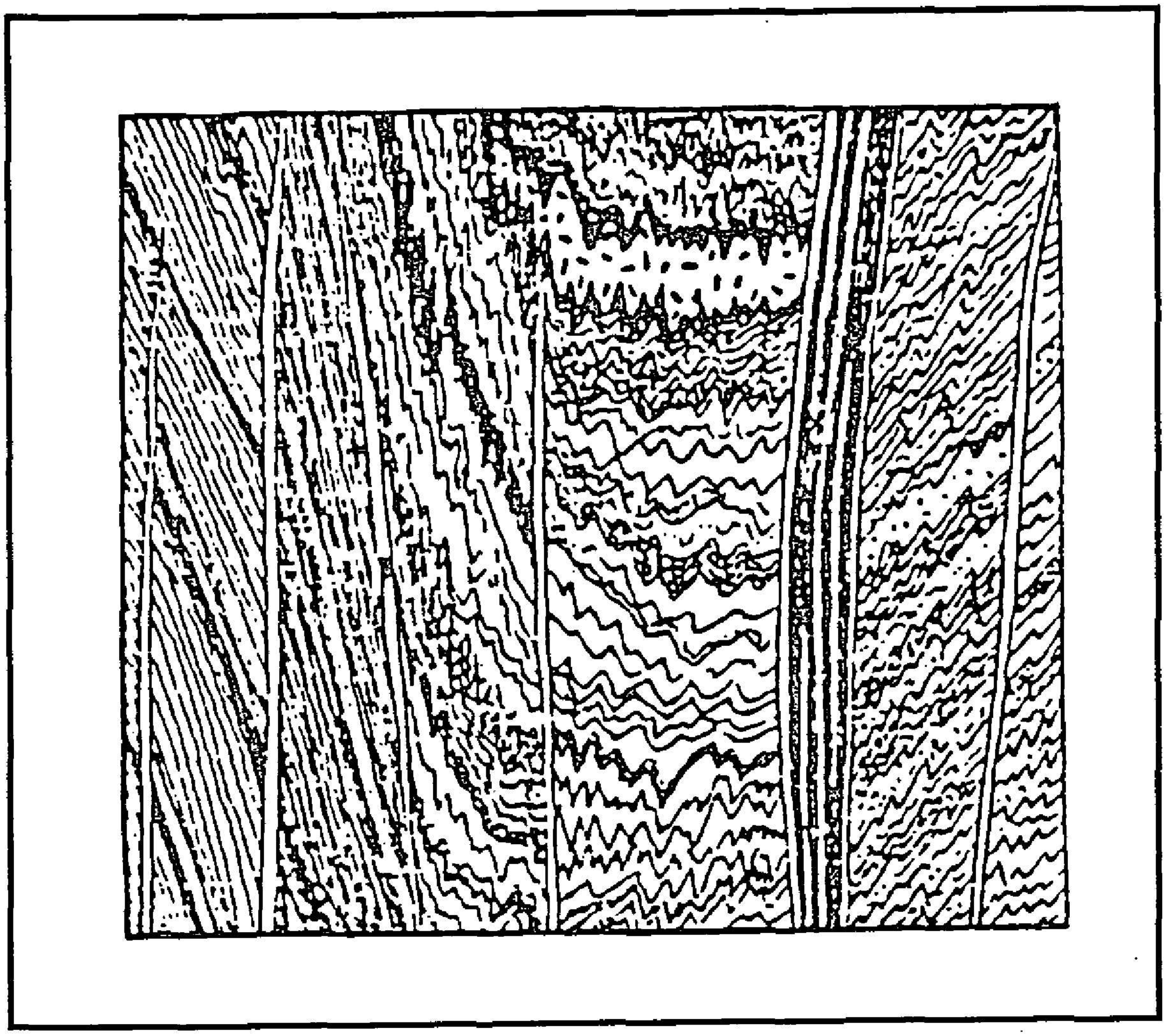

Figure 6: Shearing of crumpled phyllite parallel to axial plane, and quartz veins along shear planes. Flat, glaciated surface, $2^1/_2$ by 3 feet, hill 820 $1^1/_4$ mile southeast of Chestnut Ridge settlement. (From Balk 1936)

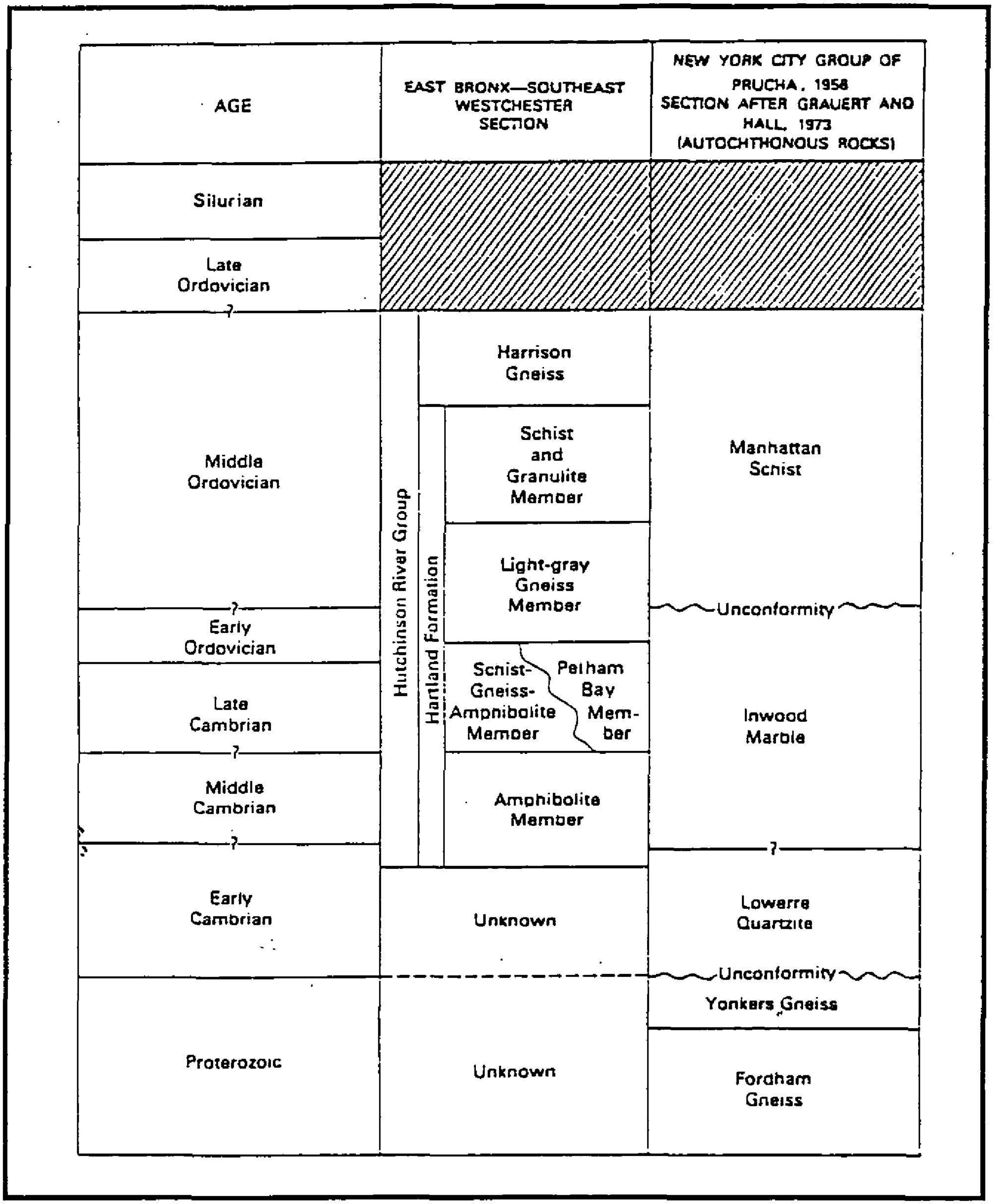

Figure 7: Diagrammatic stratigraphic column of the Hutchinson River Group at its type locality near Hutchinson River in Manhattan Prong of New England upland southeast of Webster Avenue valley in Bronx County and east of Bronx River valley in Westchester County, southeastern New York. Informal members of the Hartland Formation adopted from Hall (1976) (From Baskerville 1982)

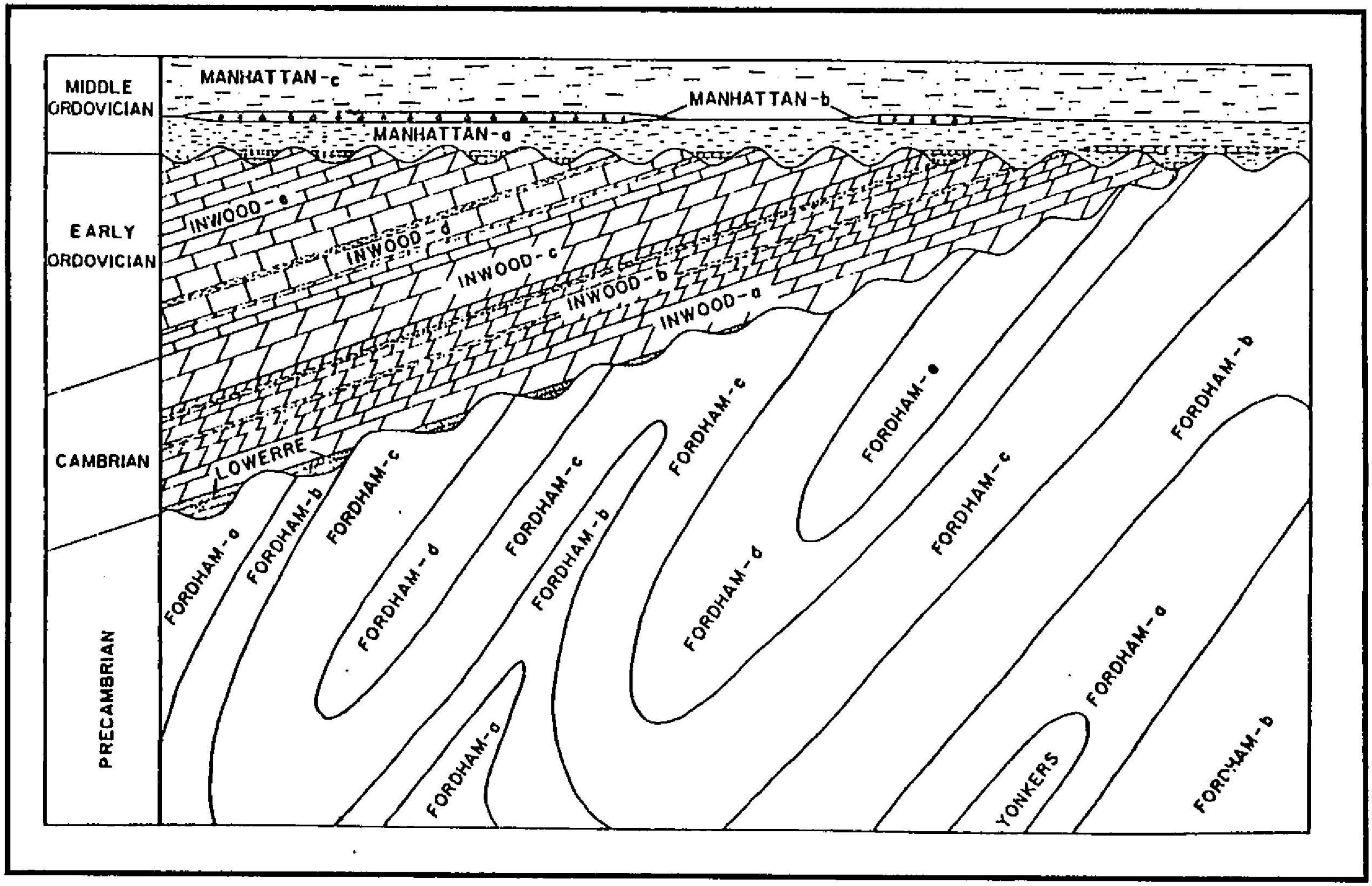

Figure 8: Diagrammatic illustration of the interpreted stratigraphic history of the Manhattan Prong. (From Hall 1968)

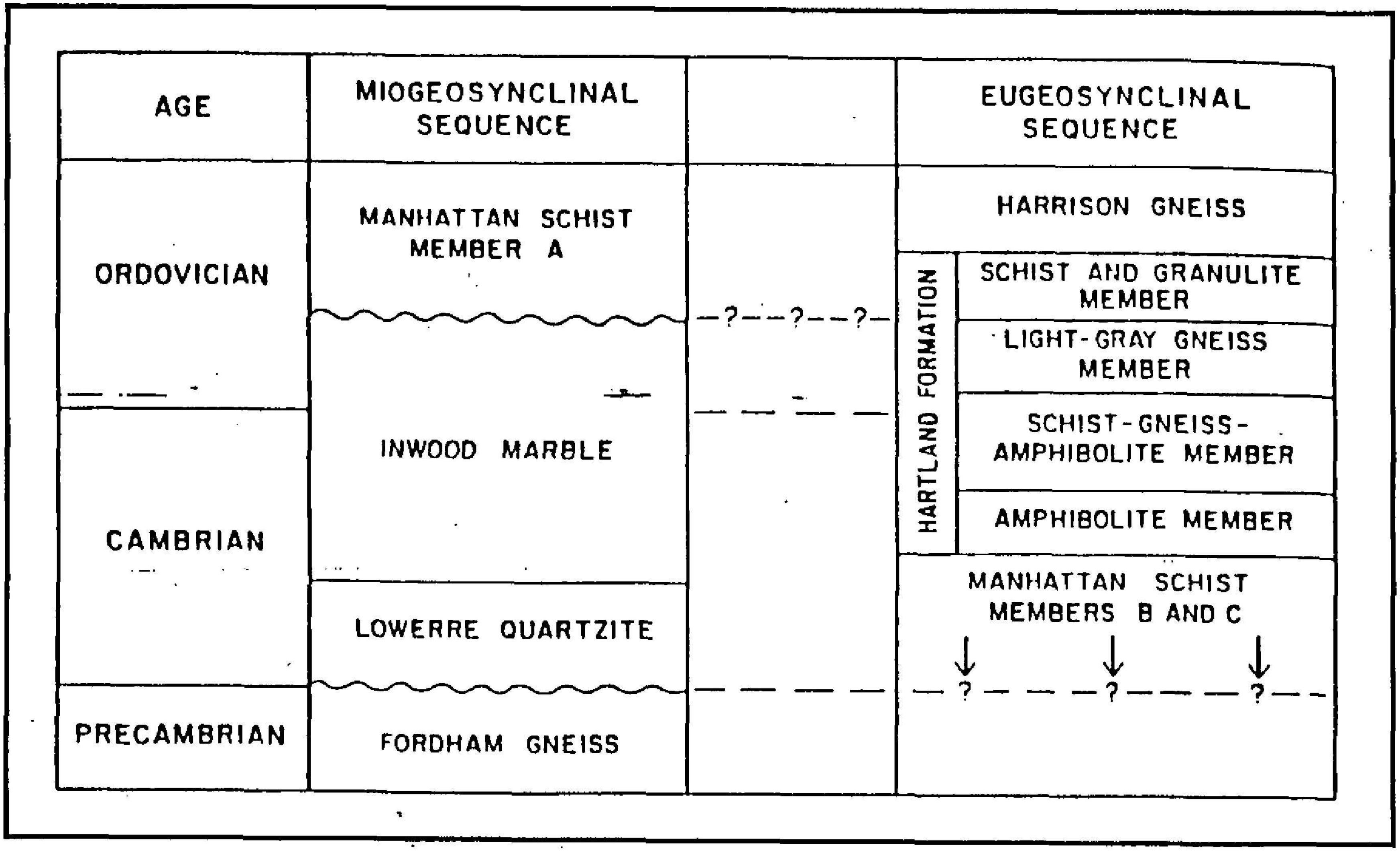

Figure 9: Suggested correlation of the miogeosynclinal and eugeosynclinal sequences in the White Plains-Glenville area. (From Hall 1968)

APPENDIX B

PHOTOGRAPHS

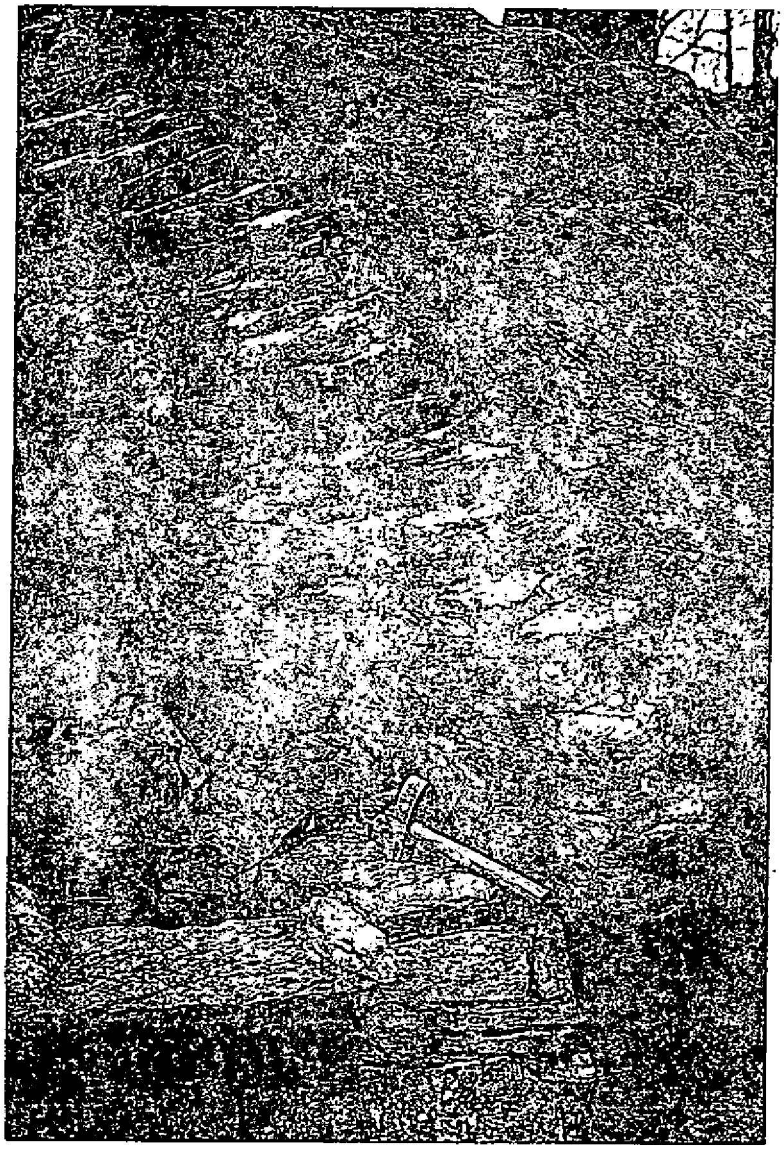

PHOTO 1: **Furman Estate quartz vein.** Nearly vertical vein of quartz missed by prehistoric miners. Approximately 5 feet high, 12 feet long and up to 1 foot thick. Glaciated surface stands out in high relief. Color is bone white, the luster highly vitreous, and entire vein is intersected by series of closely-spaced horizontal joints. Serves as example of appearance of prehistoric landscape during Late Archaic and Transitional periods.

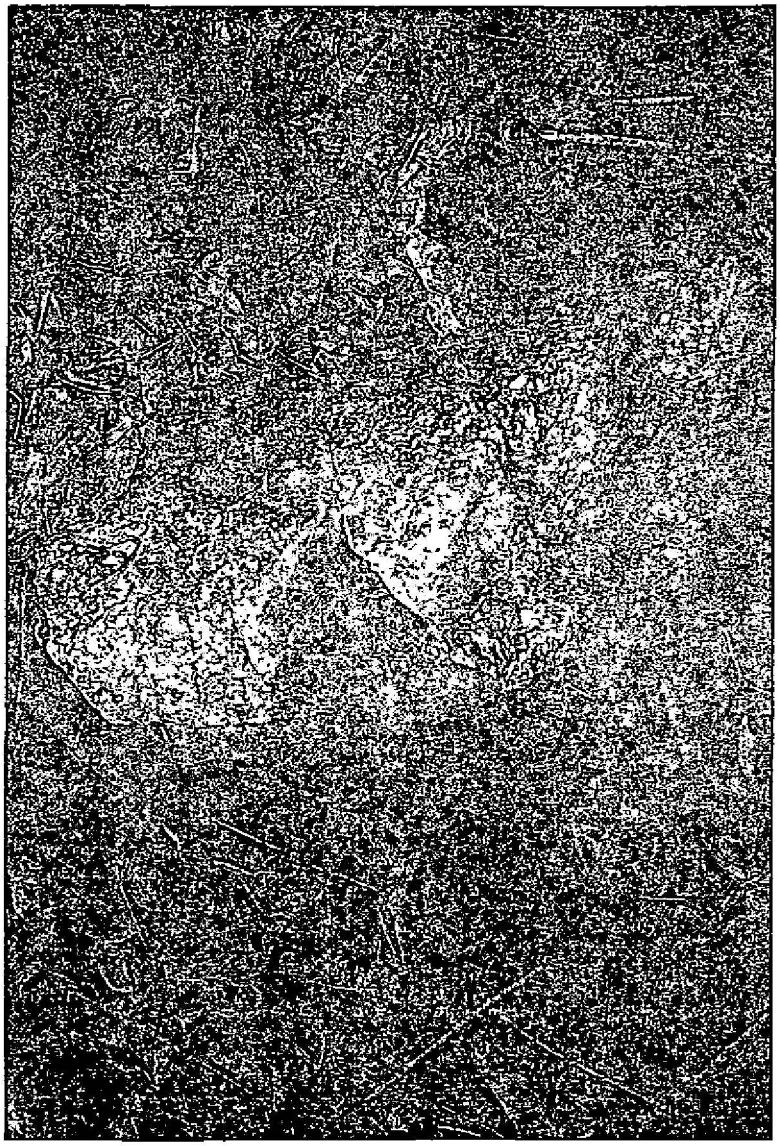

PHOTO 2: Quartz in association with country rock on Furman Estate. Vein of quartz quarried in prehistoric times. Hacked upper surface is evidence of mining. Vein surrounded by quartz debitage, quartzite hammerstones, and small, chipped chisel-like object.

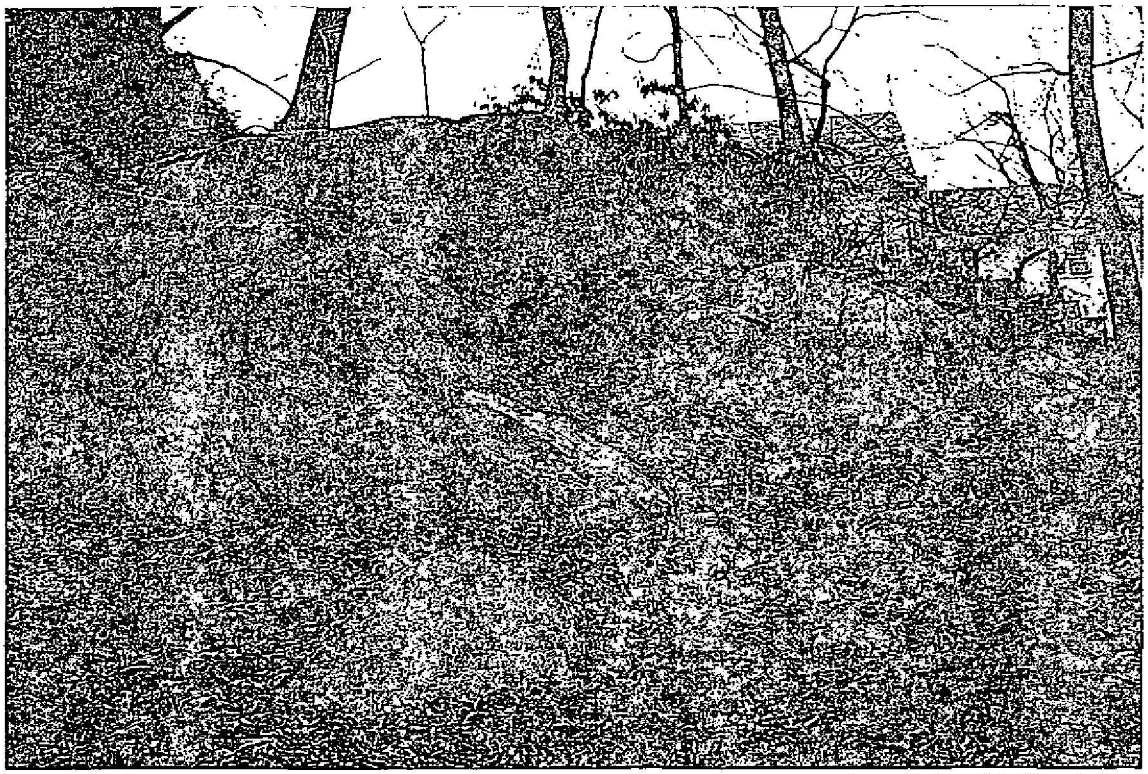

PHOTO 3: Evacuated veins in country rock on Furman Estate. Folded schist contained evacuated veins of quartz that were quarried in prehistoric times.

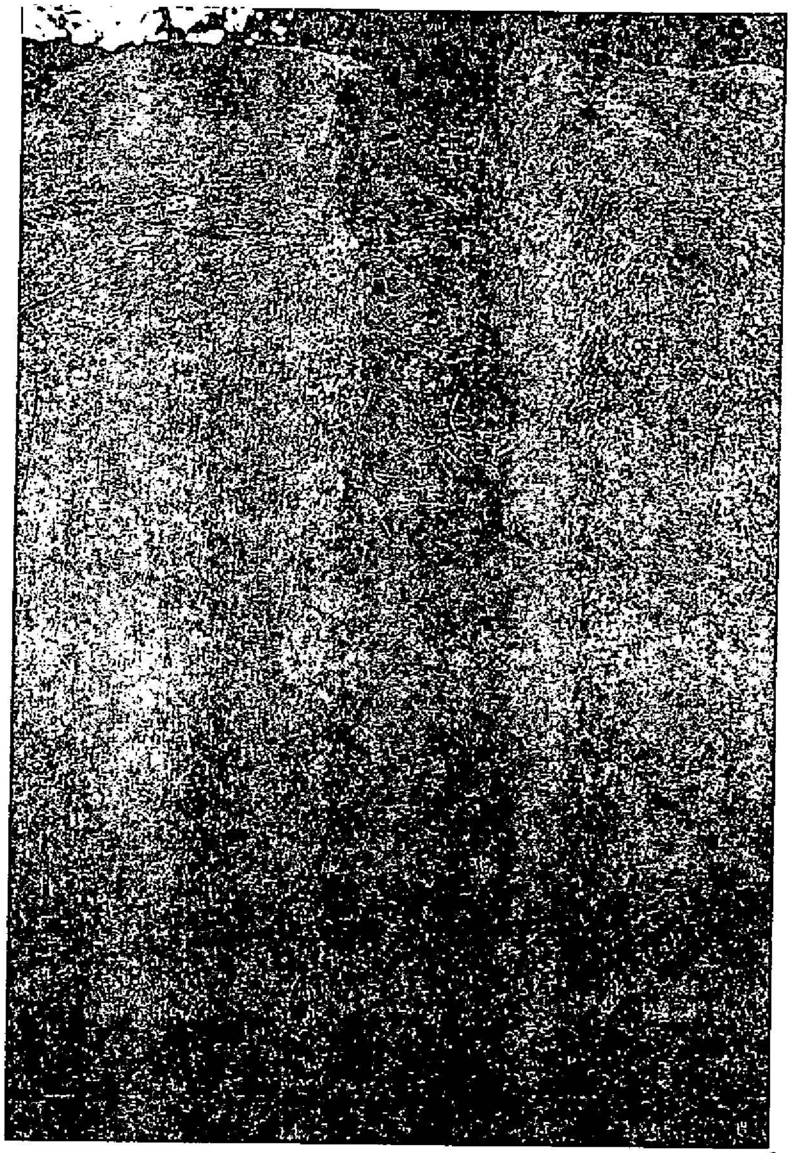

PHOTO 4: Close-up of evacuated vein on Furman Estate. Evacuated veins were found to contain hammerstone fragments. Ground beneath the veins littered with quartz debitage.

PHOTO 5: Quartz vein in association with country rock immediately west of Russian Embassy compound. Narrow quartz veins seen in association with country rock. Two large veins of micropegmatite (or aplite) are seen to right of hammer. Abundant quartzite hammerstones were seen on the nearby slope.

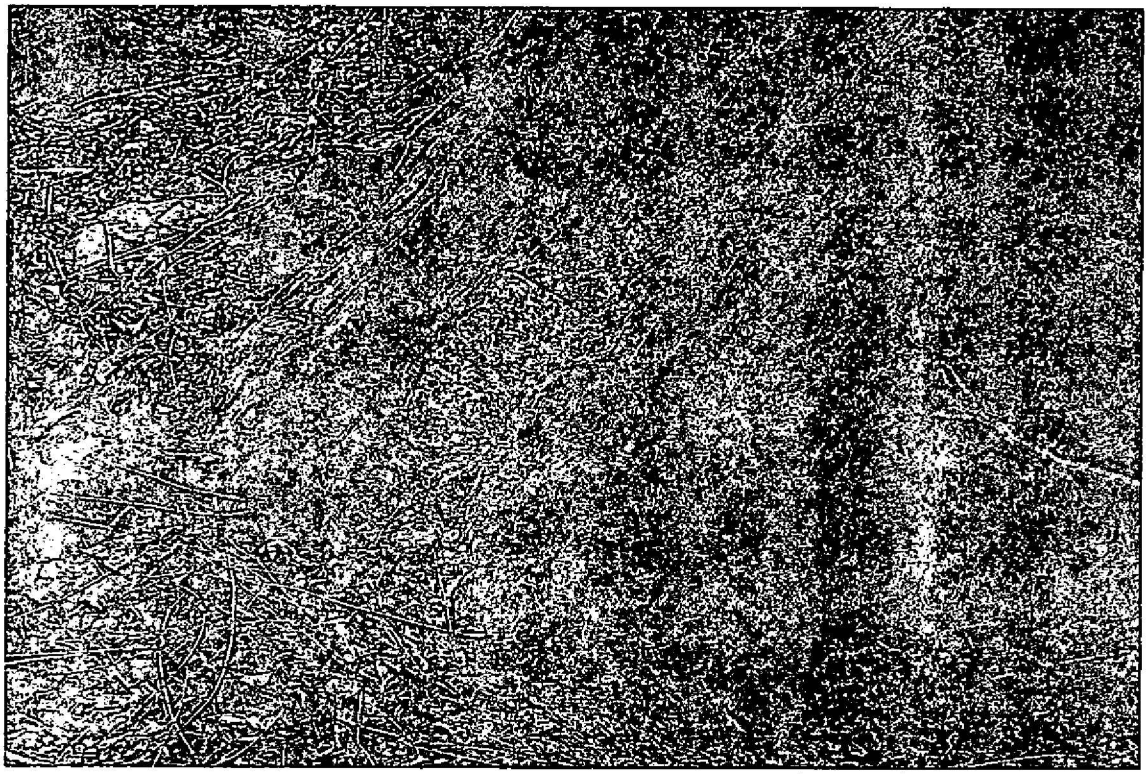

PHOTO 6: Quartz vein in association with country rock immediately west of Russian Embassy compound. Vein of quartz quarried in prehistoric times. Hammerstones were seen on nearby slopes.

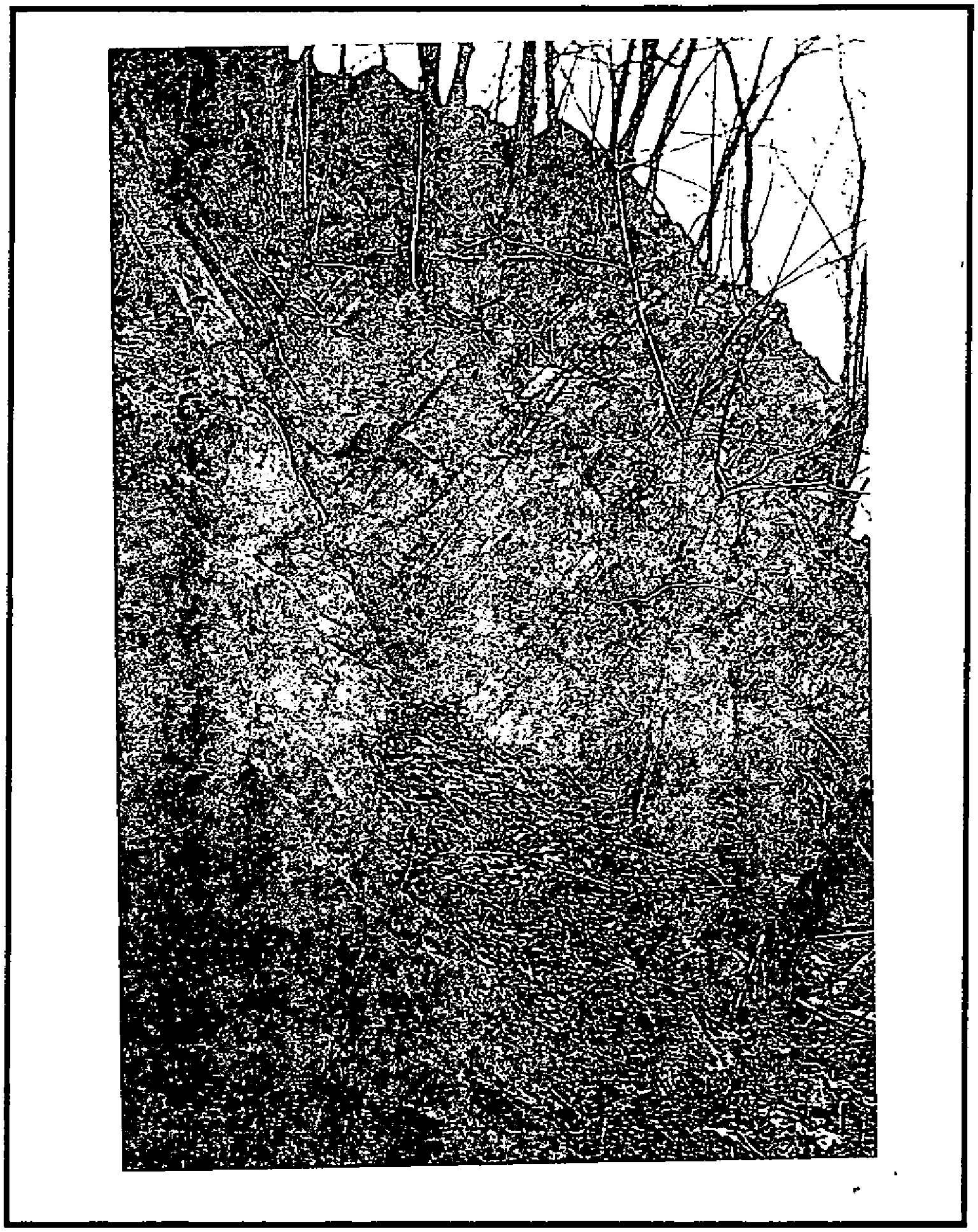

PHOTO 7: Quartz in association with country rock on Russian Embassy compound. As at other locations, hammerstone fragments were observed near the quartz vein.

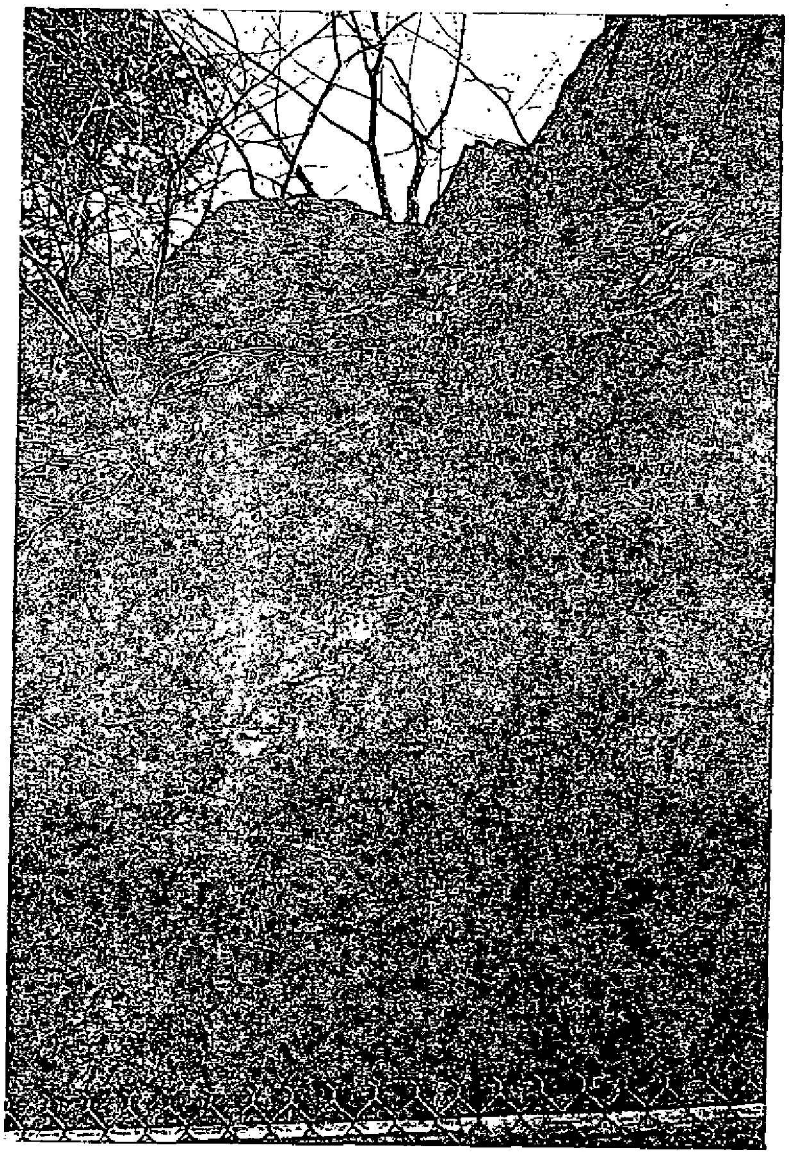

PHOTO 8: Quartz in association with country rock immediately north of Russian Embassy compound. This quartz vein is more than 50 feet in length and greater than 1 foot in width. Occurs in association with numerous thin, less-well developed stringers and pods of quartz.

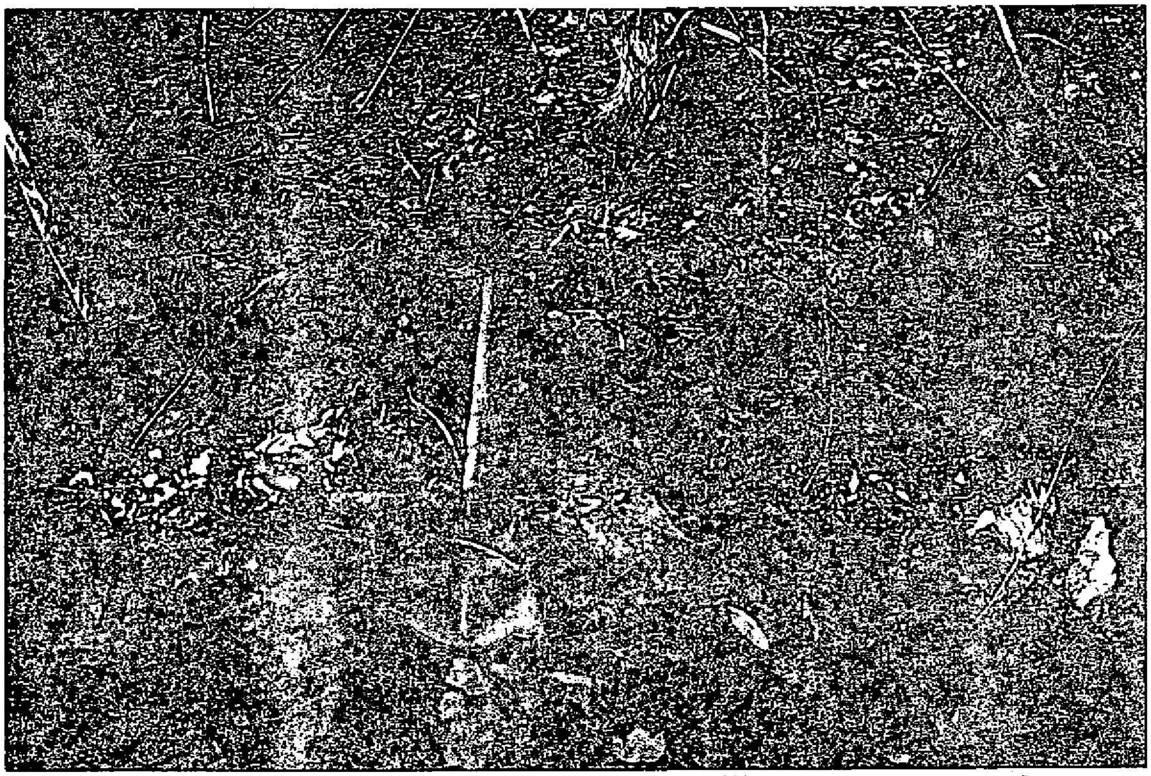

PHOTO 9: Quartz blocks associated with the tailings pile on Chapel Farm Estate. Traditionally located below the quarry face, the tailings pile is characterized by large blocky pieces of quarried material, in this case, quartz. At Chapel Farm a number of the blocks of quartz from the tailings pile have been used to line a path leading to one of the cottages on the site.

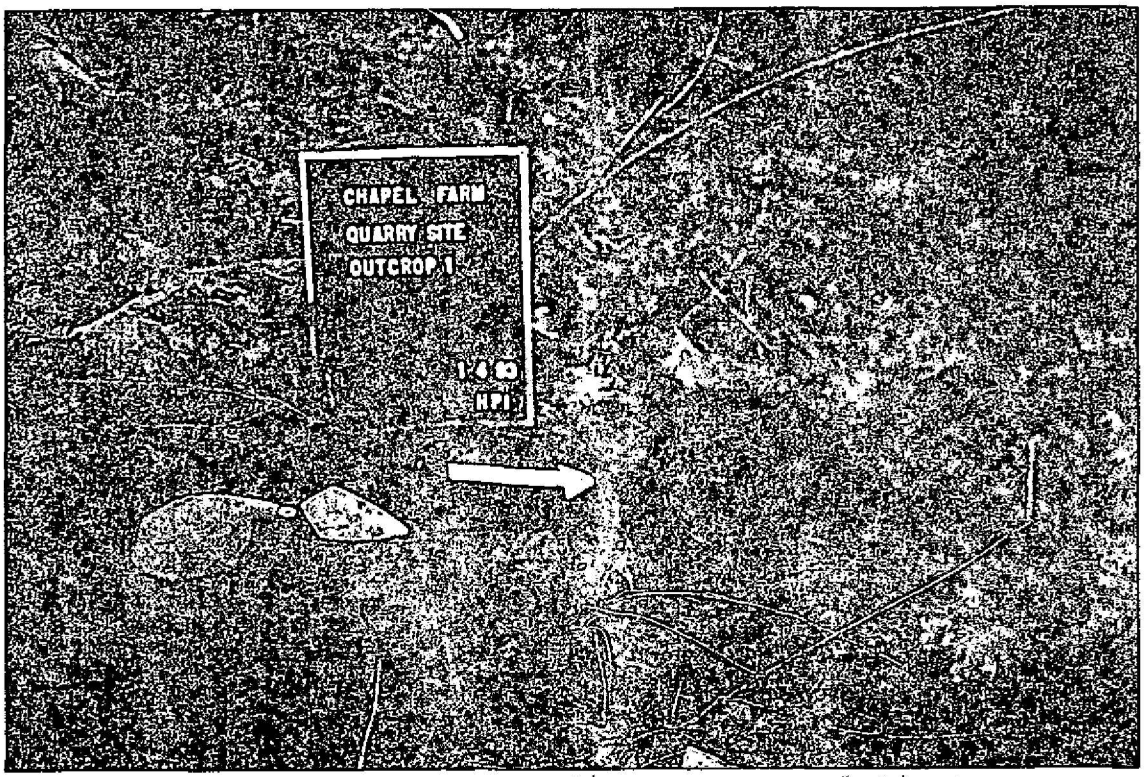

PHOTO 10: Quartz outcrop on Chapel Farm Estate site. Located on the eastern slopes of Chapel Farm Estate are a number of quartz veins that represent abandoned operations or potential prospect pits and areas of exploration and testing. Note the "beaked " hammerstone placed on the quartz outcrop. "Beaked" hammerstones are considered diagnostic artifacts on quarry sites.

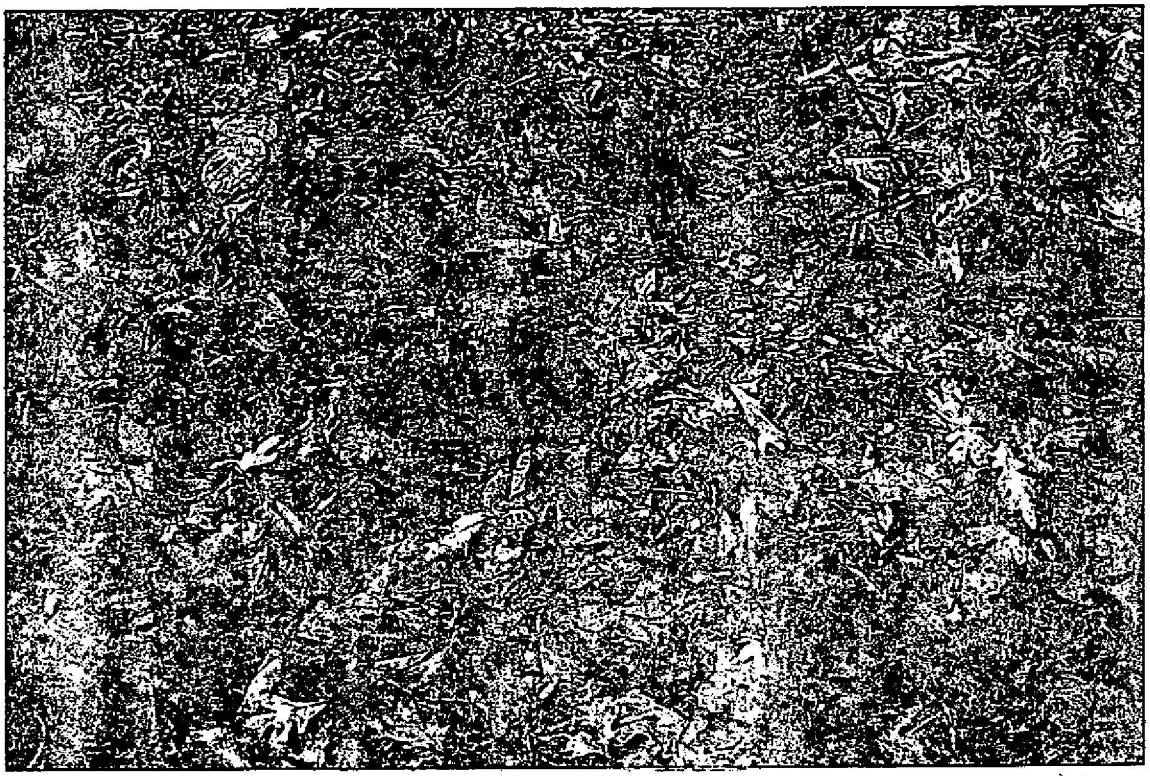

PHOTO 11: Non-portable anvil located on chert quarry site in northern New Jersey. Non-portable anvils are often associated with reduction sites. Other types of non-portable anvils may be bedrock outcrops, glacial erratics embedded in soil, or masses of loosened bedrock. Evidence for use is found in form of apron of fine flaking debris surrounding anvil.

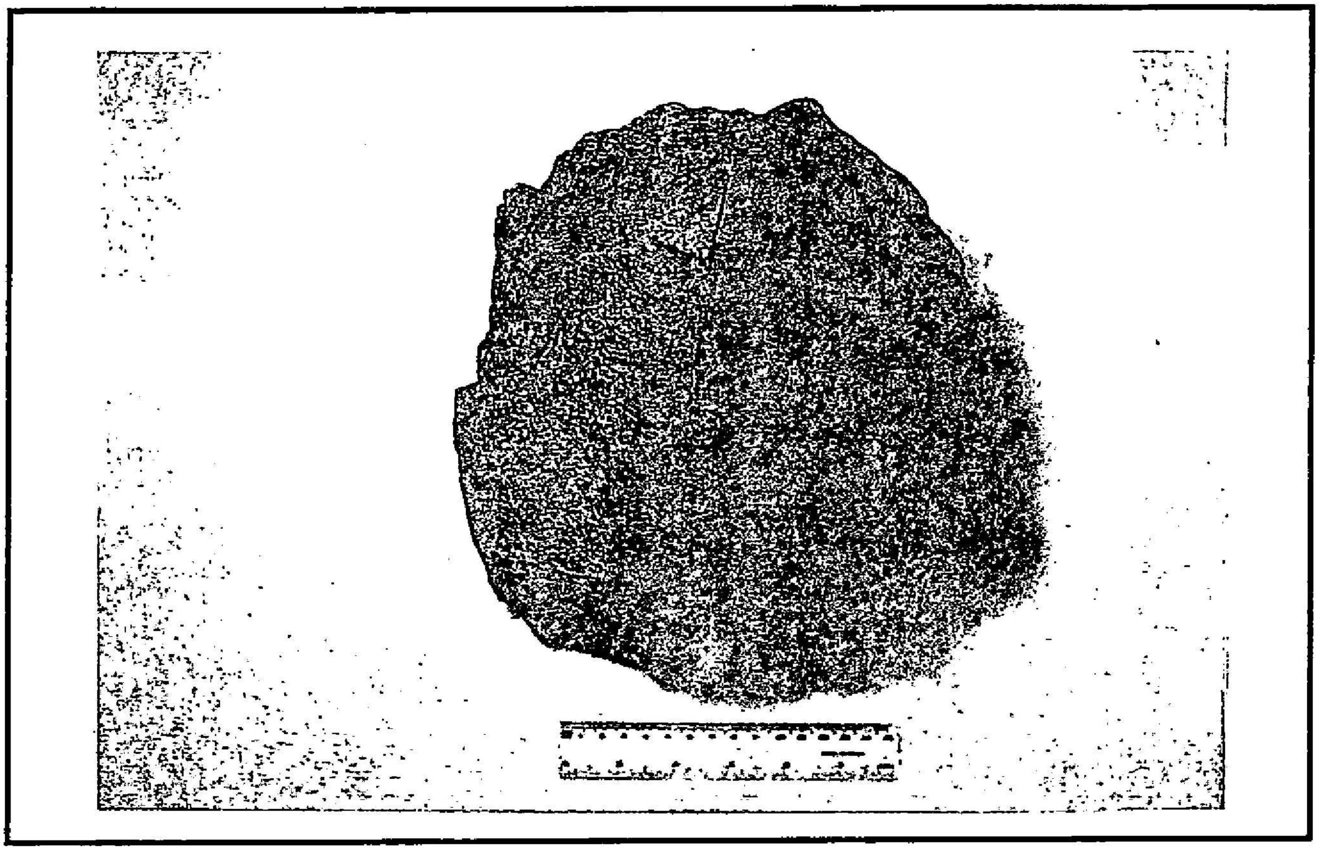

PHOTO 12: Extraction tool associated with quarry face. Large quartzite quarry instrument used at quarry face to extract lithic material. This particular artifact is Cheshire quartzite from central Vermont, but other similar in size and conformation are found in the Wallkill Valley chert quarries.

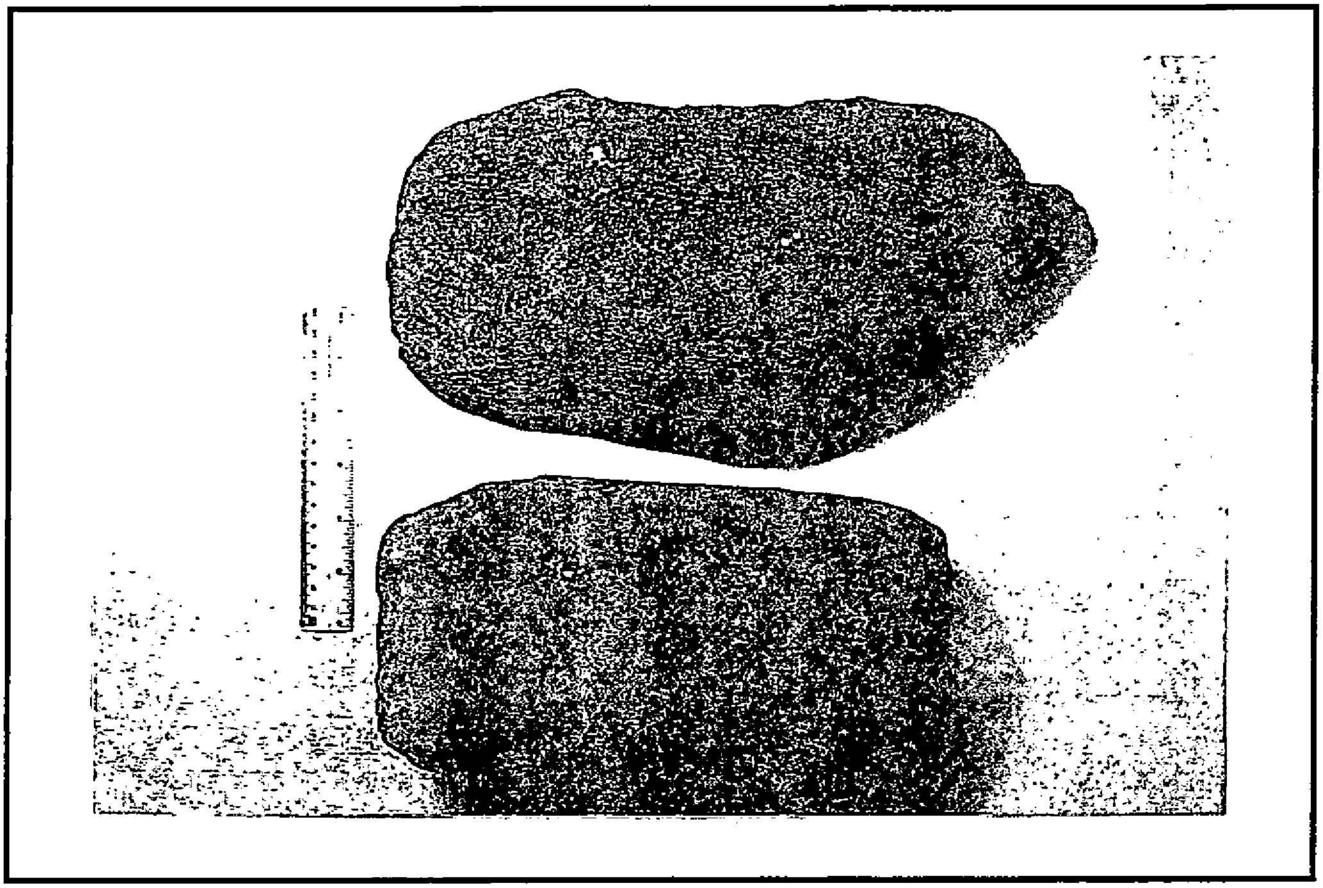

PHOTO 14: Heavy pounding instruments associated with ore dressing or milling area on quarry site. Upper: arcosic sandstone - split in half and reused as anvil. Lower: unsplit quartzite pounding instrument. These two examples are from a Wallkill Valley chert quarry.

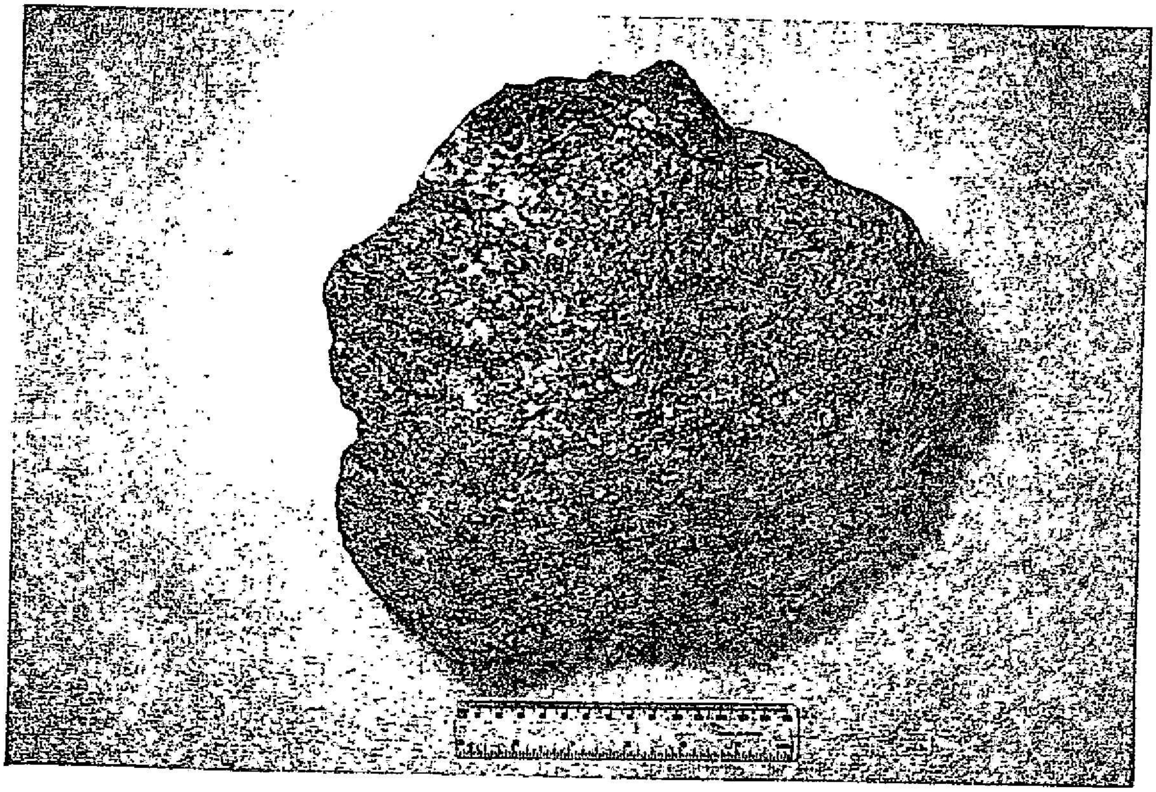

PHOTO 13: Extraction tool associated with quarry face. Large metaconglomerate quarry instrument used at quarry face to extract lithic material. This artifact was obtained from a Wallkill Valley chert quarry.

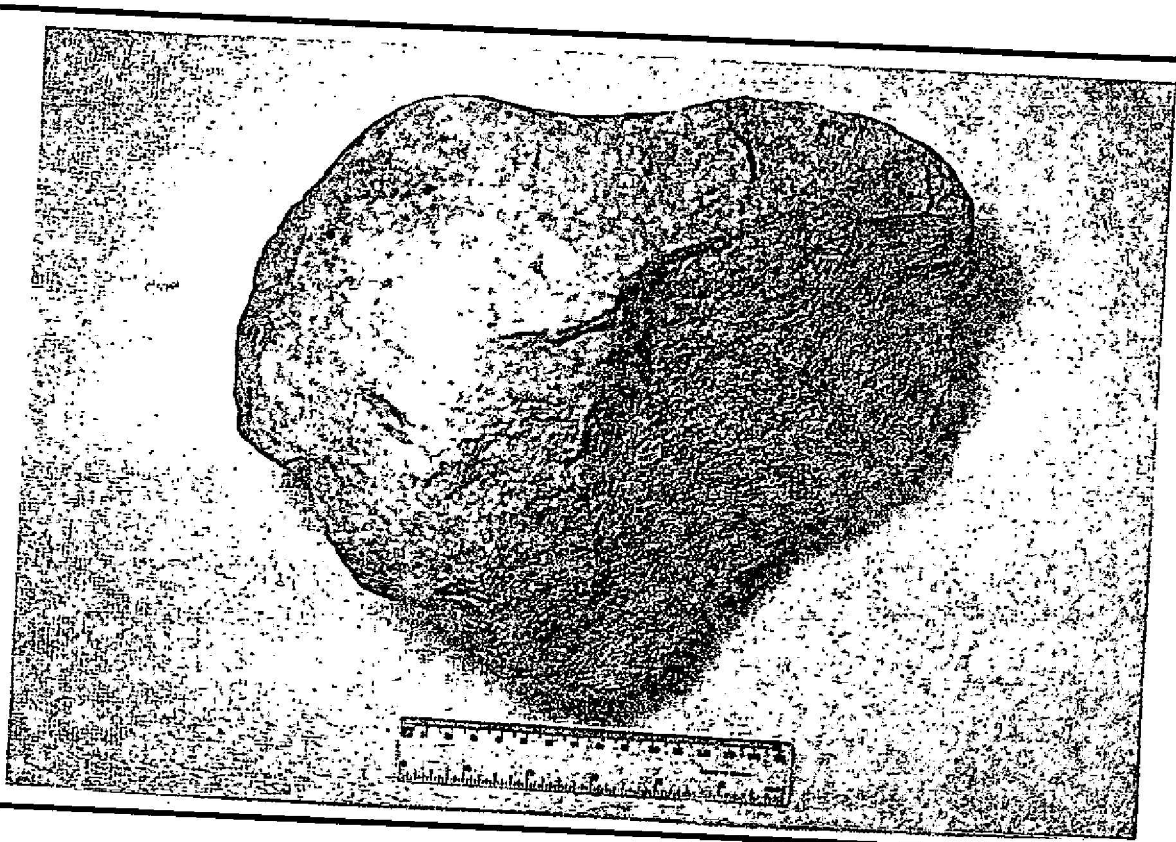

PHOTO 15: Beaked quartzite hammerstone associated with ore dressing or milling area. Wedge-shaped or "beaked" hammerstone weighing between 15 to 20 pounds are often associated with ore dressing or milling areas in a quarry site. The beaks are the result of repeated sharpening or flaking and serve as a diagnostic instrument on a quarry site.

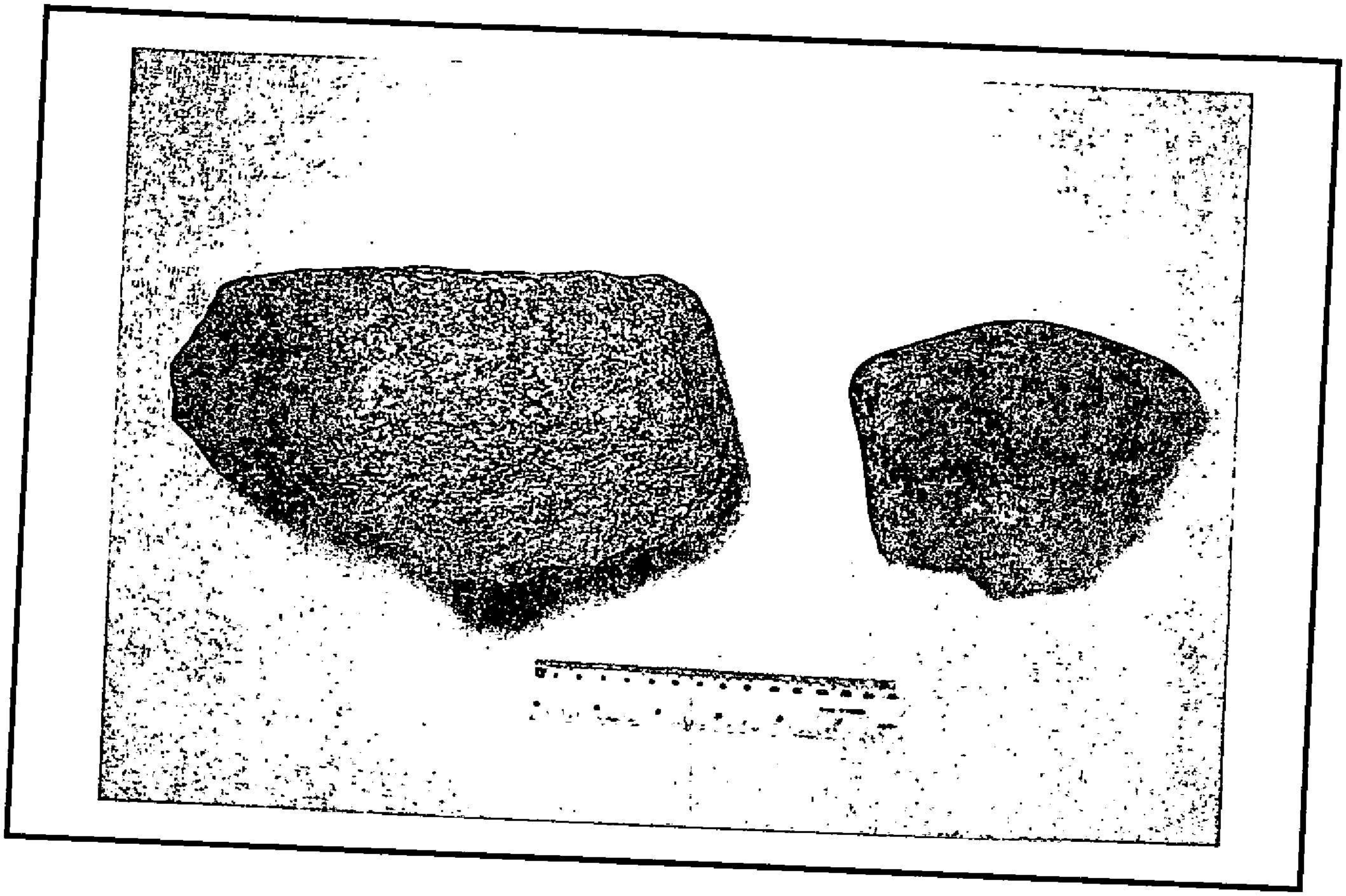

PHOTO 16: Beaked hammerstones associated with ore dressing or milling area on quarry site. Left: beaked quartzite hammerstone. Right: beaked purple quartzite hammerstone. Both these examples are from a Wallkill Valley chert quarry.

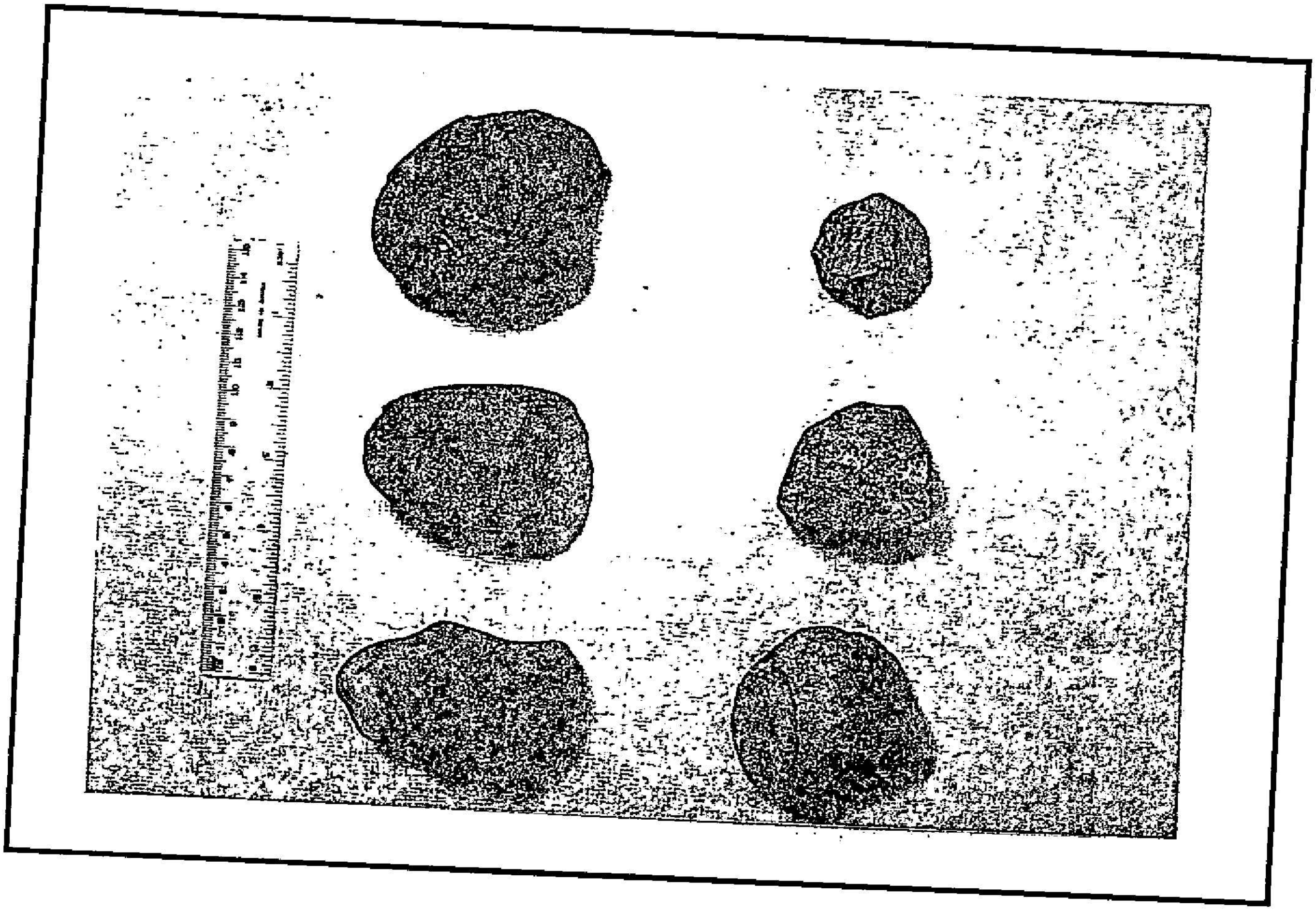

PHOTO 17: Quartzite chisels of various sizes associated with ore dressing or milling area of chert quarry. Associated with ore dressing or milling areas of quarries are frequently found groups of small, blunt and spalled stones of decreasing size. These are interpreted as chisels used to focus blows from larger pounding instruments.

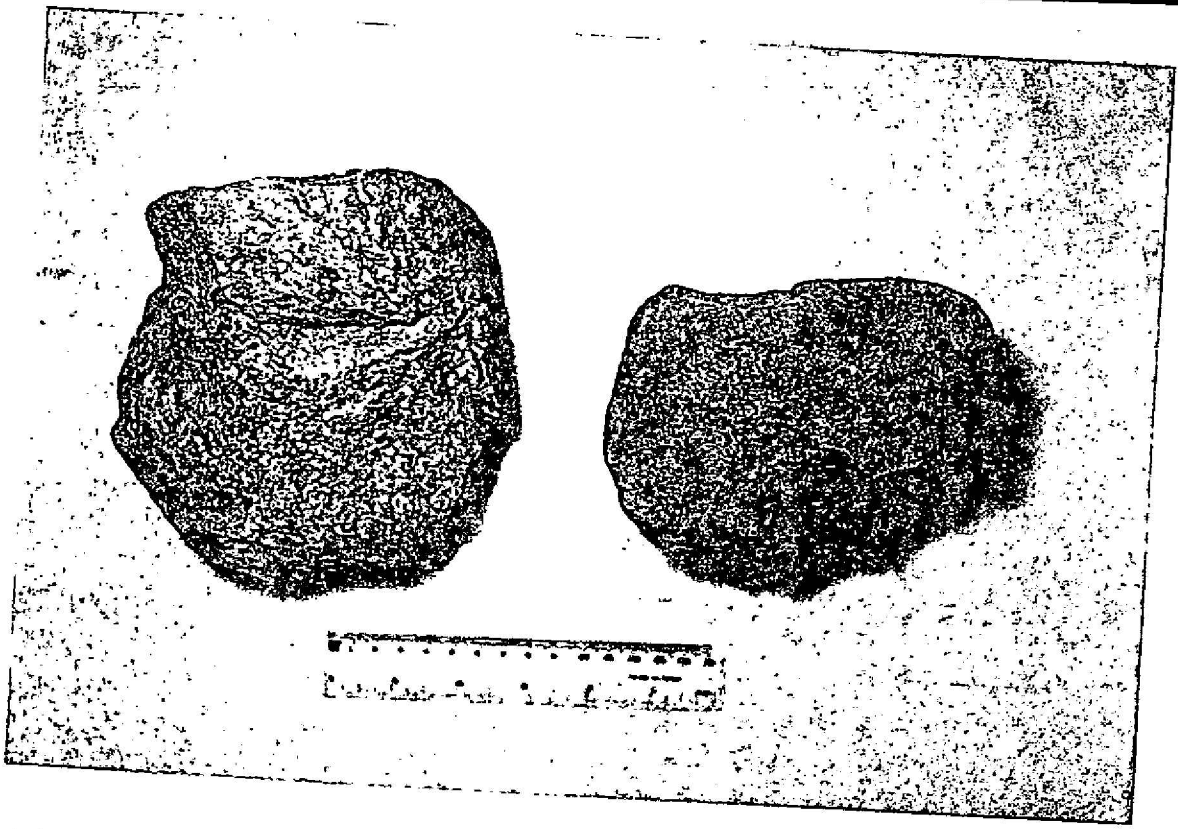

PHOTO 18: Quartzite hammerstones associated with reduction areas on quarry sites. Hammerstones of various weights are associated with reduction areas on quarry sites. Left: heat treated quartzite hammerstone. Right: heat treated purple quartzite hammerstone. Both are from Wallkill Valley chert quarries.

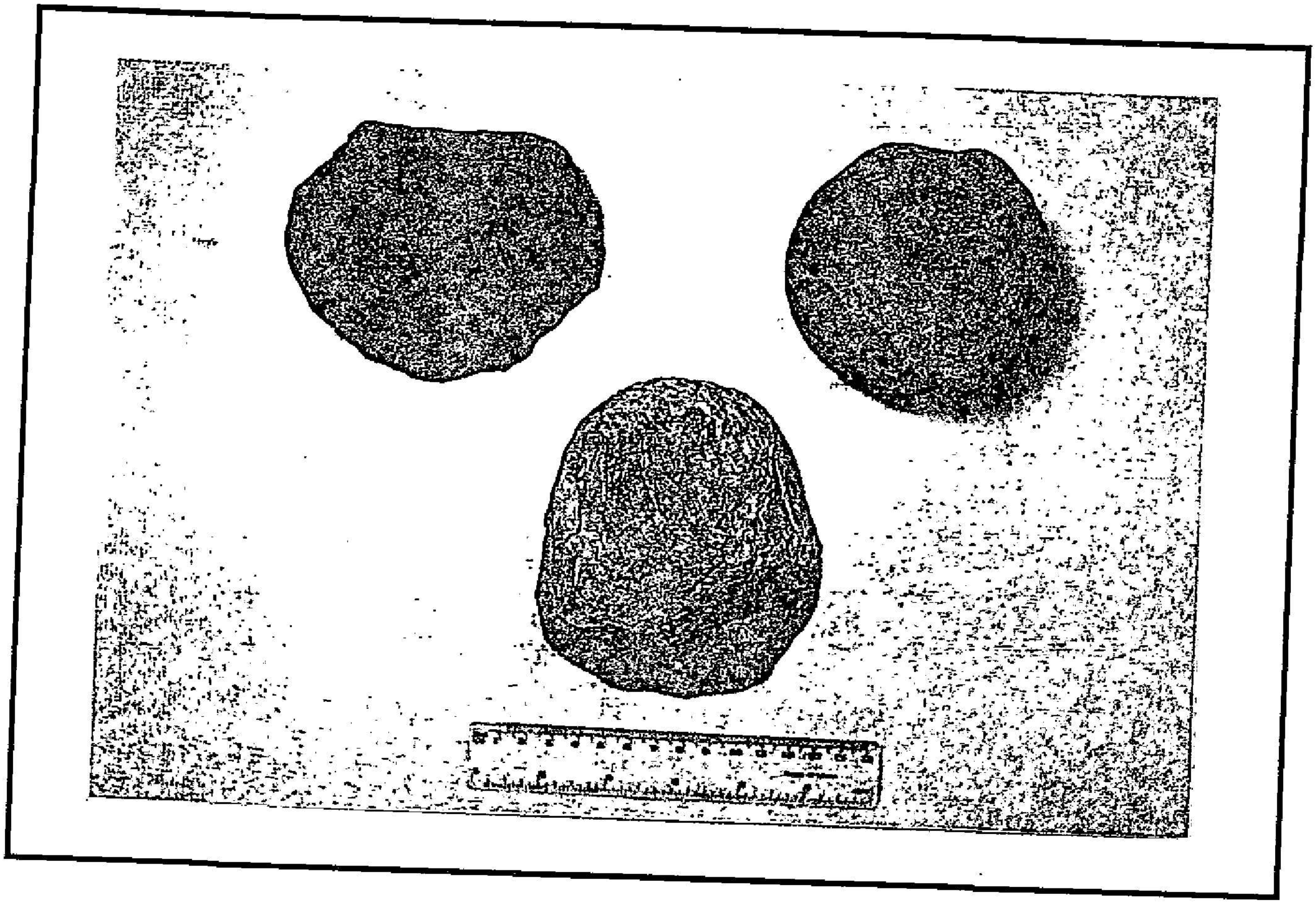

PHOTO 19: Hammerstones used *in* fine reduction at *quarry sites.* Hammerstones of this weight were used for fine reduction of lithic material at quarry sites in the Wallkill Valley. Top left: purple quartzite hammerstone. Top right: quartzite hammerstone. Lower: quartzite hammerstone. Note that the upper left and lower hammerstone are spalled and beginning to form "beaked" hammerstones. Upper right is still rounded, but spalls are obvious.

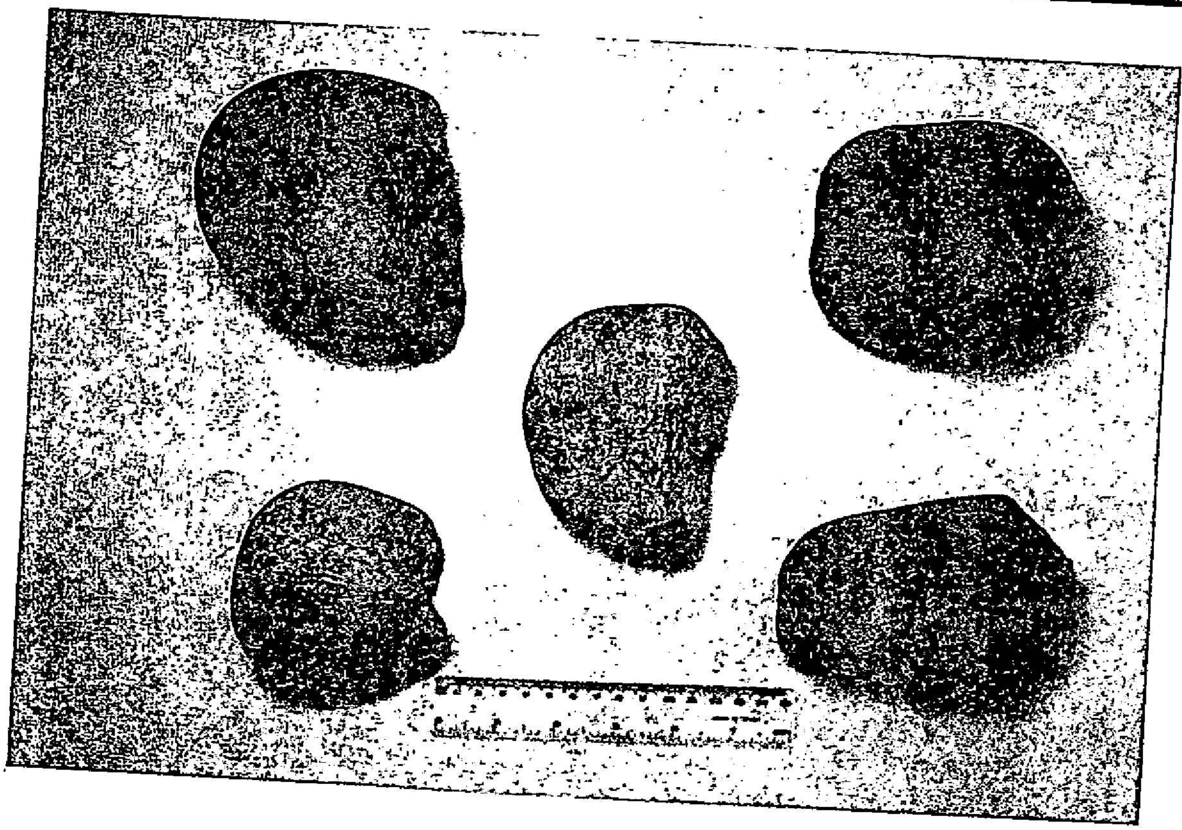

PHOTO 20: Hammerstones associated with reduction areas on quarry sites. Upper left: quartzite hammerstone (from Chapel Farm Estate reduction site). Upper right: purple quartzite hammerstone (from Wallkill Valley chert quarry). Middle: quartzite hammerstone (from Wallkill Valley chert quarry). Lower left: quartzite hammerstone (from Chapel Farm Estate reduction site). Lower right: purple quartzite hammerstone (from Wallkill Valley chert quarry). The wear patterns seen on these stones is typical, but some hammerstones may appear virtually unused.

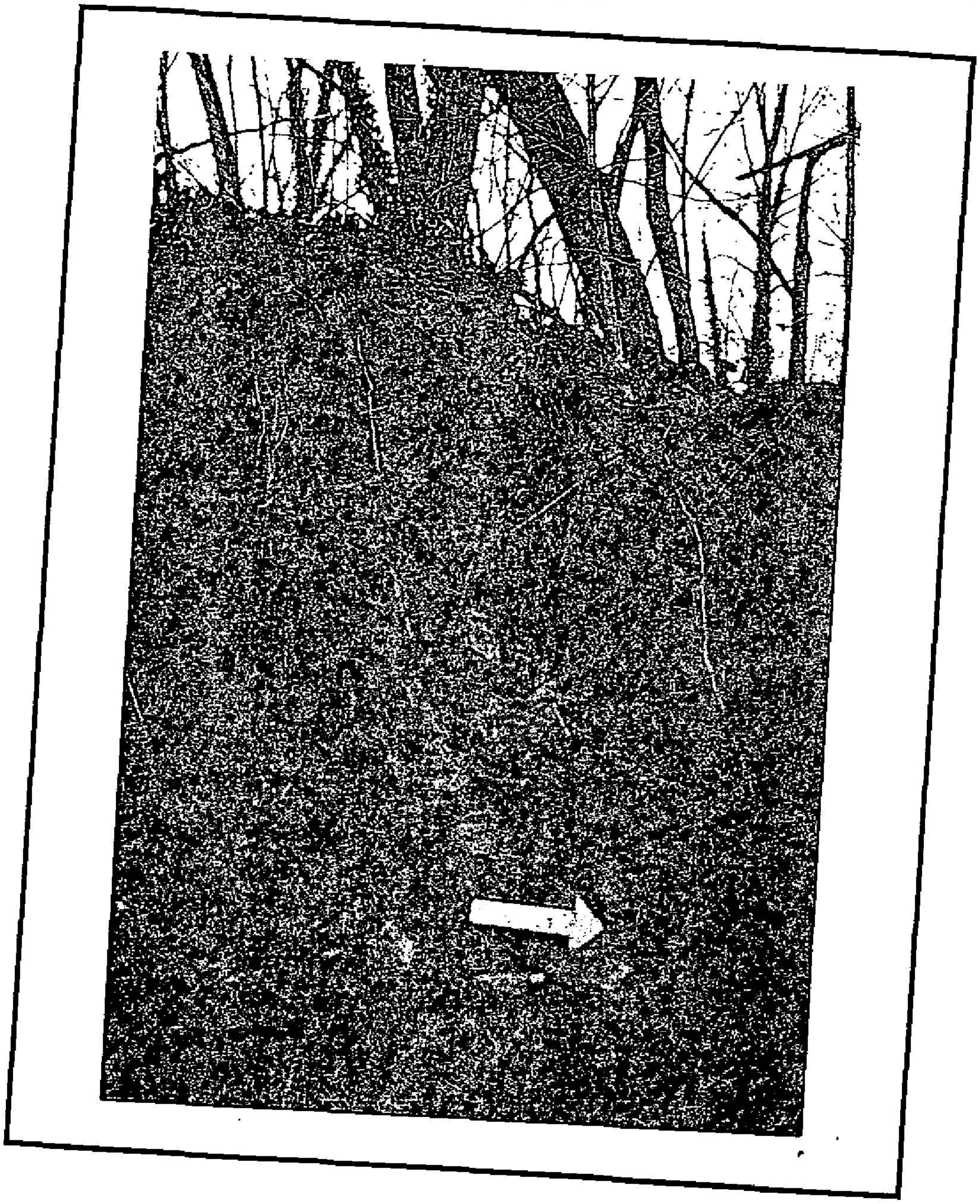

PHOTO 21: Pegmatite vein surrounded by country rock on Chapel Farm Estate site.

PHOTO 22: Micropegmatite vein in association with country rock on Chapel Farm Estate site.

PHOTO 23: To be supplied by Philip - tuckahoe road rock

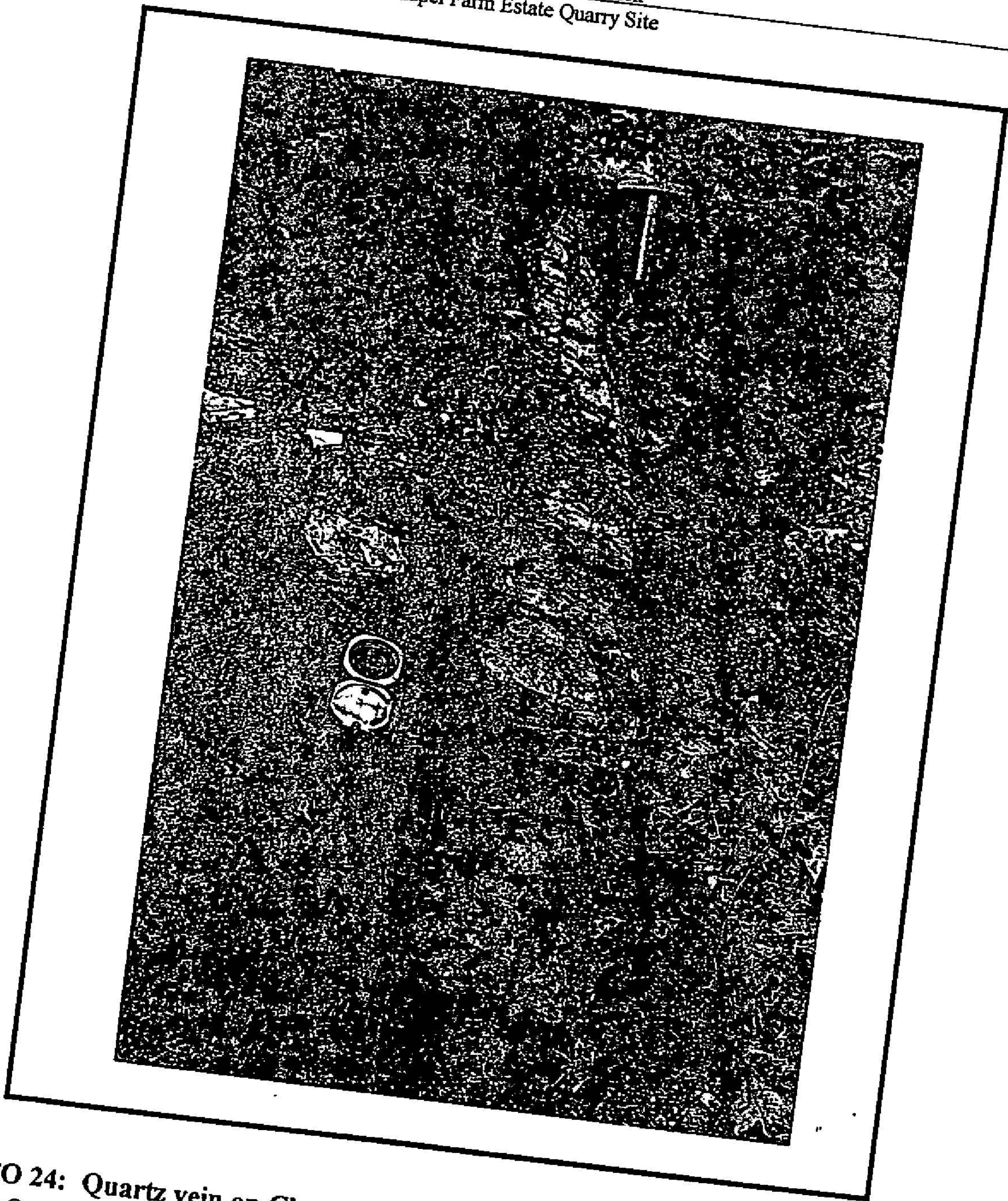

PHOTO 24: Quartz vein on Chapel farm Estate site. Located south of the mansion house. Quartz vein exhibits horizontal joints seen in other quartz veins on Chapel Farm Estate and the surrounding area. Note the hammerstone located at the bottom of the photo. Brunton indicates that the orientation of the vein is generally east-west. Hammer provided for scale.

APPENDIX C

STRATIGRAPHIC COLUMN FOR NEW YORK CITY AREA

Stratigraphic Column for New York City Area

Fordham and Yonkers Gneisses

The rock units that make up the Precambrian Yonkers Gneiss and Fordham Gneiss form a basement gneiss complex (Hall, 1966). Radiometric dating (Grauert and Hall, 1973) indicates that there is a significant age difference between the Yonkers and Fordham, but both are truncated by the unconformity at the base of the Paleozoic section, and are therefore older than the Lowerre Quartzite. The Yonkers Gneiss is a relatively homogeneous, commonly pinkish, biotite-hornblende-quartz-feldspar gneiss. The hornblende is typically the variety known as ferrohastingsite. The Fordham Gneiss has been subdivided into five rock units in the White Plains Quadrangle (Hall, 1966) and into five other rock units in the Glenville Quadrangle (Hall, 1968b). It has been subdivided into three units south of Peekskill, New York. Subdivisions of the Fordham Gneiss that have been mapped in the White Plains and Glenville Quadrangles are briefly described in the following lists. These subdivisions are not indicated individually on the geological map because of restrictions of scale. The spatial relations of the subdivisions allow a sequence to be established but the relative age of the units is unknown. The sequential relations of subdivisions in the White Plains Quadrangle with respect to those in the Glenville Quadrangle are unknown at this time.

Five subdivisions of the Fordham Gneiss in the White Plains Quadrangle

1. Fordham Gneiss Member A - This unit consists primarily of brown-weathering, garnet-biotite-quartz-feldspar gneiss, amphibolite and gray biotite-hornblende-quartz-feldspar gneiss.

2. Fordham Gneiss Member B - Gray garnet-biotite-quartz-feldspar gneiss, locally containing sillimanite and amphibolite, is the predominant rock.

3. Fordham Gneiss Member C - Gray biotite-hornblende-quartz-feldspar gneiss with pinkish or white quartz-feldspar layers and lenses constitute most of this unit. Also commonly present are amphibolite layers and pinkish biotite and/or hornblende-quartz-feldspar gneiss that is very similar to the Yonkers Gneiss and is locally extensive enough to be mapped separately.

*4. Fordham Gneiss Member D - Rusty-weathering, sulfidic sillimanite-garnet-biotite-quartz-feldspar schist or schistose gneiss with local interbeds of siliceous biotite gneiss or quartzite characterizes Member D. Calc-silicate and calcite-bearing granulite layers also are locally present.

5. Fordham Gneiss Member E - This is an interbedded assemblage of gray garnet-biotite-quartz-feldspar gneiss, brown to rusty- weathering biotite-quartz-feldspar gneiss and amphibolite. Gray biotite-quartz-feldspar augen gneiss at the base of Member E is abundant enough locally to be mapped separately.

Five other subdivisions of the Fordham Gneiss have been defined and mapped in the Glenville Quadrangle (Hall, 1968b), but have not yet been designated by any nomenclature. They are briefly described in spatial sequence as follows:

*1. Pinkish biotite and/or hornblende-quartz-feldspar gneiss, similar to the Yonkers Gneiss, is the most commonly exposed rock type in the first subdivision of the Fordham Gneiss in the Glenville Quadrangle. Dark gray biotite-hornblende-quartz-feldspar gneiss, commonly containing magnetite and/or ilmentite, is locally present with the pinkish gneiss in the Glenville Quadrangle.

2. Greenish-black, medium to coarse-grained, biotite amphibolite, constitutes nearly all of the second unit.

3. The third subdivision is characterized by light gray calc-silicate rocks that typically contain quartz, plagioclase, microcline and diopside. The abundance of calcite in these rocks is varied; some contain more than 50% calcite. Amphibolite is locally interbedded with the calc-silicate rocks.

4. Predominantly dark greenish-black amphibolite with some gray biotite-quartz-feldspar gneiss c bagel

5. Interbedded gray garnet-biotite-quartz-feldspar gneiss and amphibolite, whose outcrops commonly display a prominent layering, are the predominant rocks in this unit.

The Fordham and Yonkers Gneisses are interpreted to represent a metamorphosed Precambrian miogeosynclinal sequence that contains some intrusive rocks. The thickness of the sequence is not yet determined.

Lowerre Quartzite

The Fordham and Yonkers Gneisses are unconformably overlain by the Lowerre Quartzite (Hall, 1966), which is a discontinuous rock unit that consists of buff or tan-weathering quartzite, feldspathic quartzite and micaceous quartzite. It is typically well-bedded; bed thicknesses ranging from less than 2.5 cm to as much as 2 m.

The Lowerre Quartzite represents the beginning of deposition in this part of the Appalachian Geosyncline and is interpreted to be Cambrian. The maximum thickness of the Lowerre is 210 m, but it is more commonly 30 m thick and is absent in many places.

Inwood Marble

The Inwood Marble overlies the Lowerre Quartzite and is predominantly well-bedded dolomite marble with some calcite marble near the top. Recent work has subdivided the Inwood into four members based largely on composition, bedding characteristics and associated lithologies.

Manhattan Schist

Rocks traditionally mapped as Manhattan Schist have been divided into three members (Hall, 1968a). In terms of position in reference to the Fordham and Yonkers Gneisses, Member A is physically the lowest member of the Manhattan. Member A consists predominantly of dark gray to black, locally rusty-weathering, fissile schist. Tan-weathering, white or blue-gray calcite marble and phlogopitic calcite marble and dark gray calcite-bearing schist, are interbedded with pelitic schist near the base of Member A. The marble and calcite-bearing schist layers at the base of Member A have been interpreted by Prucha (1956), and more recently by Freedman and Kauffman (1971), to represent a gradational contact between the Inwood Marble and the Manhattan Schist.

Members B and C

A discontinuous amphibolite unit that occurs at and above the base of Member C of the Manhattan Schist has been mapped separately and designated as Member B of the Manhattan. Member B is interpreted as a metamorphosed mafic volcanic rock that probably originated as a lava flow. Member C of the Manhattan Schist is typified by feldspathic schist and schistose gneiss layers that weather brown, gray or rusty. Sillimanite is commonly present as nodules in many of these rocks. Kyanite is also present and commonly occurs with sillimanite. The rocks are well foliated, and bedding is difficult or impossible to identify except where thin amphibolite, siliceous schist or quartzite layers are present. Member C is a clastic deposit containing some volcanic material, represented by the thin amphibolite layers. Thus Members B and C are part of the eugeosynclinal sequence.

Hartland Formation and Harrison Gneiss

The Hartland Formation and Harrison Gneiss lie directly east of the study area and will not be discussed in this report.

APPENDIX D

GLOSSARY OF TERMS

Acadian:	a middle Paleozoic deformation, especially in the northern Appalachians. Its climax is dated as early in the late Devonian.
Alleghenian:	lower middle Pennsylvanian (310-280 million years ago) of eastern North America.
Allochthanous:	said of rocks or materials formed elsewhere than in there present place; of foreign origin.
Autochthanous:	formed or produced in place, where now found.
Amphibolite:	a rock consisting mainly of amphibole and plagioclase with little or no quartz.
Aplite:	a dike rock consisting essentially of quartz and alkali feldspar, with a fine grained, sugary texture.
Axial plane:	a planar surface that connects the hinge lines in the strata of a fold.
Boudin:	one of a series of sausage shaped segments occurring in boudinage structure.
Boudinage:	a structure common in strongly deformed sedimentary and metamorphic rocks, in which an original continuous, competent layer or bed between less competent layers has been stretched, thinned, and broken at regular intervals in bodies representing boudins.
Breccia:	a coarse grained clastic rock, composed of angular broken rock fragments held together by a mineral cement or a fine grained matrix.
Carbonate:	a mineral compound characterized by a fundamental anionic structure of CO3 -2. Calcite and aragonite, CaCO3, are examples of carbonates.
Clastic:	pertaining to a rock or sediment composed principally of fragments derived from pre-existing rocks or minerals and transported some distance from their places of origin, also said of a texture of such a rock.
Cleavage:	property or tendency of a rock to split along parallel, closely spaced planar surfaces. It is independent of bedding and is produced by deformation or metamorphism. .

Conjugate joint	a joint system in which the sets are related in deformational origin; also, said of the mineral deposits that may form in such joints. See definition of JOINT
Crenulation:	small-scale folding (wavelength up to a few millimeters) that is superimposed on larger scale folding. Crenulations may occur along cleavage planes of a deformed rock.
Dike:	a tabular body of igneous rock that cuts across the structure of adjacent rocks, or cuts massive rocks.
Ductile:	said of a rock that is able to sustain, under a given set of conditions, 5-10% deformation before fracturing or faulting.
Eugeosyncline:	a geosyncline in which volcanism is associated with clastic sedimentation.
Felsic:	applied to an igneous rock having abundant light colored mineral composed of aluminum and silica.
Foliation:	a planar arrangement of textural or structural features in any type of rock; especially the planar structure that results from flattening of the constituent grains of a metamorphic rock.
Formation:	a body of rock strata that consists dominantly of a certain lithologic type or combination of types. It is the fundamental rock unit. Formations may be combined into groups, or subdivided into members.
Geosyncline:	a large troughlike or basinlike downwarping of the earth's crust, in which a thick succession of sedimentary and volcanic rocks accumulated. A geosyncline may form in part of a tectonic cycle in which orogeny follows.
Gneiss:	a foliated rock formed by regional metamorphism, in which bands or lenticles of granular minerals alternate with bands or lenticles of minerals with flaky or elongated prismatic habit.
Granitization:	an essentially metamorphic process or group of processes by which a solid rock is bagel
Granoblastic:	pertaining to a type of texture in a non-schistose metamorphic rock in which recrystallization formed equidimensional crystals with normally well sutured boundaries.
Granulite:	a metamorphic rock consisting of even sized, interlocking mineral grains.
Hinge:	the locus of maximum curvature or bending in a folded surface usually a line.

Isoclinal fold:	a fold whose limbs are parallel.
Joint:	a surface of fracture or parting in a rock, without displacement.
Lithology:	the description of rocks, especially. in hand specimen and in outcrop, on the basis of such characteristics as color, mineralogic composition, grain size.
Lit-par-lit:	having the characteristic of a layered rock, the laminae of which have been penetrated by numerous thin parallel sheets and tongues of igneous material usually granitic.
Mafic:	said of an igneous rock composed chiefly of dark minerals containing iron, magnesium.
Metamorphic grade	the intensity of metamorphism, measured by the degree of difference between the parent rock and the metamorphic rock. It indicates in a general way the P-T environment or facies in which the metamorphism took place.
Metasomatism:	the process of practically simultaneous capillary solution and deposition by which a new mineral may grow in the body of an old mineral or mineral aggregate.
Miogeosyncline:	a geosyncline in which volcanism is not associated with sedimentation. See GEOSYNCLINE.
Mylonite:	a compact chertlike rock with a streaky or banded structure, produced by the extreme granulation and shearing of rocks that have
Pegmatite:	an exceptionally coarse grained igneous rock, with interlocking crystals, usually found as irregular dikes, lenses, or veins, especially the margins of batholiths. Most grains are one centimeter or more in diameter. The composition of pegmatites is generally that of granite.
Pelitic:	pertaining to or derived from pelite; especially said of a sedimentary rock composed of clay, or a metamorphic rock derived from a pelite.
Pitch:	the angle between the horizontal and any linear feature; an ore shoot or lineation, measured in the plane containing the linear feature.

Plunge:	the inclination of a fold axis or other linear feature, measured in the vertical plane. It is mainly used in the geometry of a folds
Porphyroblast:	a large crystal developed in a metamorphic rock by recrystallization.
Potash:	a term loosely used for potassium oxide, potassium hydroxide, or even for potassium for such informal expressions as potash feldspar or potash spar.
Saccharoidal:	having a granular texture resembling that loaf sugar; said of the texture of aplite.
Schist:	a strongly foliated crystalline rock, formed by metamorphism, that has well developed parallelism of more than 50% of the minerals present.
Shear Zone:	a tabular zone of rock that has been crushed and brecciated by many parallel fractures due to shear strain. Such an area is often mineralized by ore forming solutions.
Sillimanite grade:	rocks formed at the highest temperatures and pressures of a regionally metamorphosed sequence and is characteristic of the inner most zone of contact metamorphosed sediments.
Slickensides	lineations or striations that are often highly polished that occur along the interface of fault surfaces or zone of movement between rocks.
Slate:	a compact, fine grained metamorphic rock that possesses slaty cleavage, and hence can be split into slabs and thin plates. Most slate was formed from shale.
Strike:	the direction taken by a structural surface, e.g., a bedding or fault plane, as it intersects the horizontal.
Taconic:	an orogeny in the latter half of the Ordovician, named for the Taconic range in New York State.
Tension joint:	a joint that is the result of stresses that tend to pull the rock apart.
Thrust fault:	a fault with a dip of 45 degrees or less over much of its extent, on which the hanging wall appears to have moved upward relative to the footwall.

Unconformity:	a break or gap in the geologic record, such as an interruption in the normal sequence of deposition of sedimentary rocks, or a break between eroded metamorphic rocks and younger sedimentary strata. The structural relationship between two groups of rock that are not in normal succession; their surface of contact.
Vein:	a mineral filling of a fault or other fracture, in tabular sheet like form, often with associated replacement of the host rock