GEOLOGICAL SURVEY CIRCULAR 313

RECONNAISSANCE FOR URANIUM-BEARING CARBONACEOUS ROCKS IN CALIFORNIA AND ADJACENT PARTS OF OREGON AND NEVADA

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By George W. Moore and James G. Stephens

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ABSTRACT

During the summer of 1952 a reconnaissance was conducted in California and parts of Oregon and Nevada in search of new deposits of uranium-bearing carbonaceous rocks. The principal localities found in California where uranium occurs in coal are listed here with the uranium content of the coal: Newhall prospect, Los Angeles County, 0.020 percent; Fireflex mine, San Benito County, 0.005 percent; American lignite mine, Amador County, 0.004 percent; and Tesla prospect, Alameda County, 0.003 percent. An oil-saturated sandstone near Edna, San Luis Obispo County, contains 0.002 percent uranium.

INTRODUCTION

As part of a program to discover new reserves of uranium in coal and other carbonaceous materials, an investigation by the U. S. Geological Survey, on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission, was made during the summer of 1952 in California, western Nevada, and southwestern Oregon.

Although several occurrences of uranium associated with coal in the United States have been known for many years (Berthoud, 1875), only recently have they been considered more than geologic curiosities. Reconnaissance during the past 3 years has resulted in the discovery of large tonnages of coal containing small quantities of uranium (Denson and others, 1952). Coal having 0.1 percent uranium or more in the ash is now known in North and South Dakota, Wyoming, Idaho, Nevada, Montana, Colorado, and New Mexico.

Detailed studies of uranium-bearing lignite in the Dakotas were made by Denson, Bachman, and Zeller (1950). They indicate that the uranium is

secondary, being introduced by downward percolating meteoric water that has passed through overlying tuffaceous rocks in the White River and Arikaree formations. Rhyolites contain relatively large amounts of uranium (Evans and Goodman, 1941), and their tuffaceous equivalents seem to be particularly capable of releasing this uranium to solution. Spring water issuing from these rocks contains from 30 to about 80 parts per billion uranium—many times the content of most natural waters (Aberdeen and others, 1952). By searching for beds of coal overlain by rocks of volcanic origin and rhyolitic composition, low-grade deposits of uranium have been found (Hail and Gill, 1953; Love, 1952; Vine and Moore, 1952; Vine and others, 1953).

During the present investigation coals were systematically sampled throughout the area with special attention given to those deposits that are, or were, overlain by rocks of volcanic origin and rhyolitic composition. A total of 63 samples of carbonaceous rocks was taken for analysis from 38 localities (fig. 1). Results of the analysis are listed in tables 1-6.

Acknowledgments are given to the California Division of Mines and particularly to Gordon B. Oakeshott for valuable suggestions.

CALIFORNIA

Coal was investigated in 21 counties at most of the localities where it is reported in the literature or is listed in the files of the California Division of Mines. It ranges in age from Paleocene to Pliocene; and in rank, from high-volatile bituminous coal to partly coalified wood. The majority of the deposits, however, are of lignite or subbituminous coal. The coal crops out in widely scattered areas of relatively small extent. Resources, therefore, are small. They have been estimated at 100 million tons; and the total production through 1946 was 5,270,218 tons, valued at $23,400,260 (Averill and others, 1948).

NORTHERN CALIFORNIA

Significant radioactivity was not detected at any of the localities visited in northern California. Coal of Eocene age was examined at two localities in the Umpqua(?) formation at the south end of the Rogue River field, Siskiyou County; and at five localities in Trinity and Humboldt Counties. Coal and lignite of Miocene age were sampled in the Covello area, Mendocino County, and in two formations of Pliocene age at the Maple Creek and Garberville areas in Humboldt County. Carbonaceous shale was examined at two localities in Modoc County and one locality in Lake County. The results of the analysis are listed in table 1.

CENTRAL CALIFORNIA

The Ione lignite field, Amador County, is in the foothills of the Sierra Nevada. It is in the Ione formation of Eocene age in a northwest-trending syncline. The only two coal mines in operation in the State at the time of the investigation are located here, producing montan wax and other industrial chemicals. The wax is used in the manufacture of polishes, carbon paper, and similar products.

The greatest radioactivity was found at the strip mine of the American Lignite Co. in sec. 26, T. 6 N., R. 9 E. (locality 35) about 1 mile southwest of Ione. A maximum uranium content of 0.004 percent was found in the upper 9 inches of the 12-foot lignite zone (fig. 2). The uranium may have been derived from the overlying Valley Springs formation of Miocene(?) age, and concentrated in the lignite by downward and laterally percolating solutions. The Valley Springs formation is composed largely of ash of rhyolitic composition, and the formation laps unconformably across the older rocks. Greater mineralization might be found under more favorable structural and stratigraphic conditions than exist at the American lignite mine, such as on the west flank of the field where erosion remnants of the Valley Springs formation directly overlap the coal beds. Bates (1945) shows that this stratigraphic relationship exists in the Edwin clay mine about 4 miles west of Ione. At this locality, however, the lignite could not be examined because the mine workings were caved and inaccessible.

Samples were collected from the Humacid mine (locality 36), about 6 miles south of Ione, where underground operations are also producing lignite for montan wax. This lignite has 0.002 percent equivalent uranium or less. Dumps from other caved coal mines in the vicinity were tested with the Geiger counter, but the radioactivity was not above background.

The rocks in the Ione field are poorly exposed. Several coal beds are known to be present, and it is possible that the beds currently being mined are not the stratigraphically highest ones—those most likely to be mineralized by downward percolating solutions. Therefore, the Ione field merits additional investigation.

Table 1.—Analysis of samples collected in northern California

Map locality	Laboratory no.	Thickness of unit (inches)	Equivalent uranium (percent)	Uranium (percent)	Uranium in ash (percent)	Ash (percent)	Location[1] (sec., T., R., Mer.)
15	87689	12	0.001	---	---	58.6	15-38N-1E-MDM.
16	87670	1	(2)	---	---	78.9	32-33N-1W-MDM.
17	87692	3	(2)	---	---	11.1	6-33N-12W-MDM.
20	87691	12	(2)	---	---	13.7	32-32N-9W-MDM.
23	87693	12	.002	(2)	0.001	48.6	3-5S-4E-HM.
24	87694	12	.001	(2)	(2)	15.8	2-21N-13W-MDM.

[1] "MDM" indicates Mt. Diablo meridian; "HM", Humboldt meridian.
[2] Equivalent uranium or uranium content of less than 0.001 percent.

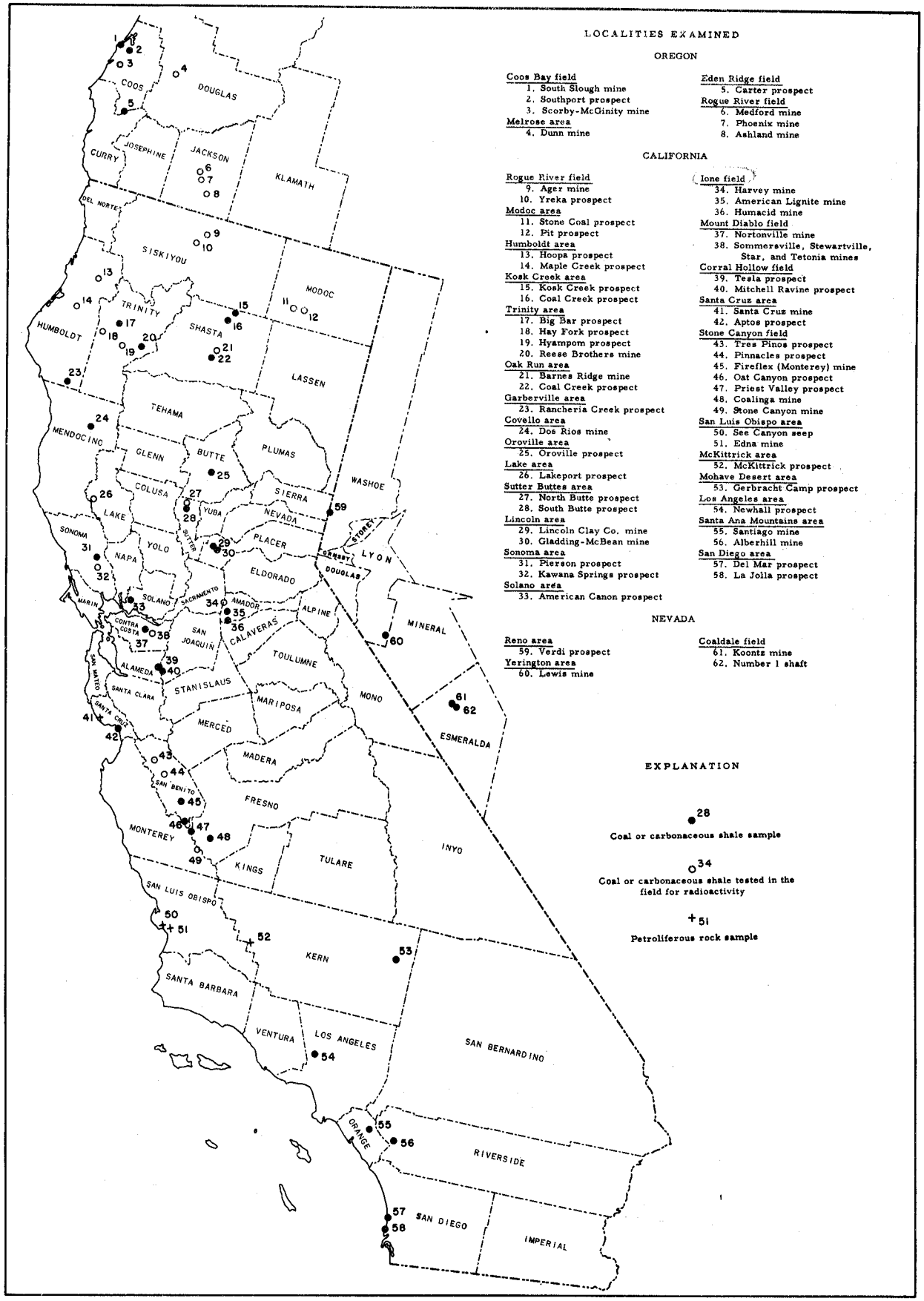

Figure 1.—Localities examined for uranium-bearing carbonaceous rocks in California and parts of Oregon and Nevada, 1952.

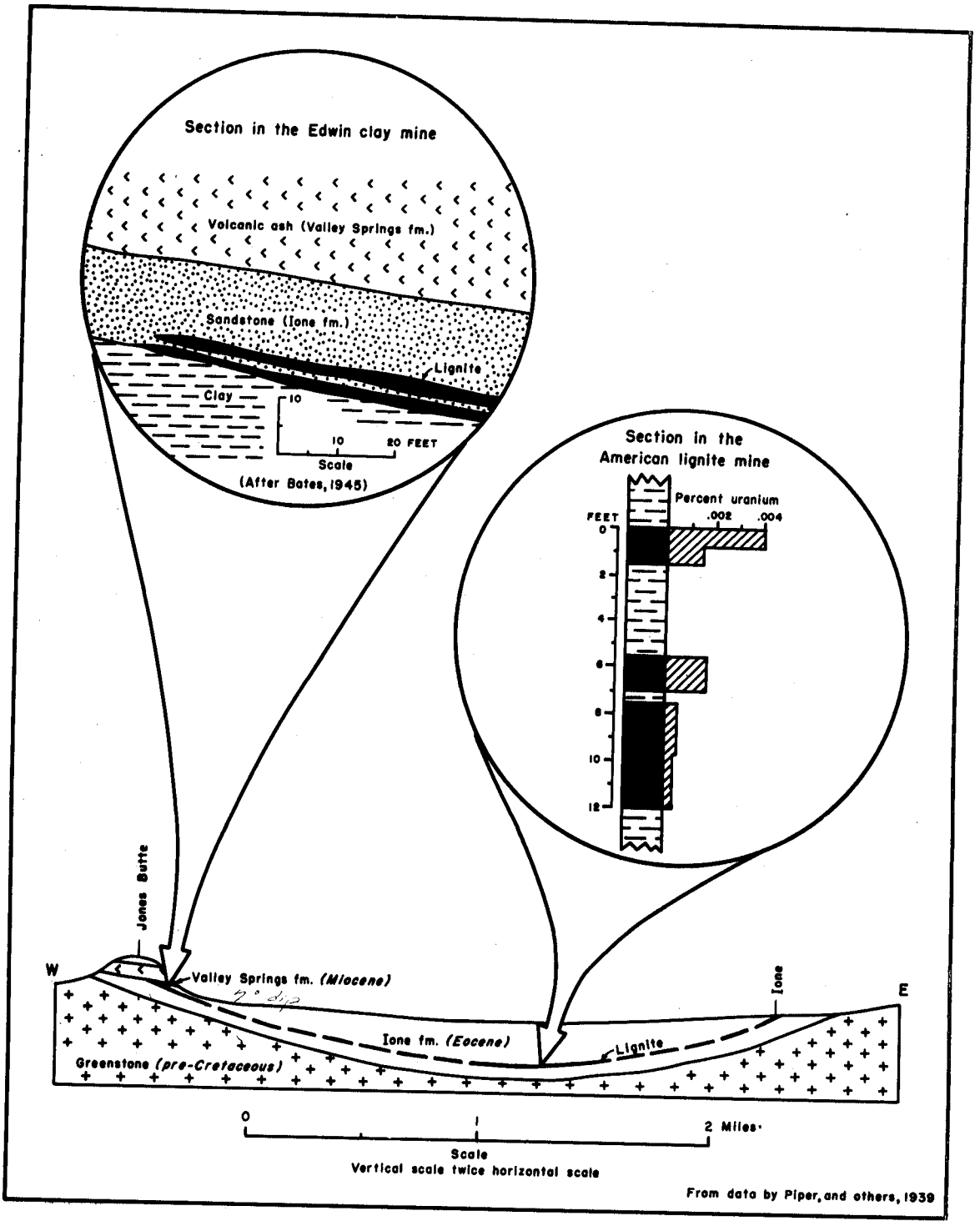

Figure 2.—Diagrammatic section through the Ione lignite field, Amador County, California.

Thin beds of lignitic shale were sampled in two clay mines about 30 miles north of the Ione field, near Lincoln, in Placer County. The lignitic shale from the Atkinson pit of the Gladding-McBean mine (locality 30) contains 0.002 percent equivalent uranium, and the gray clay directly overlying the lignitic shale contains 0.001 percent equivalent uranium. Two core samples of impure lignite from depths of 61 and 67 feet at the Lincoln Clay Co. mine (locality 29) have 0.001 percent or less equivalent uranium.

At Sutter Buttes, Butte County, Eocene rocks are exposed along the flanks of an eroded volcano; from them coal has been mined for local use at several localities. A bed of impure coal, 1 inch thick, from sec. 30, T. 16 N., R. 2 E. (locality 28), contains 0.001 percent uranium. A sample of andesite porphyry from the volcanic plug has 0.001 percent equivalent uranium. Lignite north of Oroville (locality 25) in Butte County contains less than 0.001 percent.

Lignite of Pliocene age, interbedded with the andesitic Sonoma volcanics, was sampled north of Santa Rosa (locality 31), Sonoma County. It contains less than 0.001 percent uranium. Several localities were tested south of Santa Rosa, but radioactivity was not detected.

In American Canon, Solano County, a 6-inch bed of lignite in the Domengine sandstone of Eocene age contains 0.002 percent uranium. This bed crops out in the NW¼ sec. 14, T. 4 N., R. 3 W. (locality 33). South of this locality, in Contra Costa County, is the Mount Diablo coal field, which, because of its proximity to the San Francisco market, has produced most of the coal in the State. A total of about 3 million tons has been mined, but during the past 50 years the mines have been inactive. Many localities in this field were tested for radioactivity but none was detected. The analyses of samples taken, however, show that small quantities of uranium are present in some of the beds. At Nortonville (locality 37) the uranium content of a 1-foot channel sample from the top of a 3-foot bed is 0.001 percent, but because the ash content is only 8.35 percent, the concentration of uranium in the ash is 0.007 percent.

South of the Mount Diablo field is the Corral Hollow field in Alameda County. Many coal localities in the Tesla formation of middle Eocene age were tested and found to be nonradioactive. The most highly uraniferous coal in the area is a 10-inch bed that crops out in a road cut in the NW¼ sec. 25, T. 3 S., R. 3 E. (locality 39); it contains 0.003 percent uranium.

About 2 miles south of Aptos (locality 42) in Santa Cruz County, a 1-foot bed of lignite in the beach cliffs has 0.001 percent uranium, 49.6 percent ash, and 0.003 percent uranium in the ash.

Coal and carbonaceous shale were tested at many localities in the Stone Canyon coalfield and nearby areas in San Benito, Fresno, and Monterey Counties, but only one bed has a significant concentration of uranium. This bed, 6 inches thick, is located 9 feet stratigraphically above the main 5-foot bed at the Fireflex (Monterey) mine (locality 45) in Monterey County. It contains 0.005 percent uranium, 25.1 percent ash, and 0.021 percent uranium in the ash. The main bed contains less than 0.001 percent equivalent uranium. Results of the analysis of samples from central California are shown in table 2.

SOUTHERN CALIFORNIA

In southern California only one bed of carbonaceous material was found that contains a significant quantity of uranium. This is a bed of lignite in the Saugus formation of Pliocene and Pleistocene age, cropping out about 1 mile southwest of Newhall (locality 54), Los Angeles County, in the NW¼ sec. 9, T. 3 N., R. 16 W. The 6-inch bed contains 0.020 percent uranium, the greatest concentration of uranium found in coal in this investigation. The lignite contains 37.7 percent ash and 0.054 percent uranium in the ash. Coal is not common in the Saugus formation, however, and it is not likely that beds of minable thickness will be found.

Coal was examined in the Goler formation (Dibblee, 1952) 1 mile northwest of Gerbracht Camp (locality 53) in Kern County, and was found to contain less than 0.001 percent uranium.

In the Santa Ana Mountains area in Orange and Riverside Counties, the most radioactive coal that was sampled was from the Santiago mine (locality 55) on the east shore of Irvine Lake, 8 miles east of Orange, Orange County. It contains 0.001 percent uranium, 28.4 percent ash, and 0.005 percent uranium in the ash. Other samples from this area, and from the Alberhill mine (locality 56) in the SE¼ sec. 22, T. 5 S., R. 5 W., near Elsinore, Riverside County, contain less than 0.001 percent equivalent uranium.

Lignite at Del Mar (locality 57), San Diego County, in sec. 11, T. 14 S., R. 4 W., is nonradioactive. One mile northeast of La Jolla small pods of coallike material were collected from a marine formation of Late Cretaceous age (locality 58). This material has less than 0.001 percent equivalent uranium. Table 3 shows the results of the analysis of samples collected in southern California.

SOUTHWESTERN OREGON

Coal was tested for radioactivity and sampled for uranium in the Coos Bay, Eden Ridge, and Rogue River fields in Coos, Douglas, and Jackson Counties of southwestern Oregon. Many localities were examined in the Coos Bay field, where large reserves of subbituminous coal in the Coaledo formation of Eocene age are present (Duncan, 1953a), but significant radioactivity was not found. In the Eden Ridge field, coal was examined in the Carter and Anderson beds, as well as in thinner unnamed beds. Radioactivity was not detected here, either; or to the north in the Melrose area; or to the south in the Rogue River field, where coal has been mined from the Umpqua(?) formation of Eocene age. Results of the analysis of samples from southwestern Oregon are shown in table 4.

WESTERN NEVADA

Near Verdi (locality 59), Washoe County, a sample of lignite was collected from the Truckee formation of Tertiary age in the SE¼ sec. 4, T. 19 N., R. 18 E.

Table 2.—Analysis of samples collected in central California

Map locality	Laboratory no.	Thickness of unit (inches)	Equivalent uranium (percent)	Uranium (percent)	Uranium in ash (percent)	Ash (percent)	Location[1] (sec., T., R.)
25	87696	12	0.001	(2)	0.001	39.4	11-20N-3E.
28	87695	1	.002	0.001	.001	77.2	30-16N-2E.
29A	90226	36	.001	---	---	63.6	9-12N-6E.
29B	90227	6	(2)	---	---	62.9	Do.
30	90225	12	.002	---	---	---	16-12N-6E.
31	90246	12	(2)	---	---	80.6	27-8N-8W.
33	90237	6	.001	.002	.004	38.5	14-4N-3W.
35A	90228	9	.004	.004	.007	59.8	26-6N-9E.
35B	90229	9	.002	.002	.002	73.6	Do.
35C	90230	18	.002	.002	.005	34.6	Do.
35D	90231	24	(2)	(2)	.003	13.3	Do.
35E	90232	24	(2)	(2)	.002	16.2	Do.
36A	90233	6	.002	---	---	---	29-5N-10E.
36B	90234	12	.001	.001	.004	26.9	Do.
36C	90235	24	.001	(2)	.002	6.68	Do.
36D	90236	24	.001	.001	.004	19.6	Do.
37A	90238	12	.001	.001	.007	8.35	5-1N-1E.
37B	90239	12	(2)	---	---	6.77	Do.
37C	90240	12	(2)	---	---	6.04	Do.
37D	90241	24	.001	.001	.003	39.6	Do.
37E	90242	12	.002	.001	.002	71.2	Do.
39	90245	10	.004	.003	.006	54.4	25-3S-3E.
40A	90243		.001	.001	.002	50.5	30-3S-4E.
40B	90244	12	(2)	---	---	19.0	Do.
42	95500	12	.002	.001	.003	49.6	2 miles south of Aptos.
45A	95504	6	.006	.005	.021	25.1	21-17S-10E.
45B	95505		(2)	---	---	---	Do.
46	95503	12	.001	(2)	(2)	61.2	20-19S-11E.
47	95502	12	(2)	---	---	---	21-20S-12E.
48A	95508	6	(2)	---	---	---	27-20S-14E.
48B	95509	18	.001	(2)	.001	18.2	Do.

[1] All townships are based on the Mt. Diablo meridian.
[2] Equivalent uranium or uranium content of less than 0.001 percent.

Table 3.—Analysis of samples collected in southern California

Map locality	Laboratory no.	Thickness of unit (inches)	Equivalent uranium (percent)	Uranium (percent)	Uranium in ash (percent)	Ash (percent)	Location[1] (sec., T., R.)
53A	95506		(2)	---	---	---	Gerbracht Camp.
53B	95507		0.001	(2)	0.001	49.7	Do.
54A	95519	12	.003	---	---	---	9-3N-16W-SBM.
54B	95520	6	.011	0.020	.054	37.7	Do.
55A	95517	6	.002	.001	.005	28.4	8 miles east of Orange.
55B	95518		(2)	---	---	---	Do.
56A	95511	6	(2)	---	---	---	22-5S-5W-SBM.
56B	95512	12	(2)	---	---	---	Do.
56C	95513	12	(2)	---	---	---	Do.
56D	95514	12	(2)	---	---	---	Do.
56E	95515	12	(2)	---	---	---	Do.
56F	95516	12	(2)	---	---	---	Do.
58	95521		(2)	---	---	---	1 mile northeast of La Jolla.

[1] "SBM" indicates San Bernardino meridian.
[2] Equivalent uranium or uranium content of less than 0.001 percent.

The lignite has less than 0.001 percent equivalent uranium. Other nearby lignite beds and plant compressions are not radioactive. Samples of coal in sec. 36, T. 8 N., R. 27 E., from the Lewis mine (locality 60), Lyon County, contain less than 0.001 percent equivalent uranium. Younger lignites in this vicinity are also nonradioactive. Samples were collected from the Esmeralda formation in the Coaldale field, Esmeralda County. Here, as much as 1.86 percent uranium is known to occur in a tuff of rhyolitic composition (Duncan, 1953b). The minerals autunite and phosphuranylite have been identified in the tuff. In sec. 33, T. 2 N., R. 38 E., coal collected near a fault (locality 62) which brings the tuff in contact with the coal-bearing rocks, has 0.003 percent equivalent uranium. A sample of carbonaceous shale from sec. 28, T. 2 N., R. 37 E. (locality 61) also has 0.003 percent equivalent uranium, while coal underlying this shale has only 0.001 percent uranium.

Table 5 shows the results of the analysis of samples collected in western Nevada.

PETROLIFEROUS ROCKS

Oil-saturated sandstone containing about 10 percent oil and 0.002 percent uranium was sampled in a quarry for road metal about 1 mile south of Edna (locality 51), in San Luis Obispo County. If all the uranium is present in the oil, and the oil could be leached from the rock, it would contain 0.02 percent uranium. Ashing of the leached oil would permit further concentration of the uranium. Oil-saturated sandstone was also examined near Santa Cruz (locality 41), Santa Cruz County, and near McKittrick (locality 52), Kern County. Both contain 0.001 percent, or less, equivalent uranium. Asphaltite in See Canyon (locality 50), San Luis Obispo County, has 0.001 percent uranium in the ash and 18.9 percent ash. The analysis of petroliferous rocks is shown in table 6.

Table 4.—Analysis of samples collected in southwestern Oregon

Map locality	Laboratory no.	Thickness of unit (inches)	Equivalent uranium (percent)	Uranium (percent)	Uranium in ash (percent)	Ash (percent)	Location[1] (sec., T., R.)
1	87700	12	(2)	---	---	8.4	2-26S-14W-WM.
2	87698	12	0.001	---	---	59.5	14-26S-13W-WM.
5	87697	6	.001	---	---	60.7	32-32S-11W-WM.

[1] "WM" indicates Willamette meridian.
[2] Equivalent uranium content of less than 0.001 percent.

Table 5.—Analysis of samples collected in western Nevada

Map locality	Laboratory no.	Thickness of unit (inches)	Equivalent uranium (percent)	Uranium (percent)	Uranium in ash (percent)	Ash (percent)	Location[1] (sec., T., R.)
59	90247	12	(2)	---	---	30.0	4-19N-18E-MDM.
60A	90248	12	(2)	---	---	31.4	36-8N-27E-MDM.
60B	90249	12	(2)	---	---	38.6	Do.
61A	90252	12	0.003	---	---	---	28-2N-37E-MDM.
61B	90251	12	.001	0.001	0.001	50.0	Do.
62	90250	12	.003	---	---	68.4	33-2N-37E-MDM.

[1] "MDM" indicates Mt. Diablo meridian.
[2] Equivalent uranium content of less than 0.001 percent.

Table 6.—Analysis of samples of petroliferous rocks collected in California

Map locality	Laboratory no.	Equivalent uranium (percent)	Uranium (percent)	Uranium in ash (percent)	Ash (percent)	Location[1] (sec., T., R., Mer.)
41	95501	0.001	---	---	---	4 miles west of Santa Cruz.
50	95523	(2)	(2)	0.001	18.9	20-31S-12E-MDM.
51	95522	.002	0.002	.002	89.7	1 mile south of Edna.
52	95510	(2)	---	---	---	29-30S-22E-MDM.

[1] "MDM" indicates Mt. Diablo meridian.
[2] Equivalent uranium or uranium content of less than 0.001 percent.

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