NEW YORK MINERALOGICAL CLUB

GEORGE F. KUNZ
COMPETITION PAPERS
1996

SIX ARTICLES ON NORTHEASTERN UNITED STATES MINERAL OCCURRENCES AND MINERALOGICAL HISTORY
GEORGE F. KUNZ
COMPETITION PAPERS
1996

George F. Kunz
(1856-1932)
Club Founder and First President

Featuring articles by
John H. Betts, Lawrence H. Conklin, John A. Jaszczak, Vandal T. King, Vernon L. Philips

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INTRODUCTION

George F. Kunz in 1932 bequeathed funds to establish the awarding of an annual prize for the best article on area mineralogy. For many years it was known simply as the Kunz Prize. At that time the club limited the competition to articles about mineral occurrences within 100 miles of New York City. Eventually, for reasons now forgotten, the competition was discontinued.

Beginning in 1996, the New York Mineralogical Club reinstated the George F. Kunz Competition with a first prize of $500 each year. The club also extended the regional coverage in recognition that now members are willing and able to travel farther to collect minerals. The competition is not limited to members of the club and is open to everyone.

Six papers were submitted to 1996 competition. All are presented in this publication.

1996 JUDGES

Vivien Gornitz, Research Scientist at the Goddard Institute of Space Studies, Columbia University

Peter Nalle, mining consultant, and former vice-president in charge of mining and exploration for St. Joe Lead Co., member of the Mineralogical Society of America since 1944.

Cap Beesley, founder and president of the American Gemological Laboratories

ACKNOWLEDGMENT

The New York Mineralogical Club wishes to thank the first prize winner, John Betts, for donating the award money back to the club to make possible the cost of production and distribution, to members of the club, of this publication.
THE QUARRIES AND MINERALS OF SOUTH GLASTONBURY, CONNECTICUT

John H. Betts, 215 West 98 Street, Apt. 2F, New York, New York, 10025

Mineral collectors are steadily losing their old collecting sites. Future collecting will, of necessity, be done, in new places or in forgotten, lost localities that are "re-discovered." One of the most promising forgotten locations is an area of old pegmatite quarries in South Glastonbury, Connecticut. This region was sporadically exploited by collectors over the years, but due to their proximity to other famous mines, poor quality mapping, confusing place names and undeveloped trails, it has not gotten the attention it deserves. This paper presents the results of extensive fieldwork, mapping and collecting in the region during the spring and summer of 1996.

LOCATION

The quarries discussed in this paper are the northernmost in the Middletown-Portland pegmatite district (figure 1). They are to be found in South Glastonbury, Connecticut, about 5 miles north-northeast of Portland, Connecticut, just east of Route 17. The area is roughly triangular in shape, is bounded by the Simpson Quarry on the south, the Hollister Quarry on the east, and the Howe No. 4 Quarry on the north. This zone includes one of the largest quarries of the entire Middletown-Portland quarrying district, the Howe No. 1. Access is through a trail system that follows old carriage roads, mine roads and pipeline rights-of-way.

QUARRY NAMES

There is definitive reference for the names of the quarries except four - the Hollister, Griswold, Simpson and Howe No. 1 were identified by Frederick Stugard, Jr. in The Pegmatite Quarries of Middletown, Ct. (1958). The rest were owned and operated by different people at various times and record keeping was poor. In researching the district it became clear that there are many contradictions regarding the individual quarry names.

Stugard (1958) investigated over 300 pegmatites in the adjacent areas, assigned numbers to them but only noteworthy locations were listed by name. Wiarda, Husband, Eureka, Howe No. 4 Quarries are names that have been used for quarries, but their exact locations are unclear. The Husband name has been particularly difficult because the Husband family either owned or worked many of the area quarries at one time or another, identifying the particular locations has been extremely difficult. This is also true regarding the Andrews and Howe families.
In this report, quarries and pegmatites have each been labeled. The numbers assigned by Stugard (1958) are used, when applicable, to assist in cross referencing. All other previously unidentified quarries are now assigned new numbers. They are designated in this paper with a "P" before the number (e.g., P51).

Figure 1 - Generalized geologic map, adapted from Cameron, et al (1954), showing Colton Hill formation (labeled as Bolton schist) and the active pegmatite quarries.
RESEARCH

During the spring and early summer of 1996 the author mapped the trails and quarry locations using an altimeter, a Global Positioning System (GPS) receiver and a bearing compass. This data was combined with current and out of print topographic maps as well as geological maps by Cameron (1954), Stugard (1958) and Altamura (1987). The result is a new map (figure 2). It incorporates quarry, abandoned trail, known pegmatite and other geologic information and combines them into a useable field guide to the area.

During the fieldwork, sample mineral specimens were collected from the surface of the quarry dumps. No digging or hard rock exploration was done. Considering the long time that these sites were available to collectors it was assumed that the dumps had been picked over. However all locations showed significant potential for mineral collecting.

The Peabody Museum of Natural History at Yale University was helpful by providing information on relevant mineral occurrences and photographs.

HISTORY

Starting around 1825 many pegmatites were opened and quarried for feldspar in Connecticut. Only top grades of feldspar were exported to England for processing. Not until 1850 was a grinding mill established in the United States at the Toll Gate Mine in Middletown, Connecticut. The first Howe quarry opened in 1866 and produced 200,000 tons of feldspar between 1866 to 1899. Many quarries were operated during World War II for sheet mica and beryl. From 1942 to 1945 Connecticut produced 60,000 pounds of sheet mica and 26 tons of beryl. Of this, 87% came from the Middletown area. (Bannerman et al, 1968)

Presently there is no quarrying being done in the area. Dumps have been excavated at the Howe No. 1 Quarry for use as crushed stone. David Chapman, of Portland, Connecticut, grandson of George Andrews, currently owns the Simpson and Howe No. 1 quarries. Although he is not concerned with minerals, he is interested in the history of the area. He can be contacted for more information.

GEOLOGY

All of the quarries discussed in this paper, except the Hollister, are located in the Colton Hill Formation, formerly called the Bolton schist. This formation is bounded on the east by the Glastonbury granite gneiss and on the west by mafic gneiss. The Colton Hill Formation is a coarse-grained metasedimentary formation with complex folding that outcrops in a narrow band extending from Portland through Bolton. Largely made up of biotite schist, it is sparingly interlayered with micaceous quartzite and amphibole gneiss. The eastern border of the Colton Hill Formation is a schistose facies of the Glastonbury granite gneiss (average grain size of 1 mm), indistinguishable from the Colton Hill Formation except for the presence of euhedral epidote.
Figure 2
Location Map
to
South Glastonbury, Connecticut
Pegmatite Mines
Scale 1:6000
Researched and mapped by John Bums
June, 1996
All rights reserved

KEY
ROAD
PARK AMENITIES
SEDIMENTARY CONTACT
RIVER
SMALL SHOAL
WATER
OLD QUARRY LOCATIONS
X PQ - VERIFIED QUARRY
In this area pegmatites are typically found as western exposures of elevated hills because their hardness makes them most resistant to weathering. These pegmatites formed sill shaped bodies following the foliation of the surrounding schist. The age of the nearby Hale, Andrews and Spinelli pegmatites was determined to range in age from 260 to 300 million years old.

The origin of the pegmatites is undetermined. Cameron and others (1954) concluded that they are linked to the Glastonbury granite gneiss (that they called Monson gneiss). Stugard (1958) disagreed, observing that the age of Monson gneiss was 370 million years old and the younger pegmatites could not be of same origin. Instead, he proposed that the pegmatite formed from a magma-like fluid, by a process of fractional crystallization.

Most of the area pegmatites are predominantly composed of perthite, quartz, plagioclase, and muscovite. Schooner (1961) reported 114 minerals in his reference on the area mineralogy. Beryl and tourmaline are widespread accessory minerals but account for less than 1 percent by volume. The random distribution of beryl-bearing pegmatites led Stugard (1958) to conclude that beryl was common throughout all of the area pegmatites, but was not reported because of insufficient visible exposure.

**QUARRY DESCRIPTIONS**

In order to visit the quarries along the pipeline right-of-way, start at parking location A (figure 2) at the intersection of Dayton Road and the pipeline. Then proceed southwest on the trail along the pipeline (see appendix for trail log).

**Husband Quarries (P59)**

The first quarry visible on the left is pegmatite P59. This location is generally accepted to be the Husband Quarry. Although, as mentioned earlier, there is a great deal of confusion regarding this name. (As a result the reports of mineral occurrences from the Husband Quarry cannot be attributed to an exact location.)

There are two cuts in the exposed pegmatite, one on the side nearest the pipeline and another on the far side of the hill. Much of the dump rock visible nearest the pipeline appears to be from pipeline excavations rather than from pegmatite mining.

There have been reports of good quality bismutite, molybdenite and torbernite from these locations. (Schooner, 1996) Also, the excavations for the pipeline produced a well known, one-time find, of three inch long euhedral epidote crystals associated with titanite and scapolite, in a cross-cutting quartz vein.

**Pegmatite P1**

Further west on the trail, the next prospect encountered is on a small knoll to the right of the trail. This prospect was mapped as far back as 1958 but very little excavation work is evident as compared to the surrounding quarries. The P1 prospect is at the south end of a large pegmatite
that continues north-northeast and intersects Dayton Road. Beryl crystals, up to 4 inches in diameter, are visible at several places in the wall rock (figure 3). Recent field collecting has yielded sharp, pale blue-green beryl crystals in albite matrix. Considering the proximity of this location to the trail, and how little it has been exploited, it deserves closer attention by mineral collectors.

Pegmatites P2-4, P50

When the pipeline trail begins a sharp descent, another trail intersects the pipeline that runs north-south. North along this trail (see appendix) there are four large quarries in a single pegmatite. Stugard (1958) designated this pegmatite, which extends north-northeast for 100 yards, pegmatite 50. He identified one
of these quarries is the Howe No. 4 but it is uncertain which one. The northernmost quarry pit is closest, on the Stugard map, to the site he designated P50, so that number has been used in this paper. The other quarries (from south to north) are assigned numbers P2, P3 and P4.

The size of the quarrying operations here were quite extensive. The quarries are visible east of the trail and large dumps can be seen to the west and downhill. Ninety yards north of the pipeline a large stone retaining wall is visible (figure 4). It separates dumps P2 and P3. Very little collecting has been done here.

Pegmatite P5

South of the pipeline, along the same north-south intersecting trail, (see appendix) a long cut has been made at P5. It extends from the trail north-northeast for 160 feet almost intersecting the pipeline clearing. The dumps are visible to the right of the trail. Little collecting has been done at this location in recent times.

Howe No. 1 Quarry (P73)

The Howe No. 1 Quarry, designated by Stugard (1958) as pegmatite 73, is one of the three largest quarries in the entire Middletown-Portland district. It is 200 yards south of P5 through the woods. The dumps are clearly visible through the surrounding foliage.

History

The quarry was originally opened by George Andrews. The northern part of the quarry was sold around 1880 to Joshua and William P. Husband (note unique spelling, Grant 1995) and at that time the southern part was leased to Charles Hall. Quarrying occurred in both the northern and southern sections, but it was noted that the southern zone contained higher quality feldspar. In 1905 Louis Howe acquired the entire property, including a spar mill and he produced 65-70,000 tons of feldspar between 1906 and 1928. The feldspar

Figure 5 - View looking northeast into the water filled Howe No. 1 Quarry.
was hand-separated to eliminate sodium feldspar, quartz and all visible fragments of muscovite, beryl, and tourmaline. One-fourth of the quarried rock was recovered as salable feldspar. The quarry has been inactive since 1928. At that time ground water flowed in at 300 gallons per minute and pumping costs made the operation unprofitable. In recent times, Vespa Stone Products, had been excavating the dumps (figure 6) and selling it as crushed stone. The high muscovite content made it unacceptable for construction and excavation has ceased.

The Howe No. 1 open cut is an enormous excavation when compared to most Connecticut quarries. The water filled pit is 100 feet wide and 800 feet long (figures 5 & 6). The quarry employed 30-60 men operating steam drills and 15-25 men in the grinding mill. Production peaked in 1907 at 8,300 tons. The feldspar was ground on-site to 60 or 80 mesh and then shipped for use in manufacturing bathroom fixtures and porcelain insulators. Some 200 mesh feldspar was also sold for use as scrubbing compounds such as Bon Ami. David Chapman, of Portland, Connecticut, grandson of George Andrews, currently owns the Howe No. 1 Quarry.

Minerals

Yellow-green beryl crystals, as large as six inches in diameter, were reported by the workers. These were all sent to the mine dumps. Mineral collectors found many beryl crystals here in 1996, the largest of which is 5 inches long and 2-1/2 inches in diameter.
Rare minerals can be found here too. Columbite-tantalite in masses and crystals up to ½ inch and grass-green torbernite as flakes on surfaces between pegmatite minerals, are known. The diverse mineralogy, newly exposed dumps and the size of the dumps at the Howe No. 1 Quarry make this location especially attractive for mineral collecting in the future.

Hollister Quarry (P69)

The Hollister Quarry (Stugard pegmatite 69) is reached by starting at parking location B (figure 2). An abandoned mine road extends south to the quarry. The northern open-cut and dumps are about 15 yards into the woods east of the trail (figure 7). The southern excavation is 400 yards beyond, on the west side of the trail.

Cameron (1954) reports the quarry was worked briefly for feldspar around 1930. The site was worked for several months during World War II (1943) for feldspar and muscovite mica by a gentleman called Fausto Bertolini. The property was mapped by Cameron and Shannin at this time (figure 7). The former workings consist of seven small excavations in three visible pegmatite exposures that strike due north. The three exposures, as mapped by Cameron (1943), may be connected at depth.

North Pegmatite

The north pegmatite is exposed for 240 by 25 feet and dips steeply eastward. This pegmatite is roughly parallel to the strike of the wall rock foliation but differs markedly in dip. The quarry excavation is 65 feet long, 20 feet wide and 15 feet at maximum depth.

Figure 7 - Map of the Hollister Quarry, north and south pegmatites from Cameron et al (1954).
This pit is currently filled with water making inspection or collecting difficult.

Most of the pegmatite consists of quartz, perthite, graphic granite, plagioclase in various proportions, with accessory muscovite, spessartine, elbaite, schorl, beryl and columbite-tantalite. During mining, muscovite books were found ranging in size up to 12 inches in diameter by 4 inches thick. The muscovite shows a grating-type stain, probably due to magnetite.

Casual inspection of the north dump showed obvious mineralization of interest to collectors (figure 8). Beryl, associated with quartz and plagioclase, was found scattered throughout this pegmatite in blue-green to green to yellow-green crystals, mostly less than one inch long. However, crystals as large as 2 inches diameter by 4 inches long have been found here in the past. Cameron (1954) measured the exposed surface area of 80 beryl crystals exposed over 142.9 square feet and estimated the beryl content in the headwall of the open pit to be 0.09 percent. Some of the best crystals of microlite found in this area occur at the Hollister, up to ½ inch diameter (figure 11).

The north quarry is presently part of the property that overlooks the site to the west.

**South Pegmatite**

The south pegmatite is exposed for 160 feet and varies in width between 4 and 9 feet. Quarrying occurred on the eastern flank of the pegmatite which resulted in an 80 foot long cut (figure 9). The pegmatite consists of smoky quartz, perthite, massive plagioclase, cleavlandite, garnet, beryl and traces of lepidolite and columbite-tantalite. Beryl crystals as large as 2 inches diameter by 5 inches long has been found associated with quartz and cleavlandite and is unevenly distributed throughout the pegmatite. Measurement of the exposed beryl indicates 0.11 percent content. Noteworthy minerals include elbaite, cassiterite, manganapatite, gahnite, samarskite-y, spessartine, and gemmy blue-green beryl. The Hollister Quarry has received more attention from collectors than nearby locations. It is unclear if this was because it has better mineralization or it was a published locality and access was permitted.

The present owner of the south quarry is unknown to the author.
Simpson Quarry (P80)

The southernmost quarry in the region, the Simpson Quarry (Stugard pegmatite 80), is accessed from parking location C (figure 2). There is a trail extending north from the road. This is the old East Road and it runs north from the intersection of Isinglass Hill Road and Thompson Hill Road and continues past the Simpson quarry to Dayton Road. At the point where the trail breaks to the right, a foot long pegmatite rock has been placed as a trail marker. As of June 1996 there were orange trail markers from this point on tree limbs marking a rough path to the Simpson Quarry. The markers were placed there by Ed Force of the Bristol Mineral Club for use by members on their field trips. Even with the trail markers it is rough bushwhacking along a bearing of 280° to get to the overgrown quarry dumps.

The quarries are two adjacent cuts in a pegmatite running approximately 20° north with large dumps to the east. There are other small prospects to the northwest in the woods, but collectors do best by digging in the dumps. Top quality aquamarine beryl has been found here by collectors in the past. Opaque blue-green beryl crystals up to 4 inches diameter can be found in the quarry walls. Uraninite has been reported from this quarry, unique for the area. A word of caution—snakes have been reported deep in the dumps by collectors digging during wintertime (R. Sinclair, 1996).

David Chapman, of Portland, Connecticut currently owns the Simpson Quarry.
MINERALS

Many minerals have been found in the area covered by this paper. Specimens dating back to 1905 collected by Samuel L. Penfield (1856-1906) and Hurlburt are in the collection of the Peabody Museum of Natural History at Yale University.

Table 1 - The following table lists mineral occurrences at each quarry:

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In addition, common metamorphic minerals (hornblende, staurolite, almandine, etc.) can be found in the surrounding Colton Hill Formation.
Figure 10 - Columbite, South Glastonbury, Connecticut. Collected by Hurlburt, 1906. Peabody Museum of Natural History, Yale University Specimen 1784-3.

Figure 11 - Microlite, Hollister Quarry, South Glastonbury, Connecticut. Collected by Richard Schooner and Peter Leavens. Peabody Museum of Natural History, Yale University.

Figure 12 - Monazite, South Glastonbury, Connecticut. Collected by Hurlburt, 1906. Peabody Museum of Natural History, Yale University Specimen 1911-111.

Figure 13 - Opal, Hollister Quarry, South Glastonbury, Connecticut. Collected by Richard Schooner and Peter Leavens. Peabody Museum of Natural History, Yale University.

Figure 14 - Tberberite, South Glastonbury, Connecticut. Collected by S. L. Penfield, 1903. Peabody Museum of Natural History, Yale University Specimen No. 3246-3.
CONCLUSION

This paper has described 13 quarries and accurately mapped them to assist collectors in gaining access to them. A question remains: Why has so little attention been paid to these locations by collectors over the years? Were they neglected because few collectible specimens were found? Or did nearby locations such as the Strickland Quarry or the Walden Gem Mine completely overshadow them? The author is reminded of the recent rediscovery of world-class uraninite crystals from the Swamp #1 Quarry in Topsham, Maine. For 50 years the quarry was ignored by collectors. It was merely one of dozens of feldspar pits in the area that were outshone by famous sites such as the nearby Fisher Quarry. The lack of available collecting sites led eventually to the re-evaluation of this long-abandoned quarry.

It is hoped that by informing collectors about the quarries in the South Glastonbury district, their full potential will be realized.

FUTURE COLLECTING

Whereas these quarries are located on unused land, collectors must make every effort to contact the landowner and get permission prior to entering the property. This paper cannot, in any way, grant collecting rights to the reader. If we all practice responsible collecting, these sites will always be accessible.

ACKNOWLEDGMENTS

Although the main focus of this paper is on the fieldwork and mapping of these long inactive quarries, the author gratefully acknowledges the assistance of several people. Ellen Faller, Collection Curator of the Mineralogy Division of the Peabody Museum of Natural History at Yale University, cheerfully arranged the photography of the specimens in their collection. Richard Schooner, Ed Force, Rick Sinclair, Anthony Albini helped decipher the names and misnomers of the quarries and added to the mineral lists. A special thank you to Lawrence H. Conklin, friend and fellow Kunz-Prize competitor, who edited this article after the judging was completed and greatly improved its readability. Thank you all for your kind assistance.

REFERENCES


APPENDIX

Trail Log From Parking Location A

Hiking west along pipeline:
45 yards, heading 240°.
50 yards, heading 220°, Husband Quarry ahead on the left in the trees.
80 yards, heading 200°, Husband Quarry dump on the left.
70 yards, heading 200°, green paint marker on rock in trail.
100 yards, heading 220°, low swampy area.
30 yards, heading 220°.
20 yards, heading 240°, fallen tree crossing trail.
50 yards, heading 220°, high point on trail.
60 yards, heading 260°, pegmatite P1 on right up hill.
20 yards, heading 280°, top of hill.
35 yards, heading 270°, cut at pegmatite P5 is visible on left through brush.
75 yards, heading 270°, green paint marker on rock in trail(point s). Straight ahead leads down hill to cul-de-sac at end of Raymond Road. Turn right to Howe No. 4 and pegmatites P2, P3, P4. Turn left to P5 and Howe No. 1.
Right Turn (North) From * (to Howe No. 4 Quarry)
40 yards, heading 0°, pegmatite P2 on right, dumps on left.
50 yards, heading generally 0°, wall on left retaining dumps.
50 yards around to right, pegmatite P3 ahead on right, dumps down hill on left.
80 yards, heading 0°, pegmatite P4 up hill on right, dumps on left.
40 yards, heading 20°, pegmatite P50 (Howe No. 4 Quarry?) on right.
Left Turn (South) From * (to Howe No. 1 Quarry)
38 yards around curve to left.
29 yards to trail entering from right (continue straight).
65 yards, heading 190°.
45 yards around curve to left, dumps visible on right, pegmatite P5 on left.
75 yards around to right passing washed out trail on left.
30 yards, heading 180°, to T intersection with trail. Turn right.
25 yards, heading 240°.
30 yards, heading 210°, old foundation (old crushing mill?) on left. Large dumps of Howe No. 1 Quarry visible through woods on left. Bushwhack through woods to quarry.

Trail Log From Parking Location B to Hollister Quarry
60 yards, heading 80°.
65 yards, heading 120°, swamp area.
65 yards, heading 120°.
20 yards, around curve to right.
20 yards, heading 175°, small dump on left. Hollister Quarry north pit is visible ahead on left in woods on heading 120°.
15 yards, around curve to left.
40 yards, heading 160°, Hollister Quarry up hill on left (pegmatite P69).
70 yards, heading 160°, south end of dumps on left.
60 yards around S curve, Hollister Quarry south pit is straight ahead on right of trail.

Trail Log From Parking Location C to Simpson Quarry
65 yards, heading generally 0° around curve to left, log across trail.
76 yards, heading 340°, stone wall perpendicular to trail on left.
50 yards, heading 340°.
13 yards, around S curve.
46 yards, heading 335° (trail breaks right heading 30° and will eventually end at Dayton Road) pegmatite stone trail marker on right. From this location the Simpson Quarry is through the woods heading 280°. There may be orange trail markers attached to trees.
The following article won second place in the New York Mineralogical Club 1996 George F. Kunz Competition.

KINGSBRIDGE, AN EARLY QUARRYING DISTRICT ON MANHATTAN ISLAND

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Cambrian/Ordovician marble beds comprise much of the northern end of Manhattan Island. Surface exposures of this rock were exploited by the earliest settlers there in the second half of the 17th century and commercial quarries were in operation by the late 18th century. The area yielded mineral specimens before the year 1809 and was recorded in print as an American mineral locality in 1812. Quarrying ceased in the 1840's, but in its day the Kingsbridge area was familiar to mineralogists and collectors as a source of well-crystallized diopside, pyrite, pyrrhotite, rutile, titanite, tourmaline and other minerals.

Figure 1 - Location map of area covered in this article.
INTRODUCTION

My interest in Kingsbridge was revived (I collected mineral specimens there as a boy in the 1940’s) during a visit, in 1994, to The Old Print Shop in New York City, where I purchased a quaint little drawing entitled Marble Quarry, "Kingsbridge," N.Y. in 1819 (Figure 2). Collecting these old glimpses of New York City the way it once was is one of my special interests; another is the history of early American mineral collecting. The drawing was done with brush and ink and is of the school of Archibald Robertson (1765-1835). Robertson opened the Columbia Academy of Painting on Liberty St. in New York City in 1792 and this is likely the work of a student. The Old Print Shop had other examples done in the same style, some by other hands, showing various views in the city. The acquisition of the drawing spurred me to explore the printed record to find out what could be learned about marble and mineral specimen production at Kingsbridge, and especially about the quarry and the house depicted in the sketch.

Figure 2: "Marble Quarry, Kingsbridge, N.Y. in 1819." A contemporary brush-and-ink rendering. The house, built around 1810, was owned in 1819 by the Bolton family and their quarry shown at the left foreground was then in full operation. The view is from the north-east. Collection of the author.
HISTORY

Whereas a few locations in early New York City are recorded as quarrying sites for building stone or road metal in the Manhattan schist (which, in earlier times, was called granite), no area was as extensively exploited for quarried stone as were the marble ridges near Kingsbridge, at the island’s northern tip. At least one large mansion was constructed entirely of this rock around the year 1845 and there may well have been others. Also produced were numerous tombstones, many still visible in several places on the island, funereal monuments, burial vaults and so on. Lime for mortar cement and plaster, always an important commodity, was produced by several kilns in the district.

This area was the first place recorded in the literature as a distinct Manhattan Island mineral specimen locality. Indeed, Kingsbridge is listed as one of only two specific Manhattan localities in James Dwight Dana’s (1850) Catalogue of American Localities of Minerals. The Kingsbridge location was published as a source of specimens in the year 1812 and was a mineral collecting site before 1809.

The marble industry was, apparently, well established in Kingsbridge by the end of the 18th century and it can be safely assumed that mineral specimen collecting there was not far behind or, perhaps, even preceded the formal quarrying.

Significant private mineral collections were being assembled in the city at this time, by purchase and by field-collecting. Around 1786, Samuel L. Mitchell, M.D. (1764-1831) brought to New York City, from Edinburgh, one of the earliest mineral collections to come to America. Dr. David Hosack (1769-1835) owned a large collection of minerals which he opened to public viewing at his famous “Elgin Garden,” established around 1804, at what is now Rockefeller Center near Fifth Avenue and 50th Street. However, the most important local devotee of minerals during this period was Manhattan-born, Archibald Bruce, M.D. (1777-1818). His publication The American Mineralogical Journal (New York, 1810-1814), had a strong, positive influence on the science of mineralogy and mineral collecting. Bruce built a very large collection during his short life-span.

Jacobus Dyckman’s ancestors settled in New Haerlem (an ancient village that existed for a time on northern Manhattan) around 1660. He added to his already large holdings of land there by purchasing, in the 1790’s (according to H. D. Romer and H. B. Hartman in Jan Dyckman and his Descendants, New York, 1981), “certain acreage to the north, including Marble Hill—a profitable marble quarry.” The name “Marble Hill,” however, is modern and was invented by a real-estate developer in the year 1891; but, on a map drawn for The American Scenic and

1“Blackwell’s island [in the East River, known for many years as Welfare Island and called today Roosevelt Island] near Ferry gate, is a mass of rock, similar to that part of [New] York island opposite. A considerable part of the building stone used in the city is brought from the quarries in the granite of this [167 acres] island.” (Akerly, 1814, but written before 1808.) A former stable, now the headquarters of the Colonial Dames of America, constructed entirely of this rock in the year 1799, is a unique survival on Manhattan or “York island” near the East River at 61st Street. It is reasonable to assume that the building material for this structure was transported from the Blackwell’s Island quarries directly across the river.
Historical Preservation Society by Reginald Pelham Bolton in 1906, that appears in Riverdale, Kingsbridge, Spuyten Duyvil, New York by William A. Tieck (1968), Bolton indicates a fairly large former marble quarry on Marble Hill. According to the mapmaker it existed on land that was once owned by Jacobus Dyckman. Incidentally, a founding member and one-time president of The American Scenic and Historical Preservation Society was George Frederick Kunz (1856-1932). Kunz was a gemologist and mineralogist with Tiffany & Co. and the pink variety of the mineral spodumene was named kunzite in his honor. As the founder and longtime president of The New York Mineralogical Club, Kunz organized and led many Club outings to the Kingsbridge area in order to collect mineral specimens from the marble there. (Figure 13).

Proof that marble from this area was being produced during the first quarter of the 18th century survives as a headstone in Trinity churchyard, on lower Broadway at Wall Street, with the date 1723 still visible upon it. Other Kingsbridge area marble headstones in the same churchyard are dated 1777, 1795 and 1796 and there are many others perhaps older, judging by

Figure 3 - "Residence of Isaac Dyckman. Kingsbridge, N.Y. 1861" from Valentine, (1861). The house from Figure 2 is shown here 42 years later and from the south-west. Collection of the author.
their weathered appearance, whose dates and inscriptions have been entirely obliterated by time and the elements. By contrast, nearby headstones of the same period, made of sandstone (called brownstone) quarried in the Connecticut River valley, are holding up much better.

Remains of even earlier Kingsbridge marble gravestones can be seen today in the Jews’ Burying Ground in lower Manhattan near present-day Chatham Square. This is the earliest cemetery established on the island and it is likely that it originated in the year 1652 with a grant of land by Peter Stuyvesant’s Council. Some of the gravestones almost certainly date from the 17th century but their inscriptions are long gone. In fact, some stones are so severely weathered that they have shrunk to less than half their original size and look much like melting ice cream pops. Considering their date it is likely that these stones were obtained from surface excavations, but early quarrying cannot be ruled out.

By the year 1808, production of marble had become quite extensive, as shown by a statement made by John Randel, Jr. in his narrative “City of New York, north of Canal Street in 1808 to 1821” (Randel, 1864). “From 213th to 217th street the road [called at the time the Kingsbridge road and now known as Broadway] passed along the foot of the eastern slope of marble quarries.” This places additional marble quarries in Kingsbridge, in the year 1808, on the lands of the Dyckman

Figure 4 - "Kingsbridge Ship Canal thru [sic] Limestone N.Y. City." From an old glass lantern-slide taken by Gilman S. Stanton circa 1893. An historic photograph taken during the excavation for the canal. The old house is barely visible at top-center. What may be the remains of one end of the former quarry, now filled with water, can be seen at the far right. Courtesy of Richard Hauck and the Richard Hauck Archives.
family and elsewhere. The Dyckmans at one time owned the largest single tract of land in the history of Manhattan and were honored by the naming of present-day Dyckman Street, an important east-west thoroughfare that traverses their former lands. Jacobus Dyckman lends his name to today’s Jacobus Place on Marble Hill.

John Randel, Jr., (ca. 1780-1865), a surveyor, was responsible for the field work that resulted in the historic “Commissioners Map.” This map, published in 1811 and almost eight feet in length, laid out the current grid pattern of Manhattan’s streets. The commissioners, three gentlemen of the City, had been charged by the New York State Legislature “to lay out streets, roads and public squares” in rural Manhattan (mostly north of 14th Street) and this they did, virtually ignoring the natural topography of the island. Their map is generally considered to be the most influential in the history of the development of the city.

Randel, who wrote his narrative in 1864, was but one year from his death at the time, and recollections of observations he made almost 60 years previous must, therefore, be read with some caution. It should be remembered that the streets he mentioned did not yet exist in the year 1808 and he may well have also seen, but did not record, the quarry on Marble Hill claimed by Romer and Hartman (1981) and also by Bolton in Tieck (1968).

Figure 5 - A still later depiction of the old house called, by this time, “The Old Homestead Boarding House,” viewed from the south. The former quarry site lies in the bed of the present Harlem River. Photograph from the New York Herald around 1903. Collection of the author.
The identification of the house in the sketch (Figure 2) allows the exact site of the depicted quarry to be determined. It was built around 1810 and was pleasantly situated on the southern slope of Marble Hill, 350 feet west of present-day Broadway, approximately 200 feet from, and looking down on, two small tidal creeks. It was probably built by members of the Tison or Post families who were heirs of Jan Nagel, a settler there in the year 1677. According to Reginald Pelham Bolton, in his *Washington Heights, Manhattan, Its Eventful Past* (1924), the house was purchased in 1816 by his ancestors Curtis and John Bolton who were "the pioneers in the marble industry, and alongside the High [Albany Post] Road, opposite [350 feet southeast of] their dwelling, they opened a marble quarry."

It is likely that the quarry already existed in 1816 and that the Boltons expanded the operation by, among other things, exploiting the creeks that ran between the house and the quarry as a source of power for sawing the blocks of stone. For many years this waterway was known as the Bolton Canal and then later, the Dyckman Canal until its obliteration by the Harlem Ship Canal in the 1890's. Tieck (1968) states that although the Boltons left in 1824, marble production continued in the area for some time under the auspices of the Lambert family.

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7 The land records, which are still preserved, show that the Posts sold the property to George W. Hall and John C. Bolton in 1816 and that two years later George Washington Hall transferred his interest in the property to his partner John Curtis Bolton. It is therefore probable that "Curtis and John Bolton" were unwittingly created out of John Curtis Bolton.
Dyckmans purchased this "old yellow house" and moved into it in 1850, but by that time the quarrying of marble had ceased. The house was, according to a description in Tieck (1968), of central-hall type, of good size, 40 x 25 feet, with the hall measuring about ten feet in width.

Figure 3 shows the Tison/Post-Bolton-Dyckman house, and surroundings, as it appeared in 1861 when it was owned by Isaac Dyckman. (Incidentally, this view from Valentine (1861) is reproduced by Kouvenhoven (1953) but is incorrectly identified.) Whatever remained of the quarry by 1861 does not show in this view but outcroppings of marble are prominently depicted in the foreground. The Dyckmans moved out of the house by the end of the 1860's.

A view of the quarry site from Figure 2 (or what remained of it by the year 1893) was photographed during the building of the Harlem Ship Canal (Figure 4). What may be at least part of the quarry, reduced by this time to a water-filled hole, can be seen at the extreme right in the photograph. The canal, in this vicinity, followed the path of the old tidal creeks that had been exploited by the Boltons almost a century earlier, and probably even earlier by their predecessors.
When the United States Ship Canal⁵ (now designated the Harlem River) was completed in 1895 the remains of the old quarry were obliterated by the water. The house, quite run-down by this time and fit only for use as a boarding-house, was left very close to the water’s edge (Figure 5). Ten years later the rerouting of the Hudson Railroad, along the bank of the canal, resulted in the destruction of the house but increased the exposure of the marble (Figure 6).

The construction of the Harlem Ship Canal cut off from Manhattan island a piece of land approximately 52 acres in size. That detached land, which includes some of the former acreage of the Tison/Post/Bolton/Dyckman families and the remains of other quarries on present-day Marble Hill, is still, politically, part of Manhattan although it is now physically attached only to the Borough of The Bronx. The original upper boundary of Manhattan island was an east-west creek that ran somewhat to the north of the northern slope of present-day Marble Hill and is now entirely filled in.

In a quaint work entitled Springs and Wells of Manhattan and the Bronx New York City at the End of the Nineteenth Century (1938), the author, James Reuel Smith, recorded his travels around upper Manhattan during the years 1898 to 1901, and documented, with photographs, the few surviving natural sources of fresh water. Smith was almost certainly describing an abandoned quarry in the marble, which by 1898 had become an ice pond, when he wrote—

The [Isaac Michael, not the previously mentioned Isaac, but his nephew] Dyckman ice pond is about one hundred and fifty feet north of the Seaman-Drake estate...[it] is about three hundred feet long by seventy-five feet wide and for the most part is cut out of the solid natural rock. [Emphasis added.] Heavy trees and foliage and vines surround it, and I came within a foot or two of walking into it over a bluff twenty-five feet high!

As final proof, Smith’s photograph of the pond (Figure 7) looks very much like many an abandoned, water-filled quarry that I have seen over the years. If this was, indeed, a quarry, it yielded, according to Smith’s measurements, a lot of marble—more than 20,000 cubic yards! It was situated on land that is now occupied by Columbia University’s Baker Field.

Archibald Bruce, M.D. wrote, in his The American Mineralogical Journal (Bruce, 1814a), a “Description of Some of the Combinations of Titanium Occurring within the United States.” In it he described four specimens of Kingsbridge rutile which he owned and almost certainly collected personally in the field. He depicted one in an engraved plate (Figure 14) and wrote:

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⁵The Harlem Ship Canal is, simply, the largest excavation into the marble beds of Manhattan. When it was opened to shipping in 1895, 550,000 tons of marble had been removed and an additional 5,000 cubic yards of the rock were used in the construction of retaining walls. Many buildings on Marble Hill contain some of this rock and a good deal of it was exported to Bayonne, New Jersey for use in a breakwater there. In the early stages of the excavation, in 1891, a mastodon tusk was uncovered, the only such find on the island. It is preserved at the American Museum of Natural History.
The above specimens...are from the island of New-York. They were found in the limestone ridge which crosses the island at its northern extremity, near Kingsbridge. The limestone, which is primitive, has running through it in different directions, veins from one to three or four inches thick, composed of quartz, felspar, mica, and granular lime-stone: through which the oxide of Titanium is sparingly disseminated. The quartz is of the fœtid kind, giving out an unpleasant odour on being fractured.

In the same article Bruce wrote also of “Silico-Calcareous Oxide of Titanium” (titane) and mentioned:

Small brilliant crystals...of a light colour, imbedded in primitive carbonate of lime, from the marble quarry at Kingsbridge, Island of New-York.

“The marble quarry” mentioned by Bruce as the source of his specimens could have been the Bolton quarry pictured in Figure 2, although there were others in the Kingsbridge area producing marble at the time. The Bolton quarry was, apparently, the most important. These sites were probably often visited by mineral collectors desirous of obtaining specimens to add to their cabinets. Unfortunately, no specimens known to be from the early quarries can be positively identified today.

Kingsbridge was a favorite with other early physician/mineralogists, too. In his Chymical Exercises (1819), William James MacNeven, M.D., (1763-1841) wrote extensively about the area—

The limestone district adjacent to Kingsbridge is shown, by the character of its minerals and the position of its strata, to be chiefly primitive. The marble extends two or three miles into the county of New-York [Manhattan], and is the termination of a range of primitive granular limestone [that at Kingsbridge] is stratified presenting an inclination to the south-east of from sixty to seventy degrees.

He remarked that it was the only locality in the United States at which could be found crystals of “white augite [diopside] in nearly rectangular prisms.” He also noted that “the limestone of Kingsbridge embraces pyroxene, tremolite, mica, fœtid quartz, oxide of titanium, adularia, tourmaline and sulphuret of iron.” Samuel Robinson, M.D., in his A Catalogue of American Minerals With Their Localities (1825), devoted a full page to Kingsbridge minerals, and in 1842, Lewis Caleb Beck, M.D., (1798-1853) summarized what he knew of Kingsbridge minerals in his Mineralogy of New York (1842).

By the year 1888, Benjamin B. Chamberlin was referring to Kingsbridge in the past tense (Chamberlin, 1888). He wrote: “Nearly fifty years ago the Kingsbridge quarries were much resorted to by collectors.” By the time that James G. Manchester wrote, in 1931, The Mineralogy

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4 Some readers of this statement have suggested that “dove” is a typographical error for “clove,” since titanes are not usually dove colored and a handwritten “cl” could be misread as a “d.” The careful proofreading which is evident in Bruce’s Journal makes this conclusion, in my opinion, unlikely.
of New York City and its Environs, the city was encroaching seriously on the few remaining collecting sites, and there are no further references known to me, thereafter in the literature, to mineral collecting at Kingsbridge.

GEOLoGY AND PETROLOGY

What is evidently the earliest printed reference to the Kingsbridge area marble was composed by the year 1808. Dr. Samuel Akerly (1785-1845) wrote “On the Geology and Mineralogy of the Island of New-York,” and it was published, six years later in 1814, in The American Mineralogical Journal, volume 1, number 4, pages 191-198. (Akerly, 1814). It noted “...the primitive limestone which is on the north end of the island.” Unfortunately, Akerly wrote nothing at all about the rock’s constituent minerals. Earlier, Samuel Latham Mitchell, M.D., in his report “A sketch of the mineralogical history of the State of New-York” (Mitchell, 1798) certainly had the opportunity to describe the marble beds, but did not mention them.

The marble of the Kingsbridge quarries was described by Robinson (1825) as a “granular limestone, sometimes traversed by narrow veins of granite, mica slate, and quartz” with occasional “yellow mica,” diopside, tourmaline, kyanite, feldspar, tremolite, pyrite, rutile, dolomite and titanite. He states further that the limestone unit “passes through West Chester

Figure 8 - Hawthorne Street (West 204th Street) and Cooper Street, Manhattan, the area that was “built up some twenty feet above the natural level of the land with many pieces of white marble from the quarry.” Photograph taken by James Reuel Smith on December 4, 1899. From Smith (1938). Collection of The New-York Historical Society.
KINGSBRIDGE, AN EARLY QUARRYING DISTRICT ON MANHATTAN ISLAND

[sic.] County [NY], in strata dipping to the S.E. at about 65°,” and is “connected with that extensive deposit of granular limestone which accompanies primitive rocks from Canada through the eastern parts of New England, crosses the Hudson near Stony Point into Rockland Co. [New York], and again appears in New Jersey, Pennsylvania, Maryland and Virginia.”

Leo M. Hall, writing in Studies of Appalachian Geology: Northern and Maritime (Hall, 1968), subdivided those vast Cambrian-Ordovician marble beds, as they are observed in the Greater New York area, into five units which he labeled Inwood A B C D and E and described them.

Inwood A (the Kingsbridge area): Well bedded white, gray or blue-gray dolomite marble.

Inwood B (Tuckahoe and White Plains, New York area): Interbedded white, gray, buff or pinkish dolomite-marble, tan and reddish brown calc-schist, purplish brown or tan siliceous calc-schist and granulites, tan quartzite, and calcite-dolomite marble; bedding is typically one half inch to four feet thick. He estimated them to be 2000 feet thick in some places!

Inwood C (Ossining, New York area): White or blue-gray, clean, dolomite marble.

Inwood D : (Farther North): Interbedded dolomite marble, calcite marble and some calc-schist.

Inwood E : (Still farther North): Grey or white calcite marble, commonly tan weathering.

The marble deposits of northern Manhattan had long before Leo Hall’s time been called Inwood. That name has been in general use in the area since about 1870, but Hall expanded its use to include the entire region.

Unfortunately, it was observed that even in the days of relatively low-level atmospheric pollution, much, but not all, of the Inwood A marble of Kingsbridge tended to weather rapidly and so the quarrying of it for building stone was eventually abandoned. John A. Dix (1836), reporting as the Secretary of the State of New York noted that

The marble at Kingsbridge is mixed with iron pyrites, which on exposure to the weather stains and hastens the decomposition of the stone. [Actually, the pyrite is relatively scarce in the marble and contributed very little to the weathering problem. I have personally observed no pyrite in the surviving pieces. The pyritiferous marble was obviously avoided, whenever possible, by the stonemasons.] Unless it is found in a purer state on further examination, it cannot be advantageously used for architectural purposes.

Beck (1842) believed that the quarries ceased operating by 1842, and said:
Figure 9 - Arched gateway of Inwood A marble, in its original (and present) location at Broadway and 216th Street as it appeared in the early twentieth century when it graced the entrance to the Seaman-Drake estate. The automobile is a 1910 Matheson. Collection of The New-York Historical Society.

Figure 10 - The arched gateway from Figure 9 as it appears today.
The quarries at Kingsbridge have furnished a considerable amount of marble. It is granular, and belongs to the dolomitic variety. By exposure to the weather, some of the specimens fall to pieces, and form a kind of calcareous sand. It is now, I believe, [and had been for almost two hundred years previous to this time] chiefly used for burning into lime. [Beck did not believe the included pyrite was the main weathering problem.]

Indeed, one has only to look at the gravestones, previously mentioned, in the early Jews’ Burying Ground, for examples of the weathering described by Beck, although these stones have not fallen to pieces and do not appear to bear any pyrite. The early dated headstones that survive in Trinity churchyard seem to be exceptions.

Issachar Cozzens, (1780-1865) writing in *A Geological History Of Manhattan Or New York Island* (1843), called the Inwood A formation a “primitive limestone” (it is one of the oldest of the New York City rocks) and said:

"[It] is well known; it is a Dolomite. This Dolomite I examined some 16 years ago, and found it to contain about 28 per cent of Carbonate of Magnesia, from which I manufactured good Epsom Salts (Sulphate of Magnesia) and [it] has all the varieties of white, grey and light blue, granular, coarse marble; it begins at the south end of Mr. Dyckman’s farm and runs through the middle of the Island to Spuyten Duyvel creek; the same rock runs through Westchester County, and is seen on the other side of Kingsbridge, and thence along the river toward Yonkers...[where it is known as the Tuckahoe/Inwood B marble]. A quarry was opened at Kingsbridge, some years ago, which proved unprofitable.

In New York City, in 1822, The Bank of the United States building was erected on Wall Street, just east of Broad Street and in 1853 it became the United States Assay Office. It was constructed of Inwood B marble from the Tuckahoe beds, in Westchester county, some 18 miles from the city. Tuckahoe produced a finer-grained Inwood marble than that of the Kingsbridge quarries, but it is mostly devoid of mineral specimens. In 1827 ‘The Merchants’ Exchange building, which boasted one-piece columns at least twenty-four feet high, was also built of this rock. The Merchants’ Exchange was totally consumed by the Great Fire of 1835, but the handsome facade of the Assay Office (complete with pediment) was preserved when the building was taken down in 1915 and is on display at the American Wing of the Metropolitan Museum of Art.

There were once several Inwood marble quarries located along the ridge paralleling the Bronx River in the town of Eastchester, between Crestwood and Tuckahoe. Operations there started around 1820 and continued until 1930.

Before marble quarrying began in Vermont around 1850, the Tuckahoe beds of the Inwood B were the single most important source of white marble in America. Shipments of this building stone were made from Boston to New Orleans and many places in between. Other notable buildings constructed of this marble include Lyndhurst in Tarrytown, New York (the Jay Gould
mansion), the Borough Hall of Brooklyn, New York and the United States Naval Observatory in Washington, D.C.

The site of the Ossining Correctional Facility (Sing Sing Prison) was chosen because of the availability of Inwood marble. At this location convicts quarried the rock from which the prison was built. Nice crystals of diopside and specimens of rutile on dolomite were reported from here. The Kingsbridge quarrying area was once considered as a possible site for a penitentiary for the same reasons that Ossining was chosen.

Huge quarried blocks of Inwood A/B marble can be seen today in lower Manhattan serving as the foundation of the old Custom House (later known as the Sub-Treasury building) erected in 1842 and still standing on the corner of Broad and Wall Streets. This rock came from a site around 138th Street near where the present-day Third Avenue Bridge enters the borough of the Bronx. This quarrying site was, at that time, part of Westchester County.

The Snowflake Quarry at Thornwood, Westchester County, New York survived until 1973 supplying, in its last days, Inwood B marble that was crushed for use in terrazzo and stucco, and fine marble powder that was used in paint and soap.

The commercial exploitation of the various Inwood marble beds lasted for a period of more than three hundred years.

Smith (1938) mentions the Inwood A marble deposits several times. He states that the area at Hawthorne Street (West 204th Street) near Broadway was “built up some twenty feet above the natural level of the land with many pieces of white marble from the quarry” and shows an excellent photograph of the location (Figure 8). Unfortunately there is no way to ascertain if “the quarry” was re-worked for this project or if, as seems most likely, existing material, perhaps rubble from the Harlem Ship Canal excavation, was used.

Smith continues and describes the “magnificent” Seaman-Drake estate, of 26 acres in 1898, that stood just west of present Broadway at 216th Street until it was demolished in 1939 and says that:

The dwelling [erected for Valentine Seaman around 1845 at a cost of $150,000] itself is of [Inwood A] marble [which was quarried on the property and came, almost certainly, from the excavation that produced the Dyckman ice pond shown in Figure 7]. Its large white marble entrance arch (said to have cost $30,000)... has for half a century challenged the admiring observation of every traveler entering or leaving New York City by the Hudson River Railroad.

That arch, actually an arched gateway, is the largest surviving object made of Inwood A marble. Although no longer the visual landmark it was when described by Smith (Figure 9), it survives, in situ as it were, almost swallowed up by modern Broadway. It stands today, patched with modern bricks and vandalized by graffiti, rather under-utilized as part of the entrance to an auto body repair shop. It is partly hidden from sight because it is set back from the current building line at 216th Street. (Figure 10). One suspects that it survived the modernization of
KINGSBRIDGE, AN EARLY QUARRYING DISTRICT ON MANHATTAN ISLAND

Broadway simply because the cost of its demolition and removal was (and probably still is) prohibitive. Today it is still quite impressive and, with its architectonic massiveness (sight measurements- 30 by 20 by 12 feet), is reminiscent of the well-known granite arch of New York City at Washington Square but, of course, on a much reduced scale. It seems to be holding up quite well to the weather and air pollution, and is not, as Beck (1842) noted, constructed of "the specimens [that] fall to pieces" and it contains little or no noticeable pyrite inclusions.

James G. Manchester in his The Mineralogy of New York City and Its Environs (1931) writing almost a century after Beck, Cozzens, et al., discussed the area in some detail:

The crystalline limestone [technically, it is a metamorphosed limestone, or marble] extending from Vermont to North Carolina, is a part of the rock foundation of New York City and comes to the surface at a number of points, principally in the northerly section of the city. The navigable channels around the island are submerged valleys which came into existence through the ease with which this limestone is eroded, its hardness being about 3 on the scale. [Actually it is more about solubility than hardness although the two are related. There is, surviving to this day at the northern-most end of Manhattan island, a large area substantially un-eroded and called, appropriately, Marble Hill.] In the section known as Inwood valley the prevailing rock is limestone [now called Inwood marble A] and in it many fine minerals have been found, particularly near the zones of contact with the mica schist [and its pegmatite intrusions]. The vacant land in this region, however, is rapidly being improved with buildings and it will not be many years before the opportunity to collect minerals will be somewhat limited. Among the more important minerals reported are pyrrhotite, chalcopyrite, pyrite, marcasite, rock crystal, smoky quartz, rutile, calcite, aragonite [the author pictured a specimen of "Aragonite var. Flos Ferri, Broadway and 215th Street, Manhattan Island, N.Y." as his plate No. 36. This location is but one city-block south of the great marble gateway], malachite [diopside], tremolite, asbestos, brown tourmaline [withe], muscovite, foliated talc and gypsum. During the construction of the Harlem Ship Canal [more than a half-million] tons of limestone [including what remained of the former Bolton complex] were removed and the waste pile [on the site that became present-day Baker Field] was the lure of collectors for many years. [Figure 13].

MINERALOGY

The finest collection of Kingsbridge area mineral specimens surviving today belongs to the New York Mineralogical Club and has been permanently deposited by the Club at the American Museum of Natural History in New York City. All of the species described below are represented there in at least a few examples, in some cases many.

Calcite CaCO₃

Calcite in crystals, rare from Kingsbridge, forms scalenohedrons up to 1 cm. across and has been collected on quartz crystals as in Figure 17.
Diopside $\text{CaMgSi}_2\text{O}_6$

Archibald Bruce was, it seems, the first mineralogist to encounter diopside from Kingsbridge without, apparently, knowing what it was—

A mineral presenting some characters which rendered its nature doubtful, [probable clarification: 'I did not have a clue to its identity'] we some time ago transmitted to Paris, for the examination of our venerable friend M. Haüy, [René Just Haüy (1743-1822)] who, after duly considering its structure agreeably to the laws of crystallization, has pronounced it to be Pyroxène. [The name pyroxene was created by Haüy in 1796 for a new mineral species; that name is now used for a group of minerals.] This substance is white, and occurs crystallized in eight-sided prisms, of which two opposite sides are often much larger than the other six, so as to present a tabulated form. The prism is variously terminated, sometimes resembling the Pyroxene of Vesuvius, while in other instances the termination is more complex, giving rise to a new variety which M. Haüy has named épiméride— Specific gravity 3.1. Crystals of various sizes, from minute to several inches in length are found imbedded in the primitive limestone which crosses the island of New-York at its northern extremity. [Bruce, 1814b].

Bruce’s phrase “some time ago” used in referring to his sending the specimens to Paris, probably meant 1811 or even earlier, since Haüy published his comments on the mineral in 1812. Haüy’s included a plate of crystal drawings, one of which (Haüy’s Fig. 4.) was the new form, épiméride.¹ (Figure 11). This drawing was later reproduced in Victor M. Goldschmidt’s Atlas der Krystallformen (1922) as his figure 9 of plate 7 in volume VII. Haüy was very optimistic in his report and added—

The soil of the United States of America has, in the last few years, become the subject of investigations which show the progress and development of mineralogy. In these investigations several highly distinguished scientists...Messieurs [Archibald] Bruce, [Benjamin S.] Barton, [Charles W.] Peale, [Silvain] Godon de St.-Memin, [William] Maclure and [Samuel L.] Mitchell...have participated, most of them Americans; and the progress which has already been made gives the right to expect, in the future, the harvest of that which they have begun with so much zeal and success. (Haüy, 1812).

Cleaveland, (1816), cited the notice published by Bruce and mentioned the “new and more complex variety of form,” épiméride.

¹ Haüy stated (I am afraid not too clearly) that he used this new name because it means “over-growth” or “over-extended.” These were, apparently, the first examples of crystals he had seen that decreased “one unit in size on their sides as against a greater decrease on their angles.”
In 1819 MacNeven described “white augite [diopside] in nearly rectangular prisms” from the Kingsbridge quarry and noted that “this was, for a long time, the only locality for this mineral in the United States, but Mr. Pierce has lately met with it at Singsing, higher up the Hudson,” also from Inwood marble deposits. MacNeven also made note of associated pyroxene, tremolite, mica, feldspar, rutile, adularia, tourmaline and pyrite. Robinson (1825) described the crystals as having “4 sided tables [terminations]” and “8 sided prisms.” Dana (1837) merely noted the occurrence. Beck (1842), in his review of New York State’s mineralogy, remarked that the “abandoned quarries at Kingsbridge, about 208th Street, also afford very good [diopside] specimens.” Beck depicted a crystal drawing of “épiméride.” By the time of the publishing of the sixth edition of Dana’s System of Mineralogy, (Dana, 1892), the occurrence was listed under augite— “In N. York, in N.Y. Co[unty], i.e. Manhattan, white cryst. 2-3 in. long in dolomite.”

Forty years later Manchester (1931) considered diopside (calling it “malacolite,” a now-discredited name) a common mineral of the marble, often found in crystals standing out in relief on the more soluble weathered matrix, and illustrated such a specimen in his plate 42. In fact, he stated that loose single crystals had been collected years earlier in the nearby plowed fields.

I personally collected these diopside crystals as a boy in the 1940’s when they were still known locally as malacolite. I remember vividly banging them out of their marble matrix with my hammer and chisel while seated on the ground and then being threatened with arrest by a gruff Irish policeman. As far as the officer could see, I was vandalizing a New York City marble sidewalk.

Dolomite CaMg(CO₃)₂

Robinson (1825) reported dolomite as a component of the marble at Kingsbridge, and Beck (1842) elaborated that the dolomite is “large grained ... with indications of a foliated structure.” Dana (1892) stated that augite crystals were found at Kingsbridge in dolomite, but I have never seen, nor heard of, such a specimen. Dana may have been referring to the dolomite-rich marble.

Feldspar

The early references to feldspar at Kingsbridge are rudimentary. Robinson (1825) reported “fetiéd feldspar... bluish white” in color. Bruce (1814a) and MacNeven (1819) had also reported feldspar, but without further description, except that MacNeven mentions the presence of adularia. Beck (1842) described a fetiéd feldspar as coming from a white limestone at “Thompson’s quarry, near 196th Street.” This excavation, probably a later one, was almost a mile and one-half
from the Bolton quarry and about a mile from the area described by John Randel, Jr. but was located on the same Inwood A marble unit, probably near its southern and western limits. Chamberlin (1888) described the mineral assemblage at Thompson’s quarry as including rutile, diopside, kyanite, phlogopite, brown tourmaline, fetid feldspar, tremolite and titanite. The quarry may have belonged to Samuel Thompson who Bolton (1924) called “one of the earliest of those well-to-do residents who settled on the Inwood hillside overlooking the Hudson River.” George C. Wissig, Jr., in Bedrock Geology of the Ossining Quadrangle, New York (1979), found potassium-feldspar in the Inwood beds by microprobe analysis.

**Kyanite Al₂SiO₅**

Robinson (1825) reported “raetizite” (an early synonym for kyanite) as occurring at Kingsbridge in “yellowish white, crystalline masses, laminated, translucent or transparent.” This description appears to have been taken essentially verbatim from Cleveland (1822), who cites his source as the “Rev. F. G. Schaeffer,” apparently as a personal communication from a local collector.

**Muscovite KAl₂ (Si₃Al) O₁₀ (OH,F)₂**

The designation of the “mica” as muscovite is merely a guess but a fairly safe one. Robinson (1825) reported “yellow mica.” Bruce (1814a) and MacNeven (1819) both reported “mica” without further description. Beck (1842), however, described tourmaline as occurring with a “reddish brown mica” that may perhaps have been phlogopite. Chamberlin (1888) actually does call it phlogopite, having a “handsome light brown” color. The Kingsbridge mica in general, he says, exhibits a variety of colors and occurs in plates seldom of large size but sometimes having a perfect tabular-hexagonal crystal habit.

**Pyrite FeS₂**

“Sulphuret of iron” was reported by Robinson (1825) as “small dodecahedrons with pentagonal faces,” and earlier by MacNeven (1819) without giving a description. Manchester (1931) noted pyrite as well as pyrrhotite, marcasite and chalcopyrite, all of which may have fallen under Robinson’s “sulphuret of iron.” The pyrite crystals, he said, were “quite common” in the
limestone, "where they have been found in such a variety of form and brilliancy of luster as to make them a welcome addition to any cabinet." Illustrated here (Figure 12) is an example of the type of pyrite crystal ("dodecahedrons with pentagonal faces") to which Robinson referred. Manchester collected it and Whitlock illustrated it in the American Mineralogist in 1919. Manchester also illustrated it in his 1931 book. It is the best example that I know of, and is a fine specimen by any standard of judgment. The American Museum of Natural History acquired it from me in 1962 along with a few other New York City specimens that had been illustrated in The Mineralogy of New York City and Its Environs. Manchester had also collected other specimens of pyrite in marble which he treated with acid to free the individual pyrite crystals. Ten of these were then measured goniometrically by Whitlock (1919), and one was figured as a crystal drawing. Whitlock described their habit as uniformly rather flattened, and showing combinations of 11 different crystal forms.

Pyrrhotite Fe_{1-x}S

Manchester (1931) described "small, hexagonal crystals of thin, tabular habit, iridescent blue in color." These may not have come from Kingsbridge quarries per se, but from masses of rubble thrown up during the digging of the Harlem Ship Canal. Smith (1938) noted that in 1898 for "three acres of ground, made of the white stone taken from the Canal...the United States are paying Mr. [Isaac Michael] Dyckman $2000 a year rent." (Figure 13). Those three acres are included in the present Baker Field location. Specimens of massive pyrrhotite in veins up to 2.5 cm running through the marble were also reported.

Figure 13 - The New York Mineralogical Club members collecting at the marble waste-pile excavated from the Harlem Ship Canal, 1887. Photograph by J. Rösch. Collection of the author.
Quartz SiO₂

“Fetid quartz” that gave off an odor when broken was described by Bruce (1814a) and MacNeven (1819). It is a common constituent of the veins penetrating the marble. Small clear quartz crystals of good form are seen occasionally.

Rutile TiO₂

Rutile was first reported and figured from Kingsbridge by Bruce (1814a); (Figure 14), who found it “sparingly disseminated” in veins 2.5 to 7.5 cm wide cutting granular limestone. Associated minerals were said to include fetid quartz, feldspar and mica. The specimens in his collection included: (1) “small quadrangular prismatic, nearly acicular semi-transparent crystals...of a dark red color, variously recumbent on a granitic aggregate...” (2) a “small dark red semi-transparent double [twinned] crystal...four-sided prisms...the surface highly resplendent...” (3) a “large amorphous blood-red” mass on white feldspar, and (4) “light red acicular embedded in bluish quartz.” MacNeven (1819) noted its presence as well, but without giving a description. Manchester (1931) described “finely terminated crystals ... semi-transparent, ranging from blood-red to wine color, [and] capillary crystals to one inch or more in length extending across a vug or cavity lined with calcite crystals.” (Figure 18.)

Titanite CaTiSiO₅

Titanite, like rutile, was first reported and figured from Kingsbridge by Bruce (1814a). He described “small, brilliant crystals...of a light dove colour, imbedded in granular primitive carbonate of lime.”
Tourmaline

MacNeven (1819) reported tourmaline from Kingsbridge, but without giving further description. Robinson (1825) referred to “schorl” and “red tourmaline” embedded in dolomitic limestone, as crystals in various shades of red and brown, and cited an 1820 article in Silliman’s Journal as his source which was actually the abstract of an 1819 lecture presented at the “Lyceum of Natural History, New-York” by Mr. N. Pauling. The lecturer described a red tourmaline found at Kingsbridge by Mr. I. Pierce, which was supposed at first to be rubellite but was really just a schorl. He gives a surprisingly detailed morphological description:

The fundamental form appears to be an equilateral three-sided prism, acuminated by three planes, which at one extremity are set on the lateral planes. This form is variously modified by truncation and bevelments. Most of the crystals are bevelled on the lateral edges, forming nine-sided prisms. Sometimes the lateral planes are nearly destitute of striae, though the faces of the acumination are always smooth and splendent. [He then gives a series of interfacial angles, and notes that they] agree almost precisely with the tourmaline isogene of Haïti.
Cleaveland (1822) also cited red tourmaline.

Robinson (1825) reported scorial (separately from “tourmaline”) as occurring at Kingsbridge in “brown or reddish brown, translucent, usually 9-sided prisms, terminated at each end by 3 faces. Also in brownish yellow, 6-sided prisms well-terminated by 3 planes.” Beck (1842) describes “tourmaline” crystals in brown, yellowish brown and reddish brown colors, in 6-sided prisms with three terminal faces, associated with a reddish brown mica.

Manchester (1931) adds a bit more information, describing “finely terminated brown tourmaline, some of gem quality, and small green tourmalines embedded in cream-colored calcite” at the “northerly end of Broadway where at times this mineral is to be found in many of the rock excavations of the neighborhood.” He depicted, in his frontispiece plate, two small,
brown-colored, faceted stones of this material. These stones, probably uvite, passed through my hands more than thirty years ago and, although they were small, it is my recollection that they were of fine quality.

I have never seen nor heard of any tourmaline from this location that was not almost certainly uvite or schorl.

Tremolite  \( \text{Ca}_2 (\text{Mg}, \text{Fe}^{2+})_5 \text{Si}_8 \text{O}_{22} (\text{OH})_2 \)

Robinson (1825) mentioned tremolite at Kingsbridge, “both [presumably coarsely] crystallized and in fibrous masses” in the marble. MacNeven (1819) had noted it too, but without giving a description. Beck (1842) noted “a beautiful white and bluish white tremolite,” sometimes in “broad laminated masses,” with folia sometimes “six to nine inches in length.”

Wissig (1979), writing of the overall Inwood marble deposit, added to the traditional list of species those minerals he observed by microprobe analysis. They are phlogopite, scapolite, apatite, zircon, sericite, sillimanite, biotite, olivine, serpentine and chlorite.

Figure 17 - Calcite scalenohedron 1 cm. across on quartz crystals, 207th Street and Broadway, New York Mineralogical Club collection at American Museum of Natural History #1170. AMNH photograph by Jackie Beckett.
CONCLUSION

The Kingsbridge quarries, like virtually every other early mineral collecting site on Manhattan island, are now long gone and covered over with concrete, steel, asphalt and water. There are no workable outcroppings of the marble anywhere on the island that might offer the modern collector a glimpse of what all the fuss was about nearly two centuries ago. Even the surviving mineral specimens have dwindled to a rare few as attrition has taken its toll on the early collections, leaving present-day mineralogists and collectors almost no clues at all to the former prominence of this interesting and historic quarrying district and its unique mineral assemblage.

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UNUSUAL GRAPHITE CRYSTALS FROM THE LIME CREST QUARRY, SPARTA, NEW JERSEY

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Microcrystals of graphite occurring in the Franklin Marble at the Lime Crest quarry, Sparta, New Jersey, exhibit a wide variety of unusual and interesting morphologies from sharp hexagonal crystals to completely spherical aggregates.

INTRODUCTION

Because of its extreme softness and flexibility, graphite is a common mineral that is not often represented in collections by well-crystallized specimens. However, excellent micro-crystals, can successfully be collected and preserved, and can make good micromounts. Some of the best-formed graphite crystals are known to occur up to a few mm across in calcite marbles at several localities, including:

- Crestmore Quarry, Riverside, California (Jaszczak, 1991)
- Gouverneur Talc Company No. 4 Mine, Harrisville, New York (Chamberlain et al., 1996; Gerdes and Valley, 1994)
- Sterling Mine, Ogdensburg, New Jersey (Palache, 1941; Jaszczak, 1994)
- Limberg Quarry, Pargas, Finland (Jaszczak, 1996)

The Franklin Marble at the Lime Crest quarry near Sparta, New Jersey is also host to graphite crystals of exceptional quality. Besides well-formed crystals, some very unusual graphite morphologies can also be found.

Bulk samples of graphite-bearing marble were collected from a graphite-rich zone on the lower level of the quarry by John Rakovan on April 29, 1991, and generously supplied to the author for examination. Bulk material was subsequently trimmed and examined with an optical stereo microscope. A dilute solution of hydrochloric acid (HCl) was used to partially etch away the calcite in many specimens in order to expose the enclosed, protected graphite crystals. Although graphite crystals occur in the marble to over 1 cm across, the best crystals are usually less than 2 mm across. Associated minerals include crystals of phlogopite, pyrite, pyrrhotite, molybdenite, arsenopyrite, sphalerite and a few unidentified species. The identities of the pyrrhotite, pyrite, molybdenite and arsenopyrite were confirmed by the use of energy dispersive
spectroscopy\(^1\) (EDS) capabilities of a scanning electron microscope (SEM) at Michigan Technological University’s Institute of Materials Processing.

Material similar to that described here is no doubt readily available, and simply requires some one’s careful examination to find good crystals. One hand-sized sample can yield many micromounts. Similar material from Lime Crest was subsequently given to the author by Scott Stepanski. These samples contained graphite crystals in marble with morphologies very similar to those that are the focus in this paper, but associated with a somewhat different assemblage of minerals, which appears (but has not been confirmed) to include serpentine, zircon, muscovite, apatite and diopside, in addition to those already mentioned. The geology and mineralogy of Lime Crest are briefly described by Widmer (1962), Mersger (1977) and Tracy (1991).

**GRAPHITE MORPHOLOGY**

The crystal structure of graphite (Freise, 1962) is that of a staggered stacking of sheets of carbon atoms (Fig. 1). Within the sheets, the carbon atoms are very strongly bonded together in a honeycomb arrangement, with a C-C bond length of only 1.42\(\text{Å}\) (1\(\text{Å} = 10^{-8}\) cm), which is even closer than the C-C bond-length in diamond. In contrast, the carbon sheets are separated from each other by approximately 3.40\(\text{Å}\) and are only weakly bonded to each other. This results in graphite's flexibility and softness. Both hexagonal and rhombohedral types (called polytypes) of graphite are known, depending on how the sheets are staggered in their stacking. The most common and most stable graphite polytype is the hexagonal, or 2H, polytype, which has its layers staggered in an ...ABABAB... sequence (as in Fig. 1). The rhombohedral, or 3R, polytype

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\(^1\)EDS is a micro-analytical tool that analyzes the characteristic X-rays emitted by atoms in the sample when irradiated by an electron beam of suitable energy (see, for example, England, 1991).
has its layers staggered in an ABCABC... sequence (Laves and Baskin, 1956). The rhombohedral polytype is only known as a mixture in predominantly hexagonal crystals, and can be induced to form by grinding hexagonal graphite.

As a result of the crystal structure, the symmetry and the nature of the bonding, the \{0001\} basal pinacoid faces (c-faces) of graphite crystals tend to be the lowest energy surfaces, and growth of the crystals is typically fastest at the sheet edges. These factors lead to tabular hexagonal plates as being the typical morphology of graphite crystals (Jaszczak, 1995). By far the most common crystal form for graphite at Lime Crest and elsewhere is the basal pinacoid (Figs. 2 to 5).

The c-faces of the graphite crystals from most localities are typically highly striated (Fig. 5) due to the crystals being mechanically bent and deformed by the various stresses and forces on and in the host-rock. The bending of the crystals induces so-called “mechanical twinning” that is evidenced by the striations on c-faces (see Palache, 1941). Many small graphite crystals from Lime Crest, however, can be found with no striations on the c-faces, indicating their rare escape from the many factors that could have deformed them. A few crystals have been observed that show growth twins that are evident as small triangular crystals protruding from the c-faces, as shown in Fig. 3 (Jaszczak, 1991).

A few graphite crystals from Lime Crest have been found that display spiral growth steps on the c-faces. The spirals can usually only be observed by orienting the crystals to reflect the light “just right” to make the steps visible, and are difficult to photograph. Such growth spirals are thought to emerge from defects in the crystal structure called screw dislocations, which play an important role in the growth of the crystals (Weiner and Hager, 1987).
Occasionally graphite crystals will show well-formed prism faces. These are often striated as well, not because of mechanical twinning, but because of the graphite’s layered crystal structure. Only rarely do other forms show themselves in well-formed, lustrous crystal faces (see Figs. 4 and 5).

**Figure 5** - An unusually thick graphite crystal with uncommon faces, on a basal pinacoid face of a more typical, striated, tabular graphite crystal (1.3 mm). JAJ specimen #1556i and photo.

**Figure 6** - A 1.1-mm crystal of molybdenite in partially etched calcite with minor pyrite. JAJ specimen #1556e and photo.

**Figure 7** - A well-formed hexagonal graphite crystal (1.2 mm) with a thick secondary overgrowth of graphite. The crystal is on partially etched calcite and is associated with orange phlogopite that is included with tiny graphite spheres, and an unidentified pale green mineral at the mid-lower right. JAJ specimen #1556b and photo.

**Figure 8** - SEM photo of hexagonal graphite crystals (to approximately 0.2 mm) showing a secondary overgrowth of graphite crystals as minute plates. Associated are a spray of arsenopyrite crystals at the lower right and a plate of pyrrhotite at the lower left. SEM photo by Ruth L. Kramer. JAJ specimen #1556.
Molybdenite, which can be easily confused with graphite, also occurs in the marble at Lime Crest as well-formed, lustrous, platy crystals (Fig. 6), but is much less common. However, graphite and molybdenite crystals submerged in a shallow bath of water and viewed with a microscope can readily be distinguished from one another by the difference in their color. Compared to graphite, the molybdenite shows a distinctly bluish hue. A few graphite crystals have been found having molybdenite overgrown on graphite’s c-faces. Although both the graphite and the molybdenite have their c-axes parallel in these samples, an epitaxic relationship has not yet been confirmed in these samples.

An interesting set of crystals that occur at Lime Crest shows secondary graphite overgrowths on earlier-formed, larger graphite crystals (Figs. 7 to 9). Similar graphite overgrowths from Precambrian Grenville Series marble at Eagle Lake, Essex County, New York have been described by Weis (1980). Such overgrowths have also been noted by the author from the Sterling Mine, Ogdensburg, New Jersey, the Treadway Quarry, Port Henry, New York, the Limberg quarry, Pargas, Finland, a roadcut near Dresden, New York, and a roadcut south of Gooderham, Ontario, Canada. It is interesting to note that graphite occurs at all of these localities also as spherical aggregates in sizes ranging from microns in diameter at Pargas, up to a centimeter in diameter at the Sterling Mine. This correlation suggests a possible relationship between the growth mechanisms, growth conditions, and growth sequence of the graphite spheres and the graphite overgrowths.

A whole spectrum of varying degrees of graphite overgrowth on earlier-formed graphite can be identified in material from Lime Crest. At one end of the spectrum there are the lustrous crystals with no overgrowth whatsoever. On some crystals, overgrowth is primarily localized on the crystal edges leaving areas of lustrous, earlier-formed graphite still visible (Fig. 7). This suggests that either the secondary graphite growth was nucleated by the edges of the earlier-generation graphite, or perhaps that the secondary growth took place rapidly compared to the
diffusion of carbon to the crystal surface. On other graphite crystals the whole surface can be overgrown by the second-generation graphite. At the opposite end of the spectrum are particularly thick overgrowths that seem to take on a spherical morphology (Fig. 9), similar to crystals also observed by Weis. Whereas in the partially coated crystals the secondary graphite shows some degree of order in their alignment with each other and with the substrate crystal, the thickly coated crystals appear to have more randomly oriented overgrowths. The preservation of the delicate secondary crystallites and the undistorted morphology of the first-generation graphite crystals implies that the metamorphic processes that commonly deform rock and distort or destroy the enclosed graphite crystals must have been greatly diminished by the time the graphite crystals formed.

Some of the most unusual graphites observed from Lime Crest are pseudocubic aggregates of crystals that reach up to 0.5 mm across and have a rather velvety luster (Figs. 10 to 12). In shape they are reminiscent of small balls of putty that have been dropped several times on a flat surface, giving both rounded and flatter areas. It appears, however, that the flattened areas form 90° angles with each other, as would cube faces. The aggregates are composed of flat crystal flakes (Figs. 11 and 12), which show that the dominant growth mechanism is still fastest at the edges of the graphite sheets. The cause of the overall pseudocubic morphology could be pseudomorphism after some other mineral, although this has not been verified.

Finally, distinctly spherical aggregates of graphite occur up to 0.5 mm in diameter and are commonly clustered around phlogopite crystals (Fig. 13). It will be an interesting future study to investigate if these spheres are related to the pseudocubic graphite aggregates or possibly to spherical graphite that is known to occur at a number of other localities, such as Sterling Hill and

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**Figure 11** - SEM photo of a graphite pseudo-cube (nearly 0.1 mm) on phlogopite, partially etched from calcite. Individual graphite crystals in the aggregate seem to be partially aligned. SEM photo by Ruth I. Kramer. JAJ specimen #1556.

**Figure 12** - SEM photo of a somewhat larger graphite pseudo-cube than shown in Fig. 11, viewed such that two of the cube sides are at the top left and at the right. In the area of the cube corner at the lower left, the individual graphite flakes appear to be randomly oriented. SEM photo by Ruth I. Kramer. JAJ specimen #1556.

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Among the first American minerals were, in order of their announcement: celestine, brucite, and zincite. As a group they typify the state of mineralogy which existed in the United States before 1820. However, reasonably complete knowledge of these species was not achieved for many years and even the modern names by which they are known were not always the first names given to them. In 1801, there was perhaps only a handful of people residing in the country who had more than a passing education in minerals and who may or may not have possessed the temerity to be the first to name an American mineral. Samuel Mitchill of New York City attempted to found a permanent scientific group, the American Mineralogical Society, in 1799, but the group failed in two years, apparently due to lack of participants. Mitchill did edit the Medical Repository, a journal which allowed a variety of subjects including mineralogy from 1797-1824. Mineralogical practitioners of emerging merit included George Gibbs of Newport, Rhode Island, but he and most of his predecessors were content to be collectors. "When Johan David Schöepf visited the garden in 1783, Bartrams son showed him 'all manner of rocks and minerals which are now kept in a box without any system intermixed with European specimens...' " (Greene and Burke, 1978). Certainly, there was no one in the USA before 1790 who could have claimed significant expertise in mineralogy. By even collector's standards, Josselyn's (1672, 1674, 1675) mineralogical observations have to be considered naive. Otherwise during this time period, "mineralogy" dealt with homeopathic medicine where medicinal minerals were lumped under the category *materia medica*. In 1818, Benjamin Silliman, while reviewing Cleaveland's (1816) mineralogy, lamented that when he had started his own career (c. 1801) there was no one in the country who could really advise him on what even the simplest of his mineral specimens were. Part of the scarcity of American mineralogical, if not all scientific, knowledge lay in several factors. The most important of which was America's virtual intellectual isolation caused by it's Revolutionary War. Additional impediments to intellectual stimulation included the French Revolution and the subsequent undeclared French-American war between 1797-1801. Uncertain to dangerous European politics, foreign language barriers, and the expense of travel to European centers of learning were all contributing factors to America's isolation. By 1800, there were barely 33 American colleges, virtually none of which taught courses other than classical languages, literature, mathematics and navigation, religious studies, military studies, and medicine. Even these colleges would have deemed twenty graduates a year a large class.

**THE PROGRESS OF MINERALOGY AS A SCIENCE**

Mineralogy was not all that retarded at this time period, however. Despite the publicity given to Georgius Agricola's mining books, and even to Johan Henckel's, modern mineralogy probably began in Sweden with Johan Wallerius in the 1740's and continued with his student
Axel Cronstedt in the 1750's. One of the first English language mineralogical books includes: *An Introduction to Mineralogy* by Foster (1768). In the mid-eighteenth century, there was an immense flowering of mineralogical knowledge in Europe and there ultimately arose four major schools of thought: Swedish, German, French, and English. These schools were frequently at odds, philosophically. Chemical science was also undergoing rapid advancement and the development of mineralogy was as much a consequence of chemistry studying what minerals were composed of, as mineralogists trying to establish a separate branch of study. (It should be remembered that bottled chemicals, which are so familiar to today's students, were unknown to even the best of chemists and they had to synthesize and purify their own chemicals, except for a few commonly available industrial formulations.) By the beginning of the eighteenth century, only about a dozen elements were known, but by the end, the number of actual elements had doubled and as many simple compounds containing new elements also had been isolated. The transition from alchemy to chemistry was rapid and while minerals were frequently the ammunition by which chemical battles were fought, most of the described minerals remained unanalyzed at the beginning of the nineteenth century. Another indication of how insufficient mineralogy was during this time includes the fact that crystal systems, as we know them, were not well defined until well into the 1830's and Friedrich Mohs had not announced his hardness scale until 1822. Even by 1828, Berzelius named a mineral aescynite meaning "a shame" because chemistry had not advanced sufficiently to resolve its components.

The intractability of some minerals to decomposition led to Robert Hare, Jr's invention of the hydrostatic blowpipe. Hare attended Woodhouse's chemical lectures in Philadelphia in the 1790's (Greene and Burke, 1978). While there, Hare must have heard Woodhouse lament of the inability of the normal blowpipe to affect some substances adequately. The hydrostatic blowpipe had the ability to create prolonged and very hot jets of flame. Some refractory metals such as platinum finally were fusible. This invention caused an instant sensation among the world's mineralogists and chemists and can be regarded as the first major contribution to mineralogy by an American.

**MINERALOGICAL CABINETS**

A slight digression is necessary to set the stage for the naming of the first American minerals. Given that there was a general absence of expertise in the USA previous to 1822, how would it have been possible to recognize that a mineral was new? One way would have been by assembling a collection of every mineral known and then by comparing your unknowns with the "knowns". However, probably at no time in history has there ever been a reasonably complete mineral species collection. In the USA, Samuel Mitchill was well-known to have had a good mineral collection. James Bowdoin had a collection and, as early as 1809, George Gibbs was trying to sell his collection. Waterhouse (1796) noted a major gift: "Both the English and French collection, happened to be more deficient in Italian marbles and volcanic glasses, than in almost any fossil, which deficiency has been generously supplied by the Hon. Mr. Bowdoin, who has presented the [Harvard University] Cabinet with an hundred and fifty specimens of these two productions."
Parker Cleaveland was originally hired on March 15, 1805 to teach mathematics and physics at Bowdoin College, but, by 1808, he also endeavored to teach chemistry and a non-credit course in mineralogy (Woods, 1859). It is likely that molybdenite, of unusually high quality for the times, which had been discovered in a sluiceway excavation across the river from the College in 1807 kindled Cleaveland's interest in mineralogy. As molybdenite was still poorly known at this time, it must have elicited numerous requests for specimens and Cleaveland undoubtedly received specimens from other regions in grateful exchange, but at least by Dana (1844), the mineral was noted as having come from Brunswick "but less interesting" [than even other places in Maine]. Cleaveland did eventually trade molybdenite and other minerals with Berzelius, Hätty, Brongniart, and others (Benjamin Burbank, personal communication, 1970). Benjamin Vaughan wrote to Cleaveland (May 26, 1808, BCL): "I am glad that the work of a cabinet of minerals at Brunswick is begun. ... If I see any thing which may be useful. I will send it. ... You will oblige me with the loan of your atmosphere stone from Connecticut [the Weston meteorite fell on December 14, 1807], which we wish much to see. ... I put the second edition of Kirwan by design, as being better than the first. ... I know Mr. Kirwan well [emphasis added]. He is anxious & laborious; has the command of good cabinets ..." Later in the year, Cleaveland wrote to the Bowdoin board of trustees that the college cabinet contained 320 specimens of minerals and rocks of which 217 have just recently arrived at the college. By 1812, Cleaveland (November 20, 1820, BCL) reported that the cabinet included 1661 specimens and Vaughan (April 27, 1812, BCL) wrote a letter of introduction for Mr. Svenin: "... A gentleman belonging to the Russian legation to this country. They wish to be favored with a sight of your cabinet & college... with Mr. Svenin you will have the means perhaps of making arrangements for the exchange of domestic for Siberian & other Russian minerals." Also in 1812, Adam Seybert had sold his 2000 cataloged specimens to the Academy of Natural Sciences of Philadelphia (Greene and Burke, 1978).

AMERICAN MINERALOGICAL REFERENCE BOOKS

The second way that a mineralogist could know if he had a new mineral would be by examining systematic mineralogy books. Of course, there is the problem of whose species listings you were using. Vaughan (October 1, 1808, BCL) wrote to Cleaveland: "I send you Kirwan [1794-1796] for a short period; but he is my right hand man among the English." However, if you had chosen to use books by Hätty, Babington, Werner, Cronstedt, Berzelius, etc., you would have found extensive disagreement on what species were listed. It should be noted that even the feldspars and micas were not particularly separated into species, as we understand them, until the 1840's. The pre-1820 era of American mineralogy suffered from a lack of reference works to read.

The first book on mining and, therefore, containing references to minerals, written by someone residing in the new world, was by Barba (1640), but the book was printed in Spain. In 1795, Andrés del Río published his Elementos de Ornitognosia in Philadelphia, though it is uncertain if any were ever sold in the United States as new copies. Apparently the same Bartram, as mentioned above, published an English translation of a work by Axel Cronstedt, first in The Encyclopedia Britannica, and later as an independent extract, in Philadelphia in 1798. Apparently, no other mineralogical books were published in the western hemisphere until a reprint appeared in Philadelphia in 1815 of Arthur Aikin's Manual of Mineralogy. William Phillips' very
elementary Outline of Mineralogy and Geology was reprinted in New York in 1816 after its being successfully being received in England. The reason that British mineralogy books began to be reprinted, in the USA, lay in the high cost of shipment added to the price of expensive specialized books intended for a small audience.

Part of the delay in the publication of mineralogical books by English speaking residents in the western hemisphere lay in a proposal reported on by Joseph Tilden to Cleaveland (June 23, 1810, BCL): "Mr. Godon has issued proposals for his elementary work on mineralogy probably you have one, he certainly has it in his power to make a very good book. I have my doubts whether he will say much on Geognosie [geology] on this branch his opinions seem to want a foundation - but in his descriptions of particular minerals I think he will do better than his predecessors; to be sure. I am afraid he will cudgel our brains, with hard words Synonyms, & amphibious names[.]" Godon eventually went to debtor's prison and never wrote on mineralogy again. After several years, Cleaveland began thinking of revising Thomson's [1802?] mineralogy. John Gorham (April 10, 1813, BCL) of Boston advised Cleaveland that a publisher had been contacted on his behalf and Gorham further advised Cleaveland on negotiating with the intended publisher: Cummings and Hilliard. A full account of Cleaveland's reaching the realization that an original work was needed includes the idea that Vaughan and Silliman were his principle advisors. There was also a role that the publishers played in the final form of Cleaveland's mineralogies (King, in preparation). Although the publication date of Cleaveland's textbook is listed as 1816, only Benjamin Silliman and possibly a few other people had seen the first edition in that year as the bindery did not make delivery of the book until January, 1817.

Not withstanding Cleaveland's attempt at trying to write a universal mineralogy, he wrote to Silliman (May 22, 1817, YUL): "You have probably seen Jameson's 2d edition, and can therefore judge how much my book is in arrears of the actual state of mineralogical science." Silliman revealed to Cleaveland (June 19, 1817, BCL): "As to Jameson's last edition - it costs I think 23 dollars for 3 vols. & this has prevented my buying it either for myself or the college & I have not read much in it, but my impression is that it is much improved & particularly that it is 'done into English' & ... of some portion of its revolting German Barbarisms." While a dollar for a 10 to 12 hour work day may have been adequate wages for a common laborer toward the end of the nineteenth century, at the beginning of that century, Jameson's work would have cost many months wages of 12 to 16 hour days.
With this summation of mineralogical cabinets, reference works, and formal education, there is now a perspective to examine some of the first attempts at naming American minerals. Cleaveland (1816) provided American mineralogists with the temerity they formerly lacked. A comprehensive description of mineral species resulted in the recognition of many "new" additional minerals. The flood of new minerals included (by author and date): pulverulent or crystallized carbonates of magnesia (=hydromagnesite, Pierce (1818)), neconite (=microcline, Hayden, 1819); brucite of Gibbs (1819), and schoarite (=barite, Eaton in Macneven (1819)). Europeans did manage to recognize new species among American finds: e.g. franklinite (Berthier, 1819).

CELESTINE

Celestine was acquired by a German traveler named Schütz (1791) while visiting the USA. The full locality designation including old names is: Wills Creek Formation, Wills Creek tributary of Little Juanita River, western foot of north limb of Brush Mountain, Tyrone Township, 2 km from Bellwood (formerly Bell's Mills) [Antis Township], north of Frankstown, Blair County, Pennsylvania (Hamilton, 1950). The mineral, if it were ordinary celestine might have gone unnoticed for another century had it not been for its unusual appearance. The original celestine occurred in light grayish blue parallel, though locally curved, fibrous aggregates which have the length of the fibers perpendicular to the vein. Such texture is known from only a handful of localities around the world, today, and has a distinctive enough appearance to attract the attention of even a member of the general public. As the material did not effervesce in acid and was harder than satin spar, it must have become an instant curiosity. The German school of mineralogy, established by Abraham Werner (1774), was based on the knowledge of the external characteristics of a specimen and this material did not fit any known mineral's description. Had this celestine occurred in crystals or cleavage intergrowths, it would not have been a curiosity, but for it’s actually undistinguished color.

The mineral was originally named by Schütz (1791) "fasriger schwerspath" (fibrous heavy spar) and thus constitutes the first description for what was soon to be renamed celestine. Some of Schütz’s fasriger schwerspath was examined by Martin Klaproth (1797), one of the foremost analytical chemists of his day and one who still is widely remembered as the discoverer.
of uranium, etc. The USA mineral was found to consist of strontia, now given as SrO₂, and was described (or named) by Klaproth: "schwefelsaurer Strontianit aus Pennsylvanien". Subsequently, Luis Vauquelin (in Dolomieu, 1798) also discovered what was to be named celestine, among specimens which had been acquired in 1781, by Déodat Dolomieu, from Sicily. This material was described (or named) "Strontiane sulfatée", but by the laws of priority, discovery rests with those who make the first announcement in print. The Sicilian celestine is generally colorless to white and occurs in crystals resembling barite. Part of the excitement in all of this interest in celestine was the fact that the new element strontium was only suspected in 1791 and only named in 1792. Chemists, as well as mineralogists, were eager to study a new mineral and/or a new element.

Finally in 1798 (in Emmerling, 1799), Werner re-named the Pennsylvanian mineral "Zoelestin" for the light blue color of the sky in allusion to the delicate color of the type material. Celestine continued to receive new names including sicilianite and schützite. Cleveland (1816, 1822), even though he was a Wernerian geologist, was mineralogically mostly influenced by the French, Brongniart in particular, and listed celestine as "sulphate of strontian". Other Wernerians, such as Jameson, used their mentor’s nomenclature and gradually, celestine became the name of choice, especially as mineralogy was becoming impatient with the binomial, if not "multi-nomial" nomenclature temporarily borrowed from biology and chemistry. Dana (1850) was among the last to abandon multiple names for minerals and when he did, his reputation as an internationally important systematist greatly improved. Dana and Brush (1868) arbitrarily changed celestine to celestite. Of course, many subsequent studies have continued to improve on the definition of celestine even up to the determination of its crystal structure, but there doesn’t seem to have been a time when the mineral’s definition was ever in doubt.

BRUCITE I

The first brucite (Gibbs, 1819) was the name given to what is now probably called norbergite. About 1811, Bruce had initially discovered the mineral in Sussex County, New Jersey, probably in Sparta, and he informally called it float of magnesia. Cleveland (1816) noticed it without description. An unrecorded amount of time later, Bruce’s student, William Langstaff, discovered silica in the mineral and John Torrey confirmed it by 1819 (Thomson, 1828; Greene and Burke, 1978). Based on Langstaff’s work and with his permission, Gibbs (1819) erected the new species. Unfortunately, many specimens of "brucite" had been sent to Haüy and other European mineralogists and, based on these specimens, Berzelius concluded that "brucite" was actually chondrodite - a Swedish mineral named in 1817, even though the American mineral was stated to contain fluorine and the Swedish mineral was not. Cleveland (1822) kept "brucite" as a species and listed chondrodite as a synonym. Nuttall (1822b) provided a new analysis of the New Jersey chondrodite and apparently was criticized because of what appeared to be an American capitulation. In the same article, Nuttall named maculurite for a chondrodite-like mineral from nearby Franklin. Seybert (1822) showed Nuttall (1822b) to be in error and discredited maculurite and named maculurite (new spelling). A bitter controversy appeared in print. In Vanuxem (1823), maculurite was unconvincingly argued to be a lamellar variety of pyroxene. Robinson (1825) described, rather confusedly, both brucite ("or chondrodite") and maculurite from Franklin. Alger (1844) championed the American cause by offering "Langstaffite" among the synonymy (in small font) of condrodite [sic] and indicated the mineral was also called brucite. Both brucite and
condrodite were in the same large size font and were followed by synonyms in a small font. Alger (1844) also provided his own account of the controversy and noted that he could not locate the reference containing Berzelius' analysis. Even currently, it is not an easy task to distinguish norbergite (née brucite) and chondrodite and if the reputation of Berzelius had not been behind the discrediting of the first brucite, Dana (1850) might have discredited chondrodite instead.

**BRUCITE II**

Brucite or native magnesia as it was originally known (Bruce, 1810a), was the first new mineral described by an American. Aikin (1815) re-named it, more appropriately, *hydrate of magnesia*. Actually, Bruce (1810a) acknowledged that the name had already been appropriated by Brochant. In effect, Bruce discredited Brochant's native magnesia so that he could put forward his own. Bruce's chemical analysis is entirely acceptable as that of a brucite, though without the added decimal points of precision required by modern standards. Mitchell, in Phillips (1818), somewhat belatedly had the opportunity to claim: "I had this mineral in my possession for several years, without knowing what it was. ... Dr. Bruce at length undertook a chemical analysis of the mineral..." Beudant (1824), who renamed many old minerals and many of whose names we use today, was not content to allow a multi-word chemical name stand for an "espèce unique". He gave native magnesia the name brucite in recognition of it's first describer and probably in consolation for what had happened to the earlier brucite. Shepard (1835) continued to use native magnesia. Ultimately, the new brucite did not receive nearly the same attention that celestine did. Magnesia had been relatively well studied for over half a century so chemists did not jump onto the research bandwagon with it's discovery as it was a straightforward completely understood compound. An unfortunate occurrence of the rare fibrous variety of brucite at Hoboken led Nuttall (1822a) to name it nemalite and, because it was reported to be "silicious", was unchallenged as a unique species until 1846. This confusion prevented American mineralogists from instantly accepting Beudant's (1824) brucite II. A great deal of enmity had been already invested by Americans in trying to maintain brucite I.

**ZINCITE**

Red Oxide of Zinc was named by Bruce (1810b) and was the second mineral description done entirely in America. The description was detailed and the chemical analysis was entirely satisfactory. Further, sufficient attention was paid to the differences between it and other red minerals as to show the uniqueness of the

*Figure 3: Brucite*
mineral and reveal that Bruce was a competent mineralogist. Throughout a number of European systematic mineralogical works, this mineral is referred in some variation of "zinc oxide" until Haidinger (1845) used the name "zinkit" in the form it appears today, but with the German spelling. Zincite, too, has resisted renaming; although spartalite and sterlingite (of Alger, 1844) were suggested. Although zincite has been reported in Europe, most of the "occurrences" were ore piles shipped from the original locality at Franklin, New Jersey or were deposits in refinery chimneys. Zincite has partly resisted renaming due to its extreme rarity.

CONCLUSION

What all of this discussion on the naming of minerals illustrates is that the progress of any science is such that the discoveries are relatively easily learned by students, but are hard won by practitioners who are on science’s leading edge. The above species, at least when given their modern names, are found in most mineral collections. A collector still can go into the appropriate localities and pick up specimens of these substances and immediately recognize them. The stories of these minerals, along with the context of their discovery times, illustrates that it is new knowledge which is the most difficult to acquire. Isaac Newton was far too modest when he declared: "If I saw further, it was because I stood on the shoulders of giants."

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HYDROXYL-HERDERITE FROM MAINE, ITS CONTROVERSY AND THE ROLE OF GEORGE KUNZ

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INTRODUCTION

Hydroxyl-herderite is an uncommon calcium beryllium phosphate hydroxide found in several gem-bearing pegmatites, as well as in a few other rock types. It is known in extraordinary specimens in Pakistan and Brazil. In 1828, Wilhelm Haidinger named a calcium beryllium phosphate fluoride for Baron von Herder who was director of the mines in Saxony. Several factors led to the controversy which follows. A contributing factor is that there are virtually no known specimens of herderite, there being but a single gemstone, from Brazil, to represent the species, even today. Hydroxyl-herderite dominates the field.

Originally, in the description of herderite, no chemical analysis was offered and Dana and Brush (1868) stated that Turner and Plattner had determined, probably qualitatively, that herderite was "an anhydrous phosphate of alumina and lime with fluorine." The correct composition was established by Hidden and Mackintosh (1884) using newly discovered specimens from Maine. The Saxon specimens either were entirely consumed for chemical analysis during the debate on its definition, reside in anonymous collections, or were destroyed during the several wars which have destroyed many German museums.

Although a rare mineral, herderite's status was unquestioned until the 1880's when similar specimens began to be found at the Lord Hill pegmatite in Stoneham, Maine. Not long afterwards, more herderite-like mineral was found in other Maine localities. A flurry of activity began and was reported in the scientific literature. The point was not merely to properly identify herderite as much as to verify that water, as hydroxyl, could substitute for fluorine. The verification of such a principle would have far reaching concerns for all minerals, not for just an otherwise obscure phosphate. During the latter part of the nineteenth century, the fact of hydroxyl's role in minerals was only tentatively ascribed to a simple replacement of fluorine. George Kunz was a background figure in the research which ensued. He procured the specimens, drew the scientists' attention to them, and distributed much information between interested scientists.

THE HYDROXYL-FLUORINE PROBLEM

Why anyone would get worked up about hydroxyl and fluorine is perhaps a mystery at this late date. However, the state of mineralogy and chemistry during that time period is what needs to be understood. A charming contemporary account is given by Phelps (1847): "You will perhaps smile when you learn, that chemists have placed among the elements, a substance which does not exist, or, at least, which has never yet been obtained. But such is the case, and the name which they have given to this imaginary element is fluorine. ... We shall not attempt to say any
thing about this fluorine, which, like the hero of a novel, has but an imaginary existence. Fluoric acid has hitherto resisted all attempts to decompose it, so that, if fluorine does exist, it is so well satisfied with the companion to which it is united, that no temptations can induce it to separate. Of course, much was known about the mineral fluorite from which the element derives its name. Fluorite was named for its easy fusibility and this property as a fluxing agent was noted as early as Agricola (1530). Accum (1800) reported that the unusual acidic properties of fluorite, when it was treated with strong mineral acids, were known as early as 1670 when glass etching can be said to have begun. Progress in the understanding of fluorine was slow and at least three analytical chemists were martyrs to science in the study of the element’s reactions (Weeks, 1945). Several other scientists were severely poisoned by fluorine including Sir Humphrey Davy. Wounds caused by hydrofluoric acid can require over three years to heal. Fluorine was finally proven to be an element by Ferdinand Moissan in 1886. It is no wonder that the analysis of herderite became a cause célèbre.

EARLY MINERALOGICAL STUDIES

Although several fluorine-bearing minerals were known quite early, one of the first, which added to the subject of this paper, was Breithaupt’s (1817) mineral, amblygonite: lithium aluminum phosphate fluoride. The second locality in the world for amblygonite was the Mount Rubellite quarry, Hebron, Maine (Brush, 1862). By modern standards, the Hebron mineral was identified properly. Des Cloizeaux’s luck was not as good. In 1863, he thought he had found yet another amblygonite locality in Montebas, Haute Vienne, France, but noted that it had some unusual optical properties from the original mineral. Unbeknownst to Des Cloizeaux, the optical properties of amblygonite, sensu strictu, vary with the fluorine to hydroxyl ratio (Groat, et al., 1990). By 1871, Des Cloizeaux had restudied the French mineral and found it to be deficient in
fluorine and rich in water and began making various proposals to re-name the French mineral montebrasite, especially as it had aberrant optical properties. Pisani (1871) also provided a chemical analysis and used the new name. The great German mineralogist, Karl Rammelsberg (1871), leapt to the defense of German honor and Breithaupt's defense in proclaiming, that the attempt at naming montebrasite was an error. Rammelsberg (1845) had already chemically examined the Pengau, Saxon ambygonite and said that Des Cloizeaux's mineral was not sufficiently different from ambygonite to justify the name. Rammelsberg was right. Undaunted, Des Cloizeaux published a series of papers (1871, 1872a,b, 1873) when a chemical departure was discovered among Montebras samples and he re-applied the name montebrasite to the new compound. Von Kobell (1872a,b) responded that the name montebrasite could not be resurrected as it was originally mis-applied and suggested a different name hebronite, after the American occurrence. Again, the name choice was unfortunate. Hebronite was a perfectly good, fluorine-rich, ambygonite. The new French montebrasite was hydroxyl-rich. Much of the controversy settled on what the philosophy of a species was. For example, Cooke (1863) did not erect a new name for another Hebron mineral which is now called eosporite - the manganese analog of childrenite: "Although there is a difference of over half a degree ..., the general crystallographic characters of the two sets of crystals ... are so nearly the same, that there can be no doubt that the Hebron crystals are a variety of the species, differing perhaps from the English childrenite in some not fundamental point of chemical composition." By 1878, Brush and Dana recognized the manganese-rich character of some Branchville, Connecticut specimens and finally gave the name eosporite to distinguish it from childrenite, but said: "Eosphorite then should be considered merely as a sub-species [emphasis added] under childrenite, related to it in the same way that the lithiophilite from the same locality is to triphylite."

The final piece of the sequence which led to the herderite controversy was given in the same paper as the naming of eosporite. Previously, a fluorine-rich manganese phosphate had been discovered in 1802 and was re-named triplite by Hausmann (1813). Brush and Dana (1878) stated that their new mineral triploidite, while related to triplite, was a manganese phosphate hydroxide was "entirely free of fluorine." As a note of added proof, they explained: "It should be stated that the perfect transparency and brilliant luster of the crystals analyzed prove beyond all question that the absence of fluorine and the presence of water (determined directly) are not due to any alteration. The fact that all the bases are in the lower state of oxidation would be confirmatory evidence were it needed. The
conclusion to which we are led is this - that in the compound triploidite the radical hydroxyl (OH) plays the same part as the element fluorine, the molecule R(OH)₂ taking the place of the RF₂. Triploidite was not called a sub-species of triplite, however. Evidently, the stakes were higher when it came to fluorine.

PRELUDE TO THE HERDERITE PROBLEM

Topaz from Stoneham was significant, as well. Kunz (1883), in one of his very first papers, reported that he had discovered the mineral at this locality (Kunz, 1884): "Associated with topaz that exceed in size and perfection those as yet found at any American locality. The topazes were in perfect crystals." The topaz had been discovered in 1882 and is easy to surmise that Kunz began selling these fine crystals as well as masses to scientists, museums, and collectors. Bradbury (1883) reported on the chemical analysis of topaz from Lord Hill which suggested it was deficient in fluorine and rich in water. If this were true, the results of Dana and Penfield would have been confirmed. Unfortunately, Clarke and Diller (1885) reported: "In the later part of 1883, Mr. C. M. Bradbury published an analysis of the Stoneham topaz, which, if correct, would show the mineral to be quite unlike any topaz hitherto known. His results ... make the proportions of fluorine half as high again as the generally accepted formula would require. ... If we now consider these analyses..., we find first that the topaz itself is ordinary topaz, having none of the anomalous character indicated by Mr. Bradbury's work." Genth (1886) also analyzed the mineral: "I made last fall, at the suggestion of Mr. G. F. Kunz, an analysis of the Stoneham topaz, of which he furnished me [emphasis added] with a perfectly transparent and colorless fragment, in order to clear up the doubt then existing about its composition, on account of an analysis published by Mr. C. M. Bradbury ... which gave very unusual results." By 1894, Penfield and Minor could observe:

"The chemical composition of topaz has never been satisfactorily settled. The results of the analyses thus far published show clearly that silicon and aluminum are present in the proportion 1:2, but the percentage fluorine as given in them varies from 16.12-18.83. The formula that is usually accepted is that of Groth [Al(O,F₂)]AlSiO₄, corresponding to an isomorphous mixture of (AlF₂)AlSiO₄ with the andalusite molecule (AlO)AlSiO₄ in which the former predominates and which fluorine is supposed to be replaced by oxygen....

Since it has been shown by one of us that hydroxyl so frequently replaces fluorine, and it now seems very doubtful if bivalent oxygen ever plays this role, the idea has suggested itself that perhaps the variations in the percentage of fluorine and the failure to yield a simple ratio are due to the partial replacement of fluorine by hydroxyl [emphasis added]. Accordingly tests were made for water and it has been found to be always present. This fact seems to have been generally overlooked."

While the fluorine controversy in topaz was a mere flare-up, the significance of a second fluorine-bearing mineral at the locality may have elicited more interest, especially it was not as well-known as topaz and as the differences in the herderite-like mineral appeared to be real.
GEORGE FREDERICK KUNZ

George Kunz was born in Hoboken, New Jersey on September 29, 1856 (Whitlock, 1933). He developed a lifelong and consuming interest in minerals and gems. He will long be remembered for his prolific output of 531 articles and books on these subjects, but more likely his immortality lies in the naming of “kunzite” in his honor. In 1879, at age 22 or 23, he had acquired significant knowledge to be hired by Tiffany and Company as their "gem expert." Kunz was a part-time mineral dealer in his youth and while at Tiffany's he continued selling minerals as the company's agent.

By the age of 25 or 26, he had published his first report on Maine tourmaline (Kunz, 1881). From this modest beginning, he continued all of his life to publish numerous articles concerning the minerals and gems of Maine, as well as of the rest of the world. The newly opening mines in Maine provided source material for him to write about and which helped him to greatly expand his reputation at an early age. Whitlock's (1933) bibliography of Kunz shows 22 articles issued up to the year 1890 which refer, at least in passing, to Maine. In 1887, an article on gemstones in Harper's New Monthly Magazine contained the first chromolithograph ever to appear in a magazine. The color plate featured 17 different gems, crystals, and artifacts of which four are from Maine: Mount Mica tourmaline crystals, a cut Stow amethyst, and the remarkable Stoneham aquamarine now in the Field museum in Chicago.

Kunz's letters indicate that he frequented the still famous small resort, the Poland Spring Inn, near Mount Apatite. Kunz was self-taught in gems and minerals and his Ph.D. degree was honorarily bestowed by the University of Marburg in 1906 and Knox University honored him in 1907 with a D.Sc. (Conklin, 1986, Whitlock, 1933).

HERDERITE

"Herderite" was first identified from America by Hidden (1884). Hidden's original material had been labeled "topaz" due to a slight crystallographic similarity of the two species, but detailed study, including a partial chemical analysis, revealed it's true identity. Dana (1884) added a follow-up paragraph in support of Hidden's identification. Des Cloizeaux (1884) studied some Stoneham specimens and concluded that they were identical to herderite specimens from Saxony. Hidden and Mackintosh (1884) provided a complete chemical analysis and discovered that the supposed alumina was, in fact, beryllia (Be₂O₃). They concluded: "These results, together with previously obtained crystallographic data, seemed to point conclusively to the fact that it was herderite, or a new mineral species. ... Should it prove to be otherwise [i.e. not herderite], we suggest the name Glucinite as appropriate." Several factors had emerged. What was herderite and of what significance was fluorine? Topaz and herderite had been found together in Saxony and it appeared to be the same in Maine. Given the fresh topaz affair, the general problem had become attractive due to its notoriety.
F. A. Genth wrote to Kunz on September 23, 1884 (Conklin, 1886): "I am at work with the herderite analysis. If the statement of Weisbach that H. does not contain fluorine according to Winkler, is correct, then Winkler overlooked it, it gives a strong reaction. I am just now engaged with a preliminary analysis, for which I have sacrificed one of my specimens. On ignition a part of the fluorine is lost.- It will be a very difficult and troublesome analysis. I will try to push it as fast as I can and then publish the results wherever this can be done quickest.- in Science or Am. Journ. of Science, Ramsen's Am. Journ. of Chemistry or Proc. Am. Phil. Soc.- I thought perhaps Science the best place but don't know. Then I will look up what has been done by Winkler, if it is already published.- I had a letter from Schuchardt, who was much pleased with the herderites which I bought for him from Hidden. He wants me to try to buy him an additional quantity and asks how much money I would require for that purpose which he would remit immediately.- Now let me know definitely what you are willing to do.- Sch. wants me to get them from Hidden but it makes no difference where I get them if only make the best bargain for him." Several days later he again wrote to Kunz (September 27, 1884, AMNHL), "I expected that I had already about $46- but his [Schuchardt's] draft was not honored; otherwise I would have invested the amount in Herderites. ... The herderite analysis is far more troublesome than I had anticipated, although I know that it was not easy. The preliminary analysis gave on ignition w[ith] loss of about 4%, so I thought there might be some water, but the best - xts gave from $1/3$ grm only 2 milligrams loss which is probably owing to the slight volatility of lead fluoride, and therefore the mineral contains no water. The topaz analysis - of colorless cleavage pieces- is commenced. ... Also a difficult analysis." (Notes: 1. Genth had fallen into a trap that Penfield didn't. 2. The failure of a bank to honor a draft might have been a bureaucratic problem as in those times non-corporate banks might not honor each other's checks.)

The fervent interest in being the first to make a discovery was revealed when Genth contacted Kunz (October 6, 1884, AMNHL): "The analysis of herderite is progressing and I hope to finish it in the course of next week and intend to read my paper on 3d Friday of this month, and have it printed immediately; therefore let me have the remarks which you wanted to make in time to insert in my paper. You have undoubtedly seen Winkler's analysis in the last number of the Journal of Science. His analysis I may say already is erroneous. But I have just commenced the analysis of the best xts and when finished we will see the differences." Genth published his results in the Proceedings of the American Philosophical Society in 1884. Another supply of "herderite" came eventually as Genth wrote to Kunz on September 6, 1885 (Conklin, 1886): "Accept my sincere thanks for the beautiful herderites... They are a great acquisition. ... About your Stoneham pseudomorphs I do not know what to do. At present I am almost killed by overwork...", but Genth published again in 1886 to confirm his herderite findings.

Penfield and Harper (1886) provided a "mature" analysis of "herderite", but they neglected to say where the specimen was from, although Penfield (1894) later revealed that the specimen was from Hebron. They did say: "Mackintosh [Hidden and Mackintosh, 1884] made no tests for water, and considered the mineral to be an anhydrous phosphate with fluorine. Winkler [1884, Neues Jahrbuch für Mineralogie, Band II, p.134] made no determination of fluorine and obtained no satisfactory tests for that element by etching glass. ... [Genth, 1884] proved conclusively that fluorine was given off by strong ignition, and concludes that it is replaced in part at least by oxygen. We are scarcely willing to believe that such a reaction would take place on heating an
anhydrous phosphate containing fluorine. ... In our experience we have never seen any hydrous fluoride which gives off such strongly acid water and such a marked fluorine reaction." Nathan Perry was the actual miner at Stoneham as well as in Auburn. Several of the early papers acknowledge Perry's having provided the research samples studied, but several papers simply credit Kunz. Concerning a package of mineral specimens, Kunz wrote to Perry (August 16, 1886, RPH): "I will keep the Herderite and Muscovite thus our acct. stands as follows. I think on the first lot $105.95. You can well make it $95 since there are few really fine things." The herderite was priced at $25 additional - a truly princely sum at the time for a non-gem mineral specimen. The clustered dates of the preserved Perry-Kunz correspondence suggests that although replies were usually very prompt, there is an apparent hiatus from the last cited letter broken by Perry's brusque reply (October 14, 1886, AMNHL) accepting the counter cash-offer and Perry explained: "I will not banter prices about price of last box[,] suit yourself in regards to it." In the same letter Perry offered: "I have two specimens of herderite with xls. 1/2 inch across call the two worth $10. have small blue apatite xls not best quality - also zircons and very small topaz xls. will send some of these on approval if you care for them, [I] do not value them very high." At a later date (February 4, 1888, RPHL), Kunz wrote to Perry: "...I am very glad to hear that you intend doing some active collecting, during the coming summer and also that you will promise me a fair share of the fine things that you will obtain. I wish that you would make a special effort for the herderite and I think from this locality that it will be worth while getting some more of it."

In 1885, Kunz said, indirectly citing a Perry letter, that Lord Hill had "furnished scarcely a fair crystal during the year [1884]" and: "The topaz locality (Lord Hill), though it produced no topaz, from other minerals yielded the workers [Perry] over $500 by the sale of herderite, columbite, and associated minerals." probably mostly herderite. On November 4, 1886 (AMNHL) Perry told Kunz of his plans: "As soon as I can attend to it - will send the herderite - and a few other things."

The herderite problem was resolved in the 1890's. Wells and Penfield (1892) commented: "The analysis shows the mineral to be a new and interesting variety of herderite almost free from fluorine. The result confirms the idea advanced by Penfield and Harper that fluorine and hydroxyl are mutually replaceable in herderite, and the formula deduced by them for the mineral is confirmed." Finally, Penfield (1894) decided that a new name was in order: "The analyses indicate a well defined type of herderite which may well be called hydro-herderite in distinction from the variety containing fluorine. ... As we speak of fluorapatite and chlorapatite, so can we distinguish hydro-herderite..."

AFTER THE PROBLEM

The realization of fluorine's role in minerals had started 14 years earlier and closure had been achieved. Interest in hydro-herderite remained high as Thomas Lamb, a miner in Auburn, said to George Kunz (October 18, 1896, AMNHL), "... I will do the best I can for you. the Herderite
belongs to other parties and I will try and have them send it to you. They have got some very fine crystals besides the large one[,] the man who has the selling of them is Mr J S Towne of Brunswick Me. I shall write him to send the big crystal of Herderite to you." Palache et al. (1951) renamed hydroxyl-herderite from the earlier "hydro-herderite". Interest in hydroxyl-herderite continues to remain high in Maine given its heritage in solving a mineralogical problem and its association with so many prestigious scientists.

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THE STERLING MINE - WHO KNEW?

Vernon L. Phillips, 41674 County Line Road, Gouverneur, NY 13642

The Sterling Mine, Antwerp, Jefferson County, New York, is the first and foremost American locality for the nickel sulfide, millerite. This you may have known already, but the Sterling Mine, like a ghost, has many treasures yet to be uncovered.

One of the treasures has recently been discovered. In 1995 a very fine specimen of pectoralite pseudomorph after millerite was found. This specimen has been acquired by the New York State Museum in Albany, New York.


One of the controversies arise from the Mineralogical Record article, page 200, “Today the Sterling Mine property is owned by Raymond Villeneuve. Permission to collect must be secured from Mr. Villeneuve whose farm is on the east side of Route 11, approximately 1 km south of the old lane which leads to the mine.” This paper presents information that has been uncovered regarding ownership of the mine.

BACKGROUND

If the reader has collected at the mine, you may have remembered a rock shop called Sterling Gems and Minerals, owned and operated by Bob and Ruth Johnson. If
collectors stopped to talk minerals with them or to make purchases at their shop, they may have been instructed about the millerite found back in the waste piles and how to find them. For this information Bob would ask $2.00. Bob might have mentioned something about the Sterling Mine being owned by someone from out of the state of New York. Collectors going back there to collect remember a lane with a fence on both sides with agate across this lane.

Since I was working in the mines at St. Joe Resources, Balmat, New York, now known as Zinc Corporation of America (ZCA), I really had my own mineral collecting site. So the thought
of collecting and doing research on the Sterling Mine never entered my mind. As time went on though, I had heard of others that said they had heard of a woman from out of state owning the mine.

In 1993, the author accidentally stumbled onto some information about this rumor. The Sterling Mines was on maps, showing a railroad spur from Antwerp going to it's terminus (fig. 1). A county tax map coincides with this map (fig. 1) but the county tax map shows in the space of the Sterling Mine the letters J.K..

Figure 3 - Jefferson County Tax Records
RESEARCH

Not knowing who belonged to these letters created some confusion. On that same railroad spur (fig. 1) you will notice several other mines. On the county tax map, in the same general location one will find the name Jane Kelly, J.K. Could it be the woman from out of state?

At the county clerk 5 office the answer was found. The Old Sterling Mine was in the name of a woman from out of state, Jane Olive Perrigo Connolly Kelly, or J.K. If you look at (fig.3) and (fig.4), you notice parcel number: section 25.00, block 2, lot 2, and section 25.00, block 2, lot 13. Compare this to (fig.2), the County tax assessor has section 25.00, block 2, lot 2 listed as US Rt. 11, WO 720, Mining and Quarrying, Indian River 222401, Acres 10.60, East 076016-North 154601, and section 25.00, block 2, lot 13 listed as being off US Rt. 11, XZ 729, Misc. Mining, Indian River 222401, Acres 19.70, East-075795-North-154412.

A letter was sent to Jane Kelly on March 11, 1993. There was no response to this letter.

Tax records for the next two showed they were paid promptly within a short period of time. Another letter was sent on Feb. 1, 1994, only this time via certified registered return receipt requested. Upon receiving the return receipt, the signature was not legible. Still no response! Phone calls were attempted too, with no success. The Post Office said that they would send them another return receipt requesting a legible signature, and to have it sent directly to the author.

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Figure 4 - Jefferson County Tax Records
RESULTS

On Feb. 17, 1944 at 9 A.M., before receiving this return receipt the author received a phone call. My wife, Rose, told me to let me know that I had a call from that lady in Florida. Finally we had made contact with Jane Kelly. She didn’t know why anyone could not reach her by phone. (The problem was the number was listed in his name and not hers.) His name had not yet show up anywhere. Until a few days later when I received the second return receipt. There was a legible signature, Jane Jelly’s husband, Phillip Kelley.

The story starts to unfold more now. Jane Kelly talked about the area, her land, and friends and people she knew from the area. One friend in particular the author made arrangements to meet. We visited for some time and talked about Jane and the Sterling Mine. More was learned about Jane Kelly and her family.

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Figure 5 - Public Tax Sale Notice published in Watertown Daily Times, February 12 and 26, 1944.
A call on December 18, her birthday, to Jane Kelly was answered by Olive Lane Horning, Jane Kelley’s daughter. She knew who of the author because her mom had told her about our conversations. Olive had been to Gouverneur, New York in August 1994. She had attended the Annual Miner’s Mineralogical Rock, Mineral and Gem Show. The show was organized and chaired by this writer. Olive also said she had signed our guest book and her address was there. Since then Olive visited the 1995 Miner’s Mineralogical Rock, Mineral, and Gem Show and visited the author’s home for quite some time.

In our conservation it was mentioned by Olive that her morn had bought some land for back taxes, verified by checking the Public Library and Watertown Daily Times (fig. 5). It was in 1944. Jane Kelley has paid her taxes on the Old Sterling Mining Company right to the present time.

Since then Olive has researched her mother’s property. She has had an abstract drawn up recently and is proof that Jane Kelley is the true owner of the Sterling Mine. Not only the Sterling Mine, but remember where her name was on the county tax map(fig.2). That’s right she also owns the Dickson Mine and another parcel of land 1.8 Acres on the Indian River, Rt. 11.

Olive was visiting the area because she owned a camp at Sylvia Lake. While at the Mineral Show she was hoping to find a specimen from her mother’s property. She found one and had it made into a necklace for her mother.

Jane Kelley has never had her name mentioned anywhere in the mineral as owner of the Sterling Mine. The family would like nothing more than to have recognition as the true owner of the Old Sterling Mining Company since 1944. It is hoped the latest acquisition of pecoraite pseudomorph after millerite that the New York State Museum recently acquired be named the Jane Kelley Pecoraite.

FUTURE

In conclusion, through efforts by Olive Horning and this author, the Old Sterling Mine will hopefully continue to produce fine millerite and pecoraite pseudomorph after millerite and any other related specimens. If you would like to be a part of this, let us know. We are going to form the Old sterling Mine Mineral Collecting Club. There will be a limited amount of members. If you think you might be interested in becoming a member to this club, please feel free to contact me. There will be a small fee per year of $30.00. There will be rules and regulations you must follow. By asking this small fee it will be giving back something to Jane Kelley and her family what has been taken away for so many years. It’s possible that in the future some of this fee will go towards improving accessibility. Rules will be sent to you along with a membership card, but remember membership is limited. Acceptance will be at the approval of Olive L. Horning and myself, Vernon L. Phillips at 41574 County Line Road, Gouverneur, New York, 13642 or by calling (315)-287-1860.
THE NEW YORK MINERALOGICAL CLUB

On September 21st, 1886 in the home of Professor Daniel S. Martin at 236 West 4th Street, the New York Mineralogical Club was formed through the efforts of George F. Kunz, B. B. Chamberlin and Professor Martin. Monthly meetings followed at the homes of members, with hosts presiding. George F. Kunz was elected Secretary. At the sixth meeting in March, 1887 the name New York Mineralogical Club was officially adopted. A constitution and by-laws were approved at the eighth meeting. No president being required by this Constitution, none was elected until April, 1895 when George F. Kunz became the club's first President, an office he held for many years. At the end of the club's first year it had a membership of forty-six, including many notable mineralogists.

The club's fine collection of more than 700 mineral specimens from New York City is housed at the American Museum of Natural History. The collection includes specimens of beryl, chrysoberyl, garnet, tourmaline, stilbite and xenotime together with many other species.

During the 110 years the club has been in existence several honorary members have been appointed in recognition of contributions in the field of minerals and mineralogy. They include: Joseph Arons, Sir William Henry Bragg*, Russ Buckingham, Lawrence H. Conklin, Madam Marie Curie*, Edward S. Dana*, Clifford Frondel, Victor Goldschmidt*, Richard Hauck, Carl Krotki, Alfred Lacroix*, Charles Palache*, Frederick Pough, Waldemar T. Schaller*, Leonard J. Spencer*, Herbert P. Whitlock*. (*Deceased.)


Currently the club has a membership of over 250. Monthly meetings, with guest lecturer, are held on the second Wednesday of each month (except July and August) at the American Museum of Natural History, New York City. Meetings are open to the public. Frequent field trips are organized to interesting mineral localities in the vicinity of New York City and extended trips to more distant states. Each month a bulletin is published for members and guests with news, announcements and original articles about minerals and gemstones contributed by club members. The New York Mineralogical Club is affiliated with the Eastern Federation of Lapidary and Mineralogical Societies and the American Federation of Mineral Societies.

The club is dedicated to increasing interest in the science of mineralogy through the collecting, describing and displaying of minerals and associated gemstones. Anyone interested in gems and mineralogy is welcome as a member. Dues are $20.00 for individuals, $30.00 for families per calendar year. Inquiries should be addressed to the club at: New York Mineralogical Club, P. O. Box 77, Planetarium Station, New York, NY 10024-0077 or contact membership coordinator.