

CONTAINS

1. TALC, SOAPSTONE & Pyrophyllite Productions in CA during 1948, by Counties.
2. "ASBESTOS"
 - FENELON F. DAVIS
3. "TALC, SOAPSTONE, & Pyrophyllite"
 - LAUREN A. WRIGHT
4. DIRECTORY OF PRODUCERS... 1948
 - ASBESTOS
 - TALC, SOAPSTONE, Pyrophyllite.

PLAINTIFF'S
EXHIBIT
CAM-18

☒ Pkt.	☐ Def.
Exhibit No. <u>34</u>	I.D.
Patricia Ruby, N.P. 8-12-88	
Witness <u>Muligan</u>	

STATE OF CALIFORNIA
EARL WARREN, Governor
DEPARTMENT OF NATURAL RESOURCES
WARREN T. HANNUM, Director

DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO 11
OLAF P. JENKINS, Chief

SAN FRANCISCO

BULLETIN 156

AUGUST 1950

MINERAL COMMODITIES
OF
CALIFORNIA

GEOLOGIC OCCURRENCE, ECONOMIC DEVELOPMENT, AND
UTILIZATION OF THE STATE'S MINERAL RESOURCES

Prepared by the Staff of the

DIVISION OF MINES

Under the Direction of

OLAF P. JENKINS



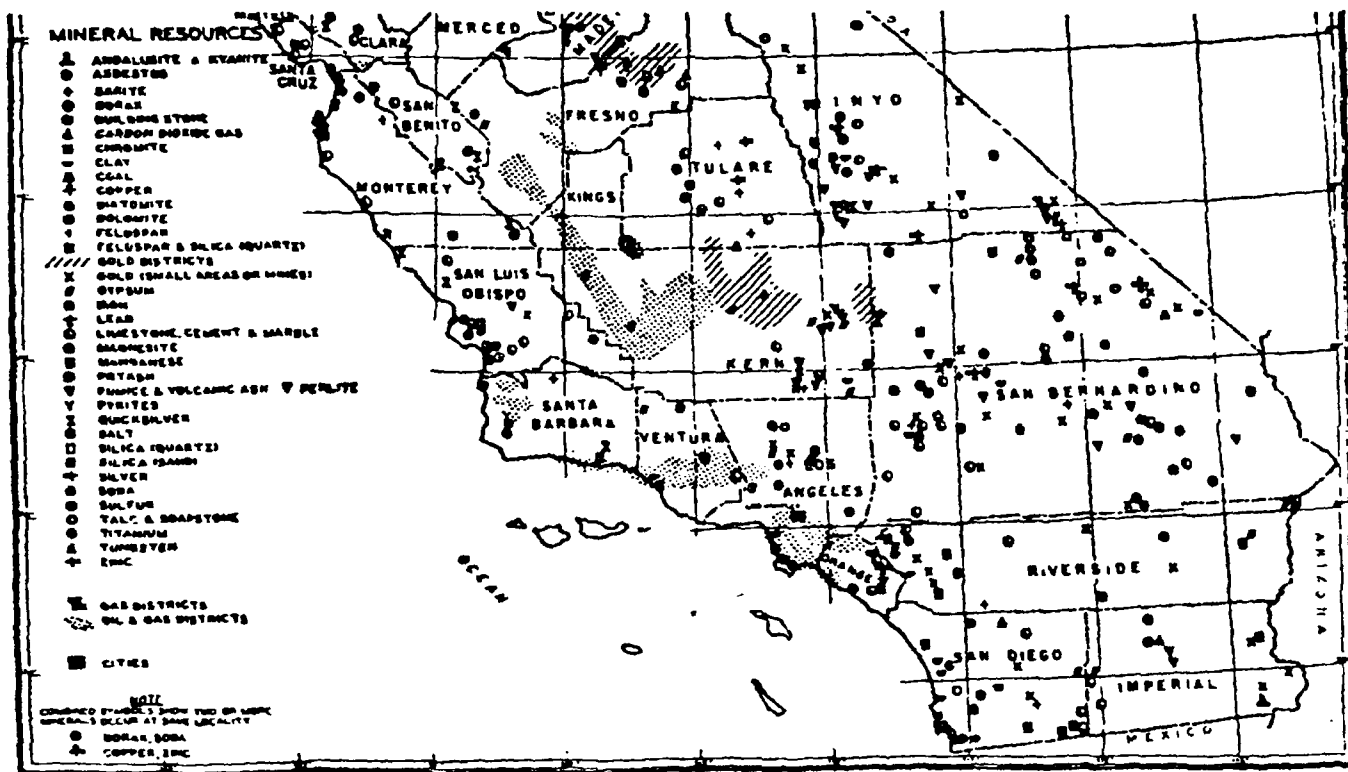
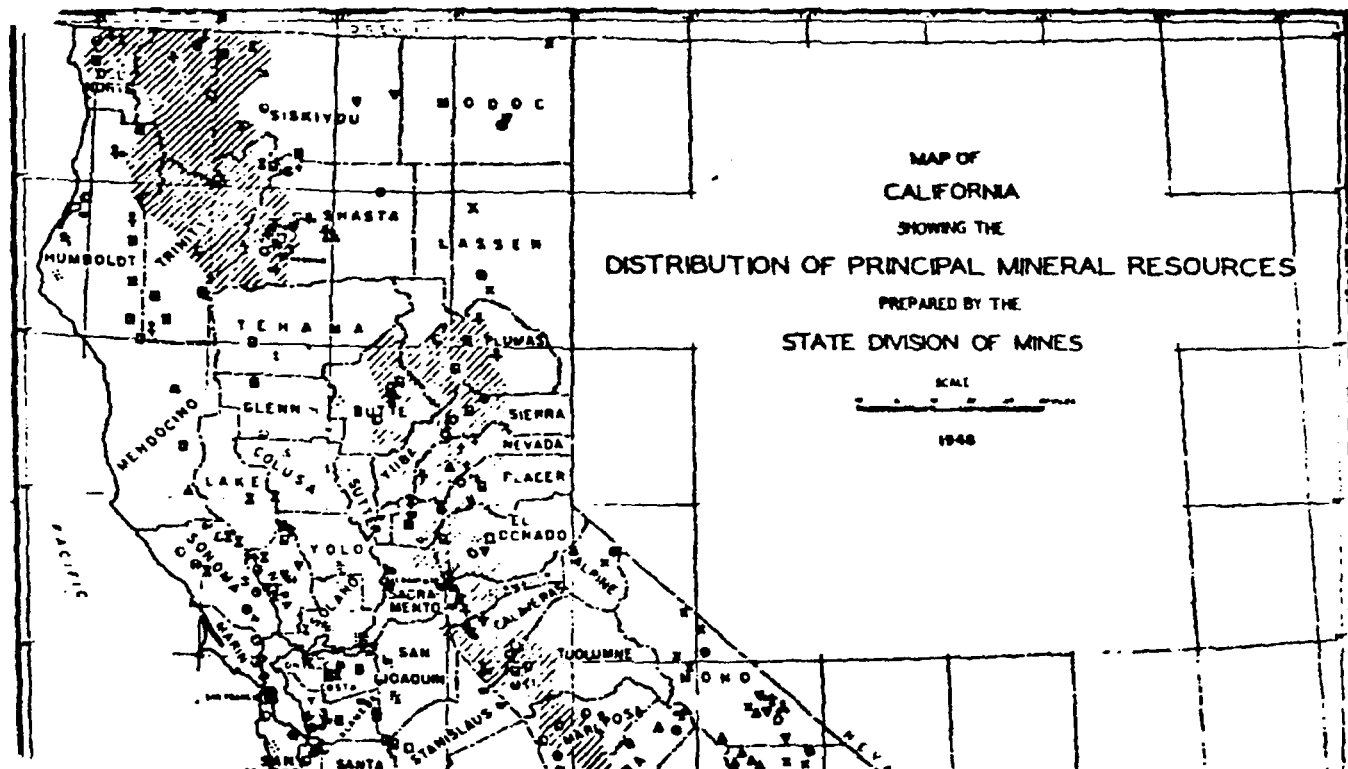
CONTRIBUTING AUTHORS

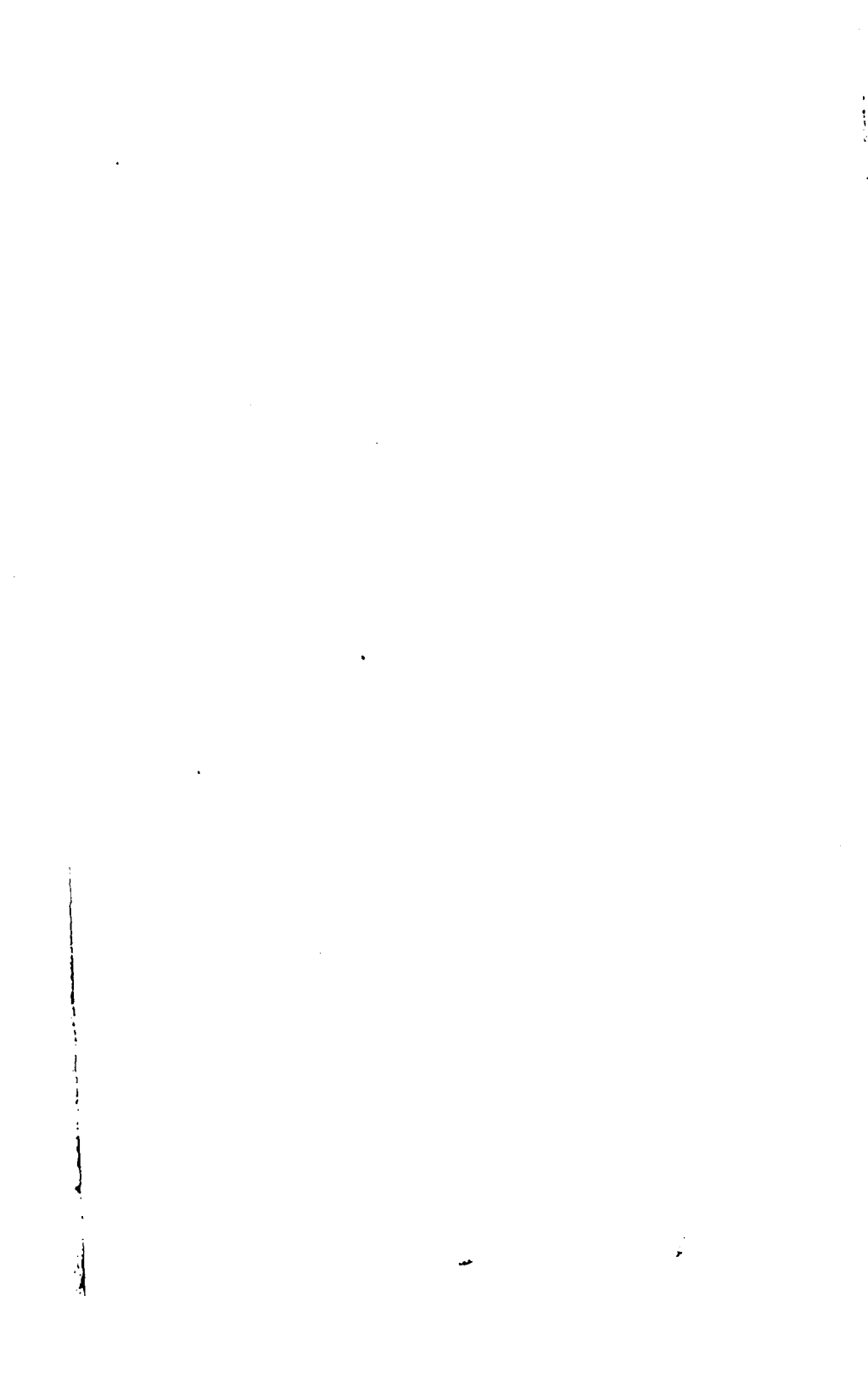
CHARLES V. AVERILL
OLIVER E. BOWEN, JR.
LEWIS T. BRAUN
CHARLES W. CHESTERMAN
RICHARD A. CRIPPEN, JR.
JAMES W. CROSBY, III
FENELON F. DAVIS
SAMUEL R. HOFFMAN
CLARENCE A. LOGAN

L. A. NORMAN, JR.
GORDON B. OAKESHOTT
JOHN C. O'BRIEN
RICHARD M. STEWART
HENRY H. SYMONS
MORT D. TURNER
JAMES W. VERNON
WILLIAM E. VER PLANCK, JR.
LAUREN A. WRIGHT

CONTRIBUTING AGENCY

UNITED STATES DEPARTMENT OF THE INTERIOR, BUREAU OF MINES





CONTENTS

36

	Page
LETTER OF TRANSMITTAL	3
PREFACE	11
NATURAL ENVIRONMENT OF MINERAL RESOURCES OF CALIFORNIA	15
PART I—SUMMARY OF MINERAL WEALTH IN CALIFORNIA FOR 1948	23
Mineral production in California during 1948 compared with 1947	25
Contributions of the counties to the mineral production of California during 1948	41
PART II—MINERAL FUELS	59
Coal	61
Coke	64
Natural gas	66
Natural gasoline and liquefied petroleum gases	80
Peat	83
Petroleum	85
PART III—NONMETALLIC INDUSTRIAL MATERIALS	109
Abrasives	111
Andalusite, kyanite, and sillimanite	116
Araucic	118
Asbestos	121
Asphalt and bituminous rock	124
Barite	130
Beryllium	132
Black sands	133
Calcite (optical)	136
Cement	138
Clays	142
Diatomite	150
Dolomite	155
Feldspar	158
Fluorspar	161
Gem stones	164
Graphite	169
Lime and limestone	171
Magnesite, magnesium, and magnesium compounds	177
Mica	184
Nitrogen compounds	186
Pebbles for grinding	187
Phosphates	189
Pumice, pumicite, and perlite	192
Pyrites	203
Quartz crystal	206

CONTENTS—Continued

	Page
Salines	208
Boron	215
Bromine	219
Calcium chloride	221
Gypsum	223
Iodine	230
Lithium	233
Potassium salts	236
Salt	242
Sodium carbonate	246
Sodium sulfate	249
Sand and gravel	251
Slate	258
Stone	260
Strontium minerals	270
Sulfur	273
Sulfuric acid	275
Talc, soapstone, and pyrophyllite	276
PART IV—METALS	283
Aluminum	285
Antimony	288
Bismuth	291
Cadmium	293
Chromite	294
Cobalt	299
Copper	300
Ferro-alloys	308
Gold	309
Iron	315
Lead	319
Manganese	324
Mercury	330
Molybdenum	337
Platinum and allied metals	340
Silver	343
Tin	349
Titanium	352
Tungsten	355
Uranium, thorium, and rare-earth elements	361
Zinc	364
Zirconium	368
PART V—DIRECTORY OF MINERAL PRODUCERS, DEALERS, AND COMMERCIAL LABORATORIES	371
Directory of producers of metallic and nonmetallic minerals in California during 1948	373
List of smelters and mineral dealers reporting purchase of metals produced in 1948	418
List of mineral dealers, custom mills, and commercial grinding plants in California	419
List of commercial assay and testing laboratories	42

ILLUSTRATIONS

Frontispiece

Map of California showing the distribution of principal mineral resources . . .

Page
4-5

37

Plates

Plate 1. Map of California showing distribution of mineral deposits; geomorphic provinces of California	18-19
2. Aerial photo showing view north toward Whiterock Bluff, from south bank of Cuyama River	224-225
3. Aerial photo showing view north toward Natividad dolomite quarry and calcining plant of Kaiser Aluminum and Chemical Corporation near Salinas, Monterey County	224-225
4. Aerial photo showing sea-water chemical plant and refractory brick plant of Kaiser Aluminum and Chemical Corporation	224-225
5. A, Photo showing Calaveras Cement Company plant, San Andreas, Calaveras County. B, Photo showing Permanente Cement Company plant, Permanente, Santa Clara County	224-225
6. A, Photo showing plant of U.S. Lime Products Corporation, Sonoma, Tuolumne County. B, Photo showing Fouch-Thompson pumice pit, Siskiyou County	224-225
7. Aerial photo showing view east toward clay pits at Lincoln, Placer County	224-225
8. Photo showing Kaiser Steel Corporation's blast furnaces at Fontana, San Bernardino County	224-225
9. Aerial photo showing route of Pacific Gas and Electric Company's 34-inch natural gas transmission main	224-225
10. A, Photo showing Malakoff hydraulic pit at North Bloomfield, Nevada County. B, Photo showing hydraulic mining at Relief Hill, Nevada County	224-225
11. A, Photo showing Shasta Dam, Shasta County. B, Photo showing large obsidian fragments, near Clear Lake, Lake County	224-225
12. A, Photo showing kyanite quarry near Ogilby, Imperial County. B, Photo showing central part of Western tale deposit, San Bernardino County	224-225
13. Aerial photo showing view east toward stacking ground and refinery, Leslie Salt Company, Newark, Alameda County	224-225
14. Photo showing mill of The Mountain-Copper Company, Ltd., Shasta County	224-225
15. A, Photo showing Western Refractories Company's Yosemite pit, near Carbondale, Amador County. B, Photo showing Desert Materials Corporation pumice pit, Cose Range, Inyo County	224-225
16. A, Photo showing Pacific Coast Aggregates, Inc., dragline mining gravel, Centerville, Alameda County. B, Photo showing view west toward Rockaway quarry, Rockaway Beach, San Mateo County	224-225
17. A, Photo showing J. M. Nelson Basalt Quarry, Solano County. B, Photo showing Thompson Divide Mining Company dragline dredge on Trinity River above Lewiston, Trinity County	224-225

Stone production of California during 1948, by counties.

County	Tons	Value
Alameda.....	1,002,200	\$742,900
Amador.....	21,270	158,894
Butte.....	224,770	508,904
Colusa.....	409,110	480,088
Contra Costa.....	178,130	618,448
El Dorado.....	416,530	23,310
Fresno.....	23,310	2,430
Humboldt.....	2,430	4,323,489
Lake.....	4,323,489	281,184
Los Angeles.....	197,150	78,812
Monterey.....	58,130	12,582
Napa.....	116,130	1,563,223
Orange.....	7,160	280,624
Riverside.....	1,195,070	728,064
San Bernardino.....	91,570	780,380
San Diego.....	780,380	301,890
San Mateo.....	301,890	255,048
Santa Barbara.....	255,048	128,418
Santa Clara.....	128,418	57,842
Shasta.....	177,778	189,836
Siskiyou.....	189,836	20,530
Sonoma.....	20,530	323,841
Trinity.....	323,841	12,318
Tuolumne.....	45,800	2,807,425
Yuba.....	1,801,420	11,836,240
Other counties ¹	11,836,240	\$13,155,464
Totals.....		

¹ Includes Del Norte, Imperial, Inyo, Lassen, Marin, Placer, Sacramento, San Benito, San Francisco, San Joaquin, San Luis Obispo, Santa Cruz, Tulare, and Ventura Counties.
² Value included under other counties.

Stone sold or used by producers in California in 1948.

Kind of stone	Dimension		Crushed	
	Short tons	Value	Short tons	Value
Granite.....	5,330	\$285,214	1,662,010	\$1,464,917
Basalt.....			1,312,000	1,379,000
Marble.....			3,140	86,444
Limestone.....	1,540	7,310	778,840	1,948,340
Sandstone.....	4,900	49,818	1,822,120	1,403,923
Miscellaneous stone.....	700	7,915	6,742,780	6,453,239
Totals.....	12,580	\$348,354	11,921,880	\$12,808,108

¹ Fewer than three producers.

² Incomplete total—dimension basalt data not included.

Strontium. During 1948 no shipments of strontium minerals were reported in California. The last production reported was in 1946, from properties in Imperial and San Bernardino Counties.

Sulfur. The sulfur mined and shipped during 1948 in California came from two properties, one in Alpine County and one in Inyo County. The 1947 sulfur output came from two properties in Inyo County.

Talc, Soapstone, and Pyrophyllite. The talc, soapstone, and pyrophyllite mined and shipped in California during 1948 totaled 98,657 short tons worth \$1,773,764, and came from properties in El Dorado, Inyo, Los Angeles, Mono, San Bernardino, and San Diego Counties. The 1947 output totaled 91,537 short tons worth \$1,595,422. The material from El Dorado and Los Angeles Counties was soapstone.

the production from San Bernardino County and part of the production from Inyo County was high-grade talc; the production from Mono and San Diego Counties, and part of the production from Inyo County was pyrophyllite.

Talc, soapstone, and pyrophyllite production in California during 1948, by counties.

County	Tons	Value
Inyo.....	23,548	\$471,808
San Bernardino.....	82,622	1,180,255
El Dorado, Los Angeles, Mono, San Diego.....	12,513	141,913
Totals.....	98,683	\$1,773,764

Titanium. Titanium concentrate (ilmenite) was produced in California during 1948 from two properties in Sand Canyon near Saugus, Los Angeles County.

Tungsten. High-grade tungsten ore and concentrates mined and shipped in California during 1948 totaled 1,767 short tons (60 percent WO₃ basis). The 1948 output of tungsten ore and concentrates showed a marked increase over that of 1947 when 394 short tons (60 percent WO₃ basis) worth \$548,233 was shipped. Eighteen operating properties were located in Alpine, Fresno, Inyo, Kern, Madera, Mono, San Bernardino, and Tulare Counties.

Zinc. The recoverable zinc produced in California during 1948 totaled 10,650,000 pounds valued at \$1,416,450, as compared with 10,830,000 pounds worth \$1,310,430 in 1947. The most important production in 1948 was made at the lead-zinc properties of the Anaconda Copper Mining Company at Darwin and Tecopa, Inyo County. The Coronado Copper and Zinc Company (Afterthought mine at Ingot, Shasta County) was the only large new zinc producer. The San Bernardino County zinc concentrates came from the Carbonate King mine near Nipton.

The average price of prime western-grade slab zinc in 1948, East St. Louis, was 13.3 cents per pound, compared with an average value of 10.5 cents per pound in 1947, and 11.7 cents per pound in 1946, including United States Government premium.

Zinc production in California during 1948, by counties.

County	Pounds	Value
Inyo.....	8,320,000	\$1,338,580
San Bernardino.....	438,000	58,254
Shasta.....	992,000	118,636
Totals.....	10,650,000	\$1,416,460

Details of mineral production for each county, 1948 and 1947 *—Continued.

Fresno County

Product	1947		1948	
	Quantity	Value	Quantity	Value
Clay products, heavy clay (other than pottery and refractories).....				
Gold.....	234	88,225		
Gypsum, crude.....			15,443	\$23,271
Mercury.....				
Natural gas.....	68,636,000	6,943,000	69,644,000	7,224,000
Natural gasoline and allied products:				
Natural gasoline.....	75,488,000	3,900,000	26,823,000	2,199,000
Liquefied petroleum gases.....	41,170,000	1,042,000	22,262,000	1,400,000
Petroleum.....	44,137,000	75,564,000	48,841,000	111,920,000
Sand and gravel.....	1,031,322	1,141,346	932,804	1,022,021
Silver.....	37	33		
Stone.....	184,810	282,835	418,530	618,486
Trappite concentrates (60% WO ₃ basis).....			11	14,848
Unapportioned (raw clay and items indicated by footnote 2).....		48,768		27,886
Total value.....		589,626,207		8124,450,368

Glenn County

Production in Glenn County in 1947-48 consisted of natural gas and sand and gravel.

Humboldt County

Product	1947		1948	
	Quantity	Value	Quantity	Value
Clay products, heavy clay (other than pottery and refractories).....				
Gold.....	138	54,865		
Sand and gravel.....	281,083	221,378	386,243	\$293,046
Silver.....	22	20		
Stone.....	60,120		33,310	
Unapportioned (raw clay, natural gas, and items indicated by footnote 2).....		92,201		114,988
Total value.....		\$318,364		\$407,988

Imperial County

Product	1947		1948	
	Quantity	Value	Quantity	Value
Gold.....			171	\$5,984
Mica (serp).....				
Sand and gravel.....	232,704		488,277	
Silver.....			83	
Stone.....				
Unapportioned (crude gypsum and items indicated by footnote 2).....		\$907,843		1,951,429
Total value.....		\$907,843		\$1,957,413

Details of mineral production for each county, 1948 and 1947.—Continued.

Inyo County

39

Product		1947		1948	
		Quantity	Value	Quantity	Value
Antimony ore	short tons			5	\$1,467
Copper	pounds	232,000	\$48,720	508,000	179,768
Gold	troy ounces	1,974	69,090	1,794	\$2,790
Lead	short tons	8,990	2,589,120	8,820	3,083,960
Lead and gravel	do			103,178	111,937
Silver	troy ounces	1,234,998	1,118,578	473,283	\$18,850
Slate					
Stone	short tons	60,720	116,471		
Sulfur ore	long tons	898	9,074		
Talc and pyrophyllite	short tons	30,444	482,007	32,546	471,598
Sand	do	702	109,384	4,060	1,239,500
Unappportioned (barren minerals, raw clay, diatomite, fuller's earth, molybdenum, pumice and pumicite, sodium salts, tungsten concentrates, and items indicated by footnote 2)			1,991,824		4,864,870
Total value			\$6,808,468		\$10,286,798

Kern County

Product		1947		1948	
		Quantity	Value	Quantity	Value
Clay products, heavy clay (other than pottery and refractories)					
Clay, raw	short tons	213,478	\$746,273	218,943	\$768,280
Petroleum, crude	long tons				
Gold	troy ounces	6,228	217,980	6,176	216,160
Silver, crude	short tons	1,352,877	1,558,268	271,908	414,233
Natural gas	cu. ft.	88,763,000	8,866,000	84,803,000	8,416,000
Mineral gasoline and allied products:					
Natural gasoline	gallons	134,520,000	8,820,000	143,854,000	11,848,000
Liquid petroleum gases	do	90,458,000	3,452,000	107,801,000	6,781,000
Petroleum	barrels	108,058,000	178,781,000	103,420,000	263,636,000
Sand and gravel	short tons	608,874	871,917	581,498	863,945
Stone	troy ounces	7,886	8,956	13,508	12,224
Slate	short tons				
Unappportioned (barren minerals, cement, pumice and pumicite, quartz, salt, tungsten concentrates, and items indicated by footnote 2)			11,218,422		11,012,378
Total value			\$209,037,916		\$263,778,123

Details of mineral production for each county, 1948 and 1947 *—Continued.
Kings County

Product		1947		1948	
		Quantity	Value	Quantity	Value
Gypsum, crude.....	short tons	41,113,000	84,404,000	40,310,000	84,548,000
Natural gas.....	M cu. ft.				
Natural gasoline and allied products:					
Natural gasoline.....	gallons	83,834,000	2,812,000	116,075,000	9,587,000
do.....		38,825,000	1,317,000	88,480,000	4,182,000
Liquefied petroleum gases.....	barrels	7,804,800	18,817,000	6,861,000	17,865,000
Petroleum.....	short tons				58,310
Sand and gravel.....					
Unapportioned (items indicated by footnote 2).....			824,750,000		836,327,310
Total value.....					

Lake County

Product		1947		1948	
		Quantity	Value	Quantity	Value
Mercury.....	flasks	304		125,000	
Sand and gravel.....	short tons	70,284		2,420	
Stone.....	do		8107,232		8110,785
Unapportioned (items indicated by footnote 2).....			8107,232		8110,785
Total value.....					

Lassen County

Product		1947		1948	
		Quantity	Value	Quantity	Value
Gold.....	tray ounces	1	835	121	84,22
Silver.....	do	6	8	102	8
Stone.....	short tons	42,980			
Unapportioned (sand and gravel and items indicated by footnote 2).....			71,788		23,89
Total value.....			871,828		888,13

Part I]

SUMMARY—CONTRIBUTIONS OF COUNTIES

Details of mineral production for each county, 1948 and 1947 *—Continued.

Los Angeles County

Product		1947		1948	
		Quantity	Value	Quantity	Value
Clay products, heavy clay (other than pottery and refractories).....			810,930,000		814,791,000
Clay, raw.....	short tons	477,011	436,148	491,187	368,784
Gold.....	tray ounces	58	5,880	218	7,823
Lime.....	short tons				
Natural gas.....	M cu. ft.	48,435,000	8,586,000	102,783,000	11,688,000
Natural gasoline and allied products:					
Natural gasoline.....	gallons	299,343,000	10,098,000	313,871,000	25,923,000
Liquefied petroleum gases.....	do	10,034,000	491,000	19,882,000	1,237,000
Petroleum.....	barrels	91,807,000	164,490,000	91,090,000	223,002,000
Quartz.....	short tons				
Sand and gravel.....	do	11,068,519	8,868,923	11,800,817	8,084,435
Stone.....	tray ounces	6	8	36	33
Stone.....	short tons	4,284,150	3,187,850	4,428,270	4,323,468
Tronox concentrate (ilmenite).....	do				
Unapportioned (mercury, diamonds, ludite, ammonite, and items indicated by footnote 2).....			3,386,329		3,881,047
Total value.....			8208,629,633		8278,436,293

Madera County

Product		1947		1948	
		Quantity	Value	Quantity	Value
Copper.....	pounds			10,000	83,170
Fluorapatite.....	long tons				
Gold.....	tray ounces	197	86,868		
Fluorapatite.....	short tons	21,730	153,473	8,311	82,719
Sand and gravel.....	do			28,309	19,440
Stone.....	tray ounces	67	82		
Stone.....	short tons				
Tronox concentrate (88% WO ₃ basis).....	do			58	
Unapportioned (natural gas and items indicated by footnote 2).....			148,758		342,808
Total value.....			8307,176		8446,827

Marin County

Production in Marin County in 1947 and 1948 consisted of raw clay, sand and gravel, and stone.

Details of mineral production for each county, 1948 and 1947.—Continued

Mariposa County

Product	1947		1948	
	Quantity	Value	Quantity	Value
Copper.....	4,100	\$840	7,525	\$253,375
Gold.....	6,365	272,705		
Platinum metal (ferule).....				
Quartz.....				
Sand and gravel.....	1,535	1,740	17,127	13,321
Silver.....			2,164	1,906
Unapporioned (barite and lime indicated by footnote 2).....				
Total value.....		108,307		2,073
		\$333,901		\$280,726

Mendocino County

Production in Mendocino County in 1947 and 1948 consisted of sand and gravel.

Merced County

Production in Merced County in 1947 and 1948 consisted of gold, crude platinum metal, sand and gravel, and silver.

Merced County

Product	1947		1948	
	Quantity	Value	Quantity	Value
Gold.....			141	\$4,204
Platinum.....			14,163	79,081
Sand and gravel.....	108,513		114,018	81,246
Silver.....	79,180		73	
Unapporioned (lumps indicated by footnote 2).....				
Total value.....		\$116,170		\$145,486

Monterey County

Product	1947		1948	
	Quantity	Value	Quantity	Value
Copper.....	18,000	\$2,780		
Gold.....	41	1,415	63	\$2,803
Platinum.....	17	4,801	2	710
Sand and gravel.....	4,733	220,068	9,583	237,325
Silver.....	7,323	6,657	788	715
Unapporioned (pyrophyllite, sand and gravel, and lime indicated by footnote 2).....				
Total value.....		96,067		94,538
		\$332,853		\$244,467

Monterey County

Product	1947		1948	
	Quantity	Value	Quantity	Value
Gold.....	048,973	\$1,022,558	24	\$840
Sand and gravel.....	147,730	232,060	908,180	1,325,800
Silver.....			6	5
Unapporioned (lime, magnesium compounds, pyrophyllite, sand and gravel, and lime indicated by footnote 2).....			197,150	281,186
Total value.....		1,724,248		2,286,144
		\$3,979,297		\$4,186,745

Napa County

Product	1947		1948	
	Quantity	Value	Quantity	Value
Gold.....			2	\$70
Platinum.....				
Sand and gravel.....			37,070	\$2,800
Silver.....			26	26
Unapporioned (mercury, pyrophyllite, and lime indicated by footnote 2).....	181,440	\$202,368	38,130	78,513
Total value.....		187,853		192,177
		\$349,811		\$303,383

more than tripled in 1915 and for several years following. From 1922-34 production continued at a 54 tons per year average, but from 1935-40 no asbestos was produced in California. Production was resumed in 1941 and has continued to the present at an average rate of more than 100 tons per year.

A chrysotile deposit 7 miles southeast of Copperopolis, Calaveras County, was one of the first to be systematically developed.² Work began in 1904 and continued intermittently until 1923. Equipment included a crusher, hammer mill, and compressor. A small tonnage of fiber was produced and used in acoustical and fire-proof plaster. Further experimental work was done in 1927.

A short-fiber chrysotile was produced in small quantities between 1917 and 1923 from a serpentine area near Washington, Nevada County.³ The rock was mined in an open pit and crushed in a 20-stamp mill equipped with air-suction and fiberizers. The stamps were later replaced by crushing rolls.

Chrysotile in a serpentine belt on the southwest slope of Sampson Peak near Hernandez, San Benito County⁴ was mined by hand methods between 1921 and 1925. The crude ore was run through a mill consisting of a crusher and some air-suction equipment. No dryer was included in the flow sheet, and the property was worked only during the dry season.

A small production of chrysotile from Monterey County and amphibole from Riverside County was reported in 1930. These were used for test purposes and as packing in the manufacture of automobile battery boxes, respectively.

Chrysotile produced in Napa County during 1933-34 was used for test purposes and for experiments in mill design. Short-fiber chrysotile was obtained from a deposit in Steel Canyon, Napa County,⁵ from 1941-45. The ore was mined from an open cut. The mill consisted of a jaw-crusher, rotary dryer, two cyclones, shaking screens, two disintegrators, and a bagger. The product was used in plaster and stucco for fireproofing war-plant buildings.

Small lenses and pockets of tremolite in peridotite at Mears Creek in the northwestern corner of Shasta County⁶ have been mined, and shipped from 1942 to the present. This fiber after hand sorting and shipping is processed by the Powhatan Mining Company and made into acid filter pads for the Gooch crucibles used in chemical laboratories.

A vein of white slip-fiber tremolite is found near Iowa Hill, Placer County, at the serpentine-shale bedrock contact in the old hydraulic-mine workings. The vein ranges from six to 15 feet in width and fibers 5 inches long have been reported. A small production of these fibers for use in acid filters has been reported from 1942 to the present.

² Logan, C. A., *Asbestos field division—Calaveras County; California Min. Bur. Rept. 16*, p. 94, 1922.

³ Logan, C. A., and Franke, Herbert, *Mines and mineral resources of Calaveras County; California Div. Mines Rept. 22*, p. 226, 1936.

⁴ MacBoyle, Etrol, *Mines and mineral resources of Nevada County; California Min. Bur. Rept. 16*, pp. 67-70, 1918.

⁵ Lutz, C. McK., *San Benito County; California Min. Bur. Rept. 22*, pp. 223, 1936.

⁶ Averill, C. V., *Mines and mineral resources of San Benito County; California Jour. Mines and Geology*, p. 47, 1947.

⁷ Davis, Penelton E., *Mines and mineral resources of Napa County; California Jour. Mines and Geology*, p. 164, 1948.

⁸ Weaver, Charles E., *Geology and mineral deposits of an area north of San Francisco; California Div. Mines Bull. 149*, 1920.

⁹ O'Brien, J. C., *Current and recent mining activities in the Redding district, California Jour. Mines and Geology*, pp. 254-255, 1945.

Utilization.⁸ Asbestos is of two commercial classes; spinning and non-spinning fiber. The long, strong, flexible fibers are spun into yarn, which is woven into heat-resisting fabrics such as brake linings, tape, and cloth. Chrysotile is best adapted to this use, although the better grades of crocidolite, amosite, and sometimes tremolite, can also be used. Some of the longer grades are used in magnesia block and pipe insulation consisting of 85 percent magnesia and 12 percent asbestos. Here, as well as in cements, plasters, and molded articles, the asbestos acts as a binder.

The shorter non-spinning grades are made into shingles, siding, and paper. The use of asbestos-cement pipe for gas, sewer, and water mains is increasing, as this pipe is resistant to acid and corrosion, and is non-conductive, and shock-proof. The fiber waste or shorts are used in making asbestos plaster, flooring, and as fillers in grease and paint. The best grades of tremolite and anthophyllite are acid-resistant and are used as filters in chemical laboratories. The low-iron variety of chrysotile found in Arizona is valuable in making electrical insulation tapes. Many new uses and adaptations for asbestos fibers are constantly being developed in the insulation and other industries. A typical example is the use of spray-coated insulation for metal, concrete, wood, and other surfaces.

Mining Methods and Treatment.⁹ Because large commercial deposits of asbestos such as those in Quebec cover extensive areas, and the fiber content of the host rock averages only from 5 to 10 percent, open-cut large-tonnage operations are almost always employed in the early stages of development. The rock is blasted, loaded with power shovels, and trucked to the recovery plant. At a later period in the life of a property underground mining methods may be introduced. Both shrinkage-stope and block-caving methods have been successfully used for final-stage operations in the Canadian mines.

Milling¹⁰ consists of separating the fiber from the barren rock by repetitive crushing, screening, and air-suction. A typical mill flow sheet would include primary and secondary rock crushing to 3-inch size, furnace drying to remove moisture, and third-stage crushing to free the fiber. The third-stage crushing product, about 1-inch size, flows to a longitudinal shaking screen. Gravity concentration occurs as the material moves along the screen, producing a layer of light-weight fiber on top and a layer of heavier rock on the bottom. The light-weight fiber is removed through a suction hood installed at the end of the screen. The oversize rock flows over the end and the undersized rock drops through the screen. The oversize is crushed to 1-inch size and rescreened as outlined above. The undersize is fed to a fiberizer, consisting of high-speed hammers which break the rock by impact, making a further separation of rock and short fibers. The latter are separated by another suction-screening operation. When free, the fiber is passed to a two-level screen for size classification. The shorts drop through both screens, the medium-length fiber is removed by air-suction from the end of the lower screen, and the long fiber is similarly removed at the end of the top screen.

Markets.¹¹ Many of the world's largest asbestos companies mine and mill the crude material at company-owned deposits, and then manu-

⁸ The uses of asbestos and asbestos products, in the Asbestos Factbook, 2d ed., pp. 5-11, Philadelphia, Secretarial Service, 1944.

⁹ Smith, C. V., Asbestos mining methods; Asbestos, vol. 16, nos. 3, 4, 5, 1944.

¹⁰ Kelleher, J. C., Milling asbestos; Asbestos, vol. 27, nos. 3, 4, 5, 1945.

¹¹ Ross, J. G., and Jenkins, George F., op. cit.

facture the finished products in their own plants. Other producers sell to consumers of raw material, either directly or through agents and mineral dealers. In the latter case it is customary for the producer or dealer to submit samples for the approval of the consumer. Sales contracts are usually based on the type and length of fiber, but may also specify fiber strength, color, flexibility, and chemical content.

In 1948 high-grade Canadian crudes and spinning fibers commanded an average price of \$609 per short ton. Only one-tenth of 1 percent of the Canadian production was placed in this classification. An intermediate grade of Canadian fibers used in shingles and sheeting averaged \$107 per short ton. About 34 percent of the production was in this category. Short fibers averaged \$33 per ton, according to the Department of Mines, Province of Quebec, Canada.¹² Most of the production, 66 percent, fell in this class.

The price on amphibole asbestos produced in California in 1948 ranged from \$50 to \$200 per short ton depending on iron content and ignition loss.

The production of asbestos in the United States was approximately 34,000 short tons in 1948, and currently constitutes about 4 percent of the country's consumption. The sources of domestic chrysotile in 1948 were the mines of The Ruberoid Co., near Eden, Vermont, and mines near Globe, Arizona. Amphibole was produced in California, Georgia, and North Carolina. The difference between domestic production and domestic demand was balanced by the importation of 687,163 net short tons of asbestos minerals from foreign deposits. Canadian chrysotile from the province of Quebec accounted for about 94 percent of the imports or 644,915 net short tons according to the U. S. Bureau of Census.¹³ The remainder of the imported fiber originated chiefly in South Africa and consisted of amosite, crocidolite, and chrysotile. An extensive program of underground development and mill expansion is underway in Canada to meet the increasing demand for Canadian chrysotile.

ASPHALT AND BITUMINOUS ROCK

By GORDON B. OAKESHOFF

The use of natural California asphalt has been traced back to prehistoric time when Indians used it to caulk their plank canoes.¹ In the early development of roads in California, local sources of asphalt and bituminous rock were used for surfacing. In later years, natural asphalt was replaced by the heavy products of petroleum refineries which have proved to be more uniform, of higher grade, and to permit better control of specifications. The largest production of natural asphalt was during the years 1910 and 1911; in 1947-48 there was only one producer in the state. In the last few years there has been renewed interest in the large deposits of bituminous rock of central and southern California, as a possible source of raw material for power development, and as a direct source of petroleum.

¹ Personal communication; also see Josephson, G. W., and Marsh, Dorothy L. *Asbestos: Minerals Yearbook*, 1948, p. 150, 1948.

² Monthly imports and exports: *Asbestos*, vol. 29, no. 11, May 1949.

³ Helzer, Robert F. Aboriginal use of bitumen by the California Indians: *California Div. Mines Bull.* 118, p. 71, 1913.

Composition. Natural asphalt consists of heavy liquid, semi-solid, and solid hydrocarbon residues left when liquid petroleum migrates upward into surface and near-surface rocks and soil and loses its lighter fractions by evaporation. This process results in various types of accumulations of bituminous material, from seeps and pools of almost pure heavy petroleum to rock in which dry petroleum fills a fraction of the pore space. Such terms as "tar sand," "oil shale," and "asphalt rock" are included in the more general term "bituminous rock," which refers to any rock carrying a substantial amount of petroleum. The so-called "oil shale" in California contains hydrocarbons in the form of natural petroleum, while elsewhere, as near Rifle, Colorado, the term "oil shales" may refer to rocks that contain a carbon compound, referred to as kerogen, which is not petroleum, but which may be processed to yield petroleum products.

Various peculiar hydrocarbon substances which are usually considered as separate mineral species, but are closely related to asphaltum (the general name applied to pure solid asphalt), are found in widely separated localities in the Coast Ranges of California. Examples are *gilsonite*, found at Sisquoc in Santa Barbara County; *amber*, found in the Simi Valley in Ventura County; *curtisite*, occurring in serpentine in San Francisco, and with cinnabar in Lake, Napa, and Sonoma Counties; *aragotite*, associated with cinnabar in Napa and Santa Clara Counties; *napalite*, found in cinnabar mines in Napa County; and *posepnyite*, occurring in the cinnabar mines of Lake and Napa Counties. Chemically, they are hydrocarbons, consisting of compounds of hydrogen and carbon, often with oxygen also present. These peculiar hydrocarbon minerals have not proved to be of commercial importance in California.

General Geologic Occurrence. The bituminous materials that are found in bituminous sandstone and shale and in oil or tar seeps originated in organic shales and migrated in a fluid state into porous and permeable reservoir rock such as sandstone, conglomerate, diatomite, and fractured shale and chert. The organic source shales in California range in age from Upper Jurassic to Pliocene, but Miocene shale, including diatomite, is nearly always found in the areas of bituminous rock and appears to have been the major source of the petroleum. Large areas of bituminous rock represent oil sands or shales which have been exposed by erosion, allowing evaporation of the lighter petroleum fractions; the exposed sands may grade down dip into wet oil sands capable of yielding oil by drilling. In such rocks the natural tar seal aids in trapping liquid petroleum at depth. Tar seeps, deposits of asphaltum, and bituminous sandstone in zones of fracture, faulting, and severe folding, commonly occur along fold axes, at contact surfaces between different rock types, and along bedding planes in stratified rocks. Dikes and sills of bituminous sandstone are also common; some are large enough to be of commercial importance. Pressure from earth movements and overlying formations forces the easily deformed and relatively plastic oil sands along zones or planes of relative weakness.

Asphalt, bituminous rock, and tar seeps are found quite generally in the petroleum-producing areas of the state. In the early history of drilling in California, wells were most often located by such signs without regard to geologic formations or structure. The most northerly oil seeps in California are in southern Humboldt County, where they

dioxide is oxidized to sulfur trioxide; platinum, or vanadium pentoxide is used as a catalyst. The sulfur trioxide is subsequently absorbed in concentrated sulfuric acid.¹

Hydrogen sulfide gas used in making sulfuric acid is selectively absorbed from oil-refinery gases by liquid sodium phenolate. It is later regenerated from solution.²

Utilization. Sulfuric acid is used in greater volume and has more applications than any other industrial chemical. As it is used by nearly every industry, the demand for sulfuric acid is an accurate and sensitive indicator of general business conditions.

Sulfuric acid is the cheapest acid per unit of chemical activity. Its outstanding chemical characteristics are its ability to decompose most metals and other substances, to remove organic matter, and to neutralize alkalis. Among its most important industrial uses are the manufacture of fertilizers, soap, paper, storage batteries, and explosives. It is also widely used in processes of electroplating, electrodeposition, and oil refining.

Marketing. Marketing of sulfuric acid is generally restricted to areas surrounding centers of manufacture. This is necessitated by its bulk, the expense of packaging, and the high cost and danger of transporting the acid compared with like considerations in transporting sulfur pyrites, and niter used to produce it. Prices vary widely, depending on the lot sizes and the area of production.³

TALC, SOAPSTONE, AND PYROPHYLLITE

By LAUREN A. WRIGHT

The commodities talc, soapstone, and pyrophyllite customarily are discussed as a group, and the U. S. Bureau of Mines combines the annual production of these materials in a single figure. The pyrophyllite occurrences of California, however, can be conveniently considered separately and are included under a separate heading of this section. In 1948 the state's combined production of talc, soapstone, and pyrophyllite was nearly 100,000 tons. In recent years talc mining has increased sharply and pyrophyllite has been mined in quantity for the first time. Soapstone, as a relatively impure variety of talc, was mined in California long before the first production of either pyrophyllite or high-quality talc. The soapstone output, however, has always been small compared with the current output of high-quality talc.

TALC AND SOAPSTONE

Mineralogy and Geology. To the mineralogist "talc" is a distinct mineral species with a composition of $H_2Mg_3(SiO_3)_4$, but in commercial usage the term commonly alludes to a mixture of minerals most of which are high-magnesium silicates. The mineral talc is usually, but not necessarily, a prominent constituent. Other common minerals in such mixtures include tremolite [$Ca_2Mg_5Si_8O_{22}(OH)_2$], serpentine (a hydrous magnesium silicate), chlorite (an aluminosilicate of iron and magnesium).

¹ Fairlie, A. M., Sulfuric acid manufacture, pp. 27-48, New York, Reinhold P. Publishing Co., 1936.

² Stockman, L. P., Standard oil operating sulfur recovery unit at El Segundo Oil and Gas Jour., vol. 35, no. 23, p. 46, 1936.

³ Kreps, T. J., The economics of the sulfuric acid industry, pp. 1-281, Studies I. (1938).

anthophyllite [$(Mg,Fe)_2Si_2O_6(OH)_2$], olivine [$(Mg,Fe)_2SiO_4$], carbonate minerals, and quartz. The chemical compositions of many commercial tales, therefore, do not approximate the composition of the pure mineral.¹ The industrial usage to which the material is put determines whether a particular mineral of this group is beneficial, harmless, or undesirable.

Soapstone commonly contains a higher proportion of the mineral talc than do some commercial "tales." But the term soapstone, as ordinarily used, implies the presence of impurities that prevent the use of the material as a high-grade commercial tale. Compactness is also an implied characteristic of soapstone.

Commercial tale deposits are ordinarily alterations of dolomite, limestones, or ultrabasic rocks. Most of the tale now produced in California has altered from dolomite or limestone. The soapstone deposits are most commonly associated with bodies of serpentine or talc-actinolite schist.

Talc Deposits of Eastern California. The talc deposits in California that have formed by the alteration of dolomite or limestone are largely confined to a 200-mile belt which parallels the California-Nevada line from the Inyo Range, Inyo County, southwestward to the vicinity of Baker, San Bernardino County. Included in this belt are three contrasting tale-bearing areas which have been designated respectively as the Inyo Range, southern Death Valley-Kingston Range, and Silver Lake tale provinces.² Each province contains deposits which are geologically similar. Each also contains a mine which was first opened in the period 1915-19 and which has since produced more than 100,000 tons of tale.

Inyo Range Province. Most of the talc deposits of the Inyo Range province are exposed on the east and west slopes of the range itself and in an area between Darwin and Keeler near the southern end of the range. The tale in this province has formed by the hydrothermal alteration of Paleozoic dolomite and, to a lesser extent, of silica rock and granitic rock.³ Many of these deposits contain talc of the type known to the ceramic industry as "steatite." Steatite is an unusually pure material which is composed almost wholly of the mineral talc and which can be used as an ingredient in the manufacture of high-frequency insulator bodies. Magnesium silicate minerals other than talc are uncommon in the Inyo Range deposits. Individual tale bodies in this province are characteristically pod-like or irregularly shaped. The largest known bodies, however, are more regular than the average and have lengths of more than 500 feet and maximum widths of 50 feet. In many of the deposits the alteration has apparently been guided by shears and fractures.

The Tule City mine, about 13 miles southeast of Keeler, Inyo County, has produced over 200,000 tons since 1915 when it was first worked. This is the largest output of any talc mine in California. During World War II this property was the nation's principal source of steatite which was critically needed in the manufacture of electrical equipment for the armed forces.

¹ In this report the term "talc," unless otherwise qualified, will be used in its commercial meaning.

² Wright, L. A., California tales: Min. Eng., vol. 187, no. 1, pp. 122-124, Jan. 1956.

³ Page, H. M., Some California tales of steatite grade: Min. and Ind. News, vol. 16, no. 1, p. 12, Jan. 1948.

The White Mountain mine, on the southeastern flank of the Inyo Range, was also an important war time stentite producer. This mine was first worked in 1935 and has been operated nearly continuously during the past 10 years. Approximately 15 other tale mines in the province have been active in the past, but none have total outputs comparable with those of the Tale City and White Mountain properties.

Northern Death Valley-Kingston Range Province. Another province that contains geologically similar tale deposits extends from the southeast portion of the Panamint Range eastward across the southern end of Death Valley to the east side of the Kingston Range. In this area all of the commercial tale has formed by the alteration of the lowermost carbonate beds in a late pre-Cambrian sedimentary series. At or near the base of the carbonate beds a diabase sill is everywhere present and is in contact with or proximate to the tale bodies. The tale, carbonate strata, and diabase are all part of the Crystal Spring formation. At several localities the talcose horizon is exposed for a distance of well over a mile, but commercial tale concentrations within it are ordinarily less continuous.

Though all tale deposits in this province have nearly the same stratigraphic position, they differ markedly in mineralogic detail. Some deposits consist almost wholly of fibrous or micaceous varieties of the mineral tale. Other deposits contain two or more types of commercial tale. These types include compact, fine-grained and thinly laminated tremolite rock; coarse-grained mixtures of tremolite, and the mineral tale; and a massive, crudely laminated variety of the mineral tale, as well as the fibrous and micaceous types.

The Western mine, immediately south of Tecopa Pass in San Bernardino County, has been the principal tale producer in the province. Since the property was first worked in 1917, it has yielded well over 150,000 tons. Most of this production has come from a single talcose zone which is more than 5000 feet long and from 20 to 90 feet wide. The zone is underlain by a diabase sill and overlain by siliceous dolomite.

Within recent years several other properties in the province have become active. These include the Excelsior mine on the west flank of the Kingston Range; the closely grouped Monarch, Pleasanton, and Ibes mines at the southern end of the Ibes Hills; the Superior and White Cap mines near Saratoga Spring at the southernmost tip of Death Valley; and the Warm Spring mine in Warm Springs Canyon in the southeastern portion of the Panamint Range. The general geologic features of all of these properties are similar to those of the Western mine and some of the deposits are being worked on a comparable scale. At the Superior and White Cap mines the commercial tale bodies lie beneath, instead of above, the diabase sill. Numerous other tale deposits in the province have been mined in the past and still others remain to be developed. At least three are scheduled to be worked for the first time in 1950 or 1951.

Silver Lake Province. The southernmost province in the eastern California talc-bearing belt is in the vicinity of Silver Lake, San Bernardino County. Three properties are currently active in this area. The largest of these operations, the Silver Lake mine, is about 10 miles north-northwest of Baker. It has been operated since 1918, and has yielded approximately 150,000 tons of tale and tale-tremolite rock. The commercial bodies are in a persistent feldspar- and diopside-rich inter-

of a highly metamorphosed sedimentary series. Igneous rocks that range from mafic to felsic in composition have extensively invaded the meta-sediments. Individual tale bodies, the largest of which has an 800-foot surface exposure, are narrow and lenticular, and represent a nearly complete replacement of carbonate strata.

Most of the tale is highly tremolitic, but relatively pure concentrations of the mineral tale are common next to the footwalls of the commercial bodies. Talc concentrations also occur, though less commonly, within the tale-tremolite bodies and next to their hanging walls.

In the Silver Lake province two other deposits, the Calmasil and Pomona mines, are being worked. These are in the vicinity of Yucca Grove, about 12 airline miles north-northeast of the Silver Lake mine. Here, as at Silver Lake, the tale bodies are tremolitic and represent alterations of carbonate strata in metasedimentary rocks. Here, also, igneous rocks are extensively exposed.

Talc and Soapstone Deposits of the Sierran Foothill Belt. In California the talc-rich rock obtained from deposits in the tale-actinolite schist and serpentine bodies of the western foothills of the Sierra Nevada has ordinarily been called soapstone. The high iron content typical of this material has made it unsuitable for most of the uses cited for the so-called high-grade talcs. Though mined in much smaller quantity than talcs of the eastern California belt, the soapstone has been in steady demand for many years. Relative nearness to markets and inexpensive mining favor the development of these deposits.

Since 1895 soapstone production has been recorded from 17 properties in seven Sierran foothill counties. Previously, soapstone had been mined and used as a construction material in this area, but specific data on this earlier production are not available. Most operations were small, and but few continued for periods greater than 10 years.

The Swift deposit near Latrobe, El Dorado County, was operated during the period 1916-24 and was again worked for about 4 years beginning in 1936. The Prouty talc mine, 1½ miles south of Shingle Springs, El Dorado County, was worked intermittently from 1919-28. The McLenn deposit in Butte County was worked from 1923-40, and the Pacific Minerals Company deposit, about 3 miles northeast of Latrobe in El Dorado County has been worked from 1929 to the present.

Other properties contributing soapstone within the last 30 years include one in Butte County, two in Calaveras County, three in El Dorado County, one in Tulare County, two in Tuolumne County, and five in Amador County.

Miscellaneous Talc and Soapstone Deposits. Talcose material has also been produced from several other deposits scattered throughout the state. Talc deposits on Santa Catalina Island, which were worked in the eighteen-nineties, are among the first for which there is a recorded output. In 1917 and 1923 a small amount of talcose rock is reported to have been obtained from a deposit near Acton, Los Angeles County. Since 1940 talc has been intermittently obtained from the Ganim mine, a gold property near Schilling, Shasta County. The tale bodies at the Ganim mine are in an altered zone in meta-andesite.

Uses and Marketing of Talc and Soapstone. Most of the tale mined in California is milled in Los Angeles; the remainder is processed at plants in the desert area, in the San Francisco Bay area, and at Ogden,

**LIST OF SMELTERS AND MINERAL DEALERS REPORTING
PURCHASE OF CALIFORNIA METALS PRODUCED IN 1948.**

Name	Address	Location of plant	Metals reported purchased
American Smelting & Ref. Co.	120 Broadway, New York, N. Y.	Garfield, Utah	Copper, lead, gold, silver
American Smelting & Ref. Co.	120 Broadway, New York, N. Y.	Hayden, Arizona	Copper, gold, silver
American Smelting & Ref. Co.	120 Broadway, New York, N. Y.	Murray, Utah	Lead, copper, gold, silver
American Smelting & Ref. Co.	405 Montgomery St., San Francisco	Bell, California	Copper, lead, gold, silver
American Smelting & Ref. Co.	120 Broadway, New York, N. Y.	Tacoma, Washington	Copper, lead, gold, silver
Asarco	25 Broadway, New York & N. Y.	Great Falls, Mont.	Copper, lead, zinc, gold, silver
Bethlehem Pacific Coast Steel Corporation	50th and Illinois Sts., San Francisco	San Francisco	Iron ore
Bradley & Elstrom	230 Market St., San Francisco	San Francisco	Manasse, chromite, iron ore
Braun Corporation	2780 E. 15th St., Los Angeles	Los Angeles	Quicksilver
Coast Chemical Division F. W. Bark & Co., Inc.	Sharon Bldg., San Francisco	San Francisco	Quicksilver
International Smelting & Ref. Co.	Neveus Bldg., Salt Lake City, Utah	Tooele, Utah	Copper, lead, zinc, gold, silver
Kaiser Co., Inc.	P.O. Box 217, Fontana	Fontana	Iron ore, manganese ore, chromite
Norfolk Chemical Co.	1025 Santa Fe, Los Angeles	Los Angeles	Quicksilver
Pacific Vegetable Oil Co., Bernard T. Roeca	67 Townsend St., San Francisco	San Francisco	Quicksilver
Quicksilver Producers Ass'n., Irving Ballard, Sec'y	407 Sansome St., San Francisco	San Francisco	Quicksilver
Tanning Laboratories	2577 Fresno St., Fresno	Fresno	Tungsten ore
U. S. Mint	Duboce & Market Sts., San Francisco	San Francisco	Gold, silver
U. S. Smelting, Refining & Mining Co.	Newhouse Bldg., Salt Lake City, Utah	Midvale, Utah	Copper, lead, zinc, gold, silver
Western Gold & Platinum Works	580 Bryant St., San Francisco	San Francisco	Platinum, gold, silver
Wildberg Bros. Smelting & Ref. Co.	742 Market St., San Francisco	San Francisco	Platinum, gold, silver*

* Gold and silver in special high-grade areas only.

LIST OF MINERAL DEALERS, CUSTOM MILLS, AND COMMERCIAL GRINDING PLANTS IN CALIFORNIA

48

FIRM	NOTES
American Minerals Co., 540 Mission Rd., Los Angeles, Calif.	Commercial grinding of minerals.
Albina, Kroll & Co., 230 California St., San Francisco 4, Calif.	Dealer in tungsten ores, mercury, gypsum and linerock.
Barold Sales Division, National Lead Co., 330 Ducommun St., Los Angeles, Calif.	Talc and other soft non-metallic minerals ground by contract or purchased.
Bishop Concentrate & Cleaning Co., Bishop, Calif.	Custom mill; purchase tungsten ores and base metal ores.
Bond, Harry E., Co., 2424 Alhambra Ave., Los Angeles, Calif.	Dealer in industrial sand and silica products.
Box Star Mines, Ltd., 957 S. Anderson, Los Angeles, Calif. (Mill at Zurich)	Dealer in talc, clay, and limestone.
Bond Bros. & Co., 461 Market St., San Francisco 5, Calif.	Dealer in export minerals.
Bradley & Ekstrom, 220 Market St., San Francisco 11, Calif.	Dealer in all commercial minerals.
Bramley-Donaldson Co., 557 Howard St., San Francisco 5, Calif. and 3050 E. Blauwin Ave., Huntington Park, Calif.	Dealer in sand, clay, limestone, dolomite, and other minerals.
Burton Bros., Riverside, Calif.	Custom cyanide mill. Gold and silver ores purchased.
Butte Lake Mining Co., Randsburg, Calif.	Custom amalgamation mill, gold-silver ore.
Commercial Minerals Co., 310 Irwin St., San Francisco 7, Calif.	Commercial grinding by contract or min- erals purchased.
Dairy Chemical Laboratories, Box 228, Oroville, Calif.	Custom mill for black sands.
Empire Star Mines Co., Ltd., Grass Valley, Calif.	Amalgamation and cyanide mill; gold ore purchased.
Hecker Co., 600 N. Mission Rd., Los Angeles, Calif.	Clay grinding plant; non-metallic min- erals ground by contract or purchased.
Ed Bros. Chemical Co., 2150 Bay St., Los Angeles, Calif.	Grinding asbestos, and custom milling of small lots of soft non-metallic minerals.
Hastley Industrial Minerals, P. O. Box 303, Rishon, Calif.	Dealer in talc, pyrophyllite, asbestos, and garnet sands.
Industrial Minerals & Chemical Co., 108 Gilman St., Berkeley, Calif.	Non-metallic minerals ground by contract or purchased.
Kearney Minerals Co., 550 E. Olympic Blvd., Los Angeles, Calif.	Non-metallic minerals ground by contract or purchased.

andalusite deposit described in the section on andalusite, kyanite, and sillimanite in this bulletin. Pyrophyllite is now being obtained at operations near the north and south ends of a pyrophyllitic zone which is exposed for a distance of about 2 miles along the lower west face of the White Mountains east of the Shealy rail siding. The pyrophyllitic zone lies to the west of the quartzose, andalusite-bearing zone and is, itself, bordered on the west by micaceous schists. Surface exposures of the pyrophyllitic zone are commonly several hundred feet in width, though not all of the zone has yet proven to be of commercial material. Both mines are quarrying operations.

Pyrophyllite has also been obtained from a recently developed deposit about 5 miles north-northwest of Aberdeen, Inyo County. Here a pyrophyllitic layer is overlain by crinoidal limestone. The extent of the deposit is largely obscured by alluvium which overlaps it on three sides.⁴

Since 1945 pyrophyllite has been obtained from the Pioneer mine in the San Dieguito area of west-central San Diego County. The pyrophyllite bodies are elongate lenses representing the alteration of Jurassic (?) volcanic rocks which are intermediate to felsic in composition.⁵ Exposures of the pyrophyllite-bearing volcanics are confined to an area of approximately 1 square mile. The primary layering in the volcanics and the long direction of the pyrophyllite lenses generally strike northwest.

The highest grade pyrophyllite schist is a lens at least 150 feet long and 15 feet in average thickness. The main workings are open cuts and have been developed primarily in this body.

Uses of Pyrophyllite. Pyrophyllite and talc are employed in many similar uses, though in California and throughout the world talc is mined in much larger quantity.

In recent years pyrophyllite has been used principally as an insecticide diluent, and as a filler in hard rubber. It is also employed as a raw material in the manufacture of wall tile and refractory ceramic bodies. Other materials in which pyrophyllite serves effectively as a filler include roofing, cotton cordage, textiles, special plasters, paper, oilcloth and linoleum, plastics, and soap. Small amounts have been used as a base for cosmetic preparations. Nearly all of the pyrophyllite mined in California to date has been marketed as insecticide dust, but in mid-1949 material from the Huntley deposit in Mono County was being shipped to the Los Angeles area as a red-burning tile ingredient.

Processing and Prices of Pyrophyllite. Like talc, pyrophyllite is dry-ground to a fine size and to standard grades. California operators have valued unground pyrophyllite at the mine in the range of \$10 to \$20 per ton.

⁴ Oakeshott, G. B., oral communication.

⁵ Jahns, R. H., and Lance, J. F., *Geology of the San Dieguito pyrophyllite area, San Diego County, California*, in preparation.

PART IV

METALS

CONTENTS

	Page		Page
ALUMINUM	285	MERCURY	330
ANTIMONY	288	MOLYBDENUM	337
BI SMUTH	291	PLATINUM AND ALLIED	
CADMIUM	293	METALS	340
CHROMITE	294	SILVER	343
COBALT	299	TIN	349
COPPER	300	TITANIUM	352
FERRO-ALLOYS	306	TUNGSTEN	355
GOLD	309	URANIUM, THORIUM, AND	
IRON	315	RARE-EARTH ELEMENTS	361
LEAD	319	ZINC	364
MANGANESE	324	ZIRCONIUM	368

Utah. Milling consists simply of dry grinding, but care is taken to maintain standard grades. Much of the talc is sold unblended, but the blending of different talc types is a common practice.

More than half of California's current talc output is consumed by the ceramic industry. Steatite from the Inyo Range is shipped to factories in the eastern United States where it is used as the principal raw material in high-frequency insulator bodies. A large part of the production of both tremolitic and non-tremolitic talc mined in the Death Valley and Silver Lake areas is marketed as an ingredient in wall tile. The principal market for this product is in the Los Angeles area, but wall-tile talc is also shipped to other western cities. Smaller quantities of California talc are used as a raw material in other ceramic ware.

Most of the remainder of the talc produced in eastern California is consumed by the paint, rubber, and textile industries. The fibrous talcs of the Death Valley area are widely used as a paint extender and for this purpose are shipped to many out-of-state consumers. The fibrous talcs are also marketed to textile mills in the eastern United States. Talc is marketed to the rubber industry both as a filler and as a lubricant. Smaller amounts are used in insecticide carriers, in cosmetics, and for various minor industrial applications.

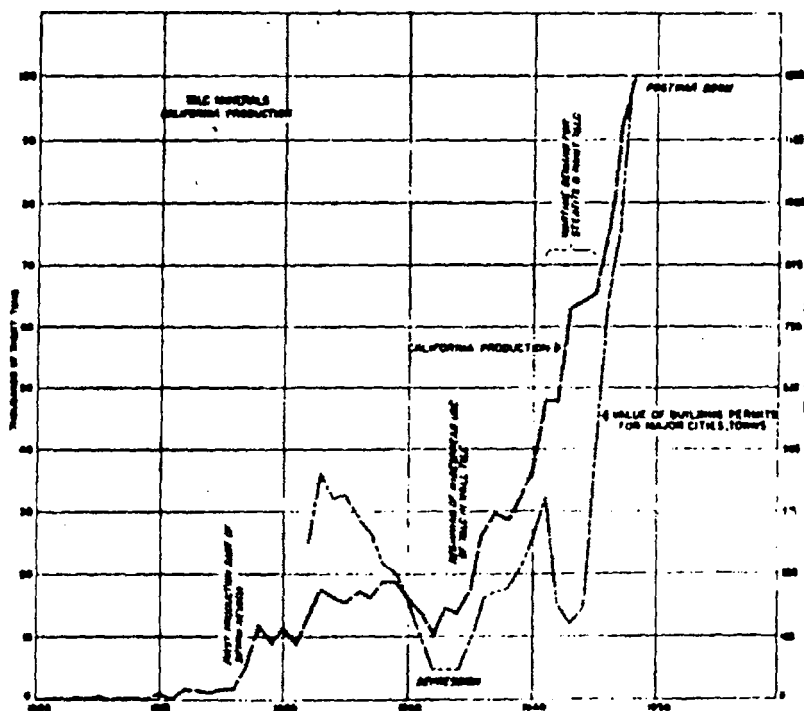


FIGURE 1. Chart showing production of talc, soapstone, and pyrophyllite in California, 1900-48, compared with value of California building permits, 1922-48.

Most of the past production of talc and soapstone from the Sierran foothill belt has been used as a filler in the manufacture of roofing. In recent years the material has been used principally as an insecticide dust.

Mining Methods. In California talc mines, underground methods are ordinarily employed, though recently a relatively large tonnage of talc at the Silver Lake mine has been removed in surface operations.

Early operations at the Talc City mine employed a glory-hole method, but underground caving was later used. More recently the ore has been removed from overhand stopes that are supported by timbers where necessary.

In the early development of most of the talc mines in the southern Death Valley-Kingston Range area adits were employed. But in their later histories mining by shafts or winzes has become necessary. Production at the Western mine is currently obtained through inclined shafts spaced at intervals along the talc body. From these and appended cross-cuts, drifts have been driven along the deposit. Most of the talc has been removed by overhand stoping. A similar method has been employed at the Superior mine.

The Monarch mine has been developed by successively longer adits that have encountered the deposits at successively deeper points. Square-set timbers have been extensively used in stoping at this property. The talc bodies at Warm Spring are mined by closely spaced parallel adits driven from a canyon wall. The adits are joined by low-angle raises that are progressively enlarged to form a modified room and pillar system.

The steeply dipping deposits at Silver Lake have been most commonly developed by shafts that are sunk to the keel of the deposits. At several levels drifts are driven to the along-strike limits of the ore bodies; the talc is removed by overhand stoping and is hoisted to the surface.

The talc and soapstone mines of the Sierran foothill belt have been chiefly quarrying operations.

Prices of Talc and Soapstone. The value of California talc as mined has been, in general, difficult to determine because the producers ordinarily market the talc after it is transported to the mill, ground, and sacked. In recent years, producers in the eastern talc belt have set values ranging from \$10.00 to \$18.00 per ton for material at the mine. Soapstone from the Sierran foothill belt has been valued in the range of \$3.00 to \$10.00 per ton at the mine.

PYROPHYLLITE

Mineralogy and Geologic Occurrence. Pyrophyllite $[Al_2Si_4O_{10}(OH)_2]$ has physical and optical properties similar to those of talc; but contains aluminum instead of magnesium. In California, as elsewhere, the geological occurrences of the two minerals are dissimilar. Most of the commercial deposits of pyrophyllite have formed by alteration of acidic volcanic rocks. But pyrophyllite also has been noted in metamorphosed sedimentary rocks and in or along gold-quartz veins.

Localities. The commercial production of pyrophyllite in California was recorded for the first time in 1945. Four properties, two in Mono County and one each in Inyo and San Diego Counties, are currently active.

The two pyrophyllite properties in Mono County are in the belt of highly metamorphosed rock which contains the White Mountain