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DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
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Division of Raw Materials
U. S. Atomic Energy Commission
P. O. Box 30, Ansonia Station
New York 23, New York

Dear Phil:

Transmitted herewith are six copies of TEI-337, "Reconnaissance for uranium-bearing carbonaceous rocks in California and adjacent parts of Oregon and Nevada," by George W. Moore and James G. Stephens, June 1953.

We are asking Mr. Hosted to approve our plan to publish this report as a circular.

Sincerely yours,

for W. H. Bradley
Chief Geologist

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UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

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

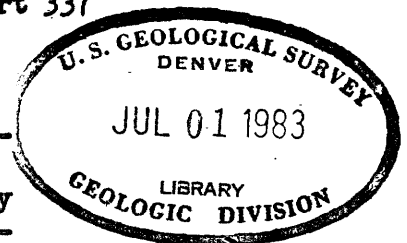
By

George W. Moore and James G. Stephens

June 1953

Trace Elements Investigations Report 337

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*This report concerns work done on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission.

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

By George W. Moore and James G. Stephens

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, Calif. 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 Geological Survey on behalf of the Division of Raw Materials of the 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 these occurrences 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 that contains 0.1 percent uranium or more in the ash is now known in the Dakotas, Wyoming, Idaho, Nevada, Colorado, and New Mexico.

Detailed studies of uranium-bearing lignite by Denson, Bachman, and Zeller (1950) have indicated that the uranium in the lignite in the Dakotas is secondary and was introduced by downward percolating meteoric water which had passed through overlying tuffaceous rocks in the White River and Arikaree formations. Rhyolites are known to contain relatively large amounts of uranium (Evans and Goodman, 1941). Their tuffaceous equivalents seem to be particularly capable of releasing this uranium to solution, as spring water issuing from these rocks contains 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 which are, or were in the past, overlain by rocks of volcanic origin and rhyolitic composition. A total of 63 samples of carbonaceous rocks were taken for analysis from 38 localities.

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

CALIFORNIA

Coal was investigated at most of the localities in California where it is reported in the literature or is listed in the files of the California Division of Mines. Deposits were examined in 21 counties in California. The coal 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.

In California the coal crops out in widely scattered areas of relatively small extent. The total coal resources, therefore, are small and have been estimated at 100 million tons by Averill, and others (1948). Total production through 1946 was 5,270,218 tons valued at \$23,400,260 (Averill, and others, 1948). Locality numbers mentioned in text are shown on figure 1.

Northern California

No significant radioactivity was 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 southern end of the Rogue River field, Siskiyou County; and 5 localities in Trinity and Humboldt Counties. Coal and lignite of Miocene age in the Temblor formation was sampled in the Covello area, Mendocino County; and in the Falor and Wildcat 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 analyses are listed on table 1. The localities from which samples were collected are shown on figure 1.

Table 1. Samples collected in northern California

| Map locality | Lab. number | Thickness of unit | Equivalent uranium (percent) | Uranium (percent) | Uranium in ash (percent) | Ash (percent) | Location Sec., T., R., Msr. ^{2/} |
|--------------|-------------|-------------------|------------------------------|-------------------|--------------------------|---------------|-------------------------------------------|
| 15 | 87689 | 1 ft. | 0.001 | -- | -- | 58.6 | 15-38N-1E-MDM |
| 16 | 87670 | 1 in. | a ^{1/} | -- | -- | 78.9 | 32-33N-1W-MDM |
| 17 | 87692 | 3 in. | a | -- | -- | 11.1 | 6-33N-12W-MDM |
| 20 | 87691 | 1 ft. | a | -- | -- | 13.7 | 32-32N-9W-MDM |
| 23 | 87693 | 1 ft. | 0.002 | a | 0.001 | 48.6 | 3-5S-4E-HM |
| 24 | 87694 | 1 ft. | 0.001 | a | a | 15.8 | 2-21N-13W-MDM |

^{1/} "a" indicates equivalent uranium or uranium content of less than 0.001 percent

^{2/} "MDM" indicates Mt. Diablo meridian; "HM" indicates Humboldt meridian

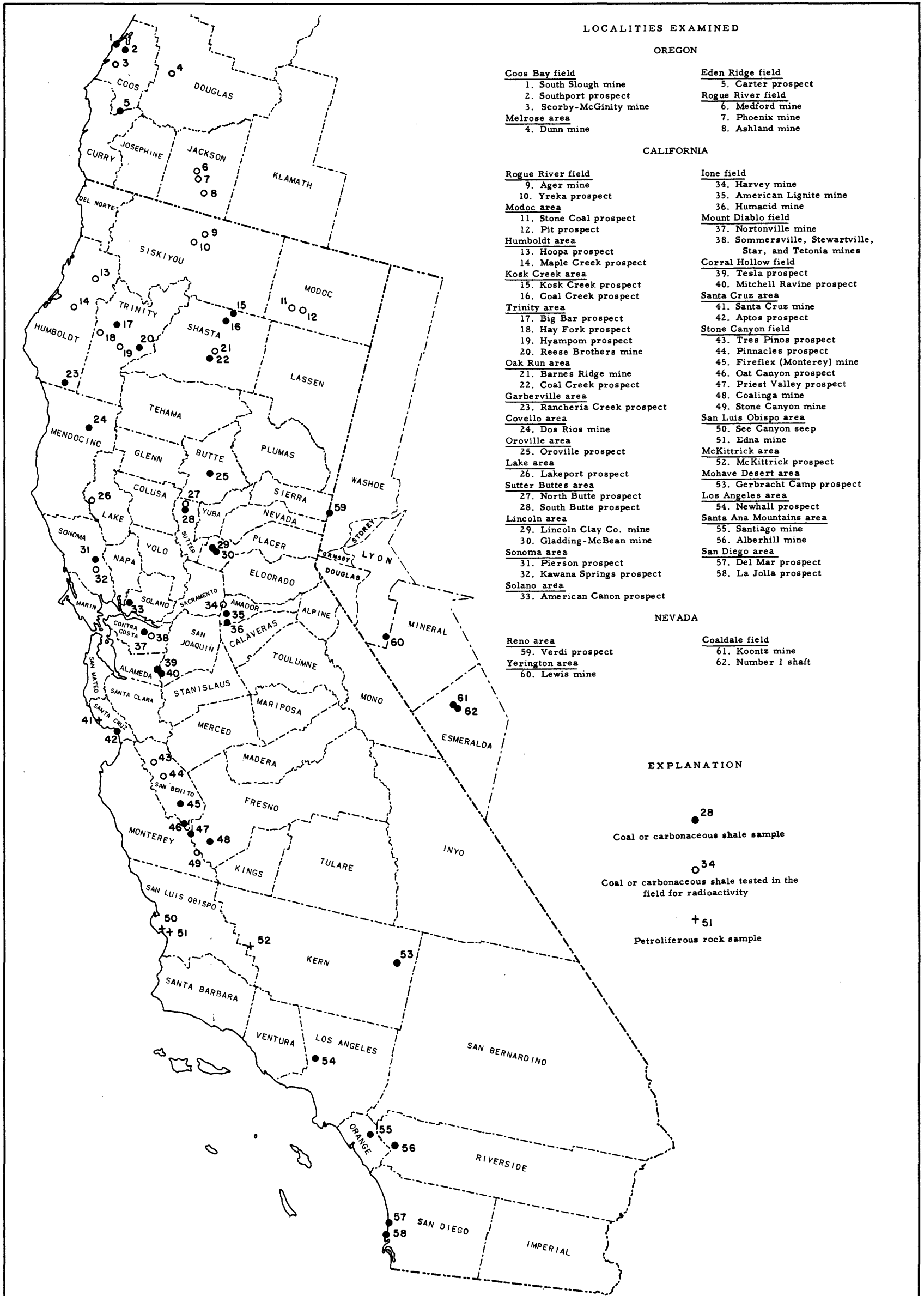
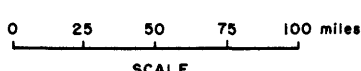


FIGURE 1.--LOCALITIES EXAMINED DURING RECONNAISSANCE FOR URANIUM-BEARING CARBONACEOUS ROCKS IN CALIFORNIA AND PARTS OF OREGON AND NEVADA, 1952



Central California

In central California, one area, the Ione lignite field, Amador County, was found that may merit additional work. The lignite beds lie in a north-west trending syncline in the foothills of the Sierra Nevada. The lignite is in the Ione formation of Eocene age and is being produced from two mines. These were the only coal mines operating in the state at the time of the investigation, and the lignite is being used for the production of montan wax and other industrial chemicals. Montan 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 Company in sec. 26, T. 6 N., R. 9 E. (loc. 35) about a mile southwest of Ione. The thickness and uranium content of this bed are shown graphically on figure 2; a maximum uranium content of 0.004 percent was found in the upper 9 inches of the 12-foot lignite zone.

The uranium in the lignite may have been introduced by downward and laterally percolating solutions which derived a low concentration of uranium from the overlying Valley Springs formation of Miocene age. 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. The lignite at this locality could not be examined at the time of the present investigation as the mine workings were caved and inaccessible.

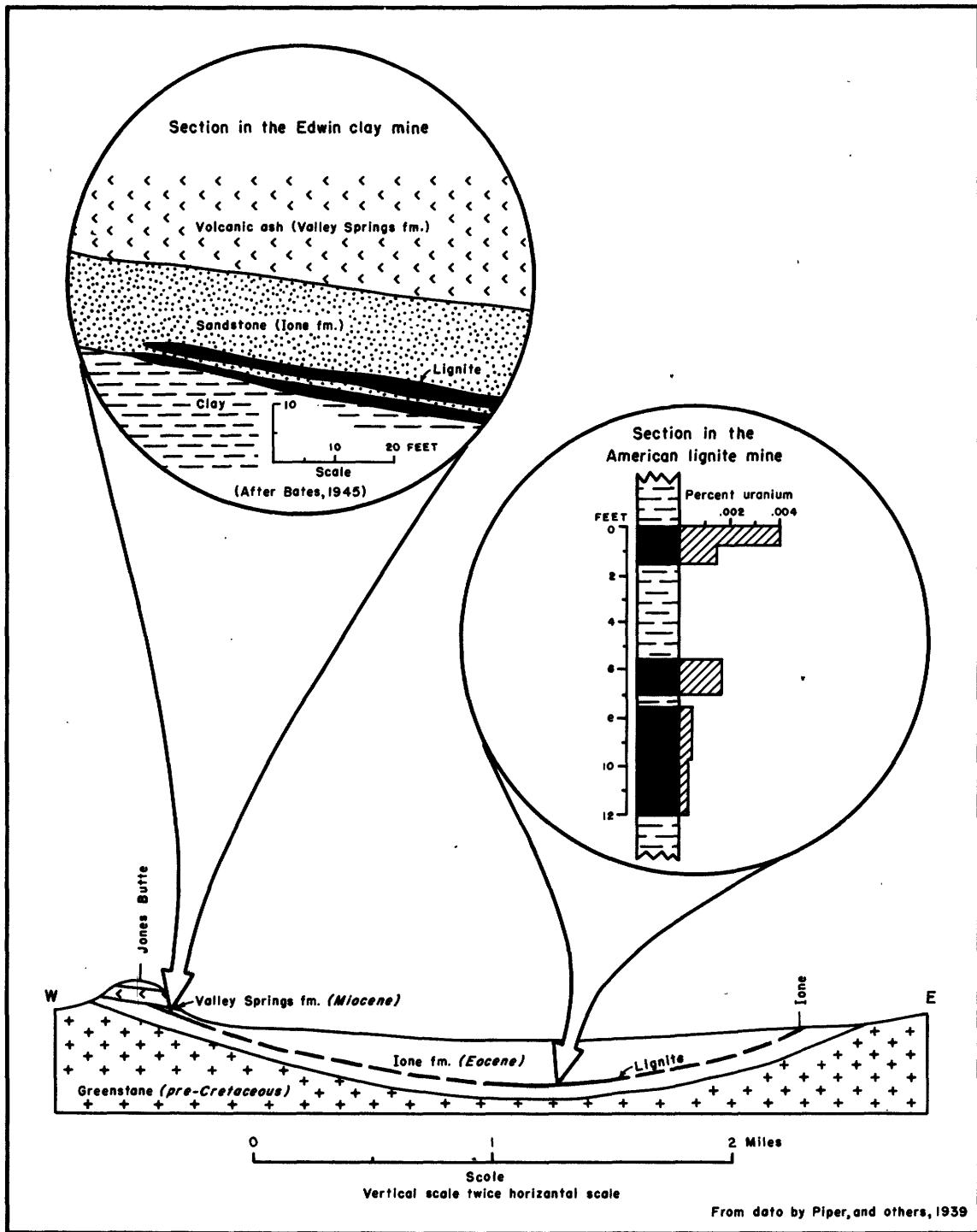


FIGURE 2.--DIAGRAMMATIC SECTION THROUGH THE IONE LIGNITE FIELD, AMADOR COUNTY, CALIFORNIA

Samples were collected from the Humacid mine (loc. 36), about 6 miles south of Ione where underground operations are also producing lignite for montan wax. The lignite contains 0.002 percent equivalent uranium or less. Dumps from other caved coal mines in the vicinity were tested with the geiger counter, but no abnormal radioactivity was detected.

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.

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 (loc. 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 (loc. 29) contain 0.001 percent or less equivalent uranium.

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

Lignite of Pliocene age interbedded with the andesitic Sonoma volcanics was sampled north of Santa Rosa, Sonoma County (loc. 31). This lignite contains less than 0.001 percent uranium. Several localities were tested south of Santa Rosa, but no radioactivity was 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 NW $\frac{1}{4}$, sec. 14, T. 4 N., R. 3 W. (loc. 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 provided most of the coal production of the state. A total of about 3,000,000 tons of coal has been mined, but during the past 50 years the mines have been inactive. Many localities were tested in the field 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 (loc. 37) the uranium content of a 1-foot sample 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 non-radioactive. The most highly uraniferous coal in the area is a 10-inch bed that crops out in a road cut in the NW $\frac{1}{4}$, sec. 25, T. 3 S., R. 3 E. and contains 0.003 percent uranium (loc. 39).

About 2 miles south of Aptos in Santa Cruz County (loc. 42), a 1-foot bed of lignite in the beach cliffs contains 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 coal field and nearby areas in San Benito, Fresno, and Monterey Counties, but only one bed contains a significant concentration of uranium. This bed, 6 inches in thickness, is 9 feet stratigraphically above the main 5-foot bed at the Fireflex (Monterey) mine in Monterey County (loc. 45).

The 6-inch bed 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.

Table 2. Samples collected in central California. (Arabic numbers in sample number refer to map localities shown on figure 1.)

| Sample number | Lab. number | Thickness of unit | Equivalent uranium (percent) | Uranium (percent) | Uranium in ash (percent) | Ash (percent) | Location 2/ Sec., T., R. |
|---------------|-------------|-------------------|------------------------------|-------------------|--------------------------|---------------|-----------------------------|
| 25 | 87696 | 1 ft. | 0.001 | a 1/ | 0.001 | 39.4 | 11-20N-3E |
| 28 | 87695 | 1 in. | 0.002 | 0.001 | 0.001 | 77.2 | 30-16N-2E |
| 29A | 90226 | 3 ft. | 0.001 | -- | -- | 63.6 | 9-12N-6E |
| 29B | 90227 | 6 in. | a | -- | -- | 62.9 | " |
| 30 | 90225 | 1 ft. | 0.002 | -- | -- | -- | 16-12N-6E |
| 31 | 90246 | 1 ft. | a | -- | -- | 80.6 | 27-8N-8W |
| 33 | 90237 | 6 in. | 0.001 | 0.002 | 0.004 | 38.5 | 14-4N-3W |
| 35A | 90228 | 9 in. | 0.004 | 0.004 | 0.007 | 59.8 | 26-6N-9E |
| 35B | 90229 | 9 in. | 0.002 | 0.002 | 0.002 | 73.6 | " |
| 35C | 90230 | 18 in. | 0.002 | 0.002 | 0.005 | 34.6 | " |
| 35D | 90231 | 2 ft. | a | a | 0.003 | 13.3 | " |
| 35E | 90232 | 2 ft. | a | a | 0.002 | 16.2 | " |
| 36A | 90233 | 6 in. | 0.002 | -- | -- | -- | 29-5N-10E |
| 36B | 90234 | 1 ft. | 0.001 | 0.001 | 0.004 | 26.9 | " |
| 36C | 90235 | 2 ft. | 0.001 | a | 0.002 | 6.68 | " |
| 36D | 90236 | 2 ft. | 0.001 | 0.001 | 0.004 | 19.6 | " |
| 37A | 90238 | 1 ft. | 0.001 | 0.001 | 0.007 | 8.35 | 5-1N-1E |
| 37B | 90239 | 1 ft. | a | -- | -- | 6.77 | " |
| 37C | 90240 | 1 ft. | a | -- | -- | 6.04 | " |
| 37D | 90241 | 2 ft. | 0.001 | 0.001 | 0.003 | 39.6 | " |
| 37E | 90242 | 1 ft. | 0.002 | 0.001 | 0.002 | 71.2 | " |
| 39 | 90245 | 10 in. | 0.004 | 0.003 | 0.006 | 54.4 | 25-3S-3E |
| 40A | 90243 | | 0.001 | 0.001 | 0.002 | 50.5 | 30-3S-4E |
| 40B | 90244 | 1 ft. | a | -- | -- | 19.0 | " |
| 42 | 95500 | 1 ft. | 0.002 | 0.001 | 0.003 | 49.6 | 2 miles S. of Aptos |
| 45A | 95504 | 6 in. | 0.006 | 0.005 | 0.021 | 25.1 | 21-17S-10E |
| 45B | 95505 | | a | -- | -- | -- | " |
| 46 | 95503 | 1 ft. | 0.001 | a | a | 61.2 | 20-19S-11E |
| 47 | 95502 | 1 ft. | a | -- | -- | -- | 21-20S-12E |
| 48A | 95508 | 6 in. | a | -- | -- | -- | 27-20S-14E |
| 48B | 95509 | 18 in. | 0.001 | a | 0.001 | 18.2 | " |

1/ "a" indicates equivalent uranium or uranium content of less than 0.001 percent.

2/ All townships are in the survey based on the Mt. Diablo meridian.

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 age cropping out about a mile southwest of Newhall, Los Angeles County, in the NW $\frac{1}{4}$, sec. 9, T. 3 N., R. 16 W. (loc. 54). The 6-inch lignite 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 a mile northwest of Gerbracht Camp (loc. 53) in Kern County. This coal contains less than 0.001 percent uranium.

Several coal localities were examined in the Santa Ana Mountains area, Orange and Riverside Counties. The most highly radioactive coal sampled in the area was collected from the Santiago mine (loc. 55) on the east shore of Irvine Lake, 8 miles east of Orange, Orange County. The coal contains 0.001 percent uranium, 28.4 percent ash, and 0.005 percent uranium in the ash. Other samples from this area and samples from the Alberhill mine (loc. 56) in the SE $\frac{1}{4}$, sec. 22, T. 5 S., R. 5 W., near Elsinore, Riverside County, contain less than 0.001 percent equivalent uranium.

Lignite at Del Mar, San Diego County, in sec. 11, T. 14 S., R. 4 W. (loc. 57) is non-radioactive. A mile northeast of La Jolla small pods of coal-like material were collected from the marine Chico formation of Cretaceous age (loc. 58). This material contains less than 0.001 percent equivalent uranium.

Table 3. Samples collected in southern California. (Arabic numbers in sample number refer to map localities in figure 1.)

| Sample number | Lab. number | Thickness of unit | Equivalent uranium (percent) | Uranium (percent) | Uranium in ash (percent) | Ash (percent) | Location ^{2/} Sec., T., R. |
|---------------|-------------|-------------------|------------------------------|-------------------|--------------------------|---------------|-------------------------------------|
| 53A | 95506 | | a ^{1/} | -- | -- | -- | Gerbracht camp |
| 53B | 95507 | | 0.001 | a | 0.001 | 49.7 | " |
| 54A | 95519 | 1 ft. | 0.003 | -- | -- | -- | 9-3N-16W-SBM |
| 54B | 95520 | 6 in. | 0.011 | 0.020 | 0.054 | 37.7 | " |
| 55A | 95517 | 6 in. | 0.002 | 0.001 | 0.005 | 28.4 | 8 m. E of Orange |
| 55B | 95518 | | a | -- | -- | -- | " |
| 56A | 95511 | 6 in. | a | -- | -- | -- | 22-5S-5W-SBM |
| 56B | 95512 | 1 ft. | a | -- | -- | -- | " |
| 56C | 95513 | 1 ft. | a | -- | -- | -- | " |
| 56D | 95514 | 1 ft. | a | -- | -- | -- | " |
| 56E | 95515 | 1 ft. | a | -- | -- | -- | " |
| 56F | 95516 | 1 ft. | a | -- | -- | -- | " |
| 58 | 95521 | | a | -- | -- | -- | 1 m. NE of La Jolla |

^{1/} "a" indicates equivalent uranium or uranium content of less than 0.001 percent.

^{2/} "SBM" indicates San Bernardino meridian.

SOUTHWESTERN OREGON

Coal was tested for radioactivity and sampled for uranium in the Coos Bay, Eden Ridge, and Rogue River fields, 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, 1953). No significant radioactivity was found. In the Eden Ridge field, coal was examined at several localities in both the Carter and Anderson beds as well as in thinner unnamed beds. No radioactivity was detected here or to the north in the Melrose area.

Several mines were examined in the Rogue River field to the south where coal in the Umpqua formation of Eocene age has been mined, but no significant radioactivity was detected.

Table 4. Samples collected in southwestern Oregon

| Map locality | Lab. number | Thickness of unit | Equivalent uranium (percent) | Uranium (percent) | Uranium in ash (percent) | Ash (percent) | Location Sec., T., R., Mer. <u>2/</u> |
|--------------|-------------|-------------------|------------------------------|-------------------|--------------------------|---------------|---------------------------------------|
| 1 | 87700 | 1 ft. | a <u>1/</u> | -- | -- | 8.4 | 2-26S-14W-WM |
| 2 | 87698 | 1 ft. | 0.001 | -- | -- | 59.5 | 14-26S-13W-WM |
| 5 | 87697 | 6 in. | 0.001 | -- | -- | 60.7 | 32-32S-11W-WM |

1/ "a" indicates equivalent uranium content of less than 0.001 percent.

2/ "WM" indicates Willamette meridian.

WESTERN NEVADA

Coal was examined at several localities in western Nevada. Near Verdi, Washoe County, (loc. 59) a sample of lignite was collected from the Truckee formation of late Tertiary age in the SE $\frac{1}{4}$, sec. 4, T. 19 N., R. 18 E. The lignite contains 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, Lyon County (loc. 60), contain less than 0.001 percent equivalent uranium. Younger lignites in the vicinity of the Lewis mine are also non-radioactive.

Several samples of coal were collected from Esmeralda formation in the Coaldale field, Esmeralda County. Uranium is known to occur in this area in a tuff of rhyolitic composition (Duncan, 1952). The minerals autunite and phosphuranylite have been identified in the tuff which contains as much as

1.86 percent uranium. Coal collected near a fault which brings the tuff in contact with the coal-bearing rocks in sec. 33, T. 2 N., R. 38 E. contains 0.003 percent equivalent uranium (loc. 62). A sample of carbonaceous shale from sec. 28, T. 2 N., R. 37 E. (loc. 61) also contains 0.003 percent equivalent uranium while coal underlying this shale contains only 0.001 percent uranium.

Table 5. Samples collected in western Nevada

| Sample number | Lab. number | Thickness of unit | Equivalent uranium (percent) | Uranium (percent) | Uranium in ash (percent) | Ash (percent) | Location Sec., T., R., Mer. <u>2/</u> |
|---------------|-------------|-------------------|------------------------------|-------------------|--------------------------|---------------|---------------------------------------|
| 59 | 90247 | 1 ft. | a <u>1/</u> | -- | -- | 30.0 | 4-19N-18E-MDM |
| 60A | 90248 | 1 ft. | a | -- | -- | 31.4 | 36-8N-27E-MDM |
| 60B | 90249 | 1 ft. | a | -- | -- | 38.6 | " |
| 61A | 90252 | 1 ft. | 0.003 | -- | -- | -- | 28-2N-37E-MDM |
| 61B | 90251 | 1 ft. | 0.001 | 0.001 | 0.001 | 50.0 | " |
| 62 | 90250 | 1 ft. | 0.003 | -- | -- | 68.4 | 33-2N-37E-MDM |

1/ "a" indicates equivalent uranium content of less than 0.001 percent.

2/ "MDM" indicates Mt. Diablo meridian.

PETROLIFEROUS ROCKS

Oil-saturated sandstone containing 0.002 percent uranium was sampled in a quarry for road metal about a mile south of Edna, San Luis Obispo County (loc. 51). If all the uranium is present in the oil and this material could be leached from the rock, the oil 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, Santa Cruz County (loc. 41) and near McKittrick, Kern County (loc. 52). Both contain 0.001 percent or less equivalent uranium. Asphaltite in See Canyon, San Luis Obispo County (loc. 50) contains 0.001 percent uranium in the ash and 18.9 percent ash.

Table 6. Samples of petroliferous rocks collected in California

| Map locality | Lab. number | Equivalent uranium (percent) | Uranium (percent) | Uranium in ash (percent) | Ash (percent) | Location Sec., T., R., Mer. ^{2/} |
|--------------|-------------|------------------------------|-------------------|--------------------------|---------------|-------------------------------------------|
| 41 | 95501 | 0.001 | -- | -- | -- | 4 miles W. of Santa Cruz |
| 50 | 95523 | a ^{1/} | a | 0.001 | 18.9 | 20-31S-12E-MDM |
| 51 | 95522 | 0.002 ^{2/} | 0.002 | 0.002 | 89.7 | 1 mile S. of Edna |
| 52 | 95510 | a | -- | -- | -- | 29-30S-22E-MDM |

^{1/} "a" indicates equivalent uranium or uranium content of less than 0.001 percent.

^{2/} "MDM" indicates Mt. Diablo meridian.

PLANS

No further work is planned on the deposits described in this report until more promising areas in other states have been investigated. Further field examination may be made of the Ione lignite and the Edna oil-saturated sandstone by parties engaged in other work in the vicinity of these deposits.

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