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

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Conducted by North Carolina Division of Waste Management, in cooperation with
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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.

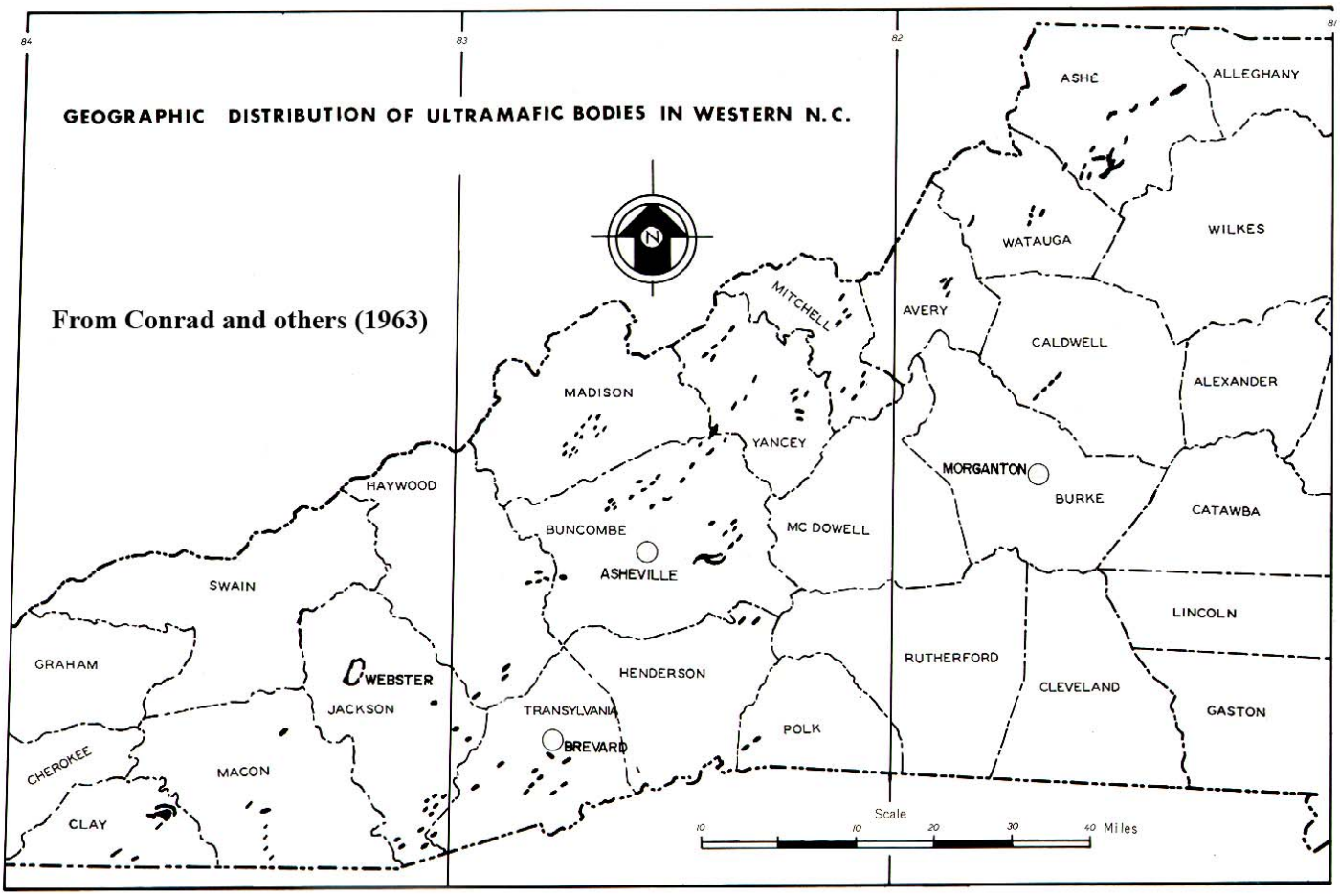


Figure 1: Geographic Distribution of Ultramafic Bodies in Western North Carolina

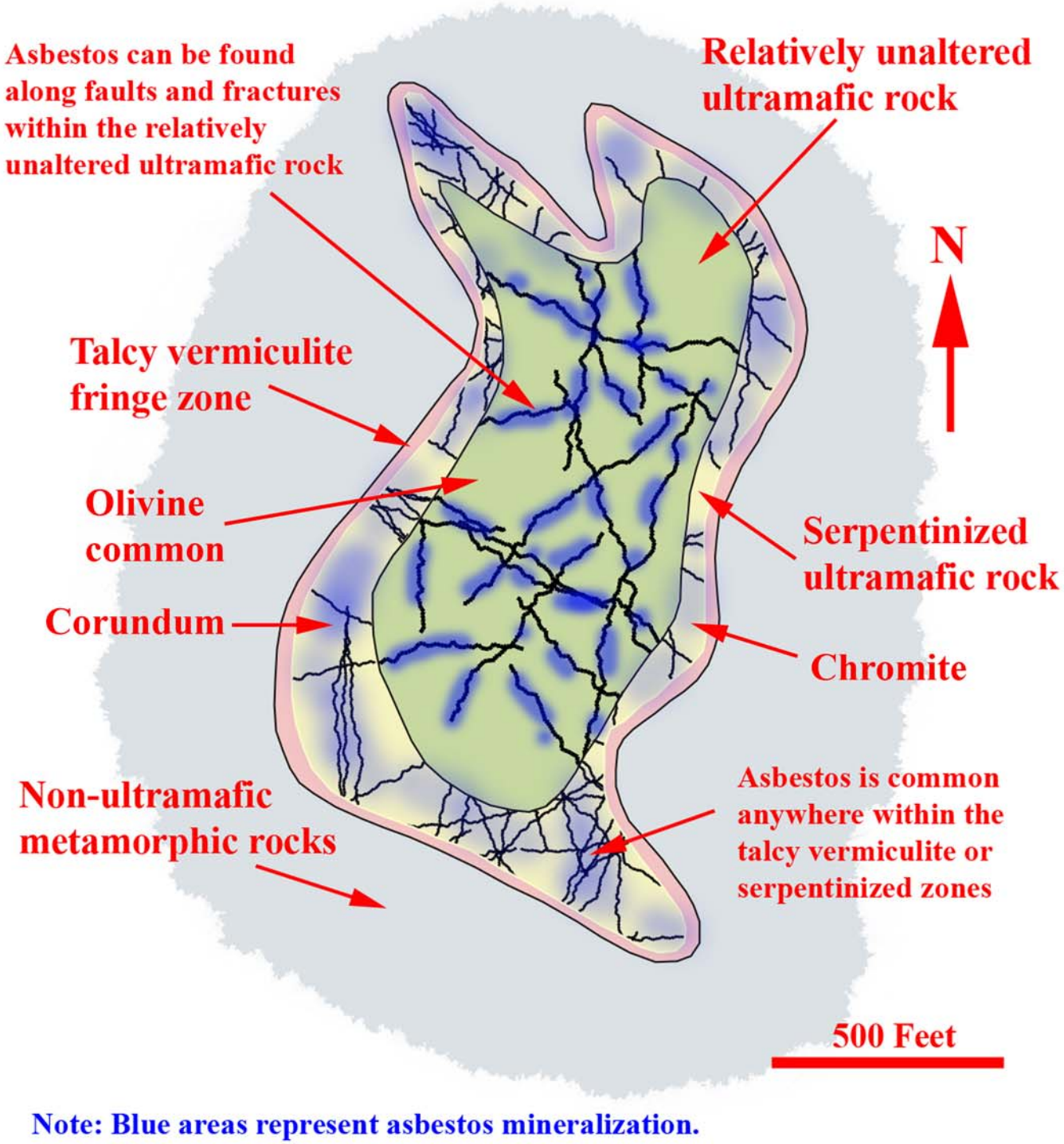


Figure 2 : A typical asbestos-bearing ultramafic body of the Blue Ridge Province of North Carolina.

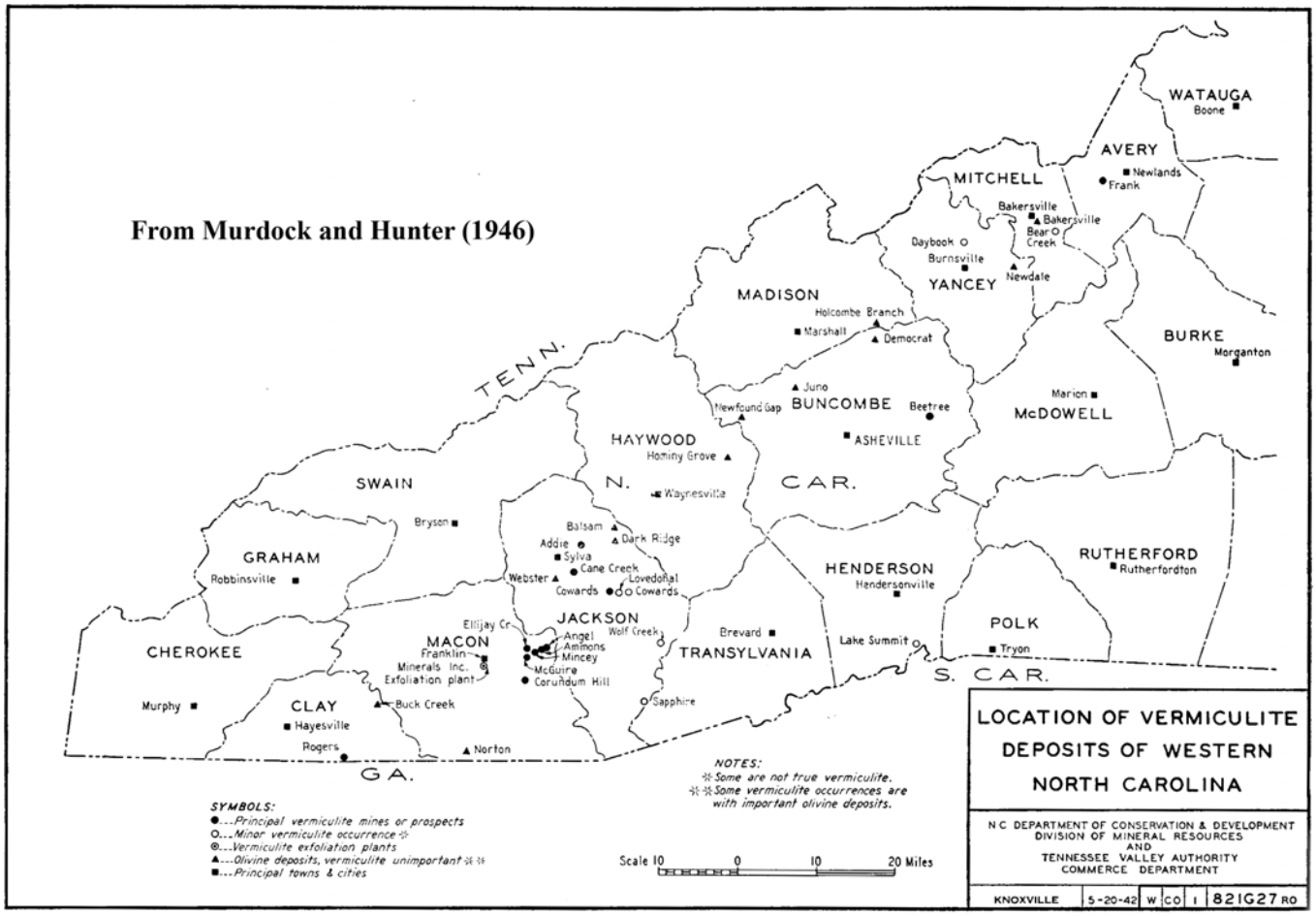
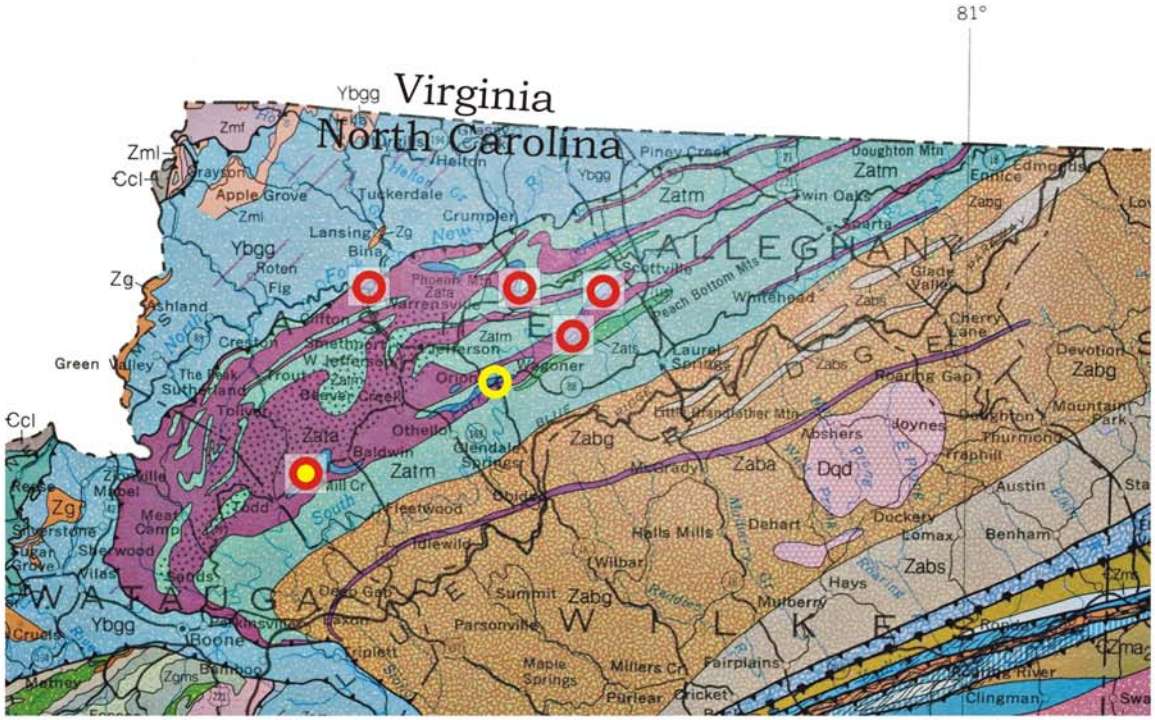


Figure 3: Geographic distribution of vermiculite deposits of North Carolina.



(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.