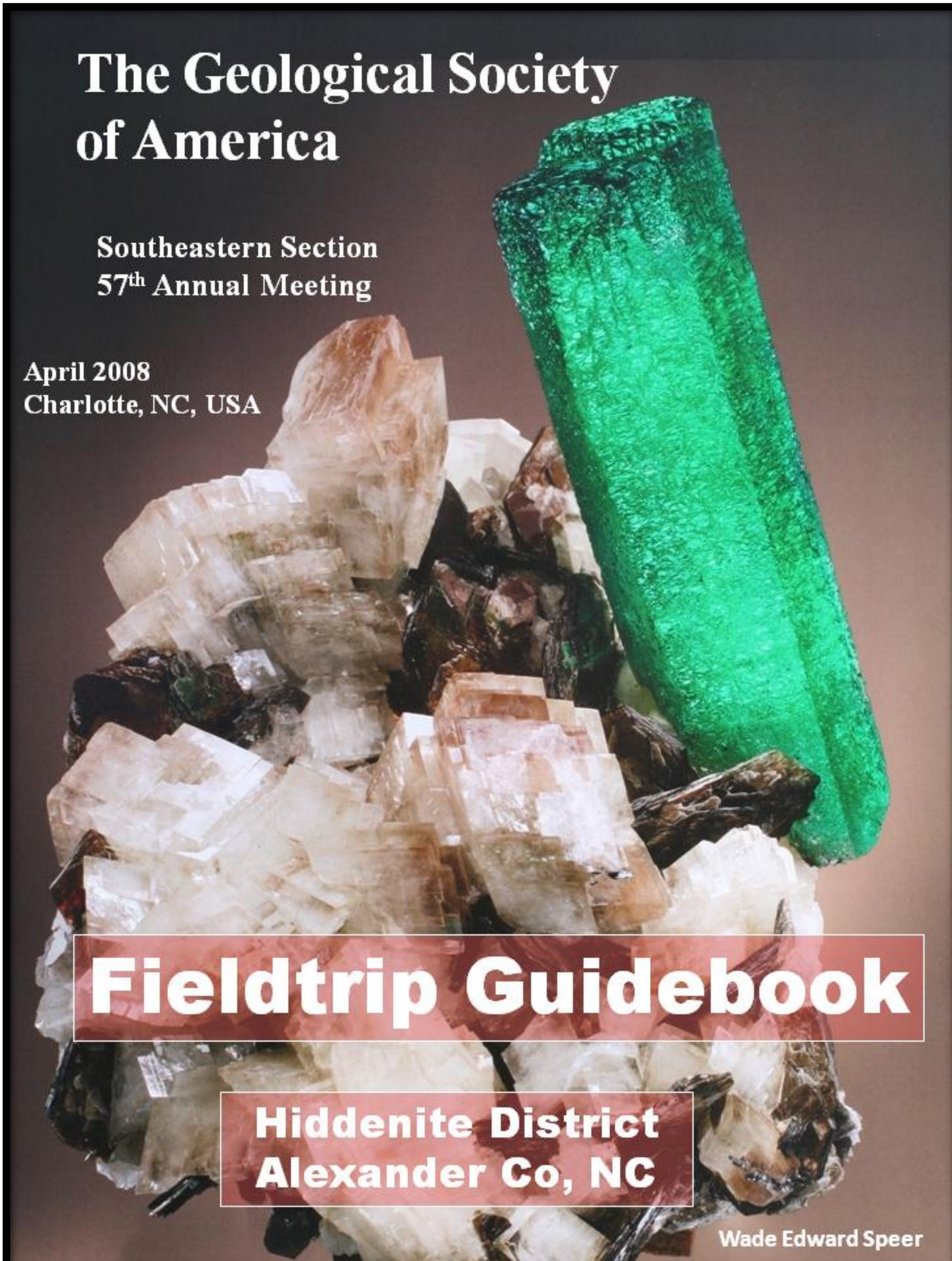
The Geological Society of America

Southeastern Section
57th Annual Meeting

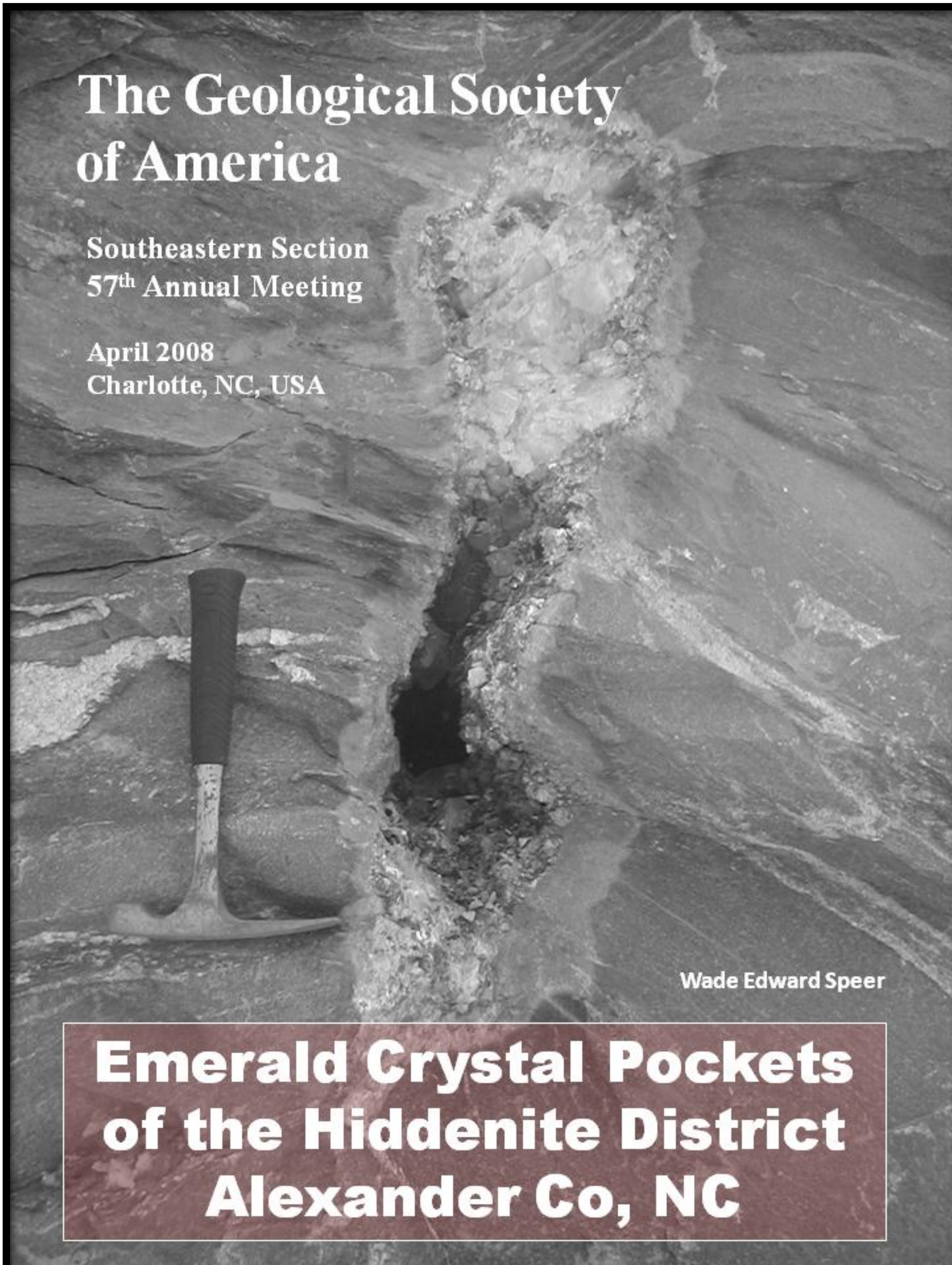
April 2008
Charlotte, NC, USA



Fieldtrip Guidebook

Hiddenite District
Alexander Co, NC

Wade Edward Speer



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Emerald Crystal Pockets of the Hiddenite District Alexander Co, NC

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The Geological Society of America, Southeastern Section 57th Annual Meeting
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Charlotte, NC, USA
Trip Leader: Wade Edward Speer

Emerald Crystal Pockets Of the Hiddenite District Alexander Co., NC

Wade Edward Speer
2008

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Cover photo: ***North America's Largest Emerald Crystal. NAEM mine (formerly the Rist Mine), Hiddenite District, Alexander County, NC; 19.5 cm (7.7 in), 1,869 carats on dolomite and muscovite. Found 2003 by James K. Hill, Jr., owner, North America Emerald Mines, Inc.; resides in the Houston Museum of Natural Science collection, Houston, Texas. Valued at more than $1 million.***
Harold and Erica Van Pelt photo.

Inside cover photo: ***Emerald-bearing quartz vein at the NAEM mine. Note vein steeply crosscuts metamorphic foliation. Vein features include sinuous contacts, a narrow alteration halo and a single crystal-lined open cavity overlain by massive white quartz.***
W.E. Speer photo.

All other photos by W.E. Speer unless indicated otherwise

Acknowledgements
I would like to extend special thanks to James (Jamie) K. Hill, Jr. and North American Emerald Mines, Inc. for providing unlimited access to their mine and data. Additional thanks to John W. Maddry for editing the manuscript and Karen R. Sousa for help preparing the illustrations. Wade Edward Speer, 2008.

Emerald Crystal Pockets of the Hiddenite District

Alexander County, North Carolina

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Abstract

The Hiddenite district has consistently produced North America's largest emeralds since the first discovery in the mid 1870s. The largest emerald is a 1,869 ct, deep-green, hexagonal crystal found in 2003 on the North American Emerald Mines (NAEM) property located on the northeast side of the 2 x 5 km district. This property has produced 70% of the district's estimated 60,000 carats of emerald including 10 of North America's 20 largest emeralds. Recent mine exposures here provide new insights to the geology and mineralogy of these unique deposits.

Emeralds are hosted by complex Alpine Type quartz veins cutting Late Silurian(?) metasedimentary rocks of the tectonostratigraphic Piedmont terrane. This exotic crustal block has a long deformational history involving multiple continental collisions. Host rocks are a sequence of fine grained siliceous sediments that reached sillimanite grade metamorphism and are mapped as migmatitic biotite gneiss of the Brindle Creek thrust sheet.

Typical veins exhibit shattered white cryptocrystalline quartz (crackle breccia) overlying open cavities lined with large euhedral crystals and partially filled with breakdown crystal breccia. The cavities, locally called pockets, occur in approximately 50% of the veins and emeralds occur in approximately 50% of the cavities. Breakdown crystal breccia is a collapse deposit of crystals that have fallen from the ceiling and walls of the cavities over an extended period of time. Re-growth, over-growth, dissolution and cementation of fallen crystals are documented. The hypogene cavity minerals include quartz, muscovite, albite, calcite-siderite-dolomite, rutile, clay, beryl, and sulfides. Hiddenite occurs in only minor amounts on the NAEM property. Emeralds are found as free-standing crystals still attached to cavity walls and as individual collapse fragments. Bleached wall-rock alteration halos up to 9 cm wide and rich in silica and chlorite are common peripheral to veins and crystal cavities.

The veins are interpreted to have originated as hydrothermal filling of tensional sites during the waning ductile/brittle stages of Alleghanian metamorphism about 250-200 Ma. Metamorphic differentiation is proposed to have mobilized and concentrated original sedimentary brines with Be, Li, Cr and V into biotite-rich melanosome layers of the migmatite and these elements were subsequently scavenged from the alteration haloes of crosscutting quartz veins and incorporated into cavity crystals including emerald and hiddenite. Unlike most emerald deposits elsewhere in the world, the NAEM emeralds are not genetically associated with pegmatites or mafic/ultramafic rocks. However, they do have some features in common with the world-famous Columbian emerald deposits.

The large size and superb quality of the emeralds make the Hiddenite district unique in the world. Remarkably, individual emerald crystals average over 50 carats in size and crystals over 1,000 carats account for 8% of the total production. Individual cavities containing up to 3,500 carats of emerald are documented on the NAEM property.

The Hiddenite district emeralds also rank among the most valuable in the world; the 1,869 ct crystal and an incredible 18.8 ct faceted gem are each valued at more than $1 million, in addition to a 7.85 ct faceted gem that sold for the largest amount ever paid per carat for any North American mineral specimen ($78, 850/ct).

Introduction

Recent mining activity by North American Emerald Mines, Inc. (NAEM) has exposed a 2.5 hectare (6 acre) open pit with depths of 20 m (65 ft) that provides the best exposures of unweathered bedrock and quartz veins seen in the district in over 120 years (see photograph at the end of this report). Detailed geologic mapping in this pit reveals new information about the origin and history of the emeralds and their host rocks. Lithologic and tectonic correlation with nearby areas mapped by others provides a framework for understanding the features observed in the NAEM pit. Finally, both published and unpublished mineralogical and chemical data presented here add to our understanding of the origin of the emeralds. This article attempts to compile all the available geological research and proposes some conclusions about the origin and history of the emeralds.

The Hiddenite district is known for large emeralds (beryl, general formula $Al_2Be_3Si_6O_{18}$ and colored by Cr^{+3} and/or V^{+3} substituting for Al^{+3}). In fact, North America's 20 largest emeralds came from Hiddenite (Table 1).

Rank	cts	
1	1,869	Hill Emerald, NAEM mine, 2003, 19.5 cm, HMNS
2	1,686	LKA Emerald, NAEM mine, 1984, 3.8 x 11.4 cm, LKA
3	1,493	Reitzel/Williams/Harwell Twin, Adams mine, 1971, 10.5 x 2.7 cm, (Wilber/Funk), SI
4	1,438	Finger [aka Stevenson] Emerald, NAEM mine, 1969, 5.4 x 7.3 cm, (AGI), LKA
5	1,400	Hill Emerald, NAEM mine, 2007, NAEM
6	1,377	Bolick/Arnold Cluster, Adams mine, 1971, SI, fractured beyond repair
7	1,276	Hidden Emerald, Adams mine, 1886, 7.0 x 4.1 cm, SI
8	1,270	Hidden Emerald, Adams mine, 1881, 21.6 cm, stolen 1950 from AMNH, still missing
9	1,215	Baltzley Twin, NAEM mine, 1970, SI?
10	965	Hill Emerald, NAEM mine, 2006, HMNS
11	934.9	Bolick Twin, Adams mine, 1971, 14.0 x 6.5 x 3.5 cm, (Sharp/Hill-Duncan), HMNS
12	900	Reitzel/Williams/Harwell Twin, Adams mine, 1971, (Morton/Bolick/Barlow), HMNS
13	858	Hill Empress Caroline Emerald, NAEM mine, 1998, SEEC
14	817.5	Baltzley Twin, NAEM mine, 1971, SI?
15	750	Wright Emerald, Ellis mine, 1907, 3.8 x 5.1 cm
16	722.7	Bolick Emerald, Adams mine, 1974, 12 cm, GMNM
17	591	Hill Twin, NAEM mine, 2006, 25.4 cm, NAEM
18	467	Ormond Twin on Goethite, NAEM mine, 1969, 1.4 x 8.9 cm, DA
19	450	Reitzel/Williams/Harwell Emerald, Adams mine, 1971, (Ledford/Tucker), NCMNS
20	433	Reitzel/Williams/Harwell Cluster, Adams mine, 1971, (Ledford), AMNH

Table 1. North America's 20 Largest Emeralds came from the Hiddenite District. The existence of a 1,676 ct emerald rumored found in 1977 at the Crabtree mine in Mitchell Co., NC, is doubtful (Watkins, 1991, p. 62; Sinkankas, 1997, p. 41) and is omitted from this list. Each entry includes rank, size in carats, name of specimen, the mine where found, the year of discovery, the dimensions (if known), interim owners (if known), and the current location of the specimen (if known). Original discoverers are indicated by specimen name while interim owners are given in parenthesis. Discoverers and interim owners include: 'Jamie' James K. Hill, Jr., Hiddenite, NC; 'Red' Robert N. Reitzel, Newton, NC; John Williams, Newton, NC; Jack Harwell, Newton, NC; 'Butch' Michael Finger, Lincolnton, NC; John Adlai Stephenson (1825-1897); William Earl Hidden (1853-1918); William Diehl Baltzley, deceased; Glenn and Kathleen Bolick, Hickory, NC; Kenneth and Patricia Arnold, Newton, NC; Eileen Lackey Sharpe (1909-2004); Hill-Duncan--Lynn Sharpe Hill, Blowing Rock, NC and Shirley Sharpe Duncan, High Point, NC; Hugh MacRae Morton (1921-2006); F. John Barlow (1914-2004); Cary Wright (1836-1908); Lewis Ormond, Kings Mountain, NC; Gary Ledford, Spruce Pine, NC; Paul Tucker, Raleigh, NC; David P. Wilber, Tucson, AZ; Dr. Funk, Baltimore, MD; and AGI, American Gems, Inc. The current location of the above specimens is given by the following abbreviations: AMNH, American Museum of Natural History, New York, NY; DA, Dal-An Museum, location unknown; HMNS, Houston Museum of Natural Science, Houston, Texas; GMNM, Grandfather Mountain Nature Museum, Linville, NC; LKA, LKA International, Inc, Gig Harbor, Washington; NAEM, North American Emerald Mines, Inc., Hiddenite, NC; NCMNS, North Carolina Museum of Natural Sciences, Raleigh, NC; SI, Smithsonian Institution, Washington, DC; and SEEC, Southeastern Emerald Consortium. Data compiled by W.E. Speer from published and unpublished sources as well as interviews.

North America's largest faceted emeralds, shown in Table 2, also came from the Hiddenite district.

carats		
18.85	Carolina Queen 1998 Hill,	valued at +$1 million, see Figure 2
15.47	June Culp Zeitner 1974 Philbeck,	see Figure 18
13.14	Tiffney Carolina 1969 Anthony,	valued at $500,000
8.85	Carolina Duchess 1995 Hill,	set in gold & diamond ring
8.05	Emerald 2003 Hill	
8.01	Emerald 2003 Hill,	exceptional
7.89	Emerald 2003 Hill	
7.85	Carolina Prince 1998 Hill,	sold for $690,000, see Figure 2
5.86	Emerald 2003 Hill	
3.92	Emerald 1974 Philbeck	
3.67	Emerald 1974 Philbeck	
3.52	Emerald 1974 Philbeck	
3.40	Heart of Carolina 1998 Hill	
3.37	Carolina Princess 1998 Hill	
2.68	Marie Emerald 1974 Philbeck,	exceptional
2.02	Emerald 1974 Philbeck	
1.43	Emerald 1974 Philbeck	

Table 2. **North America's Largest Faceted Emeralds came from the Hiddenite District.** Values are inflation adjusted 2007 dollars. All of these emeralds came from the NAEM property except the Carolina Duchess, which came from a nearby property. The 13.14 ct gemstone came from an original 59 ct crystal, while the 18.85 and 7.85 ct gemstones came from a 71 ct crystal, the 8.01, 8.05, 7.89 and 5.86 ct gemstones came from an 84 ct crystal, the 3.67, 2.68 and 1.43 ct gemstones came from a 63.3 ct crystal, and the 3.92, 3.52 and 2.02 gemstones came from a 30.3 ct crystal. The year the parent crystals were found is given, while the discoverers are listed as: 'Jamie' James K. Hill, Jr., Hiddenite, NC; A. Clyde Philbeck, Hickory, NC; and Wayne Anthony, Lincolnton, NC. See Figure 2 for photographs of the Carolina Queen and Carolina Prince, both now mounted in gold and diamond settings, and Figure 18 for a photograph of the June Culp Zeitner which was cut from a 142.25 ct crystal and set in a gold and diamond necklace. The Marie emerald set in the gold and diamond necklace featured on the May 1982 cover of Lapidary Journal has a remarkably high G.I.A. measured birefringence of 0.010 (other gems not measured). Data compiled by W.E. Speer from published and unpublished sources as well as interviews.

While the Hiddenite district is also famous as the discovery site for the rare spodumene mineral hiddenite, $LiAl(SiO_3)_2$, it is emeralds that are the focus of this study. However, both minerals occur in the same group of quartz veins and thus they have many features in common.

Some previous geological investigations were apparently hampered by the limited mine exposures in the well-developed saprolite horizon and reached questionable conclusions about the origin of the emerald and hiddenite mineralization (Sterrett, 1912a-b; Davidson, 1927; Palache and others, 1930; Brown, 1986; Brown and Wilson, 2001). However, the first mention of quartz veins hosting the emeralds and hiddenites come from the early works of Hidden (1880, 1881a-b-c, 1882a-b, 1883, 1885, 1886a-b; and Hidden and Washington, 1887) and Sterrett (1908, 1912b). The more accurate interpretation of Alpine-type quartz vein origins was first mentioned by Palache and others (1930) and first given serious consideration by Sinkankas (1976, 1981a-b, 1982, 1997); see also Wise (2004, 2008), Wise and Anderson (2003, 2006), Freeman and Speer (2008) and Speer (2008).

Although no official records exist, the total production of the entire Hiddenite district (1880-2007) is estimated to be 60,000 carats emerald and 20,000 carats hiddenite. While overshadowed by much larger emerald production from several deposits elsewhere in the world, the fame of the Hiddenite district comes from the unique occurrence of: 1) emerald in North America; 2) the discovery site of hiddenite; 3) emerald and hiddenite occurring together; and 4) the remarkably large size of the emeralds.

First Discovery

Farming led to the first recorded discoveries when unusual green stones were noticed in plowed fields. These were called 'green bolts' and were believed to be the result of lightning strikes that had fused the red soil into green glass (Trapp, 1970; Zeitner, 1982; Smith, 2002). The full value of the crystals was not immediately recognized and some locals used them in sling shots for hunting, while others gave them away. Quartz, rutile and tourmaline crystals were also common in the plowed fields and the agricultural community was called Stony Point, in reference to 'stones with points'.

John Adlai D. Stephenson (1825-1897), a merchant and avid naturalist from nearby Statesville, North Carolina became the first mineral collector to notice the green crystals when he bought some in April of 1875 (Stephenson, 1888). Stephenson developed a clever scheme to acquire mineral specimens for his collection by buying them from the locals, first letting it be known that he offered money for unique specimens and then paying based on the quality of the specimen (Brown and Wilson, 2001).

> ***"My plan of exploration was to go among the people of the country and endeavor to interest them in collecting the different crystals found in their respective sections, this I found an easy matter, especially with the children as they took hold of the idea readily, many of them soon became familiar with the work, and not only did they do good service in developing the mineral resources of the state, but many of them have acquired a good knowledge of mineralogy and general natural history."*** (Stephenson, 1888, p. 2, 3).

Stephenson recognized the emeralds and acquired several from nearby locations, but the original discovery site on the James Washington Warren farm continued to produce new finds. In addition to emeralds, Stephenson also found small fragments of an unknown green crystal that he tentatively called diopside. In 1879, he submitted samples to mineralogist Norman Spang (1843-1922) of Pittsburg, Pennsylvania for identification, but Spang found the samples unsuitable and asked for better quality ones, but none were available.

On September 17, 1879, Stephenson was visited by mineralogist William Earl Hidden (1853-1918), who was in North Carolina looking for platinum deposits (Stephenson, 1888). Having been hired by Thomas Edison to search the southeastern United States for potential platinum sources for use as filaments in Edison's new electric light bulb, Hidden sought out Stephenson and his extensive collection of North Carolina minerals. On the very next day, Stephenson took Hidden to the emerald discovery site on the Warren farm in Alexander County.

Suitably impressed, Hidden returned in 1880, acquired a lease on the farm and began mining for emeralds. His company, later called the Emerald and Hiddenite Mining Company, operated until 1888 and produced many fine emeralds including a remarkable 21.6 cm (8.5 in) long twin crystal of 1,270 carats discovered in 1881 (Hidden, 1881c; Lindsten, 1985) and a near-perfect 7.0 x 4.1 cm (2.75 x 1.6 in) hexagonal crystal of 1,276 carats found in 1886 (Hidden, 1886b; Lindsten, 1985). These two crystals held the distinction of being North America's largest emeralds. The 1,270 carat crystal was stolen from the American Museum of Natural History in New York in 1950 and never recovered (Pough, 1950; Trapp, 1970; Lindsten, 1985), while the 1,276 carat crystal resides in the Smithsonian Institution collection (Table 1).

Hidden was also intrigued by Stephenson's 'diopside' crystals, which were now showing up in his new mine. He sent samples to Dr. J. Lawrence Smith (1818-1883) of Louisville, Kentucky, who immediately identified a previously unknown Cr-green variety of spodumene (Smith, 1881). Smith named the new mineral 'hiddenite' since the samples had been submitted by Hidden. Although Stephenson had actually found the first spodumene specimens, the name hiddenite was accepted.

The new mineral was highly sought after and Hidden reported in 1882 that faceted hiddenites were selling for \$32 to \$200 per carat or \$680 to \$4,250 in 2007 dollars (Hidden, 1882b).

Throughout the 1880s Hidden published numerous accounts of his emerald and hiddenite discoveries in North Carolina (Hidden, 1880, 1881a-b-c, 1882a-b, 1883, 1885, 1886a-b; Hidden and Washington, 1887). The announcement of emeralds and the new spodumene mineral hiddenite created worldwide interest and brought great acclaim to Hidden and North Carolina. The noted American mineralogist, George Fredrick Kunz, also paid tribute to the discoveries and published several accounts (Kunz, 1887, 1907).

Hidden's mine eventually closed due to property disputes and the failure to discover new veins containing emeralds. The total value of emerald and hiddenite production (1880-1888) was reported, in 2007 dollars, to be \$171,000 (Kunz, 1907).

Hidden reported many observations about the emeralds and their mode of occurrence; however the significance of his observations are only now being fully appreciated in light of the recent geological work at the NAEM mine. Hidden's observations include:

1) Crystals occurring in open cavities with collapsed crystals
   - **a.** Emeralds..…***"are found implanted in cavities and not embedded in a matrix, as is the usual case with beryls."*** Hidden, 1880, p. 89.
   - **b.** ***"The gems and crystals occur in open pockets of very limited extent, which are cross-fractures or shrinkage-fissures."*** Hidden, 1882a, p. 501.
   - **c.** ***Emeralds "…occurring in the soil have weathered out of cavities in the rock where they were formed."*** Hidden, 1881b, p. 25
   - **d.** ***"The largest cavity yet discovered had a depth of sixteen feet, and was three feet wide and seven in length."*** Hidden, 1881c, p. 490.
   - **e.** ***"A single pocket was found, seven feet long, and about three feet in width and depth, which afforded over four hundred pounds of choice quartz crystals, and including all grades, about half a ton. It was from this pocket the remarkable emeralds…were obtained. The cavity was lined with red mud, and the quartz crystals, except at the bottom, had become detached by processes of disintegration and were imbedded in the mud."*** Hidden, 1883, p. 393-394.
   - **f.** The newest ***"…emerald pocket extended in a nearly vertical direction for twenty feet and was about one foot in diameter and four feet in its extreme lateral extent".*** Hidden, 1986b, p. 483.

2) Emerald crystal features
   - **a.** ***"Beryl occurs in green, yellow, bluish and sometimes colorless crystals. The crystals are well terminated and often highly modified, resembling those from Siberia…"*** Hidden, 1881a, p. 159.
   - **b.** Emeralds ***"….have been found there***…at the Warren farm…***loose in the soil, of a***

light chrome green color, having prisms of six and twelve sides, and with polished terminations; the prismatic faces have a characteristic feature of being striated horizontally as if having been scratched with a very coarse file." Hidden, 1881b, p. 24.

c. ***"Most of the crystals found are vertically deeply striated or ribbed, and are transparent, though not free from flaws. In some of the crystals the color near the surface is the deepest and the core is nearly colorless."*** Hidden, 1881c, p. 490.

d. Beryls with flat, simple- and complex-pyramidal terminations are illustrated in Hidden, 1880, p. 88; 1881b, p. 25; 1882a, p. 372; and Hidden and Washington, 1887, p. 505.

e. ***"The curious rough edges and pseudo-horizontal striations were noticed on nearly all of the crystals of emerald, these markings being peculiar to the beryls of the region."*** Hidden, 1885, p. 251.

f. ***"It is noteworthy that the highly modified beryls of this region only occur rarely and when associated with spodumene or albite. Another interesting feature is the white or very pale greenish beryls are found with the deepest green spodumene. It has before been noted that the quartz and beryl of Alexander Co. are more highly modified when they are implanted on the feldspathic layers of the walls of the pockets."*** Hidden and Washington, 1887, p. 505.

3) Quartz crystal features

a. Unusual quartz crystal terminations are illustrated in Hidden, 1880, p. 87 and 1881b, p. 24; and Hidden and Washington, 1887, p. 507.

b. Hidden reports a quartz crystal with a rare basal plane termination face (Hidden, 1886a, p. 204).

c. Regarding the 400 quartz crystals mentioned above, Hidden writes: ***"The crystals containing fluid cavities were of citrine-yellow to chocolate-brown color, transparent, and of high luster; they were implanted upon the crystals which had been directly attached to the walls. The cavities were of unusual size; the longest had a length of two and one half inches; others an inch in length were not uncommon, and those of smaller size were too numerous to be counted. The accompanying figure shows some of the cavities of natural size; the fluid contained was water with also some liquid carbon dioxide. Unfortunately this remarkable collection of water-bearing crystals was left exposed to a temperature below the freezing point during a night in the late autumn; by the freezing of the enclosed water the crystals were shattered and reduced to fragments, which were in some cases frozen together to a coherent mass. The ice formed was believed to be due in part to the condensation of the moisture of the surrounding atmosphere by the cold produced by the sudden expansion of the carbon dioxide liberated."*** Hidden, 1883, p. 394.

Several additional mining attempts were made by others after the closure of the Emerald and Hiddenite mine, but each soon failed. A second heyday of the property came in the 1970s when it was operated as a prospect-for-fee operation (Lowery, 1972) and collectors made numerous discoveries, including Robert Reitzel's 1,493 carat twin emerald crystal (Carson, 1972) which is currently North America's 3rd largest emerald (now in the Smithsonian collection). Today this property is known as the Adams mine or Adams farm and is leased to Terry Ledford who has recently discovered numerous remarkable hiddenites (Terry Ledford, 2007, personal communication).

The NAEM Mine Formerly the Rist Mine

Other properties in the district have also produced emeralds and hiddenites (Trapp, 1970; Harshaw, 1974; Zeitner, 1982; Brown, 1986; Brown and Wilson, 2001; Smith, 2002; Jacobson, 2007, 2008; Freeman and Speer, 2008). Small operations at the Ellis, Wooten-Rutledge, Emerald Hollow, and Rist mines have been productive at different times throughout the 1900s (Figure 1). Today, only the Rist property continues significance production. Now owned by North American Emerald Mines, Inc, it is called the NAEM mine and is the focus of the geological investigations reported here.

In 1877, the first emeralds at the future Rist/NAEM mine were reported:

> ***"During 1877, Mr. I.W. Miller brought me two emeralds found on his mother's farm two miles northeast of the 'Emerald and Hiddenite Mine.' They were of good color and quite transparent, but very rough on the surface. This promising locality is still undeveloped".*** (Stephenson, 1888, p. 4).

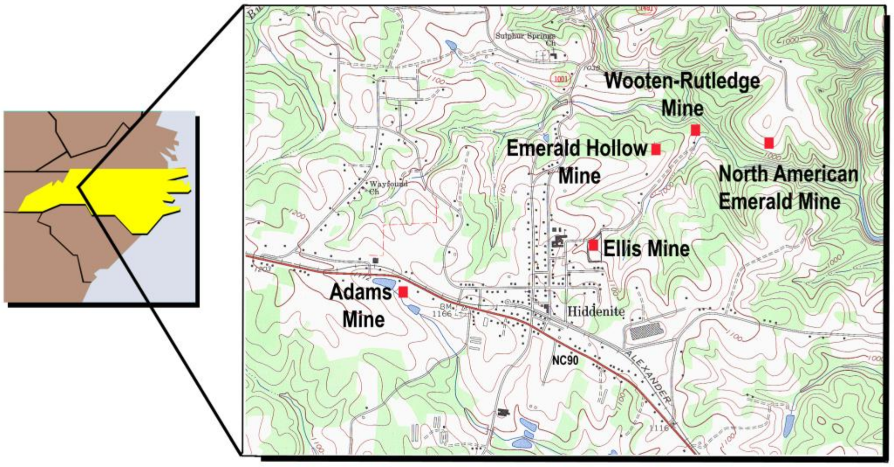

Figure 1. **Major Mines of the Hiddenite District, Alexander Co., NC.**

In 1912, the US Geological Survey reported on the property:

"Beryl crystals have been found in two places on the estate of the Miller heirs, 1 ½ miles east of Hiddenite on the ridge between Davis Creek and Little Yadkin River. Good specimens are reported from this property…two of them as emeralds…. Since these crystals were found, several prospects have been opened and beryl found in two veins. Quantities of quartz and some rutile crystals were obtained from the other openings. In one prospect on a steep hillside above Davis Creek good deep aquamarine-colored beryl crystals are reported to have been found in pegmatite. This pegmatite is composed of orthoclase feldspar, greenish muscovite, smoky quartz, and black tourmaline. The other beryl prospect is about 200 yards northwest of the one mentioned and consists of two sets of openings about 100 feet apart. The beryl occurs in pegmatite cutting decomposed gneiss, probably biotite gneiss, with an easterly strike. Little could be learned of the results of the prospecting." (Sterrett, 1912b, p. 1033-1034).

In 1958, The North Carolina Division of Mineral Resources reported:

"Emerald, Rutilated quartz, Smoky quartz, Rose quartz and Hiddenite (uncommon); located 1.2 miles northeast of Hiddenite at the end of SR 1492." (Conley, 1958, p. 8).

In 1968, the site was mentioned in Lapidary Journal:

"Emerald has also been found at the Smith farm 1.2 miles northeast of Hiddenite…" (Trapp, 1968, p. 596).

The property was opened as the Rist mine for prospect-for-fee in March 1969 and was operated by American Gems, Inc. from 1971 until 1982. Remarkable early discoveries mined from the shallow saprolite included:

1) June 1969, 250 ct 6" emerald found by William Diehl Baltzley, president of American Gems (Trapp, 1970; Sumner, 1972)
2) July 1969, 1,438 ct emerald found by Michael 'Butch' Finger; at the time North America's largest emerald (Trapp, 1970; Sumner, 1972); later renamed the Stephenson Emerald (now in LKA collection)
3) August 1970, 59 ct emerald crystal found by Wayne Anthony; cut into 13.14 ct Carolina Emerald (Tiffany Emerald), valued at $38,766/ct in 2007 dollars, now in Tiffany collection

(Crowningshield, 1971; Sumner, 1972).

Figure 18 at the back of this report features emerald jewelry made from a spectacular 1974 find.

From 1982 until 1995, the mine ownership belonged to LKA International, Inc. of Gig Harbor, Washington. The most significant discovery during this time was the 1,686 carat LKA Emerald (Brown, 1986) which took over the distinction of being the largest North American emerald and today remains the second largest (now in the LKA collection).

In 1995, a 38 hectare (94 acre) tract including the old Rist mine was acquired at public auction by Sulphur Springs Properties, LLC. Now held by the Hill and Duncan families, portions of this tract are currently being mined by James K. Hill, Jr., founder of North American Emerald Mines, Inc. which has opened a 2.5 hectare (6 acre) pit exposing fresh bedrock and emerald-bearing quartz veins at the old Rist mine site.

In 1998, Hill made his first significant emerald discovery of 3,300 carats in a single cavity only 12 feet below the surface (Icenhour, 1999a-b; Kelly, 1999; Goldberg, 1999a-b-c; Rothacker and Goldberg, 1999; Jones, 2000; NAEM, 2001). This remarkable find included an exceptional 71 carat crystal that produced North America's largest cut emerald, the 18.8 carat Carolina Queen valued at over $1 million, as well as North America's most valuable per carat cut gemstone, the 7.85 carat Carolina Prince that sold, in 2007 dollars, for $78,850/ct (NAEM, 2001; R. Gregory Jewelers, 2004). See Table 2, above; and Figure 2 at the back of this report.

In 2003, Hill discovered North America's largest emerald crystal (NAEM, 2003; Wellin, 2003; Mitchell, 2003). At 1,869 carats, this deep-green, well-formed hexagonal crystal on matrix is considered by many to be North America's finest mineral specimen (see cover page image and Table 1, above). It is valued over $1 million and is part of the Houston Museum of Natural Science collection.

Other significant discoveries continued as open-pit mining progressed. Currently, the NAEM operation produces crushed-stone aggregates in addition to emeralds and this double-product mining is proving crucial to the financial success of the operation.

Host Rocks

The host rocks exposed in the NAEM pit are migmatitic biotite gneiss which formed from siltstone and minor quartzite. Based on age dates of nearby Devonian plutons (Walker Top & Toluca granites), age dates of detrital zircons in similar gneiss nearby, and tectonostratigraphic relationships, a late Silurian age of approximately 400 Ma is assigned to the sedimentary rocks; although an older age cannot be ruled out (Hatcher, 2002; Merschat & Kalbas, 2002; Bream, 2002). See Figure 3.

The rocks are part of the Brindle Creek thrust sheet that comprises the Cat Square terrane of the Inner Piedmont terrane as proposed by Hatcher (2002) and Merschat & Kalbas (2002); see Figure 4 at the back of this report.

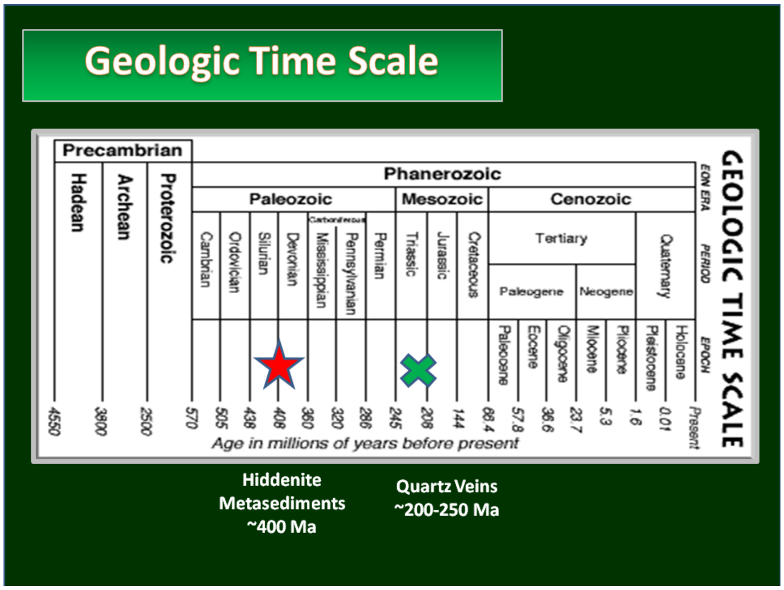

Figure 3. **Approximate age of the Hiddenite metasediments and quartz veins.**

The Inner Piedmont terrane is believed to be an exotic body of rock that was accreted to the North American craton about 350 Ma during the Neoacadian Orogeny (Hatcher, 2002). The terrane is 100 x 700 km (60 x 435 mi) in size and lies between the Brevard fault zone to the west and the Central Piedmont suture to the east. Subsequent to the deformation related to the docking of the Inner Piedmont terrane, this accreted body was subjected to at least one more episode of major deformation when the Carolina terrane to the east collided and was itself sutured to the Inner Piedmont terrane. Recent studies by several researchers suggest that the Inner Piedmont itself may be composed of two separate terranes, each of which collided with the North American craton and became sutured to it (Hatcher, 2002, Merschat & Kalbas, 2002, Bream, 2002). These multiple episodes of continental collision have produced the complex deformational features characteristic of rocks in the Inner Piedmont and visible in the NAEM pit.

Typical of the Inner Piedmont, rocks in the NAEM pit reached upper amphibolite grade sillimanite metamorphism and today are much changed from their original sedimentary nature. Based on correlation with similar features mapped by others in the Inner Piedmont, the prominent mineral layering due to metamorphic differentiation is assigned S_2 (Merschat & Kalbas, 2002). This foliation is defined by alternating light-colored quartz-and feldspar-rich leucosome layers and dark-colored biotite-rich melanosome layers (see Figure 5 at the back of this report). S_2 is approximately parallel to original sedimentary bedding but locally crosscuts bedding as seen at the hand specimen scale.

At least three S_2 folding events have been defined: 1) prominent northwest-trending, open to tight, occasionally slightly overturned folds; 2) upright open northeast-trending folds; and 3) small isolated north-northeast-trending folds (see Figure 6 at the back of this report). Additional folding events may also be present, but have not been fully delineated. The interaction of the northwest and northeast folds produced widespread basin-and-dome folds on a scale of 3-10 m (9-30 ft).

Anatectic melting of some of the leucosome fraction of the migmatitic gneiss is evident as non-foliated sills and dikes of aplite, granite, and/or pegmatite (see Figure 7 at the back of this report). Sills up to 3.3 m (10 ft) thick and rare dikes up to 20 cm (8 in) thick have been observed.

Minor original sedimentary features (paleosome) are preserved in the migmatite gneiss as: 1) thin lensoidal channel deposits of medium-grained white sandstone (now metaquartzite); and, 2) small remnant cores of massive poorly-foliated metasiltstone, occasionally surrounded by inwardly migrating concentric bands of metamorphic compositional layering.

Table 3 gives a list of host rock minerals confirmed by laboratory analyses.

Quartz	**Apatite**
Feldspar	**Zircon**
var. Oligoclase	**Pyrite**
var. Plagioclase	**Pyrrhotite**
Mica	**Chalcopyrite**
var. Muscovite	**Graphite**
var. Biotite	**Ferrosilite**
Tourmaline, var. magnesian Schorl	**Titanite**
Garnet	**Diopside**
var. Pyrope-Almandine	**Calcite**
var. Grossularite	

Table 3. **Migmatitic Biotite Gneiss Minerals, NAEM mine.** Sources: Wise & Anderson, 2006. Analyses by XDR and/or electron microprobe.

Limited trace element geochemistry of the migmatitic biotite gneiss provides some useful insights (Table 4). Vanadium, chromium, beryllium and lithium are moderately enriched in the biotite-rich melanosome layers versus the paleosome or leucosome layers. This suggests biotite in the country rock is the source for these elements present in the beryl and spodumene crystals in the vein cavities.

	Melanosome Biotite Gneiss	Melanosome Biotite Schist	Paleosome Meta Siltstone	Leucosome Feldspar-Quartz
V ppm	64.0	97.0	12.0	4.0
Cr ppm	113.7	149.1	23.9	4.1
Be ppm	1.7	1.1	2.1	0.3
Li ppm	254.5	342.9	24.1	30.0

Table 4. **Trace Element Geochemistry for 4 migmatite samples.** Analyses by ICP/ES (V & Cr--0.2 gm samples; Be & Li--30 gm samples). NAEM data.

Two observations in the NAEM pit support the whole-rock geochemistry presented above suggesting biotite in the country rock is the immediate source for Cr. First, emeralds (Cr-rich beryls) are generally found in quartz veins hosted by biotite-rich melanosome, while Cr-poor, Fe-rich green beryl and aquamarine and/or goshenite (clear beryl) are generally found in quartz veins hosted by quartz-feldspar-rich leucosome. Second, at least one 1.5 cm porphyroblastic Cr-rich emerald crystal was observed within the melanosome biotite schist matrix far removed from any quartz vein, while small 1-3 mm Cr-poor, Fe-rich pale green common beryl crystals have been observed in anatectic granites and pegmatites, again far removed from any quartz vein. These anatectic beryl crystals occur embedded in feldspar crystals and/or in the matrix between quartz and feldspar crystals.

An 1887 observation by Hidden referring to the unique crystal habits of minerals at his Emerald and Hiddenite mine also suggests a wall rock influence on the cavity minerals:

"It has before been noted that the quartz and beryl of Alexander Co. are more highly modified when they are implanted on the feldspathic layers of the walls of the pockets." (Hidden and Washington, 1887, p. 505).

Another possible source of Cr and V could be the basal amphibolite unit of the mid-Ordovician Poor Mountain Formation that immediately underlies the Brindle Creek thrust sheet as reported by Merschat and Kalbas (2002) and Bier and others (2002). Based on chemical analyses, this amphibolite is interpreted to be metamorphosed tholeiitic normal mid-oceanic basalt (Bier and others, 2002); thus it probably contains elevated Cr and V that could have been remobilized upward into the emerald and hiddenite quartz veins in the overlying Brindle Creek metasiltstones. However, no amphibolite is exposed in the Hiddenite District and the depth to the amphibolite is unknown. Of course, the presence of small isolated, closed-system quartz veins argues against source fluids from below and makes it unlikely the amphibolite is involved.

Quartz Veins

Emeralds occur in complex late metamorphic, hydrothermal, Alpine-Type quartz veins (Palache, 1930; Sinkankas, 1976, 1981, 1982, 1997; Wise and Anderson, 2003, 2006; Wise, 2008, Freeman and Speer, 2008, and Speer 2008). While pegmatites are a common host for emeralds elsewhere in the world, the pegmatites at NAEM don't contain emeralds, although they do occasionally contain small, matrix-supported Fe-rich green beryl crystals as described above.

Quartz veins occur as near-vertical, isolated, sub-parallel, lensoidal bodies (Figure 8). They have a fairly consistent northeast to east-west trend and northward dip.

Veins range in size from 2 cm to 1 m wide, 30 cm to 7 m long, and 10 cm to 5 m high. Rare hairline fractures connect some close-spaced stacked veins, but the vast majority of veins are not interconnected; thus each vein or set of close-spaced veins appears to be a closed system. They appear to represent tensional gash fractures that sharply crosscut the prominent S_2 metamorphic fabric of the host rocks, suggesting that they formed during late or post metamorphic brittle-ductile deformation (Figure 9). A possible localized bulge or up-warp in the Brindle Creek thrust sheet might have produced such tensional gash features even during compression deformation (John W. Maddry, 2008, personal communication).

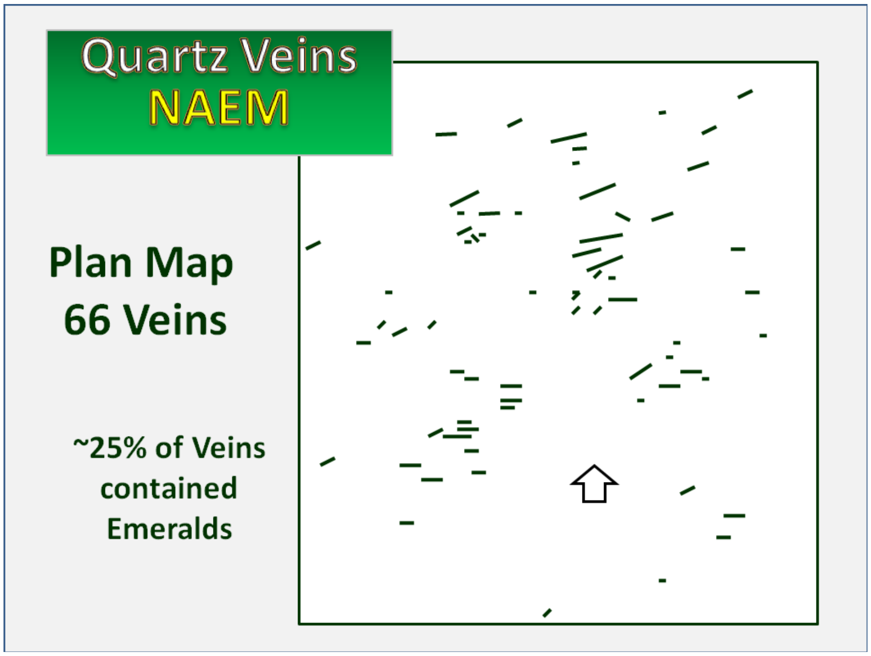

Figure 8. **Plan Map of Quartz Veins in NAEM pit.** Field of view: 61 x 76 m (200 x 250 ft).

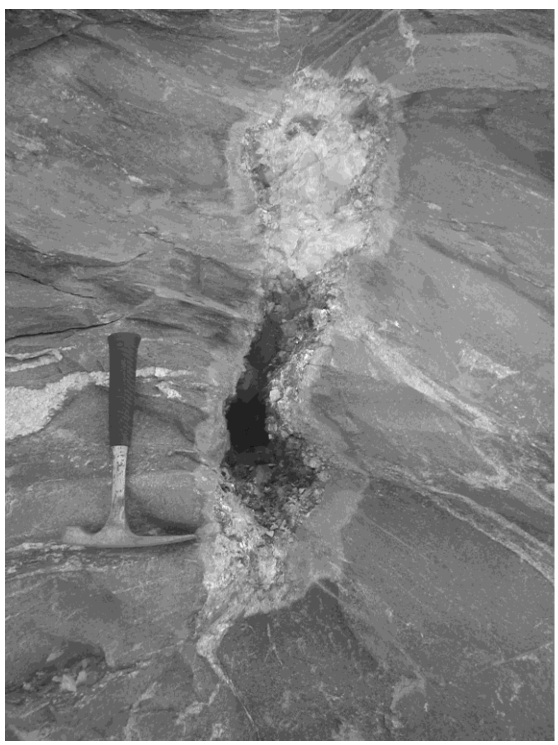

Figure 9. **Typical Quartz vein in NAEM pit.** Note the vein sharply crosscuts S_2 metamorphic layering which trends diagonally across image from lower right to upper left. The vein also exhibits sinuous contacts and has a prominent bleached alteration halo. Massive white cryptocrystalline quartz (bull quartz) fills the top of the vein and an open crystal-lined cavity occupies the bottom of the vein. Hammer is 28 cm high. Same as photograph on the inside cover.

Quartz veins in the NAEM pit exhibit both ductile and brittle features. Sinuous vein contacts such as those seen in Figure 9, suggest formation under ductile conditions; and in fact some veins do show a slight coeval interaction with the S_2 metamorphic compositional layering. Other veins have more typical straight joint-like contacts suggesting formation under more brittle conditions.

Features of brittle deformations within the quartz veins, such as the presence of crackle breccia in the massive cryptocrystalline quartz and the fragmentation of cavity crystals, are discussed in more detail below. The presence of both ductile and brittle features in the same quartz vein swarm suggests formation when the country rocks exhibited both ductile and brittle characteristics such as the waning stages of regional metamorphism following the Alleghanian Orogeny at the end of the Paleozoic. Thus, a tentative age of 200-250 Ma is suggested for the formation of the quartz veins (Figure 3).

Figures 10 (below) and 11-12 (at the back of this report) show features common to cavities in larger veins. The top of the 20Apr07 Vein cavity shown in Figure 10 is completely filled with white massive cryptocrystalline quartz (bull quartz). The cryptocrystalline quartz is a highly shattered crackle breccia; however, the fractures do not cross into the wall rock.

The cavity below the cryptocrystalline quartz in Figure 10 is 6 m^3 (220 ft^3) in size, making this the largest cavity seen to date at the NAEM mine. Nearly two thirds of the cavity is filled with 4.5 tonnes (5.0 tons) of collapse breccia composed of broken crystals, herein called breakdown crystal breccia (BCB). This collapse breccia is composed of broken crystals that have fallen from the cavity ceiling and walls (Figures 10-12).

Continued mineral growth during or following collapse is evident by widespread calcite cementing the lower portion of the BCB. Several generations of late calcite mineralization are present.

Muscovite crystals and clusters with individual crystals up to 3 cm (1.7 in) in length are abundant in the BCB in the 20Apr07 Vein cavity. Remnant rinds of muscovite, kaolinite (Miller, 2007, and Wise, 2007), siderite, rutile and albite cover small sections of the cavity walls, while other sections of the walls are devoid of crystals due to collapse and/or non-deposition.

Reticulated rutile crystals up to 5 cm (2 in) long are common in the muscovite clusters and are often found as loose crystals in the BCB.

Termination-face-dominate quartz crystals up to 30 cm (12 in) in length extend downward from the bottom of the cryptocrystalline quartz and many have broken and collapsed at various stages during growth. The presence of new silica growth on earlier broken quartz crystal surfaces further indicates continued post-collapse growth within the BCB.

Large siderite crystals up to 50 cm (20 in) long are found scattered throughout the BCB. While heavily oxidized to goethite in the 20Apr07 Vein cavity, variations in the oxidation patterns suggest primary chemical zoning existed within these siderite rhombs. And in fact, color zoning of unweathered siderite crystals has been observed in other veins.

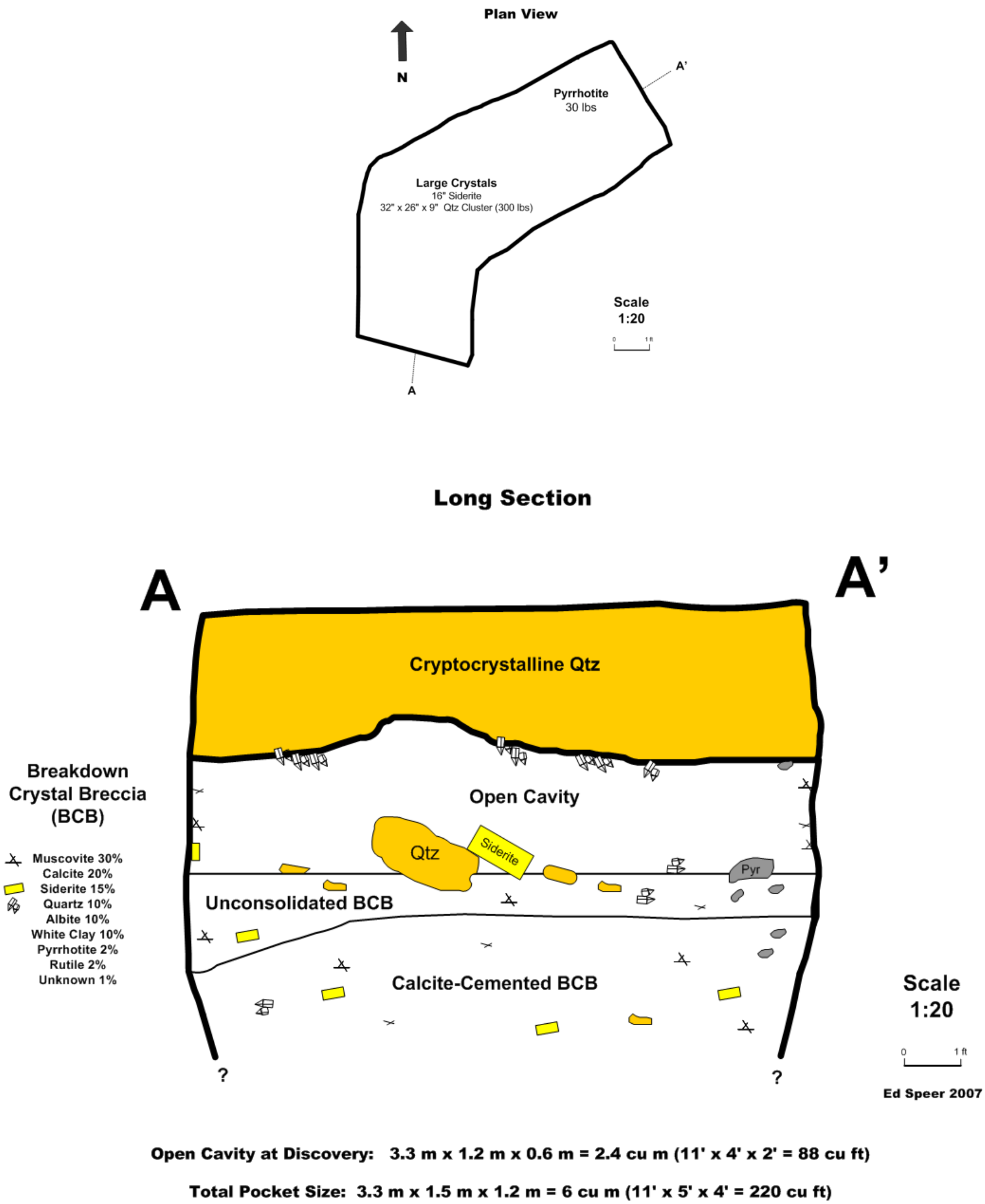

Figure 10. **20Apr07 Vein Cavity, plan and section.** Largest crystal cavity discovered to date on the NAEM property. 4.5 tonnes (5.0 tons) of breakdown crystal breccia (BCB) were removed from this cavity. Note small mass of pyrrhotite still attached to ceiling on right side of cavity and collapsed fragments of this mass at various levels in the breakdown crystal breccia directly below.

Fragments of a broken 11 kg (30 lb) mass of pyrrhotite found in the ceiling of the cavity and at various levels in the BCB directly below, also suggest repeated fracturing and collapse over an extended period of time (Figure 10, above).

Although it is seen in all large cavities, the cause of the crystal fragmentation and collapse is unknown. It is noted that small cavities often lack BCB, although they may host emeralds.

While large cavities often contain large quantities of emerald crystals (as many as 3,500 carats have been documented on the property), no emerald or other beryl have been found in the cavity shown in Figure 10. In other cavities however, emeralds are often found near the bottom of the BCB, suggesting growth early in the history of the cavity.

Vein Minerals

Hiddenite is rare on the NAEM property, but is much more common and occurs in larger crystals on the Adams farm, site of the former Emerald and Hiddenite mine.

The complete list of previously-reported minerals from the veins at Hiddenite is extensive, however many identifications are questionable. The minerals listed in Table 5 come from the veins on the NAEM property and are confirmed by XRD, electron microprobe and/or chemical analyses.

Apatite	**Graphite**
Beryl	**Kaolinite**
var. Emerald	**Molybdenite**
var. Green Beryl	**Monazite**
var. Aquamarine	**Muscovite**
var. Goshenite	**Pyrite**
Calcite	**Pyrrhotite**
var. rhombohedral	**Quartz**
var. scalenohedral	**var. cryptocrystalline**
var. platy	**var. clear**
var. hexagonal	**var. smoky**
Chabazite-Ca	**var. amethyst**
Chalcopyrite	**var. citrine**
Clinochlore	**Rutile**
Diopside	**Siderite**
Dolomite	**Sphalerite**
Feldspar, var. Albite	**Spodumene, var. hiddenite**
Fluoraptite	**Tourmaline, var. schorl**
Galena	**Xenotime**
Gersdorffite	**Zircon**
Goethite	

Table 5. **Vein Minerals, NAEM mine.** Sources: Wise, 2002, 2004, 2007, 2008; Wise & Anderson, 2003, 2006; and Miller, 2007. Analyses by XDR, electron microprobe and/or chemical analyses.

Recent mineralogical work by Wise (2002, 2004, 2008) and Wise and Anderson (2003, 2006) suggests four different mineral assemblages occur in the vein cavities:

1) Emerald-bearing cavities contain quartz, muscovite, dolomite, tourmaline, albite, zircon, monazite, apatite, beryl, rutile, siderite, and calcite;

2) Spodumene-bearing cavities contain quartz, muscovite, rutile, spodumene,

clinochlore, calcite, graphite, pyrite and chabazite-Ca;
3) Calcite-bearing cavities contain rutile, muscovite, albite, calcite, quartz, dolomite and pyrite; and
4) Amethyst-bearing cavities contain quartz, muscovite, dolomite, molybdenite, calcite, rutile, pyrite and chabazite-Ca.

Note that emerald and spodumene don't occur together in the same vein and that siderite is diagnostic of the emerald assemblage. Wise and Anderson also note complex mineralogy and crystallography with four generations of quartz growth in the cavities as well as variations in the crystal habits of several minerals, including quartz, Fe-Ca-Mg carbonates, pyrite, beryl and rutile. Unusual variations in crystal habits elsewhere in the district have also been noted by Hidden (1880, 1881a-b-c, 1882a, 1883, 1885, 1886a-b), Hidden & Washington (1887), Smith (1881), Davidson (1927), Palache and others (1930), and Sinkankas (1981b).

The mineralization process within the quartz vein cavities is suggested to have occurred within an aqueous-carbonic fluid that underwent vapor exsolution under low pressure and low temperature (230 to 290^O C), typical of many boiling geothermal systems (Wise and Anderson, 2006). This model is consistent with the observation that the veins formed as hydrothermal events during late-stage regional metamorphism. Thus mineralization within the cavities was a product of decreasing temperature and pressure during cooling of the country rocks following peak metamorphism.

Emeralds

Vanadium and chromium are the usual chromophores that give emeralds around the world their unique colors (Schwarz and Schmetzer, 2002). Emeralds at Hiddenite are no exception as revealed by recent work by Wise and Anderson (2006) and shown in Table 6. Cr^{+3} and V^{+3} commonly substitute for Al^{+3} in the beryl formula ($Be_3Al_2Si0_6O_{18}$) giving emerald its unique color. Data presented in Table 6 also gives an average Cr_2O_3/V_2O_3 ratio of ~5:1, which compares well with emeralds around the world.

Cr_2O_3 wt%	**0.22**	**0.24**	**0.15**	**0.13**	**0.31**
V_2O_3 wt %	**0.04**	**0.00**	**0.03**	**0.00**	**0.08**

Table 6. **Average Trace Element Geochemistry for Cr_2O_3 and V_2O_3 of Five Emeralds from NAEM mine.** (Wise and Anderson, 2006).

Most emeralds in the world occur as porphyroblastic crystals less than 5 carats in size and embedded in matrix. Large crystals grow best in vein cavities, such as the calcite veins of Colombia, South America, and the quartz veins at Hiddenite, North Carolina (see Table 7).

90% of Emeralds > 10 cts
50% of Emeralds > 50 cts
8% of Emeralds > 1,000 cts

Table 7. **Emerald Crystal sizes, NAEM (1969-2007).** Compare these numbers to the fact that 90% of the emeralds found throughout the world are less than 5 carats in size.

Emerald crystals from NAEM are idiomorphic (euhedral) and generally exhibit flat terminations; however pyramidal terminations are occasionally seen. Crystals are also commonly color zoned, which suggests that fluids or gases varied in chemistry, especially in Cr and V (see discussion below). Well-formed six-sided hexagonal and twelve-sided dihexagonal prisms occur up to 25 cm (10 in) in length. Single and twinned crystals are the most common; however, complex clusters are occasionally seen.

Brown (1986) reports the following measurements for Rist/NAEM emeralds: 1) specific gravity 2.73; 2) refractive index e = 1.580, o = 1.588; 3) birefringence 0.008; 4) rich blood-red color under the Chelsea filter; and, 5) reddish fluorescence under long wave ultraviolet (3660 angstroms). Zeitner (1982) reports G.I.A. measurements of 1.580-1.590 refractive index and a remarkably high 0.010 birefringence for at least one faceted emerald from the Rist/NAEM property.

Emeralds occur as free-standing crystals, matrix-hosted crystals and/or as broken crystal fragments embedded in the BCB. Emeralds have also been noted with re-growth of beryl on broken surfaces, suggesting at least some crystal growth continued after fracturing and even after formation of the BCB. Some crystal prisms exhibit re-healing of natural breaks and have noticeable offsets along the c-axis. In addition, many emeralds also exhibit dissolution features, again suggesting major changes in the mineralizing fluids during evolution of crystal growth. Figures 13-17 at the back of this report show some typical emerald features.

Two observations in the NAEM veins may be related: 1) emerald crystals are commonly darker green on their younger outer prism faces and/or at the end termination; and, 2) the presence of late-stage Fe-rich hypogene minerals such as siderite, pyrite and pyrrhotite. In discussing the coloration of Columbian emeralds, Franz and Morteani (2002) report that the very low Fe content of the emeralds is due to the removal of Fe from the mineralizing fluids by the coeval crystallization of pyrite. This phenomenon may also explain the emerald color zoning seen at Hiddenite.

Emerald Deposit Classification

All emerald deposits around the world are genetically related to pegmatites, metamorphic recrystallization, or metamorphic veins (see discussions in Schwarz, and others, 2002; Grundmann, 2002; and Franz and Morteani, 2002). As mentioned earlier, the vast majority of emerald crystals are attributed to small porphyroblastic growths enclosed in the matrix of the host rocks, while a small number of deposits contain large euhedral crystals that grew unrestrained in open spaces. Mafic or ultramafic rocks are interpreted to have supplied the Cr and/or V necessary to create the unique emerald green color found in these beryls. However, the largest, deepest green and best quality emerald crystals don't necessarily come from the usual deposit types, as evidenced by the Hiddenite deposits.

The Hiddenite emerald deposits exhibit many features in common with the Columbian deposits, including large well-formed crystals growing in open vein spaces. Franz and Morteani (2002) interpret the Columbia deposits as metamorphic hydrothermal in origin due to: 1) their close genetic relationship to the Andean Orogeny; 2) formation at temperatures and pressures suggestive of low-grade metamorphism; 3) the widespread chloritoid alteration halo around the Muzo deposit; and, 4) the highly deformed host rocks. The Hiddenite emerald deposits are herein also interpreted to be late metamorphic hydrothermal based on: 1) their close genetic relationship to the Alleghanian Orogeny; 2) the small, isolated and lensoidal nature of the quartz veins; 3) the lack of metamorphic foliation in the quartz veins; 4) the cross-cutting nature of the quartz veins relative to foliation (S_2) of the host rocks; 5) the low-temperature hydrothermal open-space vein mineralization (quartz, carbonates, muscovite, albite, etc); 6) the alteration halos around the quartz veins; and, 7) the presence of ductile and brittle features in the quartz veins suggesting formation during the waning cooling stages of regional metamorphism. Vein mineralization is believed to be due to late metamorphic decreases in temperature and pressure at the Columbian deposits (Franz and Morteani, 2002) as well as at Hiddenite. Sedimentary brines are believed to be the source of the elements (including Be) contained in the vein minerals in the Columbian deposits (see discussion in Franz and Morteani, 2002), and this may also be the case at Hiddenite.

Conclusions

The country rocks at the NAEM mine are composed of siltstones and quartzites that accumulated in a shallow sea and were subsequently regionally metamorphosed to upper amphibolite grade while being accreted to the North American craton as part of the Inner Piedmont terrane. Today they are mapped as migmatitic biotite gneiss. Metamorphic textures record multiple episodes of deformation probably related to separate continental collision events. Based on detailed mapping elsewhere by others, the rocks are assigned a Late Silurian age of about 400 Ma, while the docking of the Inner Piedmont terrane is believed to have occurred about 350 Ma during the Neoacadian Orogeny. In addition, the Alleghanian Orogeny (docking of the Carolina terrane to the east) also greatly affected the Inner Piedmont rocks about 300 Ma. Only gentle uplift and erosion have affected the rocks since the formation of the quartz veins.

A tentative age of 200-250 Ma is assumed for the formation of the quartz veins based on: 1) the lack of metamorphic fabric in the veins, 2) the late crosscutting nature of the veins relative to S_2, and 3) the presence of both ductile and brittle vein features. In addition, the mineralization within the cavities apparently occurred under low-temperature and low-pressure conditions, consistent with a late-metamorphic hydrothermal origin (i.e., early Mesozoic). The quartz veins were long-lived with massive cryptocrystalline quartz overlying open cavities apparently forming first under hotter ductile/brittle conditions while cavity mineralization may have formed under subsequent cooler and more brittle conditions. The quartz veins may have formed as tensional gash veins related to a localized bulge or up-warp of the Brindle Creek thrust sheet during the late stages of thrusting.

Large vein cavities are partially filled with breakdown crystal breccia (BCB), suggesting a repeated process of crystal growth and collapse. Renewed growth of collapsed crystals, re-adsorption of crystals and over-growth by new minerals are all documented in the cavities and in the BCB.

Emeralds grew as large idiomorphic crystals attached to cavity walls and largely unencumbered by matrix minerals. In addition, naturally broken and collapsed emerald crystal fragments are common, especially in the larger cavities. Well-formed six-sided hexagonal and twelve-sided dihexagonal prisms are often twinned and up to 25 cm (10 in) in length. Most crystals exhibit typical flat beryl terminations; however several pyramidal termination habits are known. Cr and lesser V serve as chromophores giving the emeralds their unique color. Color zoning is common in individual crystals, suggesting increasing Cr and V in the cavity fluids over the growth life of the emeralds. Small amounts of Cr-poor and V-poor beryl occur as aquamarine, common green beryl and goshenite and may represent veins cutting biotite-poor portions of the host rocks.

Emeralds occur in open cavities of late metamorphic hydrothermal Alpine-Type quartz veins cutting metasedimentary migmatitic biotite gneiss. Typical Cr-rich mafic or ultramafic source rocks, associated with many emerald deposits elsewhere in the world, are absent at Hiddenite. This leaves us with only one likely source candidate: the moderately-enriched melanosome portion of the metasedimentary host rock. It is suggested that metamorphic differentiation mobilized and concentrated original sedimentary-brine derived Be, Li, Cr and V into biotite-rich melanosome layers of the migmatitic biotite gneiss. Late metamorphic hydrothermal quartz veins, occupying tensional gash sites scavenged these and other elements from narrow wallrock alternation haloes and incorporated them into the crystals growing inside open cavities within the veins. Wallrock consumed during growth and enlargement of the cavities could have also released these same elements and contributed them to the vein crystals.

Figure 2. **North America's Largest and most Valuable Faceted Emeralds came from the NAEM property.**

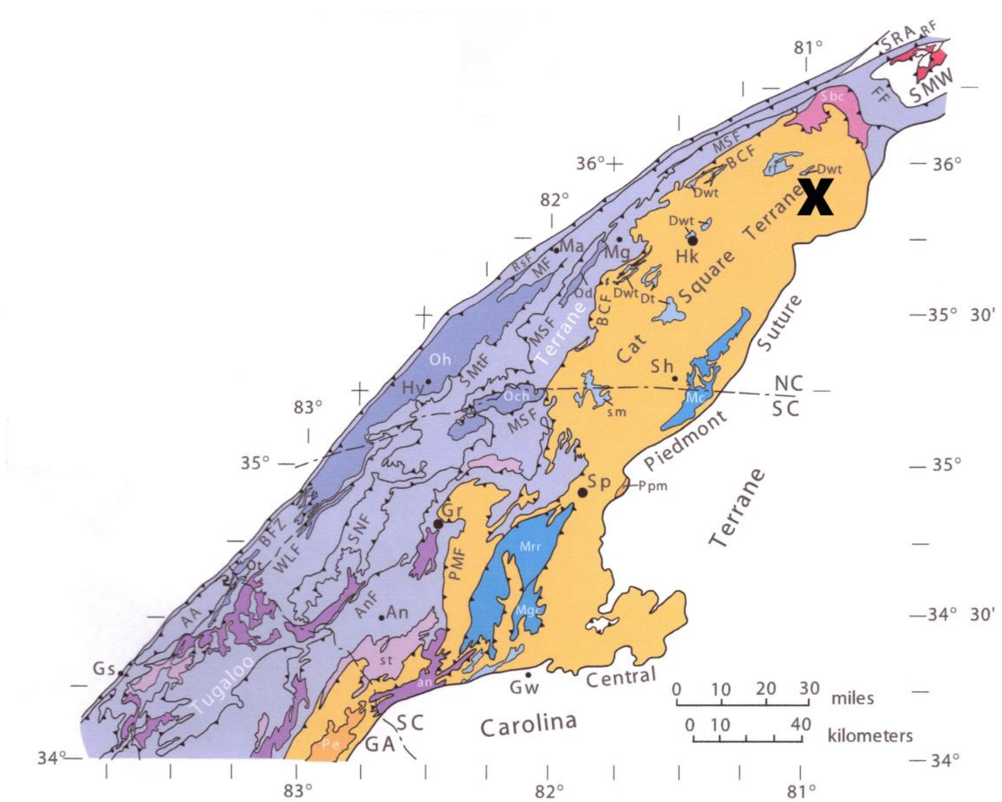

Figure 4. **Hiddenite District and the Inner Piedmont terranes.** Hiddenite district shown by "X". Modified from Figure 1 *in* Hatcher, 2002.

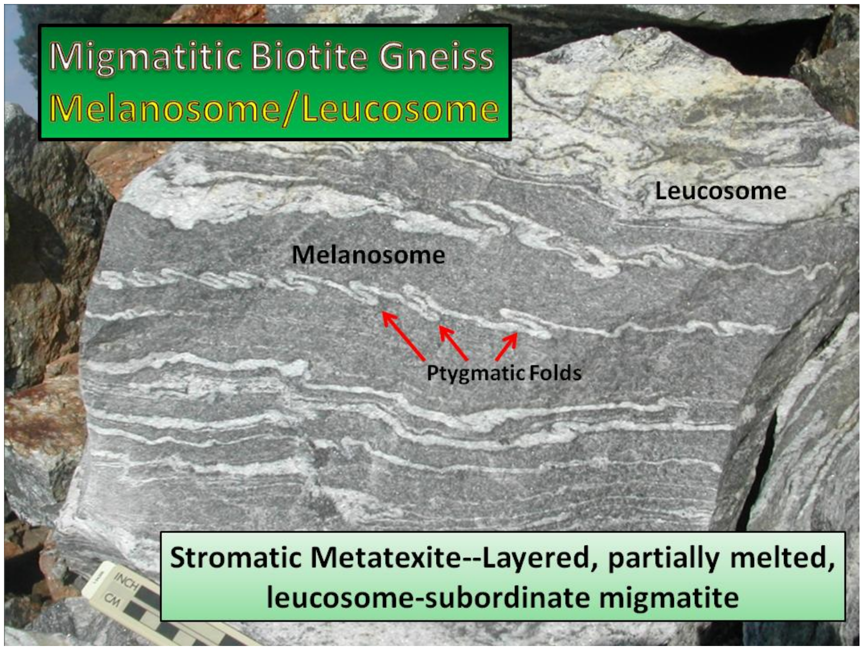

Figure 5. **Migmatitic Biotite Gneiss from the NAEM pit.** Note strong S_2 compositional layering and Ptygmatic folding due to density variations during ductile compression.

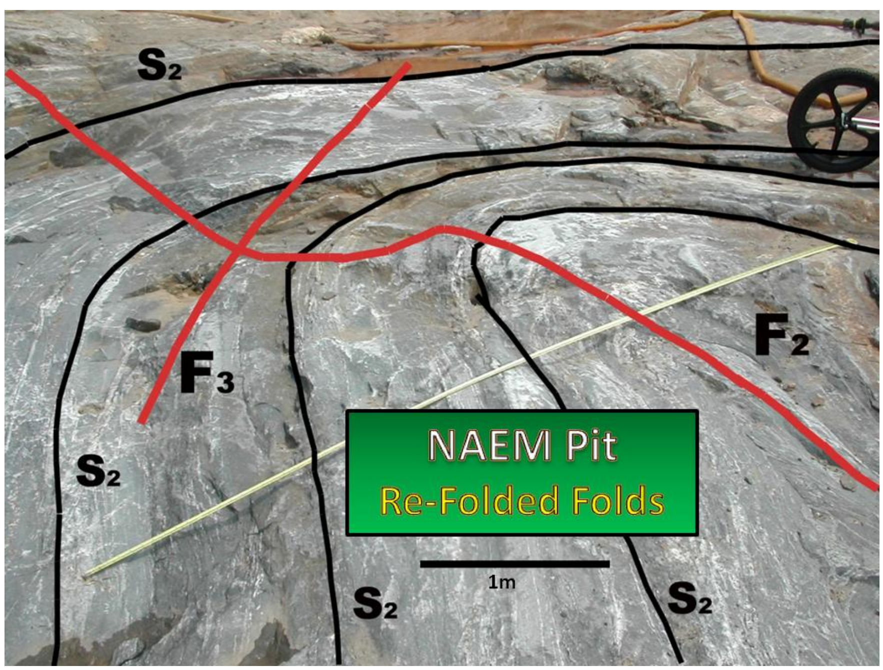

Figure 6. **Re-folded folds in NAEM pit.** S_2 is folded by northwest directed F_2 folds and by northeast directed F_3 folds. Fold axes are shown by red lines. The interaction of these two fold directions produced widespread basin-and-dome structures on a scale of 3-10 m (9-30 ft). A 12 ft. measuring tape trends across image from upper right to lower left.

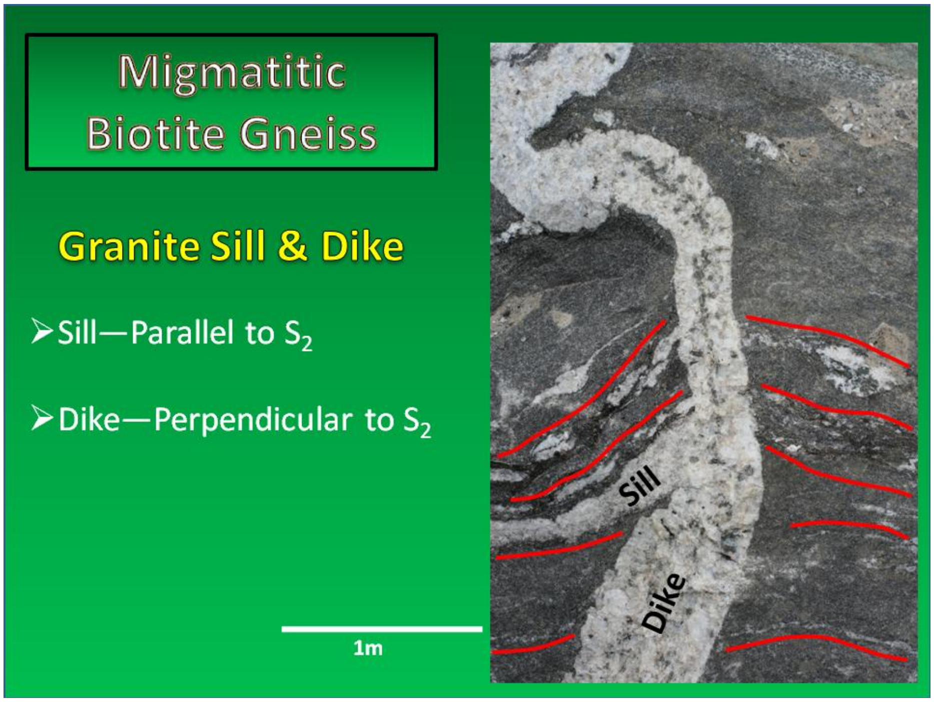

Figure 7. **Anatectic Granitic melt in Migmatitic Biotite Gneiss.** Red lines outline S_2 metamorphic differentiation.

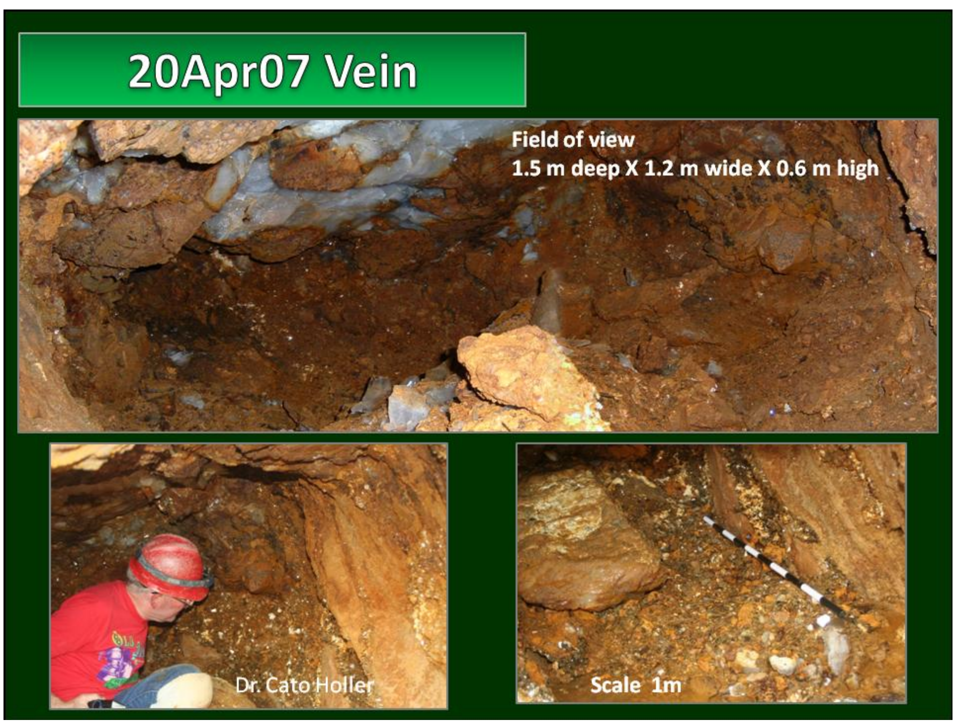

Figure 11. **Images inside 20Apr07 Vein Cavity.** Upper, collapse pile of large goethite after siderite crystals in center of cavity. Lower left, man-size natural cavity. Lower right, weathered BCB (breakdown crystal breccia) on cavity floor.

Figure 12. **Images inside 20Apr07 Vein Cavity.** Right, weathered breakdown crystal breccia on cavity floor. Left, excavated wall of breakdown crystal breccia outlined by red lines; note water standing in bottom of cavity.

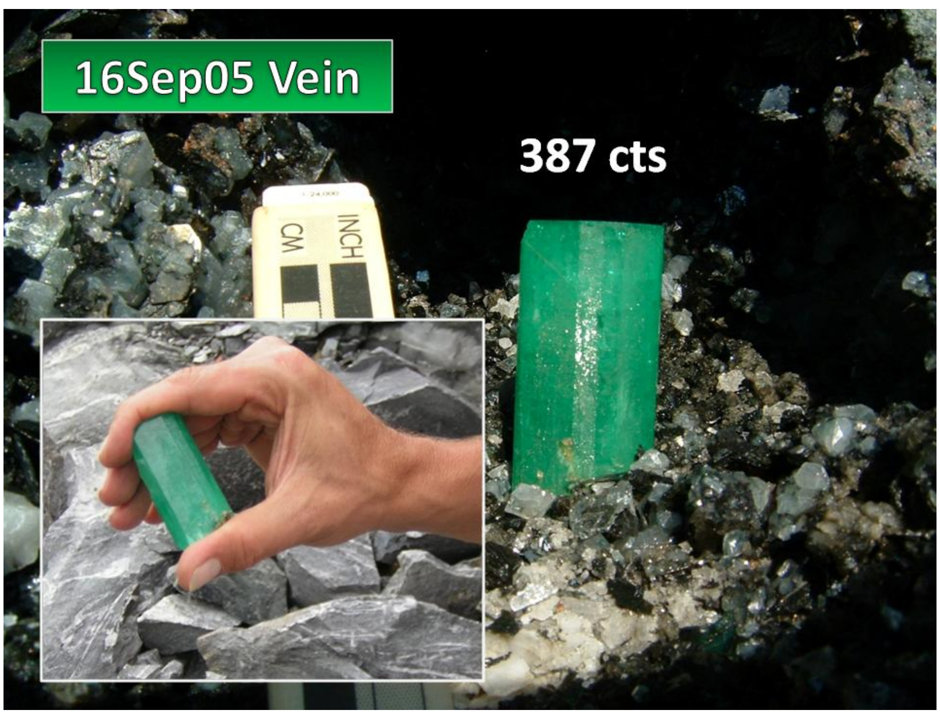

Figure 13. **Exceptionally Dark Green Hexagonal Emerald Crystal from the 16Sep05 Vein Cavity.**

Figure 14. **Hexagonal Emerald Crystals Showing Flat Terminations and Color Zoning.** The 158 ct crystal came from the 8Mar06a Vein, while the 965 ct crystal came from the 29Dec06 Vein.

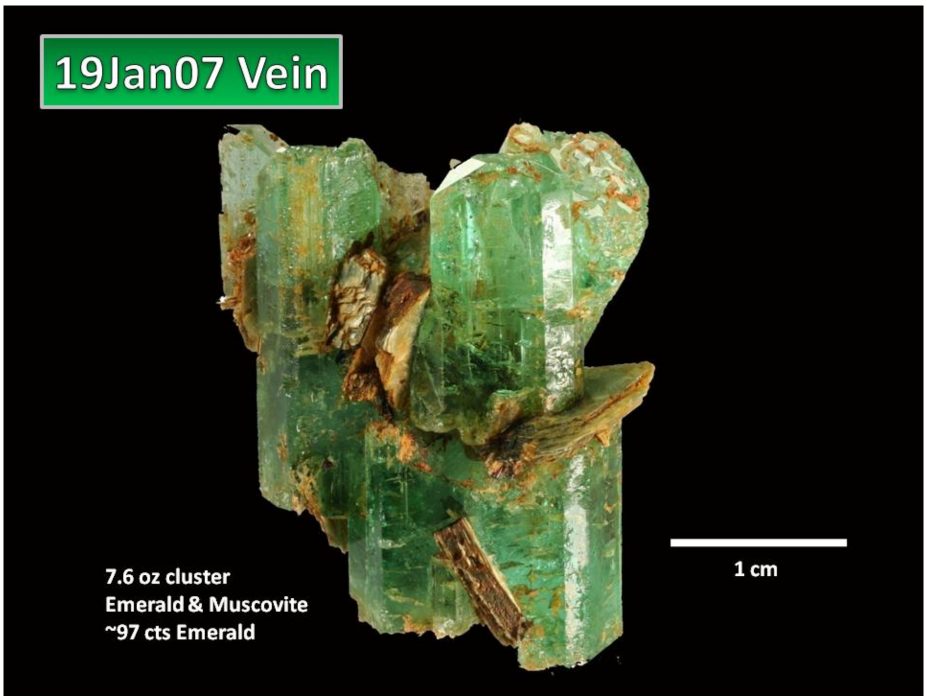

Figure 15. **Emerald and Muscovite Cluster Showing Pyramidal Termination on Emerald.**

Figure 16. **Dark Green Hexagonal Emerald Crystal in Calcite and Muscovite Matrix.**

Figure 17. **Dark Green Hexagonal Emerald Crystals in Matrix.** Note quartz crystal overgrowth.

Figure 18. **Emerald Necklace and Ear Rings.** The June Culp Zeitner emerald (15.47 cts) is set in an 18k gold and diamond necklace with matching ear rings. The June Culp Zeitner is North America's second largest faceted emerald and came from a 142.25 ct crystal found in 1974 on the NAEM property. It was named for a well-known editor of Lapidary Journal magazine. It was faceted by A.T. Grant of Hannibal, NY while the necklace and ear rings were crafted by Laszlo Kardos of Homosassa Springs, FL, the former court jeweler for the royal family of Hungary. The Zeitner was cut perpendicular to the c axis from the dark-green end termination of the original emerald crystal and the outer edges of the faceted gemstone mimic the edges of the natural crystal. The necklace contains fourteen 3 mm diamonds and fifty two 1-cm-diameter gold lace disks. Each ear ring contains an approximately 2 ct emerald (also from the NAEM property) and six 3 mm diamonds. The set includes a matching emerald and diamond ring which is not pictured.

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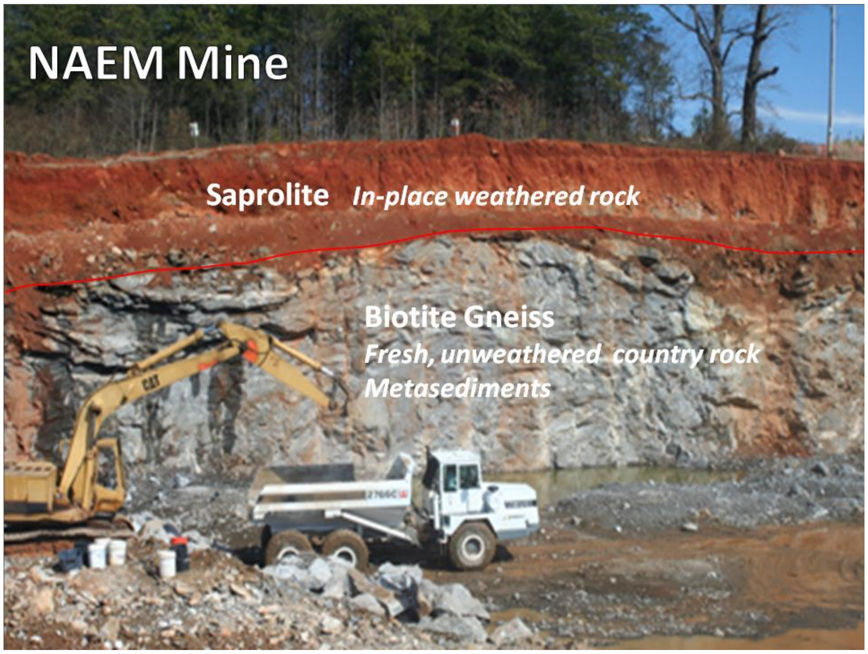

North American Emerald Mines, Inc. open pit in 2007.

Discovery of North America's 5th Largest Emerald.
On the left, the crystal is seen as an in-situ collapsed fragment
In highly weathered breakdown crystal breccia.
On the right, Jamie Hill, founder of North American Emerald Mines, Inc.
Holds the washed, but still oxide-stained crystal.