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NONMETALLIC MINERAL RESOURCES OF WASHINGTON

WITH STATISTICS FOR 1933

By
SHELDON L. GLOVER

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THE NONMETALLIC MINERAL RESOURCES OF WASHINGTON

WITH STATISTICS FOR 1933

By Sheldon L. Glover

INTRODUCTION

Minerals constitute one of Washington's most important resources. The annual production of the many aggregates and substances listed under that general term adds very materially to the wealth of the State. For many years prior to 1930 the yearly value of mineral production was over 22 million dollars; and, in spite of a lowered output during the depression, the average annual value has remained in the neighborhood of 20 million dollars. Relationships are constantly changing, but a general idea of the position of Washington among other states, particularly of the West Coast, may be obtained from the figures for 1932.[1] Washington in that year produced 0.56 per cent of the total value of the United States mineral production and ranked twenty-seventh among the states. Idaho produced 0.41 per cent; Oregon, 0.13 per cent; and California, with petroleum, natural gas, and a large gold output, produced 12.48 per cent.

The consistently large production in Washington is principally from nonmetallic minerals—those not used in producing metals. Their total yearly output in the eleven years since 1923 has been as high as $23,051,144 (in 1929) and has averaged $19,120,274 in value. They have contributed for many years from 85 to over 95 per cent of the total value of mineral production.

All of the nonmetallic minerals known to occur in the State are mentioned in this report. As much essential information as is available is given on some occurrences, particularly those upon which little has appeared in print. Minerals and various substances which have been reported in separate publications are only briefly discussed here, and references are cited which give added or complete information. All known deposits of useful but less common substances are listed. For this, all information in the files of the Division of Geology is drawn

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[1]Statistical Appendix to Minerals Yearbook, 1932-33: U. S. Bureau of Mines, p. A-11, 1934.

upon. Much of the data is first hand from examinations made by the writer or other members of the Division; some notations are from unauthenticated reports thought to be reliable; while a few are from vague references which may contain only a germ of fact. Except in one or two instances when it has seemed desirable to definitely refute certain reports, no occurrences are mentioned where the known geologic conditions throw doubt on their existence.

Statistics of production are included to show trends in mineral output and to evaluate the various substances. The figures are principally from the United States Geological Survey and the United States Bureau of Mines, with whom the Division of Geology cooperates in securing these data. Statistics on coal production are in part from the reports of the State Mine Inspector, while those on clay products were supplied through the kind cooperation of the United States Bureau of the Census. In coordinating figures from separate sources for the different minerals, the various counties, and the State totals, there is not always complete agreement with previously published statistics which may have been compiled on slightly different bases. These relatively slight discrepancies do not modify the indicated relations appreciably.

The substances treated in this report are arranged, for convenience, in alphabetical order (not in order of importance). The various topics are introduced by a brief outline of the chemical and physical properties of the mineral dealt with and its uses, so certain particulars may be obtained without consulting standard mineralogies and texts. For more complete details on physical properties and uses, the authorities in the general reference list (p. 11) may be consulted.

For the sake of brevity and uniformity the usual method of showing legal land subdivisions, such as NE. ¼ sec. 26, T. 31 N., R. 28 E., is shortened to NE. ¼ sec. 26, (31-28 E.).

The intent has been to supply accurate and usable data on the nonmetallic resources of Washington for the information of prospectors, producers, users, and all those interested in State development.

NONMETALLIC MINERALS OCCURRING IN WASHINGTON

Fifty-five distinct nonmetallic mineral substances, some of slight present value and others of great economic importance, occur in the State and are described on the following pages. To these may be added 52 more, listed below, of no economic value here, which occur as essential, accessory, or incidental constituents of certain rocks or veins.

ROCK-FORMING AND INCIDENTAL MINERALS

actinolite	glaucophane	pectolite
aegirite	halloysite	phlogopite
allophane	hastingsite	prehnite
allanite	hornblende	pyroxene
andesine	hyalite	rutile
ankerite	hypersthene	sericite
apatite	jasper	spinel
aragonite	kyanite	staurolite
augite	lepidomelane	thulite
bastite	leucite	titanite
beidellite	mineral coke	tourmaline
calcite	monazite	tremolite
chert	montmorillonite	vesuvianite
chlorite	mountain leather	wollastonite
clinochlore	nephelite	zeolites
diallage	nontronite	zoisite
diopside	octahedrite	zircon
epidote		

In addition to all these, is the long list of metallic minerals,—those from which metals are obtained or which have metallic elements prominent in their composition. These are being made the subject of a separate report.

NONMETALLIC RESOURCES OF THE COUNTIES

The position of the counties in mineral production varies somewhat from year to year. However, the variation is chiefly among the counties of small production where the value of output depends largely on the opening of sand-gravel pits and rock quarries for road work. The 1933 statistics show production much under normal; in fact, it is the least since 1906. This is not due to a reduction in the output of any one or two minerals but to the general business stagnation causing a proportionate drop in all output. So, in the following table of county resources, the 1933 figures are used since they are the latest available and show the usual proportionate output even though the total output is less than one-half its normal value.

NONMETALLIC RESOURCES, WITH PRODUCTION[1] FOR 1933, BY COUNTIES

County	*RESOURCE*	*Value*
Adams	Diatomite, sand and gravel, stone	....
Asotin	Coal, limestone, *sand and gravel*, stone	$100
Benton	Diatomite, *natural gas*, sand and gravel, *stone*	92,879
Chelan	Asbestos, clay, *clay products*, *coal*, graphite, lime, limestone, marble, mica, mineral waters, pumice, sand and gravel, silica, stone, talc and soapstone	1,028
Clallam	Clay, coal, limestone, mineral waters, petroleum, sand and gravel, *stone*	2,685
Clark	Clay, *Clay products*, *sand and gravel*, *stone*	84,426
Columbia	Pumicite, sand and gravel, stone	....
Cowlitz	Clay, *clay products*, *coal*, mineral pigments, mineral waters, peat, sand and gravel, *stone*	27,949
Douglas	*Clay*, *sand and gravel*, stone	1,782
Ferry	Asbestos, fluorite, garnet, limestone, marble, sand and gravel, *stone*, talc and soapstone	17,037
Franklin	Clay, pumicite, sand and gravel, stone	....
Garfield	*Sand and gravel*, *stone*	10,770
Grant	Clay, *diatomite*, mineral waters, pumicite, *sand and gravel*, sodium compounds, *stone*	27,416
Grays Harbor	Clay, limestone, mineral pigments, *sand and gravel*, molding sand, *stone*	65,492
Island	Sand and gravel	....
Jefferson	Clay, limestone, petroleum, *sand and gravel*, *stone*	23,869
King	*Clay*, *clay products*, *coal*, diatomite, limestone, marble, mineral waters, peat, *Portland cement*, *sand and gravel*, molding sand, *stone*	2,263,684
Kitsap	Clay, mineral waters, sand and gravel, *stone*	63,246
Kittitas	Clay, *coal*, *diatomite*, fuller's earth, limestone, *sand and gravel*, molding sand, *stone*	1,526,323
Klickitat	*Carbon dioxide*, *mineral waters*, sand and gravel, *stone*	83,553
Lewis	Clay, *clay products*, *coal*, graphite, mineral waters, pumice, *sand and gravel*, *stone*	208,877
Lincoln	Limestone, sand and gravel, stone, talc and soapstone	....
Mason	Clay, limestone, *sand and gravel*, stone	2,900
Okanogan	Asbestos, clay, *clay products*, epsomite, fuller's earth, graphite, gypsum, limestone, marl, dolomite, marble, sand and gravel, sodium compounds, *stone*, talc and soapstone	14,012
Pacific	Clay, limestone, peat, sand and gravel, *stone*	16,632
Pend Oreille	Clay, feldspar, limestone, dolomite, marble, *Portland cement*, *sand and gravel*, serpentine, stone	143,285
Pierce	*Abrasives*, clay, clay products, *coal*, diatomite, limestone, mineral pigments, mineral waters, garnet, peat, *sand and gravel*, molding sand, silica, *stone*, sulphur	688,341

[1]Resources which were produced in 1933 shown in italics.

NONMETALLIC MINERAL PRODUCTION OF WASHINGTON, 1923-1933

NONMETALLIC PRODUCTS		1923		1924		1925		1926		1927		1928	
		Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Abrasives, pulpstones	short tons	443	$38,047	....	(a)	....	(a)	....	....	....	....	....	(a)
Briquets, fuel c	do	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	63,221	c$412,603
Carbon dioxide, mfd. to "Dry ice"	do	....	....	....	....	....	....	....	....	....	....	....	....
Cement, Portland	barrels produced	2,105,711	4,969,477	1,842,113	$4,347,386	2,481,923	$5,485,049	(b)	(a)	(b)	(a)	(b)	(a)
Clay products		....	2,296,242	....	2,616,740	....	2,619,250	....	$2,604,995	....	$3,440,095	....	2,447,972
Clay, raw	short tons	10,491	29,040	19,773	35,699	24,170	43,645	12,947	31,515	31,463	40,428	35,041	39,632
Coal	do	2,946,007	11,401,047	2,654,915	9,663,890	2,522,983	8,956,589	2,584,255	9,587,586	2,631,337	9,235,992	2,519,410	8,565,994
Coke, beehive c	do	37,987	347,364	31,712	289,934	38,500	327,483	24,702	214,429	30,701	246,769	18,747	151,902
Coke, by-product c	do	31,081	237,148	39,903	283,710	40,737	289,782	42,584	303,624	40,570	283,990	40,755	285,285
Diatomite	do	645	3,030	400	5,500	....	(a)	140	1,400	760	13,900	804	12,705
Lime	do	25,895	359,510	28,188	353,450	29,636	357,297	23,783	298,014	23,959	382,294	24,529	265,922
Magnesite	do	....	(a)	....	(a)	....	(a)	....	(a)	....	(a)	....	(a)
Mineral water	gallons sold	124,273	11,883	canvass discontinued		....	....	....	....	....	....	....	....
Natural gas	M cubic feet	....	....	....	....	....	....	....	....	....	....	....	....
Sand and gravel	short tons	3,789,109	1,363,006	3,464,557	1,398,506	4,197,660	1,763,153	3,910,577	1,704,234	4,423,246	1,570,999	5,917,748	2,001,195
Sand, molding c	do	2,656	1,670	(b)	(b)	(b)	(b)	700	2,800	(b)	(b)	1,236	4,389
Silica, quartz	do	460	3,120	280	1,680	....	(a)	....	(a)	273	2,070	....	(a)
Stone c	do	678,880	953,831	d778,460	d1,596,088	576,690	1,042,165	d461,570	d979,482	975,850	958,841	1,037,160	1,325,768
Basalt	do	553,280	521,027	668,410	829,632	456,670	444,212	343,770	318,846	629,010	477,746	860,210	886,930
Granite	do	56,410	162,271	29,790	87,751	46,050	93,993	24,430	115,248	279,190	187,412	80,310	86,920
Limestone, other than for lime and cement	do	53,540	116,243	46,420	108,155	44,280	55,904	67,940	78,648	57,630	94,162	61,030	97,145
Marble (includes serpentine)	do	400	4,000	....	(a)	....	....	....	(a)	2,630	35,492	....	(a)
Miscellaneous stone	do	....	....	12,770	7,475	....	....	11,700	11,700	4,090	3,670	23,280	14,087
Sandstone	do	15,250	150,290	21,070	563,075	29,690	447,056	13,730	455,045	3,300	160,859	10,680	215,192
Miscellaneous products		....	1,088,000	....	991,724	....	838,250	....	5,995,380	....	6,395,603	....	7,426,109
Total value, eliminating duplication		....	$22,516,233	....	$21,010,663	....	$21,104,398	....	$21,202,611	....	$22,026,822	....	$22,059,803

NONMETALLIC PRODUCTS		1929		1930		1931		1932		1933	
		Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Abrasives, pulpstones	short tons	....	(a)	....	(a)	....	(a)	....	(a)	....	(a)
Briquets, fuel c	do	49,455	c$356,291	36,924	c$272,828	19,770	c$136,258	(b)	(b)	(b)	(b)
Carbon dioxide, mfd. to "Dry ice"	do	....	....	....	....	....	....	100	$5,833	207	$16,273
Cement, Portland	barrels produced	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)
Clay products		....	3,685,777	....	3,181,015	....	1,931,987	....	938,466	....	537,935
Clay, raw	short tons	28,404	39,133	28,784	24,647	21,322	20,801	10,371	11,295	6,101	7,913
Coal	do	2,591,666	8,630,247	2,290,990	7,628,996	1,837,776	5,844,127	1,604,580	4,781,648	1,404,326	3,988,285
Coke, beehive c	do	25,844	207,674	12,252	98,516	582	5,054	736	3,680	379	2,903
Coke, by-product c	do	40,879	286,153	36,221	256,807	30,104	210,728	32,610	228,270	31,817	141,267
Diatomite	do	....	(a)	840	14,800	779	11,186	465	6,015	363	5,700
Lime	do	31,598	324,683	26,913	266,131	20,619	215,033	18,862	199,617	17,214	170,281
Magnesite	do	....	(a)	....	(a)	....	(a)	....	(a)	....	(a)
Mineral water	gallons sold	....	....	....	....	....	....	....	....	....	....
Natural gas	M cubic feet	....	....	94,963	45,750	119,365	66,717	103,826	65,313	108,004	80,799
Sand and gravel	short tons	5,391,693	2,138,019	5,307,622	2,181,012	3,195,156	1,405,551	5,158,240	1,687,217	2,278,097	873,111
Sand, molding c	do	1,540	5,034	1,075	3,751	(b)	(b)	(b)	(b)	(b)	(b)
Silica, quartz	do	....	(a)	....	(a)	....	....	....	....	....	....
Stone c	do	1,673,390	1,960,460	d1,773,610	d1,782,492	1,836,150	1,743,453	d2,483,090	d2,195,076	1,395,690	1,174,041
Basalt	do	1,247,910	1,361,557	1,318,720	1,200,323	1,422,940	1,208,557	2,168,910	1,524,394	1,123,200	782,262
Granite	do	112,760	94,881	55,500	103,629	56,450	102,882	62,260	125,235	81,250	100,840
Limestone, other than for lime and cement	do	75,440	129,423	119,140	165,809	131,600	213,916	112,610	164,855	89,150	128,705
Marble (includes serpentine)	do	3,730	49,490	....	(a)	....	(a)	....	(a)	1,020	11,718
Miscellaneous stone	do	....	....	57,230	21,938	....	(a)	115,550	125,235	83,600	76,031
Sandstone	do	233,550	325,109	223,020	290,794	173,210	151,591	23,760	255,357	17,470	74,485
Miscellaneous products		....	6,272,825	....	5,625,653	....	3,847,967	....	2,698,161	....	2,137,548
Total value, eliminating duplication		....	$23,051,144	....	$20,750,497	....	$15,020,315	....	$12,588,641	....	$8,991,886

a Included under "Miscellaneous products."
b Concealed.
c Not included in total values for State to avoid duplication.
d Does not include marble production.
e Except in 1923 and 1925, includes nonclay refractories.

NONMETALLIC RESOURCES WITH PRODUCTION[1] FOR 1933, BY COUNTIES —*Continued*

County	*RESOURCE*	*Value*
San Juan.....	Feldspar, *lime, limestone,* marble, sand and gravel, stone	100,660
Skagit........	*Abrasives,* asbestos, clay, *clay products, coal,* diatomite, graphite, limestone, marble, olivine, *Portland cement,* pumicite, *sand and gravel,* silica, slate, stone, strontium, *talc and soapstone*.......	443,356
Skamania.....	Abrasives, mineral waters, pumice, sand and gravel, *stone*	44,649
Snohomish	Clay, *clay products,* coal, graphite, limestone, marble, mineral waters, peat, *sand and gravel,* serpentine, stone, strontium	10,000
Spokane	*Clay, clay products,* feldspar, graphite, mica, mineral pigments, mineral waters, andalusite, sillimanite, *Portland cement, sand and gravel,* molding sand, silica, *stone*	211,608
Stevens	Asbestos, barite, brucite, *clay, clay products,* coal, dolomite, feldspar, fluorite, garnet, graphite, *lime, limestone, magnesite, marble,* marl, mica, mineral pigments, sand and gravel, serpentine, slate, *stone,* talc and soapstone........	861,912
Thurston	Clay, *clay products, coal,* mineral pigments, mineral waters, sand and gravel, *stone*........	69,030
Wahkiakum.	Clay, *sand and gravel, stone*........	3,729
Walla Walla..	Sand and gravel, *stone*........	69,034
Whatcom	Asbestos, clay, *coal,* diatomite, graphite, lime, *limestone,* marble, mineral pigments, mineral waters, olivine, natural gas, peat, *Portland cement, sand and gravel,* molding sand, silica, stone, strontium.	610,044
Whitman	Clay, clay products, gems, sand and gravel, *stone*....	93,186
Yakima.......	Clay, *clay products,* diatomite, gypsum, mineral waters, alum, bentonite, pumicite, *sand and gravel, stone,* sulphur	37,684
Undistributed..	Sand and gravel (noncommercial production by State, counties, and railroads, from many localities)	542,773
Undistributed..	Clay products (principally from King and Spokane counties; some from other counties. See "Clay products")	537,935
	Total........	$8,991,886

GENERAL REFERENCES

Butler, E. G., A pocket handbook of minerals, New York, John Wiley & Sons, Inc., 1911.

Clarke, F. W., The data of geochemistry, U. S. Geol. Survey Bull. 770, 1924.

Ford, W. E., Dana's textbook of mineralogy, New York, John Wiley & Sons, Inc., 1932.

Kraus, E. H., and Hunt, W. F., Mineralogy, New York, McGraw-Hill Book Co., Inc., 1928.

Ladoo, R. B., Nonmetallic minerals, occurrence, preparation, utilization, New York, McGraw-Hill Book Co., Inc., 1925.

Various authors, U. S. Geol. Survey and U. S. Bureau of Mines, Mineral resources, various years.

Various authors, U. S. Bureau of Mines, Minerals Yearbook 1932 and subsequent years.

ABRASIVES

Abrasives are substances used for scouring, polishing, grinding, and sharpening. They are of many types and are used in forms that depend upon the work to be done. Some natural abrasives are also important for other characteristics and so have a more general application in industry. For this reason, such materials as clay, diatomite, feldspar, garnet, quartz, and pumicite are considered here under separate headings.

Wheels and stones for grinding and sharpening are commonly made from sandstone, although other rock types, such as quartzite, novaculite, and schist, are used for special work. Generally it is desirable for a stone to contain a very high percentage of sharp, angular uniform-sized grains of quartz, cemented by a soft, only slightly resistant binder. More tenacious binders are sometimes desirable, depending upon the class of grinding to be done. The softer cementing materials allow the stone to wear away as grinding proceeds, thus continually exposing fresh, sharp sand grains on the cutting surface.

The pre-Tertiary formations of the Cascades and the northern counties of eastern Washington contain well-cemented sandstones, quartzites, and many kinds of schists. The Eocene rocks of the coal measures of Chelan and Kittitas counties, of the Puget Sound region, and of southwestern Washington contain immense beds of sandstone. Some of these are known to be suitable for abrasive stone, and it is probable that grades suitable for many purposes could be located. Still other useful grades might be found in the well-indurated sandstones of the Olympic Mountains and in the very friable Miocene and Oligocene beds of the area to the south. Among these abundant sandstones and related rocks of Washington it should be possible to find almost any of the usual kinds of abrasive stones.

The sandstone quarry at Wilkeson, Pierce County, has been operated more or less continuously for over 50 years for the production of building stone. About 1921 it was suggested to the Walker Cut Stone Co. that they enter the pulpstone market with this sharp, medium-cemented sandstone. It was found that the rock was quite suitable for the great wheels used to grind wood into pulp, and since that time paper mills of the Northwest have been using the local stone. Grindstones and holystones are also made from the Wilkeson sandstone.

Quarries at Tenino have been large producers of sandstone for architectural purposes but have not been very active in the last few years. A small amount of holystones was produced by the Tenino Stone Co. in 1924 and 1928 and by the Western Quarry Co. in 1929.

Sandstone occurring in Skagit County has been quarried for pulpstones, and some production has been made there by the H. P. Scheel Eversharp Pulp and Burr Co.

The only other commercial operation known was a small quarry operated at one time in Skamania County between White Salmon and Stevenson in the NW. ¼ sec. 26, (4-9 E.). Whetstones were made from a fine-grained sandstone found there in an 8-foot bed lying between basalt flows.

REFERENCES

Culver, H. E., The coal fields of southwestern Washington: Washington Geol. Survey Bull. 19, 1919.

Daniels, Joseph, The coal fields of Pierce County: Washington Geol. Survey Bull. 10, 1914.

Evans, G. W., The coal fields of King County: Washington Geol. Survey Bull. 3, 1912.

Glover, S. L., Oil and gas possibilities of western Whatcom County: Washington Div. of Geol. Rept. of Investigations No. 2, 1935.

Saunders, E. J., The coal fields of Kittitas County: Washington Geol. Survey Bull. 9, 1914.

Shedd, Solon, The building and ornamental stones of Washington: Washington Geol. Survey Ann. Rept. 1902, vol. 2, pt. 1, 1903.

Weaver, C. E., The Tertiary formations of western Washington: Washington Geol. Survey Bull. 13, 1916.

ASBESTOS

The asbestos of commerce is the mineral chrysotile, a variety of serpentine often called "serpentine asbestos" from its association with that rock. It usually occurs in veins a fraction of an inch to an inch or so wide which may cut the massive serpentine in any direction. The white, silk-like crystal fibers of the mineral lie at right angles to the vein walls, hence its other common name of "cross-fiber asbestos." It is a hydrous magnesium silicate, with the formula $H_4Mg_3Si_2O_9$.

Another asbestos that has some commercial use but that is relatively unimportant is the white, silky, fibrous variety of tremolite and actinolite. These belong to the mineral group of amphiboles, so the term "amphibole asbestos" is usually applied. They are metasilicates of calcium and magnesium (tremolite, $CaMg_3Si_4O_{12}$) or of calcium, magnesium and iron (actinolite, $Ca(Mg,Fe)_3Si_4O_{12}$). The fibers occur in bunches and even large masses, parallel to the enclosing rock, and have great length as compared with serpentine asbestos. Fibers 6 inches or more in length are not uncommon in Washington. Occurrences are associated with impure dolomitic marbles and with hornblende schists and greenstones.

From either variety of asbestos, threads of fibers may be separated by rubbing or crushing between the fingers, then the important characteristic of tensile strength may be judged by bending, pulling, and breaking the threads. Serpentine asbestos will resemble cotton fibers in this test and may be twisted into yarns, but the amphibole variety has a harsher feel and soon breaks.

Serpentine asbestos has been reported in Washington, and one or two of the occurrences listed below may be of this kind. Amphibole asbestos is not uncommon and, so far, all samples submitted to the Division of Geology have been of this variety. It has a value in certain special cement admixtures, in prepared steam-pipe covering, and in various other specialties. Any deposits of large size should be investigated, for a local market could, no doubt, be found for material of good quality.

WASHINGTON OCCURRENCES

In Chelan County on Williams (Raging) Creek, tributary to Chiwawa River, about 30 miles north of Leavenworth and 9 miles by trail from the Chiwawa River road, a showing of serpentine asbestos is reported to occur high on the mountain. Another report mentions that the asbestos is exposed at two tunnels, one 3,400 and the other 4,200 feet in elevation, and describes it as veins of siliceous asbestiform material with white asbestos along the hanging-wall. It would seem that an amphibole variety would be most likely to be present, for the country rock is said to be hornblende schist.

Another occurrence of serpentine asbestos is reported east of Wenatchee Lake on Goose Creek, which crosses Chiwawa River road in sec. 13, (27-17 E.).

Asbestos-Talc Products of Washington, Inc., of Burlington, Skagit County, mines a somewhat fibrous soapstone-actinolite mixture that has developed in shear zones cutting greenstone. It is ground, mixed with asbestos and use for special cements.

Large lenses of short-fiber amphibole were mined at one time a mile from Alta Lake, 6 miles southwest of Pateros in Okanogan County. It was shipped to Wenatchee to the plant of the Asbestomine Co., where it was ground, mixed with diatomite, and made into cold-water paint.

Asbestos is said to occur on Icicle Creek near Leavenworth in Chelan County. No production is reported, but some development work was done at one time.

A 4-foot vein of radiating tremolite asbestos is reported to occur in Ferry County on Hardscrabble Mountain in the NW. ¼ of T. 38 N., R. 32 E.

An old report mentions a large deposit of long, white, silky-fibered asbestos 14 miles southwest of Twisp in Okanogan County. No information was given except to mention that several claims had been located on the outcrop, which was said to be 400 feet wide and traceable for 2,500 feet.

Another old report makes the brief mention that a 5-foot vein of asbestos occurs 8 miles east of Chewelah in Stevens County.

In western Whatcom and Skagit counties the schists which lie just south of the boundary of the Chuckanut formation are reported to contain amphibole asbestos. This zone follows a very irregular course from near the mouth of Oyster Creek to the vicinity of Samish Lake.

Amphibole asbestos was discovered in early days in Skagit County near Hamilton or across Skagit River from Lyman. The reports are vague as to location, but it is said 11 claims were staked and some development work was done. The small amount shipped was reported to be long fibered and of good quality.

Another deposit in Skagit County is northeast of Sedro Woolley in the W. ½ E. ½ sec. 27, (36-5 E.). A sample of this amphibole variety had fine white, silky fibers, 3 inches long, which were particularly flexible and strong for this kind of asbestos.

REFERENCE

Diller, J. S., The types, modes of occurrence, and important deposits of asbestos in the United States: U. S. Geol. Survey Bull. 470K, pp. 3-22, 1911.

BARITE

Barite, barium sulphate ($BaSO_4$), is also known as barytes and heavy spar. It resembles calcite or limestone in its hardness, white color, and good cleavage; but it may be variously colored and is always noticeably heavy, since its specific gravity is 4.3 to 4.6. Barite has many uses and is carefully prepared by sorting, fine grinding and, sometimes, bleaching. It is employed as a filler in paper, paint, rubber, and other products; as a white pigment, lithopone; and in making various chemicals. The users are chiefly in the East, but local markets could be developed in the paper and paint industries of the Coast.

WASHINGTON OCCURRENCES

The known occurrences are all in Stevens County; however, it is doubtful if enough attention has been paid to barite by prospectors, so other veins will probably be found in the northern counties.

At the Allen place, on the Hunters road west of Springdale in the NW. ¼ sec. 21, (30-38 E.), barite occurs in 2 veins about 6 feet and 2 feet wide, respectively, separated by 2 feet of argillite. It is exposed in pits north of the highway and above the prospect tunnels and is said to appear also in one of the tunnels. Another occurrence, possibly the same vein, is said to show south of the highway, a short distance away.

Near the headwaters of Chamokane Creek, 2½ miles northeast of the Allen place, in the SW. ¼ sec. 11, (30-38 E.), barite is exposed by 3 open cuts in an area of dolomite. The vein in 200 feet narrows from 1 foot to 6 inches, then swells in another 100 feet to a width of 3 feet. It has a strike of N. 40° E., 70° NW. Prospect tunnels expose the vein 75 feet below the outcrop. A few tons have been mined.

The Dan Kauffman claims, a mile or so northeast of the Allen place in the NW. ¼ sec. 15, (30-38 E.), have some barite exposed in pits. It is probably vein material but is not sufficiently developed for examination.

At the Shallenberger mine, in the NW. ¼ sec. 14, (30-38 E.), a 250-foot drift has been driven on a vein mineralized with iron and copper in barite gangue.

A vein of barite, several feet thick, outcrops for 500 feet along a ridge in the NW. cor. sec. 14, (30-38 E.).

Barite occurs at the High Grade mine in the Deer Trail district in sec. 6, (29-38 E.), where, mixed with calcite, it forms the gangue mineral of the ores. Widths vary from a few inches to 6 feet, and narrow stringers lead out from the ore lenses.

West of Valley about 11 miles, in the NE. ¼ sec. 19, (31-39 E.), a 3-inch vein of barite occurs, indicating the possibilities of larger occurrences in that area.

REFERENCES

Anonymous, Barytes, barium, chemical, and lithopone industries, including costs of production, 1919: Tariff Information Series No. 18, U. S. Tariff Commission, 1920.

Santmyers, R. M., Barite and barium products, Part 1 and 2, Bureau of Mines Information Circulars 6221 and 6223, 1930.

CARBON DIOXIDE

One of the last phases of volcanism is the emanation of carbon dioxide (CO_2) from fissures and old fumeroles in the vicinity of volcanoes. The gas is readily absorbed by ground water, particularly when under pressure, and this water upon issuing as a spring will give up some of the gas and so become effervescent. Such water is termed carbonated and when uncontaminated is no different from the "soda water" of the soft-drink trade. Many mineral springs of Washington contain carbon dioxide, and one large group has been developed for their gas content. (See also "Mineral Waters," pp. 68-74.)

The producing springs are in the canyon of Klickitat River about 2 miles above the town of Klickitat, Klickitat County, and 32 miles, air-line, from Mount Adams. The output available from the several springs, issuing through the river gravels and from fissures in the basalt of the region, has been increased by wells drilled into producing zones in the rock. Very pure carbon dioxide is evolved in large amounts from the clear sparkling waters, and is collected in traps and piped to the plant of the Gas-Ice Corporation, a short distance away.

The company was operating in early 1935 on gas from four drilled wells in order to obviate mechanical difficulties in collecting gas from the springs uncontaminated with air. A number of other wells were heavy producers—one made as much as 32,000 cubic feet of gas per day; but they were in the valley bottom and were damaged by flood waters of the river in December, 1933. New wells are now being drilled—a development that will probably greatly increase the available gas. It is not unreasonable to expect a continuous production from this vicinity sufficient to supply a plant two or three times the size of the one now in operation.

The plant of the Gas-Ice Corporation is excellently designed and is equipped to make 6,000 pounds of "dry ice" per day. At present (1935) about 30,000 cubic feet of carbon dioxide is being used daily. This is run through almost automatic machines whereby it is cleaned, compressed, and cooled. At minus 65 degrees Centigrade, the gas solidifies to a snow-like form, a pound of "snow" requiring a little over 7 pounds of gas. It is then compressed into blocks 10 inches square and a foot long, packed in cartons and shipped for use as a water-free refrigerant.

Production began in May, 1932, and amounted that year to 199,867 pounds, valued at $5,833. The 1933 production was 414,282 pounds, valued at $16,273, and the 1934 production was 630,391 pounds, valued at $21,641.

REFERENCE

Ludlum, Robert, Washington State Engineer, Vol. 8, No. 4, May, 1934. (Article on mechanical features of production.)

CLAY PRODUCTS

The raw materials for all the usual kinds and grades of clay products occur in Washington. (See "Clays and shales," p. 20.) Fortunately, the deposits are close to the centers of population: the largest beds of high-grade clay, suitable for practically all ceramic uses, are in the Spokane region; while in the vicinity of Puget Sound are extensive beds of clays and shales suitable for all the more usual wares. This has led to the centering of the industry in these two localities, and to a great decrease in the number of plants manufacturing clay products. Formerly, almost every community had its brick yard, turning out common brick in scove kilns from local clay; this probably because in the East, where the Washington settlers came from, lumber was scarce and brick was the universal structural material. In 1905 there were 72 operating plants, 80 per cent of which were making common brick. The small plants gradually went out of business as brick lost in popular appeal. Lumber was cheap; sense of permanence of habitation had not become developed; and brick houses were thought ordinary and unattractive.

The output of common and face brick, chiefly for business buildings, had a value of over a million dollars in 1909 and 1910 and then declined to $353,000 in 1915. By 1924 it was once more in the neighborhood of a million dollars, where it remained until the abnormal conditions of the last few years brought it to the low mark of $146,000 in 1933. The pronounced rise before the depression and a recent recovery are due not only to the increase in business construction but to the popularizing of brick for dwellings, through improvement in architecture and the realization that brick has many advantages over frame construction. This rise has not resulted in an increase in the number of plants, 15 or 20 in the larger centers being amply able to supply the demand.

In 1935 there were 30 concerns manufacturing clay products or able to resume operations upon short notice. Nine of these were potteries, the greatest number of which there is record. The rest were chiefly engaged in making common and face brick, fire brick and shapes, terra cotta, hollow building tile, drain tile, and sewer pipe. These products will continue to be the stand-by of the operators; but the high-quality clays that are available in the Spokane region together with plentiful local silica and feldspar should make possible the addition of other lines, such as china, sanitary ware, and electrical insulation, and the expansion of the present pottery and novelty lines.

	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933
Aggregate:											
Number of establishments	27	29	30	34	31	28	29	30	23	19	18
Value of products	(a)	$2,616,740	(a)	$2,604,995	$3,440,095	$2,447,972	$3,685,777	$3,181,015	$1,931,987	$938,466	$537,935
(A) Clay products (other than pottery) and nonclay refractories:											
Number of establishments	25	(a)	29	31	28	(a)	25	(a)	20	(a)	15
Value of products	$2,284,604	(a)	$2,612,822	$2,579,629	$3,398,522	(a)	$3,638,597	(a)	$1,908,864	(a)	$528,315
(B) Pottery products:											
Number of establishments	2	(a)	1	3	3	(a)	4	(a)	3	(a)	3
Value of products	(a)	(a)	(a)	$25,366	$41,573	(a)	$47,180	(a)	$23,123	(a)	$9,620
(A) Clay products (other than pottery) and nonclay refractories:											
Common brick:											
Thousands	44,505	50,000	54,883	41,454	(b)	38,477	45,756	29,582	17,035	8,430	6,112
Value	$602,693	$610,830	$639,790	$484,272	(b)	$452,914	$550,110	$339,760	$191,736	$91,889	$70,321
Face brick:											
Thousands	11,755	14,197	20,242	25,018	(b)	23,030	17,031	17,970	17,475	7,358	3,597
Value	$256,236	$345,950	$449,991	$489,662	(b)	$462,395	$373,952	$451,940	$339,543	$140,859	$75,836
Terra cotta:											
Short tons	4,122	4,973	3,619	5,357	(b)	(d)	(c)	(d)	(c)	(d)	(c)
Value	$493,499	$629,635	$545,609	$682,824	(b)	(d)	(c)	(d)	(c)	(d)	(c)
Hollow building tile:											
Short tons	26,909	33,946	40,739	37,396	34,222	38,942	41,205	37,593	16,146	7,624	1,942
Value	$251,013	$322,711	$282,707	$225,187	$252,196	$286,633	$303,751	$290,099	$151,330	$44,577	$19,749
Draintile:											
Short tons	7,485	4,123	3,471	5,377	(b)	4,263	5,302	3,672	3,129	2,360	2,572
Value	$74,128	$45,202	$31,811	$47,032	(b)	$43,458	$52,010	$38,057	$33,755	$24,403	$25,115
Sewer pipe:											
Short tons	16,209	(d)	(c)	(c)	(b)	(d)	18,173	(d)	(c)	5,424	(c)
Value	$256,660	(d)	(c)	(c)	(b)	(d)	$256,867	(d)	(c)	$102,227	(c)
Flue lining:											
Short tons	....	....	(c)	2,044	....	(d)	2,029	....	(c)	(d)	(c)
Value	....	....	(c)	$52,560	....	(d)	$34,189	....	(c)	(d)	(c)
Fire-clay brick, block, or tile (9-inch equivalent):											
Thousands	2,993	3,048	(c)	3,769	(b)	(d)	6,715	(d)	(c)	(d)	(c)
Value	$107,432	$113,766	(c)	$100,213	(b)	(d)	$253,666	(d)	(c)	(d)	(c)
Clay sold, raw or prepared:											
Short tons	13,443	1,323	(c)	1,738	(b)	6,926	(c)	(d)	(c)	(d)	(c)
Value	$31,510	$9,343	(c)	$19,412	(b)	$7,912	(c)	(d)	(c)	(d)	(c)
Other clay products (except pottery) and nonclay refractories *e*:											
Value	$211,433	(a)	$662,914	$478,467	(a)	(a)	$1,814,052	(a)	$1,192,500	(a)	$337,294
(B) Pottery products:											
Red earthenware (flowerpots, etc.):											
Value	(f)	(d)	(f)	$24,596	$41,573	(d)	$36,911	$33,395	$23,123	(d)	$9,620
Other pottery products *g*:											
Value	(f)	....	(f)	$770		(d)	$10,269	(d)		(d)	....

a No data. See nonmetallic mineral production summary.
b Some production probably, but no data available.
c Production reported; data included in figure for "Other clay products (except pottery) and nonclay refractories."
d Production reported; not published separately but value included in State aggregate above.
e Includes, for different years, fancy or ornamental brick; hollow brick; roofing tile; floor, faience, and wall tile; vitrified brick or blocks; chimney pipe and tops; wall coping; special fire-clay shapes; refractory cement; etc.
f Production reported; data not available.
g Chiefly garden pottery and art pottery.
h Data supplied by Bureau of the Census.

MANUFACTURERS OF CLAY PRODUCTS, 1935
(Some temporarily inactive)

OPERATOR	*PRODUCT*	*LOCATION*
Chelan County—		
Wenatchee Brick & Tile Co.	Common brick	Wenatchee
St. Luise Bros.	Common brick	Chelan
Clark County—		
Hidden Brick Co.	Common brick	Vancouver
R. B. Muffitt	Common brick, structural and drain tile	Ridgefield
Cowlitz County—		
Art Pottery (Spear)	Novelty ware	Kalama
King County—		
Abrahamson Brick Co.	Common brick	Seattle
Builders Brick Co.	Common and face brick, hollow tile, etc.	Seattle
Seattle Brick & Tile Co.	Common brick	Seattle
Gladding, McBean & Co.	Vitrified face, fancy and fire brick; also other products exclusive of pottery	Renton
Potlatch Potteries	Novelty ware	Seattle
Northwestern Pottery	Flower pots	Seattle
Seattle Pottery & Tile Co.	Flower pots, mantel and wall tile	Seattle
Lange Pottery	Art pottery, vases, and various hollow ware	Auburn
Japanese Pottery	Flower pots	Auburn
Bothell Brick & Tile Co.	Common brick and drain tile	Woodinville
Lewis County—		
Chehalis Brick & Tile Co.	Common brick and drain tile	Chehalis
Okanogan County—		
Oroville Brick Yard	Common brick	Oroville
Pierce County—		
Farwest Clay Co.	(inactive)	Clay City
Skagit County—		
Knapp Brick & Tile Co.	Common brick and drain tile	Mount Vernon
Snohomish County—		
Everett Brick Works	Common brick and hollow building tile	Everett
Meadowdale Pottery	Flower pots	Meadowdale
Spokane County—		
Building Supplies, Inc.	....	Spokane
Gladding, McBean & Co.	Face and fire brick, sewer pipe, hollow and quarry tile, etc.	Mica
Washington Brick, Lime & Sewer Pipe Co.	Sewer pipe, hollow and quarry tile, etc.	Spokane
Pioneer Brick Co.	Common brick	Spokane
Jacob Gorsek Pottery	Art and novelty ware, tea sets	Dishman
Stevens County—		
Washington Brick, Lime & Sewer Pipe Co.	Common, face and fire brick, terra cotta	Clayton
Thurston County—		
Paul Kirston Pottery	Novelty ware	McKenna
Whitman County—		
Uniontown Brick Yard	Common brick	Uniontown
Yakima County—		
Granger Clay Products Co.	Common brick and drain tile	Yakima

REFERENCES

Statistics on clay products manufactured in Washington: U. S. Dep't of Commerce, Bureau of the Census, various years.
See references after "Clays and shales," p. 28.

CLAYS AND SHALES

Clays and shales are abundant and of widespread occurrence in Washington. Almost every kind for which there is a ceramic use is represented, but so far development has been chiefly of types suitable for refractory ware, sewer pipe, drain tile, and general structural ware. The most useful beds in western Washington include shales of the Puget and Chuckanut formations (Eocene age, coal bearing), clays of the Hammer Bluff formation (Pleistocene, pre-Glacial) occurring along Green River, and the very abundant Pleistocene clays of aqueo-glacial and nonglacial origin. The most economically important beds of eastern Washington include shales of the Swauk formation (Eocene age, coal bearing in part), the Palouse or "basaltic" clays (Pleistocene to Recent), and particularly the kaolins and buff-burning clays of the Latah formation. These last, from the general vicinity of their occurrence, are generally termed "Spokane clays" and include some that do not belong to the Latah formation.

Anticipating the advent of cheap power from Bonneville and Grand Coulee, much study is being given to the production of aluminum from Washington clays. It has been found possible to produce the metal under laboratory methods, so the economic utilization of certain clays for this purpose may develop.[1] The requirements of such clays are: great tonnage available for cheap open-pit mining, high alumina (Al_2O_3) content, and low iron oxide (Fe_2O_3) content. Clays filling all these conditions occur only in the Spokane region, but there they are abundant in the vicinity of the foot of Silver Hill, Mica Peak, and other granitic masses. Deep decomposition of the granite has produced residual kaolin in immense quantities. Colluvial and sedimentary clays have been derived from the residual, so that outcrops, occasional prospect holes, and numerous clay pits indicate several thousand acres underlain by high-alumina low-iron clays.

The following lists give locations of clay and shale deposits in the State that have been visited and sampled. The "Refractory" and "Buff-burning" lists are as complete as could be made at the time the work was done; the "Red and brown-burning" list is of a few accessible deposits and merely gives the characteristics of some representative examples of one of the most abundant mineral resources of the State.

[1]Parkman, H. C., Sulphuric acid leaching of Washington clays for the production of alumina and aluminum metal: Washington State College School of Mines and Geology and State Metallurgical Research Laboratory. Bull. E, 1935.

The "Sample Numbers" refer to the original samples and to the numbers under which the details and properties of these clays are given in bulletin 18 of the University of Washington Engineering Experiment Station and in a forthcoming bulletin (No. 24) of the Division of Geology. An asterisk after the location indicates that the clay has been mined and used at some time. The quantity available in the many separate deposits is unknown, but, in general, may be assumed to be large since data on deposits definitely known to be small are not included.

The use for which the various clays and shales are suited, either with or without blending or special treatment, is indicated by the numerals in the last column. These denote:

1. Suitable for refractories (fire brick, furnace lining, and similar products).
2. Suitable for No. 2 or low-grade refractories.
3. Suitable for buff-colored pottery body.
4. Suitable for porcelain and white ware (after treatment).
5. Suitable for buff-colored facing brick and high-quality structural wares.
6. Suitable for terra cotta body.
7. Suitable for red and brown structural wares, including common red brick, tile, and similar products.

REFRACTORY (HIGH ALUMINA) CLAYS AND SHALES

These are distinguished from others by their refractory character—that is, their ability to withstand a high degree of heat. This feature is developed to various degrees in the different clays and ranges from those classed as low-grade or No. 2 refractories with a cone fusion of 26 to 31, to high-grade No. 1 refractories with a cone fusion above 31. Under this heading are included certain clays with properties which make them useful for light-colored pottery, high-grade structural wares, facing brick, and terra cotta as well as refractories.

REFRACTORY CLAYS AND SHALES

Sample No.	*County*	*LOCATION*	*Use*
....	Chelan	N. W. L. Brown prospects 3½ mi. S. of Wenatchee, NW. cor. sec. 27, (22-20 E.)*...	1, 5
....	Douglas	Gladding, McBean & Co. clay mine, 3½ mi. N. of Wenatchee, NW.¼ sec. 23, (23-20 E.)*	1, 5
158	King	"Hammer Bluff" on Green River, NE.¼ sec. 28, (21-6 E.)	2, 5
168	do	"Flint clay," Kummer mine, NE.¼ sec. 26, (21-6 E.)*	1
169	do	Overlying 168, Kummer mine	2
171	do	No. 1 clay tunnel—do*	1
....	do	Harris Coal mine fire clay, ½ mi. W. of Issaquah*	1
317	Lewis	Buswell farm, E. side Cowlitz R., NW.¼ sec. 25, (11-2 W.)	1, 6
336-b	do	Above No. 4 coal, old Ladd mine	1, 5
339-a	do	Ry. cuts just S. of Napavine	2, 5
184-a	Pierce	Ry. cuts ½ mi. N. of LaGrande*	2
184-b	do	do*	1
185-a	do	do*	2, 5
186-a	do	Pit, Far West Clay Co., Clay City (certain phases)*	2
66	Spokane	N. of Tekoa, 4 mi., near center sec. 36, (21-45 E.)	2, 3
78	do	Pit, W. B. L. & S. P. Co., (N. of station) Freeman*	1, 4
90	do	Cut just SE. of Saxby station on C. M. & St. P. Ry.	1, 3, 5, 6
94	do	N. end "fire clay" pit of Amer. Fire Br. Co., Mica*	1, 3, 5
94-b	do	"Sandpit" Amer. Fire Brick Co., Mica*	1, 3, 5
94-c	do	Pit of W. B. L. & S. P. Co., W. of Mica* ...	1, 3, 5, 6
127	do	Well, SW.¼ sec. 21, (27-44 E.)	2, 3, 5
130-b	do	SE. of Milan ½ mi., W. of river, N. center sec. 2, (26-43 E.)	1, 3, 5, 6
136	Stevens	Pit of W. B. L. & S. P. Co., Clayton*	1, 5, 6
200	Whatcom	Smith place, 3 mi. SE. of Sumas, N. center sec. 7, (40-5 E.)*	1
204	do	Old Denny-Renton clay mine, SE.¼ sec. 12, (40-4 E.), Seam 16 & 18*	2, 5, 6
205	do	Old Denny-Renton clay mine, Seam 22*	1, 5
206	do	do, Ganister	2
207	do	do, Seam 5*	1

*The clay has been mined and used at some time.

BUFF AND GRAY-BURNING CLAYS AND SHALES

These clays and shales burn to some shade of a buff or gray color. A few are quite refractory but, in general, they are semi-refractory or below the grade of clays from which products are made that depend chiefly upon the heat-resisting characteristic. They are useful for high-quality structural wares, and some would be classed as pottery and terra cotta bodies. Special treatment or mixing would be required to ultilize some deposits given below. Others could be used as mined for the purpose mentioned.

BUFF AND GRAY-BURNING CLAYS AND SHALES

Sample No.	*County*	*LOCATION*	*Use*
342	Cowlitz	Cellar excavation, Bingham farm; SE.¼ sec. 32, (19-3 W.)	5
308	do	Road cut 2 mi. S. of Kelso; Temple farm...	5
....	Douglas	Clay mine of Gladding, McBean & Co. 3½ mi. N. of Wenatchee in NW.¼ sec. 23, (23-20 E.)	5
159	King	"Hammer Bluff" on Green River, NE.¼ sec. 28, (21-6 E.)	3, 5
159-a	do	Old prospect just E. of "Hammer Bluff"...	5, 6
160	do	"Hammer Bluff" just E. of sample 159	5, 6
160-a	do	Same location as 159-a	5, 6
162	do	Old pit on Brooks farm just W. of "Hammer Bluff"*	5
164	do	Green River pit of Northern Clay Co., SE.¼ sec. 28, (21-6 E.)*	3, 6
178	do	Shale quarries and mine at Taylor*	5
379	do	Clay pits by N. P. Ry., E. of Palmer, NW.¼ sec. 14, (27-7 E.)*	3, 5, 6
....	do	Alcorn pits, 11 mi. E. of Auburn on Green River, near center, sec. 27, (21-6 E.)* ...	3
....	do	Shale with coal, New Black Diamond mine*..	5
....	do	Pits in W. city limits of Issaquah*	3, 5, 6
316 316-a 318 320	Lewis do do do	Buswell farm, E. side Cowlitz R., NW.¼ sec. 25, (11-2 W.)	5, 6
336-a 336-b	do do	Shale above No. 5 coal, Ladd mine NW.¼ sec. 7, (17-5 E.)	5
371	Mason	Road cut near Eagle Creek, SE.¼ sec. 32, (19-3 W.)	5
335	Pierce	Kapowsin-Eatonville road cuts, NW.¼ sec. 7, (17-5 E.)	5
138	Stevens	Kulzer clay mine near Valley, NE.¼ sec. 2, (31-41 E.)	5
71-a	Spokane	SE. of Latah 2 mi., W.½ sec. 33, (21-45 E.)*	5
78-a	do	Cut at Lockwood siding on O. W. R. & N. Ry.	5
100	do	Pit 3 mi. E. of Chester, SE.¼ sec. 35, (25-44 E.)*	3, 5, 6
117	do	Well on Pleasant Prairie center S.½ sec. 11, (26-44 E.)	3, 5, 6
117-a	do	Well on Pleasant Prairie NE.¼ sec. 23, (26-44 E.)	1, 3, 5
118-a, b	do	N. side Deadman Cr. Valley, E.½ sec. 28, (27-44 E.)	3, 5, 6
118-d	do	Fuher place pit ¼ mi. W. of 118-a, b	3, 5
130-a	do	W. bank of river ½ mi. SE. of Milan, N. center sec. 2, (28-43 E.)	5
132	do	Abbott pit, 6 mi. N. of Clayton, N. center sec. 32, (30-42 E.)*	2, 6
135	do	Conner pit, 5 mi. NE. of Clayton, NE.¼ sec. 4, (29-42 E.)*	2, 6
135-a, b	do	Neafus pit, 8 mi. NE. of Clayton, SE.¼ sec. 34, (30-42 E.)*	3, 5
....	do	Medical Lake, 1¾ mi. W. of N. end	5, 7
....	do	Cheney, near highway just W. of depot	5
....	do	Mueller place, 3 mi. S. of Vera, NW.¼ sec. 31, (25-45 E.)	2, 3, 5
....	do	Old Cox place, 3 mi. SE. of Vera, SW.¼ sec. 30, (25-45 E.)	5, 7
34	Whitman	Pit of old Pioneer Pottery, NW.¼ sec. 7, (16-46 E.)*	3, 5
36	do	Pit of old Pioneer Pottery, NW.¼ sec. 7, (16-46 E.)*	1
306	Wahkiakum	Watkins farm, ¾ mi. N. of Cathlamet	5

*The clay has been mined and used at some time.

RED AND BROWN-BURNING CLAYS AND SHALES

These are of widespread occurrence throughout every county in the State. It is material suitable for making common brick and may be developed almost wherever there is a market for the product. The following list gives a few characteristic occurrences that have been sampled. Some of these are of excellent quality and suited to the manufacture of high-grade red structural ware; others may be of very ordinary quality or may require blending and careful treatment to be used successfully.

RED AND BROWN-BURNING CLAYS AND SHALES

Sample No.	County	LOCATION	Use
156	Chelan	Pit of Wenatchee Brick & Tile Co., Wenatchee*	7
300	Clark	Pit of old D-R. C. & C. Co., Image*	7
302	do	Prospect pits, Bedell place, NE.¼ sec. 10, (1-4 E.)	7
769	do	Pit of Hidden Brick Co., Vancouver*	7
365	Clallam	40-ft. bank by post office, Port Angeles	7
367	do	Ry. Cut E. side Twin River valley, NW.¼ sec. 25, (31-10 W.)	7
311 } 312-d }	Cowlitz	Bingham place, 3 mi. W. of Castle Rock	7
341	do	Cut, Cowlitz R. road, 2 mi. S. of Olequa	7
11-a	Franklin	In bluffs, 400 ft. above Columbia, SE.¼ sec. 33, (13-28 E.)	7
1	Grant	Above Ry. in bluff ½ mi. W. of Corfu	7
354	Grays Harbor	Road cut W. of Aberdeen, near center N.½ sec. 32, (17-10 W.)	7
355	do	Road cut on McKay Road, N. of Hoquiam	7
356	do	Above river bridge, 1½ mi. E. of Humptulips	7
358	do	Road cut NW. of Hoquiam NE.¼ sec. 21, (18-10 W.)	7
359	do	Road cut W. of Hoquiam, NE.¼ sec. 34, (13-10 W.)	7
360	do	Bluffs at Grays Harbor sta., W. of Hoquiam	7
361	do	Wishkah roadcut, N. of Aberdeen SW.¼ sec. 28, (18-9 W.)	7
362	do	Wynooche road cuts NW. of Montesano, NE. ¼ sec. 33 and NW.¼ sec. 34, (18-8 W.)	7
364	Jefferson	S. end Bolton Peninsula (E. of Quilcene)	7
369	do	Road cut 50 yds. from Ry. 3 mi. N. of Quilcene	7
157	King	Prospect pit N. of Diamond Mineral Springs, SW.¼ sec. 21, (21-7 E.)	7
165	do	Under Brooks bridge, Green River near center sec. 28, (21-6 E.)	7
170	do	400 ft. SW. of portal tunnel No. 1, south Kummer mine	7
172	do	Shale overlying flint clay, Kummer mine	7
173	do	Pit of old Bayne paving brick plant, Bayne*	7
174	do	50 ft. from portal, main tunnel, Durham Colliery, Bayne	7
175	do	N. P. Ry. cut on Big Six mine spur, NW.¼ sec. 14, (21-7 E.)	7
175-a	do	Shale from Big Six coal mine	7
175-b	do	Shale from Ravensdale coal mine	7
176 } 177 }	do	Shale from Taylor clay mine*	7

*The clay has been mined and used at some time.

RED AND BROWN-BURNING CLAYS AND SHALES—Continued

Sample No.	*County*	*LOCATION*	*Use*
182	do	Prospect pit 8 mi. E. of Enumclaw, near Chinook Pass Highway	7
184	do	Prospect tunnel near East Twin Cr., NE.¼ sec. 1, (19-8 E.)	7
187-a, c, d 188	do	Pit of Far West Clay Co., Clay City*	7
380	do	Hudson mine, Palmer Junction	7
381	do	Road cut, foot of Cedar Mt., sec. 30, (23-6 E.)	7
382	do	Road cut above Cedar Mt. sta. C. M. & St. P. Ry.	7
385	do	Bank of Puget Sound Brick & Tile Co., Seattle*	7
386	do	Bank of Abrahamson brick yard, Seattle*...	7
390	do	Bank of Seattle Builders Brick Co.*	7
391	do	Bank of Lohse Brick Co., Seattle*	7
392	do	Renton shale quarry, Gladding, McBean & Co., Renton	7
395	do	Shale above No. 1 coal, Beacon Coal mines, 1 mi. S. of Black River Junction	7
....	do	Weathered shale at Newcastle, NW.¼ sec. 27, (24-5 E.)*	7
7	Kittitas	Clay above diatomite, Great Western Silica Co., Roza	7
376	Kitsap	Bank of Harper Hill Brick & Tile Co., Harper*	7
321-a, b	Lewis	Pit of old Little Falls Fire Clay Co., Vader*	7
322	do	S. of Winlock on Olequa Cr. sec. 5, (11-2 W.)	7
324	do	By highway, ½ mi. SW. of Napavine	7
325	do	Ry. cut 2½ mi. NE. of Napavine	7
326	do	On highway 1 mi. N. of Napavine hill	7
327	do	3 mi. SW. of Centralia near center sec. 24, (14-3 W.)	7
338	do	Road cut by Napavine station	7
340	do	S. end Olequa bridge just N. of Winlock ...	7
343	do	Pit of Chehalis Brick & Tile Co., Chehalis*..	7
344	do	Head of ravine above powder house, Mendota Coal & Coke Co.	7
345	do	Just beyond fault, 4th level, new slope Mendota Coal & Coke Co.	7
346	do	Ogle farm, ¼ mi. from Ry. in low hills NW. of Mendota	7
347	do	Road cut SE. of Pe Ell	7
372	Mason	Road cut near Eagle Cr., SE.¼ sec. 32, (19-3 W.)	7
152	Okanogan	Road cuts along Tonasket Cr., 4 mi. NE. of Oroville	7
348	Pacific	Road cut 1½ mi. E. of Francis, South Bend Road	7
349	do	Road cut 1½ mi. W. of Lebam, So. Bend road	7
350	do	Road Cut 2 mi. SE. of Raymond, So. Bend road	7
351	do	Road cut 1 mi. SE. of Raymond, So. Bend road	7
352	do	Road cut 1½ mi. W. of business center of Raymond	7
353	do	Road cuts in hills W. of South Bend	7
141	Pend Oreille	Well W. of Ione, NE. corner sec. 1, (37-42 E.)	7
144	do	Near Ione post office	7
180	Pierce	W. of old No. 6 Tunnel 100 ft., Carbon Hill Coal Co., Carbonado	7
189	Skagit	Road cut in outskirts of McMurray	7

*The clay has been mined and used at some time.

RED AND BROWN-BURNING CLAYS AND SHALES—Continued

Sample No.	County	LOCATION	Use
190	do	Pit of old Alger brick yard, S. end of Samish Lake*	7
191	do	Cuts, Skagit River road between Van Horn and Sauk	7
192	do	Clay from Wash. Portland Cement Co's quarry, Concrete*	7
193	do	S. side river road, 7 mi. E. of Sedro Woolley, S.½ sec. 30, (35-6 E.)	7
196	do	Road cut just S. of Hoogdale	7
387	Snohomish	Meadowdale Pottery, Meadowdale*	7
388	do	Everett Brick & Tile Co., Everett*	7
389	do	Snohomish brick plant, Snohomish*	7
65	Spokane	Road cut 4 mi. N. of Tekoa, center N.½ sec. 25, (21-45 E.)	7
74	do	Road cut 2½ mi. SE. of Fairfield, SW.¼ sec. 21, (22-45 E.)	7
79-a	do	South pit W. B. L. & S. P. Co., Freeman*	7
90-a	do	C. M. & St. P. Ry. cut just SE. of Saxby sta.	7
125-a	do	S. P. & S. Ry. cut W. of Latah Cr. in SW. part of Spokane	7
128	do	Road cut near head of Deep Cr. valley, NW. cor. sec. 28, (28-44 E.)	7
130	do	Road cut 2½ mi. S. of Milan, near center N. line sec. 13, (28-43 E.)	7
131	do	Road cut 2½ mi. SW. of Milan, E.½ sec. 10, (28-43 E.)	7
714	do	Pits of Davies Brickyard, SW. of Spokane*	7
736	do	Overburden, Pit of Amer. Fire Brick Co., Mica*	7
138-a	Stevens	Pit of old Chewelah Brick Co., Chewelah*	7
139	do	Near Bissell, NW.¼ sec. 3, (31-37 E.)	7
140	do	Road cut S. side Colville River, SW.¼ sec. 35, (36-37 E.)	7
148	do	Hooks farm, NE.¼ sec. 17, (17-38 E.)	7
373	Thurston	N. P. Ry. cut near NW. cor. sec. 19, (16-10 W.)	7
303, 304	Wahkiakum	N. of Skamokawa 1 mi., E.½ sec. 8, (9-6 W.)	7
305-a	do	W. of Cathlamet 2 mi., sec. 7, (8-5 W.)	7
198	Whatcom	Pit on Smith place near center N.½ sec. 7, (40-5 E.)	7
211	do	Old Sumas clay mine of D-R C. & C. Co.*	7
393	do	Shale above coal, Bellingham coal mine	7
394	do	Quarry of old Coast Clay Co., S. of Bellingham*	7
17	Whitman	Road cuts NW. of Pullman	7
23	do	Road cut, SW.¼ sec. 12, (13-34 E.)	7
24	do	Road cut north of Colton, NW.¼ sec. 26, (13-45 E.)	7
25	do	Pit of Geo. Herboth Brick Co., Uniontown*	7
31, 32	do	Pits of old Pioneer Pottery, S. of Palouse*	7
61	do	Road cut, 4 mi. S. of Rosalia, NW.¼ sec. 3, (19-43 E.)	7
6-c, 6-e, 6-f	Yakima	Pit of Granger Clay Prod. Co., Granger*	7

*The clay has been mined and used at some time.

CLAY PRODUCTION, 1923-1933

Year	*Pro-ducers*	*Fire Clay*		*Stoneware Clay*		*Miscellaneous clays and shales*		*Total*	
		Short tons	*Value*	*Short tons*	*Value*	*Short tons*	*Value*	*Short tons*	*Value*
1923	8	5,524	$19,549	(*a*)	(*a*)	4,967	$8,916	10,491	$29,040
1924	7	4,317	16,142	....	....	15,456	20,132	19,773	35,699
1925	7	3,576	19,418	....	....	20,594	24,227	24,170	43,645
1926	8	1,500	15,381	756	$2,268	10,691	13,866	12,947	31,515
1927	9	720	8,423	726	2,178	30,017	29,827	31,463	40,428
1928	7	5,906	18,925	(*a*)	(*a*)	29,135	20,707	35,041	39,632
1929	7	894	9,862	6,500	4,000	21,010	25,271	28,404	39,133
1930	6	1,421	4,785	(*a*)	(*a*)	27,363	19,862	28,784	24,647
1931	5	9,094	13,036	(*a*)	(*a*)	12,228	7,765	21,322	20,801
1932	5	674	2,307	(*a*)	(*a*)	9,697	8,988	10,371	11,295
1933	4	848	3,046	(*a*)	(*a*)	5,253	4,867	6,101	7,913

a Included under "Miscellaneous clays and shales."

REFERENCES

Landes, Henry, and contributions by Roberts, Milnor, Clay materials: Washington Geol. Survey Ann. Rept. for 1901, vol. 1, pt. 3, pp. 13-23, 1902.

Miller, R. M., A survey of the aluminum industry and its metallurgical processes with reference to the utilization of Northwest clays: Washington State College School of Mines and Geology and State Metallurgical Research Lab. Bull. D, 1935.

Parkman, H. C., Sulphuric acid leaching of Washington clays for the production of alumina and aluminum metal: Washington State College School of Mines and Geology and State Metallurgical Research Lab. Bull. E, 1935.

Shedd, Solon, The clays of the State of Washington: Washington State College, 1910.

Tyler, P. M., Clay: U. S. Bureau of Mines Information Circular 6155, 1935.

Wilson, Hewitt, The clays and shales of Washington: University of Washington Eng. Exp. Sta. Bull. 18, 1923.

.........................., Kaolin and china clay in the Pacific Northwest: University of Washington Eng. Exp. Sta. Series Bull. 76, 1934.

COAL

Coal is the most valuable mineral resource of Washington. It has contributed approximately 118 million dollars to the wealth of the State during the 74-year period from 1860, when production records were first kept, to the end of 1933. In the last 46 years, the yearly output has been as high as $4,128,424 (in 1918) and has never been below a million dollars. Among the nonmetallic minerals, from 37 to 51 per cent of the value of total production from 1923 to 1933 has come from coal, the yearly average being 42 per cent. A resource of this importance naturally receives much attention, and excellent reports are available on geology, mining, and treatment. Useful references are listed at the end of this section; no attempt will be made here to more than generalize on a few essential features and to present tabulated statistics from figures assembled by the U. S. Geol. Survey, the U. S. Bureau of Mines, and the State Mine Inspector.

The principal coal fields of the State are in Cowlitz, King, Kittitas, Lewis, Pierce, Skagit, Thurston, and Whatcom counties. Distinctly minor fields or coal occurrences upon which some work has been done are in Asotin, Chelan, Clallam, Snohomish, and Stevens counties; while small amounts of coal are contained in the rocks of still other counties. With a few unimportant exceptions, the beds in western Washington are in rocks of the Puget and related Chuckanut formations, of Eocene (Tertiary) age; in eastern Washington, in the Roslyn formation, also of Eocene age.

All ranks of coal are represented in the State from woody brown lignite to anthracite. The brown lignite occurs in Miocene rocks exposed along the ocean in many places. One bed, about 3 feet thick, is in Asotin County in the NW. ¼ sec. 33, (7-44 E.); it was formed in interbasalt sediments and is probably Miocene in age. Other occurrences are in Pleistocene sediments in the Puget Sound region. None is of commercial value, although openings are sometimes made in the expectation of an improvement in quality with depth.

Subbituminous coal occurs in Cowlitz, western Lewis, and Thurston counties in southwestern Washington, and similar coal, but of slightly higher rank, occurs in the western part of King and Whatcom counties. These areas have been in production since the early days of the State and have been a dependable source of free-burning easily mined fuel.

Bituminous coal is found in Pierce, King, Kittitas, Skagit, Whatcom, and central Lewis counties. The largest mines of the State are in this coal, and the value of output leads that of any other rank. Some beds produce an excellent coking coal, notably those of Pierce County. Good coking coal occurs also in Skagit County, where for many years a large output was obtained from the old Cokedale mine. Large reserves of this important type of coal exist from South Prairie to Ashford in Pierce County, in the Cumberland, Day, and Rick Creek areas of Skagit County, and in parts of the King and Kittitas fields.

Semibituminous and semianthracite coals occur in a few places where bituminous beds have been locally subjected to severe dynamic stresses or to heating through proximity to large igneous intrusions. Examples have been found in mines of the Pierce County field; some are mined, or have been in the past, but the quantity of such coal is not great.

Anthracite coal is found in two areas. The Glacier field, north of Mount Baker in central Whatcom County, is the best known locality. Here, coal of anthracite rank occurs in lenses and distorted, broken beds with coals of lower rank. There is no present production; although a great amount of prospecting has been done, and at one time two properties were able to produce a small amount of high-quality coal. The second, and probably larger area, includes the Packwood, Cowlitz Pass, Summit Creek and Carlton Pass fields of eastern Lewis County. The sedimentary rocks in these localities contain a large number of coal beds, some of which, when considered with intercalated bony coal and carbonaceous shale, have remarkable thickness. In the series are several beds of high-quality anthracite thick enough and sufficiently free from rock to be commercial. The structure is less complicated than that of the Glacier field, and mining probably could be carried on without undue difficulty. That the area is not a producer of high-rank coal is chiefly due to its location and lack of transportation. It is hoped that it will be made more accessible before long, and in anticipation of that, prospecting is being actively carried on.

Some coals, chiefly of local interest, occur outside the principal coal-producing areas:

In Chelan County a mine operated for a few years prior to 1934 in Dry Gulch, 2½ miles southwest of Wenatchee, in sec. 21, (22-20 E.). A 4-foot bed of bony coal, bone, and carbonaceous shale occurring in the Swauk formation (Eocene age) was developed for a small local demand.

Coaly matter has been encountered elsewhere in the Swauk rocks, but, so far, no commercial beds have been opened. In a test for oil on Wenatchee Heights the Northwest Oil Research Corporation, drilling in this formation in 1935, encountered a 6-foot bed of coal. The small sample recovered from the deep bore hole was of excellent grade and between subbituminous and bituminous rank.

In Clallam County at Freshwater Bay and just east of Clallam Bay several beds of bituminous coal up to 30 inches or so thick occur in rocks of Miocene age. The Clallam Bay bed was mined many years ago and considerable prospecting was carried on.

In Snohomish County a subbituminous coal was mined for a time near Jordan, about 5 miles southeast of Arlington. This occurrence is in strata probably of Oligocene age.

In Stevens County a mine was formerly operated 2½ miles southwest of Valley, in the west center sec. 28, (31-40 E.), on coal which occurs in shales between igneous flows. The coal is of subbituminous rank and measures, with several dirt partings, approximately 4 feet in thickness. A bed similar to this in appearance and occurrence is exposed in the ravine of Sand Creek 2 miles east of Detillion bridge in the southwest corner of the county, while another occurs in the northwest corner of Lincoln County near the Columbia, in the NE. cor. sec. 15, (28-31 E.).

The importance of coal as a Washington resource will increase with the depletion of West-Coast oil reserves and with the development and adoption of more efficient methods of utilization. A greater demand for coal may be expected as domestic and industrial stokers become more popular and as by-product processes are perfected. The highest degree of efficiency and economy may only be attained when the products of coal are used in place of raw coal. Such methods of use will lead to maximum production. Another increase in use may be expected as metallurgical and chemical industries are drawn to the Northwest by advantages such as cheap electric power.

Estimates by the U. S. Geological Survey of Washington's original coal resource were 63,877,000,000 tons, divided into ranks as follows:

Anthracite and semianthracite.....	23,000,000
Bituminous	11,412,000,000
Subbituminous	52,442,000,000
Total	63,877,000,000

These figures were based on maximum working depths of 3,000 and 6,000 feet; a minimum thickness of bed of 14 inches for high-rank coals and 2 feet for subbituminous coals; and maximum ash content of 25 per cent. Daniels[1] points out that the production to date of approximately 118 million tons, or even three times that figure (to cover waste and unreported production), is an insignificant part of the total estimated tonnage. His comparison, based on as reliable statistics as are available for the Pacific Coast states and the Province of British Columbia, shows that California, with 43 million tons has less than 0.1 per cent; Oregon, with 10,000 million tons, has 6.9 per cent; Alaska, with 19,593 million tons, has 13.4 per cent; British Columbia, with 52,204 million tons, has 35.8 per cent; while Washington, with 63,500 million tons, has 43.8 per cent of the probable coal reserves.

COKE

The manufacture of coke has been an important industry in Washington for the last 50 years owing to the fact that the extensive beds of coking coal occurring here are practically the only ones on the Pacific Coast. (See "Coal," p. 29.) During the last few years the production has fallen off to a marked degree. The greatest value of total yearly output was $1,295,258 in 1918; the value in 1933 was only $144,170. In former years, coke was made at Wilkeson, Fairfax, Carbonado, and Cokedale; but at the present time the only mining company making coke is at Wilkeson, and those ovens are operated at only a small fraction of their capacity. The Seattle Lighting Company produce by-product coke in the manufacture of gas from Washington coal, their large output serving to maintain the State production at a considerable amount.

[1]Daniels, Joseph, Coal in Washington: University of Washington Engineering Experiment Station Report No. 3, 1934.

SUMMARY OF COKE PRODUCED IN WASHINGTON, 1923 TO 1933
VALUE, NUMBER OF OVENS, AND AVERAGE YIELD

Year	BY-PRODUCT							BEEHIVE						TOTAL	
	Plants	Ovens	Coal used (net tons)	Yield of coke from coal (per cent)	Coke produced (net tons)	Value of coke at ovens: Total	Value of coke at ovens: Per ton	Ovens	Coal used (net tons)	Yield of coke from coal (per cent)	Coke produced (net tons)	Value of coke at ovens: Total	Value of coke at ovens: Per ton	Coke produced (net tons)	Value of coke at ovens
1923	1	20	54,811	56.7	31,081	$237,148	$7.63	408	55,730	68.2	37,987	$347,364	$9.14	69,068	$584,512
1924	1	20	70,968	56.2	39,903	283,710	7.11	408	49,339	64.3	31,712	289,934	9.14	71,615	573,644
1925	1	20	68,655	59.3	40,757	289,782	7.11	332	62,644	61.5	38,500	327,483	8.51	79,257	617,265
1926	1	20	67,544	63.0	42,584	303,624	7.13	332	49,265	62.9	24,702	214,429	8.68	67,286	518,053
1927	1	20	64,926	62.5	40,570	283,990	7.00	332	47,953	64.0	30,701	246,769	8.04	71,271	530,759
1928	1	20	64,458	63.2	40,755	285,285	7.00	235	29,353	63.9	18,747	151,902	8.06	59,502	437,187
1929	1	20	65,845	62.1	40,879	286,153	7.00	190	34,894	74.1	25,844	207,674	8.04	66,723	493,827
1930	1	20	59,837	60.53	36,221	256,807	7.09	80	15,928	76.92	12,252	98,516	8.04	48,473	355,323
1931	1	20	55,736	54.01	30,104	210,728	7.00	80	957	60.82	582	5,054	8.68	30,686	215,782
1932	1	20	57,672	56.54	32,610	228,270	7.00	80	1,206	61.03	736	3,680	5.00	33,346	231,950
1933	1	20	56,818	56.00	31,817	141,267	4.44	80	622	60.93	379	2,903	7.66	32,196	144,170

COMPARABLE SUMMARIES FOR WASHINGTON COAL INDUSTRY, 1923 TO 1933 INCLUSIVE *a*

	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933
Number of counties producing coal.......	7	7	7	7	7	7	6	6	7	9	9
Number of mines and openings..........	57	58	65	60	59	50	59	52	59	68	79
New, or old mines reopened............	16	23	2	..	7	3	4	4	12	21	7
Mines closed or abandoned.............	10	15	15	1	7	3	9	7	8	4	8
Total production of coal, short tons.....	2,946,007	2,654,915	2,522,983	2,584,255	2,631,337	2,519,410	2,591,666	2,290,990	1,837,776	1,604,580	1,404,326
Total value of coal at mines............	$11,401,047.09	$9,663,890.60	$8,956,589.65	$9,587,586.05	$9,235,922.87	$8,565,994.00	$8,630,247.78	$7,628,996.70	$5,844,127.68	$4,781,648.40	$3,988,285.84
Average value at mines per short ton....	$3.87	$3.64	$3.55	$3.71	$3.51	$3.40	$3.33	$3.33	$3.18	$2.98	$2.84
Total production of coke, short tons......	37,000	38,473	35,118	25,299	31,109	18,474	25,844	12,252	582	740	399
Total value of coke..................	$340,031.00	$352,324.10	$293,376.81	$200,700.70	$249,769.32	$151,901.56	$207,673.81	$98,516.36	$5,050.75	$5,878.43	$2,902.35
Average value of coke, short tons........	$9.04	$9.23	$8.36	$7.93	$8.02	$8.10	$8.03	$8.04	$8.67	$7.94	$7.27
Total number inside employees at mines..	3,286.5	3,237.5	3,152.9	3,833.4	2,856.9	2,632.2	2,583.2	2,433.0	2,334.0	2,467.7	2,154.0
Total number outside employees at mines.	1,055.5	1,068.6	1,010.9	398.5	950.5	630.2	695.9	677.3	636.5	735.5	663.7
Total number of employees............	4,342.0	4,306.1	4,163.8	3,731.9	2,807.4	3,362.4	3,279.1	3,110.3	2,970.5	3,203.2	2,817.7
Average days mines operated...........	170.42	166.55	197.0	199.5	206.0	218.3	221.3	204.0	165.2	143.8	151.0
Yearly production per employee, tons....	679	516	606	692	690	750	791	736	618	498	499
Daily average per employee, tons........	3.18	3.24	3.08	3.47	3.35	3.43	3.57	3.60	3.74	3.48	3.30

a From Annual Report State Mine Inspector, 1933.

FUEL BRIQUETS

Briquets made from bituminous and subbituminous slack coal have been manufactured in Washington for many years. They make a convenient and clean fuel for domestic use and furnish an outlet for coal of small size and good quality which may not otherwise be easily disposed of. The oldest plant is that of the Pacific Coast Coal Company at Renton, put in operation in 1914. It has produced steadily and was the only one reporting an output in 1933. Three other briquet manufacturers have operated recently: the Wilkeson Coal & Coke Co. (Fairfax plant) started in 1926, and the Northwestern Briquetting Co. of Ravensdale started in 1928 and was succeeded in 1929 by the Paramount Briquet Co. of Seattle.

The production of briquets in 1931 was 19,770 tons valued at $136,258. The figures for other years are concealed to prevent the disclosure of individual operation.

WASHINGTON COAL PRODUCTION FROM 1860 TO 1933, INCLUSIVE

Year	*Tons*	*Year*	*Tons*
1860	5,374	1898	1,775,257
1861	6,000	1899	1,917,607
1862	7,000	1900	2,418,034
1863	8,000	1901	2,464,190
1864	10,000	1902	2,690,789
1865	12,000	1903	3,190,477
1866	13,000	1904	2,905,689
1867	14,500	1905	2,846,901
1868	15,000	1906	3,290,523
1869	16,200	1907	3,722,433
1870	17,844	1908	2,977,490
1871	20,000	1909	3,590,639
1872	23,000	1910	3,979,569
1873	26,000	1911	3,548,322
1874	30,352	1912	3,346,946
1875	99,568	1913	3,831,647
1876	110,342	1914	3,040,361
1877	120,896	1915	2,409,331
1878	131,660	1916	3,019,600
1879	142,666	1917	4,002,759
1880	145,015	1918	4,128,424
1881	296,000	1919	3,059,580
1882	177,340	1920	3,756,881
1883	244,990	1921	3,422,106
1884	166,936	1922	2,601,058
1885	380,250	1923	2,946,007
1886	423,525	1924	2,654,915
1887	772,601	1925	2,522,983
1888	1,215,750	1926	2,584,255
1889	1,030,578	1927	2,631,337
1890	1,263,689	1928	2,519,410
1891	1,056,249	1929	2,591,666
1892	1,140,575	1930	2,290,990
1893	1,208,850	1931	1,837,776
1894	1,131,660	1932	1,604,580
1895	1,163,737	1933	1,404,326
1896	1,202,534		
1897	1,330,192	Total	117,704,731

COAL PRODUCTION (TONS) BY COUNTIES FOR THE YEARS 1923 TO 1933 INCLUSIVE a

County	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933
Chelan	....	....	....	....	....	....	....	....	235	615	362
Cowlitz	114	1,342	1,589	2,676	716	556	....	....	....	586	310
King	663,061	621,471	600,347	535,626	456,230	542,747	645,779	561,813	519,503	492,034	553,490
Kittitas	1,358,359	1,056,606	871,299	1,077,593	1,198,497	1,076,694	1,089,830	949,103	794,557	697,998	498,853
Lewis	113,114	106,647	95,622	53,983	66,935	69,266	80,131	88,166	67,380	63,399	62,676
Pierce	355,715	387,955	402,907	402,188	341,466	284,121	302,539	265,271	182,168	157,103	174,530
Skagit	....	....	....	....	....	....	....	....	....	83	40
Thurston	268,202	282,884	277,521	271,028	279,322	279,353	259,470	202,731	109,421	73,109	24,095
Whatcom	187,442	198,010	273,698	236,161	288,171	266,673	213,917	223,906	164,512	119,653	89,970
Total tons	2,946,007	2,654,915	2,522,983	2,584,255	2,631,337	2,519,410	2,591,666	2,290,990	1,837,776	1,604,580	1,404,326
Total value	$11,401,047	$9,663,890	$8,956,589	$9,587,586	$9,235,992	$8,565,994	$8,630,247	$7,628,996	$5,844,127	$4,781,648	$3,988,285

a From Annual Report State Mine Inspector, 1933.

COAL MINING STATISTICS FOR THE YEAR 1933 *a*

Name of company	*Name of mine*	*Town*	*Tons coal shipped*	*Sold to employees and local trade*	*Used for power*	*Total coal production*	*Coal value at mine per ton*
Chelan County—							
Wenatchee Coal Co.	Dry Gulch	Wenatchee	....	362	......	362	$3.41
Totals for county	....	....	....	362	......	362	$3.41
Cowlitz County—							
Glenz Coal Co.	No. 1	Castle Rock	....	8	......	8	$3.00
Elling-Park Coal Co.	No. 1	Castle Rock	....	268	34	302	2.90
Totals for county	....	....	....	276	34	310	$2.90
King County—							
Alta Coal & Coke Co.	No. 1	Kangley	....	2,064	150	2,214	$2.85
Big Four Coal Co.	No. 1	Palmer	20,602	22,686	215	43,503	2.72
Bianco Coal Mines	No. 1	Issaquah	....	39,110	......	39,110	2.95
B. & R. Coal Co.	Newcastle	Newcastle	....	26,431	......	26,431	2.92
Black River Coal Co.	No. 1	Renton Jct.	....	636	......	636	4.06
Carbon Fuel Co.	Carbon	Bayne	23,007	9,238	......	32,245	2.94
Dale Coal Co.	McKay & Dale	Ravensdale	43,028	14,318	......	57,346	2.33
Desimone Coal Co.	No. 1	Renton Jct.	....	3,133	......	3,133	3.05
Echo Lake Coal Co.	No. 1	Renton	....	66	......	66	2.45
Foster Coal Co.	No. 1	Tukwila	....	482	......	482	2.50
Green River Coal Co.	No. 1	Enumclaw	....	896	13	909	2.50
Harris Coal Co.	No. 1	Issaquah	....	14,210	......	14,210	3.10
Hudson Coal Co.	No. 1	Palmer	....	....	......	Prospect	......
Husky Coal Co.	No. 1	Ravensdale	....	....	......	Prospect	......
Kummer Coal Co.	No. 1	Kummer	....	2,956	186	3,142	3.10
Landsburg Coal Co.	No. 1	Landsburg	....	3,069	154	3,223	2.95
Lawson Coal Mines	No. 1	Lawson	7,012	....	140	7,152	3.14
Morris Bros. Coal Min. Co.	Occidental	Palmer	29,216	12,142	......	41,358	2.59
Navy Coal Co.	No. 1	Cumberland	....	1,336	......	1,336	3.50
Palmer Coking Coal Co.	Durham	Durham	1,167	3,162	10	4,339	2.35
P. C. C. Company	New Black Diamond	New Black D.	172,540	16,633	127	189,300	2.35
Reynolds Coal Co.	No. 1	Issaquah	....	2,416	......	2,416	3.40
Romano Coal Co.	Red Devil	Renton	....	321	132	453	3.00
Springbrook Coal Co.	No. 1	Renton	....	2,139	......	2,139	2.75
Springbrook Mining Co.	No. 1	Renton	....	470	......	470	2.75
Strain Coal Co.	Renton	Renton	....	11,108	......	11,108	2.10
Strain Coal Co.	Coal Creek	Newcastle	....	120	......	120	3.33
Swan Person Coal Co.	No. 1	Ravensdale	....	139	77	216	1.90
Tiger Mt. Coal Co.	Tiger Mt.	Issaquah	....	904	......	904	1.93
West Coast Fuel Co.	No. 1	Cedar Mt.	18,492	47,037	......	65,529	3.35
Totals for county	....	....	315,064	237,222	1,204	553,490	$2.67

a From Annual Report State Mine Inspector, 1933.

COAL MINING STATISTICS FOR THE YEAR 1933—Continued

Name of company	Name of mine	Town	Tons coal shipped	Sold to employees and local trade	Used for power	Total coal production	Coal value at mine per ton
Kittitas County—							
Beekman Coal Co.	No. 1	Roslyn	....	3,757	....	3,757	$3.60
Blue Flame Coal Co.	No. 1	Roslyn	....	2,360	....	2,360	2.73
Cle Elum Coal Co.	No. 1	Cle Elum	....	2,551	....	2,551	3.00
Jonesville Coal Co.	Nos. 1 & 2	Roslyn	....	12,747	....	12,747	3.67
N. W. I. Co.	No. 3	Ronald	106,686	781	3,659	111,126	2.74
N. W. I. Co.	No. 5	Roslyn	102,509	5,315	769	108,593	2.74
N. W. I. Co.	No. 7	Cle Elum	159,952	2,898	458	163,308	2.74
N. W. I. Co.	No. 9	Roslyn	17,852	....	79	17,931	2.74
Roslyn-Cascade Coal Co.	No. 1	Ronald	52,551	7,601	345	60,497	3.23
Roslyn-Cascade Coal Co.	Nos. 3 & 4	Ronald	14,098	33	130	14,261	2.61
Sunset Coal Mining Co.	No. 1	Ellensburg	....	141	97	238	2.75
Superior Coal Co.	No. 1	Cle Elum	....	1,484	....	1,484	2.66
Totals for county	....	....	453,648	39,668	5,537	498,853	$2.83
Lewis County—							
Black Prince Coal Co.	No. 1	Packwood	13,057	2,240	91	15,388	$2.08
Fords Prairie Coal Co.	No. 1	Fords Prairie	5,738	1,413	445	7,596	2.34
Hanaford Coal Co.	No. 1	Centralia	....	310	....	310	2.35
Lincoln Coal Co.	No. 1	Salzer Valley	....	1,772	....	1,772	2.20
Monarch Coal Co.	No. 1	Kopiah	9,411	....	225	9,636	1.90
Morton Coal & Coke Co.	No. 1	Morton	....	788	....	788	3.70
Peoples Coal & Mining Co.	Nonpariel	Centralia	2,987	5,760	267	9,014	2.45
Reliance Coal Co.	No. 1	Chehalis	466	5,474	....	5,940	2.00
Royal Coal Co.	No. 1	Centralia	....	1,341	....	1,341	2.30
Silver Lake Coal Co.	No. 1	Silver Lake	....	67	....	67	2.50
Smith Coal Co.	No. 3	Mendota	3,312	813	365	4,490	2.10
Stoker Coal Co.	No. 1	Centralia	....	5,017	....	5,017	2.28
Wabash Coal Co.	No. 1	Centralia	....	111	....	111	1.92
Wakefield Coal Co.	No. 1	Salzer Valley	....	1,066	....	1,066	1.67
Western Coal Co.	No. 1	Morton	....	68	....	68	2.80
Winlock-Vader Coal Co.	No. 1	Vader	....	72	....	72	2.25
Totals for county	....	....	34,971	26,312	1,393	62,676	$2.17

COAL MINING STATISTICS FOR THE YEAR 1933—Continued

Name of company	Name of mine	Town	Tons coal shipped	Sold to employees and local trade	Used for power	Total coal production	Coal value at mine per ton
Pierce County—							
Blue Bell Coal Co.	No. 1	Wilkeson	...	8	...	8	$3.00
Buralli Coal Co.	No. 1	Wilkeson	...	1,242	20	1,262	4.00
Burn-it Coal Co.	No. 2	Burnett	...	2,906	43	2,949	3.17
Carbon Canyon Coal Co.	No. 1	Orting	...	21	...	21	3.00
Crocker Coal Co.	No. 1	Crocker	...	57	...	57	2.57
Dependable Coal Co.	No. 1	Wilkeson	...	2,399	...	2,399	4.16
P. C. C. Company	Carbonado	Carbonado	138,005	3,137	1,143	142,285	3.46
Peanut Coal Co.	No. 1	Wilkeson	...	4,089	115	4,204	2.91
Queen Coal Co.	No. 1	Wilkeson	57	1,487	51	1,595	3.75
Wilkeson Coal & Coke Co.	Wilkeson	Wilkeson	17,405	1,723	...	*b*19,750	4.13
Totals for county	...	...	155,467	17,069	1,372	174,530	$3.52
Skagit County—							
Skagit Coal Co.	No. 1	McMurray	...	40	...	40	$2.70
Totals for county	...	...	...	40	...	40	$2.70
Thurston County—							
Black Jewel Coal Co.	No. 1	Tenino	...	239	58	297	$2.40
Bucoda Coal Mining Co.	No. 1	Tono	21,913	1,885	...	23,798	2.02
Totals for county	...	...	21,913	2,124	58	24,095	$2.03
Whatcom County—							
Bellingham Coal Mines	No. 1	Bellingham	67,248	18,627	2,741	88,616	$3.38
Blue Canyon Coal Co.	No. 1	Park	...	295	38	333	3.50
Glen Echo Coal Co.	No. 1	Bellingham	...	584	178	762	4.03
Rome Hill Coal Co.	No. 1	Bellingham	...	259	...	259	2.80
Totals for county	...	...	67,248	19,765	2,957	89,970	$3.38
Grand total 1933	...	...	1,048,311	342,838	12,555	1,404,326	$2.84
Grand total 1932	...	...	1,315,028	270,653	17,694	1,604,580	$2.98
Decrease over 1932	...	...	266,717	...	5,139	200,254	$0.14
Increase over 1932	...	...	...	72,185	...	...	...

b Used for coke, 622 tons.

REFERENCES

Bird, B. M., and Messmore, H. E., The float-and-sink testing of fine-size coal: University of Washington Engineering Experiment Station Bull. 46, 1928.

Culver, H. E., The coal fields of southwestern Washington: Washington Geol. Survey Bull. 19, 1919.

Daniels, Joseph, The coal fields of Pierce County: Washington Geol. Survey Bull. 10, 1914.

————, Coal in Washington: University of Washington Engineering Experiment Station Report No. 3, 1934.

Evans, G. W., The coal fields of King County: Washington Geol. Survey Bull. 3, 1912.

Jenkins, O. P., Geological investigation of the coal fields of western Whatcom County: Washington Div. of Geol. Bull. 28, 1923.

————, Geological investigation of the coal fields of Skagit County: Washington Div. of Geol. Bull. 29, 1924.

Landes, Henry, The Coal deposits of Washington: Washington Geol. Survey Ann. Rep't for 1901, vol. 1, pt. 5, 1902.

————, and Ruddy, C. A., Coal deposits of Washington: Washington Geol. Survey Ann. Rep't for 1902, vol. 2, pt. 2, 1903.

————, Notes on Glacier coal field: Pacific Mining Journal, vol. 2, No. 4, 1913.

McMillan, E. R., and Bird, B. M., Coal washing problems of the Pacific Northwest: University of Washington Engineering Experiment Station Bull. 28, 1924.

Saunders, E. J., The coal fields of Kittitas County; Washington Geol. Survey Bull. 9, 1914.

Smith, E. E., Coals of the State of Washington: U. S. Geol. Survey Bull. 474, 1911.

Weaver, C. E., The Tertiary formations of western Washington: Washington Geol. Survey Bull. 13, 1916.

Willis, Baily, Report on the coal fields of Washington Territory: Tenth Census Report on the Mining Industries of the United States, pp. 759-771.

————, Some coal fields of Puget Sound: U. S. Geol. Survey, Eighteenth Ann. Rep't, pt. 3, pp. 399-436, 1898.

————, and Smith, G. O., Tacoma folio: U. S. Geol. Survey Geol. Atlas, folio No. 54, 1899.

Wilson, G. S., Yancey, H. F., and Daniels, Joseph, Preliminary testing of thirteen Washington coals in a powdered coal boiler plant at the University of Washington: University of Washington Engineering Experiment Station Bull. 58, 1931.

Woodruff, E. G., The Glacier coal field, Whatcom County, Washington: U. S. Geol. Survey Bull. 541-I, pp. 13-22, 1914.

Various authors, Analyses of Washington coals: U. S. Bureau of Mines Technical paper 491, 1931.

DIATOMITE

Diatomite, or diatomaceous earth (also known by some 15 other names), is a material that never fails to attract attention when found. As it occurs in Washington, it resembles chalk, being a light-gray to pure-white very fine-grained lightweight material that under slight pressure of the fingers crushes to an impalpable white powder. It is a form of opal, a hydrous silicate ($SiO_2.nH_2O$), that is formed by microscopic aquatic organisms known as diatoms. These minute plant forms, living in all bodies of water, secrete a test or shell of silica; as the diatoms die, the tests sink to the bottom and, accumulating, build up thick deposits of diatomite.

The unbroken individual tests may be of various shapes, depending upon the particular species, but they all are hollow thin-walled cells. The "dead" air held in these minute siliceous chambers gives one of the chief values to the material—that of sound- and thermo-insulation. This same characteristic, with the added feature of exceedingly fine pore space that obtains when different species are packed together, makes diatomite a valuable filtering and absorbent medium. It is also used as a filler in rubber, phonograph records, and in many other products; as a mild abrasive in many polishes and cleansing compounds; and as an easily soluble silica in the chemical industry.

Thick deposits of diatomite occur in swamps and old lake beds of western Washington; but there the organic and sometimes clay content detracts from possible commercial value. By calcining, these deposits might be of use in special cements for pipe covering and other purposes. The much more extensive Miocene deposits of eastern Washington, however, are remarkable for their purity. In fact, there is so little foreign matter with the diatomite that the material lacks binder and so is not sufficiently solid to be cut into blocks, as is the usual California procedure for preparing thermo-insulation. An analysis of Kiona, Benton County, diatomite is indicative of the usual purity of the eastern Washington beds.

Analysis of Kiona diatomite[1]

Silica (SiO_2)	86.25
Alumina (Al_2O_3)	0.62
Iron (Fe_2O_3)	0.80
Lime (CaO)	0.45
Magnesia (MgO)	0.31
Moisture	5.74
Loss on ignition	5.48

Some deposits in Kittitas and Grant counties have produced intermittently for many years. The process is simple, involving exposure of the bed by stripping off the overburden of soil and rock and the mere sacking of the soft chunks and powder for shipment. Some deposits are opened by tunnels; in one, auto trucks go underground for loading. Others had simple disintegrating mills run in connection with the deposits and air-classified diatomite was bagged and shipped. Most of the output has gone to sugar mills; some has been used in special paints and for thermo-insulation; but the market is not well

[1]Analyst, Falkenburg & Co., Seattle.

organized and is most irregular. It is hoped that studies now contemplated will show ways of successfully bonding the powder, so that insulating blocks may be put on the market, and that other uses will be developed to increase and stabilize the demand.

WASHINGTON OCCURRENCES

Hatton deposit, Adams County. This is 10 miles east of Othello in the NE. ¼ sec. 25, (16-30 E.). A 15-foot bed outcrops on the north side of an arroyo. It is reported to have been struck in drilled wells in secs. 23, 24, 25, and 26. A considerable amount was mined about 30 years ago.

Kiona deposit, Benton County. A 20-foot bed of diatomite is partially exposed between basalt flows 3½ miles west of Kiona in the SE. ¼ NW. ¼ sec. 15, (9-26 E.).

E. J. Webley deposit, Grant County. This is near the center of sec. 16, (18-23 E.). Twelve feet of diatomite is exposed, but the total thickness is not known. It is overlain by a bed of clay and a thin layer of basalt. The deposit has been worked intermittently for years and recent shipments have been made. Development is by an open pit and by a ramifying system of tunnels in which pillars of diatomite give support to the roof. A large amount has been mined by shovelling underground directly into trucks.

Several other deposits occur in this general vicinity, as in the S. ½ secs. 16 and 17; SW. cor. sec. 15; N. ½ sec. 20 and 21; most of sec. 22; N. ½ sec. 27; S. ½ S. ½ sec. 27; and near the center of sec. 33, (18-23 E.). One, in the SW. ¼ sec. 22, extends along a low hillside for several hundred feet and has been opened in a face exposing a thickness of 30 feet.

Jacobson deposit, Grant County. The exposure is in a spur in the side of a gully in sec. 17, (18-23 E.), and shows for 150 feet. It has been opened to a depth of 12 feet and has had some development.

Grennell & Son deposit, Grant County. In the NE. ¼ and SE. ¼ sec. 32, (18-23 E.), are two exposures, 2,000 feet or so apart, on what is apparently the same bed. One shows for 500 feet and has been opened to a depth of 30 feet. The diatomite is being used for insulation and other purposes.

Sammamish River diatomite, King County. The white material is exposed in many places in the cultivation of the low fields bordering the river. The thickness and purity of the beds are unknown.

Kittitas Diatomite Co. deposits, Kittitas County. This company controls several deposits in the vicinity of Squaw Creek, the principal one being about 19 miles from Kittitas in sec. 15, (15-20 E.), where a 12-foot bed is exposed for 400 feet. Considerable tonnage has been mined by this and earlier organizations.

East Roza deposit, Kittitas County. East of Roza 1½ miles, in the W. ½ sec. 14, (15-19 E.), is an outcrop extending for several hundred feet. It is exposed to a depth of 10 feet with the total thickness unknown. There was some development here in the past; the overburden of gray clay, broken basalt, and soil was stripped off and the diatomite was milled and shipped.

West Roza deposit, Kittitas County. This is 1 mile west of Roza in the NE. ¼ sec. 17, (15-19 E.). A bed is exposed for 350 feet to a depth of 4 feet that was worked for several years by a Japanese company, the output, it is said, being shipped to Japan. Other companies, also, have operated on this deposit. The diatomite is underlain by basalt and overlain by 6 to 13 feet of clay and sand which is overlain in turn by 2 feet or so of basalt.

Denny deposit, Kittitas County. An old abandoned workings in sec. 10, (15-20 E.), shows a thickness of 12 feet of diatomite.

Clerf deposit, Kittitas County. This is an occurrence 6 miles east of the deposit of the Kittitas Diatomite Co.

McDonald deposit, Kittitas County. East of the pit of the Kittitas Diatomite Co. about ½ mile, in sec. 15, (15-20 E.), is an exposure that is probably a continuation of that company's deposit.

Other Kittitas County deposits are reported to occur in secs. 10, 11, 14, and 15, (15-20 E.), from some of which considerable tonnage was mined many years ago. The average thickness of these bodies is said to be 9 feet.

Parkland deposit, Pierce County. A recent deposit covering 20 acres to a depth of 20 feet or more occurs 1 mile west of Parkland on Rainbow Ranch in sec. 8, (19-3 E.). There has been no development.

Big Lake deposit, Skagit County. On Nookachamp Creek about ½ mile north of the town of Big Lake, diatomite of recent origin is known to occur over an area of 20 acres and has been explored to a depth of 12 feet. There has been no development.

Whatcom County deposits. Diatomite occurs 2 miles or so east of Nooksack in sec. 27, (40-4 E.), covering 2 or 3 acres to a depth of about 6 feet. It has not been developed or fully explored. Deposits of small extent and thickness occur in sec. 9, (40-1 E.), and east part of sec. 18, (40-2 E.), and others in several places have been reported in drilling water wells.

Naches deposit, Yakima County. On the east side of Naches Valley, 6 miles from Yakima in sec. 33, (14-18 E.), a bed of diatomite, that is reported to have a thickness of 30 feet, is exposed to a depth of 10 feet. It outcrops for several hundred feet. Some development has been carried on.

Maple Grove deposit, Yakima County. An occurrence is located 4 miles or so north of Sunnyside in about sec. 35, (11-22 E.). This deposit is of large extent and upward of 16 feet thick. It is not developed.

Selah tunnel deposit, Yakima County. This deposit is exposed in the highway cut just south of Selah tunnel between Ellensburg and Yakima in sec. 9, (14-19 E.). It is too small to be commercial and is none too pure; but it may be easily seen from cars and is often mentioned by tourists.

REFERENCES

Eardley-Wilmot, V. L., Diatomite: Canada Dept. of Mines, Mines Branch No. 691, 1928.

Patty, E. N., and Glover, S. L., Mineral resources of Washington: Washington Geol. Survey Bull. 21, pp. 95-98, 1921.

Sovereign, H. E., Unpublished report: 7227 6th Avenue N. W., Seattle, Wash.

EPSOMITE

Epsomite, magnesium sulphate ($MgSO_4.7H_2O$), is the material known commercially as epsom salts. It occurs naturally as clear crystals, is soluble in water, and has a characteristic salty-bitter taste. It may also occur as white granular masses or crusts. The first form results from slow, quiet crystallization out of oversaturated brines, and the second form from rapid crystallization at the surface of salt lakes and salt-impregnated muds. A large amount of this salt is used by the leather and textile industries and, in purified form, by the drug trade.

WASHINGTON OCCURRENCES

Bitter Lake deposit, Okanogan County. This is a small lake of 4 acres which is known also as Epso, Salts, Poison, and Spotted Lake. It is on Krueger Mountain about 3 miles northwest of Oroville, in the SE. cor. sec. 7, and NE. cor. sec. 18, (40-27 E.). Long evaporation of water containing magnesium sulphate has caused a rather pure epsomite to form between mud segregations to a depth of from 4 to 20 feet. A large tonnage was produced during and for a few years after the war; it was mined during the dry season and at other times dissolved by the addition of other brine. The solid salts were hauled and the concentrated brine pumped to a plant near Oroville where, by simple treatment, the refined salts were prepared for shipment.

Poison Lake deposit, Okanogan County. This lake, known also as Bitter and Epso Lake, is 8½ miles south of Oroville in the NE. cor. SE. ¼ sec. 5, (38-27 E.). Epsomite forms a solid bed about 30 feet thick over an area of 15 acres and is covered by 20 feet of mud. The salt is very pure except for some admixture of fine clay. This deposit was operated with that of Bitter Lake during the war. The salts were mined and hauled to the Oroville plant where they were dissolved in brine pumped from Bitter Lake. Subsequent evaporation produced a refined product for shipment.

REFERENCES

Hill, J. M., and Loughlin, G. F., Magnesium and its compounds in 1922: U. S. Geol. Survey Mineral Resources, pt. 2, pp. 52-54, 1922.

Jenkins, O. P., Spotted lakes of epsomite in Washington and British Columbia: Amer. Jour. Sci., 4th ser., vol. 46, pp. 638-644, 1918.

Shedd, Solon, The mineral resources of Washington: Washington Div. of Geol. Bull. 30, pp. 137-138, 1924.

FELDSPAR

The feldspar minerals are divided into two main groups, orthoclase and plagioclase, and each of these into several varieties. The first group includes the potash-aluminum silicates ($KAlSi_3O_8$) and is the one of chief importance in the ceramic industry. The second group includes sodium-aluminum silicates ($NaAlSi_3O_8$), calcium-aluminum silicates ($CaAl_2Si_2O_8$), and various mixtures of these combinations. They are found as small white and variously colored crystals, showing good cleavage, in granites and as large crystals and massive segregations in pegmatites. Only the latter occurrences are commercially important.

A small amount of feldspar is used as a mild abrasive; and some is employed in other fields; but over 80 per cent of that used in the United States goes to the ceramic industry where it is used in whiteware bodies, glazes, and enamels. The Eastern deposits supply the large ceramic centers and the small Washington market. Local deposits have no importance now; but, as more pottery is made here, and when a whiteware industry becomes established, Washington sources of feldspar will be useful.

WASHINGTON OCCURRENCES

Deer Harbor deposit, San Juan County. Feldspar of very high quality occurs in three pegmatite dikes, 25 to 45 feet thick, and in a fourth of lower grade, 60 feet thick, along the west shore of Deer Harbor in sec. 7, (36-2 W.). It is easily accessible and suitable for porcelain ware. Tests by Hewitt Wilson, Ceramist, U. S. Bureau of Mines, Seattle Station, showed the burned color to be pure white and gave a cone-fusion of 8½.

Analysis of Deer Harbor feldspar[1]

Silica (SiO_2)	75.26
Alumina (Al_2O_3)	15.26
Iron Oxide (FeO)	0.94
Lime (CaO)	0.37
Magnesia (MgO)	1.00
Alkalies (Na_2O)	6.61
(K_2O)	1.33
Loss on ignition	0.39

Pegmatites that possibly could be a source of feldspar occur in the vicinity of Mica Peak in Spokane County and near the borders of the great granite areas of Stevens and Pend Oreille counties. One occurrence that has received some attention is in Pend Oreille County, 8 miles east of Ruby, in sec. 35, (35-45 E.); this proved to be inaccessible and of noncommercial quantity, but it does indicate the possibilities of the area.

REFERENCES

Bastin, E. S., Economic geology of the feldspar deposits of the United States: U. S. Geol. Survey Bull. 420, 1910.

McLellan, R. D., Geology of the San Juan Isands: University of Washington publications in geology, vol. 2, pp. 172-174, 1917.

Spence, Hugh S., Feldspar: Canada Dept. of Mines, Mines Branch No. 731, 1932.

FLUORITE

Fluorite, or fluorspar, is calcium fluoride (CaF_2), a glassy variously colored mineral that usually occurs as cubic crystals. It is a common gangue mineral in the sulphide veins of some mining regions and in a few places forms the bulk of the vein. It is used chiefly by the steel industry as a fluxing material, lesser amounts being used by aluminum, ceramic, and chemical industries.

WASHINGTON OCCURRENCES

No large deposits are known to occur in Washington comparable with those of the eastern states, but a small amount of fluorite has been mined in Ferry County. It occurs there northwest of Keller, near the NE. cor. sec. 24, (30-32 E.), as a 16-inch vein in the Colville granite. About 60 tons were mined in 1918, no production being reported since then. It is an abundant accessory mineral in the phonolite of the Sheridan district, about 9 miles northwest of Republic. A characteristic occurrence is at the American Flag mine, near the NE. cor. sec. 36, (38-31 E.), where it forms up to 30 per cent of the rock mass in certain zones.

Fluorite occurs in Stevens County in association with the quartz gangue at the Germania Tungsten mine, about 17 miles

[1]Analyst, Carl Woods, U. S. Bur. Mines, Seattle Station.

southwest of Springdale in sec. 13, (29-37 E.). It is also reported as occurring with molybdenum in a deposit near Phalen Lake; and it is an accessory mineral of the granite, especially near schist and quartzite contacts, at other places in the county.

REFERENCES

Pardee, J. T., Geology and mineral deposits of the Colville Indian Reservation, Washington: U. S. Geol. Survey Bull. 677, p. 127, 1918.

Weaver, C. E., The mineral resources of Stevens County: Washington Geol. Survey Bull. 20, p. 128, 1920.

FULLER'S EARTH

Fuller's earth is a clay or clay-like substance that has the peculiar property of being able to absorb bases and basic colors, thus removing them from certain liquids such as water and oil. Large amounts are used for clarifying and bleaching all kinds of oils, fats, greases, and waxes. Chemical composition, color, or other physical characteristics are no guide in the determination of fuller's earth. Most earths are nonplastic to weakly plastic and show an "acid reaction" to litmus, due to their absorption of bases. The only sure way to test earth is to try it in actual bleaching work, and then ascertain for what phase of clarifying and for what kind of oil it is best adapted.

The abundant clays of divers origin offer an attractive field for a fuller's earth investigation in Washington. Very little has been done in this regard, although a few silty glacial clays of western Washington were tested with promising results a number of years ago at the University of Washington.

The Pleistocene silts occurring in the vicinity of Oroville, Okanogan County, are reported to have the characteristics of fuller's earth, and some beds might be entirely satisfactory. Similar material is very plentiful in northeastern Washington and should be tested.

A four-foot bed of clay underlying basalt and soil and overlying diatomite at East Roza, Kittitas County, in sec. 14, (15-19 E.), was tested at one time. After pulverizing and roasting, the clay was tried with lard and cotton seed oils; the results were said to be exceptionally favorable.

REFERENCES

Miser, H. D., Developed deposits of fuller's earth in Arkansas: U. S. Geol. Survey Bull. 530, 1911.

Parson, C. L., Fuller's earth: U. S. Bureau of Mines Bull. 38, 1913.

Porter, J. T., Properties and tests of fuller's earth: U. S. Geol. Survey Bull. 315, 1906.

GEM AND ORNAMENTAL STONES

Very little in the way of semiprecious stones has been found in Washington. Garnets of excellent color occur in beach sands of the Olympic Peninsula, but they are too small to be of value; larger ones found in schists of eastern Washington lack the desirable clear color. Amethystine quartz forms part of a vein on the Siegmund ranch, 1 mile north of Clay City in Pierce County; it is reported also from an area 15 miles or so northeast of Republic in Ferry County. Agate and chalcedony are found occasionally in both ancient and present day beach and stream gravels, and are particularly abundant along the upper Newaukum River of Lewis County. Onyx of gem variety was briefly mentioned in a report of 1891 as having been discovered in the Naches district, Yakima County.

Opalized wood is of widespread occurrence in the Columbia Plateau region of eastern Washington, pieces ranging from small fragments to almost entire tree trunks being found occasionally. The original wood grew in sediments laid down on the surface of basalt flows during Miocene time. Later flows inundated the trees and covered the sediments containing buried wood. Eventually some of the remains became silicified or opalized and are now found where exposed by erosion or excavations. The pieces are generally yellow, brown, or variegated in color and show very distinctly the grain of the original wood.

Fire opals have been found at two places as cavity fillings in vesicular basalt. One location is in Moses Coulee in Grant County. No details are available on this report. The other occurrence is in Whitman County about 3 miles northeast of Pullman on the west line of the SW. ¼ sec. 20, (15-46 E.). Precious and fire opals were discovered here in 1890; in 1891 and 1892 several pits were opened and gem stones to the value of nearly $6,000 were produced. There has been no production since then, but there is no apparent reason why it should not be resumed.

Varicolored rock of vivid hue is in some demand for use in stucco and terrazzo. Several deposits are operated intermittently in Stevens County to supply the market. White, green, red, and blue carbonate rocks are used for terrazzo, owing to the ease with which the chips and fragments may be ground in finishing floors. For stucco "dash," any kind of rock of suitable color may be used, as the crushed fragments are only embedded in the wall to give an ornamental effect.

REFERENCE

Sterrett, D. B., Gems and precious stones: U. S. Geological Survey Mineral Resources, pt. 2, p. 874, 1910.

GLASS SAND

See "Silica" and "High-silica sand and sandstone," pages 95-96.

GRAPHITE

Graphite, an elemental form of carbon, is a dark-gray or black greasy-feeling mineral that is soft enough to blacken the fingers and mark paper. It may originate in several ways, but as commonly found in graphitic argillites and schists, it is the product of the metamorphism of carbonaceous matter in the original sediments.

Its refractoriness, high heat and electric conductivity, resistence to acids, softness, and color, give graphite many uses, and a large amount is employed in industry. Of that consumed in the United States, crucibles take 45 per cent; foundry facings, 25 per cent; lubricants, 10 per cent; and pencils, paints, stove polish, and other uses take 20 per cent.

WASHINGTON OCCURRENCES

Many of the pre-Tertiary metamorphic rocks of Washington probably contain sufficient free graphite disseminated through the rock mass to be of commercial importance. A content as low as 2½ per cent is worked in some states, although up to 8 or 10 per cent is more usual, and exceptional deposits may carry up to 50 per cent graphite. Analyses are not available, but a number of promising occurrences in this State are listed. The only production known was in 1890 from the Samish Lake deposit.

Chelan County. Graphite is reported as "veins" or lenses in a graphitic schist near the confluence of Nason and White Pine creeks, several miles west of Nason Creek station.

Graphitic schist is exposed in cuts on the new road leading to Maverick Peak, about 6 miles east of Wenatchee Lake.

A deposit developed by Mr. John Maloney of Skykomish is reported to contain crystalline flake graphite under 0.5 mm. in diameter. Lack of transportation has prevented marketing this material.

King County. Lenses of altered carbonaceous material occur near Skykomish on Foss River, Anthacite Creek, and Maloney Creek in shales adjacent to igneous intrusives. Some are more or less coaly; others are graphitic. Years ago the region was unsuccessfully prospected for coal, and there has been some search for workable bodies of pure graphite. More thorough prospecting, with the idea in view of obtaining commercial graphite by the application of concentration methods, might show value in the impure lenses and, also, in the graphitic sediments.

Lewis County. A good grade of graphite is reported to occur 5 miles from Morton, but more definite location is unknown.

In 1893, the Olympic Graphite Co. of Olympia was developing a deposit said to be situated in Lewis County at the base of the main range of the Cascades at an elevation of 1,500 feet. The reports were that a 15-foot ledge of "trap rock" could be traced for 1,000 feet; it contained segregations of graphite ranging from a few ounces to 30 pounds in weight.

Okanogan County. Graphitic argillite is exposed in cuts on the road along Tonasket Creek about 4 miles northeast of Oroville.

Pierce County. An old report states that, in 1897, graphite, upon which several parties filed claims, was discovered on South Prairie Creek near Wilkeson.

Skagit County. Mr. Wright,[1] Skagit County Engineer, reports an occurrence of graphite 1½ miles west of Big Lake near the east line of sec. 27 or 34, (34-4 E.).

The Pacific Graphite Co. was organized in 1933 to mine a deposit discovered near Blanchard. It is understood this location was abandoned when found to be noncommercial.

Graphitic schist is exposed in trail cuts about 6 miles east of Rockport and 2 miles from the Skagit River road in T. 34 N., R. 35 E. The graphite content appears high enough to warrant investigation.

Skagit or Whatcom County. Fairhaven Graphite Co. was operating near Samish Lake in 1890 and is credited with having shipped graphite to a company at Tacoma who used it in the manufacture of fire-proof paint. Little is known of this occurrence, the old reports mentioning only that surface material was being used, and better quality was hoped for in future work.

Snohomish County. A great quantity of graphitic rock is reported to be exposed by a landslide on Pugh Mountain in the S. ½ T. 31 N., R. 11 E. The location is probably between Bedal Falls and the mountain top near the Lookout Station trail, about 16 miles southeast of Darrington up Sauk River.

Spokane County. A report dated 1906 gave the brief mention of a vein 40 feet wide of high-quality graphitic rock having been discovered east of Spokane on Sheep Mountain.

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[1] Personal communication.

Stevens County. Graphitic schists, which might be a source of commercial graphite, occur near the town of Boundary.

Whatcom County. East of Bellingham, near the head of Anderson Creek, about the center of sec. 16, (38-4 E.), are outcrops of sericite-graphite schist. Samples from here appear to carry considerable graphite.

Whatcom County. About five miles south of Kulshan in the NW. ¼ sec. 13, (38-5 E.), a road cut exposes black graphitic schist. Similar rocks are commonly found in the western part of the county.

REFERENCE

Spence, H. S., Graphite: Canadian Dep't of Mines Bull. 511, 1920.

GYPSUM

Gypsum, hydrous calcium sulphate ($CaSO_4 . 2H_2O$), is a soft mineral which is generally white or colorless when pure. Commercial deposits occur as beds interstratified with sedimentary rocks. Such occurrences resemble limestone, but the mineral is softer than calcite, being easily cut with a knife and even scratched by the finger nail. It has properties which make it a very useful material, especially in the building trades, where a large amount is used annually. Plaster of paris, special plasters and stuccos, plaster boards, and many other products are made from calcined gypsum, and the crude rock is used in Portland cement and for agricultural and other purposes.

Considerable gypsum is now used in Washington, but it is all brought in from other states. No commercial deposits have ever been reported here, although a small amount was mined at one time from a thin layer occurring with magnesium sulphate in Poison (Epso) Lake on Krueger Mountain near Oroville, Okanogan County. (See "Epsomite," p. 42.)

One other occurrence which is being investigated by a Washington company for possible economic value is at the top of Mount Adams, Yakima County. Gypsum occurs there as a cavity filling and as the cementing material of brecciated volcanic debris in the crater of the extinct volcano. It is associated with sulphur and had a similar origin.

REFERENCE

Stone, R. W., and others, Gypsum deposits of the United States: U. S. Geol. Survey Bull. 667, 1920.

LIME

Lime is a manufactured product made by heating limestone in kilns to a temperature sufficient (usually between 1,200° F. and 1,400° F.) to drive off the carbon dioxide and leave calcium oxide or mixtures of calcium oxide and magnesium oxide. A pure limestone is calcium carbonate and "burns" to pure calcium oxide; but some magnesium carbonate is present in almost all deposits, and may amount to a large percentage. The calcined product is still called lime even though the content of magnesium carbonate is high enough for the crude rock to be termed dolomite (theoretically, 45.7% $MgCO_3$). For most purposes, a lime low in magnesium oxide is desirable, and care is usually taken to operate only on rather pure limestone. For some chemical uses other specifications prevail; so rock deposits are selected which will produce lime of the type wanted.

The building trades generally use the greatest percentage of the lime produced. Agricultural uses and general chemical needs (for paper mills, sugar factories, and glass works) take the rest of the output. The industry is an important one in Washington, and for over forty years a high quality of lime has been produced from the relatively pure limestones of the San Juan Islands. Lime has also been burned at various other places where suitable limestone occurs; some of these operations were intermittent or of short duration; others have run for many years, marketing an excellent product.

The smallest annual output of lime in the period from 1904 to 1934 was 17,214 tons in 1933, valued at $170,281. The largest output was in 1906 when 59,094 tons, valued at $347,924, were produced. The average yearly output has been in the vicinity of 25,000 tons. The price per ton has varied considerably: the lowest was $5.76 in 1905; the highest, $13.92 in 1922; and the 1933 price was $6.28.

LIME KILNS NOW OR RECENTLY OPERATING

OPERATOR	*LOCATION*	*COUNTY*
Superior Lime & Mining Co.	Near Entiat	Chelan
Henry Cowell Lime & Cement Co.	W. shore San Juan Island	San Juan
Orcas Lime Co.	W. shore Orcas Island	Do
Tacoma & Roche Harbor Lime Co.	Roche Harbor	Do
Idaho Lime Co.	Evans	Stevens
Eric Carlson, formerly Tulare Mining Co... (Lessee, Crown Willamette Paper Co.)	5 mi. E. of Colville	Do
International Lime Co.	Kendall	Whatcom

LIME KILNS OPERATED AT ONE TIME

OPERATOR	*LOCATION*	*COUNTY*
Th. B. Wuelfinger	Lake Chelan	Chelan
James O'Laughlin	do	Do
J. W. Budd	do	Do
Republic Gold Mines & Lime Co.	Republic	Ferry
John Nopp	Chesaw	Okanogan
Unknown	2¼ mi. N. of Wauconda	Do
Okanogan Lime Co.	Okanogan	Do
Preston Hanley	Brewster-Twisp	Do
Oroville Lime Co.	Oroville	Do
Frank Fox	....	Do
H. L. Martin	Metaline Falls	Pend Oreille
Bunker Hill Smelter	Ione	Do
Tacoma Lime Products & Fertilizer Co.	McMillin	Pierce
Langdon Lime Co.	East Sound	San Juan
Henry Cowell Lime & Cement Co.	"Deer Harbor" deposit	Do
J. A. Soderburg	West Sound	Do
Unknown	NE. shore Orcas Island	Do
Washington Brick, Lime & Sewer Pipe Co.	2 mi. SE. of Springdale	Stevens
Unknown	3 mi. SE. of Valley	Do
Unknown	On Mill Creek, NE. of Colville	Do
Unknown	2 mi. S. of Kettle Falls	Do

LIME PRODUCTION, 1923-1933

Year	No. plants in operation	Building uses		Sugar refineries		Chemical and miscellaneous uses		Paper mills		Total	
		Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1923	6	18,204	$275,887	(a)	(a)	7,691	$83,623	(a)	(a)	25,895	$359,510
1924	6	20,742	266,174	1,500	$20,196	5,946	67,080	(a)	(a)	28,188	353,450
1925	6	21,107	257,337	2,780	37,381	5,749	62,579	(a)	(a)	29,636	357,297
1926	4	18,942	238,330	(a)	(a)	4,841	59,684	(a)	(a)	23,783	298,014
1927	4	14,983	263,338	(a)	(a)	5,018	61,790	3,958	$57,166	23,959	382,294
1928	4	15,217	167,012	(a)	(a)	5,799	61,341	3,513	37,569	24,529	265,922
1929	4	12,926	141,465	(a)	(a)	6,659	66,010	12,013	117,208	31,598	324,683
1930	5	13,301	137,086	(a)	(a)	6,323	59,834	7,289	69,211	26,913	266,131
1931	5	5,248	63,201	17	207	7,408	79,277	7,946	72,348	20,619	215,033
1932	5	5,221	66,982	(a)	(a)	4,029	45,311	9,612	87,324	18,862	199,617
1933	5	2,615	29,961	(a)	(a)	3,769	41,839	10,830	98,481	17,214	170,281

a Included under "Chemical and miscellaneous uses."

REFERENCES

Shedd, Solon, The cement materials of Washington: Washington Geol. Survey Bull. 4, 1913.

Various authors, The mineral resources of Washington: Washington Geol. Survey Bulletins 11, 21, and 30.

U. A. Geol. Survey and U. S. Bureau of Mines Mineral Resources, various years.

LIMESTONE

Limestone, a sedimentary rock composed chiefly of calcite, calcium carbonate ($CaCO_3$), is one of the most important mineral substances of the State. It is the principal material entering into the composition of Portland cement; it is calcined to make lime, which is used in construction work and for many chemical purposes; and the natural rock, sometimes after crushing, is used by paper mills, sugar factories, in metallurgy, and for agricultural and other purposes. The total use of limestone in a normal year may be indicated by the figures for 1926. In that year, approximately 624,000 tons were produced and used here in industry; its value was $5,210,000.

Limestone is widely distributed; but the largest deposits are in eastern Washington, far from the chief centers of use, and, because of the long haul, not now available to western Washington industry. They occur there in Chelan, Ferry, Okanogan, Pend Oreille, and Stevens counties; smaller deposits occur in Kittitas County and on Snake River in Asotin County; and an unimportant occurrence is in Lincoln County at the G. W. Capps talc mine. These limestones have great variation in composition, ranging from very pure varieties to high-magnesia types and dolomite. They are all of pre-Tertiary age, and the one-time sediments, folded and faulted with the associated metamorphic rocks, have become marbles. They have been mined at various places, but at the present time only a few deposits are in production. (See "Lime," pp. 50-53, and "Cement," pp. 85-87.)

The eastern Washington deposits are a great potential source of limestone and dolomite which will become increasingly important as the industrial development of that part of the State advances. They may become available to a larger area as other reserves are depleted and with changes in transportation methods or costs.

The western Washington deposits are relatively small, but they are mostly of high-calcium content and of great economic importance. Some have been in production for many years; others are closely held as reserves; while some deposits have been entirely exhausted. It is realized that limestone is scarce in that part of the State, and already one company has gone to

Alaska for its supply. The various deposits in western Washington may be considered in three groups.

Group one includes the principal deposits of value, located in King, San Juan, Skagit, Snohomish, and Whatcom counties. They are mostly of crystalline type which should be classed as marble, pre-Tertiary in age, and associated with chert, quartzite, argillite, and related metamorphic rocks. They are characterized by a high calcium and low magnesia content. The San Juan deposits are nearly all lenticular or pod-shaped bodies which in only a few instances contain over a million tons of minable rock. They, however, are exceptionally pure and supply most of the lime, paper, and sugar market. The other counties, with a few larger deposits, supply cement plants and have certain high-quality beds which for many years have been important producers of lime.

Group two includes small deposits of limestone in Grays Harbor, Pacific, and Pierce counties. In the first two counties are Tertiary (Oligocene) limestones that are interbedded with sandstones and shales. They are relatively pure and are suitable for agricultural uses, and possibly for lime. The Pierce County deposit is travertine, a Recent spring deposit of cellular calcium carbonate, well-suited to agricultural use, but, unfortunately, nearly exhausted.

Group three includes the little-known but probably very extensive limestone beds of the Olympic Peninsula in Clallam, Grays Harbor, Jefferson, and Mason counties. Examples occur on the road above Lake Cushman in the SE. ¼ sec. 32, (24-5 W.), and in conjunction with nearly all of the manganese deposits of the area. It is a very fine grained hard bluish-gray rock that is generally stained to reddish brown. Analyses are lacking, but appearances indicate a high silica and iron content. There has been no development, unless for the associated manganese; but these beds warrant some investigation with, for example, natural cement rock and lithographic stone in mind.

Reference should be made to Washington Geological Survey Bull. 4, 1913, by Solon Shedd for details of location, description, and analyses of limestone. For convenience, and to list some new occurrences, the known deposits of western Washington (with the exception of those of the Olympic Peninsula) will be catalogued here.

WESTERN WASHINGTON LIMESTONE

Grays Harbor County

East Fork Humptulips River deposit. This is 7½ miles northeast of Humptulips in the north center of sec. 4, (20-9 W.). Limestone forms a small hill 50 feet high by 100 or 150 feet in diameter on the northwest side of the river and also outcrops in a moderately thick bed in the opposite bank of the river.

King County

Denny Mountain deposit. This occurrence is 1½ miles west of Snoqualmie Pass in the W. ½ NW. ¼ sec. 5 and the E. ½ NE. ¼ sec. 6, (22-11 E.). Limestone outcrops in a bed of varying width (up to about 300 feet) for a length of 2,000 feet or so on the steep mountain side. It lies in a series of metamorphic rocks intruded by granodiorite and basic igneous dikes.

Northwestern Portland Cement Co.'s deposits. Several deposits occur on Palmer and Crosby mountains south of Grotto in secs. 13, 24, and 25, (26-10 E.). They have been known as the Baring deposits. The limestone beds are several hundred feet long and from 100 to 250 feet wide and occur in a series of metamorphic rocks intruded by granodiorite and basic dikes.

Pacific County

Bear River deposit. The correct location is probably in the NW. cor. sec. 27 and SW. cor. sec. 22, (10-10 W.), although it is described also as the SW. cor. sec. 21. A prominent rounded hill about 50 feet high and 200 feet in diameter is composed of Oligocene limestone. The deposit appears to be lenticular and is interbedded with shales. An analysis showed 97 per cent calcium carbonate and very low silica and magnesia. A little work was done here at one time; a mill was built to grind the rock for fertilizer, and some stone was burned for lime.

Menlo deposit. Southwest of Menlo 1¼ miles, in the SW. ¼ NW. ¼ sec. 24, (13-8 W.), is an outcrop of a few square feet surrounded by alluvium. It is not commercial but is indicative of the possibilities of the Oligocene sediments of southwest Washington.

Pierce County

McMillin deposit. A small deposit of travertine is near McMillin in the NW. ¼ sec. 18, (19-5 E.). It has accumulated to a thickness of several feet in places and in others forms only a cement for glacial sand and gravel. It has been mined intermittently for many years, supplying agricultural limestone, some fluxing stone, and even was burned for lime.

San Juan County

Roche Harbor deposits. These, in the neighborhood of Roche Harbor, are the largest in the islands and contain a very high quality rock. The Roche Harbor Lime & Cement Co. has operated in this vicinity for many years. There are three large quarries and several smaller ones. Small limestone lenses occur to the south and southwest for several miles.

Orcas Lime Co. deposit. South of Roche Harbor quarry one-half mile, in the SE. ¼ sec. 15, (36-4 W.), is a deposit which was quarried for lime at one time.

Henry Cowell & Co. deposit. This is a large body occurring on the west shore of San Juan Island near the foot of Mount Dallas in the NE. ¼ sec. 23, (35-4 W.). The deposit has been quarried for many years.

Three miles northwest of Friday Harbor is an old abandoned quarry in sec. 34, (36-3 W.). Considerable tonnage remains here.

Limestone Point deposit. This occurs on the north end of San Juan Island in the NE. cor. sec. 18, (36-3 W.). The old quarry here has considerable remaining tonnage.

Mitchell Bay deposits. Several small bodies, mostly in sec. 34, (36-4 W.), are being operated by Puget Sound Pulp & Timber Co.

Rocky Bay deposits. Two small lenses in approximately the SW. ¼ sec. 20, (36-3 W.), are being quarried by the above company.

Many other deposits, probably too small to be commercial or which have been practically worked out, occur on San Juan Island in addition to those listed above.

Orcas Lime Co. deposit. This, known as the "Deer Harbor deposit," is west of Orcas Knob in the NW. ¼ sec. 31, (37-2 W.). It is operated by the company for various crude uses and is also burned for lime.

McGraw-Kittinger deposit. This is on Orcas Island in the north center sec. 2, (36-2 W.). Recently put into production, it has been heretofore the largest undeveloped limestone body in the county.

Langdon (Tacoma Smelter) deposit. The American Smelters Securities Co. operated a large quarry at one time on the east side of East Sound in the SE. ¼ sec. 25, (37-2 W.). They produced rock for calcining and also for crude limestone. Considerable remains of the original large tonnage.

Payton Lime Co. deposit. This is north of the above in the NE. ¼ SW. ¼ sec. 19, (37-1 W.). There are two main lenses and other smaller ones. It is being quarried for crude limestone.

Between Rosario and Olga are several small bodies of limestone, one of which might be commercial in a small way.

J. Soderburg deposit. Limestone occurs west of Orcas Knob in the north center sec. 31, (37-2 W.). It was quarried there at one time.

Imperial Lime Co. deposit. This deposit is southwest of Orcas Knob in the SE. ¼ sec. 36, (37-3 W.). Most of the available stone has been removed by old operations.

West Sound deposits. A small lens occurs to the east of Sheep Island and another on the shore to the southwest of Double Island.

Pineo deposit. A rounded knob of limestone outcrops 2½ miles northeast of Orcas, in the SE. ¼ sec. 3, (36-2 W.), and is being quarried for crude stone. A smaller occurrence nearby may be a continuation of the main deposit.

Between Point Lawrence and the foot of Buck Mountain, on the northeast shore of Orcas Island, are many small limestone lenses. One, in sec. 22, (37-1 W.), was operated for a time for calcining, but was abandoned due to low-grade stone and expense of mining in this particular area.

Other small deposits, probably noncommercial, occur at various places on Orcas Island.

Jones Island deposit. A layer of limestone outcrops on the east shore, 2 miles west of Deer Harbor. This, or a similar bed, shows in the bay on the north end and also on the west shore of the Island. As the bed is only 15 feet or so thick, it would require underground mining.

Henry Island deposits. Several small lenses outcrop along the shore, and a quarry was operated in one larger deposit. Considerable tonnage remains in the main body.

Shaw Island deposits. Several small bodies of probably noncommercial limestone occur along the southwest shore and in the west central part of the island.

Cliff Island. Limestone was quarried at one time on the north shore, 2 miles southwest of Deer Harbor. There was only a small tonnage and the quarry was abandoned.

Skagit County

Concrete deposits. Large deposits of limestone occur in the hills to the north of Skagit River. The Superior Portland Cement Co. has operated quarries for many years to supply their plant at Concrete, and at one time another plant, the Washington Portland Cement Co., was also located there and secured limestone from near that town. The beds are interstratified with quartzite and argillite and show marked variation in purity. They are less lenticular than most Washington deposits, and, by following the strike of the strata, large tonnages are available.

Jackman Creek deposits. These are occurrences north of Van Horn in secs. 4, 5, 8, and 9, (35-9 E.), and also in secs. 35 and 36, (36-9 E.). They are large beds with thicknesses up to 75 feet in places, similar to those quarried at Concrete. They are not developed.

Sauk deposits. Limestone occurs in the hills from 1 to 3 miles north and west of Sauk in secs. 9, 15, and 16, (35-9 E.). Very little prospecting has been done, but the outcrops indicate considerable quantity.

Rockport-Marblemount deposits. Limestone occurs 1 mile north of Rockport, and other bodies outcrop northeast of Rockport and between there and Marblemount. The first occurrence is exposed for 800 feet or so to a width of over 100 feet, and the quality is exceptionally good.

Marble Creek deposit. About 10 miles east of Marblemount and 3½ miles up Marble Creek from the highway, in the NE. ¼ sec. 3, (35-12 E.), is limestone that has not had much investigation. There are indications of considerable tonnage at this place.

Baker Lake. A limestone body on the mountain just southeast of Baker Lake is indicated by "float" found in a dry creek channel there.

Snohomish County

Granite Falls deposits. There are three deposits in the general vicinity of Granite Falls. They are all relatively small, but of workable size and good quality. The Everett Lime Co. operated on one that is 3 miles northeast of Granite Falls in the south center of sec. 9, (30-7 E.). This was in production for a long time and is now practically exhausted. Another body in the NE. ¼ SE. ¼ sec. 5, is being quarried for the paper mills by the Hadelgo Lime & Rock Co. The Everett Lime Co. is likewise operating on this same deposit, the sites of the two companies adjoining. A third deposit, in the NW. ¼ sec. 14, (30-7 E.), was worked at one time. Probably considerable stone is available in these last two deposits.

Galbraith deposit. This is about 6 miles (air line) west of Darrington, near the north line of sec. 23, (32-8 E.), at an elevation of about 2,500 feet. A large body, or series of lenses, outcrops along the mountain side. It has been prospected to a certain extent, but details as to quantity and quality are not available.

Whitechuck deposit. The Whitechuck River trail crosses 35 feet of limestone about 1½ miles up from Sauk River in about sec. 18, (31-11 E.).

Whatcom County

Olympic Portland Cement Co., Balfour quarry. This deposit, near the east line of the NE. ¼ sec. 28, (40-5 E.), has supplied the Bellingham cement company for many years. The limestone is in a large body interstratified with quartzite and argillite outcropping on the west side of Columbia Valley.

International Lime Co. quarry. Their deposit is in the north center sec. 14, (40-5 E.), at an elevation of 1,750 feet on the mountain east of Columbia Valley. A large body of limestone outcrops as a cliff and has been quarried for many years. It is burned here by the company and made into hydrated lime.

Old Northwestern Portland Cement Co. deposits. These occur 1½ miles north of Kendall in the NE. ¼ SW. ¼ sec. 23, (40-5 E.). Isolated small bodies of limestone outcrop here upon which only a small amount of development work has been done.

Maple Falls deposit. This is about 3½ miles northeast of Maple Falls on Boulder Creek in the NW. ¼ sec. 22, (40-6 E.). Another reported occurrence is in sec. 28; they are probably separate lenses in the same series and may be of commercial quantity, although neither is very large. The first was developed a little for marble at one time.

Limestone is reported to occur on the mountain west of Skagit River in about the SW. ¼ sec. 3, (36-11 E.). No details are available, but the deposit is probably very difficult of access.

Considerable "float" in a small stream tributary to Skagit River, about 2 miles below Ruby, indicates that a limestone body occurs above that place.

LIMESTONE PRODUCTION, 1923-1933

Year	*Plants reporting*	*Crushed for road metal and concrete aggregate. Some riprap.*		*Fluxing stone*		*Paper mills and sugar factories*		*Agriculture and miscellaneous*		*Total*	
		Short tons	*Value*	*Short tons*	*Value*	*Short tons*	*Value*	*Short tons*	*Value*	*Short tons*	*Value*
1923	5	(*a*)	(*a*)	31,210	$79,877	10,910	$17,403	11,420	$18,963	53,540	$116,243
1924	5	....	....	22,540	58,908	(*a*)	(*a*)	23,880	49,247	46,420	108,155
1925	6	(*a*)	(*a*)	23,490	19,956	(*a*)	(*a*)	20,790	35,948	44,280	55,904
1926	7	(*a*)	(*a*)	28,370	17,123	24,990	50,032	14,580	11,488	67,940	78,648
1927	6	....	....	24,970	22,127	30,540	62,060	2,120	9,975	57,630	94,162
1928	6	(*a*)	(*a*)	18,480	18,288	40,520	69,805	1,530	9,052	60,530	97,145
1929	7	....	....	18,790	16,259	45,450	77,890	11,200	35,274	75,440	129,423
1930	6	1,050	$ 4,038	21,900	19,734	93,210	131,919	2,970	10,118	119,130	165,809
1931	7	40,000	80,000	18,770	15,266	69,540	104,889	3,290	13,760	131,600	213,915
1932	7	37,200	46,502	17,090	13,241	56,270	97,274	2,050	7,838	112,610	164,855
1933	6	30,820	38,527	14,260	9,981	42,290	73,038	1,480	7,159	88,850	128,705

a Included under "Agriculture and miscellaneous."

REFERENCES

Shedd, Solon, Cement materials and industry in the State of Washington: Washington Geol. Survey Bull. 4, 1913.

————, The building and ornamental stones of Washington: Washington Geol. Survey Ann. Rept., 1902, vol. 2, pt. 1, 1903.

MAGNESITE

Magnesite, $MgCO_3$, a magnesium carbonate composed of 47.6 per cent magnesia (MgO) and 52.4 per cent carbon dioxide (CO_2), is a mineral which occurs in commercial quantities in only a few places in the United States, yet it is of great importance in the steel and other industries. The principal domestic occurrences are in Washington, California, and Nevada; production is from the first two only. As found in Washington, magnesite greatly resembles marble; in fact, it was quarried for building stone long before 1916, when its true character was first recognized. It is slightly more dense than marble, having a specific gravity of 2.9 to 3.1, but it may have the crystalline character and variety of colors (white, yellow, reddish, or nearly black) that is commonly associated with the calcium carbonate. The old U. S. Marble quarry (the present Keystone deposit) is credited with a production of $100,000 in dressed stone sold as marble—not peculiar, considering the fact that magnesite with a hardness of 3.4 to 4.5 is easily cut and takes a beautiful polish.

The Washington deposits now known are all in Stevens County. They are large, some measuring hundreds of feet in their various dimensions; but they are generally without definite boundaries, the magnesite interfingering with the dolomite in which the deposits occur. The quality may have marked variation in the deposit, for high calcium and silica variants form zones in otherwise very pure magnesite. Such features make it most difficult to estimate available tonnages. This becomes more apparent when it is realized that, so far, a chemical analysis is required to distinguish between commercial and noncommercial grades. Nine, or possibly ten, deposits have been discovered, and different estimates have been advanced of the available tonnages and mineral reserves. In 1917, it was thought that several deposits contained over a million tons each, and that the total available quantity lay between 5 and 7 million tons. In 1920, the U. S. Geological Survey stated that more detailed work involving diamond drilling had shown that although there are several million tons of magnesite in Stevens County, it is not all of commercial grade, and that ore containing the low percentage of silica and lime specified by the refractory industry may not exceed 3½ million tons.[1] In 1928 and 1929, and again in 1934 and 1935, the Division of Geology was engaged in detailed work on the whole problem of magnesite occurrence. This study will be continued, and it is expected that the new data on the genesis and structure of the deposits will make possible a revision of estimates to a figure based upon accurate information.

The United States is a large consumer of magnesite, but the supply comes chiefly from Austria-Hungary with lesser amounts from Greece and other foreign countries. When those sources were cut off during the World War, Washington and California supplied the industry. These states still are able to keep part of the market with the aid of a protective tariff which was imposed in 1922. Washington is able to lead in production when competition does not include foreign supplies; so with favorable market conditions, magnesite is an important resource.

The mineral has many uses, chief of which is for basic refractories for the steel industry. For this purpose magnesite is calcined in kilns until all of its carbon dioxide content is driven off. The Northwest Magnesite Company at Chewelah has the largest installation in the United States for producing this "dead burned" magnesite. It is the only operator in the State at present and controls almost all of the known deposits. In order to stabilize its output and utilize certain by-products, the company began in 1928 to produce also a structural material called Thermax for sound-proofing and thermo-insulation.

Another important use of magnesite is in making oxychloride or Sorel cement, a structural material used for special floorings, stucco, and numerous specialties. Magnesium metal may also be made from magnesite; although this is yet a new industry, the use of extra-light alloys of this metal will find an increasing application in replacing steel fabrications in airplanes and structural work.

Most of the Washington production is processed here by those who mine the magnesite. The value of the calcined product is far greater than that of the crude mineral. That larger amount cannot be published without disclosing figures on individual operations, so it is included with the value of miscellaneous resources in the table facing page 11. The tonnage of crude magnesite mined since 1916, with a more or less arbitrary mine valuation (since it was mainly processed and not sold as "crude"), is given below.

[1]Yale, C. G., and Stone, R. W., Magnesite: U. S. Geol. Survey Mineral Resources, pt. 2, p. 15, 1920.

CRUDE MAGNESITE PRODUCTION *a*

Year	Tons mined	Value	Year	Tons mined	Value
1916	715	$5,362	1925	56,060	$560,600
1917	105,175	783,188	1926	79,560	596,700
1918	147,528	1,050,790	1927	77,740	583,050
1919	106,206	743,442	1928	85,900	644,250
1920	221,985	1,664,888	1929	125,000*b*	875,000*c*
1921	No production	No production	1930	85,000*b*	595,000*c*
1922	20,000*b*	140,000*c*	1931	40,000*b*	280,000*c*
1923	73,900	165,100	1932	20,000*b*	140,000*c*
1924	52,860	139,600	1933	65,000*b*	455,000*c*
Total tons mined 1,362,629			Total value $9,421,970		

a From statistics of the U. S. Geol. Survey Mineral Resources, 1916-1923 and of the U. S. Bureau of Mines Mineral Resources and Minerals Yearbook, 1924-1933.
b Estimated from statistics on combined Washington-California production.
c Value based on an arbitrary unit price.

WASHINGTON OCCURRENCES

Finch deposit, 5 miles southwest of Chewelah in the NE. ¼ NW. ¼, NW. ¼ NW. ¼, and SW. ¼ NW. ¼ sec. 30, (32-40 E.). This is the principal quarry and mine of the Northwest Magnesite Company and has been operated since 1916. The mineral is trammed to the plant at Chewelah.

Allen deposit, 5¼ miles southwest of Chewelah in the SW. ¼ sec. 30, (32-40 E.). The quarry on this deposit is about 600 yards south of the Finch quarry. It has been a large producer and is worked intermittently in conjunction with the Finch quarry.

Moss deposit. This is a continuation of the Allen deposit. The Moss quarry is south of the Allen quarry in the NE. cor. sec. 36, (32-39 E.). The two are now worked as one operation.

Woodbury deposit, 1½ miles southwest of the Allen deposit near the NW. cor. sec. 1, (31-39 E.). This deposit operated for a few years after 1916, magnesite being calcined in vertical kilns on the property, but it is now held in reserve.

Keystone deposit, 8½ miles northwest of Valley, near the W. line SW. ¼ sec. 9, (31-39 E.). This property was operated as the U. S. Marble Co. from 1898 to 1903, and a large tonnage of magnesite was shipped as "marble." It was the first deposit in the State to be operated for magnesite, but it is now held idle as a reserve.

Double Eagle deposit, 9½ miles west of Valley in the SE. ¼ sec. 18 and SW. ¼ sec. 17, (31-39 E.). This was one of the early producers of calcined magnesite. Kilns were built on the property and were operated intermittently for several years, the product being trucked to Valley and shipped.

Crosby deposit, ¼ mile southwest of the Double Eagle quarry. A quarry was operated here for a short time and abandoned on account of doubtful quantity and quality.

Red Marble deposit, 10½ miles west of Valley in the SE. cor. sec. 24, (31-38 E.). This is a large body of magnesite that was in operation at one time, the rock being hauled to Valley by truck. Extensive developments were made for quantity production that still lies in the future.

Midnight deposit, 1½ miles west of the Keystone quarry in the NW. ¼ SE. ¼ sec. 7, (31-39 E.). A small quarry has been opened here, but it has not been put into production.

Other deposits of magnesite are known to occur in the 23-mile belt of Stensgar dolomite that trends southwest from near Chewelah. One of these is in sec. 10, (30-38 E.); others will probably be found when market conditions justify prospecting in relatively inaccessible parts of the belt. There is also a possibility of finding entirely new occurrences in other dolomite formations of northeastern Washington.

REFERENCES

Various authors, Magnesium and its compounds: U. S. Bureau of Mines Mineral Resources and Minerals Yearbooks, various years from 1924.

Various authors, Magnesium and its compounds: U. S. Geol. Survey Mineral Resources, various years to 1924.

Weaver, C. E., The mineral resources of Stevens County: Washington Geol. Survey Bull. 20, 1920.

Whitwell, G. E., and Patty, E. N., The magnesite deposits of Washington, their occurrence and technology: Washington Geol. Survey Bull. 25, 1921.

MARL

Marl is the term applied to calcareous soils and also to certain lake deposits containing calcium carbonate. Only the latter are considered here. These deposits are unconsolidated, usually light gray or buff in color, and have no fixed composition. The predominant constituent is calcium carbonate, which occurs as chemically precipitated particles and as shells and shell fragments of fresh-water organisms. Clay, silt, and sand are present in varying amount, and considerable organic material from decayed vegetation may occur.

Marl is a very usable form of calcium carbonate for agriculture. It requires no grinding and is readily used as a soil "sweetener" and, mixed with peat or other materials, as a fertilizer and dressing. It may occasionally be almost pure calcium carbonate and so take the place of limestone for some purposes. When white in color, marl is sometimes ground and used for whiting.

WASHINGTON OCCURRENCES

Deposits are known to occur in the State, but little is known of their size or abundance. It makes up the silty oozes at the bottoms of some lakes, particularly in eastern Washington and forms a few beds and terrace deposits where lakes formerly existed. It has been noted in Clark Lake near Bissell, Stevens County, in lakes northwest of Riverside, Okanogan County, and it probably occurs in many other lakes in limestone regions.

The Booher Lake deposit is 4 miles northwest of Riverside, Okanogan County, in the SW. cor. SE. ¼ sec. 3, (35-26 E.). Exceptionally light colored, almost white, marl occurs on the south, east, and north sides of the lake in a bed formed when the water stood at a higher level. The best exposures are to the north, where open cuts and trenches have been dug in the powdery, chalk-like, only slightly consolidated material. The marl is said to have a depth of 40 feet, and has been traced for 1½ miles to the north up Wagon Road Coulee.

At Crumbacher Lake, in the NE. ¼ sec. 26, (36-26 E.), is another deposit. It is not so high in calcium carbonate as the Booher Lake and occurs to a depth of 8 feet or so under from 1 to 3 feet of overburden.

MICA

Of the several minerals of the mica group, muscovite, $H_2KAl_3(SiO_4)_3$, is the only one of great commercial importance. It is a complex silicate of potassium, aluminum, and hydrogen, sometimes with other elements, which occurs in transparent, usually colorless flakes and sheets in granites, pegmatites, and other rocks. The mica which is so abundant in flakes a half inch or less in diameter ordinarily has no value; but when it occurs over two inches in diameter it begins to be important, if in sufficient minable quantity. The value rises rapidly as the sizes of the sheets increase, reaching several dollars a pound for those over 6 inches in diameter. Its peculiar properties of electric nonconductivity, transparency, elasticity, and remarkable cleavage gives muscovite a wide range of uses in many unrelated industries. Probably 70 per cent or so of the domestic production is used for electric insulation.

Under certain conditions and for special purposes, other members of the mica group have some value. Phlogopite, an amber-colored mica, is mined in eastern Canada; biotite, a smoky or black mica, has been produced occasionally, although there is little market for it; and a variety called vermiculite, which has the property of swelling to a fluffy, flaky mass when heated, is becoming commercially important.

WASHINGTON OCCURRENCES

Very little has ever been done with mica deposits here, and little is known about those that occasionally have been reported. Commercial bodies might be expected to occur in the pegmatites of the northeastern counties, and some have been found just over the line in Idaho.

An old report of 1897 vaguely locates a deposit of "gold mica," probably phlogopite, 1½ miles from Chelan Falls in Chelan County. It is said to be in a ledge traceable for 3,000 feet, outcropping from ¾ to 1½ miles from Columbia River. Prospectors extracted 700 pounds from small "kidneys" which yielded sheets about 2 by 3 inches.

Another report mentions that a deposit occurs on Mad River, north of Leavenworth in Chelan County, and states that a company was incorporated at one time to develop this.

One other mica occurrence, thought to be important enough to be reported in 1896, was said to be near Marcus in Stevens County, 5 miles from Colville River. No other details were given.

Muscovite, in small flakes, is abundantly present in the residual high-kaolin clays of the Freeman-Mica district south of Spokane. It could be recovered in clay washing plants and might prove to be a by-product that would have value to industries requiring flake or ground mica.

At the Denison or Latshaw silica deposit, 12 miles north of Spokane in the E. ½ NE. ¼ sec. 14, (27-42 E.), the quartz of a massive pegmatite forms a prominent rounded hill. It would be expected that large segregations of feldspar and mica would occur also, but they would be less resistant to erosion and so might be in the soil-covered valley surrounding the hill. A shallow pit or well just south of the quartz hill could be entered in 1919; its bottom was entirely in soft, weathered mica, appearing to be biotite, but fresh material would be needed for proper variety determination.

REFERENCES

Horton, F. W., Mica: U. S. Bureau of Mines Information Circular 6822, 1935.

Schaller, W. T., Mica: U. S. Geol. Survey Mineral Resources, 1918.

Sterrett, D. B., Mica deposits of the United States: U. S. Geol. Survey Bull. 740, 1923.

MINERAL PIGMENTS

Mineral pigments and fillers include a wide range of materials whose characteristics have great variety. Ground barite, calcite, dolomite, gypsum, asbestos, silica, coal, graphite, and many other minerals and rocks have properties which make them useful for bodies, fillers, and components of certain paints. Other minerals and aggregates which have a more general application as fillers and pigments are limonite, a hydrous oxide of iron ($2Fe_2O_3.3H_2O$); hematite, iron sesquioxide (Fe_2O_3); and mixtures of these minerals with clay. A clayey limonite is known as yellow ocher; a clayey hematite is called red ocher; while various mixtures and other types prepared by heat treatment are given special names.

WASHINGTON OCCURRENCES

Several limonitic clay and shale deposits have been mined in Washington at various times and used as ingredients of paint. Materials high enough in iron oxide to be useful occur in many places, and some of the more highly colored ones are mentioned here.

Roadcuts on the Pacific Highway, just west of Kalama in Cowlitz County, expose abundant reddish-brown clays which have been tested for use as pigments.

The Aberdeen Clay and Color Co. formerly operated in Grays Harbor County on local materials and on others from Stevens County.

The Mashell Paint Co. of Tacoma at one time operated a quarry in the Mashell River Canyon, Pierce County (between the Chicago, Milwaukee & St. Paul Railway and the Mount Rainier Highway), on a shale carrying 20 per cent iron oxide. A pigment was produced similar in color to Italian burnt sienna.

The Clay City deposits in Pierce County, operated by the Far West Clay Co., contain highly colored clays carrying over 12 per cent iron oxide. Similar materials are abundant in that vicinity and can produce sienna.

The Vera deposit, 2 miles east of Chester in Spokane County, has bright-red and yellow clays under the 15 feet of gray clay that is used for ceramic purposes.

Four miles north of Tekoa in Spokane County, near the north center of sec. 25, (21-45 E.), roadcuts expose a bright-red fine, even-textured clay.

Near the Idaho line, southeast of Saxby station, a cut on the Chicago, Milwaukee & St. Paul Railway exposes bright-red and yellow clays that appear to have characteristics suitable for pigments.

The Deer Park Ocher and Sienna Co. deposit, 7 miles north of Deer Park in Stevens County, SW. ¼ sec. 34, (30-42 E.), has received considerable attention and has produced pigment material for commercial use. Here, a thick bed of gray buff-burning clay is underlain by 3½ to 5 feet of ocher in which occurs 2- to 6-inch layers of sienna. The analysis and results of tests made on this pigment are given by Wilson (see references).

Near Yelm in Thurston County, in secs. 4 and 6, (17-1 E.), is a deposit of limonite (bog-iron), 2 to 6 feet in thickness, which carries 54.05 per cent iron oxide, 14.9 per cent silica, and 7.25 per cent alumina. A plant designed to utilize this material for paint was installed at one time but was incapable of giving the necessary fine grinding.

Sumas Mountain, northeast of Bellingham in Whatcom County, has on its west flank large beds of shales which carry an unusually high amount of iron oxide. The colors are not bright, but some of the shales might be useful material, after treatment, for fillers or pigment. Even brighter colored red shales occur at the north end of Sumas Mountain near the center of the N. ½ sec. 7, (40-5 E.).

REFERENCE

Wilson, Hewitt, Ochers and mineral pigments of the Pacific Northwest: U. S. Bureau of Mines Bull. 304, 1929.

.........................., Iron oxide mineral pigments of the United States: U. S. Bureau of Mines Bull. 370, 1933.

MINERAL WATERS

Mineral waters, in the general use of the term, commonly issue as springs carrying a sufficient content of dissolved minerals to give them a characteristic or noticeable taste, odor, or medicinal effect. They may occur also as salt or alkaline lakes. There are many such sources of water in Washington, they vary greatly in temperature from cold to very hot, and they exhibit a wide range in mineral content. Some are chiefly popular for bathing; others, for their curative effect on certain ailments; and some, for their palatability as table drinks.

At various times the waters of certain springs and lakes have been bottled and sold, and figures are available from 1903 to 1923 on the value of the output. At the latter date the Bureau of Mines discontinued that canvass, so more recent data are not available. However, the production figures do not represent the actual money value of this resource to the State. The real amount can only be estimated, for it is involved in the money tourists, vacationists, and invalids spend in traveling to and from the springs and lakes and for the accommodations supplied at those places. The available statistics show that the highest reported value was $28,777, reached in 1914. This was for bottled water only, and takes no account of the money received by hotels and operators of resorts where mineral waters are exploited, so the actual figure is no doubt many times the one given. Since most of the mineral springs are located in mountainous regions of great scenic beauty, they give added attraction to tours and serve as interesting destinations for outing parties. Consequently, as transportation facilities and hotel accommodations at the various springs and lakes have improved, the real value of these resources has steadily increased.

PRODUCTION OF MINERAL WATERS, 1903 TO 1923

Year	*Quantity (gallons)*	*Value*	*Year*	*Quantity (gallons)*	*Value*
1903	55,000	$10,550	1913	150,498	$18,834
1904	24,900	10,580	1914	180,787	28,777
1905	30,000	10,101	1915	158,865	11,703
1906	38,500	10,800	1916	151,528	9,476
1907	68,400	10,820	1917	155,265	7,265
1908	38,900	13,650	1918	No data	No data
1909	39,260	15,958	1919	165,911	5,093
1910	31,200	12,571	1920	162,560	5,888
1911	148,800	14,654	1921	140,442	5,536
1912	156,171	17,542	1922	117,399	6,389
			1923	124,273	11,883

MINERAL LAKES

Soap Lake, in Grant County, is one of the many salt and alkaline lakes occurring in the more arid portion of eastern Washington. It is readily accessible and for many years has attracted visitors who are interested in the scenery or who wish to bathe in its waters. Sodium carbonate, sodium sulphate, and sodium chloride predominate, while minor amounts of other chemicals are present. Hotels and cottage camps are available for those coming to the lake, and salts derived from the water have been on the market in package form.

Medical Lake, in Spokane County, has always been popular with vacationists and those desiring a mild mineral water. Sodium chloride, potassium chloride, and sodium carbonate are the chief chemical constituents, although others are present in small amounts. The lake is easily reached and facilities are available for transients.

The many other so-called alkaline lakes have received no particular attention from those interested in "mineral waters," although there is no reason why certain favorably located ones should not be popularized. Some are discussed further under the heading of "Sodium compounds" (see p. 97).

MINERAL SPRINGS

Soda Springs — Chelan County

About 8 miles west of Wenatchee Lake, near Little Wenatchee River, NW. ¼ sec. 10, (27-15 E.). A small flow of cold water, well charged with carbon dioxide; strong iron taste, but not unpleasant. The Soda Springs Guard Station and a camp ground is nearby, reached by a good road from Lake Wenatchee.

Soda Spring — Chelan County

At water's edge by trail crossing Little Wenatchee River at Ford Camp, W. ½ sec. 13, (28-13 E.). A moderate flow of clear, sparkling water that has a "rusty" taste.

Sol Duc Hot Springs — Clallam County

South of Lake Crescent and about 12 miles from the Olympic Highway. NW. ¼ sec. 32, (29-9 W.). Several springs with a moderately large flow of hot sulphur water occur near Sol Duc River. They are well developed, being pumped to a natatorium and baths run in connection with a hotel and large cottage camp. A good road connects with the highway.

Olympic Hot Springs — Clallam County

About 10 miles up Elwha River and Boulder Creek by good road from the Olympic Highway. NW. ¼ sec. 28, (29-8 W.). Twenty-one springs with a large combined flow of hot sulphur water (130° F.). They are well developed and supply a natatorium and baths run in connection with a modern hotel and cottage camp.

Soda Springs — Cowlitz County

Located on Green River, a branch of Toutle River, in the NE. ¼ sec. 2, (10-4 E.), and reached by a Forest Service trail. There are two saline springs here of warm carbon dioxide-charged water containing some iron.

"Flaming Geyser" — King County

On Green River about 14 miles east of Auburn. South center sec. 27, (21-6 E.). This is a drilled well from which cold salt water and inflammable gas issues in "heads." The interval between and the amount of the flows vary considerably. Gas also issues naturally from a creek bed nearby. An auto camp park has been developed here.

Diamond Mineral Spring King County

In Green River Valley east of Auburn. SW. ¼ sec. 2, (21-7 E.). A small spring of cold, slightly mineralized water containing a small amount of inflammable gas issues from a concreted basin.

Scenic Hot Springs King County

Located near the station of Scenic, 12 miles east of Skykomish. This is a group of fairly warm springs (112° F.) that have a moderate flow of sulphur water. They were developed at one time and used for baths at a resort that was located here.

Green River Hot Springs King County

At the station of Hot Springs on the Northern Pacific Railway. The springs here were at one time a prominent resort attraction. The Green River area is now reserved for Tacoma's water supply, so visitors are not permitted in the district.

Skykomish Soda Springs King County

By Skykomish River, ½ mile east of Miller River. Two springs with a small flow of cold carbon dioxide-saturated water are located on the river bank.

Money Creek Soda Springs King County

These small springs are located on Money Creek about 3 miles upstream from Skykomish River in the SE. ¼ sec. 30, (26-11 E.).

Mineral Spring Kitsap County

A well-mineralized spring, said to have been popular with the Indians of early days, is reported to exist near Bremerton. (Probably a spring containing some sulphur which occurs at Port Orchard; utilized at one time for drinking water.)

Klickitat Mineral Springs Klickitat County

Two miles up Klickitat River from the town of Klickitat. NW. cor. sec. 23, NE. ¼ sec. 24, (4-13 E.) and N. ½ NW. ¼ sec. 19, (4-14 E.). Many springs of cold palatable water, well charged with carbon dioxide, occur here. The gas from the largest springs, amplified by that from drilled wells, is piped to the plant of the Gas-Ice Corporation where it is compressed into solid cakes of "dry ice" and shipped for refrigeration purposes. (See also "Carbon dioxide," p. 16.) The water is bottled by the company and shipped for use as a sparkling, effervescent table water.

Blockhouse Mineral Springs — Klickitat County

Seven miles west of Goldendale at Blockhouse. These springs have been developed for use in baths in connection with a hotel located nearby.

Summit Creek Soda Spring — Lewis County

About 4½ miles by trail from the Carlton Creek bridge on the Ohanapecosh Hot Spring road. Near the center of sec. 18, (14-11 E.). This is a single small flow of palatable cold carbon dioxide-charged water. It is not developed.

Ohanapecosh Hot Springs — Lewis County

In the SE. corner of Mt. Rainier National Park. SW ¼ sec. 4, (14-10 E.). There is one principal spring and adjacent to it are several small ones. The temperatures range from slightly warm to very warm. The water has a moderate soda and sulphur content and is piped to the natatorium and baths of a hotel and cottage camp. The springs are reached by a good road from the main highway.

Alpha Mineral Springs — Lewis County

At Alpha, 15 miles east of Chehalis. These springs were developed and put in commercial production at one time.

Longmire Springs — Pierce County

At Longmire, in the south part of Mt. Rainier National Park. This is a group of springs that have been well known since the early days of this country. They range in temperature and mineral content from cold carbon dioxide-charged springs to hot sulphur-iron springs. The flow from individual springs is only moderate. They are readily accessible to visitors by car to the Park.

Government Springs — Skamania County

About 15 miles northwest of Carson in sec. 31, (5-7 E.). These have a fairly large flow of cold water containing carbon dioxide and some iron. They have been developed, and a hotel is located nearby.

Collins Hot Spring — Skamania County

This hot spring at Collins is said to have been covered and ruined by railway grading operations.

Rock Creek Hot Spring — Skamania County

Located about 4 miles northwest of Stevenson on Rock Creek in NE. ¼ sec. 27, (3-7 E.).

Moffett's Hot Springs — Skamania County

This location is 1½ miles northwest of North Bonneville in the SW. ¼ sec. 15, (2-7 E.). The hot springs have been developed and a camp or hotel constructed there.

Little Soda Spring — Skamania County

About 13 miles northwest of Carson in the SE. ¼ sec. 5, (4-7 E.). This spring has a very small flow of cold water carrying carbon dioxide and some iron. It is not developed.

St. Martin Hot Springs — Skamania County

One mile east of Carson in the SE. cor. sec. 21, (3-8 E.). The group of springs have a fairly large flow of very warm water. The water is not unpleasant for drinking and is also used to supply the baths of the hotel located here.

Sulphur Creek Hot Springs — Snohomish County

These springs are located on Sulphur Creek, a tributary of Suiattle River, in the SE. ¼ sec. 18, (32-13 E.). They are reached by a Forest Service trail.

Kennedy (Byrne) Hot Springs — Snohomish County

These are on Whitechuck River, 23 miles east of Darrington near Glacier Peak, in the NE. ¼ sec. 1, (30-12 E.). There are two groups of springs which have a very small flow of fairly hot water containing carbon dioxide, iron, and sulphur. A Forest Service camp is situated here.

Garland (Star) Mineral Springs — Snohomish County

Located on North Fork Skykomish River in the north center sec. 25, (28-11 E.) and reached by about 14 miles of good road from Index. The four principal spring groups have a moderate flow of water ranging from 50° to 84° F. They vary considerably in mineral content, and, being low in sulphur and iron, have a not unpleasant taste. They have been developed and supply a natatorium and baths in conjunction with a modern hotel and cottage camp.

Schafer's Medical Springs — Spokane County

These springs, located near Dishman, were developed for medicinal purposes at one time.

Olympia Hygeian Spring — Thurston County

Water from this cold spring, located at Tumwater, was bottled at one time and sold for table use.

Baker Hot (Morovitz) Springs — Whatcom County

Located about 3 miles northwest of Baker Lake on Morovitz Creek in the SE. ¼ sec. 19, (38-8 E.). This is a warm spring with a small flow of sulphur water. A Forest Service camp is situated here.

Klickitat Soda Spring Yakima County

This is in Klickitat Canyon, 25 miles northeast of Mt. Adams in the SW. ¼ sec. 26, (11-13 E.). It is a large spring of cold water well charged with carbon dioxide. It is not developed and should not be confused with the Klickitat Mineral Springs near the town of Klickitat.

Goose Egg Soda Springs Yakima County

These springs on Milk Creek, tributary of Tieton River, are in the NW. ¼ sec. 4, (13-14 E.) and are reached by 2 miles of trail from the Tieton River Highway. They have a large flow of cold water containing carbon dioxide and considerable iron. There has been no development.

Ahtanum Soda Springs Yakima County

These springs are located near Yakima in the NW. ¼ sec. 17, (12-15 E.). There are several groups with a moderate flow of cold water charged with carbon dioxide. The water has a pleasant taste. A camp ground has been developed here.

Artesian Mineral Well Yakima County

Located in the city of Yakima, this well, with its large flow of hot water (92° F.) containing various minerals, is utilized to supply water to a natatorium.

Bumping River Soda Spring Yakima County

This is about 6 miles up river from the American River post office in the NW. ¼ sec. 34, (17-13 E.). It is a cold spring with a moderate flow of palatable carbon dioxide-charged water. It is accessible to a Forest Service camp.

Quartz Creek Soda Spring Yakima County

This is a small spring of cold carbon dioxide-charged water which is located on West Quartz Creek and is reached by 4 miles of trail from the Crow Creek Guard Station.

MOLDING SAND

Molding sand for foundry use has no definite, identifying physical or chemical characteristics. In general, the grains should cohere when slightly damp, be refractory enough to withstand the molten metal, have a texture suitable to the work at hand, and be permeable enough to allow the escape of steam and gases. The only satisfactory way to determine if a given sand is suitable is to have it tested by use at a foundry.

WASHINGTON OCCURRENCES

Montesano deposit — Grays Harbor County

A deposit of sand owned by the City of Montesano occurs 1¼ miles west of town in the bluffs along the east side of Wynoochee River Valley. A pit, exposing a thickness of 50 feet, has produced several hundred carloads and was being worked in 1934.

C. W. Miller deposit — Grays Harbor County

This adjoins the Montesano deposit on the north and has produced molding sand.

Other pits in this vicinity have been worked from time to time. The deposits are extensive and very satisfactory for molding purposes.

West Aberdeen deposit — Grays Harbor County

This is of recent development and was being worked in 1934. The sand is reported to be at least 50 feet thick and satisfactory for molding use.

East Aberdeen deposit — Grays Harbor County

A clayey sand that has been used rather extensively by foundries outcrops in the upper part of cliffs above the highway along Chehalis River in the northern part of sec. 10, (17-9 W.). The bed is over 50 feet thick and is only partly exposed in the pits that have been opened.

Cedar Mountain deposit — King County

Sand, occurring on a low bench on the north side of Cedar River near the bunkers of the Cedar Mountain Coal Co. in sec. 19, (23-6 E.), has been worked extensively and is practically exhausted. A new pit has been opened recently on the mountainside nearby, but it is doubted if any great quantity of sand is available.

Ellensburg deposit — Kittitas County

On the east side of Craigs Hill in the northeast part of Ellensburg a fine clayey sand occurs which has proved to be very satisfactory for foundry use, several hundred tons having been shipped during the last 10 or 12 years. The deposit is not unlimited but still contains an ample reserve tonnage.

Steilacoom deposit — Pierce County

The Pioneer Sand & Gravel Co. is reported to have produced some molding sand at one time in connection with their sand and gravel output from the Steilacoom pits.

McKinley deposit — Spokane County

This deposit is 5 miles from Spokane in sec. 26, (26-42 E.). It is said to have been prospected over an area at least 400 by 100 feet and to underlie 18 inches of overburden. The depth is not known. There has been no production, but the sand is said to have been satisfactory in tests.

Some production of molding sand has been reported from other places, as for instance, from Spokane County during the war, and from Whatcom County (Lind Gravel Co.) a number of years ago. There is no question but that many more deposits than have been mentioned are available, and tests of sands that appear favorable would probably prove deposits to exist near many centers of use. (See also, "Sand and Gravel," pp. 90-93.)

PEAT

Peat is a swamp material which results from the accumulation of plant remains and their alteration products under conditions of deficient oxygen and excess water. It may be of various kinds, depending on type of original vegetation, depth of water, and conditions of deposition, and its characteristics and economic value are equally varied. Muck is an alteration product derived from peat by the action of micro-organisms in the presence of air. The following table from A. P. Dachnowski-Stokes[1] classifies peat and describes the chief varieties.

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[1]Dachnowski-Stokes, A. P., Instructions for field work in peat and muck resources: U. S. Dep't of Agriculture, Soil Survey Div., Bureau of Chemistry and Soils: Mimeographed pamphlet.

CHARACTERISTICS OF DIFFERENT CLASSES OF PEAT AND MUCK

Major classes of peat and muck	*Subdivisions (types) of peat and muck*	*Vegetation sources of peat and muck*	*Color of peat and muck*	*Texture of peat and muck*	*Structure of peat and muck*
I. Sedimentary peat	Oozy, macerated or pulpy peat	Aquatic	Olive-green, brown to black	Coarse to very fine grained, pasty	Amorphous, soft, sticky, impervious
	Calcareous sedimentary peat		Gray to grayish brown or cream-colored	Coarse to finely divided	Gritty, crumbly
	Silicious sedimentary peat		Grayish brown to black	Fine grained	Plastic to friable
Ia. Sedimentary-fibrous peat	Cattail peat, Tule peat, etc.		Dark brown to black	Partly stringy fibered, sticky to platy	Dense, plastic to lumpy
II. Fibrous peat	Reed peat	Marsh	Yellowish, reddish to dark brown	Coarse to fine fibered, loamy to powdery	Matted to felty, porous, brittle
	Sedge peat		Reddish brown to dark brown	do	Do
	Hypnum-moss peat		Yellowish brown to dark brown	Fine fibered	Loose to firm porous
	Sphagnum-moss peat	Bog	Yellowish brown to dark reddish brown	Coarse to fine fibered	Spongy porous to fluffy
IIa. Woody-fibrous peat	Heath-shrub peat		Brown to dark reddish brown	Partly fibered, coarse fragmented	Firm, lumpy
	Willow-alder peat	Swamp forest	Brown to very dark brown	Partly fibered to coarse woody, granular	Sticky to loose crumbly
	Bay-shrub peat		Brown to blackish brown	do	Compact, sticky to lumpy
III. Woody peat	Coniferous woody peat		Reddish brown to dark brown	Coarse woody fragments to granular	Loose to firm, lumpy or crumbly
	Mixed woody peat		Brown to dark brown	Woody fragments to loamy granular	Lumpy to friable
	Deciduous woody peat		Dark brown to black	do	Lumpy to mellow loamy

Some kinds of peat have little, if any, use in agriculture; others improve the physical properties of certain soils and, to a certain extent, may be chemically beneficial. Their use is determined by a careful study of crops, soil, and peat, and may involve milling and treatment of the peat and combining it with fertilizers. Sphagnum-moss peat has additional uses as bedding for cattle, absorbent for some liquids, packing for perishable vegetables, either wet or dry, and as a root pack for nursery stock in both growing and shipping.

WASHINGTON OCCURRENCES

Peat of one kind or another is rather common in Washington, but only a few deposits have had commercial production. Rigg,[1] who has studied peat bogs for many years, mentions 48 that he has investigated in this State.

Soper and Osbon[2] report, "The largest areas of high-grade sphagnum moss in this country are in Washington and Oregon. It is estimated that there are 25,000 acres of bog land in the western part of Washington alone, much of which is overgrown by sphagnum moss suitable for surgical dressings and packing material. Some of this moss grows in climbing bogs, and in a few of the bogs the center is higher than the margin, a condition favorable for the growth of surgical sphagnum."

It should be possible to produce various types of peat economically if the market for such material ever warrants the development. The deposits have not the great extent of those of some other states or of British Columbia. The authorities quoted above consider the topography unfavorable for the accumulation of large deposits but mention that many small undrained areas adjoining lakes and rivers in the central and eastern parts of the State contain small peat beds. They write that peat has been reported in some of the lakes and river valleys of Cowlitz, King, Pierce, and Snohomish counties, but most of it is believed to be high in ash and unfit for fuel. As to this particular characteristic, Washington has abundant coal and so need not look to peat for fuel for a long time, but agriculture and certain other industries may derive benefit from the utilization of peat in other ways.

A peat bog in Whatcom County is being operated by the Washington Peat Co. of Deming. The deposit contains about 25 acres near the center of the E. ½ sec. 14, (38-5 E.). Sphagnum peat that has only a scant cover of brush occurs to a depth of 4 feet. This is underlain by 2 feet of sticks and woody material and an unknown depth of brown, decomposed peat.

[1]Rigg, G. B., The utilization of sphagnum bogs on the Northwest Coast: Am. Peat Soc. Jour. 18, Jan., 1925.

[2]Reference at end of section.

The company marketed 10,000 bales of 100 pounds in 1935 and 1936 and reports a sufficient supply to furnish 6,000 bales per year for 12 years.

A cranberry bog near North Beach, Pacific County, covering 960 acres in secs. 21, 22, 27, and 28, (10-11 W.), is underlain by peat said to be from 6 to 30 feet deep, with an average depth of 15 feet. The old Milton swamp, Pierce County, now in berry culture, probably contains an extensive deposit of peat of sphagnum type. A small quantity of peat has been dug from deposits on Fennil Creek, 4 miles or so southeast of Sumner, Pierce County. A deposit on Whidby Island was operated for a time, but poor quality and drainage difficulties caused abandonment. Another peat bog is reported to occur in the Mt. Hill district east of Oroville, Okanogan County. All of these and many others are a potential source of commercial peat.

PRODUCERS OF PEAT

OPERATOR	*LOCATION*	*REMARKS*
Washington Peat Co.	Deming	Producing and marketing
E. F. Gregory	Tacoma	Do
D. D. Johnson	Seattle	Producing
Krause's Nursery & Greenhouse	Spokane	Reported in operation
Charles Hart	Spokane	Do
P. A. Krebes	Spokane	Do
Marshall Greenhouse	Marshall	Do
E. L. Forbus	Port Angeles	Do
E. C. Balzer	Spokane	Do
A. Morrison	Greenacres	Do
Pacific Coast Coal Co.	Seattle	Past operation reported

REFERENCES

Dachnowski-Stokes, A. P., Grades of peat and muck for soil improvement: U. S. Dep't of Agriculture Circular No. 290, Aug., 1933.

————, Moss peat, its uses and distribution in the United States: U. S. Dep't of Agriculture Circular No. 167, June, 1931.

————, Factors and problems in selection of peat lands for different uses: U. S. Dep't of Agriculture Bull. 1419, October, 1926.

Odell, W. W., and Hood, O. P., Possibilities for the commercial utilization of peat: U. S. Bureau of Mines Bull. 253, 1926.

Rigg, G. B., Physical conditions in sphagnum bogs: Botanical Gazette, vol. 61, pp. 159-163, 1916.

————, The utilization of sphagnum bogs on the Northwest Coast: Am. Peat. Soc. Jour. 18, Jan., 1925.

————, Some sphagnum bogs of the Pacific Coast of North America: Ecol. 6, pp. 260-278, 1925.

————————, and Richardson, Carl T., The development of sphagnum bogs in the San Juan Islands: Am. Jour. Botany 21, pp. 610-622, 1934.

————————, Puget Sound Peat, Northwest Gardens, Seattle, Jan., 1935.

Soper, E. K., and Osbon, C. C., The occurrence and uses of peat in the United States: U. S. Geol. Survey Bull. 728, 1922. (Washington reference on pages 80 and 202.)

PETROLEUM AND NATURAL GAS

Geologic conditions are such that the occurrence of oil and gas in certain parts of Washington is to be expected. Already, one commercial gas field has been developed, and a second one is on the verge of commercial production. Gas has become a valuable resource, and the indications are that its importance will increase. Oil, too, has been produced, though not commercially, and there is no apparent reason why it should not become an important resource in some present or future test.

Some areas of the State are unfavorable for the occurrence of oil or gas because of the igneous and metamorphic rocks making up those parts. They include the general region of the Cascade Mountains, the mountainous portion of the Olympic Peninsula, the Okanogan Highlands (comprising the northern row of counties east of the Cascades), and most of the eastern tier of counties. The most favorable areas, in general, are those of Tertiary marine formations lying north and west of the Olympic Mountains, throughout southwestern Washington, and in parts of the Puget Sound region. Other places of more restricted area and where the chances are mostly in favor of gas production are in the western part of Whatcom and possibly Skagit counties, and parts of eastern Chelan and Kittitas counties. A large area that warrants attention, but which is unique and would not normally be considered favorable, is in the Columbia basalt plateau of central and south-central Washington with adjacent areas east of the southern Cascades. This basalt region attained promise when gas was discovered in Benton County.

It should be understood that even in the most favorable formations, accumlations of oil and gas will occur only where structural conditions are right. If tests are to be made, a very careful, detailed study is necessary to locate places where drilling is warranted. In all the more promising areas there are (1) formations which contain source material for gas or oil, (2) porous and impervious beds that could hold and retain the hydrocarbons, and (3) anticlines and other structural forms which could concentrate them into commercial accumulations. In addition, several bona fide oil seeps are known, so there is proof that oil exists, at least in small amount, in a number of places. Drilling during the past fifty years has been in some instances on favorable structures, but an unfortunately large number of tests were put down without regard to geologic data or were abandoned before completion, owing to various misfortunes. This pioneering has developed a commercial gas field in Benton County, has proved the existence of gas in what is probably commercial quantity in Whatcom County, and has shown considerable gas to occur in other localities. It also has given showings of oil in a number of wells and a considerable amount in a few. The indications extant and the results so far attained give ample justification for the thorough testing of geologically favorable locations.

WASHINGTON OCCURRENCES

The Rattlesnake Hills of Benton County are a prominent topographic feature extending northwest from the north central part of the county. They were formed by a pronounced arching of the Yakima basalt and, presumably, such formations as may underlie it. A well drilled for water in 1913 on the north flank of this anticline struck gas at a depth of about 700 feet in basalt. No use was made of it until in 1929, when, several other producing wells having been drilled, the gas was piped to towns of the Yakima Valley. Up to the present time, no well has gone through the basalt, although one has been drilled to a depth of over 2,200 feet; so the total thickness of that rock and the nature of what underlies it are unknown. There are now 15 wells in secs. 18, 20, 21, 27, 28, and 29, (11-26 E.), all producing from depths of 700 to 1,260 feet in basalt. The pressure has always been remarkably low and all wells are pumped. The field is operated by the Northwestern Natural Gas Corporation; and the gas is distributed by adequate pipe lines and laterals to Grandview, Granger, Mabton, Sunnyside, Prosser, Toppenish, and Zillah, where it is used principally for domestic purposes.

DISTRIBUTION DATA, RATTLESNAKE GAS FIELD

PIPE LINES	Miles	Sizes (inches)
Connecting wells	2 2 1 3	6 4 3 2
Between wells and compressor	1	10
Compressor to Toppenish	40 4	6 4
Main branch lines to:		
Sunnyside	3	4
Mabton	4	3
Granger	2	2
Zillah	3	3
Grandview	1	4
Prosser	5	4
Total main lines	62	
Town systems	70	2, 3, 4, and 6

Complete distributing plants in towns, 7. Main lines built for 300 pounds pressure and carry 125 pounds. Two pressures in town systems, 5 to 20 pounds and 4 to 10 ounces.

PRODUCTION FROM RATTLESNAKE GAS FIELD

Year	M. cubic feet	Value
1930	94,963	$ 45,750
1931	119,365	66,717
1932	103,826	65,313
1933	108,004	80,799
1934	141,137	92,093
1935	207,355	116,248
Total (6 years)	774,650	$466,920

In western Whatcom County, many wells drilled north of Bellingham have encountered large amounts of gas. Some wells were as little as 175 feet deep, the gas coming from unconsolidated sediments of aqueo-glacial origin overlying Eocene sandstones and shales. It was expected that this gas could be used commercially, but difficulties developed when several wells were connected to a trial distributing system for local use. This production problem is being worked on, so that it is probable the gas eventually will be utilized.

PRODUCING WELLS OF THE SHALLOW-GAS FIELD, SIX MILES NORTH OF BELLINGHAM

Name	*Location*	*Depth*	*Estimated capacity (cubic feet per day)*	*Pressure (pounds per sq. inch)*
Whatcom No. 1	E.¼ cor. sec. 28, (39-2 E.)	175	3,000,000 to 4,000,000	50
Chamber of Commerce No. 1	NW.¼ SW.¼ NW.¼ sec. 27, (39-2 E.)	171	900,000	27
Chamber of Commerce No. 2	SW.¼ SW.¼ NW.¼ sec. 27, (39-2 E.)	172	1,250,000	28
Chamber of Commerce No. 4	SE.¼ SW.¼ NW.¼ sec. 27, (39-2 E.)	166	750,000	52
Hunter No. 1	SW. cor. NE.¼ SW.¼ sec. 27, (39-2 E.)	193	5,000,000	70

In addition to the shallow wells, gas has been discovered in several wells drilled into the Chuckanut formation underlying the Pleistocene sediments. That these wells are not productive of commercial quantities of gas appears to be due solely to misfortunes of drilling and water shut-off. Testing is still being carried on, and the prospects are good for gas production from this area to be used for supplying the surrounding district and possibly more distant markets.

Other wells in various parts of the State have produced considerable gas during drilling. In the search for oil, these showings have been cased off or at least not developed. Some were of small account, others showed large volumes of gas that verged on the commercial, while all indicate the possibilities of favorable structures in certain formations. The following list of such wells, probably not complete and exclusive of the Benton and Whatcom county wells, is given to show the wide geographic range of gas production in large or small amounts.

WELLS SHOWING GAS

NAME	*LOCATION*	*COUNTY*
Northwest Oil Research Corp. well	Wenatchee Heights	Chelan
Wenatchee Produce Co. water well	Wenatchee	Do
Washington Oil Co. well	Forks	Clallam
Forks Prairie Oil Co. well	do	Do
Sol Duc Oil Co. well	On Sol Duc River, 6 mi. west of Forks	Do
Hislop & Frank well, also other wells	Near Vesta	Grays Harbor
Gray-Tac Oil Co. well	Near Aberdeen	Do
Olympia Oil Co. well	Copalis	Do
Leslie Oil Co. well, also other wells	Near Hoh River mouth	Jefferson
Lawson coal test ("Flaming Geyser")	On Green River, 10 mi. E. of Auburn	King
Salzer Valley Prospecting Co. well	3 miles SE. of Centralia	Lewis
Sol Duc Oil Co. wells	3 miles E. of Snohomish	Snohomish
Mabton City water well	Mabton	Yakima
Miocene Petroleum Co. well	Union Gap	Do

That some petroleum does occur in the State is proved by a number of seeps, by small showings in many test wells, and by considerable amounts of oil being encountered in the old Washington well at Forks and in the Sims No. 1 and Kipling No. 1 wells at the mouth of Hoh River. Some seeps are readily seen; others are so dependent on the fluctuating ground-water level that they may be observed only under certain favorable conditions. Information on seeps in addition to those listed below has been received from time to time from reliable sources, but those mentioned here are well known and serve to demonstrate that paraffin-base oil, not so unlike Pennsylvania crude, exists in many places in the rocks of the State.

PETROLEUM SEEPAGES

Chelan County. Wenatchee seeps, at foot of Fifth Street and just south of town in the NW. ¼ sec. 14, (22-20 E.).

Clallam County. On the DeKay place, 7 miles southwest of Port Angeles.

Clallam County. Near Point of Arches, within a mile both north and south.

Island County. At Coupeville.

Jefferson County. "Jefferson seep," near the mouth of Hoh River, in sec. 12, (26-14 W.).

Jefferson County. "Lacy seep," 6 miles east of Hoh Head, in sec. 11, (26-13 W.).

Jefferson County. "Smell muds" of the Hoh formation; for example, 3½ miles southeast of LaPush.

Skagit County. On the Scott place, Samish Island.

Whatcom County. Near intersection of Alabama and Orleans Streets, Bellingham.

Oil, congealing to a vaseline-like consistency and color after being exposed for a time to the air, was taken out of the old Washington Oil Company's well at Forks, Clallam County. Samples were plentiful at one time, for it is reported that many barrels were bailed up before the hole was lost, but the existence of any at present is uncertain.

Of equal interest are reports, considered reliable, of the results of a test made by the Leslie Oil Co. in its Sims No. 1 well near the mouth of Hoh River, Jefferson County, in the NE. ¼ sec. 12, (26-14 W.). The drill encountered an oil-saturated sand in November, 1931. This was cased off for deeper drilling after bailing tests were run. The tests showed the sand capable of producing 20 barrels per day of 39.5° Baumé paraffin-base oil. Four other saturated sands were reported before drilling stopped at 2,200 feet, but the well was never placed on production.

A more recent test (April-May, 1936) is the Kipling No. 1 well, drilled 140 feet east of the Sims well. This encountered 41.1°-Baumé oil at a depth of 287 to 314 feet. The capacity is not known, though a production of 3½ barrels per hour was obtained for a short time by means of a small and inadequate pump. An expected further production is awaiting the solution of certain technical problems.

REFERENCES

Glover, S. L., Oil and gas possibilities of western Whatcom County: Washington Div. of Geol. Rep't of Investigations No. 2, 1935.

——————, Preliminary report on petroleum and natural gas in Washington: Washington Div. of Geol. Rep't of Investigations No. 4, 1936.

Lupton, C. T., Oil and gas in the western part of the Olympic Peninsula, Washington: U. S. Geol. Survey Bull. 581-B, 1914.

Washburne, C. W., Reconnaissance of the geology and oil prospects of northwestern Oregon: U. S. Geol. Survey Bull. 590, 1914.

Weaver, C. E., The Tertiary formations of western Washington: Washington Geol. Survey Bull. 13, 1916.

PORTLAND CEMENT

Portland cement is a manufactured product made from limestone (calcium carbonate) and clay or shale (containing silica, alumina, and iron). A small amount of gypsum (calcium sulphate) is added as a retarder. The materials are chosen so that the mixture will have a certain composition varying within a very narrow range; they are finely pulverized, heated to incipient fusion in kilns, and the resulting fused mass or "Clinker" is pulverized to form the Portland cement of commerce.

Cement is a very important resource, the materials for which are practically unlimited. (See "Limestone," p. 53.)

Abundant limestone occurs in Pend Oreille, Stevens, Ferry and Okanogan counties, and suitably large deposits are known also in Asotin, Chelan, King, Skagit, and Whatcom counties. The deposits of other counties are hardly large enough for the tonnage that is required for the long-time operation of a cement plant. The large undeveloped bodies are principally in eastern Washington; but the economics of cement manufacture will not allow a long rail haul, so those deposits are not available for western Washington plants at the present time. Water transportation is feasible, however; and one of the last plants to be erected, the Pacific Coast Cement Co., secures limestone from extensive beds on Dall Island, Alaska, where the rock is quarried, crushed, and shipped by steamer to the Seattle plant.

The manufacture of Portland cement was begun in Washington in 1907, when the Washington Portland Cement Co. commenced operation at Concrete in Skagit County. Seven other plants have been built since then. The old Washington company was eventually taken over by the Superior Portland Cement Co., located also at Concrete and the second to be built in the State. One plant, built by the Idaho Portland Cement Works at Asotin, Washington, was never put in operation.

The present operating companies are as follows:

Lehigh Portland Cement Co., Metaline Falls, Pend Oreille County. Using limestone trammed from a quarry 1 mile east of the plant, and shale from a quarry about 4 miles south of the plant; dry process; 2 rotary kilns; capacity 2,000 barrels in 24 hours.

Northwestern Portland Cement Co., Grotto, King County. Using limestone trammed from Palmer Mountain quarry, 9,000 feet air-line west of the plant, and clay from a deposit 1,200 feet northwest of the plant; wet process; 1 rotary kiln; capacity 2,000 barrels in 24 hours.

Olympic Portland Cement Co., Ltd., Bellingham, Whatcom County. Using limestone shipped by rail from a quarry near Kendall, approximately 30 miles northeast of the plant, and clay from deposits at Brennan, 4 or 5 miles north of the plant; wet process; 3 rotary kilns; capacity 3,000 barrels in 24 hours.

Pacific Coast Cement Co., Seattle, King County. (Under lease to the Superior Portland Cement Co.) Using limestone shipped by steamer from Dall Island, Alaska, 674 miles by water from the plant, and clay from a deposit 2½ miles south of the plant; wet process; 2 rotary kilns; capacity 3,600 barrels in 24 hours.

Spokane Portland Cement Co., Irvin, Spokane County. Using limestone shipped by rail to the plant from the Powell quarry, 1 mile south of Evans, Stevens County, and clay from the same vicinity; dry process; 2 rotary kilns; capacity 1,800 barrels in 24 hours.

Superior Portland Cement Co., Concrete, Skagit County. Using limestone trammed from a quarry 1.3 miles northeast of the plant, and clay from deposits ¾ of a mile east of the plant; wet process; 6 rotary kilns; capacity 5,000 barrels in 24 hours.

Although cement is an artificial product, its manufacture is comparatively simple, requiring only combining of raw materials, grinding, and calcining. Most resources require some kind of preparation, such as milling, washing, or other treatment, so it is customary to consider cement with other mineral products. When compared with them, the value of the Portland cement production in Washington is second only to that of coal. It took second rank soon after it was first produced and has held its place consistently. Maximum production was in 1928, the production in 1933 being far below normal. Details of shipments, factory prices, and total production have not been published separately for this State since 1925 in order to conceal certain out-of-state operations listed with those of Washington. However, the 1923-25 figures, given on the following table, show relationships and are particularly valuable due to 1925 being a rather normal year with average business activity.

PORTLAND CEMENT PRODUCTION, 1923-1925 *a*

Year	*No. of active plants*	*Shipments*		*Average factory price per bbl.*	*Stock on hand Dec. 31 (bbls.)*	*Total Production (bbls.)*	*Value of total production*
		Quantity (bbls.)	*Value*				
1923	4	2,111,479	$4,988,022	$2.36	240,892	2,105,711	$4,969,477
1924	4	1,793,403	4,236,554	2.36	289,602	1,842,113	4,347,386
1925	4	2,499,237	5,523,324	2.21	272,300	2,481,923	5,485,049

a In order to conceal the output of certain out-of-state plants the statistics on Portland cement have not been published separately since 1925. The total annual production is included under the heading of "Miscellaneous products" in the table on "Nonmetallic mineral production of Washington, 1923-1933."

REFERENCES

Eckel, E. C., and others, Portland cement materials and industry in the United States: U. S. Geol. Survey Bull. 522, 1913.

Shedd, Solon, Cement materials and industry in the State of Washington: Washington Geol. Survey Bull. 4, 1913.

PUMICE

Pumice is a highly vesicular volcanic glass. The cellular, sponge-like structure, which is characteristic, is caused by the sudden expansion of included gases in quickly cooled fragments of molten lava ejected from volcanoes. Its chemical composition may vary, depending on the nature of the original melt, but usually corresponds to that of the acid rocks such as rhyolite. Beds of pumice have formed in the vicinity of some volcanoes. They may be composed of fragmental material of varying size ranging from sand to boulders and large blocks. The material is usually gray in color and, due to the cellular structure, of such light weight that it will float for a time on water.

Italy supplies almost all of the pumice used in the United States. Some is used in block and lump form for certain abrasive purposes, but in general it is ground to different degrees of fineness and used as a scouring and polishing powder with many different commercial applications. For some purposes, the naturally powdered form of the same material, pumicite (see below), may be used in place of ground pumice.

WASHINGTON OCCURRENCES

Chelan County, about 20 miles north of Wenatchee Lake. Pumice occurs near the juncture of Buck Creek and Chiwawa River, on the ridge northeast of Buck Creek and at various places in that vicinity in secs. 25 and 36, (31-15 E.) and sec. 6, (30-16 E.). The few beds investigated were 3 or 4 feet thick and were made up of pumice lumps up to 1½ inches in diameter in a finer aggregate of the same material. They are flat lying or nearly so, have a slight overburden of soil, and lie on a gneiss bedrock.

Lewis County, about 14 miles southeast of Morton. Granules and pellets of pumice, some up to 2 inches in diameter, occur in beds along Cispus River road for 3 miles or so above Quartz Creek, starting near the east line of sec. 10, (11-6 E.). The material is light gray, usually fine, and is exposed in small patches in road cuts. It is easily accessible and less weathered than the Chelan County beds, so might repay prospecting if a market could be developed.

Skamania County, about 6 miles north of Spirit Lake. Beds of pumice similar to the Cispus River exposures are abundant on the north slopes of Goat Mountain above the head of Quartz Creek.

Other beds occur on the north slope of Mount St. Helens, showing in patches and dune-like mounds along the Spirit Lake-St. Helens road from the north line of sec. 27, (9-5 E.), south to the snow fields of the mountain. The depth of these beds is not known. It is mostly a granular light-gray material with pellets up to 1½ inches or so in diameter.

PUMICITE

Pumicite, or volcanic ash, is a fine-grained sand or dust made up of sharp, angular fragments of volcanic glass. It has been laid down as beds, at times very thick, on land or in water by the settling of clouds of ash thrown out by violently erupting volcanoes. Most deposits are light gray in color and may exhibit a silvery sheen, particularly if the grains are somewhat coarse; shades of buff are not uncommon. Washington deposits are sufficiently consolidated, as a rule, to prevent lumps from being crushed in the hands, yet the powder is readily rubbed off. Unconsolidated beds are common, but have usually resulted from the erosion and reworking of the compact material. Pumicite is distinguished in the field by its light color, rather low apparent specific gravity (not as low as diatomite), its sheen (when present), and the harsh feel of the powder.

When of uniform size, fine grained, and free from impurities, pumicite is used as an abrasive in certain cutting, scouring, cleaning, and polishing compounds. One example is its use in Old Dutch Cleanser, which is approximately one-half pumicite and one-half soap powder and sodium carbonate. It has been used as a cement admixture and might be used in the manufacture of special pozzolanic mortars.

WASHINGTON OCCURRENCES

Pumicite is abundant in this State, but a few outstanding deposits have received most of the attention so that only three or four occurrences are well known.

Saddle Mountains, Grant County. A bed of very pure pumicite over 40 feet thick outcrops about 4½ miles southeast of Beverly in the SW. ¼ NW. ¼ sec. 23, (15-23 E.). It is interbedded with basalt, but erosion has uncovered enough to make a large tonnage available for quarrying. Continuations of this bed, not necessarily connected, outcrop a mile south of Jericho on the steep cliffs of Saddle Mountains, and no doubt other occurrences could be located in this general vicinity.

Pumicite outcrops 1½ miles southwest of Beverly in the steep cliffs of the north side of Saddle Mountains. It shows as a light-colored bed between black flows of basalt through sec. 4, (15-23 E.) and sec. 32, (16-23 E.). This occurrence is of particular interest due to nearness of rail transportation.

Snipes Mountain, Yakima County. Two or three separate beds of pumicite occur near the top of the south end of Snipes Mountain in the vicinity of the center of sec. 32 and west center of sec. 33, (10-22 E.). One bed, 12 feet or so thick, has been quarried and considerable tonnage taken out. It is interbedded with silty clay and ashy silt and is moderately consolidated. The material is not as fine grained as some deposits, but is very pure and has a silvery luster.

Other deposits occur in eastern Washington. One, of fine-grained buff-colored ash, is exposed on the lower end of New York Bar on Snake River about 5 miles below Central Ferry in Columbia County. A 6-foot bed shows there for 300 feet. Others are reported in the vicinity of Connell, Mesa, and Pasco, Franklin County. Powdery reworked ash is exposed in many road cuts in tributary valleys of Snake River. Great amounts are available if a market should arise in the Northwest.

Skagit River deposit, Skagit County. This is the only occurrence known in western Washington. It is on the west bank of the river about 9 miles above Marblemount. The material is of good quality and is reported to occur in a fairly extensive deposit. A small amount has been shipped.

SAND AND GRAVEL

Washington is well supplied with deposits of sand and gravel suitable for all the more general uses. The northern part of the State was glaciated, and deposits of glacial or aqueo-glacial origin occur as benches along streams and as a veneer over large areas. Streams have carried these sands and gravels into some parts of the unglaciated regions. Other streams have usable deposits from the erosion of the bedrock along their courses. Southwestern and particularly southeastern Washington are poorest supplied with deposits and must depend for most of their needs on materials brought in from other localities.

It is fortunate that the best and most abundant gravels occur close to the chief centers of population. Practically unlimited supplies may be obtained from the prairies south of Tacoma, and pits have operated there for years. At Steilacoom a great delta of a stream which existed during Glacial time furnishes excellent gravel and sharp clean sand. The deposit is in a great bluff above the Sound; so excavation, sizing, washing, and transportation are all carried on with mimimum expense. Similar deposits are available at many places on Puget Sound and amply care for the market in this part of the State.

The Chehalis-Centralia and the Grays Harbor territories are supplied from good gravels available in large amount in the Chehalis Valley below Centralia. The rest of southwestern Washington depends on occasional and scattered deposits along local streams, on material dredged from Columbia River, and, to a small extent, on beach sand.

In eastern Washington, gravel bars of Yakima River and tributary streams furnish materials for the towns of that district. Wenatchee and the region tributary to it secure sand and gravel from bars and bench deposits along Wenatchee and Columbia rivers. The Walla Walla region is poorly supplied; it is dependent on outside materials except for such as may be obtained from scattered deposits along Walla Walla and Touchet rivers. The Palouse country has very few deposits and brings in most of the sand that is used. Spokane is well supplied from the extensive flats and benches of outwash gravels that occur along Spokane and tributary valleys, and the pits operated there ship into the less favored regions to the south. Bench and terrace deposits of good sands and gravels are abundant in the northern counties of eastern Washington, so there is no need to go far to fill the needs of the various communities.

The production of sand and gravel usually amounts to over a million dollars annually and, in some years, has exceeded two million. As a resource, it occupies third to fifth place among nonmetallics. Sand for general building use is most important, followed by paving, engine, and other sands. Paving and building gravel are of about equal importance, and that used for railroad ballast reaches a value nearly as great.

Pits are operated by the State Highway Department, by the counties, and by private concerns. Some have operated for many years and are permanent industries in their communities. Many others are opened, used to supply material for some road or other project, and then abandoned. The changing locations make it difficult to list all operations, but those reporting in 1932 or 1933 are tabulated with such locations as are known.

SAND AND GRAVEL PITS IN OPERATION IN 1932 OR 1933

OPERATOR	*LOCATION*	*COUNTY*
Adams County	Othello	Adams
R. O. Camp	....	Do
J. H. Nave	Asotin	Asotin
Benton County	Hanford	Benton
State Highway Dept.	....	Chelan
State Highway Dept.	....	Clallam
Edland & Burger	....	Do
Clark County	....	Clark
Dorman-Kampe Co.	....	Do
Washougal River Gravel Co.	Camas	Do
Portland Gravel Co.	Vancouver	Do
State Highway Dept.	....	Columbia
Portland Gravel Co.	....	Do
Leslie Waters	Woodland	Cowlitz
State Highway Dept.	Waterville	Douglas
Columbia Concrete Products Co.	Near Wenatchee	Do
Puget Sound Power & Light Co.	....	Do
State Highway Dept.	....	Ferry
Franklin County	Connell, Kahlotus	Franklin
J. S. Johns	Pasco	Do
Northern Pacific Railway	....	Do
E. W. Poe	....	Garfield
State Highway Dept.	....	Grant
D. A. Sullivan & Co., Inc.	....	Do
Great Northern Railway	....	Do

SAND AND GRAVEL PITS IN OPERATION IN 1932 OR 1933—Continued

OPERATOR	*LOCATION*	*COUNTY*
State Highway Dept.	....	Grays Harbor
Grays Harbor County	Montesano	Do
Grays Harbor Construction Co.	do	Do
Fred G. Redmon	....	Do
Harbor Sand & Gravel Co.	South Bend	Do
State Highway Dept.	....	Jefferson
Jefferson County	....	Do
Port Townsend Sand & Gravel Co.	Port Townsend	Do
State Highway Dept.	....	King
King County	....	Do
Pioneer Sand & Gravel Co.	Rainier Beach	Do
Columbia Sand & Gravel Co.	....	Do
Crosby Lighterage Co.	Maury Island and Hadlock	Do
Hart & Shaughnessy	Auburn	Do
K. E. Jellum	Haller Lake	Do
Kirkland Sand & Gravel Co., Inc.	Kirkland	Do
Klinker Sand & Gravel Co.	....	Do
Meade Transfer Co.	Auburn (Meade Pit)	Do
Queen Anne Sand & Gravel Co.	....	Do
Renton Sand & Gravel Co.	Renton	Do
Stoneway Dock Co.	Black Diamond and Renton	Do
Western Gravel Co.	Maple Valley	Do
Mutual Materials Co.	....	Do
Tongaw & Olson	....	Do
Northern Pacific Railway	....	Do
State Highway Dept.	....	Kitsap
State Highway Dept.	....	Kittitas
Ellensburg Sand and Gravel Co.	....	Do
Peter R. Tjossem	....	Do
State Highway Dept.	....	Klickitat
Lewis County	Centralia, Chehalis, Mineral and Onalaska	Lewis
Lewis County Gravel Co.	Centralia	Do
Edland, White & Edland	Mossy Rock	Do
Hendricks & Co.	Toledo and Mossy Rock	Do
Great Northern Railway	....	Lincoln
State Highway Dept.	....	Mason
Shelton Sand & Gravel Co.	....	Do
State Highway Dept.	....	Okanogan
Triangle Construction Co.	....	Do
A. H. Cuples	Long Beach	Pacific
State Highway Dept.	....	Pend Oreille
D. A. Sullivan & Co., Inc.	....	Do
State Highway Dept.	....	Pierce
Pioneer Sand & Gravel Co.	Steilacoom	Do
Glacier Gravel Co.	Gravel Center	Do
The Harrison Bros. Co.	....	Do
Island Sand & Gravel Co.	....	San Juan
Pioneer Sand & Gravel Co.	Friday Harbor	Do
Skagit County	N. Bayview Ridge	Skagit
State Highway Dept.	Bellville	Do
Blackmore Transfer Co.	Clear Lake	Do
Norris Bros.	Burlington	Do
Great Northern Railway	....	Do
State Highway Dept.	....	Skamania
Skamania County	Stevenson	Do
Spokane, Portland & Seattle Ry.	....	Do

SAND AND GRAVEL PRODUCTION, 1923-1933

Year	Plants reporting	Molding sand		Building sand		Engine sand		Paving sand		Other sands		Building Gravel		Paving gravel		Railroad ballast		Total	
		Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1923	51	2,656	$1,670	619,173	$310,438	14,140	$6,160	191,107	$85,008	b450	$600	787,043	$377,615	735,715	$311,185	1,438,825	$270,330	3,789,109	$1,363,006
1924	52	(a)	(a)	488,231	246,982	41,966	14,990	500,957	277,267	3,345	5,462	753,295	399,533	449,067	214,114	1,227,696	240,158	3,464,557	1,398,506
1925	64	(a)	(a)	725,819	363,416	65,915	25,687	276,774	143,361	32,171	8,388	813,462	410,473	1,110,922	598,787	1,172,597	213,041	4,197,660	1,763,153
1926	96	700	2,800	511,882	280,932	43,765	13,940	438,237	208,437	13,415	6,699	900,834	383,177	1,072,158	573,735	929,586	234,514	3,910,577	1,704,234
1927	84	(a)	(a)	551,113	249,983	110,581	32,418	269,320	118,832	37,627	11,232	787,227	320,943	965,773	478,399	1,701,605	359,192	4,423,246	1,570,999
1928	87	1,236	4,389	661,777	299,266	40,662	10,624	484,665	239,847	43,414	12,357	1,091,783	403,821	1,620,528	693,814	1,973,683	337,077	5,917,748	2,001,195
1929	103	1,540	5,130	668,057	366,497	67,672	34,134	304,864	139,153	55,054	13,906	800,257	387,805	1,795,377	942,645	1,698,872	248,845	5,391,693	2,138,019
1930	97	1,075	3,751	716,631	354,664	82,061	25,478	355,800	142,730	8,810	4,385	1,162,385	535,008	2,272,079	991,741	708,781	123,255	5,307,622	2,181,012
1931	81	(a)	(a)	482,190	214,370	95,384	22,421	306,825	150,379	13,293	7,118	641,809	287,279	1,481,040	680,348	174,615	43,636	3,195,156	1,405,551
1932	97	(a)	(a)	242,952	97,880	37,718	15,015	350,206	132,535	4,346	650	389,288	163,337	2,930,382	1,166,016	1,203,348	111,784	5,158,240	1,687,217
1933	46	(a)	(a)	189,889	75,297	(a)	(a)	154,590	54,527	23,764	4,229	315,932	106,646	1,486,456	618,586	107,466	13,826	2,278,097	873,111

a Included under "Other sands" to conceal individual operations.
b "Other sands" include grinding and polishing sand in 1923 (450 tons) and in 1925.
Filter sand included in 1928 and 1931.

SAND AND GRAVEL PITS IN OPERATION IN 1932 OR 1933—Continued

OPERATOR	LOCATION	COUNTY
State Highway Dept.	....	Snohomish
Snohomish County	Machias and Everett	Do
Great Northern Railway	....	Do
Hat Island Sand & Gravel Co.	Gedney Island	Do
Paul Heyner	....	Do
State Highway Dept.	....	Spokane
Fred G. Redmon	Cheney	Do
Ajax Sand & Gravel Co.	....	Do
Chicago, Milwaukee & St. Paul Ry.	....	Do
Northern Pacific Railway	....	Do
Amos Lewis	Chester	Do
Joslin & McAllister	Spokane (3 plants), Meade, and Irvin	Do
Hawkeye Fuel Co.	....	Do
Union Sand & Gravel Co.	Fort Wright	Do
State Highway Dept.	....	Stevens
F. R. Hewett	Chewelah	Do
E. N. Poe	....	Do
State Highway Dept.	....	Wahkiakum
Brookfield Quarry & Towage Co.	Cathlamet	Do
Knappton Tow Boat Co.	Cathlamet	Do
Walla Walla County	Attalia and Wallula	Walla Walla
Oregon-Washington R. & N. Co.	....	Do
State Highway Dept.	....	Whatcom
Lind Gravel Co.	Blaine and Lynden	Do
Wilder & Montfort	Blaine	Do
Whitman County	Winona	Whitman
State Highway Dept.	....	Yakima
Yakima County	....	Do
R. C. Elton	....	Do
Sand & Gravel Supply Co.	....	Do

REFERENCES

Bretz, J. H., Glaciation of the Puget Sound region: Washington Geol. Survey Bull. 8, 1913.

Leighton, M. M., The road building sands and gravels of Washington: Washington Geol. Survey Bull. 22, 1919.

SILICA

Silica is the usual name for silicon dioxide (SiO_2), the chemical compound which forms the minerals quartz, flint, agate, and, with combined water, opal. It is one of the most abundant rock constituents, but to have economic value must be nearly pure, accessible, and in a usable physical form. The chief sources of commercial silica are massive crystalline quartz of pegmatites and veins, quartzite (recrystallized sandstone), sandstone, and quartz sand. (See, also, "Abrasives," p. 12, and "Diatomite," p. 38.) In one or another of its various forms it is used for abrasives, for ceramic and refractory purposes, in metallurgical and chemical industries, and for electrical, optical, and decorative purposes.

For making glass, a very pure silica sand or soft sandstone is used. It must consist of practically nothing but colorless quartz grains, free from iron, if it is to be used for clear, colorless glass; and it may contain only a very small amount of iron if cheap colored ware, such as green bottles, is to be made. Uniform texture and medium grain are desirable; but for use in Washington, far from the principal sources of high-grade sand, it might be feasible to process a reasonably pure sand. Massive quartz can be used for glass and is employed for certain special varieties; however, it is not economically possible, on account of grinding and other preparation costs, to use it in competition with glass sand for most ware.

WASHINGTON OCCURRENCES

MASSIVE QUARTZ

Chelan County. A dike of white quartz as much as 50 feet wide crops out for a mile or more on a south spur of Burch Mountain, 5 miles east of Cashmere. It trends northwest through the W. ½ sec. 4, NE. cor. sec. 5, (23-20 E.) and E. ½ sec. 32, (24-20 E.). Samples carried 96.6 per cent silica. With some sorting, it is probable that a very large amount of high-grade quartz is available below the poorer surface material.

Merritt deposit. A large body of white vein quartz occurs on the Smith place near Merritt. It is conveniently located for rail transportation, and a small amount has been produced by the owner.

Pierce County. A 25-foot vein of quartz, traceable for several hundred yards, occurs on the Siegmund ranch, one mile north of Clay City. It was opened as a gold prospect at one time, but is probably more useful for its silica content.

Skagit County. Vein quartz is common in the county and one body has been opened and operated in a small way at Rockport by the H. P. Scheel Eversharp Pulp-Burr Company, of Tacoma.

Spokane County. The Denison or Latshaw deposit, in the E. ½ NE. ¼ sec. 14, (27-42 E.), is a segregation of pegmatitic quartz of remarkable purity and size. It is about 7 miles, by road, south of the railroad station of Denison and 13 miles north of Spokane. It forms a small hill, covering 3½ acres, and has a half million tons in sight with probably many times that amount available. Analyses range from 95 per cent silica for the stained surface material to 98 per cent for cleaner rock. Several small quarries have been opened in the deposit, and small shipments have been made intermittently during the last 35 years. It is owned by Floyd Latshaw and J. B. Carson, both of Spokane.

High-grade vein quartz as a by-product of the metal-mining industry has been proposed by various operators in northeastern Washington. Such material could be placed on the market whenever a demand should make it worth while.

QUARTZITE

Beds of sandstone, metamorphosed to quartzite, cover great areas in the northern Cascades and particularly in the Okanogan Highlands. Some are apparently very high in silica, showing nothing to the eye but recrystallized quartz. Characteristic examples occur at Kettle Falls in Stevens County and just south of Spokane, near the north center NE. ¼ sec. 15, (24-43 E.). A large body reported to be quartzite was quarried at one time by the Denny-Renton Clay & Coal Co. and used in the manufacture of silica brick. This occurrence is 8 miles E. of Enumclaw, King County, on the old McClellan Pass Highway. The rock resembles quartzite or chert, but may be an entirely silicified igneous rock.

HIGH-SILICA SAND AND SANDSTONE

Chelan County. In Stemilt Canyon, south of Wenatchee in the NW. ¼ sec. 36, (22-20 E.), are high cliffs of wind-sculptured sandstone containing a high percentage of silica. The rock would require sorting, crushing, and washing; but with this treatment it would produce a fairly pure quartz sand and a semirefractory clay by-product.

In Squilchuck Canyon, 3 miles south of Wenatchee, in the SW. cor. sec. 22, (22-20 E.), are other cliffs of Swauk sandstone similar to the above, which have been prospected and tested for high-silica sand. The rock is soft, easily crushed, and can be quarried in large quantities. By sorting and washing, a silica content of 98 and 99 per cent has been obtained with 0.3 per cent and less of iron and a correspondingly small amount of alumina and other impurities.

King County. A preglacial series of unconsolidated clays and clayey sands, the Hammer Bluff formation, lies on the Eocene rocks a few miles east of Auburn. These sediments are well exposed in the vicinity of Hammer Bluff on Green River near the north center of sec. 28, (21-6 E.), on the Alcorn property in the NE. ¼ sec. 27, (21-6 E.), and near Palmer. The sands are very high in silica and may be easily separated by washing from the accompanying semirefractory clay. They are iron stained in places, but prospecting might prove useful amounts free from iron. Pits opened many years ago on the Brooks farm, sec. 28, (21-6 E.), showed 10 or 12 feet of unstained sand with total depth and extent undetermined. Quartz sand washed from this deposit was used with excellent results in test runs for glass.

The minerals other than quartz in the abundant Pleistocene sands of northwestern Washington prevent the use of such sands for purposes requiring a high-silica content, although their present field of use might be increased by treatment. The Eocene sandstones of the Coal Measures of Pierce and King counties might be made high enough in silica for use as quartz sand by crushing, washing, and magnetic treatment. A green glass of good color was produced in this way from the Kummer sandstone. At one time a glass factory was operated at Renton on sand obtained by crushing sandstone mined in the Renton coal mine, and attempts were made to use other sandstones in the vicinity. With present-day methods such materials probably could be used successfully for colored ware.

Spokane County. Quartz grains—angular and of various sizes—occur abundantly in the residual and colluvial kaolins and clays of the Spokane region. This material should prove a valuable by-product and source of high-silica sand in any clay-washing and beneficiation plant.

Whatcom County. The basal conglomerate of the Chuckanut formation is in many places very high in angular quartz pebbles and, with treatment, might be a useful source of silica for certain purposes. One easily accessible outcrop is on the northeast shore of Samish Lake in the NE. ¼ sec. 26, (37-3 E.), although the bed is thicker in other places. A thick exposure is on Saar Creek southeast of Sumas. Another is said to occur in the NW. ¼ sec. 17, (40-5 E.), and a thickness of 80 feet carrying 98 per cent silica and very little iron is reported.

REFERENCES

Cole, L. H., Silica in Canada, its occurence, exploitation and uses: Canada Dep't of Mines, Mines Branch No. 555, 1923.

Evans, G. W., The coal fields of King County: Washington Geol. Survey Bull. 3, pp. 44-47, 1912.

Glover, S. L., Oil and gas possibilities of western Whatcom County: Washington Div. of Geol. Rep't of Investigations No. 2, 1935.

Weigel, W. M., Technology and uses of silica and sand: U. S. Bureau of Mines Bull. 266, 1927.

Wilson, Hewitt, and Zvanut, F. J., Properties of quartz sands washed from koalins of the Pacific Northwest: University of Washington Eng. Exp. Sta. Bull. 88, 1936.

SODIUM COMPOUNDS

Many sodium compounds occur in nature as minerals. Most of these are soluble in water, so form in large quantities only in more or less arid places where conditions are favorable for the evaporation and concentration of waters containing these chemicals. Among the more common ones are sodium chloride (salt), sodium tetraborate (borax), sodium nitrate (Chili saltpeter), sodium carbonate (soda ash), and sodium sulphate (salt cake). In addition to these chemical terms and common names, they all have specific mineralogic names.

The sulphate and carbonate are used in the chemical and drug industries and in the manufacture of glass. Sodium sulphate is used also in making certain kinds of paper. They both occur in Washington and are the only sodium compounds known to be here in commercial quantities.

Suitably arid conditions exist in parts of eastern Washington, so that many lakes occupying undrained depressions in areas of scabland basalt or glacial moraine have become highly saline, and some have developed beds of solid crystalline salts. These lakes are marked by the absence of vegetation along their shores and by a white efflorescence on the muds of those that become dry during the summer. Salt bodies are seldom apparent and may lie deep under mud that has accumulated with them in the depression. The known deposits are limited to sodium sulphate and sodium carbonate, although other salts occur in minor amounts both in the solid beds and in the brines. Magnesium sulphate, occurring in the same way, is mentioned on page 42.

WASHINGTON OCCURRENCES

Grant County. Sulphate Lake is 11½ miles west of Warden at about the quarter corner of secs. 15 and 16, (17-28 E.). It is in the undrained eastern end of a depression in basalt. A freshwater spring forms a pond in the western end and furnishes some water to the sulphate lake. The lake covers about 9 acres and contains water during only the wet season. Most of the year it is a surface-dry expanse of mud, coated with a white efflorescence of sodium sulphate. Beneath a few inches of mud is a body of mirabilite, hydrous sodium sulphate ($Na_2 SO_4 . 10 H_2O$), 14 feet thick in places. Practically the only impurity of the salt is a small amount of disseminated clay.

The deposit was operated at one time, and several hundred tons were extracted for use in the manufacture of kraft paper. The crystal was mined in open pits, piled on the shore, and small amounts at a time were thinly spread and air dried to the powdery form, thenardite, Na_2SO_4. It was later shipped without further treatment for use in paper mills. Crystal has formed in the old pits so that they are again level with the lake surface.

Carbonate Lake is a few miles east of Sulphate Lake and about 10 miles (air line) west of Warden in the SW. ¼ sec. 18, (17-29 E.). It occupies an undrained depression about four-tenths of a mile long by one-tenth wide and a hundred feet or so below the general level of a rough, broken basalt region. Patches of open brine and surface-dried mud make up the lake, and crusts of salts form over irregular areas. Conditions change with the season, but under the variable amount of crust, brine, and mud is a solid deposit of salts about 16 feet thick. The brine is a mixture of different dissolved salts that is approximately 90 per cent sodium carbonate, the rest being chiefly sodium sulphate, sodium chloride, and magnesium sulphate. The solid crystal has about the same composition as the brine.

A number of years ago a large well-equipped plant was built at this lake to extract and refine the salt. No attempt was made to separate the various chemicals occurring in minor amounts, only water and clay being eliminated. The process involved the solution of the crystal in heated brine, the removal of the clay which settled out, and the evaporation of the supersaturated brine. The latter operation was conducted in a "cyclone chamber" after the method used in evaporating milk. A considerable amount was prepared and sold, but the plant is now closed and partially dismantled.

Mitchell Lake, dry except in the spring, is about 2½ miles south of Wilson Creek near the center of sec. 23, (22-29 E.). Sodium carbonate with some clay occurs over an area of 40 acres and has been prospected to a depth of 40 feet in one test hole. The crystal itself is remarkably pure, analyses showing over 99 per cent natron ($Na_2CO_3 . 10H_2O$). An efficient plant has recently been built by Alkali, Inc., to mine the crystal, separate the clay, and dehydrate the carbonate. Both sal soda and soda ash are marketed.

Okanogan County. There are scores of lakes in the county; most of these have no name or are only known locally, and their mapped locations are in some instances only approximate. Many are known to have a high concentration of salts, but details are lacking. The following, within a 12-mile radius south of Okanogan, are among the better known. Various operations have been carried on at times and a small tonnage of sodium sulphate has been produced from a few lakes. The salt occurs as mirabilite in the form of solid beds and as segregations in the muds of more or less filled depressions.

B. J. Lake, SW. ¼ sec. 26, (32-25 E.).
Cameron Lake SE. ¼ sec. 3 and NE. ¼ sec. 10, (32-26 E.).

Hauan Lake, NW. ¼ sec. 35, (32-26 E.).
Lake 32, E. center sec. 6, (31-26 E.).
Lawson Lake NW. ¼ sec. 11, (31-26 E.).
Morris Lake, cor. secs. 34 and 35, (32-26 E.) and secs. 2 and 3, (31-26 E.).
Murray Lake, SE. ¼ sec. 20, (32-27 E.).
Penley Lake, center E. ½ sec. 10, (32-26 E.).
Salt or Soap Lake, corners in secs. 25, 26, 35, 36, (32-25 E.).
Stevens Lake, SE ¼ sec. 29, (32-26 E.).
Virginia Lake, SE. cor. sec. 23, (32-25 E.).

Some of these lakes have been prospected, so rather definite information is available on the size of the sulphate bodies. Others have had little attention and only rough estimates may be made of the quantity of salts present. The amounts reported give some idea of the magnitude of the deposits and range from 24,000 tons for B. J. Lake to 500,000 tons for Hauan Lake. Certainly, a very large tonnage of sodium sulphate is available whenever the market warrants the erection of plants for extraction and refining.

Mr. Joe Murray of Okanogan very kindly supplied some detailed information: Hauan Lake has been prospected to a depth of 38 feet and has been proved to contain at least that much mirabilite of 98 per cent purity. He estimates the quantity at one to one and one-half million tons. Murray Lake has been prospected to a depth of 8 feet, with undetermined salts below this, giving 100,000 tons of 99.53 per cent mirabilite. It was in production by a Spokane company at one time. Mr. Murray makes the estimate of 3 million tons of sodium sulphate for the lakes of this vicinity.

REFERENCES

Cole, L. H., Sodium sulphate of western Canada: Canada Dep't of Mines, Mines Branch No. 646, 1926.

Wells, Roger C., Sodium sulphate: its sources and uses: U. S. Geol. Survey Bull. 717, 1923.

STONE

Stone is one of the most important nonmetallic resources of Washington, ranking for many years from third to fifth place in value. A production of $365,098 was reported in 1918; by 1923 it had reached a value of $953,831; and in 1932 exceeded $2,195,076. Architectural uses still take considerable dimension stone, chiefly granite and sandstone, but that demand fluctuates widely and depends largely on the construction of public buildings. Concrete, fancy face brick, and terra cotta have taken the place of stone in most construction of permanent type. Other uses, however, keep the production up and give this resource its economic importance. These include stone for road metal, railroad ballast, riprap, concrete aggregate, monuments, and use in smelters, paper mills, and sugar factories.

BASALT

Basalt is the most common surface rock of the State. It forms the bedrock, or underlies Pleistocene and Recent deposits, throughout a large part of eastern Washington; it and related rocks make up most of the southern Cascades and are abundant as flows, dikes, and sills in western Washington. When agglomeratic, very vesicular, or much weathered, it has little value; but the fresh, black fine-grained rock is a very important resource. It leads all other stone in value of total production on account of the great amount used in the crushed form for surfacing roads and for concrete. A smaller amount is used for rubble and riprap on road and railway construction and on river and harbor works, and some is used for railroad ballast and other purposes.

Since it is usually possible, particularly in eastern Washington, to open a basalt quarry alongside the road or other engineering project upon which the rock is to be used, there are few permanent quarries; they are operated for a time and then abandoned when needs have been supplied. High-quality basalt and andesite are not so widespread in western Washington, so quarries are operated longer and the rock transported greater distances. Those at Fisher (Clark County), Mt. Coffin (Cowlitz County), Duwamish (King County), Charleston (Kitsap County), Bunker and Meskill (Lewis County), Brookfield (Wahkiakum County), and others were operated for many years and some are still large producers.

Quarries are opened by private parties, by city and county engineers and commissioners, and by the State Highway Department. The men in charge of these operations appreciate the necessity for unaltered rock of definite character in order to withstand hard road-wear, so the material is carefully studied and a high quality of output maintained.

BASALT QUARRIES IN OPERATION IN 1933

OPERATOR	*LOCATION*	*COUNTY*
Benton County	Kennewick	Benton
Great Northern Railway	....	Do
State Highway Dept.	....	Clallam
Clark County	Amboy	Clark
Do	Washougal	Do
Do	Hockinson	Do
Columbia Contract Co.	Fisher	Do
Star Sand Co.	Kelso (Mt. Coffin)	Cowlitz
Weyerhaeuser Timber Co.	Hemlock Pass	Do
F. R. Hewitt	Republic	Ferry
State Highway Dept.	....	Garfield
E. W. Poe	Pomeroy	Do
Grant County	Wilson Creek and 2 other quarries	Grant

BASALT QUARRIES IN OPERATION IN 1933—Continued

OPERATOR	*LOCATION*	*COUNTY*
Mathieson Construction Co.		Do
State Highway Dept.	2 quarries	Grays Harbor
State Highway Dept.		Jefferson
General Construction Co.	Port Ludlow	Do
State Highway Dept.	3 quarries	King
Northern Pacific Railway		Do
Kitsap County		Kitsap
Independent Asphalt Paving Co.	Charleston	Do
Yakima Reclamation Project	Ronald	Kittitas
State Highway Dept.	4 quarries	Klickitat
Klickitat County	Bickleton	Do
Lewis County	Bunker	Lewis
Do	Doty	Do
Do	Eveline	Do
Do	Morton	Do
Graham Bros. & Medly		Do
State Highway Dept.		Okanogan
M. O. Nelson		Do
Pacific County	Ilwaco	Pacific
Do	South Bend	Do
Do	Long Beach	Do
Do	Naselle	Do
Do	North River	Do
Do	Seaview	Do
A. W. Hammond	Stryker Creek	Do
Ed. L. Edland		Pierce
State Highway Dept.	Stevenson	Skamania
Skamania County	Cape Horn	Do
Do	Stevenson	Do
Do	Underwood	Do
Portland Sand & Gravel Co.		Do
Spokane County	Spokane	Spokane
Do	Cheney	Do
Do	Deer Park	Do
Do	Elk	Do
Do	Dishman	Do
Do	Fairfield	Do
Do	Latah	Do
Do	Medical Lake	Do
Do	Mica	Do
Do	Millwood	Do
Do	Moab	Do
Do	Nine Mile	Do
Do	Spangle	Do
Do	Tyler	Do
Mathieson Construction Co.		Do
City of Spokane	Spokane	Do
Mitchell Bros.	Spangle	Do
Brookfield Quarry & Towage Co.	Brookfield	Wahkiakum
State Highway Dept.	2 quarries	Walla Walla
Walla Walla County	Clyde	Do
Do	Lamar	Do
Do	Paddock	Do
Do	Pleasant View	Do
Do	Touchet	Do
Do	Waitsburg	Do
State Highway Dept.	2 quarries	Whitman
R. O. Camp		Do
O. W. R. & N. Ry. Co.		Do
Joslin & McAllister	Various	Do
Mathieson Construction Co.	Rosalia	Do
Yakima County	Yakima	Yakima
F. R. Hewitt	Naches	Do

BASALT QUARRIES OPERATED WITHIN THE PERIOD 1923-1933

COUNTY	*LOCATION*
Adams	Hatton, Keystone, Lind, Ritzville, Schragg
Asotin	Anatone, Asotin, Clarkston
Benton	Kennewick, Pioneer, Prosser
Chelan	Wenatchee
Clark.......	Amboy, Camas, Fisher, Hockinson, Washougal, Yacolt
Columbia ...	Dayton
Cowlitz.....	Hemlock Pass, Kelso, Mt. Coffin, Stella, Woodland
Douglas	Coulee City, Farmer, Orondo, Waterville
Ferry.......	Republic
Franklin....	Eltopia, Kahlotus, Mesa
Garfield.....	Pomeroy
Grant	Ephrata, Hartline, Neppel, Quincy, Ruff, Wilson Creek
Jefferson....	Port Ludlow
King	Enumclaw, North Bend, Riverton, Rockdale, Veazie
Kitsap......	Charleston
Kittitas.....	Blewett, Easton, Ellensburg, Hyak, Kittitas, Vantage, Ronald
Klickitat....	Bickleton, Goldendale, Lyle, Wishram
Lewis	Adna, Bunker, Doty, Eveline, Independence, Klaber, McCormick, Mayfield, Meskill, Mineral, Morton, Mossy Rock, Napavine, Pe Ell, Randle
Lincoln	Wilbur
Okanogan...	Omak, Pateros, Twisp
Pacific......	Bear River, Chinook, Ilwaco, Long Beach, Naselle, North River, Raymond, Seaview, South Bend, Stryker Creek
Pend Oreille	Metaline Falls, Tiger
Pierce	Alder, Ashford, Elbe
Skamania...	Cape Horn, Cooks, Stevenson, Underwood
Spokane	Camden, Cheney, Deer Park, Dishman, Elk, Espanola, Fairfield, Latah, Mead, Medical Lake, Mica, Millwood, Moab, Nine Mile, Rockford, Spangle, Spokane, Tyler
Wahkiakum.	Brookfield, Rockpoint
Walla Walla	Bolles Junction, Clyde, Dixie, Lamar, Lowden, Paddock, Pleasant View, Reese, Touchet, Waitsburg, Wallula
Whatcom ...	Glacier
Whitman ...	Albion, Colfax, Colton, Endicott, Farmington, Garfield, Hooper Junction, Lamont, Oakesdale, Palouse, Penewawa, Pullman, Rosalia, Steptoe, Union Flats, Uniontown
Yakima.....	Dalton, Mabton, Naches, Selah, Toppenish, Yakima

BASALT AND RELATED ROCKS PRODUCTION, 1923-1933

Year	Plants reporting	Crushed stone for concrete and road metal		Rubble and riprap		Crushed stone for railroad ballast		Other uses		Total	
		Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value	Short tons	Value
1923	30	368,370	$448,872	112,580	$57,399	72,330	$14,756	....	....	553,280	$521,027
1924	44	561,940	766,489	90,840	56,143	15,630	7,000	....	....	668,410	829,632
1925	35	355,460	355,148	74,540	78,140	(a)	(a)	26,670	$11,924	456,670	445,212
1926	28	300,420	269,104	34,650	35,677	(a)	(a)	8,700	14,065	343,770	318,846
1927	41	547,310	365,893	46,080	71,576	34,950	34,945	670	5,332	629,010	477,746
1928	70	726,200	739,857	80,970	96,657	52,580	47,668	460	2,748	860,210	886,930
1929	77	1,127,600	1,266,433	40,110	41,006	78,750	53,009	1,450	1,109	1,247,910	1,361,557
1930	88	1,158,020	1,063,787	66,020	68,563	64,680	52,973	30,000	15,000	1,318,720	1,200,323
1931	89	1,359,670	1,153,123	33,140	27,533	26,000	27,126	4,130	775	1,422,940	1,208,557
1932	71	1,413,920	1,064,271	754,990	460,123	....	....	....	....	2,168,910	1,524,394
1933	60	834,380	605,516	198,980	145,747	33,274	11,121	56,564	19,878	1,123,198	782,262

a Included under "Other uses."

GRANITE

Granite, as the term is used in the building and monument trades in Washington, includes true granite of several varieties and also granodiorite and related coarse-grained light-colored rocks. It is abundant in the northern and central Cascades (granodiorite), in the northern row of counties of eastern Washington, and in Spokane County; while smaller occurrences are in Whitman County and a few other localities.

Quarries have been opened at many places. Some were for road metal, riprap, and rubble, and have operated intermittently or were abandoned after certain needs were filled; others, as in the Index district and Spokane-Medical Lake district, have operated almost continuously for many years. Stone well suited to almost all uses is available. There is no need to go out of the State for granite except to secure greater variety in color and texture than may be had from the few operating Washington quarries, and even that necessity could be obviated with a reasonably sure and somewhat greater demand so that new quarries could be opened.

GRANITE QUARRIES NOW OR RECENTLY OPERATED

Operator	*Purpose*	*Location*	*County*
King County Engineer	Road metal	(5 quarries)	King
Fred G. Redmon	Road metal	....	Pierce
Western Granite Co.	Architectural, monumental, riprap	Index	Snohomish
R. C. Keene	Monumental	Medical Lake (Morris quarry)	Spokane
J. W. Morris Granite Quarry...	Architectural and monumental	Medical Lake	Spokane
Washington Monumental & Cut Stone Co.	Architectural and monumental	Medical Lake (Silver Lake quarry)	Spokane
Empire Granite Products Co. ..	Monumental	Near Spokane	Spokane

GRANITE, QUARRIED AT ONE TIME

LOCATION	*PURPOSE*	*COUNTY*
Near mouth of Grande Ronde River......	Monumental	Asotin
Chelan	Road metal	Chelan
Devil's Elbow quarry, 18 mi. N. of Kellar..	....	Ferry
Snoqualmie	Road metal	King
Landsburg	Riprap	Do
Skykomish	Monumental and building	Do
Baring	do	Do
Kapsowsin, N. of town	Riprap	Pierce
Halford	Riprap and rubble	Snohomish
Medical Lake, County quarry	Road metal and concrete	Spokane
On Little Spokane River, sec. 34, (27-42 E.)	Monumental	Do
Moab	Road metal	Do
Fairfield	do	Do
Granite Point, 2 mi. above Wawawai on Snake River	General building and heavy masonry	Whitman

GRANITE PRODUCTION, 1923-1933

Year	No. of plants in operation	Monumental				Riprap and rubble		Architectural and misc. c	Total	
		Dressed		Rough						
		Cubic feet	Value	Cubic feet	Value	Short tons	Value	Value	Short tons approx.	Value
1923	6	a9,250	a$52,480	(a)	(a)	55,130	$59,525	$50,266	56,410	$162,271
1924	6	5,670	57,573	2,010	$4,471	(b)	(b)	25,707	29,790	87,751
1925	7	5,840	58,227	3,350	4,595	(b)	(b)	31,171	46,050	93,993
1926	5	3,560	35,652	6,690	17,824	19,070	10,254	51,517	24,430	115,248
1927	9	3,790	49,562	11,030	11,565	277,560	115,973	10,312	279,190	187,412
1928	15	a5,100	a24,488	(a)	(a)	36,720	20,323	42,109	80,310	86,920
1929	15	a4,220	a14,410	(a)	(a)	36,550	19,350	61,121	112,760	94,881
1930	11	3,360	21,893	1,570	4,412	15,800	8,781	68,542	55,500	103,629
1931	11	2,540	29,166	720	1,078	9,620	4,788	67,850	56,450	102,882
1932	7	....	(b)	....	(b)	38,730	31,856	93,379	62,260	125,235
1933	4	1,040	12,100	650	915	....	....	87,825	81,250	100,840

a Rough stone included with dressed stone.
b Included under "Architectural and miscellaneous."
c Includes various units of measure, hence quantity not specified.

LIMESTONE

Washington limestone is used as a mineral rather than as a "stone,"—that is, in cement, lime, chemical, and metallurgical industries, but very little for construction. So reference may be made to it on pages 53-61, and also under the headings of "Portland cement," page 85, "Lime," page 50, and "Marble," page 107.

MARBLE

Marble is usually considered as being any metamorphosed, recrystallized limestone. Such effects take place, to some extent, so early in the consolidation of a deposit of calcium carbonate that it is difficult to classify some limestones on the basis of that definition alone. In the trade, the term "marble" is applied to any limestone capable of taking a polish. With few exceptions the limestones of Washington are metamorphosed, recrystallized, and capable of taking a polish, so should be classed as marbles. The deposits are abundant, particularly in eastern Washington, and are mentioned more fully under the heading of "Limestone" (see pp. 53-61). Marble, showing great variation of color, texture, and pattern, could be obtained from nearly all "limestone" deposits of the State with the exception of those in Grays Harbor County, Pacific County, and the Olympic Peninsula. Whether they would be suitable for architectural and monumental purposes would depend chiefly on the amount of jointing which might prevent quarrying in large blocks.

Considerable marble was produced in former years for building stone, trim, and monuments. This was almost entirely from northeastern Washington, particularly in Stevens County. It is interesting to note that the greatest activity was on deposits which were later recognized as magnesite and not marble as was originally thought.

The present small output is confined almost entirely to the production of terrazzo, stucco "dash," poultry grit, and various manufactured products using calcium carbonate. Operators now or recently producing include the following, all of Chewelah, Stevens County: Manufacturers Mineral Co., The Feltstone Co., Italian Marble Products Co., J. J. Schoenberg, and John Mutti.

SANDSTONE

Sandstone in thick beds occurs prominently in the Puget and Chuckanut formations of western Washington. In many places it is admirably suited for quarrying, for working into stone for architectural and other uses, and for easy transportation to the larger cities. Thick beds of sandstone are present in other formations also, such as the Roslyn and Swauk of eastern Washington; and, while not so uniform, compact, and low in iron as those mentioned above, may be more accessible to some towns and be a quite usable and useful building material.

Quarries have operated in Washington since the early days; but the increased use of concrete and other structural materials has decreased the demand so that only two, those of the Walker Cut Stone Co., near Wilkeson, Pierce County, and the Western Quarry Co., at Tenino, Thurston County, were operating in 1935. The yearly production of sandstone is commonly a considerable amount. This is due partly to the occasional demand for rough and dressed stone for large buildings and partly to other uses such as for flagstones, paving blocks, rubble, riprap, concrete aggregate, and road metal. The increasing use of sandstone for its abrasive properties is mentioned under the heading of "Abrasives" on page 12.

The following list of quarries includes some which have been recently active and some which have not operated for 40 years or more. Even those long inoperative are of interest, since construction may be inspected where the stone was used and the physical properties under weathering may be ascertained. The temporary road-metal quarries are not considered.

SANDSTONE QUARRIES OF WASHINGTON

COUNTY	*QUARRY NAME*	*LOCATION*	*PRINCIPAL USE*
Asotin	....	Near Clarkston, NE.¼ sec. 8, (10-46 E.)	Local building.
Ferry	....	Republic, 2 quarries	Local building.
King	Eureka	Cumberland, sec. 28, (21-7 E.)	Seattle building.
Kitsap	Reynolds	NE.¼ SE.¼ sec. 3, (24-1 E.), on Sound	Riprap, Tacoma water front.
Do	Waterman	NE. of Waterman, on Sound	Riprap.
Pierce	Walker (Wilkeson)	1½ mi. NE. of Wilkeson, sec. 27, (19-6 E.)	Building and general. Abrasives.
Do	Fairfax	1½ mi. NW. of Fairfax, sec. 22, (18-6 E.)	Local coke-oven construction.
San Juan	....	Humphrey's Head, Lopez Island	....
Do	....	3 quarries on Reid Harbor, Stuart Island	Belgian blocks.
Do	Sucia Island Quarry Co.	2 quarries on Sucia Island	....
Do	Alaska Barge Co.	E. side Pt. Disney, Waldron Island	Belgian blocks and riprap.
Thurston	Hercules (Western Quarry Co.)	1 mi. NE. of Tenino	Building and general.
Do	Tenino Stone Co.	½ mi. W. of Tenino	Building and general.
Whatcom	Chuckanut Bay	Chuckanut Bay, secs. 13 & 24, (37-2 E.)	Building and general.
Yakima	....	Near Yakima	Local building.
Do	Howard	Near Selah	Local building.
Do	....	Near Prosser	Local building.

SERPENTINE

Serpentine, hydrous magnesium silicate ($H_4Mg_3Si_2O_9$), formed by the alteration of magnesian rocks and minerals, is common in Washington wherever basic rocks belonging to the older formations occur. Massive serpentine of a quality suitable for ornamental stone is present in a few places, and there has been a small intermittent production from some quarries. The soft, greasy-feeling variegated green rock composed of this mineral must be in large blocks free from joints if use is to be made of it for wall trim and counter tops. Most of that which has been worked occurs with marble, dolomite, and, in places, magnesite and brucite, so there is great variation in purity, hardness, and color. This may have the effect of adding to the value, owing to the demand for variety and unusual patterns.

Serpentine occurrences, some of which had considerable production many years ago, are listed below, the only one with recent activity being the McGrath property. Other bodies probably suitable for production could be located if a better market should develop. Due to the common association and close relationship between the two minerals, the known talc deposits (see p. 115) may be used as one guide to new serpentine bodies.

SERPENTINE OCCURRENCES

COUNTY	NAME	LOCATION	DEVELOPMENT
Pend Oreille	Spokane Marble Co.	6 mi. NW. of Milan, sec. 32, (30-43 E.)	Old quarry and mill site.
Snohomish	....	1 mi. E. of Granite Falls, SE.¼ sec. 18, (30-7 E.)	None.
Stevens	Royal Serpentine Marble Co.	5 mi. E. of Chewelah, sec. 9, (32-41 E.)	Very little. Few openings.
Do	Green Mt. Marble Co.	1½ mi. E. of Valley, sec. 13, (31-40 E.)	Small amount.
Do	Pacific Coast Marble, Tiling & Mfg. Co.	2 mi. E. of Valley, sec. 18, (31-41 E.)	Old quarry and mill site.
Do	North American Marble & Onyx Co.	11 to 12 mi. W. of Valley and 5½ mi. NW. secs. 12 and 19, (31-39 E.); secs. 24 and 25, (31-38 E.)	Outcrops and a few openings.
Do	U. S. Marble Co. (Present Keystone quarry)	12 mi. NW. of Valley, secs. 8 and 9, (31-39 E.)	Old Greenway quarry and prospects.
Do	James J. McGrath	Near Valley	Producing for terrazzo, stucco, etc.
Do	....	Large area E. of Laurier	None.

SLATE

Slate is common in the older metamorphic rocks of the northern Cascades and in the northern counties of eastern Washington. A grade of rock, however, which could be quarried economically and which would split into fair-sized thin slabs is almost unknown at present. Most occurrences are unsuitable for commercial stone because of jointing and undulatory cleavage. As inaccessible parts of the State are opened by roads, it is reasonable to presume that slates which might have commercial value will be discovered.

A deposit 1½ miles south of Sedro Woolley, Skagit County, on the railroad near the center of sec. 36, (35-4 E.), has been quarried at various times. It contains a slate that is less jointed than some and which has a moderately flat, smooth cleavage. So far as known, it has been used only for riprap, but some parts of the bed might be suitable for roofing and other uses.

A quarry was opened many years ago about 13 miles by road west of Valley, Stevens County, in sec. 19, (31-39 E.). Some development work was done on a slate of fairly good quality. Good-sized blocks are available that can be split rather easily into medium-smooth comparatively thin plates. The rock is variously colored to shades of purple and silvery green where weathered, and grass-green to bluish black where unweathered.

REFERENCES

See references under the heading of "Abrasives," page 12.

Burchard, E. F., Stone: U. S. Geol. Survey Mineral Resources, pt. 2, pp. 1398-1408, 1913.

Landes, Henry, Non-metalliferous resources of Washington, except coal: Washington Geol. Survey Ann. Rept. 1901, vol. 1, pt. 3, pp. 1-12, 1902.

————, The road materials of Washington: Washington Geol. Survey Bull. 2, 1911.

————, The Mineral Resources of Washington: Washington Geol. Survey Bull. 11, pp. 7-12, 1914.

Shedd, Solon, Cement materials and industry in the State of Washington: Washington Geol. Survey Bull. 4, 1914.

STRONTIUM

The important commercial minerals of strontium are celestite, strontium sulphate ($SrSO_4$), and strontianite, strontium carbonate ($SrCO_3$). Celestite is commonly light blue or white, transparent to nearly opaque, and noticeably heavy (specific gravity 3.95 to 3.97). Strontianite is mostly white and may occur as masses of radiating elongated crystals or as a sugary-appearing mass. Both minerals are generally present in an occurrence. They are used in preparing strontium compounds for drugs and chemicals, "red fire" and signal flares taking the largest amount.

WASHINGTON OCCURRENCES

A vein of celestite with minor amounts of strontianite outcrops in the sea cliff 1½ miles southwest of LaConner, Skagit County, in sec. 2, (33-2 E.) on what is known as the Wm. Alverson property. Several thousand tons are said to be available above the water level. Samples partly analyzed by A. A. Chambers, U. S. Geol. Survey, showed the strontianite to be 75.80 per cent strontium carbonate, 0.75 per cent strontium sulphate, and with calcium carbonate present; the celestite was 97.03 per cent strontium sulphate with only a trace of carbonate. A 110-foot tunnel has been driven on the vein, and 100 feet of trench exposes the outcrop on top of the cliff 80 feet above the tunnel. As exposed by this development, the celestite and what is apparently secondary strontianite are scattered through a shattered zone from 3 to 4 feet wide in a serpentinized dunite. The richest ore, about 30 inches wide, is exposed by the trench. A few hundred tons were shipped during the war to various users. Prospecting was being carried on in 1934 in the expectation of proving a greater extent of mineralization.

Stose[1] mentioned in 1919 that strontium ore was reported by H. B. Brown of Edmonds as occurring in Whatcom County just above the gorge of Skagit River near the mouth of Ruby Creek. It was said to be extensive and of good grade.

Weaver[2] reports that in the Index district of Snohomish County a 4-inch seam of strontianite occurs as a vein on the north side of Ethel Creek.

REFERENCE

Landes, K. K., The strontium occurrence near LaConner, Wash.: Amer. Mineralogist, vol. 14, pp. 408-413, 1929.

SULPHUR

Sulphur, combined chemically in many ways with various other elements, is extremely abundant in nature. It may also occur free in an almost pure state and then is not unlike the sulphur of commerce—a yellow to light yellowish gray soft, brittle material which melts at a low temperature and burns with a characteristic blue flame and suffocating odor.

A large amount of sulphur is used in various industries of the country, but in the Pacific Northwest the chief use is in the manufacture of paper pulp from wood fiber by the sulphite process. This application accounts for a very appreciable percentage of the total United States production.

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[1]Stose, G. W., Strontium: U. S. Geol. Survey Mineral Resources, pt. 2, p. 98, 1919.
[2]Weaver, C. E., Geology and ore deposits of the Index Mining District: Washington Geol. Survey Bull. 7, p. 64, 1912.

WASHINGTON OCCURRENCES

The only large occurrence of sulphur now known in this State and one which appears to have definite commercial possibilities is that which is being prospected under the ice in the crater of Mount Adams, Yakima County. Sulphur occurs there as veinlets, cavity fillings, and cementing material in volcanic breccia and tuff, and originated as a sublimate from the fumes accompanying the end of volcanism. The deposits are being explored by test pits and diamond drilling, although the elevation of 11,500 to 12,000 feet renders the work arduous and expensive.

On Naches Highway in sec. 33, (20-8 E.), Pierce County, sulphur is reported to occur in a shallow open cut beside the highway where the railway of the White River Lumber Co. crosses the river. It is said to occur as veinlets and cavity filling in a 10-foot brecciated zone in granite. Samples analyzing 26.2 per cent sulphur are reported.

On Sulphur Creek, tributary to Suiattle River in sec. 18, (32-14 E.), Snohomish County, sulphur has been reported to occur as "float" in the vicinity of a hot sulphur spring, indicating a deposit nearby. This occurrence (or what might possibly be a similar one near a sulphur spring ascribed to eastern Lewis County) has been mentioned several times in the literature. The original reference was a brief, vague note in a publication of 1896 merely stating that sulphur occurred.

A source of sulphur that no doubt could be developed in Washington is that of the sulphide ores. When pure, pyrite (iron sulphide) contains 53.4 per cent sulphur; pyrrhotite (another iron sulphide), 39.6 per cent; and chalcopyrite (copper-iron sulphide), 35.0 per cent. The sulphur from these and other sulphides is readily driven off by roasting and is used in the manufacture of sulphuric acid, while the remaining iron and copper are made available for metallurgical purposes. Washington deposits of pyrite and pyrrhotite could be utilized in this way, and processes might be developed to make the sulphur from these ores available to the paper mills.

REFERENCES

Various authors, Sulphur and pyrite: U. S. Bureau of Mines Mineral Resources and Minerals Yearbooks, various years from 1924.

Various authors, Sulphur and pyrite: U. S. Geol. Survey Mineral Resources, various years to 1924.

Wells, A. E., and Fogg, D. E., The manufacture of sulphuric acid in the United States: U. S. Bureau of Mines Bull. 184, pp. 25-34, 1920.

TALC AND SOAPSTONE

Talc, a hydrous magnesium silicate ($H_2Mg_3(SiO_3)_4$), is a soft, soapy-feeling white, gray, or green mineral. When massive and containing impurities such as chlorite, serpentine, and calcite, the aggregate is termed soapstone. Both occur in metamorphic rocks, either of basic igneous or dolomitic types, and may form large bodies of economic importance or narrow high-grade veins of little value.

The greatest use of talc is by the manufacturers of paper; others using large amounts are the paint, prepared roofing, rubber, textile, linoleum, and cosmetic industries. Some soapstone is ground and used as low-grade talc, but its value lies chiefly in its resistance to acids and heat and to its massive structure, whereby panels, trays, and dimension blocks may be sawed out.

WASHINGTON OCCURRENCES

Chelan County. Soapstone is reported to occur on White River northwest of Wenatchee Lake. A sample from that district was of fair quality and indicates the possibilities of the area. It is said to occur also on Williams Creek in connection with the asbestos of that location. (See p. 13.)

Ferry County. On the new Kettle Falls road about 12 miles southeast of Republic in sec. 20, (36-34 E.), a shear zone in schist carries considerable talc. In the same road cut, talc shows to a width of 3 or 4 feet at the contact of felsite and serpentine. The occurrence is not commercial but indicates the possibilities of the area.

Lincoln County. The G. W. Capps talc mine, 10½ miles north of Mondovi in the W. ½ NW. ¼ sec. 34, (27-38 E.), has been prospected for many years, and a small amount of talc has been produced. At one time a mill was located on the property and ground talc was shipped to paper mills. The country rock here is calcareous schist and dolomitic limestone with dioritic intrusives nearby. Talc of fairly good grade, although not uniform, occurs in a shear zone in the calcareous rocks. It varies from a few inches to 10 feet in width, with a probable average width of 5 feet, and has been opened by trenches and cuts for several hundred feet.

South of Reardon in the NE. ¼ sec. 6, (24-39 E.), talc is said to have been encountered in an excavation for a building on the old Travis farm. The country rock is argillaceous quartzite and talc-schist near granitic intrusives.

Okanogan County. At the Kaaba mine, 1 mile southwest of Nighthawk in secs. 14 and 23, (40-25 E.), crystalline talc is reported to occur to a thickness of 18 inches on the hanging wall of the vein.

Northwest of Omak about 9 miles, in the south center of sec. 32, (35-26 E.), is an area of metamorphosed basic igneous rock in which the alteration has produced serpentine, talc, and associated minerals. A one-inch vein of high-grade light-green talc shows at an old open cut. There is the possibility that prospecting might prove a commercial amount of talc or soapstone to be present in this general area.

Skagit County. At the north edge of Burlington, a hill of greenstone has more or less impure talc and fibrous asbestiform minerals occurring in shear zones. No large body of either talc or soapstone has been developed, but the fibrous talcose aggregate is mined and milled at Burlington for special cements and other products by the Asbestos-Talc Products Co. of Washington, Inc.

South of Skagit River from Lyman, in the vicinity of the S. ½ sec. 30, (35-6 E.), a talcose clay covers a large area under a few inches of soil. Several borings showed from 3 to 6 feet of this rubbery bluish-white material. It might prove to be of value for its talc content and peculiar physical characteristics. In any event, it indicates certain possibilities for the hills to the south from which it must have been washed.

The Alvard talc deposit is about 4 miles northeast of Marblemount at approximately the NE. cor. sec. 21, (36-11 E.). It was the first recorded discovery of talc in this vicinity, being made some 40 years ago. The property had considerable development; a mill was erected at one time, and ground talc was barged down Skagit River. The City of Seattle Skagit Railway was built later through the property and occasional shipments are once more being made. The untreated talc is shipped by H. P. Scheel of Sedro Woolley to the St. Helens Pulp & Paper Co. to be used in furnace lining.

A large amount of soapstone occurs on the property and with it some high-grade talc, but the value is lowered by ankerite (calcium-iron-magnesium carbonate) inclusions. These nodules vary in size, possibly averaging an inch in diameter, and are particularly troublesome in the otherwise purer parts of the deposit.

The Alvard talc and soapstone, like all of the other large bodies in the vicinity, have apparently been derived from very basic igneous rocks and some schist by the alterational effects, almost regional in magnitude, of solutions from invading granodiorite. The various deposits are similar, in that outcrops are practically all soapstone with a few later basic intrusives and give but little idea of the original rock. Some serpentine is present and ankerite, to some degree, occurs in each exposure.

The McMyrl-Wilson property is about 4 miles northeast of Marblemount in the NE. ¼ sec. 21, (36-11 E.), and is said to include part, at least, of the old Alvard property. Eleven mining claims have been taken up on soapstone and talc, and on some of these a high-grade mineral is developed. A quarry was opened and for a time dimension soapstone was cut for refractory use. In some prospect tunnels, a pale-green talc was encountered in bodies up to 10 feet wide. The property is idle at the present time (1934).

The Skagit Talc, Inc., is on Portage Creek about 7 miles northeast of Marblemount in sec. 11 and 14, (36-11 E.). Outcrops, open cuts, and tunnels expose a great amount of excellent soapstone containing some high-grade talc. The geologic occurrence is similar to the other deposits of the upper Skagit,—in altered basic rocks close to the granodiorite contact. The property was discovered in 1929 and has been operated since that time. It consists of 4 or 5 mining claims. The soapstone is mined in underground rooms opening off a main tunnel. An electrically operated saw is used to quarry the material in large blocks. The rough pieces are later cut into dimension blocks at the plant located on the property, and the finished product is shipped to paper mills for furnace lining.

The Cascade River deposit, a talc and soapstone body, locally known as Mrs. Sadie Cudworth's claim, is on the new highway about 13 miles southeast of Marblemount near the SE. cor. sec. 21, (35-12 E.). Soapstone outcrops for 1,000 feet or so along the road, but the angle of cut to the strike of the body is not known, and so the actual width of the occurrence is in doubt. Some narrow veins of very high-grade crystalline talc occur in the soapstone. There has been no development of this deposit.

The Boulder Creek deposit is about 5 miles southeast of Marblemount in approximately sec. 11, (35-11 E.). Some prospecting work has been done, but the soapstone is rather hard and contains considerable serpentine and ankerite.

Stevens County. Talc, sometimes known as the Springdale or Firminhac deposit is located about 18 miles west of Springdale and just north of the Hunters road in the W. ½ SW. ¼ sec. 15, (30-38 E.). The country rock is slate, quartzite, and dolomite, all cut by basic dikes. Talc has resulted from the alteration of the carbonate rocks in certain places; and several open cuts, prospect tunnels, and pits have been dug in the attempt to develop a commercial body of this mineral. One cut shows a vein of high-grade talc a few inches wide, and a nearby excavation exposes another vein that is 3 feet wide, in part very pure. The wider vein has been followed for 50 feet to where it begins to narrow, and several tons have been mined.

An 8-foot vein of lower grade is reported to occur in this vicinity. So far as known, no talc has been shipped.

The C. F. Allen deposit is just north of the Hunters road in the NW ¼ sec. 21, (30-38 E.). The rocks and mineralization are similar to that of the so-called Springdale deposit, although more schistosity is apparent and less high-quality talc present. Two prospect tunnels expose a talcose serpentinized schist that is most variable in composition, and an open cut near the road and west of the tunnels shows a vein of high-calcium impure talc. The mineral exposed is of doubtful value but is an indication of the possibilities of the region.

A large area of basic diorite is reported by Weaver[1] to occur east of Laurier. He mentions that talc occurs as an abundant alteration product of the ferromagnesian pyroxenes of the diorite. No other reports of this talc are known, but the area should be investigated for commercial deposits.

REFERENCES

Ladoo, R. B., Talc and soapstone, their mining, milling, products, and uses: U. S. Bureau of Mines Bull. 213, 1923.

Spence, H. S., Talc and soapstone in Canada: Canada Dep't of Mines, Mines Branch No. 583, 1922.

Wilson, Hewitt, and Pask, J. A., Talc and soapstone in Washington: Am. Inst. Min. Met. Eng. Contributions 99, 1936.

MISCELLANEOUS MINERALS

A number of minerals occurring in Washington may have a future value if they are found to exist in sufficient quantity or if a market should develop. These are listed below and with them are included a few minerals of general interest which have been mentioned in reports and in the literature.

ALUM

Natural alum occurs in moderately thick beds over a considerable area near the top of Mount Adams, in Yakima County. It is associated with sulphur and doubtless was formed by the action of sulphuric-acid waters on the pumicite and volcanic rocks of the upper cone. The alum minerals so far identified[2] include alumian, $(Al_2O)(SO_4)_2$; alunogen, $Al_2(SO_4)_3.18H_2O$; and aluminite, $Al_2O_3.SO_3.9H_2O$; together with smaller amounts of mendozite, melanterite, copiapite, and blödite.

Some prospect work has been done on the deposits, and a few hundred pounds have been taken out for experimental purposes.

[1]Weaver, C. E., The mineral resources of Stevens County: Washington Geol. Survey Bull. 20, p. 132, 1920.

[2]Fowler, C. S., Private report, through the courtesy of Mr. W. H. Dean.

Alunogen and halotrichite, $Fe_2SO_4.Al_2(SO_4)_3.24H_2O$, are commonly present as a fine, fur-like growth of delicate white crystals and as crusts on the walls of old tunnels, particularly in coal mines. These minerals are soluble in water and have the bitter astringent taste of alum.

ANDALUSITE

Andalusite and sillimanite (aluminum silicates, Al_2SiO_5) occur as large crystals in graphitic mica schist and in pegmatite and aplite dikes on Silver Hill, 11 miles southeast of Spokane and are mentioned by Collier[1] in his report on the tin prospects of that vicinity. The minerals do not form a large enough percentage of the rock to be usable for ceramic purposes without some method of concentration.

BAUXITE

Bauxite, aluminum oxide ($Al_2O_3.2H_2O$), is occasionally reported to occur at various places in Washington, but, so far, the reports have proved erroneous or could not be authenticated.

BENTONITE

No commercial deposits of bentonite, a clay-like mineral, are known in the State; but thin beds, probably derived from the alteration of pumicite, have been reported from the vicinity of Ellensburg and Yakima, and conditions in the Ellensburg and Ringold formations are favorable for its occurrence.

BERYL

A large deposit of beryl, beryllium silicate ($Be_3Al_2Si_6O_{18}$), from which at least two choice crystals are said to have been sold, is reported to occur about 4 miles west of Monte Cristo, in the vicinity of Del Campo. A field trip to verify the report was unsuccessful, but, owing to the inaccessibility of the region, may have missed the correct location.

Other minerals are sometimes mistaken for beryl, as in the case of massive actinolite from the Stevens Pass region of Chelan County. So far, no deposits of commercial size are known and authentic occurrences are only of small, isolated crystals.

BORAX

The literature of 30 years or more ago contained references to borax deposits in certain parts of eastern Washington. Borates may be present in the waters of salt and alkaline lakes and as impurities in the sodium sulphate deposits (see p. 97) but no commercial occurrence is known.

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[1]Collier, A. J., Tin ore at Spokane, Washington: U. S. Geol. Survey Bull. 340, pp. 295-305, 1907

BRUCITE

Brucite, a soft, easily-carved greenish-gray mineral resembling talc but which is a magnesium hydroxide, $Mg(OH)_2$, occurs in considerable quantity in Stevens County. It is associated with the magnesite in the Keystone quarry (see p. 63), where it forms a lenticular mass about 40 feet long and 20 feet thick. Another occurrence is in an old quarry 400 feet north of the Keystone, and still others no doubt occur. Some brucite with accompanying magnesite was quarried at one time as marble and used for structural purposes, particularly ornamental trim. The delicate, translucent green color of the brucite and the ease with which it could be elaborately carved led to the use of a considerable amount for vases and ornaments. Later, it was quarried for a time with magnesite for refractory uses.

DOLOMITE

Dolomite is calcium-magnesium carbonate, $CaMg(CO_3)_2$. This mineral and high-magnesium limestones are abundant in Stevens County and occur in Pend Oreille, Ferry, and Okanogan counties. The best known occurrences are those of the Stensgar dolomite belt, which is described by Weaver[1] as lying near the crest of the Huckleberry Mountains and extending for about 21 miles from Eagle Mountain, 5 miles northwest of Chewelah, to near the center of T. 29 N., R. 37 E. Dolomite occurs also in various other formations of that vicinity, notably the Old Dominion limestone. Many of these deposits and other scattered bodies of high-magnesium rock grading into dolomite are mentioned by Shedd[2] in his report on the limestones of Washington.

The demand for dolomite in this State has never been large. It undoubtedly will be much greater with future industrial expansion and particularly if, as appears entirely possible, dolomite should become an ore of magnesium.

So far, the only dolomite mined is from a large deposit 5 miles east of Colville, Stevens County, in sec. 18, (35-40 E.). The Tulare Mining Co. opened a quarry here in 1917. Operation by the company, by its successor Eric Carlson, and by a lessee, the Crown Willamette Paper Co., has been more or less continuous since that time. The rock is calcined in kilns on the property and as much as 500 tons per month has been shipped to paper mills at Camas, Washington, and Oregon City,

[1]Weaver, C. E., The mineral resources of Stevens County: Washington Geol. Survey Bull. 20, pp. 57-59, 1920.

[2]Shedd, Solon, Cement materials and industry in the State of Washington: Washington Geol. Survey Bull. 4, 1914.

Oregon, to be used in making bisulphite acid for cooking wood pulp.

GARNET

The garnet group includes several minerals with specific names which have similar properties and crystal structure. They are usually recognized by a pink, red, or brown color, a hardness about like quartz, and a habit of forming isolated dodecahedral crystals in schists. Garnet may also occur in a massive form as a contact-metamorphic mineral usually in crystalline limestones.

Minute clear pink rounded garnets are abundant in some of the beach sands of the Olympic Peninsula. They have been mistaken for rubies and even for cinnabar! They are too small to have any value.

Massive garnet, probable variety grossularite, $Ca_3Al_2(SiO_4)_3$, forms an irregular body 10 feet or more in width adjacent to limestone on the south end of Denny Mountain, 600 to 1,000 feet above Denny Creek. This is in King County, 1½ miles airline due west of Snoqualmie Pass. Massive garnet occurs, also, at the Guye iron prospect on the west side of the shoulder connecting Guye Peak with Snoqualmie Mountain, about 2 miles north of Snoqualmie Pass. Both occurrences owe their origin to contact effects between granodiorite and a limestone-argillite-quartzite series. The garnet might have value as an abrasive and should be tested for desirable physical properties.

Massive contact garnet was encountered in test pits 15 miles northeast of Republic, Ferry County, in the NW. cor. sec. 12, (37-34 E.). Chunks up to 10 inches in diameter show on the old dumps.

Reddish-brown garnets are a common mineral of the Orient gneiss of Stevens County and occur in the limestone near intrusive contacts. They have formed in schists and other metamorphic rocks of the northern counties, but, so far, none with commercial value has been reported.

LITHIUM MINERALS

A dike containing lepidolite, a lithia mica, has been reported to occur a few miles west of Riverside, Okanogan County, but the exact location is unknown. Another reported occurrence of lithium minerals is with the ores of the Royal Development Co. at their mine in approximately sec. 34, (30-16 E.), about 20 miles north of Wenatchee Lake, Chelan County.

NITRATES AND PHOSPHATES

Salt incrustations thought to be nitrates have been reported: two such occurrences, in prospect tunnels three miles east of Steamboat Rock in Northrop Canyon, Grant County, were investigated by Mansfield and Boardman[1], who found traces, only, of nitrate and phosphate with salts which were chiefly sodium and aluminum sulphates.

Vivianite, a hydrous ferrous phosphate usually associated with organic remains, occasionally occurs in clays; apatite, calcium phosphate ($Ca_4(CaF)(PO_4)_3$), is a common accessory mineral of the igneous rocks in some parts of the State; but "phosphate rock," a massive impure form of apatite and the chief source of commercial phosphates, is not known to occur in Washington, although at one time a commercial amount was reported from near Bellingham in Whatcom County.

OLIVINE

Olivine (chrysolite), an iron-magnesium orthosilicate ($(Mg,Fe)_2SiO_4$), is the principal constituent of many basic rocks of Washington. An outstanding occurrence is in the Twin Sisters Mountains southwest of Mount Baker in Whatcom and Skagit counties; that great mass is largely dunite, a rock almost entirely formed of olivine. Dunite is abundant also on Cypress and Fidalgo islands.

POTASH

Potassium enters into the composition of some common rock-forming minerals,—for instance: orthoclase feldspar, a common constituent of granite, is 16.9 per cent potash (potassium oxide). The potash of commerce is, however, a salt of potassium and in that form occurs widely in saline lakes of eastern Washington but not, so far as is now known, in anything like commercial amount. Deposits mentioned in the early literature were sodium and magnesium sulphates with very minor percentages of potash.

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[1]Mansfield, G. R., and Boardman, Leona, Nitrate deposits of the United States: U. S. Geol. Survey Bull. 838, p. 98, 1932.

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