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PRELIMINARY EVALUATION OF BEDROCK POTENTIAL FOR NATURALLY OCCURRING ASBESTOS IN ALASKA

by
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Tremolite (UAMES 34960) displaying the soft, friable fibers of asbestiform minerals. Sample collected from the Cosmos Hills area, Kobuk District, Alaska, by Eskil Anderson. Image courtesy of the University of Alaska Museum Earth Sciences Department.

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TABLE OF CONTENTS

PHOTOS

SHEETS

Sheet 8 Locator index C4: Kuskokwim Delta area, Alaska, containing the communities of Bethel, Unalakleet, and Aniak

Sheet 9 Locator index C5: Central Alaska, containing the communities of Anchorage, McGrath, and Healy

Sheet 10 Locator index C6: East-central Alaska, containing the communities of Valdez, Whittier, Tok, and Glennallen

Sheet 11 Locator index D3: Nunivak and Pribilof islands, Alaska

Sheet 12 Locator index D4: Bristol and Kuskokwim bay areas, Alaska, containing the communities of Dillingham, Chefornak, and Egegik

Sheet 13 Locator index D5: Kodiak Island and Kenai Peninsula areas, Alaska, containing the communities of Homer, Seward, Kodiak, and Naknek

Sheet 14 Locator index D6: Prince William Sound, Alaska, containing the communities of Cape Yakataga and Chenega Bay

Sheet 15 Locator index D7: Southeast Alaska, containing the communities of Juneau, Haines, Yakutat, and Sitka

Sheet 16 Locator index D8: Prince of Wales Island area, Southeast Alaska, containing the communities of Ketchikan, Hydaburg, and Kake

Sheet 17 Locator index E1: Attu and Kiska islands area, western Aleutians, Alaska

Sheet 18 Locator index E2: Adak and Atka islands area, central Aleutians, Alaska

Sheet 19 Locator index E3: Umnak and Unalaska islands area, eastern Aleutians, Alaska

Sheet 20 Locator index E4: Alaska Peninsula, Alaska, containing the communities of Cold Bay, Akutan, and Sand Point

Sheet 21 Locator index E5: Alaska Peninsula and southern Kodiak Island, Alaska, containing the communities of Chignik, Port Heiden, and Old Harbor

GLOSSARY

Sources:

- Centers for Disease Control website, http://www.cdc.gov/, last accessed 5/6/2015
- Merriam-Webster Dictionary website, http://www.merriam-webster.com/, last accessed 5/7/2015
- Neuendorf, K.E., Mehl Jr., J.P., Jackson, J.A., eds., 2011, Glossary of Geology, 5th edition: Alexandria, VA, American Geological Institute, 800 p.

actinolite—A bright-green or grayish-green monoclinic mineral of the amphibole group: $Ca_2(Mg,Fe)_5(OH)_2[Si_8O_{22}]$. It may contain manganese. 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. *Glossary of Geology*

alluvium—A general term for clay, silt, sand, gravel, or similar unconsolidated detrital material, deposited during comparatively recent geologic time by a stream or other body of running water, as a sorted or semisorted sediment in the bed of the stream or on its floodplain or delta, as a cone or fan at the base of a mountain slope; especially such a deposit of fine-grained texture (silt or silty clay) deposited during time of flood. The term does not apply to subaqueous deposits in seas, estuaries, lakes, and ponds. *Glossary of Geology*

amphibole—(a) A group of dark rock-forming ferromagnesian silicate minerals, closely related in crystal form and composition and having the general formula: $A_{2\text{-}3}B_5(Si,Al)_8O_{22}(OH)_2$, where A = Mg, Fe^{2+}, Ca, or Na, and B = Mg, Fe^{2+}, Fe^{3+}, Li, Mn, or Al. 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 (some are wholly metamorphic), and they are analogous in chemical composition to the pyroxenes. (b) A mineral of the amphibole group, such as hornblende, anthophyllite, cummingtonite, tremolite, actinolite, riebeckite, glaucophane, arfvedsonite, etc. (c) A term sometimes used as a synonym of hornblende. *Glossary of Geology*

asbestiform—Said of a mineral that is composed of separable fibers, for example, chrysotile. *Glossary of Geology*

asbestos—(a) 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. (b) A mineral of the asbestos group, principally chrysotile (best adapted for spinning) and certain fibrous varieties of amphibole (especially amosite, anthophyllite, and crocidolite). (c) A term strictly applied to the fibrous variety of actinolite. Certain varieties are deleterious to health. *Glossary of Geology*

asbestosis—A serious, progressive, long-term disease of the lungs. Asbestosis is not a cancer. Inhaling asbestos fibers that irritate and inflame lung tissues, causing the lung tissues to scar, causes asbestosis. The scarring makes it hard to breathe and difficult for oxygen and carbon dioxide pass through the lungs. Asbestosis generally progresses slowly. The latency period for the onset of asbestosis is typically 10–20 years after the initial exposure. The disease can vary from asymptomatic (no symptoms) to disabling and potentially fatal. *http://www.atsdr.cdc.gov/asbestos/asbestos/health_effects/#asbestosis*

basalt—(a) In the IUGS classification, a volcanic rock defined modally by Q/(Q+A+P) between 0 and 20% or F/(F+A+P) between 0 and 10%, P/(A+P)>65%, and M>35%. Because modes are difficult to estimate for these rocks, basalt is also defined in the TAS diagram as rock falling in the area bounded by points with the SiO_2 and total alkali coordinates: 45, 0; 45, 5; 52, 0; 52, 5. (b) A general term for dark-colored mafic igneous rocks, commonly extrusive but locally intrusive (such as dikes), composed chiefly of calcic plagioclase and clinopyroxene; the fine-grained equivalent of gabbro. Nepheline, olivine, orthopyroxene, and quartz may be present in the CIPW norm, but not all simultaneously: nepheline and olivine can occur together, as can olivine and orthopyroxene, and orthopyroxene and quartz, but nepheline does not occur with orthopyroxene or quartz, nor quartz with nepheline or olivine. These associations and incompatibilities are discussed by Yoder and Tilley (1962) and by Muir and Tilley (1961). *Glossary of Geology*

calc-alkaline magma series—(a) Subalkaline basalts, andesites, dacites, and rhyolites that frequently (and perhaps exclusively) occur at convergent margins and show a trend of low iron enrichment with increasing silica content, as commonly discriminated from the tholeiitic magma series (also subalkalic) by Miyashiro's (1977) discriminant line on a plot of FeO/

MgO vs. SiO_2. In specific occurrences, as in volcanoes or plutons, individual magmas in the series are often taken to be genetically related (for example, by crystal fractionation, mixing, etc.). (b) A series as in (a) discriminated from calcic and alkaline magma series by relative amounts of CaO and alkalis, following Peacock (1931). This classification line is little used at present. Usage is contentious at present, as, in addition to the above, some authors use modal mineralogy (for example, presence of hornblende) or equate hypersthene series (vs. pigeonite series) with calc-alkaline series. *Glossary of Geology*

carbonatite—An igneous rock composed of at least 50% carbonate minerals (Bell, 1989). *Glossary of Geology*

chrysotile—A white, gray, or greenish orthorhombic or monoclinic mineral of the serpentine group: $Mg_3(OH)_4Si_2O_5$. It is a highly fibrous, silky variety of serpentine, and constitutes the most important type of asbestos. Not to be confused with chrysolite. Synonyms: serpentine asbestos; clinochrysotile. *Glossary of Geology*

colluvium—(a) A general term applied to any loose, heterogeneous, and incoherent mass of soil material and/or rock fragments deposited by rainwash, sheetwash, or slow continuous downslope creep, usually collecting at the base of gentle slopes or hillsides. (b) Alluvium deposited by unconcentrated surface runoff or sheet erosion, usually at the base of a slope. *Glossary of Geology*

dolostone—A term proposed by Shrock (1948a, p. 126) for the sedimentary rock dolomite, in order to avoid confusion with the mineral of the same name. *Glossary of Geology*

dolomite—A common rock-forming rhombohedral mineral: $CaMg(CO_3)_2$. Part of the magnesium may be replaced by ferrous iron and less frequently by manganese. Dolomite is white, colorless, or tinged yellow, brown, pink, or gray; it has perfect rhombohedral cleavage and a pearly to vitreous luster, effervesces feebly in cold dilute hydrochloric acid, and forms curved, saddlelike crystals. Dolomite is found in extensive beds as dolomite rock; it is a common vein mineral, and is found in serpentinite and other magnesian rocks. *Glossary of Geology*

deformation—(a) A general term for the process of folding, faulting, shearing, or fabric development of the rocks as a result of Earth stresses. (b) The change in the geometry of a body of rock that occurs as a consequence of stress, for example, translation, rigid body rotation about an axis, and strain or distortion. *Glossary of Geology*

alkali feldspar—(a) A group of feldspars composed of mixtures, or mixed crystals, of potassium feldspar ($KAlSi_3O_8$) and sodium feldspar ($NaAlSi_3O_8$) in any ratio; a group of feldspars containing alkali metals but little calcium. (b) A mineral of the alkali feldspar group, such as microcline, orthoclase, sanidine, adularia, albite, anorthoclase, and plagioclase in which the proportion of the An molecule is less than 20%. *Glossary of Geology*

felsic—A mnemonic adjective derived from *fe*ldspar + *l*enad (feldspathoid) + *si*lica + *c,* and applied to an igneous rock having abundant light-colored minerals in its mode; also, applied to those minerals (quartz, feldspars, feldspathoids, muscovite) as a group. It is the complement of "mafic." *Glossary of Geology*

gabbro—(a) In the IUGS classification, a plutonic rock with Q between 0 and 5, P/(A+P) greater than 90, and plagioclase more calcic than An_{50}. (b) A group of dark-colored, basic intrusive igneous rocks composed principally of calcic plagioclase (commonly labradorite or bytownite) and clinopyroxene (augite), with or without olivine and orthopyroxene; also, any member of that group. It is the approximate coarse-grained equivalent of basalt. Apatite and magnetite or ilmenite are common accessory minerals. Gabbro grades into monzonite with increasing alkali–feldspar content. According to Streckeisen (1967, p. 171, 198), plagioclase with more than 50% anorthite distinguishes gabbro from diorite; quartz is 0–20% of the light-colored constituents, and the plagioclase/total feldspar ratio is 90/100. *Glossary of Geology*

greenstone—A field term applied to any compact dark-green altered or metamorphosed mafic igneous rock (for example, spilite, basalt, gabbro, diabase) that owes its color to the presence of chlorite, actinolite, or epidote. *Glossary of Geology*

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

intrusion—The process of emplacement of magma in pre-existing rock; magmatic activity; also, the igneous rock mass so formed within the surrounding rock. *Glossary of Geology*

limestone—(a) A sedimentary rock consisting chiefly (more than 50% by weight or by areal percentages under the microscope) of calcium carbonate, primarily in the form of the mineral calcite, and with or without magnesium carbonate; specifically a carbonate sedimentary rock containing more than 95% calcite and less than 5% dolomite. Common minor constituents include silica (chalcedony), feldspar, clays, pyrite, and siderite. Limestones are formed by either biotic or abiotic processes, and may be detrital, chemical, oolitic, earthy, crystalline, or recrystallized; many are highly fossiliferous and clearly represent ancient shell banks or coral reefs. Limestones include chalk, calcarenite, coquina, and travertine, and they effervesce freely with any common acid. (b) A general term used commercially (in the manufacture of lime) for a class of rocks containing at least 80% of the carbonates of calcium or magnesium and which, when calcined, gives a product that slakes upon the addition of water. *Glossary of Geology*

lithology—(a) The description of rocks, especially in hand specimen and in outcrop, on the basis of such characteristics as color, mineralogic composition, and grain size. As originally used, "lithology" was essentially synonymous with "petrography" as currently defined. (b) The physical character of a rock. *Glossary of Geology*

loess—A widespread, homogeneous, commonly nonstratified, porous, friable, slightly coherent, usually highly calcareous, fine-grained blanket deposit (generally less than 30 m thick), consisting predominantly of silt with secondary grain sizes ranging from clay to fine sand. It covers areas extending from north-central Europe to eastern China as well as the Mississippi Valley and Pacific Northwest of the U.S. Loess is generally buff to light yellow or yellowish brown, often contains shells, bones, and teeth of mammals, and is traversed by networks of small narrow vertical tubes (frequently lined with calcium-carbonate concretions) left by successive generations of grass roots, which allow the loess to stand in steep or nearly vertical faces. Loess is now generally believed to be windblown dust of Pleistocene age, carried from desert surfaces, alluvial valleys, and outwash plains, or from unconsolidated glacial or glaciofluvial deposits uncovered by successive glacial recessions but prior to invasion by a vegetation mat. The mineral grains, composed mostly of silica and associated heavy minerals, are fresh and angular, and are generally held together by calcareous cement. In some regions, such as Moravia and China, more than 10 successive loess formations are separated by red to dark brown paleosols. A "lee-desert loess" commonly found in the Middle East on the downwind side of the northeastern Sahara is reddish in color and commonly noncalcareous. Pronunciation: luehss. *Glossary of Geology*

mafic—Said of an igneous rock composed chiefly of one or more ferromagnesian, dark-colored minerals in its mode; also, said of those minerals. The term was proposed by Cross and others (1902, p. 561) to replace the term "femag", which they did not consider to be euphonious. A mnemonic term derived from *ma*gnesium + *f*erric + *ic.* It is the complement of felsic. *Glossary of Geology*

mesothelioma—A rare cancer, which may affect the lining of the chest cavity, outside the lung (pleura) or the abdominal contents (peritoneum). Most mesotheliomas are caused by exposure to asbestos. *http://www.atsdr.cdc.gov/asbestos/asbestos/health_effects/*

metadolostone—Metamorphosed dolostone

metagabbro—Metamorphosed gabbro

metaigneous—Metamorphosed igneous rock or body

metamorphism—The mineralogical, chemical, and structural adjustment of solid rocks to physical and chemical conditions that have generally been imposed at depth, below the surface zones of weathering and cementation, and differ from the conditions under which the rocks in question originated. *Glossary of Geology*

metasomatism—The open-system metamorphic process in which the original chemical composition of a rock is changed by reaction with an external source. The process is commonly thought to occur in the presence of a fluid medium flowing through the rock (infiltration metasomatism). Metasomatism may also occur by grain-boundary diffusion or by diffusion through a static fluid medium (diffusion metasomatism). Skarn, tactite, and serpentinite are examples of metasomatic rocks. *Glossary of Geology*

monoclinic system—One of the six crystal systems, characterized by either a single twofold axis of symmetry, a single plane of symmetry, or a combination of the two. Of the three nonequivalent axes, one is perpendicular to the plane formed by the other two. *Glossary of Geology*

morphology—The study of structure or form, *http://www.merriam-webster.com/dictionary/morphology*

NOA—Naturally occurring asbestos

ophiolite—An assemblage of ultramafic and mafic intrusive and extrusive rocks, widely believed to represent oceanic crust (Coleman, 1977). In a complete ophiolite, sheared and serpentinized ultramafic rocks are overlain by less deformed ultramafic and mafic cumulates, which are overlain by a sheeted dike complex topped by pillow lavas and deep marine sediments. The entire sequence is rarely preserved. Originally defined as a group of mafic and ultramafic igneous rocks ranging from spilite and basalt to gabbro and peridotite, including rocks rich in serpentine, chlorite, epidote, and albite derived from them by later metamorphism, whose origin was associated with an early phase of the development of a geosyncline. *Glossary of Geology*

palygorskite—(a) A white, grayish, yellowish, or grayish-green chain-structure clay mineral: $(Mg,Al)_2Si_4O_{10}(OH)\cdot 4H_2O$. It crystallizes in several monoclinic and orthorhombic polytypes. (b) A group name for monoclinic minerals with an analogous composition, but with Mg replaced by Mn or Na, and Al replaced by Fe^{3+} or Mn^{3+}. (c) The term has also been used as a group name for lightweight fibrous clay minerals showing a considerable amount of substitution of aluminum for magnesium and characterized by distinctive rodlike shapes under the electron microscope. *Glossary of Geology*

peralkaline—Said of an igneous rock in which the molecular proportion of aluminum oxide is less than that of sodium and potassium oxides combined; one of Shand's (1947) groups of igneous rocks, classified on the basis of the degree of aluminum-oxide saturation. *Glossary of Geology*

plagioclase [feldspar]—(a) A group of triclinic feldspars of general formula: $(Na,Ca)[Al(Si,Al)Si_2O_8]$. At high temperatures it forms a complete solid-solution series from Ab $Na[AlSi_3O_8]$ to An $Ca[Al_2Si_2O_8]$. The plagioclase series is arbitrarily subdivided and named according to increasing mole fraction of the An component: albite (An 0–10), oligoclase (An 10–30), andesine (An 30–50), labradorite (An 50–70), bytownite (An 70–90), and anorthite (An 90–100). The Al/Si ratio ranges with increasing An content from 1:3 to 1:1. Plagioclase minerals are among the commonest rock-forming minerals, have characteristic twinning, and commonly display zoning. (b) A mineral of the plagioclase group; for example, albite, anorthite, peristerite, and aventurine feldspar. The term was introduced in 1847 by Breithaupt, who applied it to all feldspars having an oblique angle between the two main cleavages. *Glossary of Geology*

pluton—A deep-seated igneous intrusion. *Glossary of Geology*

protolith—(a) The unmetamorphosed rock from which a given metamorphic rock was formed by metamorphism. Synonym: parent rock. (b) The parent or unweathered rock from which regolith is formed. *Glossary of Geology*

pyroxene—(a) A group of dark rock-forming silicate minerals, closely related in crystal form and composition and having the general formula: $A_2B_2Si_4O_{12}$, where A = Ca, Na, Mg, or Fe^{2+}, and B = Mg, Fe^{2+}, Fe^{3+}, Cr, Mn, or Al, with silicon sometimes replaced in part by aluminum. It is characterized by a single chain of tetrahedra with a silicon:oxygen ratio of 1:3; by short, stout prismatic crystals; and by good prismatic cleavage in two directions parallel to the crystal faces and intersecting at angles of about 87° and 93°. Colors range from white to dark-green or black. Pyroxenes may crystallize in the orthorhombic or monoclinic systems; they constitute a common constituent of igneous rocks, and are similar in chemical composition to the amphiboles (except that the pyroxenes lack hydroxyls). (b) A mineral of the pyroxene group, such as enstatite, hypersthene, diopside, hedenbergite, acmite, jadeite, pigeonite, and especially augite. *Glossary of Geology*

schist—A strongly foliated crystalline rock, formed by dynamic metamorphism, that can be readily split into thin flakes or slabs because of the well-developed parallelism of more than 50% of the minerals present, particularly those of lamellar or elongate prismatic habit (such as mica and hornblende). The mineral composition is not an essential factor in its definition unless specifically included in the rock name (for example, quartz–muscovite schist). Varieties may also be based on general composition (such as calc–silicate schist, amphibole schist) or on texture (such as spotted schist). *Glossary of Geology*

sedimentary—(a) Pertaining to or containing sediment; for example, a "sedimentary deposit" or a "sedimentary complex." (b) Formed by the deposition of sediment (such as a "sedimentary clay"), or pertaining to the process of sedimentation (for example, "sedimentary volcanism"). n. A sedimentary rock or deposit. *Glossary of Geology*

serpentine— (a) A group of common rock-forming minerals having the general formula: $(Mg,Al,Fe,Mn,Ni,Zn)_{2\text{-}3}(Si,Al,Fe)_2O_5(OH)_4$. Serpentines 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. Serpentines are always secondary minerals, derived by alteration of magnesium-rich silicate minerals (especially olivines), and are found in both igneous and metamorphic rocks; they generally crystallize in the monoclinic system. Translucent varieties are used for ornamental and decorative purposes, often as a substitute for jade.

(b) A mineral of the serpentine group, such as chrysotile, antigorite, lizardite, parachrysotile, and orthochrysotile. *Glossary of Geology*

serpentinite—A rock consisting almost wholly of serpentine-group minerals, for example, antigorite, chrysotile, or lizardite, derived from the hydration of ferromagnesian silicate minerals such as olivine and pyroxene. Accessory chlorite, talc, and magnetite may be present. Synonym: serpentine rock. *Glossary of Geology*

skarn—An old Swedish mining term for silicate gangue (amphibole, pyroxene, garnet, etc.) of certain iron-ore and sulfide deposits of Archean age, particularly those that have replaced limestone and dolomite. Its meaning has been generally expanded to include calcium-bearing silicates of any geologic age, derived from nearly pure limestone and dolomite with the introduction of large amounts of Si, Al, Fe, and Mg. In American usage the term is more or less synonymous with tactite. *Glossary of Geology*

syenite—(a) In the IUGS classification, a plutonic rock with Q between 0 and 5, and P/(A+P) between 10 and 35. (b) A group of plutonic rocks containing alkali feldspar (usually orthoclase, microcline, or perthite), a small amount of plagioclase (less than in monzonite), one or more mafic minerals (especially amphibole), and quartz, if present, only as an accessory; also, any rock in that group; the intrusive equivalent of trachyte. With an increase in the quartz content, syenite grades into granite. *Glossary of Geology*

tactite—A rock of complex mineralogical composition, formed by contact metamorphism and metasomatism of carbonate rocks. It is typically coarse grained and rich in garnet, iron-rich pyroxene, epidote, wollastonite, and scapolite. *Glossary of Geology*

trachyte—(a) In the IUGS classification, a volcanic rock defined in the QAPF diagram by Q/(Q+A+P) between 0 and 5 and P/(P+A) between 10 and 35, and in the TAS diagram by a field partly bounded by points with SiO_2 and total alkali coordinates: 57.6, 11.7; 61, 13.5; 63, 7; and 69, 8. The field is bounded at high silica contents by a vertical line with its lowest end at 69, 8. In addition, normative quartz is <20%. (b) A group of fine-grained, generally porphyritic, extrusive rocks having alkali feldspar and minor mafic minerals (biotite, amphibole, or pyroxene) as the main components, and possibly a small amount of sodic plagioclase; also, any member of that group; the extrusive equivalent of syenite. Trachyte grades into latite as the alkali feldspar content decreases, and into rhyolite with an increase in quartz. *Glossary of Geology*

tremolite—A white to dark-gray monoclinic mineral of the amphibole group: $Ca_2Mg_5Si_8O_{22}(OH)_2$. It has varying amounts of iron, and may contain manganese and chromium. Tremolite occurs in long blade-shaped or short stout prismatic crystals and also 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 of much commercial talc. *Glossary of Geology*

ultramafic—Said of an igneous rock composed chiefly of mafic minerals, for example, monomineralic rocks composed of hypersthene, augite, or olivine. *Glossary of Geology*

PRELIMINARY EVALUATION OF BEDROCK POTENTIAL FOR NATURALLY OCCURRING ASBESTOS IN ALASKA

by

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ABSTRACT

Naturally occurring asbestos (NOA) develops in predictable geologic settings worldwide. On digital geologic maps of Alaska, we identified the map units associated with these settings and rated each unit for its likely NOA potential. Sheets 1 through 21 show the geologic map units rated according to their interpreted potential to host NOA. To summarize locations of known asbestos occurrences, we searched the U.S. Geological Survey's (USGS's) Alaska Resource Data File (http://ardf.wr.usgs.gov) and Mineral Resource Data System (http://mrdata.usgs.gov/mineral-resources/mrds-ak.html) for references to asbestos in Alaska. Table 1 compiles the resulting 62 documented asbestos occurrences.

INTRODUCTION

Asbestos has come under close scrutiny in recent decades because of its link to lung diseases such as asbestosis, lung cancer, and malignant mesothelioma. These health-hazard concerns arose where asbestos was mined, milled, or used in manufacturing processes or where man-made products with asbestos were installed or disturbed (Ross, 1981). Risk depends on the amount of inhaled asbestos particles, the duration of exposure, whether a person smokes cigarettes, and the type, size, and morphology of the asbestos itself (Guthrie and Mossman, 1993; Dodson and Hammar, 2006). More recently, studies have looked at environmental exposure to asbestos in natural rock outcrops and resulting gravel and soils (Paoletti and others, 2000; Meeker and others, 2006; Buck and others, 2013). While levels of airborne asbestos can be expected to be higher where these deposits are disturbed, it is not yet clear how low-level environmental exposure affects health, or what levels are safe (Gunter and others, 2007). Consequently, it is prudent to have prior knowledge of whether the local geology could contain asbestos in order to minimize potential risk from disturbing these deposits.

The Alaska Department of Transportation & Public Facilities (DOT&PF) has been impacted by naturally occurring asbestos (NOA) deposits during the course of several projects since 2000 (Perkins and others, 2009). Since then, the department established a NOA task force, which has gathered information and posted it on the DOT&PF website: http://www.dot.alaska.gov/stwddes/desmaterials/noa.shtml. Due to the potential hazard of construction materials containing NOA, sampling and testing of construction materials (as outlined by DOT&PF) is recommended to eliminate the potential for their containing NOA prior to their use.

DOT&PF's NOA program is instrumental in developing Alaska Statutes regulating the testing and use of NOA in construction material sources in Alaska. In Alaska Statute Sec. 44.42.430, NOA is defined to mean:

> "…chrysotile, amosite, crocidolite, fibrous tremolite, fibrous anthophyllite, and fibrous actinolite asbestos-containing material that has not been processed in an asbestos mill and that, when tested using a bulk method prescribed by the Department of Transportation and Public Facilities by regulation, is determined to have a content equal to or greater than 0.25 percent naturally occurring asbestos by mass." (http://www.legis.state.ak.us/basis/statutes.asp#44.42.430)

To better predict where NOA may exist in Alaska, DOT&PF contracted the Alaska Division of Geological & Geophysical Surveys (DGGS) to evaluate the bedrock geology of the state for NOA potential. Based on known geologic settings where asbestos is most likely to be present (Van Gosen, 2007; Buck and others, 2013; Hendrickx, 2009), we developed a set of criteria to rate relative NOA potential according to rock type (appendix 1). Using existing geologic map compilations of the state (listed in appendix 2), we assigned a rating to each bedrock map unit. The accompanying maps show the resulting distribution of relative NOA potential in Alaska. Individual rating, relevant lithology (rock type), and the amount of a given lithology composing each NOA-favorable map unit are described for each polygon in the GIS attribute table. This estimate is based solely on the

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map unit description in the cited references. DGGS did not check the accuracy of the maps used for the compilation of this project, nor conduct additional field work as part of this study. Abundance of NOA-favorable lithology is assigned according to estimated percentage of total rock volume: trace (less than 1%), minor (1–10%), moderate (11–50%), and major (greater than 50%). These definitions are also used in appendix 1.

Throughout the world, only a few geologic settings are known to be conducive to the formation of NOA (Van Gosen, 2007). Some of these geologic settings host major asbestos mines, but more common are smaller-scale occurrences in the form of veins or pods. Though these rock types have been rated as having high NOA potential (most likely to host asbestos), it is important to understand that they do not necessarily contain NOA. Conversely, units rated as having zero-to-low potential for NOA could actually include localized NOA, and cannot be assumed to have no potential. There may well be additional bodies of rock with high NOA potential that are not reflected on these maps. Consequently, DGGS does not guarantee the accuracy or completeness of bedrock units rated with NOA potential. This study did not evaluate NOA potential of surficial-geologic units or the potential locations of detrital NOA eroded from known or potential sources.

Known occurrences of asbestos in bedrock were derived from the Alaska Resource Data File (http://ardf.wr.usgs.gov/welcome.html) and USGS Mineral Resource Data System, Alaska (http://mrdata.usgs.gov/mineral-resources/mrds-ak.html) and tabulated in the accompanying table (table 1). Data in the Alaska Resource Data File (ARDF) were compiled by the USGS "using published literature, unpublished reports and data from various sources including the United States Bureau of Mines, USGS, and industry" (ARDF website). The USGS Mineral Resource Data System (MRDS) "describes metallic and nonmetallic mineral resources throughout the world. Included are deposit name, location, commodity, deposit description, geologic characteristics, production, reserves, resources, and references. It includes the original MRDS and MAS/MILS data" (MRDS website). Both databases were searched for references to asbestos; search results were combined and duplications deleted. The project's scope did not include a comprehensive literature search to produce this table; consequently, if there are NOA occurrences that are not included in either ARDF or MRDS, they are also not in the table.

This publication consists of this report with appendices, a table listing known asbestos occurrences in Alaska, and 21 maps of NOA potential in bedrock, available digitally or printed on demand.

GENERAL GEOLOGY OF ASBESTOS

Asbestos has been defined somewhat differently by the geologic, regulatory, industrial, and medical communities (Lowers and Meeker, 2002). In this report we use the term in the geologic sense, in which asbestos is the subset of a group of minerals that sometimes display asbestiform morphology. This morphology, or shape, is fibrous, behaving like a fiber that is strong and can bend under force, and that will split lengthwise into thinner fibers (Zoltai, 1981; Gunter and others, 2007). The minerals that can exhibit this morphology include chrysotile (one of the serpentine minerals) and several of the amphibole minerals, including crocidolite (asbestiform riebeckite), amosite (asbestiform grunerite), and the asbestiform varieties of anthophyllite, tremolite, and actinolite. These are the minerals covered by Alaska Statute Sec. 44.42.430 (quoted above). Additional amphibole minerals that can have a fibrous morphology include winchite and richterite (fibrous minerals present in the former Libby, Montana, vermiculite mine and implicated in causing increased rates of respiratory disease; Meeker and others, 2003; Gunter and others, 2003), fluoro-edenite (found in volcanic rocks on Mount Etna, Italy; Gianfagna and others, 2003; Burragato and others, 2005), and possibly magnesiohornblende (Meeker and others, 2006; Buck and others, 2013). These additional minerals exhibit the same qualities, possibly with similar health concerns, as the regulated minerals. The unregulated fibrous amphiboles, such as winchite, richterite, and fluoro-edenite, form in geologic settings in common with some of the regulated amphibole asbestos minerals; thus, this study does not distinguish among the amphibole-forming geologic settings.

Another unregulated asbestiform mineral is erionite. It is one of the zeolite group minerals that can have a fibrous morphology. In Cappadocia, Turkey, erionite occurs in altered volcanic glass, and it has been implicated in environmentally-caused cases of malignant mesotheliomas in some local residents (Carbone and others, 2007). We do not have data regarding erionite in Alaska, and though its presence cannot be ruled out, this study does not address the potential for erionite occurrences in Alaska.

Palygorskite (or paligorskite) is a fibrous, clay-like mineral that could be considered asbestiform but has not been regulated as asbestos. There are two known palygorskite localities in southeastern Alaska (ARDF MF080 and MRDS 10233917); ARDF locality MF080 was mined on a small scale for hand specimens (photo 1), which occur as masses in replaced Paleozoic limestone proximal to copper–molybdenum-bearing veins. Palygorskite is included in table 1, but is not discussed further due to the uniqueness of the occurrence.

Photo 1. Palygorskite "mountain leather" fiber mat (UAMES 34961). Sample collected from Lemesurier Island, Mt. Fairweather Quadrangle, Alaska, by K. Kennedy. Two asbestos prospects are described on Lemesurier Island: MRDS Deposit ID 10233917 and ARDF number MF080. Image courtesy of the University of Alaska Museum Earth Sciences Department.

Van Gosen (2007) has an excellent discussion of the geologic environments that can host NOA minerals. These geologic environments include:

- Metamorphosed ultramafic rock
- Metasomatized mafic volcanic and plutonic rocks
- Metamorphosed dolostones
- Metamorphosed iron formations
- Metasomatized alkaline igneous rocks

Structural deformation such as folding and faulting has been associated with formation of NOA minerals (Ross, 1981). Calc-alkaline plutonic rocks in an extensional stress regime in Arizona and Nevada (Potts and Metcalf, 1997; Honn and Smith, 2008) have also been shown to host fibrous amphiboles resulting from hydrothermal alteration (Buck and others, 2013).

It is important to understand that NOA minerals generally constitute only a part of the rock in which they are found. The NOA minerals form as secondary alteration products and require specific conditions for growth. The geologic requirements for formation of NOA include a magnesium- (± iron-) rich host rock that has experienced an influx of hot, silica-rich fluids derived from metamorphic (at moderately high temperatures and pressures) or magmatic processes, in the presence of a folding or faulting event (Van Gosen, 2007). This process of altering mineral and rock composition through the addition of hydrothermal fluids is called metasomatism. Thus, even in rocks of appropriate composition for development of NOA (assigned as High Potential in this study), there is commonly no NOA, or only thin veins or small localized zones of NOA due to lack of other necessary geologic factors. Where NOA is present in mineable quantity, NOA minerals may constitute essentially 100 percent of the rock.

NATURALLY OCCURRING ASBESTOS POTENTIAL IN ALASKA

Table 1 lists the reported asbestos localities in Alaska, compiled from ARDF and MRDS data. In Alaska there has been only a very limited amount of historic small-scale asbestos mining (Heide and others, 1949): of the 62 localities listed, only one has reported production of asbestos (ARDF AR016). Tremolite and chrysotile asbestos, along with jade, were mined in the first half of the 20th century near the summit of Asbestos Mountain in the Kobuk River district near Ambler (Heide and others, 1949). A mine on Jade Mountain (ARDF AR006) was a source of jade, but NOA was present at the site as well. The rest of the sites are either prospects that have had some exploration or development work but no production (photo 2), or occurrences that have been reported but are largely unexplored (U.S. Geological Survey, 1996). Note that many of the NOA localities listed in table 1 volumetrically include only a small percentage of the overall rock in the region.

A.

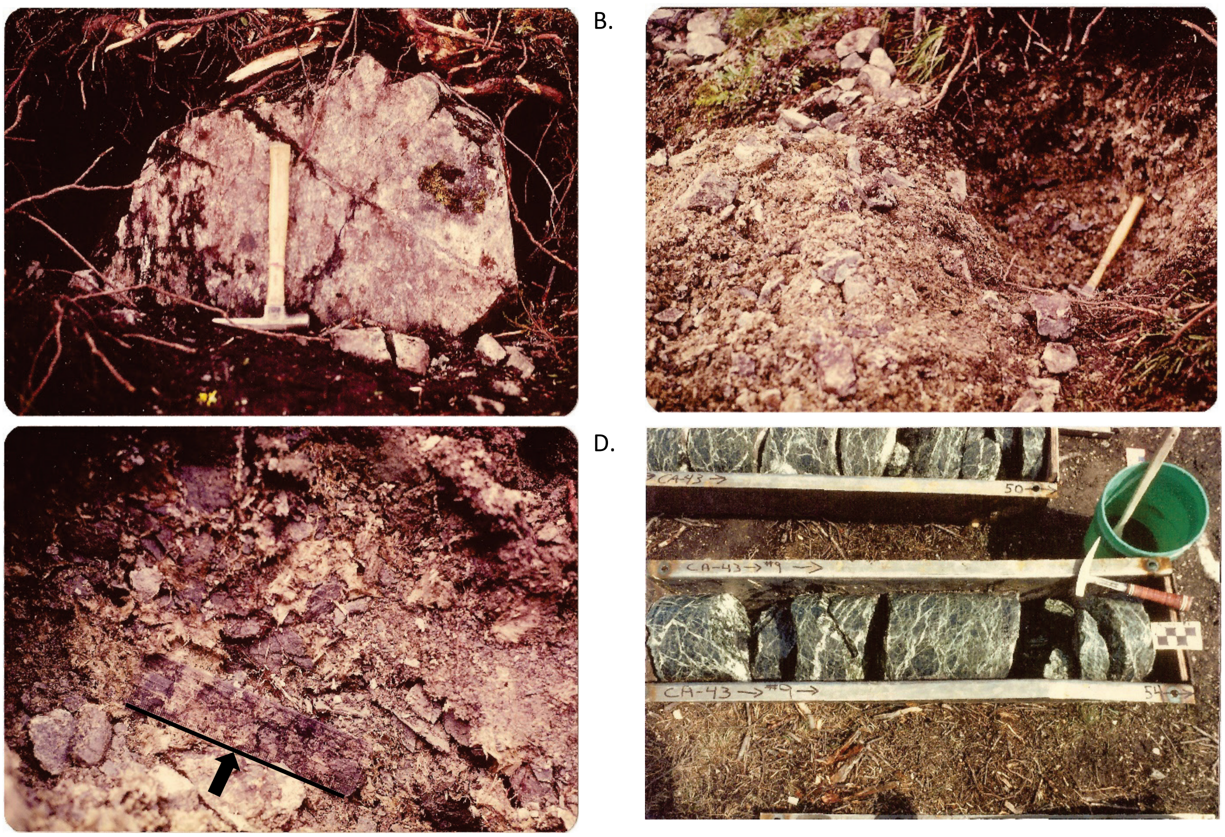

Photo 2. Exploration of the Slate Creek chrysotile asbestos prospect. Photos A–C are from 1980; photo D was taken in 1983. The prospect is on the south side of Slate Creek near the headwaters of the North Fork of the Fortymile River, Eagle Quadrangle, Alaska (Doyon land; ARDF number EA043; Foster, 1969). Photos were taken by Bob Rogers and provided by Doyon, Limited. A. Serpentinite boulder with asbestos veining. B. Small test pit. C. Close-up of the test pit with considerable chrysotile float and a 6-inch transparent scale (shown by a black line). D. Abundant chrysotile veining in 12-inch-diameter core.

About 20 percent of the 62 known asbestos occurrences are in stream deposits. They are generally downstream of, but in close proximity to, bedrock with high potential for asbestos.

The majority of known asbestos in rock localities in Alaska, about 60 percent, are hosted in ultramafic rocks, which are commonly serpentinized. This is in line with observations in California, where at least 70 percent of reported asbestos occurrences are in altered ultramafic rock/serpentinite (Van Gosen and Clinkenbeard, 2011). There are undoubtedly numerous additional occurrences of asbestos in serpentinized ultramafic rocks in Alaska that are not listed in ARDF and MRDS data tables (for example, NOA at Serpentine Slide, Livengood C-1 and C-2 quadrangles; Juday, 1992). Due to the generalized nature of the USGS mapping (1:250,000 scale) on which this study's maps are based, and the small scale (1:500,000) of the maps produced for this project, not all of the ultramafic outcrops appear on the maps. For example, serpentinized ultramafic rocks on Ahtell Creek in the Gulkana Quadrangle (Gold–Quartz prospect; Richter, 1964) are part of a mapped unit of unmetamorphosed volcanic rocks, which overall is indicated to have low NOA potential.

The maps (sheets 1–21) show where existing mapping of bedrock units indicates the potential to host NOA throughout Alaska. As the data sources do not report NOA in all NOA-favorable lithologies, the potential exists for unreported NOA occurrences throughout Alaska. Ultramafic bodies, generally limited in extent, are scattered across the state. The volumetrically more prevalent, NOA-favorable, mafic metaigneous rocks are commonly found in association with ultramafic rocks. Most of the known NOA occurrences are associated with these rock types.

Nine of the asbestos occurrences in table 1 are not described in the data sources; consequently, their geologic settings are ambiguous. Of the remaining occurrences, four are different from typical metaigneous-associated asbestos occurrences. These include two localities of palygorskite on Lemesurier Island; an amphibolite asbestos layer/vein in mica schist (ARDF JU219); and an occurrence of asbestos veins in greenstone (ARDF AR009), though asbestos in serpentinite is also reported at this locality.

Dolostone is another Mg-bearing rock that can form asbestos given the correct metamorphic conditions, unlike limestone which lacks the Mg required to form asbestos minerals. Dolostone is generally associated with limestone, and may be only a minor component of the rock package. The Donovan site, one of the ambiguous occurrences in table 1, lists limestone as its primary commodity with asbestos as an accessory. The site is near Fox, in the Fairbanks D-2 Quadrangle, and may reference the marbles that are part of the amphibolite-grade metamorphic rocks in the area (Newberry and others, 1996). No further information about this asbestos occurrence is available.

No NOA occurrences associated with alkalic igneous rocks are reported in this study. One carbonatite is included (Tanana A-2 and A-3 quadrangles, about 15 km north of Manley Hot Springs), along with numerous alkaline plutonic intrusions, but the database does not show any associated NOA. However, metasomatism is common in the alkaline rock suites and conditions for localized NOA development are possible.

No metamorphosed Precambrian (at least 540 million years old) banded iron formations were identified in this study.

LIMITATIONS OF THE DATA

- Asbestos will not actually be present in many areas displayed as having NOA potential. The map series serves as a guide to locations where NOA could occur based on geologic setting. Note that areas of high potential may have NOA-favorable lithologies (rock types) but may lack other conditions such as metasomatic alteration or structural stress required for NOA formation; in these cases, NOA will not have formed.
- There is a very good chance that asbestos exists in significant quantities in areas indicated as having zero-to-low potential for NOA. Use the maps as a guide to where NOA is most likely to be present, but do not disregard the potential for NOA in the zero-to-low-potential areas. Most maps used in this study are compilations at 1:250,000 scale (for example, Wilson and Hults, 2008), which must generalize the geology to some degree. Thus, finer geologic details such as small ultramafic bodies may not appear on the maps or in map unit descriptions. In these cases, map units rated with zero-to-low NOA potential could contain localized potential for NOA.
- For this report, surficial deposits (which could contain redistributed NOA) were not evaluated for NOA. NOA in unconsolidated surficial deposits can be derived from rocks containing NOA. Highest NOA potential in surficial deposits will generally be found close to bedrock with the highest potential for NOA. However, different types of surficial deposits will inherit different amounts of NOA minerals. Development of a more detailed report discussing NOA in surficial deposits in Alaska is under consideration.
- At the time of this study, some geologic maps were not yet available digitally. In those map areas, we scanned and digitized from raster images of published maps, combining geologic data from sources with different scales and levels of detail. In these digitized maps, we generalized and combined map units that were assigned either a NOA potential of zero to low or were classified as surficial deposits. Thus, specific detailed data on these individual original map units are not available.

Units with medium- and high-rated NOA potential were digitized individually and their NOA-favorable rock types recorded. References for the scanned geologic maps are listed in appendix 2.

- At the time of this study, some of the available digitized geologic maps listed in appendix 2 were preliminary versions. Revisions to these maps will undoubtedly change some unit descriptions. Thus, evaluations of NOA potential in this study might not conform to how final digitized USGS map versions would be evaluated.
- Known asbestos occurrences in table 1 are derived from ARDF and MRDS databases, not a comprehensive literature search. There are certainly additional occurrences in Alaska that are not listed in the ARDF or MRDS databases, and thus not included in table 1.
- Interpretation of NOA potential was based on published rock unit descriptions. The percentages of NOA-favorable rocks in each unit were not always reported, which resulted in necessarily subjective interpretations for this project (for example, is the amount of amphibolite in a metamorphic unit moderate, minor, or trace?). Correlative map units on adjacent maps may be rated differently depending on how NOA-favorable lithologies are described in the source publications.
- Accuracy of plotted locations of ARDF and MRDS data varies. As stated on the MRDS website, "…many records were located on the basis of published reports containing imprecise or scant information on the specific geographic location." Thus, some error must be expected when comparing the point data to the geologic polygons. Locations of ARDF and MRDS asbestos occurrences were not field checked as part of this project.

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Appendix 1: Rating Criteria for NOA potential

High to Known

Map units are rated High to Known if they consist entirely of, or contain a major amount (>50%) of, lithologies (rock types) known to host asbestos elsewhere in the world. NOA-favorable rock types are listed below (also see discussion above); of these lithologies, serpentinite and ultramafic rocks are the most common hosts of NOA. However, the occurrence of any of these lithologies only signifies the potential to host NOA, not that there is necessarily NOA in them. Consider a rating of High to Known as guidance for where to be particularly alert to possible occurrences of asbestos.

- Serpentinite
- Ultramafic rocks, including:
  - Peridotite
  - Dunite
  - Pyroxenite
  - Harzburgite
  - Wehrlite
  - Lherzolite
  - Websterite
- Metamorphosed/metasomatized mafic intrusive and extrusive igneous rocks, such as:
  - Greenstone
  - Actinolitic (secondary amphibole-bearing) basalt
  - Altered basalt
  - Serpentinized ophiolitic rocks
  - Metagabbro
  - Altered gabbro
  - Amphibolite
  - Actinolitic or mafic schist
- Metamorphosed dolostones, due to regional or contact metamorphism, including:
  - Magnesium-rich marble
  - Skarns in dolostone
- Metasomatized alkaline intrusive and extrusive igneous rocks, such as:
  - Alkali-basalt
  - Syenite, peralkaline granite
  - Carbonatite
  - Pyroxenite
- Highly sheared, metasomatized igneous rocks, especially in regions of extensional deformation
- Metamorphosed iron formations

Medium

A map unit is rated Medium if it is either a compound unit consisting of multiple rock types that include one or more NOA-favorable lithologies, or a unit including rock types that may host NOA only in areas affected by metasomatism, metamorphism, or deformation. Thus, units rated with Medium NOA potential should be considered to possibly contain NOA in localized portions of the unit. More detailed mapping would be required to further refine the NOA potential of these units.

- Compound unit that includes minor to moderate amounts of NOA-favorable lithologies (listed under High to Known, above). The scale of mapping does not allow splitting out the NOA-favorable rock types from the non-favorable rock types. Thus, these units could be considered high potential within the portions that contain NOA-favorable lithologies, but not throughout the whole unit.
- Compound unit that consists of moderate to major amounts of alkali-rich intrusive rocks, not described as metasomatized. These rocks could potentially host NOA in localized areas of metasomatism or metamorphism.
- Compound unit that consists of moderate to major amounts of dolomite. These rocks could potentially host NOA in localized areas of metasomatism or metamorphism.

ZERO TO LOW

Map units were rated Zero to Low if they contain zero to trace (<1%) amounts of highly NOA-favorable lithologies (rock types), minor to major amounts of low-NOA-favorable lithologies (such as basalt, gabbro or marble), and NOA-unfavorable lithologies. Overall these units are not likely to host NOA. However, due to the scale of mapping, units mapped with rock types unfavorable for hosting NOA cannot be guaranteed not to contain some portion of NOA-favorable rock types. Therefore, this category combines map units with zero NOA potential, low NOA potential, and trace amounts of high NOA potential.

- Compound unit that includes trace amounts of one or more NOA-favorable lithologies (listed under High to Known, above).
- Unit that includes up to major amounts of mafic intrusive and extrusive igneous rocks (such as basalt or gabbro), which could have elevated potential in localized zones of shearing and/or alteration, not discernible at map scale.
- Unit that includes up to major amounts of marble. Localized areas of metadolostone or metasomatism would have elevated NOA potential.
- Compound unit that includes up to minor amounts of dolomite.
- Unit that includes up to minor amount of alkaline igneous rocks (not described as metasomatized).
- Unit that consists of felsic and intermediate intrusive and extrusive igneous rocks.
- Unit that consists of sedimentary rocks. Sedimentary rocks generally have low NOA potential, except those derived from NOA-bearing source rocks. Scale of mapping does not allow distinguishing levels of NOA potential for these units.
- Unit that consists of metamorphic pelitic rocks, such as schist, shale, and paragneiss.
- Unit that consists of limestone.

SURFICIAL DEPOSITS

These map units, generally Quaternary (up to 2.4 million years) in age, consist of unconsolidated surficial deposits, and have not been evaluated for NOA potential. They can contain asbestos if there is asbestos in the source material from which the deposit is derived. Surficial deposits include:

- Alluvial deposits
- Glacial deposits
- Colluvial deposits
- Loess

UNKNOWN

In some areas, the source maps from which geology was taken do not show geologic data, most commonly because the areas have not been geologically mapped. Thus, NOA potential is labeled Unknown.

NULL (NO RATING)

No assignment is made for hydrologic units such as rivers, streams, lakes, oceans, ice fields, and glaciers.

Appendix 2: References for digital geologic maps used in map sheets

Publicly available digitized geologic maps used for NOA-potential maps:

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TABLE 1: ALASKA ARDF AND MDRS LOCATIONS WITH ASBESTOS

Table 1. Known occurrences of naturally occurring asbestos (NOA) in Alaska. Occurrences were derived from the Alaska Resource Data File (http://ardf.wr.usgs.gov/welcome.html) and Mineral Resource Data System: Alaska (http://mrdata.usgs.gov/mineral-resources/mrds-ak.html). The Alaska Resource Data File (ARDF) data were compiled by the U.S. Geological Survey (USGS) "using published literature, unpublished reports and data from various sources including the United States Bureau of Mines, USGS, and industry" (ARDF website). The Mineral Resource Data System (MRDS) "describes metallic and nonmetallic mineral resources throughout the world. Included are deposit name, location, commodity, deposit description, geologic characteristics, production, reserves, resources, and references. It includes the original MRDS and MAS/MILS data" (MRDS website). Both databases were searched for references to asbestos; search results were combined and duplications deleted. Identifying ARDF and/or MRDS numbers are given in the table. A comprehensive literature search was not part of the scope of this project and hence, if there are occurrences not included in either ARDF or MRDS, they will not be in the table.

This table is part of a study of potential occurrences of naturally occurring asbestos funded by the Alaska Department of Transportation & Public Facilities (DOT&PF) and carried out by the Alaska Department of Natural Resources, Division of Geological & Geophysical Surveys (DGGS). NOA information is provided on the DOT&PF website http://www.dot.alaska.gov/stwddes/desmaterials/noa.shtml. This table is part of DGGS report Miscellaneous Publication 157 (MP157) accessible at http://dx.doi.org/10.14509/29447.

Object ID	ARDF No	MRDS deposit ID	Site Name	Quad 250	Quad 63	Latitude	Longitude	Asbestos development	Asbestos mineral reported	Asbestos associated minerals	Other minerals commodities	Host rock reported	ARDF URL or MRDS URL
1		10208746	Asbestos Creek	Tanana	D-2	65.77523	-150.66283	Prospect	Asbestos				http://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10208746
2		10233296	Asbestos Mountain	Ambler River	A-2	67.01284	-156.82845	Prospect	Asbestos	Talc, soapstone			http://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10233296
3	RM032		Bear Creek	Russian Mission	A-3	61.0513	-159.7887	Occurrence	Asbestos		Gold mine; cinnabar, platinum	Hornfelsed or regionally metamorphosed Jurassic volcanic and sedimentary rocks cut by mid-Cretaceous granitic plutons and Jurassic gabbro; asbestos and graphite were dredged from bedrock	http://mrdata.usgs.gov/ardf/show-ardf.php?ardf_num=RM032
4	JU219		Bear Creek	Juneau	B-3	58.2593	-134.8102	Prospect	Tremolite			Amphibole-mica schist; 18"-thick vertical layer of tremolite asbestos that strikes N 45 W and can be traced on surface for 60 ft; contains veins of cross-fiber asbestos 0.75" thick and 6–8" long	http://mrdata.usgs.gov/ardf/show-ardf.php?ardf_num=JU219
5		10232791	Big Creek	Circle	D-6	65.94191	-146.91244	Occurrence	Asbestos				http://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10232791
6	AR010		Bismark Mountain	Ambler River	A-3	67.05	-157.26	Prospect	Chrysotile	Nephrite (jade), magnesite, nemalite, serpentine		Serpentinized ultramafic rocks cutting schist; low-grade cross- and slip-fiber chrysotile veinlets 0.5"–2.0" wide in area of serpentine float	http://mrdata.usgs.gov/ardf/show-ardf.php?ardf_num=AR010
7	LC031		Blanca Dinero	Lake Clark	B-3	60.35	-154.11	Occurrence	Asbestos			Tertiary volcanic rocks; reported by U.S. Bureau of Mines (1995) as an asbestos deposit	http://mrdata.usgs.gov/ardf/show-ardf.php?ardf_num=LC031
8		10137174	Broxson Gulch Ultramafic	Mount Hayes	B-5	63.34406	-146.08464	Occurrence	Asbestos		Cu, PGE, Ag, Co, Ni		http://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10137174
9	SH001		California Creek	Shungnak	D-2	66.9571	-156.6251	Occurrence	Asbestos	Nephrite	Gold mine	Gravel from lower to mid-Paleozoic metavolcanic rock, phyllite, and intrusions; subangular boulders of greenstone and greenschist up to 3 ft in diameter; nephrite boulders common, but few of gem quality; asbestos fibers said to be up to 3" long found in placer workings	http://mrdata.usgs.gov/ardf/show-ardf.php?ardf_num=SH001
10		10282918	Canwell Glacier	Mount Hayes	B-4	63.33106	-145.62743	Occurrence	Asbestos		Cu, Au, Ni, PGE, Co		http://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10282918
11		10258811	Cape Newenham	Hagemeister Island	C-7	58.63344	-162.07126	Occurrence	Asbestos		PGE, Ni, Cu		http://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10258811
12		10258708	Chagvan Mountain	Hagemeister Island	C-6	58.70485	-161.85437	Occurrence	Asbestos		Cu, Ni, PGE		http://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10258708
13		10282332	Champion Creek	Eagle	B-2	64.48447	-141.72772	Prospect	Asbestos				http://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10282332
14	NB003		Corky; Roseie; Ram's Horn; Verde	Nabesna	D-6	62.9536	-143.6877	Prospect	Asbestos	Serpentine, rodingite, nephrite, magnesite, dolomite, quartz		Alpine-type ultramafic body in Devonian metasedimentary rocks; serpentinite locally contains rodingite inclusions with thin nephritic rims and lenses of magnesite-dolomite-silica rock	http://mrdata.usgs.gov/ardf/show-ardf.php?ardf_num=NB003
15	AR011		Cosmos Creek	Ambler River	A-3	67.01	-157.14	Prospect	Chrysotile, tremolite	Jade, nephrite (jade)	Gold	Low-grade chrysotile and tremolite asbestos veinlets <1.5" wide; minor nephrite reported in nearby creek gravels	http://mrdata.usgs.gov/ardf/show-ardf.php?ardf_num=AR011
16		10234074	Crooked Creek	Medfra	A-4	63.10757	-154.85294	Occurrence	Asbestos		Past producer Au		http://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10234074
17	AR016		Dahl Creek Head; Asbestos Mountain, Ing-Ink	Ambler River	A-2	67.009	-156.825	Mine	Chrysotile, tremolite	Nephrite (jade), talc, soapstone, quartz		Serpentinized basic intrusive (peridotite?) in mica schist; shear zone containing veins of slip-fiber tremolite; seams of slip-fiber chrysotile and small veinlets of cross-fiber chrysotile; abundant tremolite and chrysotile float	http://mrdata.usgs.gov/ardf/show-ardf.php?ardf_num=AR016
18		10282164	Donovan	Fairbanks	D-2	64.95107	-147.64465	Occurrence	Asbestos		Limestone prospect		http://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10282164

Object ID	ARDF No	MRDS deposit ID	Site Name	Quad 250	Quad 63	Latitude	Longitude	Asbestos development	Asbestos mineral reported	Asbestos associated minerals	Other minerals commodities	Host rock reported	ARDF URL or MRDS URL
19		10208694	Fortymile Dome	Eagle	B-1	64.46118	-141.04299	Prospect	Asbestos				http://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10208694
20		10185518	Gillett Pass	Mount Hayes	A-1	63.07828	-144.28936	Occurrence	Asbestos		Cr, Ni		http://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10185518
21	GU013		Gold-Quartz	Gulkana	C-1	62.736	-144.008	Occurrence	Chrysotile	Calcite	Ag-Au-Cu-Pb-Zn prospect; chalcopyrite, galena, gold, pyrite, sphalerite, ankerite, carbonate, quartz	Serpentinized basalt or gabbro with chrysotile-calcite veinlets	http://mrdata.usgs.gov/ardf/show-ardf.php?ardf_num=GU013
22		10160812	Gorge	Bradfield Canal	A-6	56.23195	-131.78962	Occurrence	Asbestos				http://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10160812
23	AR004		Hunt River	Ambler River	B-6	67.33	-158.55	Occurrence	Tremolite			Veinlets of tremolite asbestos < 0.5" wide containing fibers up to 2" long	http://mrdata.usgs.gov/ardf/show-ardf.php?ardf_num=AR004
24	AR007		Jade Hills	Ambler River	A-4	67.17	-157.8	Occurrence	Asbestos?	Garnierite?, nephrite (jade)	Ni	Ultramafic rocks	http://mrdata.usgs.gov/ardf/show-ardf.php?ardf_num=AR007
25	AR006		Jade Mountain	Ambler River	A-5	67.21	-158.05	Prospect	Chrysotile, tremolite	Nephrite (jade) mine		Highly serpentinized ultramafic rock; 0.25"–0.5"-wide veinlets of chrysotile and tremolite asbestos; some slip-fiber chrysotile in fibers up to 5" long	http://mrdata.usgs.gov/ardf/show-ardf.php?ardf_num=AR006
26		10185754	Kapho Mountain	Bradfield Canal	B-5	56.26226	-131.60181	Prospect	Asbestos				http://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10185754
27		10185646	Landslide Creek	Mount Hayes	B-5	63.32045	-146.26944	Occurrence	Asbestos		Cr		http://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10185646
28		10233917	Lemesurier Island Paligorskite	Mount Fairweather	B-1	58.29002	-136.06736	Prospect	Paligorskite (palygorskite)				http://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10233917
29		10112112	Lost Creek	Livengood	D-2	65.88609	-147.98167	Occurrence	Asbestos		Mn, Cu, Zn		http://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10112112
30		10160450	Lost Mine	Tanana	D-2	65.79963	-150.54893	Prospect	Asbestos				http://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10160450
31	SH002		Lower Dahl Creek	Shungnak	D-2	66.957	-156.885	Occurrence	Asbestos?	Nephrite (jade) mine	Gold mine	Conglomeratic metasediments and black phyllite of early to mid-Paleozoic age; nephrite, greenstone, and metamorphosed conglomerate in stream gravels	http://mrdata.usgs.gov/ardf/show-ardf.php?ardf_num=SH002
32	SR298		Lucky Girl; Murphy	Seward	A-3	60.0117	-148.0152	Occurrence	Asbestos		Cu prospect; chalcopyrite, pyrite, pyrrhotite, calcite, quartz	Quartz-calcite veins in greenstone and slate, also containing pyrite, pyrrhotite, chalcopyrite, quartz, and asbestos; some of the veins were 3" thick, asbestos was perpendicular to the wall of the veins	http://mrdata.usgs.gov/ardf/show-ardf.php?ardf_num=SR298
33	MU003		Misheguk Mountain—east	Misheguk Mountains	A-4	68.24948	-161.00371	Occurrence	Asbestos		Cr, Cu?; chromite	Serpentinite rubble containing bands and disseminations of chromite, presumably from underlying mafic-ultramafic complex	http://mrdata.usgs.gov/ardf/show-ardf.php?ardf_num=MU003
34	MU002		Misheguk Mountain—west	Misheguk Mountains	A-4	68.25	-161.06	Occurrence	Asbestos?	Garnierite?	Cr, PGE, Ni; chromite	Large serpentinized dunite-peridotite central core of ultramafic and gabbroic ophiolite complex; discontinuous bands, small pods, and disseminations of chromite and garnierite(?)	http://mrdata.usgs.gov/ardf/show-ardf.php?ardf_num=MU002
35		10281637	Mount Harper	Eagle	A-6	64.18752	-143.75465	Prospect	Asbestos				http://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10281637
36		10136382	Mount Sorenson	Eagle	D-5	64.98006	-143.05841	Occurrence	Asbestos		Cr, Co, Ni, PGE		http://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10136382
37		10281970	North Peak	Eagle	D-3	64.81117	-142.11246	Occurrence	Asbestos				http://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10281970
38		10106581	Nyac Area	Russian Mission	A-3	61.00765	-159.93616	Occurrence	Asbestos		Gold producer; Hg (cinnabar), graphite	Gravel	http://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10106581
39		10112093	Parker	Livengood	B-3	65.49407	-148.39743	Occurrence	Asbestos	Antigorite	Cr prospect; Co, Fe, Ni, PGE, Ti; chromite, diopside, magnetite		http://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10112093
40	NB004		Patten	Nabesna	D-6	62.9312	-143.6386	Occurrence	Asbestos	Nephrite (jade) prospect; serpentine, rodingite	Chlorite	Alpine-type ultramafic body; thin band of serpentinite	http://mrdata.usgs.gov/ardf/show-ardf.php?ardf_num=NB004
41		10233700	Quartz	Bradfield Canal	A-1	56.07757	-130.18506	Occurrence	Asbestos				http://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10233700
42		10209454	Rainy Creek Ultramafic	Mount Hayes	B-4	63.32326	-145.90213	Occurrence	Asbestos?		Ni		http://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10209454

Object ID	ARDF No	MRDS deposit ID	Site Name	Quad 250	Quad 63	Latitude	Longitude	Asbestos development	Asbestos mineral reported	Asbestos associated minerals	Other minerals commodities	Host rock reported	ARDF URL or MRDS URL
43		10136091	Ray Mountains	Tanana	C-2	65.63823	-150.70372	Occurrence	Asbestos		Mn		http://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10136091
44	AR009		Shungnak Rivers; Shingnek Creek	Ambler River	A-3	67.031	-157.235	Prospect	Asbestos	Nephrite (jade), serpentine	Gold mine; Ag, Cu; native copper, native silver	Nephrite jade, low-grade asbestos in greenstone, and serpentine gravel along river	http://mrdata.usgs.gov/ardf/show-ardf.php?ardf_num=AR009
45		10209107	Siniktanneyak	Howard Pass	B-5	68.31894	-158.44258	Occurrence	Asbestos		Cr, Cu, Zn		http://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10209107
46	EA043		Slate Creek Asbestos; Alaska Asbestos; Eagle Asbestos	Eagle	C-3	64.5674	-142.497	Prospect	Chrysotile	Antigorite		Chrysotile asbestos is generally found in densely-fractured and altered zones in tectonically-emplaced serpentinized harzburgites; antigorite cut by closely spaced subparallel veins of cross-fiber chrysotile asbestos	http://mrdata.usgs.gov/ardf/show-ardf.php?ardf_num=EA043
47		10258762	Timber Creek	Tanacross	A-6	63.07159	-143.70824	Occurrence	Asbestos				http://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10258762
48	BH014		Tuluksak River	Bethel	D-3	60.9877	-159.9873	Occurrence	Asbestos		Ag-Au-Pt mine; gold, graphite	Hornfelsed or metamorphosed Jurassic volcanic and sedimentary rocks cut by mid-Cretaceous granitic plutons and Jurassic gabbro; asbestos and graphite were dredged from bedrock	http://mrdata.usgs.gov/ardf/show-ardf.php?ardf_num=BH014
49	AR003		Unnamed	Ambler River	B-6	67.31	-158.8	Occurrence	Tremolite		Cu; chalcopyrite, malachite	Tremolite asbestos in serpentinite and chalcopyrite and malachite in mafic rocks	http://mrdata.usgs.gov/ardf/show-ardf.php?ardf_num=AR003
50	TN007		Unnamed (Asbestos Creek; Dreamland Creek)	Tanana	D-2	65.77456	-150.66065	Prospect	Chrysotile	Serpentine		Mississippian–Jurassic sedimentary and mafic volcanic rocks, plus abundant gabbro and sparse ultramafic rocks; serpentine common in the mafic and ultramafic rocks, many of which are highly magnetic	http://mrdata.usgs.gov/ardf/show-ardf.php?ardf_num=TN007
51	TN008		Unnamed (Little Salt Creek)	Tanana	D-1	65.77567	-150.4532	Occurrence	Asbestos	Serpentine		Devonian or Carboniferous greenstone interbedded with thin beds of slate, chert, and limestone; few pieces of serpentine float containing small stringers of asbestos	http://mrdata.usgs.gov/ardf/show-ardf.php?ardf_num=TN008
52	SH009		Unnamed (mouth of Stockley Creek)	Shungnak	D-2	66.99	-156.85	Occurrence	Chrysotile	Antigorite	Ni	Asbestiform minerals in stream float; sample of chrysotile and antigorite contains nickel	http://mrdata.usgs.gov/ardf/show-ardf.php?ardf_num=SH009
53	MF080		Unnamed (near Iceberg Point, Lemesurier Island)	Mount Fairweather	B-1	58.263	-136.076	Inactive Mine	Paligorskite (palygorskite)		Bornite, chalcopyrite, molybdenite, calcite, epidote, garnet, pyroxene, quartz	Replacement of Paleozoic limestone near copper-molybdenum-bearing vein occurrences; paligorskite masses	http://mrdata.usgs.gov/ardf/show-ardf.php?ardf_num=MF080
54	MH024		Unnamed (north-east of Dot Lake)	Mount Hayes	C-1	63.7424	-144.0238	Occurrence	Asbestos	Chrysotile?	Serpentine	Asbestos seams up to 0.75” wide	http://mrdata.usgs.gov/ardf/show-ardf.php?ardf_num=MH024
55	TK065		Unnamed (south-east of Mount Watana)	Talkeetna Mountains	C-3	62.7148	-148.097	Occurrence	Asbestos	Serpentine	Ag, Au, Cu, Ba, Ni; ar-senopyrite, malachite, pyrite, pyrrhotite, calcite, quartz	Pennsylvanian to lower Permian basaltic to andesitic metavolcanic rocks, with local ultramafic rocks, chert, and marble; serpentinized ultramafic rocks, locally cut by asbestos veins, occur in float	http://mrdata.usgs.gov/ardf/show-ardf.php?ardf_num=TK065
56	SH013		Unnamed (upper Wesley Creek area)	Shungnak	D-3	66.993	-157.016	Occurrence	Tremolite	Nephrite	Au, Pb; galena, gold, quartz	Tremolite asbestos and gem-quality nephrite jade gravel have been found near the head of Wesley Creek	http://mrdata.usgs.gov/ardf/show-ardf.php?ardf_num=SH013
57	BR002		Unnamed (west of Rice Gulch Creek)	Black River	C-1	66.5172	-141.3142	Occurrence	Asbestos		Cu; chalcopyrite, quartz	Small ultramafic body contains minor chalcopyrite and asbestos; asbestos occurs in 2”–5”-wide veins	http://mrdata.usgs.gov/ardf/show-ardf.php?ardf_num=BR002
58	MH117		Unnamed (west side of Broxson Gulch)	Mount Hayes	B-5	63.3155	-146.1672	Occurrence	Chrysotile	Serpentine	Cu, Pb, Zn	Upper Triassic serpentinized dunite sill, part of the informally named Eureka ultramafic complex; deposit consists of 0.25” veinlets and larger veins of chrysotile asbestos in the dunite	http://mrdata.usgs.gov/ardf/show-ardf.php?ardf_num=MH117
59	AR002		Unnamed Occurrence	Ambler River	B-6	67.3	-158.85	Occurrence	Tremolite		Cu	Tremolite asbestos veinlets and Cu staining on fractures in serpentinite	http://mrdata.usgs.gov/ardf/show-ardf.php?ardf_num=AR002
60	SH003		Upper Dahl Creek	Shungnak	D-2	66.9755	-156.8592	Occurrence	Chrysotile, fibrous serpentine	Nephrite	Gold mine; native silver, Cd, Cr, Cu	Nephrite boulders have been recovered during placer mining; serpentinite near Dahl Creek around the confluence of Stockley Creek contains chrysotile and fibrous serpentine	http://mrdata.usgs.gov/ardf/show-ardf.php?ardf_num=SH003
61		10001174	Wesley Creek Placer Occurrence	Shungnak	D-2	66.98897	-156.98095	Occurrence	Tremolite	Nephrite	Au, gemstone	Gravel	http://mrdata.usgs.gov/mrds/show-mrds.php?dep_id=10001174
62	KC153		Yellow Hill	Ketchikan	A-5	55.106	-131.574	Occurrence	Chrysotile		Cr, PGM; chromite, magnetite	Hornblende gabbro and partly-serpentinized dunite; sparse, thin veinlets, and disseminated grains of magnetite and chromite in massive dunite that also contains abundant thin seams of chrysotile	http://mrdata.usgs.gov/ardf/show-ardf.php?ardf_num=KC153