A SET OF

WASHINGTON ROCKS AND MINERALS

FOR SCHOOLS

Prepared cooperatively by the

DIVISION OF MINES AND GEOLOGY

WASHINGTON DEPARTMENT OF CONSERVATION

and

STATE SUPERINTENDENT OF PUBLIC INSTRUCTION

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Cover photo: Prospector at portal of Lone Jack gold mine, northern Cascade Mountains, by Wayne S. Moen.

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INTRODUCTION

> The United States has become a strong, wealthy nation, largely because of its abundant resources of petroleum, coal, iron, and many other metals and minerals. Through the years the use of these valuable raw materials has increased steadily, matching our growth in population and our ever-rising increase in standard of living. The per capita consumption of minerals and fuels in the United States for many years has exceeded that of any other country in the world.
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> The deposits of minerals and fuels on which we depend so heavily were formed in the earth throughout the geologic past by slow, natural processes. Most occur in small, isolated deposits, and many are hidden deeply underground. Others are so sparsely concentrated that often they can be detected only by use of special instruments and techniques.
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> Mineral deposits are non-renewable resources. Once used, the deposits are exhausted and new ones must be found. With consumption of minerals and fuels at an all-time high, and still headed more steeply upward, the job of finding new supplies is becoming more difficult, more exacting, and has greater economic significance. 1/

The objective of the Washington Division of Mines and Geology is to stimulate and maintain interest in Washington's mineral resources and to promote their full utilization. For this purpose the Division has prepared for use in our State schools this rock and mineral set containing 24 samples that are representative of some of the State's more important and abundant rocks and minerals. It is hoped that, through these sets, rocks will be recognized as having value for something more than just ammunition for a slingshot, and that our young people will develop a facility for accurate observation and an active inquisitiveness with regard to the materials of which our earth is made.

All these rocks and minerals represent the basic raw materials from which thousands of manufactured products are made. Most of the minerals and rocks in the set are from mines or pits operated by companies that are actively engaged in mining and processing the raw material.

At the end of the rock and mineral descriptions is a list of references that will be helpful to anyone who wishes to learn more about rocks and minerals. One in particular, Geology and Earth Science Sourcebook, edited by Robert L. Heller, is an excellent reference book for teachers of earth science.

DESCRIPTIONS OF SPECIMENS IN THE SET

Ore Minerals

URANIUM ORE (1)

The sample of uranium ore in the set is from the Midnite Mine in southern Stevens County. The principal uranium minerals in the ore are autunite, a light-yellow to green, yellow-fluorescing

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1/ From "Shall I Study Geological Sciences?"—a booklet on career opportunities in geology and geophysics. Single copies of this booklet are available free from the American Geological Institute, 2101 Constitution Ave., N.W., Washington 25, D.C.

hydrous calcium uranium phosphate that contains 60.0 percent U_3O_8; coffinite, a black uranium silicate that contains up to 60 percent uranium; and uranophane, a powdery yellow calcium uranium silicate that is 65 percent U_3O_8. Some of the samples in the sets have visible autunite or uranophane, and most of the samples contain the black, shiny-lustered coffinite. The radioactivity of this ore can be demonstrated with a Geiger counter. The black country rock in the specimen in the set is a silicified argillite; the tan rock is argillite also, that has been bleached and altered.

Uranium has been reported from 11 counties in the State, but only in Stevens, Spokane, and Pend Oreille Counties has it been mined. Uranium production in Washington in 1961 had a value of $3,582,000.

Uranium's most important use is as a source of nuclear energy. Other uses are in the chemical industry, as a coloring agent in glass, and in manufacturing luminous paint.

CHALCOPYRITE (2)

Chalcopyrite is a brassy yellow copper-iron sulfide mineral having a chemical formula of $CuFeS_2$. It is the most abundant and widely distributed of the copper ore minerals; it occurs in veins and as small grains disseminated in a host rock. Chalcopyrite contains 34.5 percent copper, 30.5 percent iron, and 35 percent sulfur.

Copper is known to occur in 23 of the State's 39 counties. Fourteen counties have had recorded copper production from 94 mines, most of the production being prior to 1958. The largest copper producer in the State was the Holden mine in Chelan County, which, prior to its closure in 1957, had an average production of approximately 600,000 tons of ore a year for 19 years. This mine had a total production of 216,000,000 pounds of copper, 598,396 ounces of gold, 2,000,000 ounces of silver, 57,000 pounds of lead, and 42,000,000 pounds of zinc during that time.

The sample in the set is from the Kromona mine, in the Sultan Basin of Snohomish County. Most of the specimens are in either a milky to glassy quartz or granite gangue.

About two-thirds of all the copper used in the United States goes into the electrical industry. Other uses are in making alloys, automobile parts, ammunition, coins, and tubing.

GALENA (3)

Galena is the principal ore mineral of lead. Characteristically, it has a shining metallic luster, is dark gray colored, and when crushed it breaks into cubes. It is a lead sulfide containing 86.6 percent lead, and its chemical formula is PbS.

Lead has been reported from 15 of the State's counties, but only 10 have a record of production. Mines in Pend Oreille and Stevens Counties have been the largest producers. Lead production in Washington in 1961 had a value of $1,659,000.

The sample in this rock and mineral set is from the Metaline mining district in Pend Oreille County, in which the Pend Oreille and Grandview mines are the principal producers.

The dull-gray gangue in the specimen in the set is silicified limestone; the white gangue is calcite and quartz. Galena and sphalerite are commonly found together, so the sample in this set may contain both minerals.

About 50 percent of the lead produced is used in making batteries, cable covering, and high-octane gasoline. Other uses are in making paint pigments, dyes, pipes, medicine, insecticides, sheet metal, weights, shot, and ballast.

GOLD-BEARING QUARTZ (4)

Gold is one of the elements, and it is expressed chemically by the symbol Au. When pure it is bright yellow, very heavy, ductile, and malleable.

Gold was first reported in Washington in 1853 from along the Yakima River. Other early discoveries of placer gold were made near Colville, in the Similkameen River, and in Ruby Creek in Whatcom County; and lode gold in the Blewett Pass area. Today most of the gold produced in Washington comes from vein deposits in Ferry and Chelan Counties. In 1960, two Washington mines ranked as the second and third largest lode gold mines in the United States. The total value of the gold production in Washington from the early 1800's through 1961 is $98,000,000.

The sample in the set, which is from the Gold King mine at Wenatchee, in Chelan County, is a gold ore made up of quartz with some calcite and country rock. The gold is so finely disseminated that it cannot be seen and is recovered only by milling and smelting.

Gold is used chiefly as the base for our monetary system. It is also used to make jewelry, in dental work, sign painting, and in medicine.

Quartz is one of the most important rock-forming minerals. Typically, it is white, but it may be dark gray or other colors. It occurs in massive deposits in which no structure is evident, as veins associated with valuable mineral deposits, and as crystals along cavity and fracture surfaces.

Quartz crystals are used in the electronics industry and as semiprecious gems. Other forms of quartz are used for metallurgical flux, as an abrasive, as poultry grit, and in making glass.

MAGNETITE (5)

Magnetite is one of the principal ore minerals of iron. It is an iron oxide containing 72.4 percent iron and 27.6 percent oxygen, having the chemical formula Fe_3O_4. One interesting physical property of magnetite is that it is magnetic (strongly attracts a compass needle).

In Washington, iron was first smelted in 1881 at a plant near Port Townsend, Jefferson County, using ore from the nearby Chimacum Creek area. Production continued intermittently until 1919, using ore mostly from Canada. Iron from the plant was used in building the battleships Oregon and Nebraska.

Iron ore has been produced from 20 properties in 9 counties; however, the production has been small. The Kulzer mine, in Stevens County, has had a more consistent record of production than any other iron mine in the State. The magnetite sample in the set is from the Buckhorn iron deposit, east of Chesaw, in Okanogan County.

The largest use for iron is in the manufacturing of steel. Other uses for which Washington magnetite has been produced are for ship ballast, magnesite refractories, heavy concrete aggregate, and in the manufacture of special kinds of portland cement.

SPHALERITE (6)

Sphalerite is a light- to dark-brown resinous-lustered zinc sulfide mineral having a chemical formula ZnS. It contains 67 percent zinc and 33 percent sulfur, and is the most important and abundant ore mineral of zinc.

The first recorded production of zinc in Washington was from Pend Oreille County in 1911. Since that time, production has been almost continuous. Zinc has been reported in 18 of the State's 39 counties, but production has been mainly from Pend Oreille, Stevens, Chelan, Okanogan, and Ferry Counties. In recent years, almost all the production has been from Pend Oreille, Stevens, and Chelan Counties. Zinc production in Washington in 1961 had a value of $4,650,000.

The sample in the set is from the Pend Oreille Mines and Metals mine, in the Metaline mining district in Pend Oreille County, where this and the Grandview mine are the principal producers. The dull-gray gangue material is silicified limestone; the white gangue minerals are quartz and calcite. Sphalerite and galena commonly occur together, and the sample in the set may contain both minerals.

Nonmetallic Minerals

BARITE (7)

Barite is barium sulfate, having the chemical formula $BaSO_4$. It has a high specific gravity (4.50), which is its most valuable property. This means that barite is 4½ times as heavy as water. Note the weight of the specimen.

Barite has been reported in 5 counties; Stevens, Pend Oreille, Okanogan, Ferry, and Mason. The only production, however, has been from Stevens and Pend Oreille Counties. Barite production in Washington in 1961 had a value of $42,000. The sample in the set is from the Newport mining district in Pend Oreille County.

Barite is used extensively in powdered form as an additive to oil well drilling mud. Its high specific gravity helps to float the rock chips to the surface after they have been cut by the drill. Barite is also used as a pigment in paint and as a filler in glass, rubber, and paint.

CALCITE (8)

Calcite is one of the important rock-forming minerals, being the main constituent of limestone and marble. It also occurs in veins, cavity fillings, and coatings along fracture surfaces. It has cleavage in three directions, not at right angles, causing it to break into rhombohedrons. It is white to transparent in color and has a hardness of 3. Its chemical formula is $CaCO_3$.

Calcite occurs in all 39 counties of the State, but none of the occurrences have any economic significance except those in which the calcite is in the form of limestone or marble. In many places it is a common gangue mineral associated with valuable metals such as gold, lead, or zinc. The sample in the set is from the Pend Oreille mine, in the Metaline mining district, Pend Oreille County.

Calcite has the same uses that limestone and marble have, inasmuch as it is their principal constituent but because vein and cavity filling deposits are so restricted in size the calcite in them is not put to the same uses that limestone and marble are, such as making of cement, lime, and as a soil conditioner. Pure transparent calcite is used in optical systems that polarize light, such as certain special microscopes.

CLAY (9)

Clay is a soft earthy compact material made up essentially of hydrous aluminous silicate clay minerals such as kaolinite and montmorillonite. It is usually plastic when wet and hard and brittle when dry. It has an earthy odor, and when touched to one's tongue has a clinging quality.

Usuable clay has been reported from 23 of the State's counties; however, only a few counties actually produce clay commercially. The value of common clay (not including fire clay) produced in Washington in 1961 was $138,000.

The sample in the set is from the Lande clay pit near Clayton, in southern Stevens County.

Washington clays are used to make fire brick, common brick, drain tile, and flower pots. High quality clay is used to make porcelain, pottery, and china.

COAL (10)

Coal is a mineral fuel that is sometimes classified as a sedimentary rock. It was formed by the accumulation and partial decay of plants, followed by their compaction. The decaying vegetable matter collected in considerable quantity in swampy areas, where it was coverted to peat. The peat was eventually covered by sand and mud, the volatiles were driven off, and the plant material was reduced to carbon compounds. Coal is classified by the degree of this change. Lignite, the lowest grade of coal, is brown and woody; bituminous is dark gray to black, brittle, banded, and jointed, and is called soft coal; anthracite is black, has a high luster, is clean, has a conchoidal fracture, and is called hard coal.

Washington has larger coal reserves than any other state in the Pacific Northwest. The larger deposits are in Kittitas, Whatcom, Skagit, King, Pierce, Thurston, Lewis, and Cowlitz Counties. The value of coal production in Washington in 1961 was $1,381,000.

The coal in the sample set is bituminous in rank and is from Northern Pacific Railway Company's No. 9 mine at Roslyn, in Kittitas County.

Coal's principal use is as fuel for heating plants, steam-electric plants, and industrial plants. Certain coals in Pierce and Kittitas Counties can be used to make coke for metallurgical industries.

DIATOMITE (11)

Diatomite is an earthy white chalklike material that is composed of the siliceous skeletons of microscopic aquatic plants called diatoms. These minute organisms live in almost every body of water, and when they die their skeletons sink to the bottom and sometimes accumulate to great thicknesses.

Diatomite is found in both eastern and western Washington, but the largest deposits in the State are in Grant and Kittitas Counties. The sample in the rock and mineral set is from the Squaw Creek deposit, in Kittitas County.

Diatomite is used as a filtering agent, a filler in rubber, paper, and paint, as an abrasive, and as an admixture in concrete.

MAGNESITE (12)

Magnesite is a magnesium carbonate that contains 47.8 percent magnesium oxide; its chemical formula is $MgCO_3$. It resembles ordinary marble, and in Washington was quarried as

marble before it was recognized to be magnesite. The only known large deposits in the State are near Chewelah, in Stevens County. These deposits are the largest in the United States, and Washington is the leading state in magnesite production.

The sample in the set is from the Red Marble quarry, southwest of Chewelah.

The principal use of magnesite is in making refractory bricks for lining smelting furnaces. It has minor uses in making fertilizers, a special kind of cement, and rubber.

OLIVINE (13)

Olivine is a light-green magnesium silicate mineral that is found associated with dark-colored iron-magnesium-rich igneous rocks.

Olivine occurs in 5 of Washington's counties but has been mined only from the largest deposit, in Whatcom and Skagit Counties. The State has more known olivine than any other state in the Union. The sample in the set is from the Twin Sisters area, in Skagit County, which is one of the largest olivine deposits in the United States.

The sample in the set may contain small black grains of chromite, a chromium oxide mineral.

Olivine is used in making refractory products, as a molding sand, and as a sandblasting agent. In the latter two uses it has eliminated the danger of silicosis. Olivine is also a potential raw material for the manufacture of magnesium metal and chemicals.

SOAPSTONE (14)

Soapstone is a massive impure variety of talc, which is a magnesium silicate. It is a metamorphic mineral that is found in association with iron-magnesium-rich rocks. It is one of the softest minerals, and its color is usually some shade of green.

Soapstone has been reported from 8 counties in Washington. Skagit County is the only one, however, that has produced any soapstone commercially. The sample in the rock and mineral set is from deposits near Marblemount, in Skagit County.

Soapstone is used in powder form as an insecticide carrier and as a filler in paper and textiles; and in solid form for greaseless pancake griddles, for switchboard panels, for table tops, steel-marking pencils, and tailor's chalk. Its resistance to chemicals makes it valuable for use in making sinks in laboratories, and its refractory qualities make it suitable for use as furnace liners.

Igneous Rocks

BASALT (15)

Basalt is the most abundant extrusive igneous rock in Washington. It is formed when hot molten lava flows out onto the earth's surface during volcanic eruptions. The lava cools quickly, and consequently becomes glassy to fine grained or microcrystalline. Its main mineral constituents are feldspar and augite, with lesser amounts of magnetite and titanium minerals. Usually there is a certain amount of volcanic glass that surrounds the mineral crystals or, in other words, forms a matrix.

Basalt is the most widely distributed rock in Washington. Extensive outcrops occur in the eastern and southwestern parts of the State and around the Olympic Peninsula. The sample in the set is from the Columbia Plateau in eastern Washington.

Basalt is used as road gravel, riprap, and jetty rock.

GRANITE (16)

Granite is one of the most abundant intrusive igneous rocks. It is formed deep within the earth's crust by the slow cooling of molten rock called magma. Some granite is formed by metamorphic processes. The mineral composition of granite is mostly feldspar and quartz, but minor amounts of mica, amphibole, and other minerals may also be present. Granite is a visibly granular or crystalline rock, and the mineral grains have an interlocking texture.

Granite is found across much of the northern part of Washington. The specimen in the rock and mineral set is from a roadcut at the north end of Grand Coulee near Electric City, in Douglas County.

Some of the more attractive varieties of granite are used as monumental stone and building stone. Other uses are for road gravel, riprap, chicken grit, and roofing chips.

PUMICE (17)

Pumice is formed when gas expands in a rapidly cooling magma, leaving a frothy, cellular-textured rock. Most commonly it is formed during violent or explosive volcanic eruptions and is ejected from the volcano as small fragments and dust (the dust is called pumicite or volcanic ash). It has no specific mineral composition and is made up mostly of volcanic glass with a few crystals of various rock-forming minerals scattered through it.

Pumice and pumicite are very common in the areas northeast of Mount St. Helens and southeast of Glacier Peak. The value of pumice and pumicite production in Washington in 1959 was $112,000.

The specimen in the rock and mineral set is from the north flank of Mount St. Helens.

Pumice is used as light-weight aggregate for concrete and building blocks, and pumicite is used as an admix (pozzolan) in concrete and as an abrasive in scouring and polishing compounds.

Sedimentary Rocks

LIMESTONE (18)

Limestone is a sedimentary rock that is predominantly calcium carbonate with varying amounts of impurities. It is formed in three general ways: by precipitation of calcium carbonate from sea water, by lime-secreting organisms such as algae, and by the accumulation of shells and calcium carbonate grains.

Limestone occurs in most of Washinton's northern counties and in Pacific County in the southwestern part of the State. The sample in the set is from a limestone reef in Pacific County and is an algal limestone; that is, it is composed mostly of the reamins of algae that secreted calcium carbonate.

The most important use for limestone in Washington is in the manufacture of portland cement. Other uses are in making paper, refining sugar, as a flux in the steel industry, in making lime, and as a soil conditioner.

SANDSTONE (19)

Sandstone is a medium-grained sedimentary rock commonly made up of quartz, feldspar, and other, less abundant mineral grains. Originally these sand grains were deposited as sand dunes, as beaches, or as beds on the bottom of lakes and oceans. Following its deposition and burial, the sand was compacted and cemented to become sandstone.

Sandstone occurs in the vicinity of Wenatchee, Cle Elum, Bellingham, in southwestern Washington, and many other places in the State. The sample in the mineral set is from the Wilkeson quarry, in Pierce County, and is the same kind of stone as that used to build several of the State Capitol buildings in Olympia, including the Legislative or Capitol building.

Sandstone is used as riprap, building and ornamental stone, and in making glass.

SHALE (20)

Shale is a fine-grained sedimentary rock that characteristically splits into thin platy slabs parallel to the bedding. It is made up of clay minerals such as kaolinite and montmorillonite and very fine grains of quartz and mica.

Shale occurs most abundantly in western Washington but is also found in other parts of the State. The sample in the set is from the Fulton coal seam, near Black Diamond, in King County. The black material on the surface of the sample is carbon left by the coalification of leaves. Most of the samples in the sets have leaf imprints on them.

Metamorphic Rocks

MARBLE (21)

Marble is a carbonate rock that has been formed by the metamorphism and recrystallization of a limestone or dolomite. The crystal size is large enough so that individual crystals are visible to the unaided eye. Marble is either calcium carbonate (calcite) or calcium-magnesium carbonate (dolomite), but may contain some impurities such as quartz.

Marble occurs in all the northern counties of the State. The sample in the set is from the Suiattle River area, in northeastern Snohomish County.

Marble is used as a metallurgical flux, for roofing and terrazzo chips, as building and monumental stone, and in making cement and lime.

QUARTZITE (22)

Quartzite is a metamorphic rock that once was sandstone. It is composed chiefly of the mineral quartz. The quartz grains have been so tightly cemented by silica that when the rock is broken, the fracture passes through both cement and quartz grains with equal ease.

Quartzite is most abundant in northeastern Washington. The sample in the set is from a talus slope along side the highway just north of Addy, in Stevens County.

Quartzite is used for road gravel, riprap, as an abrasive, a metallurgical flux, poultry grit, and silica brick.

SCHIST (23)

Schist is a metamorphic rock in which the platy and elongated minerals are all aligned parallel with one another. It contains an abundance of platy minerals such as mica, chlorite, and talc, or long needlelike minerals such as amphibole.

Schist is found in all the northern counties of the State. The sample in the set is from a small quarry on the west city limits of Leavenworth, in Chelan County.

The only commercially valuable schists found in Washington are the talc and mica schists. Talc is ground into a powder and is used in cosmetics, as an insecticide carrier, and as a filler in textiles, soap, and cosmetics. Mica schist is ground and used as a filler and in roofing paper.

SLATE (24)

Slate is a metamorphic rock derived from shale. The preexisting and newly formed platy minerals in slate have been oriented in such a way that they impart to the rock a distinct cleavage. The chemical composition of slate is very similar to that of shale.

Slate is found only in the northern counties of the State. The sample in the set is from a slate quarry west of Valley, in Stevens County.

Slate is used for roofing tile, flagstone, electrical panels, pencils, and slate boards.

GLOSSARY

ABRASIVE - A substance used for grinding and polishing.

ARGILLITE - A rock that formed through increased induration of a shale or claystone.

CLEAVAGE - The ability of a mineral to break or split with ease along definite parallel planes.

CONCHOIDAL - Shell shaped. Fracture that produces a concave or convex surface such as the curved surface along the edge of a piece of broken glass.

COUNTRY ROCK - The general rock type that makes up an area or is adjacent to a vein.

EXTRUSIVE IGNEOUS ROCK - Rock formed from molten material erupted from a volcano and cooled on the earth's surface.

FLUORESCENCE - The emission of light by a mineral when exposed to ultraviolet light.

FLUX - A material that promotes fusion in extracting metals from ore in a metallurgical furnace.

GANGUE - The part of an ore that contains no metal or has no value.

HOST ROCK - The wallrock of a mineral deposit, or the rock that has been replaced by a mineral deposit.

HYDROUS - Contains water. For example, a hydrous aluminum oxide is a mineral made up of aluminum, oxygen, and water.

IGNEOUS ROCK - Rock that is formed by the cooling and hardening of molten rock, such as a rock that forms by cooling of lava.

INTRUSIVE IGNEOUS ROCK - Rock formed by the cooling of molten rock below the surface of the earth's crust, as opposed to extrusive igneous rock, which cools on the earth's surface.

LUSTER - The character of the light reflected by a mineral. There are many kinds, the most common of which are: metallic, the luster of metal; vitreous, the luster of glass; resinous, the luster of resin; pearly, like the luster of the mother of pearl layer of an oyster shell; silky, like the luster of silk.

MAGMA - Molten rock.

MATRIX - Material that fills the voids between, or cements, the larger grains of a rock.

METAMORPHIC ROCKS - New rocks that have been derived from preexisting rocks by the application of heat and pressure within the earth.

MICROCRYSTALLINE - Applies to rocks in which the individual crystals can be seen only with the aid of a microscope.

POZZOLAN - An admix used with portland cement to produce concrete of superior strength and resistance to saline and acid solutions.

RADIOACTIVITY - The property some elements have of emitting charged particles from their nuclei. The radioactivity can be measured with a Geiger counter.

REFRACTORIES - Materials that can be subjected to extreme heat without undergoing a physical change. This is a quality that is especially desirable for furnace lining.

RIPRAP - Broken rock used to protect shore lines or river banks from wave or current erosion.

SEDIMENTARY ROCKS - Rocks that are formed by the accumulation of sediment (rock and mineral fragments and chemical precipitates) in water, ice, or air.

SILICEOUS - Containing abundant silica.

SILICIFIED - Rock that has been partially or totally replaced by silica.

SILICOSIS - An illness affecting the lungs, caused by inhaling quartz or silica dust.

TALUS - Accumulation of rock fragments at the base of a cliff or steep slope.

TERRAZZO CHIPS - Small chips of soft rock that are embedded in cement which is then polished and used as flooring. Flooring chips.

VOLATILES - Fractions of a rock that are easily converted to a gaseous state, such as the gases that are given off by heating or burning coal.

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