Screening of Historic Asbestos Mines, Historic Asbestos Prospects, and Natural Asbestos Occurrences in North Carolina

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The United States Geological Survey recently published Open File Report 2005-1189: Reported Historic Asbestos Mines, Historic Asbestos Prospects, and Natural Asbestos Occurrences in the Eastern United States by Bradley S. Van Gosen. In response to the documented presence of naturally occurring asbestos deposits in the mountain regions of North Carolina, the North Carolina Division of Public Health, Epidemiology Section has made the following statement concerning public exposure to naturally occurring asbestos:

> Exposure to asbestos can increase the risk of the public for certain diseases including some cancers. The potential for human exposure to asbestos would be greater when materials are disturbed. Activities that could disturb naturally occurring asbestos include the cutting of new roads, excavation, chipping or hammering on rocks containing asbestos, sifting dry materials and/or other activities that may cause dust or loosen pieces of rock. As such, it seems prudent to consider whether naturally occurring asbestos is present prior to conducting activities that might disturb naturally occurring asbestos-containing materials. Each site will be different and some may not contain asbestos. If a site is found to contain asbestos, practices should be introduced to minimize exposure of the public and workers to asbestos.

Screening Summary

The U.S. Geological Survey report documents 46 historic asbestos mines, prospects, and occurrences within North Carolina (Table 1). Preliminary screening has been completed for these 46 sites. Four sites were added and also screened. Of the sites screened, 27 were past producers, 9 were prospects and 13 were occurrences. All sites were plotted on USGS 7.5' topographic maps. Aerial photos at the same scale as the topographic maps were examined to determine which sites had the highest potential for disturbance by human activity. More detailed photographs were examined in cases that were questionable. Site visits were conducted for 26 of the sites in October and November 2005. Twenty-four sites were screened using aerial photographs and literature search only. Land use in close proximity to the 50 sites is summarized below (number of sites with each land use are given):

Land Use Category	Sites	Land Use Category	Sites
Residential	18	Development within 200 ft	17
Commercial	3	Construction in progress	4
Industrial	3	Wooded/undeveloped	22
Farming	8	Recent mining (within last 20 years)	7
Recreational	2	Permitted active mines	2
Closed mines (closed permit)	4	Permitted inactive mines	2

Note: Some sites fall into multiple land use categories.

The initial screening of these 50 sites in late 2005 indicates that human activity is impacting many of the sites (Table 2). The ultramafic host rocks for the asbestos deposits are present in a swath through western North Carolina from Virginia to Georgia (Figure 1). While most of the larger ultramafic bodies have been mapped and appear on geologic maps, potentially hundreds of smaller bodies have yet to be located and mapped. Development in this area is rapidly increasing and encountering one of these asbestos-bearing bodies during construction is becoming more likely. Many homes have already been built on or near these asbestos sources. At least one of the asbestos-bearing ultramafic rock bodies is being mined for olivine.

Nature of the Asbestos-Bearing Ultramafic Bodies

The asbestos-bearing ultramafic bodies occur as discrete masses that often contrast markedly with the surrounding host rocks. They are typically composed of dark-colored (mafic) minerals that result in a dark-colored rock mass. The ultramafic bodies vary in size from less than an acre up to 300 acres. Most are small and cover only a few acres of surface exposure (Robinson and others, 1992). Figure 2 summarizes the characteristics of a typical ultramafic body in the Blue Ridge Province of North Carolina and is based on the Balsam Gap dunite deposit as described by Hunter (1941, p.68). The ultramafic body consists of an inner core of relatively unaltered ultramafic rock and a fringe zone of altered ultramafic rock surrounding the core. The fringe zone often contains the alteration minerals serpentine, talc, vermiculite, chlorite, and anthophyllite asbestos. These minerals are scattered throughout the zone. Fractures and faults within the relatively unaltered ultramafic rock at the core of the body can contain these same alteration minerals including asbestos. Local areas within the fringe zone were the target of exploration for asbestos as this zone contained the bulk quantities of asbestos necessary for economical mining. Sufficient quantities of asbestos were not present in the interior veins and fractures of the ultramafic bodies to be of economic interest. Asbestos may be present in sufficient quantities within all zones of the ultramafic body to be problematic when the rock or soil is physically disturbed. The focus of attention solely on the immediate vicinity of old mines and prospects could lead to not recognizing nearby areas of equal asbestos exposure potential. The geographic distribution of ultramafic bodies in western North Carolina is given in Figure 1 (Conrad and others, 1963).

Mining History

Several mineral commodities have been mined from within the ultramafic bodies in North Carolina. In addition to asbestos, commodities either mined or prospected include olivine, vermiculite, corundum, gemstones and chromite. The probability of encountering asbestos while mining or prospecting any of these commodities is high. The locations of historic mines, prospects and occurrences of all of these commodities provide valuable information about the location of asbestos bearing rock bodies. These mining operations are briefly described below:

Asbestos

As shown in Figure 2, asbestos may occur anywhere within the ultramafic bodies. It is most often encountered in mineable quantities within the highly altered outer shell of the ultramafic bodies (see talcy-vermiculite zone in Figure 2). Of the 27 past producing asbestos mines in North

Carolina, nearly all were located within this zone. Most of the asbestos prospects were located within this zone as well. Most of these ultramafic bodies are likely to contain asbestos. The asbestos site location coordinates given in the attached screening report (Table 1) may be a bit misleading by giving the erroneous impression that these sites are point sources of asbestos. They are not. While many of the old mines, prospects, and occurrences can be located accurately, the location of an individual site does not necessarily give a good perspective of the aerial extent of the asbestos associated with that site. Since asbestos can occur at any location within the host ultramafic body (see Figure 2), potential asbestos exposure problems could result from disturbing any portion of the ultramafic body.

Asbestos was mined in North Carolina as late as 1977 (Robinson and others, 1992). All of the historic production was asbestiform anthophyllite. The fibers of this variety of asbestos are quite short and have lower tensile strength than some of the other asbestos varieties but they have better resistance to acids and heat than the others, especially chrysotile. Asbestos from North Carolina mines has been used in pipe insulation, filters for use in acid environments, fire proofing, roofing shingles, floor tile and wall board.

Two plants were built in North Carolina to process asbestos. The National Asbestos Company built a plant in about 1927 to process asbestos from the Frank mine (Stuckey, 1965, p. 359-360). The plant was in the small Avery County town of Minneapolis, about 2.5 miles north of the Frank mine. According to Stuckey, the mine operated intermittently until the late 1930's when it closed. A long-time Minneapolis resident pointed out the location of the plant. It was on the east bank of Cranberry Creek on the west side of Highway 19-E. The area is now used as a staging area for logs and no asbestos bearing rock was noted on the site. Debris from the mill operation may have been washed away during episodes of flooding along Cranberry Creek. Another plant was built at about the same time as the Minneapolis plant in the Macon County town of Norton. Records do not indicate any production from this plant (Stuckey, 1965, p.360).

Olivine

Mining of olivine commenced in North Carolina in 1933 and continues today. The Daybook Olivine mine is the only producing mine in operation though several mines are permitted and are operated on an intermittent basis.

Olivine is a green granular mineral that is very resistant to the effects of heat. This property makes it ideal for use in refractories and foundry sand. It is used in the brick linings of kilns and furnaces. It is also used as a substitute for silica sand in sand blasting, a use that should be carefully monitored for asbestos contamination. In a recent study (Goff and others, 2000), the large reserves of olivine in North Carolina were considered to be an important resource for magnesium for use in a process to remove carbon dioxide from smokestack emissions (carbon dioxide sequestration).

Olivine is an important component in most asbestos bearing ultramafic bodies. It is commonly found in the less-altered central core of these bodies (Figure 2). Asbestos is often present within fracture zones that cut the olivine but it is usually a minor component in these areas.

Vermiculite

Vermiculite is a micaceous mineral produced by weathering of the mica family members, biotite, chlorite, or phlogopite (Robinson and others, 1992, p.41). When heated these minerals expand like an accordion making them an excellent lightweight insulating material. Vermiculite has been widely used as attic insulation in homes, as a component of lightweight concrete blocks and bricks, and as a soil conditioner.

Vermiculite and asbestos often occur together in ultramafic bodies within the outer alteration shell (Figure 2) as well as within fractures and faults in the less-altered core of the bodies. Not surprisingly, the geographic distribution of vermiculite (Figure 3) is very similar to that of asbestos given in Figure 1. The mines were rather small operations and most operated intermittently. Mining of vermiculite from the ultramafic rocks of the Blue Ridge Province began in 1933 and continued until 1955. Production was reported from Corundum Hill, Moores Knob, Bud Mincey and Ellijay Creek deposits, Macon County, and the Bee Tree deposit near Swannanoa in Buncombe County (Robinson and others, 1992). Most of the vermiculite mined in North Carolina was exfoliated in plants located near the mines in Swannanoa and Franklin (Murdock and Hunter, 1946, p.1). The Bee Tree plant area is now residential with large wooded lots. The Franklin plant site has not yet been located.

Gemstones

Numerous gemstone mines catering to the tourist industry are operated in the North Carolina mountains stretching from Franklin-Highlands area to Spruce Pine (Table 3). Most of these are not mines in the strict sense but they offer tourists buckets of dirt or sediment they can wash in an onsite flume. In some cases gemstones from areas outside North Carolina have been added to the buckets ("salted"). Most of the mines offer buckets of "native" soil or sediment that contain gemstones commonly found in North Carolina. The "native" buckets contain material dug from either stream sediments or saprolite (very weathered disintegrated rock). Asbestos is common in some of the same rock types that contain gemstones. Rubies and sapphires for example are often found in the ultramafic rocks that host asbestos deposits. Most of the gemstone mines offer buckets of "native" material containing rubies and sapphires. The rubies and sapphires found in western North Carolina may be found in other rock types such as amphibolite or hornblende gneiss that have a lower potential for hosting asbestos. Rubies and sapphires are different colored varieties of the same mineral, corundum. Corundum is very hard and can survive transport by a stream for long distances. The needle-like asbestos fibers abrade quickly in a fast-flow stream environment and are not transported long distances downstream. Even if a host rock body contains both corundum and asbestos, the likelihood of corundum-bearing stream sediments also containing asbestos lowers quickly with distance downstream from the source rock.

Mine permit records of the North Carolina Land Quality Section indicate that there were seven permitted gemstone mines in North Carolina as of December 31, 2005. Two of these mines are within the Piedmont Province in Alexander County near Hiddenite and are not near any known asbestos bearing rocks. Five of the permitted gemstone mines are located within the Blue Ridge Province of North Carolina where asbestos-bearing ultramafic rocks occur. Records show that two of the permits are active and three are inactive. The active permits include the Rose Creek Mine and Mason's Ruby Mine. The inactive operations are the Cherokee, Shamiami, and Sheffield mines. All of these mines are in Macon County near the town of Franklin.

An article in the Eclectic Lapidary magazine (Bova, 2005) states that in October 2005 the Sheffield mine was the last remaining lode gemstone deposit open to the public in the Franklin (Cowee Valley) area. Pratt and Lewis (1905, p. 218, 249) described the corundum bearing rock at the mine as an amphibole schist or gneiss. Thin sections of the rock were prepared and analyzed in their study and no asbestos was noted in the rock. The Shamiami mine was apparently mined for garnet abrasives when first permitted in 1975 (McDaniel and McKenzie, 1976). Although the mine's permit expired in 1995, it remains on the inactive permitted mines list as a gemstone mine. The Cherokee and

Mason's Ruby mines are placer deposits and therefore have a low potential for asbestos. No asbestos bearing ultramafic rocks have been noted in the geologic literature for the Cowee Valley area where these mines are located. The Rose Creek mine's website mentions their permit status but does not give information about the material mined (placer or load?). They do mention that visitors can dig and fill their own buckets in the onsite mine tunnel. This is likely just a shed constructed to look like a mine adit, judging from a photo on their website.

Several of the non-permitted mines are likely candidates for closer scrutiny. The Nantahala River Gem Mine website says that some of their gemstone material comes from the local area. Since the local sites are not easily accessible, the material is brought to their bagging plant where it is bagged and then taken to their gem mine. It is not stated whether the material is from placer or lode sources. Many of the mines on the attached spreadsheet advertise "native" material without describing the source of the material. The sources probably change depending on current availability. Most of the "native" sources are probably placer but lode sources cannot be ruled out. Both the lode and placer materials could be mined without a permit if the total mining operation is less than an acre in aerial extent.

Corundum

Corundum was mined in North Carolina between 1871 and 1898 and briefly between 1917 and 1919 (Robinson and others, 1992, p.39). It is a very hard mineral and was used as an abrasive. Mining of corundum ceased when suitable synthetic abrasives were developed. The largest production of corundum came from the Corundum Hill mine with lesser amounts mined at the Buck Creek and Joe Mincey mines (Robinson and others, 1992, p.39). Corundum is found mostly in the altered outer margins of the ultramafic bodies, a product of the same alteration that formed asbestos. Asbestos was likely encountered during the mining of corundum.

Sapphires and rubies are actually corundum with different impurities that produce their unique colors. Recreational prospectors looking for these minerals often use asbestos as a guide to the most likely rocks to contain these coveted gems.

Chromite

Chromite is present in most of the ultramafic bodies of western North Carolina. Although prospectors have searched for the mineral in economic quantities since the Civil War, only about 1000 tons have actually been mined. Like corundum chromite is most often found near the margins of the ultramafic bodies (Lewis, 1922, p.114-115; Hunter, 1938, p.18) in close proximity to asbestos.

Ultramafic Bodies Not Included in USGS OFR 2005-1189

There are no representatives of a group of ultramafic bodies in northwestern North Carolina on the USGS list of asbestos mines, prospects and occurrences within Open File Report 2005-1189. These bodies occur in Ashe and Allegheny Counties (Figure 4) and have no known history of mining activity. The bodies appear to be more altered than the ultramafic bodies of the Spruce Pine and Franklin areas and such economic minerals as olivine are present in only remnant traces. Scotford and Williams (1983) and Raymond and Abbott (1997) have described some of the bodies in reconnaissance fashion and conclude that all have the potential for containing tremolite and/or anthophyllite. In a few cases they mention the

presence of asbestiform varieties of these minerals. A quick reconnaissance sampling survey of several of these bodies indicates the presence of asbestiform tremolite-actinolite or anthophyllite may be common within this group of ultramafic bodies. Samples taken from ultramafic bodies at or near Warrensville, Nathan's Creek (Shatley Springs), Little Peak Creek and Cranberry Creek all were found to contain asbestiform tremolite-actinolite. Asbestiform anthophyllite was found in some landscaping boulders near the Todd ultramafic body. Analyses were performed by polarized light microscopy (PLM) methods and no attempt was made to quantify the amount of asbestos present in the rocks. No asbestos was detected in samples from the ultramafic body near Index. In summary, asbestos was found in five of the six ultramafic bodies sampled in Ashe County (Figure 4).

Examples of Site Visits

The following are examples of some of the conditions found during the site visits:

Addie chromite prospect- This site was actually an olivine mine that closed in 1988. Olivine was mined from two open pits. The ultramafic rocks here are part of a ring structure that extends between the towns of Addie and Webster, a distance of about 5 miles. Four areas along a 1.5-mile strike length of the ultramafic body were sampled and analyzed for asbestos. Anthophyllite asbestos was detected at all four locations. Two of these locations were in the immediate vicinity of the Addie olivine mine. One sample was from a spoil pile that had been leveled next to a dirt road that serves as the access to a development of mobile homes. The road gravel used on this road is mostly mine waste. The other sample was from an excavation that appeared to be a new mobile home site. Several homes as well as a medical facility, a recycling center, and a landfill transfer station are located on the ultramafic body in the vicinity of the olivine mine. The asbestos bearing ultramafic rock can be traced north of the mine area into the small town of Addie where it underlies at least a part of the old Scotts Creek Elementary School. The new Scotts Creek Elementary School is about a mile northwest and may be underlain by the same ultramafic rock unit. Anthophyllite asbestos was detected in an outcrop about 2000 feet east of the school. No ultramafic rocks were observed on the school property during a quick reconnaissance of the area.

Sapphire mine- Asbestos was mined at this site as late as 1961. It was known as early as the late 1800's that the ultramafic rock here contained sapphires. The mine is part of a large resort, Fairfield Sapphire Valley, and lies within a residential section of the resort known as Holly Forest. The mine is now called the Sapphire Valley gem mine and guests and residents of the resort are encouraged to take advantage of the free gem mine and enjoy a day outside with their children searching for a special treasure. A review of the internet shows that several other tourist related businesses promote the use of the mine. The parking area of the mine is on Highway 64 and is readily accessible to the public. A trail leads from the parking area to the mine. Anthophyllite-rich rock fragments are scattered along the trail. The field identification has been confirmed by analyses using polarized light microscopy methods. The mine itself contains a large outcrop and some huge boulders at the edge of a small stream. Visitors to the mine have been hammering on boulders at the site exposing areas with very high anthophyllite asbestos content. Chunks of this asbestos-rich rock are scattered all around the site. The asbestos in the freshly broken rock is very friable. This recreational mine has been available to the public for at least twenty years according to Darryl Wood, President of Sapphire Management Company, Inc. and the mine has received thousands of visitors during that time. No less than 5 asbestos-bearing ultramafic bodies lie within the Fairfield Sapphire Valley Resort, mostly in the residential areas. Even in areas where the rock has weathered to clay, asbestos fibers remain and appear to be relatively fresh.

Day Book olivine mine- This site is an active olivine mine which sits literally at the edge of NC Highway 197. Anthophyllite asbestos is associated with this deposit. A processing plant for the olivine is located here and it also sits at the edge of the road. Several houses are near the mine property and one house on the north end of the mine sits at the base of huge bare spoil piles. A volunteer fire station is located north of the mine. A gravel road across from the station is littered with anthophyllite asbestos.

Screening Reports Methodology

Preliminary screening has been completed for 50 sites that have a potential for containing asbestos. Forty-six of these sites were contained in the United States Geological Survey Survey's Open File Report 2005-1189. The presence of asbestos at all 46 of these sites is mentioned in the published geologic literature. Asbestos is likely to occur in many ultramafic bodies that have not been well documented in the geologic literature. Some bodies were studied but asbestos was not reported as it was not relevant to those targeted studies. Four additional sites were screened and are included in this report as potential representatives of such bodies that may contain asbestos although its presence is not mentioned prominently in the geologic literature.

Screening of these sites was initiated by a thorough review of the available pertinent geologic literature on the ultramafic bodies of the Blue Ridge and Inner Piedmont provinces of North Carolina. All of the sites were located on registered digital copies of USGS 7.5' topographic maps using MapInfo 5.5. A topographic map and corresponding aerial photograph at the same scale were examined for each site. Most of the initial aerial photography used was black and white and was taken in 1993. Color infrared photography (mostly 1998 vintage) was obtained for those sites with obvious potential for cultural disturbance. Light blue or gray areas on this photography were viewed as potential indications of human activity. Using this method of initial screening, twenty-two of the sites were determined to be within wooded/undeveloped areas. These sites were not scheduled for a site visit unless they were near sites chosen for a field visit. In that case a drive-by examination was performed to substantiate the lack of human interaction at the site. For those sites targeted for a field visit, an attempt was made to document current site use and where possible determine the presence or absence of asbestos. Samples containing suspicious fibrous minerals were taken and later analyzed by polarized light microscopy (PLM). No attempt was made to quantify the amount of asbestos present in the samples. All site information, along with directions to each site was recorded on forms which became the body of the reports.

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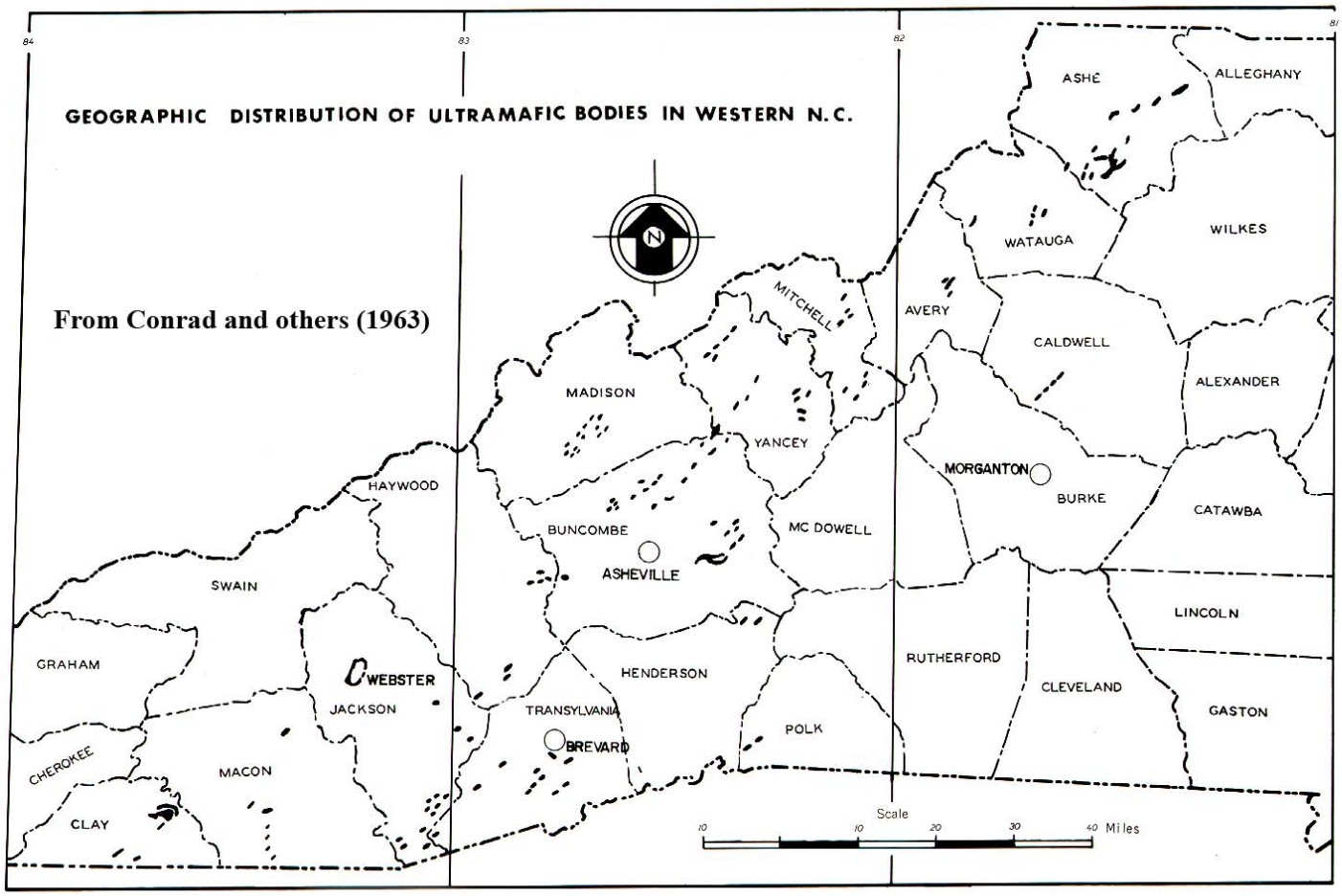


Figure 1: Geographic Distribution of Ultramafic Bodies in Western North Carolina

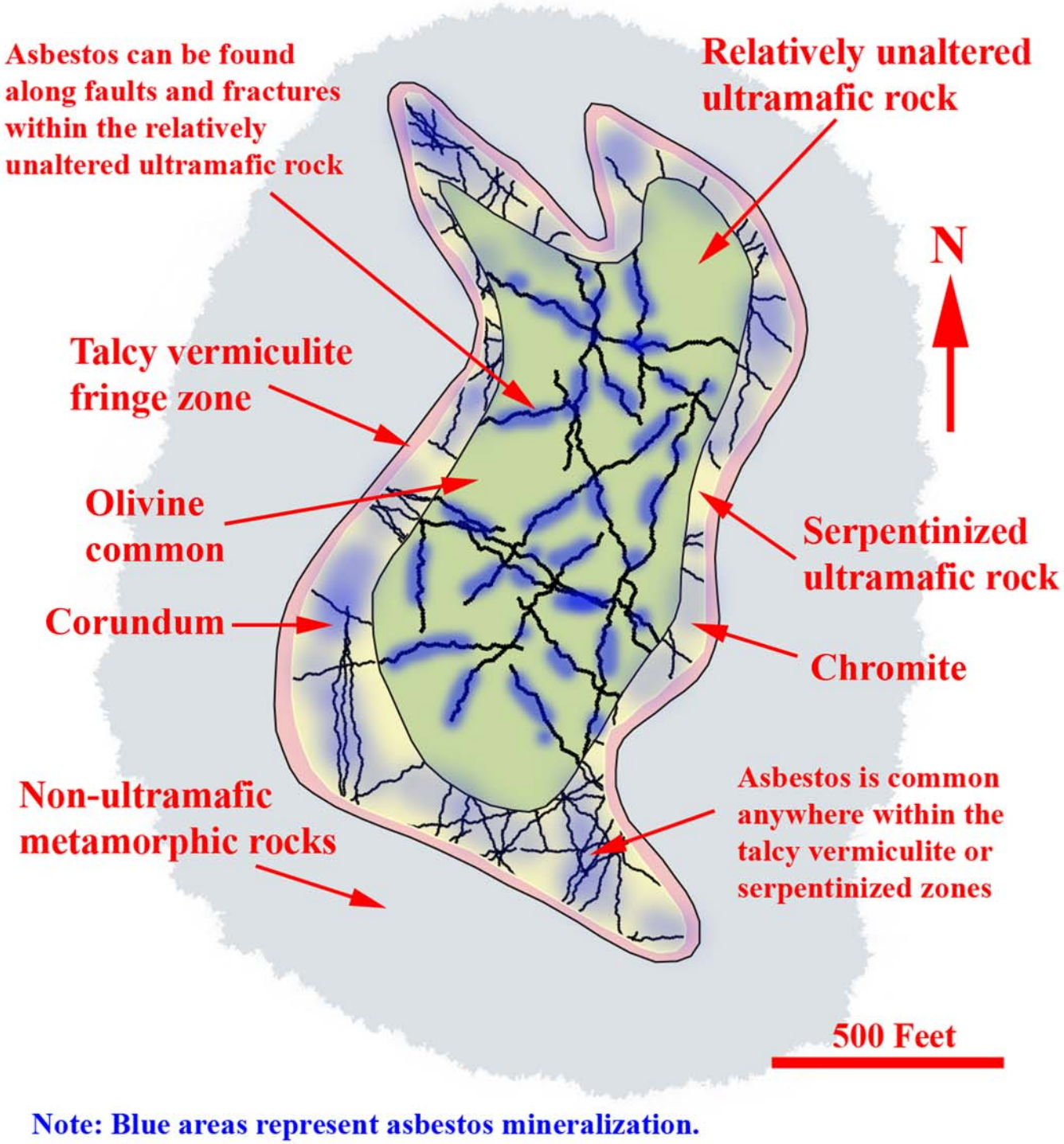


Figure 2 : A typical asbestos-bearing ultramafic body of the Blue Ridge Province of North Carolina.

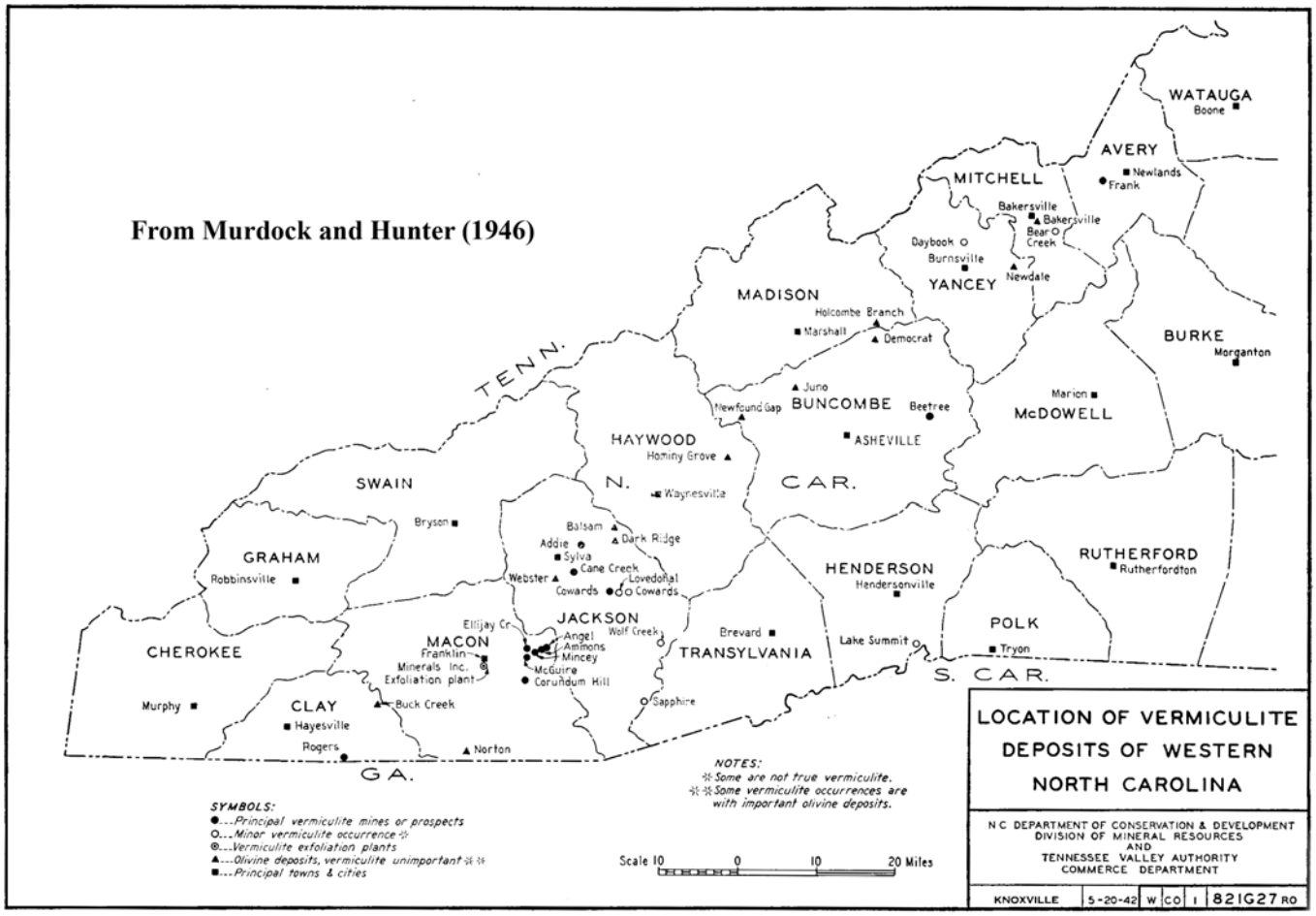
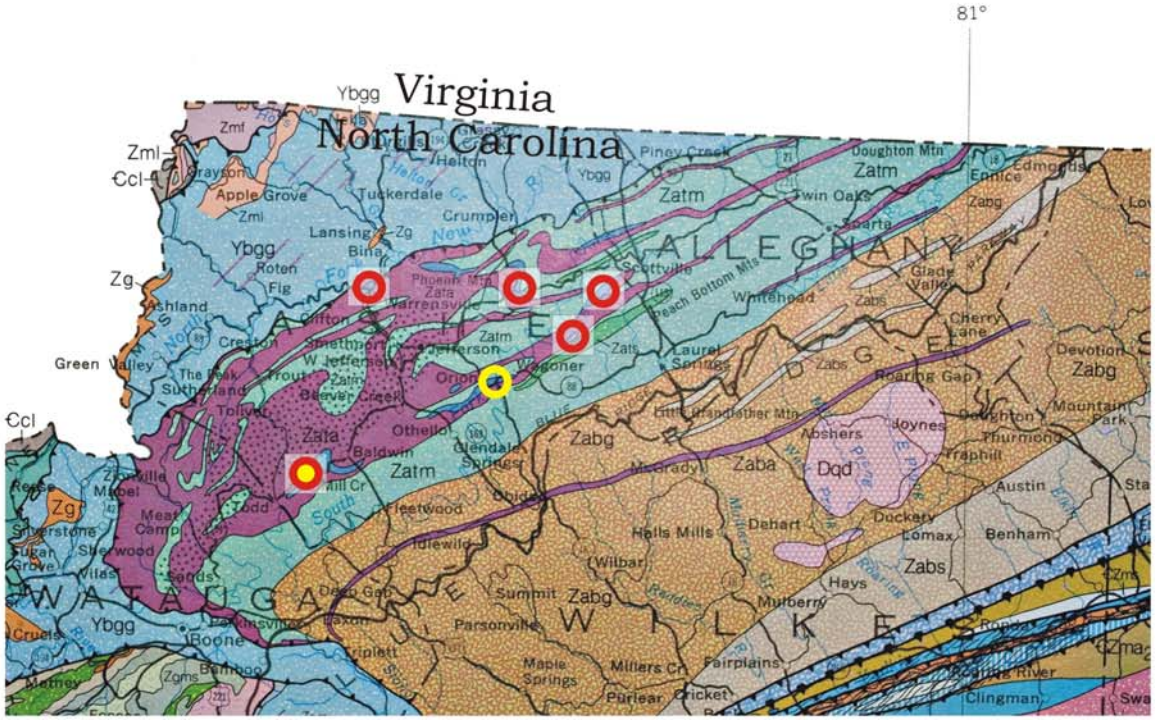


Figure 3: Geographic distribution of vermiculite deposits of North Carolina.



(From 1985 State Geologic Map of North Carolina)

Asbestiform tremolite-actinolite detected in ultramafic rock sample.

Asbestiform anthophyllite detected in ultramafic rock sample.

No asbestos detected in ultramafic rock sample.

Figure 4: Reconnaissance sampling of selected ultramafic bodies in Ashe County, North Carolina.

Table 1

Historic Asbestos Mines, Historic Asbestos Prospects, and Natural Asbestos Occurrences in North Carolina*

*** (Adapted from: Reported Historic Asbestos Mines, Historic Asbestos Prospects, and Natural Asbestos Occurrences in the Eastern United States, USGS Open File Report 2005-1189, by Bradley S. Van Gosen, 2005.)**

Site Number	Historic site name as reported	Latitude	Longitude	State	County	7.5' Quad	Development	Asbestiform mineral(s) reported	Associated minerals reported	Host rock(s) reported	References
NC-1	Addie chromite prospect	35.3992	-83.1593	NC	Jackson	Sylva North	occurrence	anthophyllite asbestos	chromite, talc, chlorite	dunite	Hunter and others (1942, p. 12-14)
NC-2	Alders mine	35.185	-83.113	NC	Jackson	Big Ridge	past producer	anthophyllite asbestos	talc	peridotite	Conrad and others (1963, p. 40)
NC-3	Asbestos mine	35.1181	-83.0105	NC	Jackson	Cashiers	past producer	anthophyllite asbestos	olivine, chromite, magnetite, talc, chlorite, vermiculite	dunite	Conrad and others (1963, p. 32-34)
NC-4	Bad Creek prospect	35.100	-83.018	NC	Jackson	Cashiers	past prospect	anthophyllite asbestos	corundum, chlorite, vermiculite, olivine, tremolite, talc, limonite, magnetite, magnesite	not reported	Conrad and others (1963, p. 35-36)
NC-5	Balsam Gap olivine deposit	**35.42556**	**-83.09587**	NC	Jackson	Hazelwood	occurrence	chrysotile	olivine, antigorite, talc, bronzite, chromite, magnetite, chlorite	dunite	Hunter (1941, p. 67-74)
NC-6	Blue Rock mine	35.8922	-82.1872	NC	Yancey	Micaville	past producer	anthophyllite asbestos	chlorite, talc, magnetite, olivine, serpentine	ultramafic rock	Brobst (1962, plate 1); Conrad and others (1963, p. 24-25)
NC-7	Brockton mine	35.128	-83.001	NC	Jackson	Big Ridge	past producer	anthophyllite asbestos	corundum, enstatite, magnesite, magnetite	ultramafic rocks	Conrad and others (1963, p. 35)
NC-8	Bryson mine	35.134	-83.172	NC	Jackson	Glenville	past producer	anthophyllite asbestos	not reported	dunite, peridotite	Conrad and others (1963, p. 37, 39-40)
NC-9	Burleson mine	**36.05834**	**-81.95335**	NC	Avery	Newland	past producer	anthophyllite asbestos	talc, enstatite	pyroxenite	Bryant (1962, p. D-28); Conrad and others (1963, p. 21-22)
NC-10	C.W. Allen prospect (Cane River mine)	35.8940	-82.3730	NC	Yancey	Burnsville	past producer	anthophyllite asbestos	olivine, serpentine, chlorite	dunite	Conrad and others (1963, p. 27)
NC-11	Cas Thomas prospect	35.984	-82.194	NC	Yancey	Micaville	past prospect	anthophyllite asbestos	not reported	pyroxenite	Conrad and others (1963, p. 27)
NC-12	Chesnut Gap chromite prospect	35.375	-83.149	NC	Jackson	Sylva South	occurrence	anthophyllite asbestos	chromite, talc, vermiculite	dunite	Hunter and others (1942, p. 12)
NC-13	Coldsides Mountain mine	35.036	-83.081	NC	Jackson	Cashiers	past producer	anthophyllite asbestos	chlorite, vermiculite	peridotite	Conrad and others (1963, p. 36-37)
NC-14	Commissioner Creek prospect	35.010	-83.402	NC	Macon	Prentiss	past producer	anthophyllite asbestos	tremolite, olivine, chlorite, talc, serpentine, magnesite, magnetite, limonite	peridotite	Hunter (1941, p. 106-107); Conrad and others (1963, p. 42)
NC-15	Day Book dunite deposit	**35.96686**	**-82.28392**	NC	Yancey	Burnsville	occurrence	anthophyllite asbestos	olivine, talc, vermiculite, chromite, enstatite, tremolite, antigorite, ferroan phlogopite, bronzite, chlorite	dunite	Kulp and Brobst (1954); Hunter (1941, p. 48-53)
NC-16	Deposit Number Nine	35.190	-83.280	NC	Macon	Corbin Knob	occurrence	chrysotile	olivine, vermiculite, chlorite, chromite, antigorite	dunite	Hunter (1941, p. 100-102)
NC-17	Frank mine	**36.06846**	**-82.00525**	NC	Avery	Carvers Gap	past producer	anthophyllite asbestos	enstatite, bronzite, talc, vermiculite, olivine, antigorite, chlorite, chromite	dunite	Hunter (1941, p. 43-47); Brobst (1962, p. A22); Conrad and others (1963, p. 22)
NC-18	Harris prospect	35.212	-82.978	NC	Jackson	Lake Toxaway	past prospect	anthophyllite asbestos	vermiculite, talc, tourmaline	dunite or peridotite	Conrad and others (1963, p. 37)
NC-19	Henderson mine	35.165	-83.167	NC	Jackson	Glenville	past producer	anthophyllite asbestos	not reported	not reported	Conrad and others (1963, p. 40)
NC-20	Higdon mine	35.190	-83.277	NC	Macon	Corbin Knob	past producer	anthophyllite asbestos	olivine	dunite	Conrad and others (1963, p. 40-42)
NC-21	Hogback Creek mine	35.119	-83.005	NC	Jackson	Cashiers	past prospect	anthophyllite asbestos	not reported	not reported	Conrad and others (1963, p. 34)
NC-22	Holden mine	35.182	-83.115	NC	Jackson	Big Ridge	past producer	anthophyllite asbestos	not reported	dunite	Conrad and others (1963, p. 40)
NC-23	J.C. Woody mine	**35.9753**	**-82.214**	NC	Yancey	Micaville	past producer	anthophyllite asbestos	talc, chlorite, vermiculite, magnetite, limonite	dunite	Brobst (1962, plate 1); Conrad and others (1963, p. 26)
NC-24	J.H. Pannell prospect	36.0025	-82.1467	NC	Mitchell	Bakersville	past prospect	anthophyllite asbestos, chrysotile	olivine, serpentine	peridotite	Hunter (1941, p. 57); Brobst (1962, p. A22); Conrad and others (1963, p. 22)
NC-25	Jennings No. 1 mine	**35.05318**	**-83.05208**	NC	Transylvania	Cashiers	past producer	anthophyllite asbestos	chlorite, vermiculite, tourmaline, garnet	peridotite	Conrad and others (1963, p. 31-32)
NC-26	Jennings No. 2 mine	**35.05544**	**-83.05234**	NC	Jackson	Cashiers	past producer	anthophyllite asbestos	enstatite, olivine, corundum	not reported	Conrad and others (1963, p. 36)
NC-27	Johns River mine	35.884	-81.703	NC	Caldwell	Collettsville	past producer	anthophyllite asbestos	serpentine, olivine, magnetite, chlorite, magnesite, talc	dunite	Conrad and others (1963, p. 42-44)
NC-28	Kilpatrick mine	35.188	-82.922	NC	Transylvania	Lake Toxaway	past producer	anthophyllite asbestos	talc, chlorite	dunite	Conrad and others (1963, p. 29)
NC-29	L.E. Cash property	35.086	-82.988	NC	Transylvania	Reid	past prospect	anthophyllite asbestos	not reported	not reported	Conrad and others (1963, p. 32)
NC-30	Manus mine	35.133	-83.175	NC	Jackson	Glenville	past producer	anthophyllite asbestos	vermiculite, talc	peridotite	Conrad and others (1963, p. 39-40)
NC-31	Miller mine	35.095	-83.006	NC	Transylvania	Cashiers	past producer	anthophyllite asbestos	enstatite, talc, chlorite, serpentine, olivine, magnetite, chromite, pyrite	pyroxenite	Conrad and others (1963, p. 30-31)
NC-32	Newdale mine	35.9160	-82.2003	NC	Yancey	Micaville	past producer	anthophyllite asbestos	enstatite, talc, olivine, chlorite, serpentine, magnetite, chromite, vermiculite	dunite	Hunter (1941, p. 53-57); Brobst (1962, plate 1); Conrad and others (1963, p. 25-26)
NC-33	Oakland mine	**35.11419**	**-82.98049**	NC	Transylvania	Reid	past producer	anthophyllite asbestos	enstatite, tremolite, talc, chlorite, actinolite, olivine	pyroxenite	Conrad and others (1963, p. 29-30)
NC-34	Peterman mine	35.009	-83.382	NC	Macon	Prentiss	past producer	anthophyllite asbestos	talc	dunite or peridotite	Conrad and others (1963, p. 42)
NC-35	Rattlesnake corundum mine	35.126	-83.005	NC	Jackson	Big Ridge	occurrence	anthophyllite asbestos	corundum, enstatite, olivine, talc, chlorite, serpentine, magnetite	not reported	Conrad and others (1963, p. 34-35)
NC-36	Round Mountain mine	35.029	-83.033	NC	Jackson	Cashiers	past producer	anthophyllite asbestos	not reported	peridotite, dunite	Conrad and others (1963, p. 36)
NC-37	Sam Grindstaff mine	35.9653	-82.2168	NC	Yancey	Micaville	past producer	anthophyllite asbestos	not reported	dunite	Brobst (1962, plate 1); Conrad and others (1963, p. 26-27)
NC-38	Sapphire mine	**35.11814**	**-83.00503**	NC	Jackson	Cashiers	past producer	anthophyllite asbestos	enstatite	dunite, pyroxenite	Conrad and others (1963, p. 34)
NC-39	Soapstone Branch prospect	36.025	-82.060	NC	Mitchell	Carvers Gap	occurrence	anthophyllite asbestos	talc, serpentine, olivine, chlorite, tremolite and/or actinolite, chromite	peridotite, dunite	Brobst (1962, plate 1); Conrad and others (1963, p. 22, 24)
NC-40	Socrates corundum mine	35.100	-83.014	NC	Transylvania	Cashiers	occurrence	anthophyllite asbestos	corundum, talc, magnesite, serpentine, olivine, tremolite, chlorite, magnetite, chromite, limonite	dunite or peridotite	Conrad and others (1963, p. 32)
NC-41	unnamed occurrence	35.155	-83.299	NC	Macon	Corbin Knob	occurrence	"asbestos"	talc	amphibolite	Murdock and Hunter (1946, p. 35, plate 13)
NC-42	unnamed occurrences	35.896	-82.065	NC	Mitchell	Spruce Pine	occurrence	anthophyllite asbestos	tremolite, olivine, magnetite, talc	peridotite, dunite	Brobst (1962, plate 1); Conrad and others (1963, p. 24)
NC-43	unnamed prospect	36.05	-81.97	NC	Avery	Newland	past prospect	anthophyllite asbestos	not reported	ultramafic body	Conrad and others (1963, p. 22)
NC-44	unnamed prospect	36.044	-81.939	NC	Avery	Newland	past prospect	anthophyllite asbestos	not reported	ultramafic body	Bryant (1962, p. D-28); Conrad and others (1963, p. 22)
NC-45	unnamed prospect	35.131	-83.287	NC	Macon	Corbin Knob	past prospect	"asbestos"	not reported	not reported	Murdock and Hunter (1946, plate 13)
NC-46	Walnut Cove mine	35.17	-82.92	NC	Transylvania	Lake Toxaway	past producer	anthophyllite asbestos	talc, chlorite, vermiculite	peridotite	Conrad and others (1963, p. 30)
Sites NC-47 through NC-50 below have been added to the USGS list of asbestos mines, prospects and occurrences.											
NC-47	Corundum Hill mine	35.1482	-83.2898	NC	Macon	Corbin Knob	occurrence	anthophyllite asbestos	olivine, enstatite ,corundum, talc, chlorite, tremolite	dunite	Yurkovich (1977, p. 55-68), Pratt and Lewis (1905 , p. 41, 86-91, plate VI), Hunter (1941, P. 104-106), Hunter and others (1942, p. 15, plate 8), Murdock and Hunter (1946, p. 31, 34, plate 13)
NC-48	Dark Ridge olivine deposit	35.4125	-83.1016	NC	Jackson	Hazlewood	occurrence	chrysotile	olivine, bronzite, chromite, talc, serpentine	dunite	Hunter (1941, p.75-80)
NC-49	Sylva- Hwy. 23 Bypass dunite	35.38369	-82.20202	NC	Jackson	Sylva North	occurrence	Chrysotile mimics	olivine, fibrous talc, brucite	dunite	
NC-50	Todd ultramafic body	36.32956	-81.58063	NC	Ashe	Todd	occurrence	anthophyllite asbestos	tremolite, talc, chlorite, olivine, enstatite	ultramafic body	Rankin and others (1972), Scotford and Williams (1983, p. 78-94), Raymond and Abbot (1997, p. 67-85)
	Note: Latitude and Longitude values in bold type are a refinement of positions given by Van Gosen (2005)										

Table 2

Screening Summary of Historic Asbestos Mines, Asbestos Prospects, and Natural Asbestos Occurrences in North Carolina *

Site Number	Historic site name as reported	Type of Screening	Land Use in the Vicinity of the Asbestos Site										Followup Recommended
			Residential	Commercial	Industrial	Farming	Recreational	Development within 200 Feet	Construction in progress	Wooded/ Undeveloped	Recent Mining **	Mine Permit Status	
NC-1	Addie chromite prospect	Site Visit	X	X	X			X	X		X	Closed	X
NC-2	Alders mine	Aerial Photo Inspection								X			
NC-3	Asbestos mine	Site Visit	X					X					X
NC-4	Bad Creek prospect	Site Visit								X			
NC-5	Balsam Gap olivine deposit	Site Visit									X	Closed	
NC-6	Blue Rock mine	Aerial Photo Inspection								X			
NC-7	Brockton mine	Aerial Photo Inspection	X					X					X
NC-8	Bryson mine	Aerial Photo Inspection								X			
NC-9	Burleson mine	Site Visit	X					X					?
NC-10	C.W. Allen prospect (Cane River mine)	Site Visit	X					X					?
NC-11	Cas Thomas prospect	Aerial Photo Inspection								X			
NC-12	Chesnut Gap chromite prospect	Site Visit				X		X					?
NC-13	Coldsides Mountain mine	Aerial Photo Inspection								X			
NC-14	Commissioner Creek prospect	Aerial Photo Inspection								X			
NC-15	Day Book dunite deposit	Site Visit	X		X			X			X	Active	X
NC-16	Deposit Number Nine	Site Visit									X	Closed	
NC-17	Frank mine	Site Visit							X		X	Inactive	?
NC-18	Harris prospect	Aerial Photo Inspection								X			
NC-19	Henderson mine	Aerial Photo Inspection				X							?
NC-20	Higdon mine	Site Visit									X	Closed	
NC-21	Hogback Creek mine	Site Visit	X					X					X
NC-22	Holden mine	Aerial Photo Inspection								X			
NC-23	J.C. Woody mine	Aerial Photo Inspection								X			
NC-24	J.H. Pannell prospect	Site Visit	X			X		X					?
NC-25	Jennings No. 1 mine	Aerial Photo Inspection								X			
NC-26	Jennings No. 2 mine	Aerial Photo Inspection								X			
NC-27	Johns River mine	Aerial Photo Inspection								X			
NC-28	Kilpatrick mine	Aerial Photo Inspection				X							?
NC-29	L.E. Cash property	Aerial Photo Inspection	X					X					?
NC-30	Manus mine	Aerial Photo Inspection								X			
NC-31	Miller mine	Site Visit								X			
NC-32	Newdale mine	Site Visit	X					X			X	Active	X
NC-33	Oakland mine	Site Visit	X				X	X					X
NC-34	Peterman mine	Site Visit				X				X			
NC-35	Rattlesnake corundum mine	Aerial Photo Inspection	X										?
NC-36	Round Mountain mine	Aerial Photo Inspection								X			
NC-37	Sam Grindstaff mine	Aerial Photo Inspection								X			
NC-38	Sapphire mine	Site Visit	X				X						X
NC-39	Soapstone Branch prospect	Aerial Photo Inspection								X			
NC-40	Socrates corundum mine	Site Visit								X			
NC-41	unnamed occurrence (Jacobs Knob)	Site Visit	X										?
NC-42	unnamed occurrences (Spruce Pine)	Site Visit	X	X	X			X	X				X
NC-43	unnamed prospect (Big Elk Mtn.)	Aerial Photo Inspection				X							
NC-44	unnamed prospect (Hawshaw Mtn.)	Aerial Photo Inspection				X							
NC-45	unnamed prospect (near Gneiss)	Site Visit	X			X		?					?
NC-46	Walnut Cove mine	Aerial Photo Inspection								X			
NC-47	Corundum Hill mine	Site Visit	X					?					?
NC-48	Dark Ridge Olivine deposit	Site Visit								X		Inactive	
NC-49	Sylva-Hwy. 23 Bypass Dunite	Site Visit		X				X	X				?
NC-50	Todd Ultramafic body	Site Visit	X					?					?

*** Sites NC-1 through NC-46 are listed in USGS Open File Report 2005-1189, Reported Historic Asbestos Mines, Historic Asbestos Prospects, and Natural Asbestos Occurrences in the Eastern United States, by Bradley S. Van Gosen, 2005. Sites NC-47 through NC-50 have been added to the USGS list.**

**** Has been the site of mining within the past 20 years.**

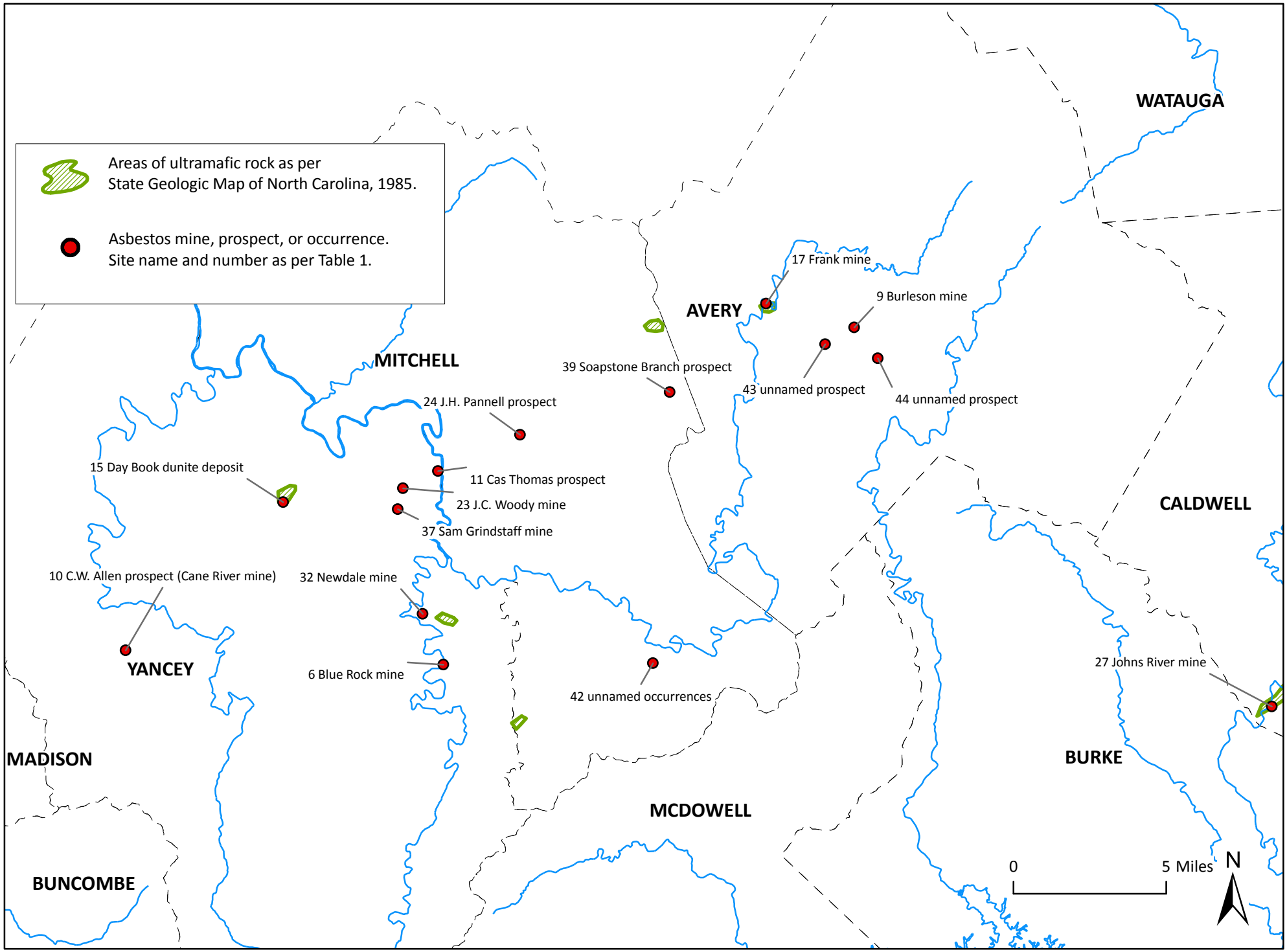
Site visits were conducted between October 31 and November 11, 2005.

Table 3 (Part 1)

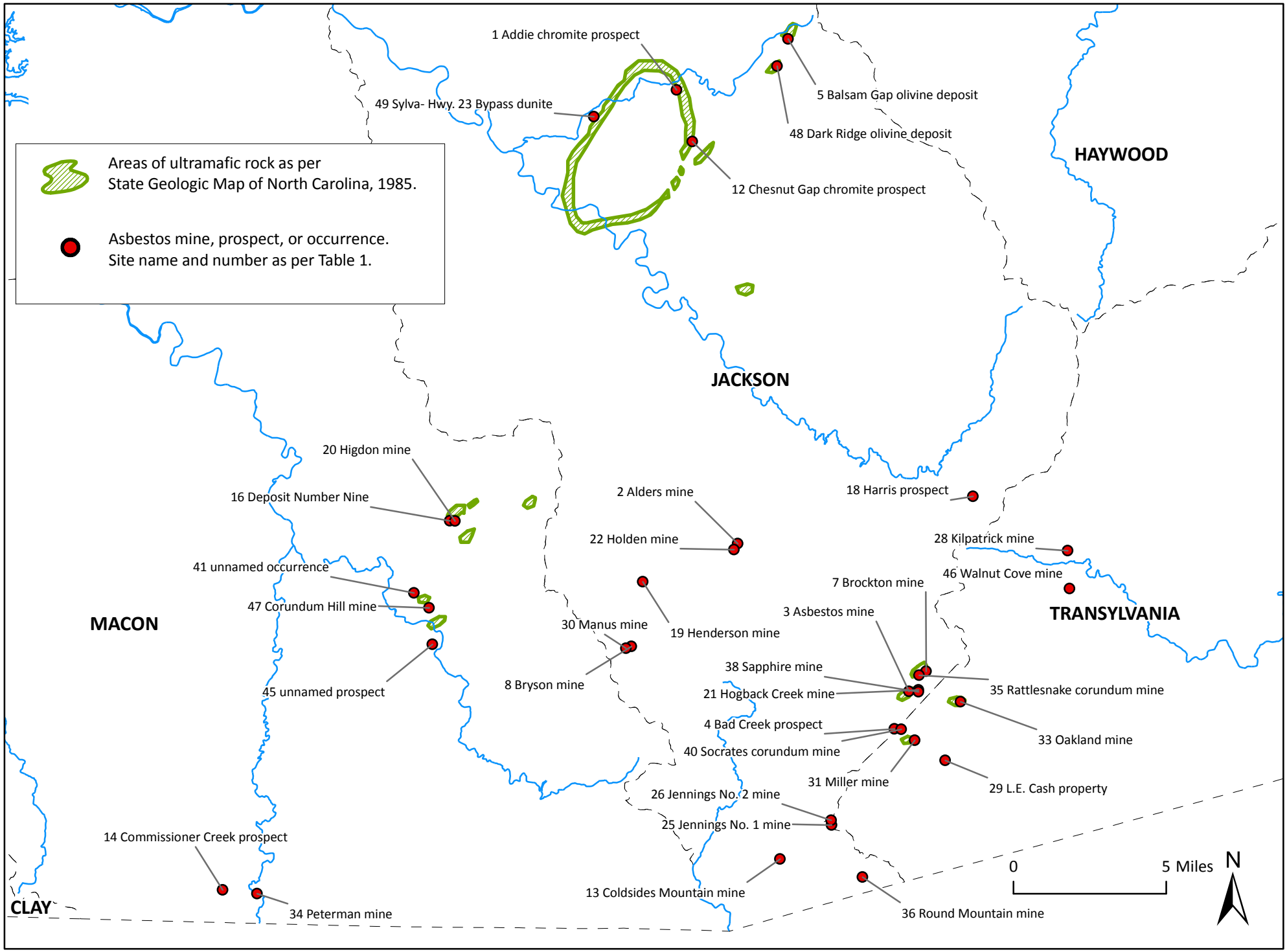
Mine Name	Web Link	Phone	Permitted Mine (Active)	Permitted Mine (Inactive)	County	7.5' Quadrangle
Blue Ridge Gemstone Mine (McKinney)		828-765-5264			Mitchell	
Caler Creek Ruby Mine					Macon	
Cherokee Mine		828-524-5684		Inactive: Permit issued: 6/10/1993, Expiration:10/0/2007	Macon	
Cowee Gift Shop and Mining		828-5244570			Macon	
Cowee Mountain Ruby Mine		828-369-5271			Macon	
Dale and Demko's Mine					Macon	
Emerald Mine of Little Switzerland	http://www.theemeraldmine.com/	828-765-6832			Mitchell	
Emerald Village	http://www.emeraldvillage.com/	828-765-6463			Mitchell	
Gem City Mine					Macon	
Gem Mine at Gem World		828-369-5271			Macon	
Gem Mountain	http://www.gemmountain.com/about.htm	828-765-6130			Mitchell	
Gibsons Ruby Mine					Macon	
Gold City Gem Mine	http://www.goldcityamusement.com/gemmining.htm	828-369-3905			Macon	
Greater Foscoe Gem Mining Company		828-963-5928			Watauga	
Great American Mining Adventure		828-369-5212			Macon	
Gregory's Ruby Mine					Macon	
Holbrook's Ruby Mine					Macon	
Jacob's Ruby Mine (Cabin Rental)	http://www.valuevacationrentals.com/vacation-rentals/5939/	828-342-7764			Macon	
Jackson Hole Mine		828-524-5850			Macon	
Jones Ruby Mine		828-524-5946			Macon	
Magic Mountain Mini Golf and Gem Mine		828-265-4653			Watauga	
Mason Mountain Rhodolite and Ruby Mine		828-524-4570			Macon	
Mason's Ruby and Sapphire Mine		828-369-9742	Active: Permit issued: 8/21/1992, Expiration: 6/04/2013		Macon	Wayah Bald
Moonstone Gem Mine		828-524-7764			Macon	
Mountain Top Gem Mine						
Nantahala River Gem Mine	http://www.carolinaoutfitters.com/gem-mine.htm	800-468-7238			Swain	
Old Cardinal Mine		828-369-7534			Macon	
Old Pressley Mine	http://www.oldpressleymine.com/page2a.html	828-648-6320			Haywood	
Rio Doce Mine		828-765-2099			Mitchell	
Rocky Face Mine		828-524-3148			Macon	
Rose Creek Mine	http://www.rosecreekmine.com/	828-349-3774	Active: Permit issued: 4/19/1978, Expiration: 8/21/2008		Macon	Franklin
Shamiami Mine				Inactive: Permit issued: 6/6/1975, Expiration: 5/24/1995		
Sheffield Mine	http://www.sheffieldmine.com/	828-369-8383		Inactive: Permit issued: 6/6/1972, Expiration: 9/22/2015	Macon	Alarka
Shuler Ruby Mine						
Spruce Pine Gem and Gold Mine	http://www.angelfire.com/rock3/spruce_pine_gem_mine/	828-765-7981				

Table 3 (Part 2)

Mine Name	Latitude	Longitude	Native	Enriched	Placer	Lode	Geologic References	Web References	Comments
Blue Ridge Gemstone Mine (McKinney)									old pegmatite mine
Caler Creek Ruby Mine	35.26528	-83.37722						http://www.lat-long.com/North-Carolina/Caler-Creek-Ruby-Mine_1017672.html	**Closed?**
Cherokee Mine	35.27361	-83.37083			Yes			http://www.lat-long.com/North-Carolina/Cherokee-Ruby-and-Sapphire-Mine_1017665.html	**Closed?**
Cowee Gift Shop and Mining									
Cowee Mountain Ruby Mine	35.23000	-83.33944						http://www.lat-long.com/North-Carolina/Cowee-Mountain-Mine_1017678.html	
Dale and Demko's Mine	35.27083	-83.37944						http://www.lat-long.com/North-Carolina/Dale-and-Demkos-Mine_1017673.html	**Closed?**
Emerald Mine of Little Switzerland									
Emerald Village									
Gem City Mine	35.19361	-83.36389						http://www.lat-long.com/North-Carolina/Gem-City-Mine_1017679.html	
Gem Mine at Gem World									
Gem Mountain			Yes	Yes					
Gibsons Ruby Mine	35.26917	-83.37528						http://www.lat-long.com/North-Carolina/Gibsons-Ruby-Mine_1017669.html	
Gold City Gem Mine			Yes	Yes					
Greater Foscoe Gem Mining Company									
Great American Mining Adventure									
Gregory's Ruby Mine	35.27139	-83.36917						http://www.lat-long.com/North-Carolina/Gregorys-Ruby-Mine_1017664.html	**Closed?**
Holbrook's Ruby Mine	35.26972	-83.37167							
Jacob's Ruby Mine (Cabin Rental)	35.26889	-83.37694	Yes	No				http://www.lat-long.com/North-Carolina/Jacobs-Mine_1017670.html	Gem mining offered with cabin rental. No public mining.
Jackson Hole Mine			Yes	Yes					
Jones Ruby Mine	35.27139	-83.37528						http://www.lat-long.com/North-Carolina/Jones-Ruby-Mine_1017668.html	
Magic Mountain Mini Golf and Gem Mine									
Mason Mountain Rhodolite and Ruby Mine			Yes	Yes					
Mason's Ruby and Sapphire Mine	35.21389	-83.45278	Yes	No	Yes	No		http://www.lat-long.com/North-Carolina/Masons-Sapphire-Mine_1017683.html	
Moonstone Gem Mine									
Mountain Top Gem Mine	35.27500	-83.28778						http://www.lat-long.com/North-Carolina/Mountain-Top-Gem-Mine_1017662.html	
Nantahala River Gem Mine									
Old Cardinal Mine	35.23611	-83.39528						http://www.lat-long.com/North-Carolina/Old-Cardinal-Mine_1017680.html	
Old Pressley Mine			Yes						
Rio Doce Mine									
Rocky Face Mine	35.22611	-83.36083	Yes	Yes				http://www.lat-long.com/North-Carolina/Rocky-Face-Mine_1017676.html	
Rose Creek Mine	35.23710	-83.40820	Yes?	Yes				http://www.lat-long.com/North-Carolina/Rose-Creek-Mine_1017682.html	
Shamiami Mine	35.08100	-83.35880						http://www.mindat.org/loc.php?loc=101337&ob=4	**Closed?**
Sheffield Mine	35.26910	-83.39350	Yes	Yes	No	Yes	Pratt and Lewis (1905), pps. 183, 249, 273.	http://eclecticlapidary.com/el_cfm2/main.cfm?dest=FetchArticle&iid=ELHV%5De334&aid=2005_10_23 http://www.lat-long.com/North-Carolina/Sheffield-Mine_1017674.html	
Shuler Ruby Mine	35.27111	-83.37167			Yes			http://www.lat-long.com/North-Carolina/Shulers-Ruby-Mine_1017666.html	**Closed?**
Spruce Pine Gem and Gold Mine									



Asbestos Mines, Prospects, and Occurrences in the Spruce Pine Area, North Carolina.



Asbestos Mines, Prospects, and Occurrences in the Sylva-Franklin-Cashiers Area.