

MINERAL IDENTIFICATION & MANAGEMENT GUIDE

INTRODUCTION

A. PURPOSE

This Mineral Identification & Management Guide (“Guide”) provides investigatory tools that will be used to assess whether Protocol Mineral Fibers (“PMFs”) are present at Heidelberg Materials Northeast LLC’s (“Heidelberg”) Rock Hill quarry, located in East Rockhill Township, Bucks County, Pennsylvania (“Quarry”). PMFs are defined in this Guide to include “asbestos” and “all other asbestiform amphiboles, asbestiform serpentines, and all durable asbestiform zeolites.”

The goals of the program outlined in the Guide are to identify and manage areas where PMFs may occur, and to help determine the presence of PMFs (if any), and their mineralogy at the Quarry.

Note: This Guide is intended only as a protocol to identify and manage PMFs at the Quarry. Heidelberg acknowledges that the Pennsylvania Department of Environmental Protection (PADEP) may require amendments to this Guide at any time, and that any amendments are only effective following approval by PADEP.

This Guide does not separately authorize any operations beyond that authorized by the Quarry Surface Mine Permit No. 7974SM1 (“Permit”), nor does it limit any condition(s) or requirement(s) in the Permit. Further, this Guide does not limit any applicable statutory, regulatory, or permitting requirements for the Quarry, including but not limited to PADEP’s applicable air quality permitting and regulatory requirements.

B. PROTOCOL MINERAL FIBERS

1. **Asbestos PMFs.** “Asbestos” is a commercial term that includes six (6) silicate minerals that belong to the serpentine and amphibole mineral groups—but are “asbestos” only when those minerals crystallized in nature as asbestiform fibers (i.e., crystallized with the mineralogical habit of “asbestos”).

Table 1 provides information about these six (6) minerals. Note again that the minerals are (a) classified as “asbestos” only when they formed in nature with the asbestiform mineral habit; and (b) not classified as “asbestos” when they formed in nature with the nonasbestiform mineral habit.

Table 1. Asbestos and Nonasbestos Forms of Six (6) Minerals.

Mineral (and Crystalline Habit)	Commercial or Common Name	CAS No.
Asbestiform Serpentine	Chrysotile Asbestos	12001-29-5
Asbestiform Riebeckite	Crocidolite Asbestos	12001-28-4
Asbestiform Cummingtonite-Grunerite	Amosite Asbestos	12172-73-5
Asbestiform Anthophyllite	Anthophyllite Asbestos	77536-67-5
Asbestiform Tremolite	Tremolite Asbestos	77536-68-6
Asbestiform Actinolite	Actinolite Asbestos	77536-66-4
Nonasbestiform Serpentine	Antigorite	12135-86-3
Nonasbestiform Riebeckite	Riebeckite	17787-87-0
Nonasbestiform Cummingtonite-Grunerite	Cummingtonite-Grunerite	14567-61-4
Nonasbestiform Anthophyllite	Anthophyllite	17068-78-9
Nonasbestiform Tremolite	Tremolite	14567-73-8
Nonasbestiform Actinolite	Actinolite	13768-00-8

Notes:

1. “Asbestos” is regulated in the U.S. by numerous state and federal agencies, including EPA, OSHA, and MSHA. A full reference to all regulations is beyond the scope of this Guide.
 2. The term “asbestiform” means the mineralogical habit or form of a mineral in which ultra-fine single crystal fibers (fibrils) occur in bundles that can be separated into increasingly finer fiber bundles that typically display curvature.¹
 3. “Asbestos” possesses (certain) properties such as long fiber length and high tensile strength. Under the light microscope, samples exhibit the asbestiform habit as defined by several of the following characteristics: (a) mean aspect ratios ranging from 20:1 to 100:1 or higher for fibers longer than 5 µm, (b) very thin fibrils, usually less than 0.5 µm in width, (c) parallel fibers occurring in bundles, (d) fiber bundles displaying splayed ends, (e) fibers in the form of thin needles, (f) matted masses of individual fibers, and (g) fibers showing curvature.²
2. **Other PMFs (Not Asbestos).** It is important to emphasize that Heidelberg’s Guide goes beyond “asbestos” and includes certain asbestiform minerals that Heidelberg has conservatively elected to treat as a potentially equivalent hazard as “asbestos.”

These “Other PMFs” include a variety of (a) amphiboles that formed in nature with the asbestiform habit but are not classified as “asbestos” (e.g., asbestiform winchite, asbestiform richterite, asbestiform fluoroedenite, etc.); and (b) naturally occurring “durable asbestiform zeolites” (e.g., erionite). “Other PMFs” are not “asbestos” and they are not currently regulated by most U.S. authorities in the same manner as “asbestos.”

All PMFs exist more commonly in a prismatic crystal growth habit or form (i.e., a nonasbestiform habit or form). These nonasbestiform minerals tend not to grow with parallel alignment, but instead form multi-directional growth patterns. When enough

¹ See, for example, EPA, 1993. “Method for the Determination of Asbestos in Bulk Building Materials” (EPA/600/R-93/116).

² (a) National Institute of Standards and Technology (NIST), Certificate of Analysis, Standard Reference Material® 1867a, Uncommon Commercial Asbestos; (b) EPA, 1993.

pressure is applied, the crystals fracture easily, fragmenting into prismatic particles called cleavage fragments. While some cleavage fragments are acicular or needle shaped as a result of the tendency to cleave along two dimensions but not along a third, they do not possess the characteristics described above for asbestiform minerals. Furthermore, these cleavage fragments are not associated with asbestos-related diseases, as documented in the published, peer-reviewed scientific literature.

It is not possible to create asbestos from common rock or cleavage fragments by crushing or processing them. Likewise, cleavage fragments cannot be created from “asbestos.” When a PMF occurs in nature, the corresponding nonasbestiform habit of that mineral will also always be present. However, the converse is not always true due to the unique set of geologic conditions necessary for minerals to crystallize in the asbestiform habit.

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SECTION 1 - Periodic Inspection Program

The Periodic Inspection Program is a key component of this Guide. Field examination by the geologist may identify PMFs—or may simply highlight certain areas where PMFs are more (or less) likely to occur.

A. PERIODIC INSPECTIONS

Heidelberg will develop the following protocol, processes, and tools:

1. A site inspection protocol for the Quarry that describes the general inspection methods, resources, responsibilities, and inspection report content and format.
2. A sampling and analysis protocol that describes the goals and steps for effective sample collection, examination, and analysis.

A Heidelberg geologist or other qualified professional will inspect the Quarry annually or at such periods established by the geologist and other professional staff. The Heidelberg professional will also visually inspect all walls, floors and benches that are safely accessible to determine if PMFs are or may be present. After the initial field evaluation, future periodic inspections to focus only on the active walls, floors and benches at the Quarry.

B. Rock Hill Quarry Routine & Periodic Inspection Plan

- Inspection of the Quarry will occur annually or at such periods related to mining activity established by the geologist and other professional staff or as required by PADEP.
- The geologist will visually inspect all active faces on operating levels of the Quarry, walls, floors and benches that are safely accessible to determine if PMFs are or may be concentrated. After the initial field evaluation, future periodic inspections to focus only on the active walls, floors and benches.
- Shot rock and muck piles will also be visually inspected by knowledgeable site personnel as those materials are produced in the mining process.
- Settled dust sample(s) will be collected and analyzed as a means to monitor fine particulate resulting from the mining process. Sampling location(s) will be representative of the type and location of equipment permitted to be utilized at the site.
- In some cases, PMF identification may be obvious in the field. In other cases, indications for the potential presence of PMFs may include the type of rock mass or, for example, the relationship to joints, faults/shear zones, or intrusions.
- Training will be provided by a Heidelberg geologist on how to identify suspect material. Employees working in the Quarry will also be informed of the geologic survey results to indicate where suspect material has previously been identified. Employees will receive annual training to visually recognize suspect area where PMFs might be found.
- All employees who work at the Quarry will immediately report to the site management the potential discovery of any PMFs, so that an appropriate investigation can ensue.

- Method to identify/confirm suspect material:
 1. If designated site personnel identify suspect material, they will follow the reporting protocol and with the involvement of the geologist, determine by visual inspection and/or laboratory testing (Polarized Light Microscopy (PLM), CARB Method 435, or similar method to evaluate asbestos in soil or bulk materials) that the material does or does not contain PMFs.
 2. Suspect material will be identified based on criteria defined by the geologist, including the following: any minerals identified in the rock that appear to be present in bundles of long, thin, flexible fibers. These minerals may appear in several different forms in the Quarry, including bundles of parallel fibers, radiating fibers, matted masses of fibers, or in needle-like formations.
- Action protocol:
 1. If suspect material is found to contain protocol fibers, appropriate personnel will be informed, and additional sampling and testing will be initiated to determine if protocol mineral fibers are present or not.
 2. Based on these results, actions will be undertaken to isolate and move the material from the active quarrying area per the Removal Protocol.
- Active mining within a delineated affected area where suspect material has been identified will temporarily cease and cannot resume until appropriate actions have been taken to move the suspect material from the active mining area per the Removal Protocol.
- Recording and Reporting:
 1. Location(s) of suspect material identified will be recorded and include coordinates (northing and easting) and elevation within the Quarry.
 2. Results of suspect material inspections, photographs of collected materials, narrative descriptions of suspect materials and laboratory reports will be documented and reported to appropriate knowledgeable mine personnel..
 3. Reports will also be produced and distributed as described in the Asbestos Monitoring and Mitigation Plan (AMMP).
- Removal protocol:
 1. Material identified as suspect material will be delineated by the site geologist.
 2. The material will be wetted prior to any movement or disturbance.
 3. Any personnel involved in the removal of suspect material will wear appropriate protective equipment.
 4. Suspect material will be moved using appropriate equipment to a location designated by the geologist within the authorized permit area.
 5. Suspect material will be placed within permanently inactive areas of the Quarry and covered with non-PMF material overburden.
 6. Locations of any suspect material will be provided to the appropriate personnel for inclusion in Quarry records.
 7. Similarly, the final location of removed suspect material within the Quarry will be provided to the appropriate personnel for inclusion in Quarry records.

In some cases, PMF identification may be obvious in the field. In other cases, indications for the potential presence of PMFs may include the type of rock structure, and the relationship to joints, faults/shear zones, or fractures.

Per the Recording and Reporting Protocol (above), the geologist will document the presence and location (e.g., easting, northing, elevation), of PMFs, and take photographs and bulk samples. The geologist will examine all samples with a hand lens to determine if they should be evaluated microscopically consistent with the PMF identification process outlined in the Appendix.

Heidelberg further expects all employees who work at the Quarry to immediately report to the site management the potential discovery of any PMFs, so that an appropriate evaluation can ensue.

SECTION 2 - Program for Testing Settled Dust

The goal of this Section is to ensure that samples reflecting the complete production of the Quarry over the sample period are collected.

A. PROCESS FOR COLLECTING SETTLED DUST SAMPLES

1. Create a sample log. The log will contain the name of the Quarry sampled, the exact sample location, the sample period start-date and end-date, sample collection time, and the sample collector's name. Additional information will include the specific areas of the site quarried, tonnage produced during the sample period, etc.
2. Collect one (1) settled dust sample per year at the Quarry. Collect samples simultaneously during the test period. In addition, if PMFs are identified during a periodic inspection, one (1) additional settled dust sample will be collected at that time. If the settled dust sample results are reported as Not Detected (ND), this dust sample will be counted as the yearly sample if it was collected before the annual dust sample.
3. Use sample containers of similar size to a wide-mouth Nalgene® jar (approx. 4¾ in. dia. and 1¾ in. deep). A container with these dimensions will provide adequate surface area for proper collection of the settled dust sample. Label each container in advance with a unique site ID, sample number, the sampling start date, collection time, sample location, etc.
4. Select sample locations protected from thrown rock particles, wind, precipitation, and accidental disturbance by normal work activities. However, the location must allow for enough settled dust to accumulate inside the container over the sample period (approx. ¼ to ½ in. depth is usually adequate for analysis). Locations can include: inside surge tunnels and screening towers, under crushers, etc., and Q.C. labs that are dedicated to one specific production site.
5. Sampling periods typically last up to several weeks, depending on production rates, sample location (to avoid over- or under-filling of the container), and other variables.
6. Properly collected samples will have a consistency similar to flour. The samples should not be gritty, sandy, or contain rock chips, and should not exceed more than one handful of material. Large sample quantities or those containing rock chips suggest that the sample site is not appropriate or that the sample has been "scooped up" rather than settled from the airborne dust over the time period of interest. If samples appear to be improperly collected, the coordinator should work with site management to ensure that samples are correctly gathered in the future. This may mean repositioning the sample collection device to a different location.
7. After sample collection, seal each container, mark the sample end-date and collection time on the container label, and log the sample information into a sample log.
8. Do not comingle settled dust samples with any other samples intended for any other purpose.
9. Prepare a chain-of-custody form if half of the split sample will be sent to an outside laboratory for analysis (Appendix).

10. The sample will be analyzed by PLM using CARB Method 435. If PLM analysis does not detect asbestos fibers in the sample, the sample will be analyzed by TEM to verify results using EPA Method 600/R-93/116, Method for the Determination of Asbestos in Bulk Building Materials.
11. The coordinator and geologist will promptly review the laboratory's analytical results.
12. If the laboratory analysis determines (and the geologist verifies) that the sample contains PMFs, Heidelberg will evaluate the current geologic survey for the Quarry to determine if any additional analysis is necessary.

APPENDIX - Identification of Protocol Mineral Fibers

The geologist or analyst will microscopically analyze all samples as suggested by this Guide:

1. Inspect hand and core samples with the Binocular Microscope, ranging from 10x to 60x magnification.
2. Using a fine steel pick (dental pick), scrape the surface of the suspect mineralization to determine if any of the minerals display the typical asbestiform habit and characteristics such as fiber bundles, splayed ends, or matted or fibrous masses.
3. If PMFs are found, a representative sample will be sent to a qualified outside laboratory for verification and/or further analysis to establish mineral identification.
4. Samples will be analyzed by PLM using CARB Method 435 or similar method to evaluate asbestos in soil or bulk materials and will include a count with dimensions (width and length) and digital images of PMFs.

For the purposes of this Guide, “qualified laboratory” means a laboratory selected from the list of asbestos analytical laboratories that are part of the National Voluntary Laboratory Approval Program (NVLAP) and are accredited by the American Industrial Hygiene Association (AIHA). Any accredited laboratory that meets the requirements listed above can be used for sample analysis.

GLOSSARY

Actinolite - A bright-green or grayish-green monoclinic mineral of the amphibole group with the general formula: $\text{Ca}_2(\text{Mg,Fe})_5\text{Si}_8\text{O}_{22}(\text{OH})_2$. The specific chemical compositions for which the name actinolite formally applies are given by Leake et al., 1997. It sometimes occurs in the form of asbestos, and also in fibrous, radiated, or columnar forms in metamorphic rocks (such as schists) and in altered igneous rocks.

Aggregate - (a) A mass or body of rock particles, mineral grains, or a mixture of both. (b) Any of several hard, inert materials, such as sand, gravel, slag, or crushed stone, used for mixing with a cementing or bituminous material to form concrete, mortar, or plaster; or used alone, as in railroad ballast or graded fill. The term sometimes includes rock material used as chemical or metallurgical fluxstone, or filtration medium.

Amosite - A commercial term for an iron-rich, asbestiform variety of amphibole of the composition cummingtonite-grunerite, that is mined in the Transvaal region of South Africa.

Amphibole - A group of dark rock-forming ferromagnesian silicate minerals, closely related in crystal form and composition and having the general formula: $\text{AB}_2\text{C}_5\text{Z}_8\text{O}_{22}(\text{OH,Cl,F})_2$, where A = Na, K; B = Mg, Fe^{2+} , Ca, or Na; C = Mg, Fe^{2+} , Fe^{3+} , Li, Mn or Al; and Z = Si, Al, or Ti. It is characterized by a cross-linked double chain of tetrahedra with a silicon:oxygen ratio of 4:11, by columnar or fibrous prismatic crystals, and by good prismatic cleavage in two directions parallel to the crystal faces and intersecting at angles of about 56° and 124° ; colors range from white to black. Most amphiboles crystallize in the monoclinic system, some in the orthorhombic. They constitute an abundant and widely distributed constituent in igneous and metamorphic rocks, and they are similar in chemical composition to the pyroxenes.

Anthophyllite - A clove-brown to colorless orthorhombic mineral of the amphibole group with an ideal formula of: $(\text{Mg,Fe}^{2+})_2(\text{Mg,Fe}^{2+})_5\text{Si}_8\text{O}_{22}(\text{OH})_2$. Variations in composition permitted under the name anthophyllite are specified by Leake et al, 1997. Anthophyllite occurs in metamorphosed ultrabasic rocks, typically with olivine, pyroxene, or talc. It may be found in monomineralic aggregates of parallel or radiating asbestiform fibers. It has been mined for asbestos.

Asbestos - A commercial term applied to a group of silicate minerals that readily separate into thin, strong fibers that are flexible, heat resistant, and chemically inert, and therefore are suitable for uses (as in yarn, cloth, paper, paint, brake linings, tiles, insulation, cement, fillers, and filters) where incombustible, nonconducting, or chemically resistant material is required. According to the National Institute of Standards and Technology (NIST), Certificate of Analysis, Standard Reference Material® 1867a, Uncommon Commercial Asbestos, "asbestos minerals possess (certain) properties such as long fiber length and high tensile strength. Under the light microscope samples exhibit the asbestiform habit as defined by several of the following characteristics: 1) mean aspect ratios ranging from 20:1 to 100:1 or higher for fibers longer than $5\text{ }\mu\text{m}$, 2) very thin fibrils, usually less than $0.5\text{ }\mu\text{m}$ in width, 3) parallel fibers occurring in bundles, 4) fiber bundles displaying splayed ends, 5) fibers in the form of thin needles, 6) matted masses of individual fibers, and 7) fibers showing curvature."

Asbestiform - (a) The habit of asbestos. (b) A technical term which refers to a mineral habit where mineral crystals grow in a single dimension, until they form long, thread-like fibers with aspect ratios ranging from 20:1 to 100:1 or higher for fibers longer than $5\text{ }\mu\text{m}$; very thin fibrils, usually less than $0.5\text{ }\mu\text{m}$ in width; parallel fibers occurring in bundles; and one or more of the following: fiber bundles displaying splayed ends, matted masses of individual fibers, or fibers showing curvature.

Chrysotile - A white, gray, or greenish orthorhombic or monoclinic mineral of the serpentine group: $\text{Mg}_3\text{Si}_2\text{O}_5(\text{OH})_4$. Chrysotile is a highly fibrous, silky variety of serpentine, and constitutes what was historically the type of asbestos most commonly used.

Cleavage fragment - A fragment of a crystal that is bounded by smooth surfaces, formed by preferential breakage from a larger crystal along the planes of relatively weak chemical bonds. The shapes of a cleavage fragment are defined by the number and orientation of the most well-developed cleavage planes in the parental mineral.

Crocidolite - The commercial name for riebeckite asbestos. A lavender-blue, indigo-blue, or leek-green asbestiform variety of the amphibole riebeckite.

Erionite - A white, relatively common sedimentary zeolite, found in either acicular or fibrous habits. Erionite and many other natural zeolites are typically associated with weathered volcanic tuffs. Asbestiform erionite is referred to as woolly erionite.

Fiber - Commonly, a slender, elongated, threadlike object or structure. In regulatory and biomedical literature, “fiber” has been used many ways, and has no specific, standalone meaning. Generally, “fiber” is a relative term that has come to mean any elongated particle that satisfies specific dimensional constraints. Dimensional constraints placed on the definition of the term “fiber” are specific to the particular analytical method/exposure metric by which fiber concentrations are determined for a particular application. In contrast to other terms such as “asbestiform,” “fiber” is not linked to a specific list of mineralogical properties which give it a consistent meaning across analytical methods and/or exposure metrics.

Fibrous - A relative term that is used to denote a material composed primarily of fibers or one that appears to be composed of fibers.

Greenfield - Land from which aggregate materials have not previously been mined.

Habit - The characteristic crystal form or combination of forms of a mineral, including characteristic irregularities; the way a mineral grows or is formed in nature.

Igneous - Said of a rock or mineral that solidified from molten or partly molten material, i.e., from a magma or lava; also, applied to processes leading to, related to, or resulting from the formation of such rocks. Igneous rocks constitute one of three main classes into which rocks are divided, the others being metamorphic and sedimentary.

Metamorphic - Pertaining to the process of rock transformation by heat, pressure, and/or hydrothermal solutions, referred to as metamorphism, or to its results.

Muck pile - Broken material left over after a tunnel has been bored, or a surface area has been affected by drilling and blasting.

NIST - National Institute of Standards and Technology.

Nonasbestiform - not asbestiform in habit.

Overburden - Term used to describe rock and/or soil which lies above an economically valuable material (ore) that contains material intended to be used in end product. Overburden is distinct from

tailings, the material that remains after economically valuable components have been extracted from processed ore.

Peer-reviewed - The process of subjecting scholarly work, research, or ideas to the scrutiny of others who are experts in the same field. Generally, peer-review is a process used to screen manuscripts and funding applications.

PLM - Polarized Light Microscopy.

Prismatic - Term for a mineral habit of an elongated mineral with sides that are defined by planes having parallel intersections.

Protocol Mineral Fiber - Defined in the Introduction of this Guide. As used herein, the term includes chrysotile, actinolite asbestos, crocidolite, amosite, anthophyllite asbestos, and tremolite asbestos, as well as all asbestiform amphiboles, asbestiform serpentines, and all durable asbestiform zeolites. Durable asbestiform zeolites include, but are not limited to, erionite and mordenite.

Reserve - Portion of Quarry deposit which can economically be mined given the then-existing state of mining practices and related technology.

Serpentine - A group of common rock-forming minerals having the simplified general formula: $\text{Mg}_3\text{Si}_2\text{O}_5(\text{OH})_4$. Serpentine have a greasy or silky luster, a slightly soapy feel, and a tough, conchoidal fracture; they are usually compact but may be granular or fibrous, and are commonly green, greenish-yellow, or greenish-gray and often veined or spotted with green and white. Serpentine are always secondary minerals, derived by alteration of magnesium-rich silicate minerals (especially olivines), and are found in metamorphic rocks; they generally crystallize in the monoclinic system. Translucent varieties are used for ornamental and decorative purposes, often as a substitute for jade. The minerals in the serpentine group include antigorite, lizardite, and chrysotile.

Site Inspection Protocol - Describes for the Quarry the general inspection methods, resources, responsibilities, and inspection report content and format.

TEM - Transmission Electron Microscopy.

Tremolite - A white to dark-gray monoclinic mineral of the amphibole group with an ideal formula: $\text{Ca}_2\text{Mg}_5\text{Si}_8\text{O}_{22}(\text{OH})_2$. The specific chemical compositions to which the name tremolite formally applies are given by Leake et al., 1997. It has varying amounts of iron and may contain manganese and chromium. Tremolite occurs in long blade-shaped or short stout prismatic crystals and in columnar, fibrous, or granular masses or compact aggregates, generally in metamorphic rocks such as crystalline dolomitic limestones and talc schists. It is a constituent in much commercial talc. Under some conditions, it may form asbestos.

Zeolites - A generic term for a large group of white or colorless (sometimes tinted red or yellow by impurities) hydrous aluminosilicate minerals that have an open framework structure of interconnected $(\text{Si},\text{Al})\text{O}_4$ tetrahedra with exchangeable cations and H_2O molecules in structural cavities. Zeolites have long been known to occur as well-formed crystals in cavities in basalt and as authigenic minerals in the sediments of saline lakes and the deep sea and especially in beds of altered tuff. They form during and after burial, generally by reaction of pore waters with solid aluminosilicate materials (e.g., volcanic glass, feldspar, biogenic silica, and clay minerals).