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NATURAL RESOURCES OF NORTHWESTERN CALIFORNIA

REPORT APPENDIX

GEOLOGY
MINERAL RESOURCES
MINERAL INDUSTRY

UNITED STATES DEPARTMENT OF THE INTERIOR
PACIFIC SOUTHWEST FIELD COMMITTEE

PREPARED BY THE GEOLOGICAL SURVEY AND
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OF
NORTHWESTERN CALIFORNIA

GEOLOGY

MINERAL RESOURCES

MINERAL INDUSTRY

REPORT APPENDIX

by

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GEOLOGICAL SURVEY

and

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BUREAU OF MINES

UNITED STATES

DEPARTMENT OF THE INTERIOR

PACIFIC SOUTHWEST FIELD COMMITTEE

1960

UNITED STATES
DEPARTMENT OF THE INTERIOR
PACIFIC SOUTHWEST FIELD COMMITTEE
NORTHWESTERN CALIFORNIA INVESTIGATIONS

VICINITY MAP

AUGUST 15, 1956

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Pacific Southwest Field Committee
Northwestern California Resources Investigation Subcommittee

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Geology, Mineral Resources, Mineral Industry
Report Appendix, 1960
Geological Survey and Bureau of Mines
Land Use, Land Classification, Timber Resources[1/]
Preliminary Report Appendix, 1956
Bureau of Reclamation
Water Resources, Surface Water Hydrology, Ground-Water Conditions, Quality of Water[1/]
Preliminary Report Appendix, 1956
Geological Survey
Recreation Resources Supplement, Economic Aspects[1/]
Preliminary Report Appendix, 1957
National Park Service
Recreation Resources Supplement, History and Archeology[1/]
Preliminary Report Appendix, 1958
National Park Service
Recreation Resources[1/]
Preliminary Report Appendix, 1958
National Park Service
Fish and Wildlife Resources
Report Appendix, 1960
Fish and Wildlife Service
Plans of Water Development
Report Appendix, 1960
Bureau of Reclamation
Water Requirements
Report Appendix, 1960
Bureau of Reclamation
General Economy
Report Appendix, 1960
Bureau of Reclamation

1/ Also appendix to the Report, 1960

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INTRODUCTION

The geology, mineral resources, and mineral industry of the area in northwestern California that is drained principally by the Klamath, Trinity, and Eel rivers is discussed in this report, which was prepared jointly by the Geological Survey and the Bureau of Mines of the United States Department of the Interior. The report treats the past and present production of the mineral industry in the area and establishes a basis for discussing the outlook for future water and power needs for mining. The parts of the report pertaining to geology were prepared by W. P. Irwin and D. B. Tatlock of the Geological Survey; Frank Wiebelt, G. B. Shea, and R. B. Maurer of the Bureau of Mines compiled the mineral industry data and prepared the estimates of water and power needs.

SUMMARY

From 1880, when the total mineral output of the counties comprising the basins was first recorded, through 1957, the value of the minerals produced was $153,964,000 (figure 1 and table 1), or an annual average of $1,999,500. In 1957, however, the value of the minerals produced was $7,925,400. The dollar value of mineral output in the basins in 1957 was therefore 296 percent greater than the 77-year average for the years 1880-1957, but the 1957 quantities of materials were not as much larger as the dollar values indicate, owing to inflation of unit prices.

For the period 1880-1957 gold accounted for 61 percent of the dollar value of the total mineral production (figure 2); miscellaneous crushed stone, including sand and gravel, amounted to 24 percent; chromite, 5 percent; and, copper, 4 percent. The remaining 6 percent includes the values of mercury, manganese ore, natural gas, clay, silver, platinum, limestone, sandstone, gem stones, coal, granite, tube-mill pebbles, magnesite, lead, bituminous rock, marble, pumice, and asbestos. In 1957, however, the yield of crushed stone, sand, and gravel contributed 76 percent of the area's total mineral value; and gold, natural gas, and chromite were respectively 10, 7, and 6 percent, with combined silver, copper, mercury, and lead outputs amounting to only 1 percent. These figures accurately reflect the response of the mining industry to current economic conditions. Of special interest are (1) the increase in production of some nonmetallic commodities resulting from the growing population and construction

Summary

Table 1.--Mineral Production in the Klamath, Trinity, and Eel River Basins, 1880-1957[a/]

Mineral	Unit	1880-1957 Quantity	1880-1957 Value	1957 Quantity	1957 Value
Metals and Metallic Ores			$		$
Gold	fine ounces	3,956,600	94,436,300	23,444	820,540
Platinum	fine ounces	1,850	129,200	-	-
Silver	fine ounces	839,860	630,700	50,139	45,379
Copper	pounds	41,648,300	6,338,300	136,700	41,147
Lead	pounds	32,600	3,300	3,600	515
Chromite	long tons	113,000	7,935,000	4,920	479,509
Manganese ore[b/]	long tons	39,700	1,454,800	-	-
Mercury	flasks	35,000	1,726,000	23	5,681
Total			112,653,600	Rounded	1,392,800
Nonmetallic minerals					
Asbestos	short tons	114	5,700	-	-
Bituminous rock	short tons	450	2,250	-	-
Clays	short tons	116,600	337,600	-	-
Limestone	short tons	31,300	91,300	-	-
Magnesite	short tons	660	6,000	-	-
Pumice	short tons	9	240	-	-
Sand and gravel	short tons	26,337,000	21,033,000	4,424,000	4,502,000
Stone, crushed	short tons	12,124,000	13,025,000	1,368,000	1,501,000
Stone, sand and gravel not separable	short tons	3,016,000	2,413,000	-	-
Tube-mill pebbles	short tons	3,700	17,100	-	-
Granite	cubic feet	18,600	17,400	-	-
Marble	cubic feet	175	580	-	-
Sandstone	cubic feet	26,500	41,800	-	-
Gem stones		c/	31,200	c/	1,928
Total			37,022,200	Rounded	6,004,600
Mineral fuels and nonfuel gas					
Coal	short tons	3,975	21,160	-	-
Natural gas	million cu.ft.	21,188	3,325,000	2,087	528,000
Petroleum (crude)	barrels	350	700	-	-
Total			3,346,900		528,000
Nonfuel natural gas					
Carbon dioxide		c/	d/	-	-
Listed minerals not separable			941,400		-
Grand Total			153,964,000		7,925,400

a/ Bureau of Mines and California State Division of Mines data; some details estimated. Includes mercury production prior to 1880.

b/ Does not include manganese ore and concentrate shipped to low grade stockpiles for future beneficiation.

c/ Not available.

d/ Included with listed minerals-not separable.

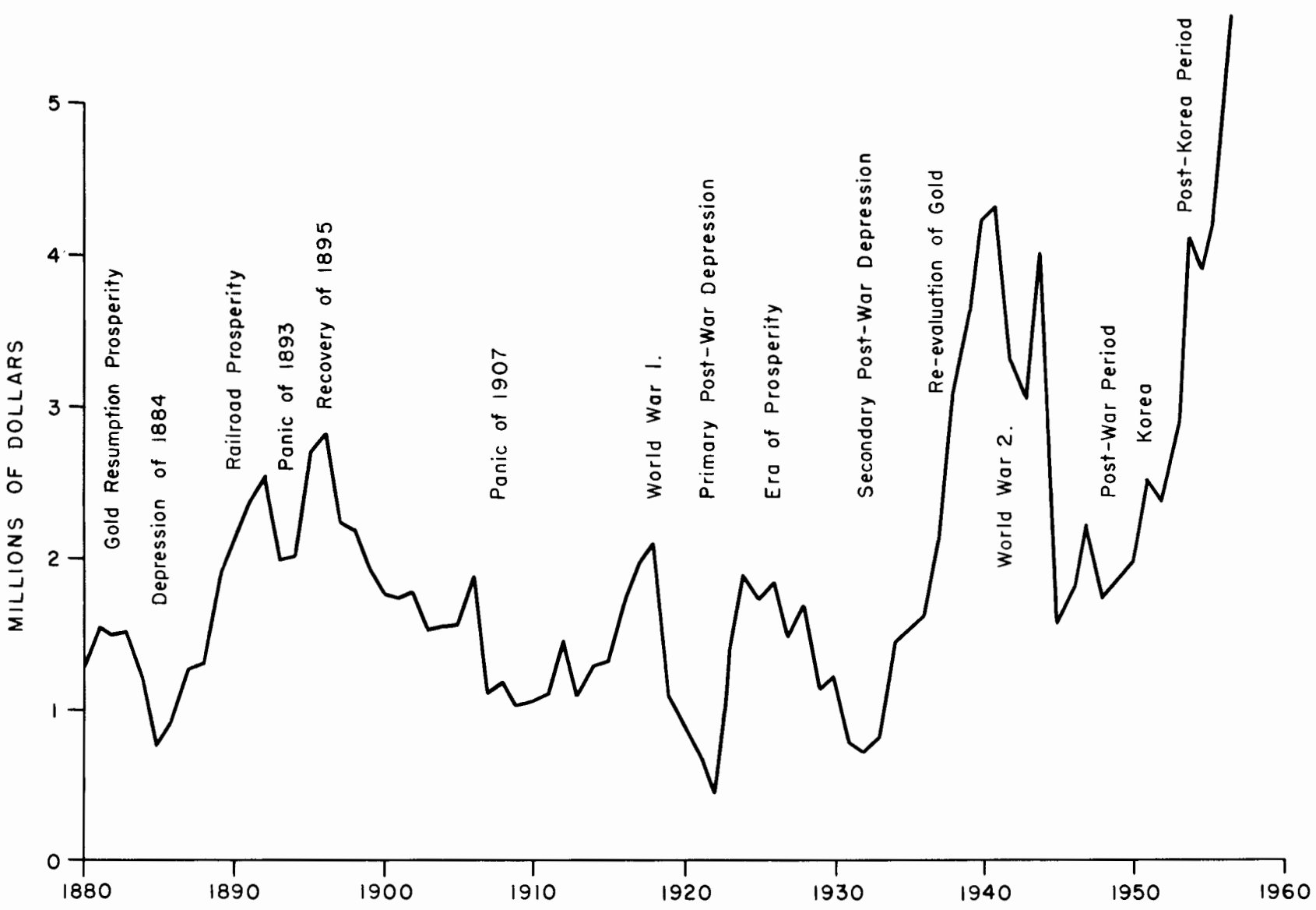

FIGURE 1. VALUE OF MINERAL PRODUCTION IN THE KLAMATH, TRINITY, AND EEL RIVER BASINS, NORTHWESTERN CALIFORNIA, 1880-1957, BY YEARS.

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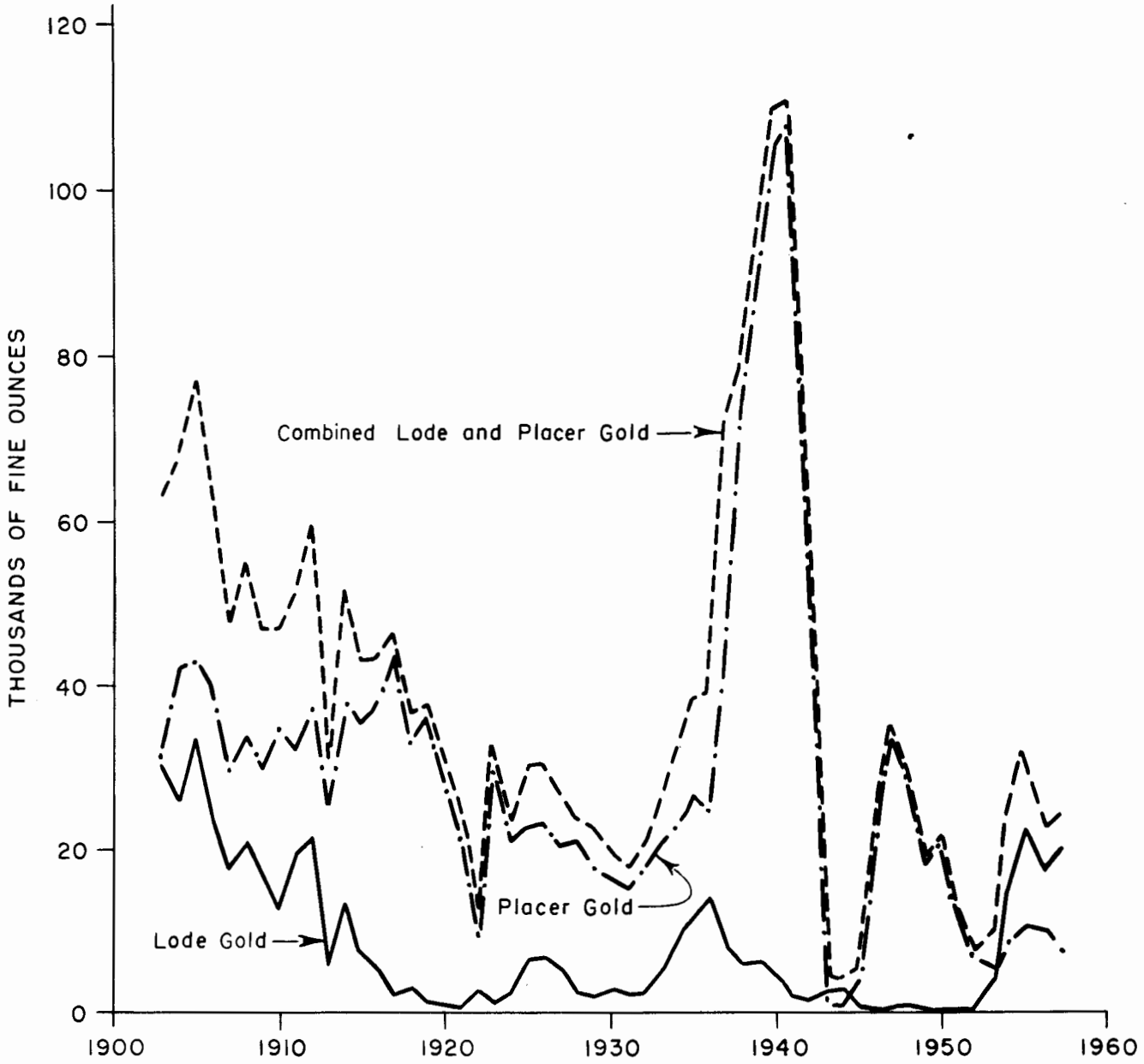

FIGURE 2. PRODUCTION OF GOLD IN THE KLAMATH, TRINITY, AND EEL RIVER BASINS, NORTHWESTERN CALIFORNIA, 1903-1957, BY YEARS.

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activities in the area, (2) the increase in production of chromite, owing to Government supported prices, and (3) the decrease in gold production, owing to an unfavorable relation between the Government price and the current value of the dollar.

Production of sand, gravel, and crushed stone, the principal aggregate materials for building and highway construction, has advanced steadily in recent years. Conversely, outputs of dimension stone and clay, the latter used principally for common brick, have declined. Limestone is not now being quarried, but it is fairly abundant in the area and has potential use for lime and as an ingredient of portland cement. Chrysotile asbestos, suitable grades of which are imported to supply the Pacific Coast industries, is found in the basins, but to date scant exploration has not found a sufficient tonnage to support commercial production. Any increase in production of construction commodities as a group will depend largely upon industrial expansion, including cement and lime plants, and a buildup of the population in the basins to consume these materials.

Coal, which is principally of subbituminous rank and in small quantity, has not been mined for several years in the basins. Its future consumption would be restricted chiefly to specific uses in competition with liquid and gaseous fuels and hydraulic power. Natural gas is being produced in the basins, but the estimated reserves will not allow any appreciable yearly increase in output over the present yield. A small quantity of petroleum was produced

commercially in the area for the first time in 1953, but none has been produced since 1954.

To maintain or expand the production of chromite and manganese ore continued price and market assistance, as well as advances in the metallurgical treatment of the ores, likely will be necessary. Copper and mercury mining can be revived only through the discovery of new ore deposits adequate to sustain production. A restored copper industry could result in some output of the accessory zinc and silver. Nickel, on the other hand, may become an important product in the future. Uranium has been found only in small amounts in a few places in the area, and it seems unlikely that exploitable deposits will be discovered.

A resurgence of gold production, the principal mineral commodity of the basins in the past, to a level somewhere between the present output and the peak years will depend upon unpredictable future events, such as an increase in the price of gold; the return to economic conditions favoring low-cost operations; and the attitude of the public toward gold mining with reference to soil conservation, debris disposal, and stream pollution.

To calculate the future water and power requirements of the mineral industry in the area on the basis of present consumption would be presumptuous because of reduced activity at gold mines, which were the principal users of water and power in past years. Therefore,

Summary

the following data are based on estimates of the maximum potential of the basins' mineral resources.

A total of 92,000 acre-feet of water is the estimated peak requirement for mineral recoveries and mineral processing, taking into consideration all possible recirculation of water. Actually, only about 5,000 acre-feet of water would be consumed under any circumstances because practically all the water required in mining and plant operations eventually is coursed back into the main drainage channels. Power requirements would be 120,000,000 kilowatt-hours.

GEOLOGY

The geology of northwestern California has been studied less than that of any other area of comparable size in California. The northeastern and coastal portions of this area have been studied most because of better accessibility and better base maps. During World War II considerable work was done by the Geological Survey in search of strategic materials, but most of this work was aimed at an understanding of small areas near deposits of strategic minerals. Since 1945 the few geologic studies that have been made were confined largely to the coastal areas and local ground-water basins.

The present geologic study was begun by the Geological Survey early in 1953 as part of an investigation of the drainage basins of the Eel, Trinity, and Klamath Rivers made by the Department of the Interior. The purpose of the geologic study was to prepare, by compilation of existing maps and field reconnaissance, a geologic map which would permit a more precise evaluation of the mineral potential of the area. As geologic maps suitable for compilation were found to be available for only a small part of the region, the field reconnaissance required to learn the distribution of the major geologic formations of the hitherto unmapped portions of the area extended through the summers of 1953 and 1954. The geologic map accompanying this report, plate 1, combines, therefore, the published and unpublished maps of many geologists and the reconnaissance mapping of Irwin and Tatlock. The various commodity maps were compiled by H. L. Sobel

of the Geological Survey from published and unpublished data in the files of the Bureau of Mines, California Division of Mines, and Geological Survey.

The watershed of the Eel, Trinity, and Klamath Rivers falls in parts of three distinct geologic provinces: the Cascade Range in the northeast, the Klamath Mountains in the northwest, and the Coast Ranges in the southwest and south. These provinces differ from one another in topography, in the character of the underlying rocks, and to a large extent in their mineral resources.

The Cascade Range in California is the southern end of a narrow range of volcanic rocks of Tertiary and Quaternary age extending northward through Oregon into southern Washington. The topography is characterized by sharp volcanic peaks, such as Lassen Peak and Mt. Shasta, which rise high above a thick series of young volcanic rock. Except for scattered deposits of pumice, the volcanic rocks of the Cascade Range in California contain only unimportant mineral deposits; and these rocks completely blanket any ore deposits that may lie in the older rocks below.

The Klamath Mountains province is an area of precipitous mountains in northwestern California and southwestern Oregon in which many of the peaks are higher than 5,000 feet, and some are more than 8,000 feet above sea level. In California the area is drained by the Klamath, Trinity, and Smith Rivers, which form a dendritic drainage that is in sharp contrast to the trellis drainage of the Coast Ranges. The

eastern boundary of the province in California is Shasta Valley to the north and the Sacramento Valley to the south. The western boundary is sharply defined for much of its length by South Fork Mountain, a nearly straight ridge that trends northwest and maintains a remarkably uniform altitude of approximately 5,000 feet.

The Klamath Mountains consist mainly of rocks that are much older than those of the Cascade Range, and somewhat older than most of the rocks of the Coast Range; however, the province also contains sizable areas of younger rocks. The ages of most of the older rocks are not accurately known. Gneiss and schist found along the east side of the area are either Paleozoic or Precambrian in age. Along the northern border of California are slightly metamorphosed sedimentary and volcanic rocks of Triassic and Jurassic age; lithologically similar rocks of Paleozoic age can be traced southward to the west side of the Sacramento Valley. The Jurassic and older rocks have been intruded by large quantities of granitic and ultramafic rocks. Several small areas of Late Jurassic and Early Cretaceous marine sedimentary rocks overlie the older rocks near the eastern and southern borders of the Klamath Mountains province. Sedimentary rocks of Tertiary age, and of continental origin, are found locally in the vicinity of Hyampom, Hayfork, and Weaverville, whereas rocks of similar age but of probable marine origin, form a narrow band along the northeast side of the province.

Geology

The principal mineral deposits in the Klamath Mountains province are those of metals, found either as lode deposits in or near the bodies of intrusive rock or as placer deposits formed by stream concentration of material eroded from the lodes. The principal metallic commodities are gold, copper, chromite, and quicksilver, but many other metallic minerals have been found in small amounts. Nickel, although not now being mined, may become one of the most important commodities in the near future. Among the nonmetallic commodities coal has been mined from several deposits, but the small production has been of little economic significance. A small amount of limestone has been quarried, mainly for agricultural purposes and the manufacture of quicklime. These and other deposits of nonmetallic commodities found in the Klamath Mountains have not been fully utilized in the past owing to the remoteness of the deposits from large centers of population.

The northern Coast Ranges of California are bounded on the west by the Pacific Ocean and on the east by the Klamath Mountains province and the Sacramento Valley. The portion of the northern Coast Ranges herein considered is drained principally by the Mattole, Eel, Van Duzen, and Mad Rivers, and to a minor extent by the lower reaches of the Trinity, Klamath, and Smith Rivers. The rivers drain northwesterly, and in general are parallel to one another. They are separated by northwest-trending ranges. The highest range is along the west side

of the Sacramento Valley and is at a general altitude of 6,000 feet. Toward the coastline the crests of the ranges are progressively lower.

The principal rocks that underlie the northern Coast Ranges have long been considered to be part of the Franciscan formation, and appear to range in age from late Jurassic to early Upper Cretaceous. These rocks may be grouped into two general types: (1) clastic sedimentary rocks, consisting of sandstone, mudstone, and conglomerate; and (2) volcanic and associated rocks, consisting of greenstone, basalt, rhythmically bedded chert, and minor amounts of limestone. Viewed broadly, the two groups of rocks form three parallel, northwest-trending bands. The southwestern band consists almost solely of clastic sedimentary rocks, whereas the central band contains about 25 percent of the volcanic and associated rocks; the northeastern band consists of slightly metamorphosed rocks that otherwise are similar to the rocks in the southwestern and central bands. Younger rocks overlie a broad area of Franciscan rocks in the vicinity of Eureka, Petrolia, and Garberville, and are found locally throughout the central band. These rocks are dominantly marine sandstones, mudstones, and conglomerates, which range in age from Late Cretaceous(?) to early Pleistocene. Early Pleistocene lake sediments and valley fill are found in small patches in Potter, Willits, and Round Valleys. Recent alluvium covers most of the valley areas as well as several large areas along the coast.

Geology

Northwest-trending faults are the dominant structural feature of the northern Coast Ranges, and these are reflected topographically by the alignment of the ranges and courses of the streams. These faults appear to be far more abundant in the central band in the areas underlain by volcanic rocks than they are in the two bordering bands. Along the faults in the central band, bodies of serpentine and glaucophane schist are found, and in the same areas landslides and debris flows are exceptionally common.

In the northern Coast Ranges the production of sand and gravel far exceeds that of other nonmetallic and metallic mineral commodities. Many wells have been drilled for oil and gas in the Cape Mendocino area, but the production has been small. At least one well in the area is producing carbon dioxide used in the manufacture of dry ice. The principal metallic mineral commodity in the northern Coast Ranges is manganese, which has been recovered from several relatively small deposits. Copper has been produced from one mine, and small quantities of chromite have come from several deposits, but the production of metallic minerals, other than manganese, has been negligible compared to that from the Klamath Mountains.

The distribution of the various rocks that underlie northwestern California has a pervasive effect on the resource potential, economy, and culture of the entire area. By comparing the geologic map (plate 1) with the various commodity maps (figures 3 to 10), many mineral commodities are seen to be restricted to certain provinces,

and in many instances to specific kinds of rocks. The most obvious examples are the restriction of gold deposits to the Klamath Mountains province and the occurrence of chromite deposits only in ultramafic rocks. Commercial deposits of nickel and asbestos will be found in northwestern California only in areas of ultramafic rocks, and quicksilver also is likely to be associated with the same kind of rocks. Deposits of manganese are found predominantly in the northern Coast Ranges, and in that province are restricted to bodies of chert in the central band of Franciscan rocks. A knowledge of the distribution of the rocks that underlie an area, therefore, not only allows one to limit the areas of mineral potential but also provides a valuable aid in the exploration for mineral deposits and their subsequent development.

The distribution of the various rocks in northwestern California also has a profound effect on many aspects of land utilization apart from mining. For example, the most heavily and uniformly timbered areas in the northern Coast Ranges are underlain by the two outer bands of clastic sedimentary rocks, and throughout the central band the timbered areas occur only as irregular patches separated by brush or grass-covered areas. Within this band the timbered patches are underlain mainly by clastic sedimentary rocks, whereas the brush and grass-covered areas generally are underlain in large part by volcanic and associated rocks. Agricultural activities are carried on almost wholly in the central band in several broad valleys and in the areas

underlain largely by sheared volcanic and associated rocks. Along the zones of most intense shearing the slopes are devoid of timber or brush, and the escape of ground water along the shear zones provides an adequate supply of water for the growth of grass and the watering of cattle.

The locations of the principal towns and transportation routes in the northern Coast Ranges have been determined largely by the topography, which in turn is a reflection of the character of the underlying bedrock. Most of the towns and major transportation routes are in the central band underlain by sheared rocks, and along this band faulting is active. Earthquakes are an expression of this activity, and they are most damaging in the central band and in the area near Cape Mendocino where this band reaches the ocean. A recent example was the serious damage to Eureka in late 1954. Landslides, which are a related feature, are abundant throughout the central band. The most publicized slide is that crossed by the Northwestern Pacific Railroad along the Eel River near Island Mountain, where large sums of money have been spent for many years for relocating tracks and in futile attempts to control the slide. Landslides also necessitate large expenditures for the maintenance of both major and secondary roads throughout the central band. In addition, many outlying areas serviced by unsurfaced roads that cross broad shear zones are nearly, or completely, inaccessible during the rainy season. The lithology of the bedrock and distribution of landslides should be given more

consideration in the locating of roads than heretofore; and similarly, the active faulting in the central band should be seriously considered in the locating of dams, tunnels, and other major structures in the northern Coast Ranges.

MINERAL COMMODITIES

Metals

Gold.--Gold was the metal first diligently sought in northwestern California, and during the middle and late 1800's prospectors probably discovered most of the better deposits of the region. Most of the production of gold has been from Trinity and Siskiyou Counties from placer deposits (figure 3) in stream and terrace gravels by means of sluices, dredges, and hydraulic mining equipment, but more than a dozen lode deposits (figure 4) also have a record of substantial production.

Gold has accounted for approximately 61 percent of the area's recorded mineral production of $153,964,000 from 1880 through 1957, or an average annual production of $1,226,000. In 1957 the value of gold produced from both placer and lode properties was only $820,540, or 10 percent of the total mineral production of $7,925,400. No breakdown of gold production from lode and placer deposits prior to 1903 is available, but during the period 1903-1957 the yield of approximately 2,079,500 ounces consisted of 453,700 ounces from lodes and 1,625,800 ounces from placer workings. In 1957 the gold production was 23,444 ounces, of which 19,491 ounces was produced from lode deposits and 3,953 ounces from placer deposits.

Gold production reached its peak during the period 1937 through 1942, prior to interruption of mining during World War II. An increase in the price of gold from $20.67 to $35.00 per ounce in 1934 greatly stimulated the gold mining industry in the basins. By 1943,

however, the rising tendency of wages, the movement of miners into defense industries and the armed forces, shortages of equipment and supplies, plus Government restrictions including War Production Board Order L-208, forced most of the gold mines to close, although some of the larger placer mines were able to continue working. In July 1945, Government restrictions on nonessential industries, including gold mining, were lifted; but most of the machinery and equipment used in placer mining had been transferred to war industries, underground workings had deteriorated, and operating costs had risen. With a fixed price for the metal, gold mining has been slow to recover. Contributing to the decline in gold production was the depletion of some important placer areas and deposits of high grade ore.

The lode deposits of gold are genetically related to the bodies of intrusive rock, and no doubt the erosion of the lode deposits during Cenozoic time furnished the gold to form the placer deposits. All of the lode deposits of gold that have been discovered in the region are in the Klamath Mountains province, and it is unlikely that significant deposits will be found in the other provinces. The placer deposits, having been derived from the lode deposits, are also found mainly in the Klamath Mountains province. The placer gold found in a few small deposits in river gravels and beach sands in the northern Coast Ranges province probably was derived from the Klamath Mountains province.

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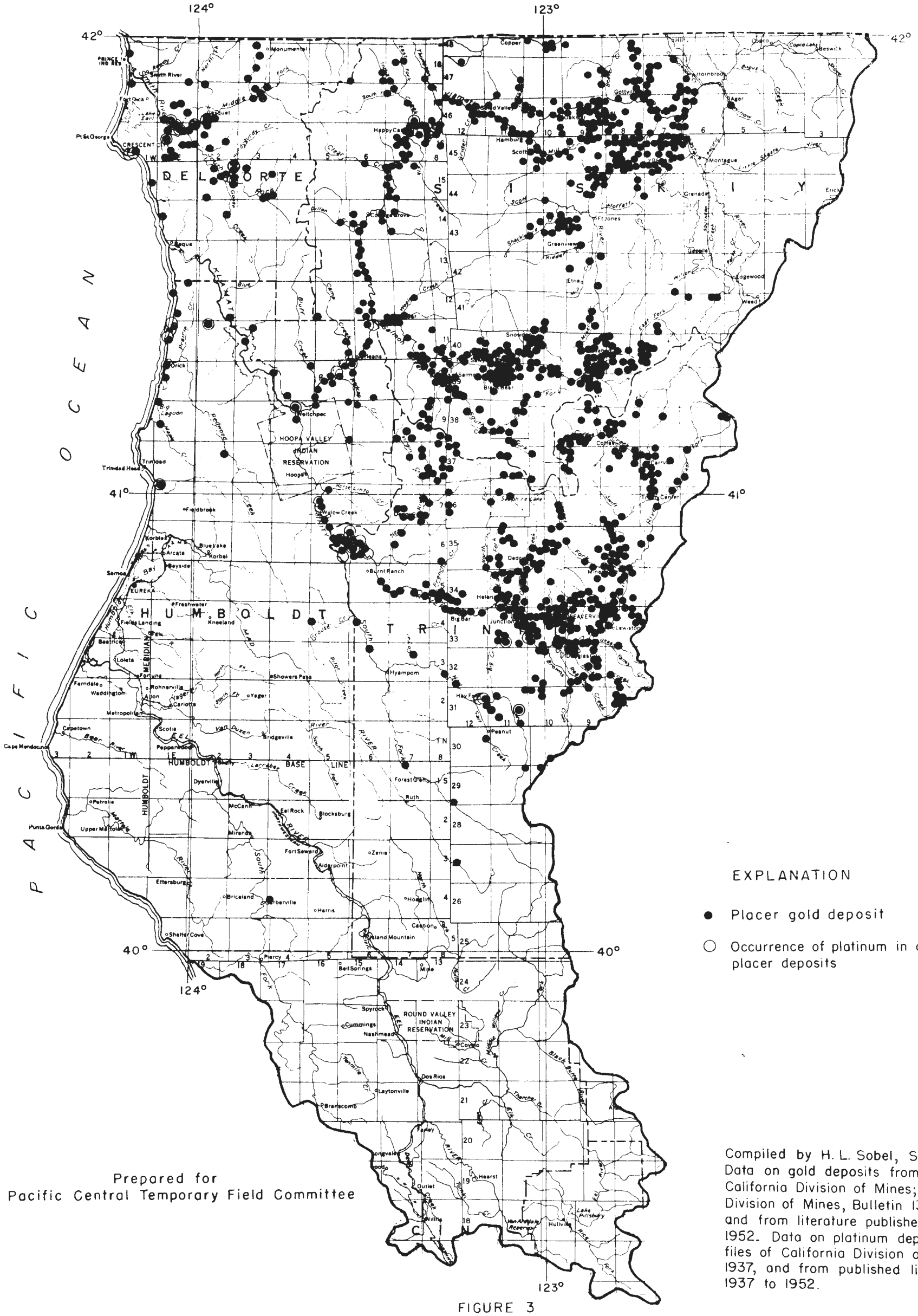

EXPLANATION

- ● Placer gold deposit
- ○ Occurrence of platinum in gold placer deposits

Compiled by H. L. Sobel, September 1952. Data on gold deposits from files of California Division of Mines; California Division of Mines, Bulletin 134, Plate 4; and from literature published from 1937 to 1952. Data on platinum deposits from files of California Division of Mines to 1937, and from published literature from 1937 to 1952.

Prepared for
Pacific Central Temporary Field Committee

FIGURE 3
MAP OF NORTHWESTERN CALIFORNIA SHOWING LOCATION OF
PLACER GOLD AND PLATINUM DEPOSITS

0 10 20 30 40 MILES

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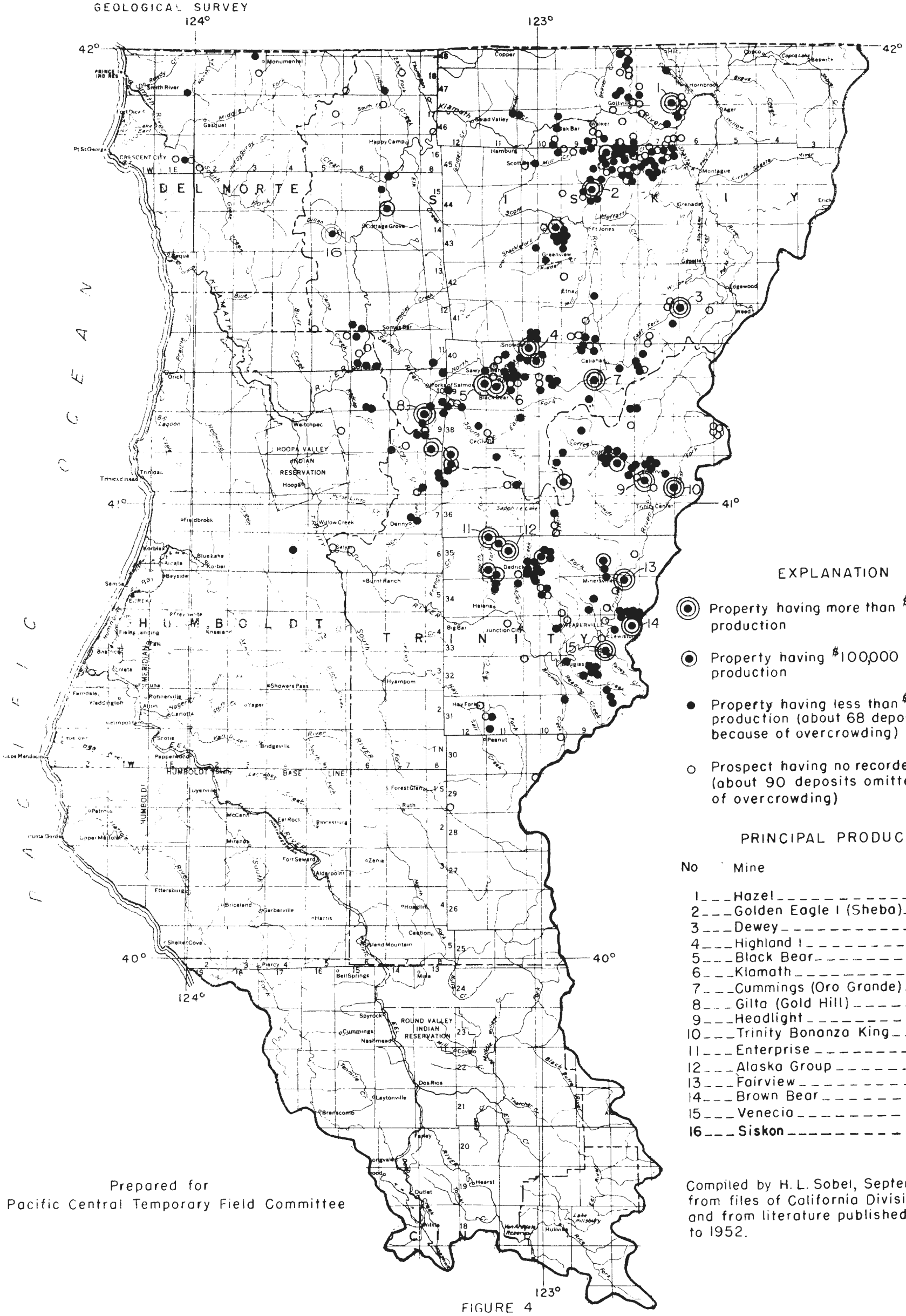

EXPLANATION

- Property having more than $500,000 production
- Property having $100,000 to $500,000 production
- Property having less than $100,000 production (about 68 deposits omitted because of overcrowding)
- Prospect having no recorded production (about 90 deposits omitted because of overcrowding)

PRINCIPAL PRODUCERS

No	Mine	Approximate Production
1	Hazel	$800,000
2	Golden Eagle I (Sheba)	1,000,000
3	Dewey	900,000
4	Highland I	500,000
5	Black Bear	3,000,000
6	Klamath	600,000
7	Cummings (Oro Grande)	500,000
8	Gilta (Gold Hill)	1,000,000
9	Headlight	500,000
10	Trinity Bonanza King	1,250,000
11	Enterprise	500,000
12	Alaska Group	600,000
13	Fairview	5,000,000
14	Brown Bear	10,000,000
15	Venecia	500,000
16	**Siskon**	**2,700,000**

Compiled by H. L. Sobel, September 1952 from files of California Division of Mines and from literature published from 1937 to 1952.

Prepared for
Pacific Central Temporary Field Committee

FIGURE 4

MAP OF NORTHWESTERN CALIFORNIA SHOWING LOCATION OF
LODE GOLD DEPOSITS

0 10 20 30 40 MILES

GPO 971638

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Mineral Commodities

The chief function of gold is as a monetary metal. It is also used in gilding and plating, in decorating ceramic ware, in chemical and laboratory ware, and as an alloy in thermo-electrical instruments. The mining of gold is not strategically important, but in previous years of greater production it was responsible for the employment of a large portion of the population in many communities in Siskiyou, Trinity, and Humboldt Counties. Under present economic conditions it is likely that gold production will continue approximately at its present rate. Given the stimulus of a substantial increase in price or a change in economic factors favoring lower operating costs, gold yield might be expanded to about four times the present output over a sustained period of years, in which case gold mining may be the chief mineral activity in the basins. It must be considered, however, that regulations affecting tailings disposal, stream pollution, and soil conservation have been tightened during the past decade, and any resumption of gold mining, particularly placering on a large scale, will meet with opposition in some areas where heretofore dredging and hydraulicking were pursued with a minimum of restrictions. As calculating ore and auriferous gravel reserves would require multiple assumptions as to the cost of production and the price of gold, it is beyond the scope of this report.

Platinum.--Platinum occurs in some of the placer deposits, and small amounts have been recovered as a by-product of gold mining (figure 1). Although the platinum in the placers probably has been

derived from different sources than the gold, no concentrations that would allow mining solely for platinum have been found. The future production of the metal, therefore, depends entirely on the placer gold mining.

The recorded yield of platinum from the area for the period 1880-1957 was approximately 1,850 ounces valued at $129,200, or an average of $1,700 per year. No production of platinum was recorded in 1957.

Silver.--A small amount of silver has been produced in the area as a by-product of gold, copper, and to a lesser extent lead mining operations. The future production of silver will be dependent on these other metals, as no reserve of silver ore is known.

From 1880 through 1957 the recorded silver production was approximately 840,000 ounces valued at $630,700, an annual average of only $8,200. From 1903 through 1957 the recorded production was 683,900 ounces, of which 482,900 ounces came from lodes and 201,000 ounces from placers. No breakdown for years prior to 1903 is available. In 1957 the recorded silver production was 50,139 ounces, of which 49,715 ounces was contributed by lode operations and 424 ounces by placer mines. The 1957 production was valued at $45,379.

Chromite.--Chromite mining in the area has been essentially a wartime or defense activity. It contributed approximately 5 percent of the recorded mineral production through 1957, but in 1957 chromite accounted for about 6 percent of the total mineral production of $7,925,400 for that year, or $479,500.

Mineral Commodities

The peaks of chromite production occurred during the period 1917-1920 and from the beginning of World War II (1941) to 1957. The continuation of the high production rate which commenced during World War II resulted from the considerably above market price paid by the Government during the stockpiling program, which expired June 1958. The chief chromite producing areas in northwestern California are in Del Norte and Siskiyou Counties.

The mineral chromite is the only important commercial source of chromium. Although the consumption of chromium is small compared to that of many other metals, a steady supply is of strategic importance during times of war, as chromite is used for the manufacture of special steels, refractories, and chemicals. Chromium chemicals are used in dyeing, tanning, electroplating, and in the manufacture of pigments.

Chromite occurs in both primary and detrital deposits. The primary deposits occur only in ultramafic rocks, whereas the detrital deposits are the erosional products of the primary deposits and are found in stream gravels and beach sands. From the standpoint of production the detrital deposits are unimportant, although they provide a large reserve of low-grade ore. The distribution of the chromite deposits is shown on figure 5, and the distribution of ultramafic rocks, the host of the primary deposits, is shown on the geologic map accompanying this report. Most of the chromite deposits, as well as the larger areas of ultramafic rocks, are in the Klamath Mountains province.

Mineral Commodities

The deposits in Del Norte County have the greatest total production, closely followed by those in Siskiyou County.

Most of the production of chromite from northern California has been from small high-grade deposits, which yield ore that can be sorted by hand for shipping to distant points. Such high-grade pods are rapidly depleted, and the discovery of many more virgin outcrops of such ore cannot be expected. As underground exploration for concealed bodies of chromite is nearly on a hit-or-miss basis, it seems unlikely that production from deposits of this type can be maintained at the prevailing rate for many years. Deposits of disseminated chromite are becoming of increasing interest, and although they are much lower in grade than the small high-grade type, they contain in the aggregate far more chromite. Ore from deposits of the disseminated type, in contrast to the more easily handled high-grade ore, must be milled at or near the deposit before being shipped. It is only from the disseminated deposits, or, less likely, from a radical improvement in technique for the discovery of high-grade deposits, that a dependable production of chromite may be expected on a long-term basis.

The reserve of disseminated ore is about 400,000 tons ranging in grade from 8 to 20 percent chromic oxide. Some of the beach sands contain between 5 and 20 percent chromic oxide, but their tonnage is not known. Further metallurgical research to develop a process which will result in an economic recovery of chromite from ores carrying as

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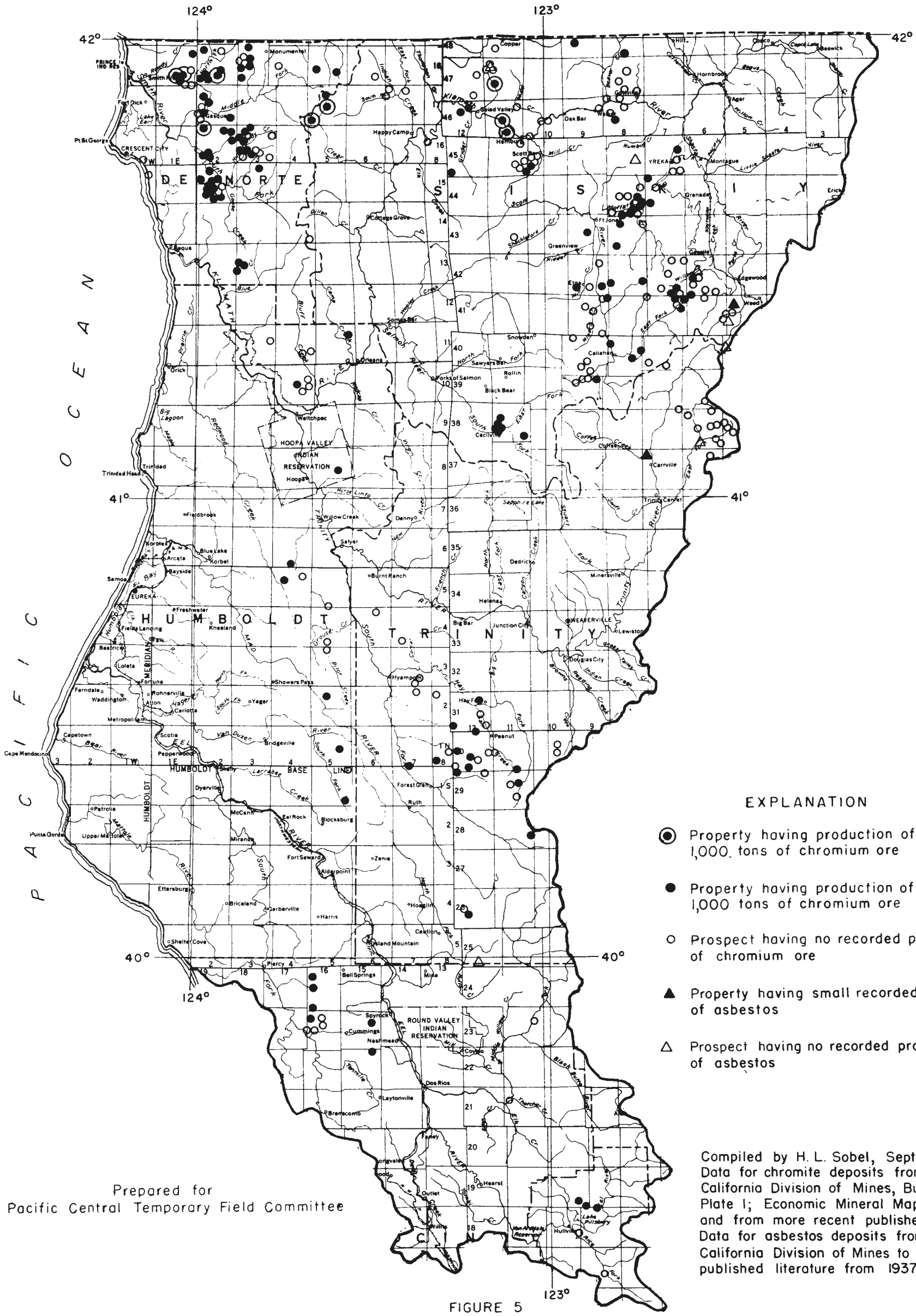

EXPLANATION

- ◉ Property having production of more than 1,000 tons of chromium ore
- ● Property having production of less than 1,000 tons of chromium ore
- ○ Prospect having no recorded production of chromium ore
- ▲ Property having small recorded production of asbestos
- △ Prospect having no recorded production of asbestos

Compiled by H. L. Sobel, September 1952. Data for chromite deposits from files of California Division of Mines, Bulletin 134, Plate 1; Economic Mineral Map Number 3; and from more recent published literature. Data for asbestos deposits from files of California Division of Mines to 1937 and from published literature from 1937 to 1952.

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FIGURE 5

MAP OF NORTHWESTERN CALIFORNIA SHOWING LOCATION OF
CHROMITE AND ASBESTOS DEPOSITS

0 10 20 30 40 MILES

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little as 5 to 8 percent chromic oxide is highly desirable, because it is in this range of values that the large ore reserves lie. A metallurgical solution for the lower grade deposits, many of which have a high chromium to iron ratio, should result in an increased annual production of chromite from the area for some years in the future only if prices compatible with increased costs of additional processing prevail. With the continuation of the current guaranteed price for chromite by the Government, the annual rate of production for the area should continue at about the present level for the duration of the program.

Copper.--The area does not rank among the well known copper producing districts in California, but 174 copper deposits have been reported, and a few of these have creditable production records. The value of the copper production has been about 4 percent of the recorded mineral production of $153,964,000 from 1880 through 1957. In 1957 copper accounted for less than 1 percent of the total mineral production of $7,925,000 for that year. The two peak periods of copper production were from 1915 through 1930, and from 1943 through 1945. During the period 1943-1945, Siskiyou County ranked first in California among copper producing counties.

The deposits of copper are chiefly in the Klamath Mountains province (figure 6). The principal mines are the Gray Eagle and Blue Ledge, and both have production records of more than 1,000,000 pounds of copper. Several other mines in the province have produced between

100,000 and 1,000,000 pounds. A third mine that has a production of more than 1,000,000 pounds of copper is the Island Mountain mine, the only copper producer known in the northern Coast Ranges province. A recent copper development is the Copper Bluff mine in the Hoopa area of Humboldt County.

No reliable estimate of unmined copper ore is available, but it is known that a relatively large tonnage remains in some of the larger mines as pillars and as unmined marginal ore. One property is said to have blocked-out ore reserves of 150,000 tons containing 4.4 percent copper, 2.0 percent zinc, 0.125 ounces gold, and 5.0 ounces silver per ton. Recent geophysical work by the Geological Survey indicates that a substantial quantity of ore may yet remain at the Island Mountain property.

Zinc is contained in some of the copper ores. There is no record of zinc concentrates being produced in the area, but the milling of lower grade copper ores in the future presents the possibility of some zinc yield from the basins.

A revival of copper mining in the area would depend upon the results of extensive exploration or a greatly increased price for copper. The working of any copper deposit is also dependent on the future cost of operation and the prevalent price of the accessory metals, zinc, gold, and silver.

Quicksilver.--The yield of quicksilver amounted to approximately 1 percent of the area's recorded mineral production of $153,964,000

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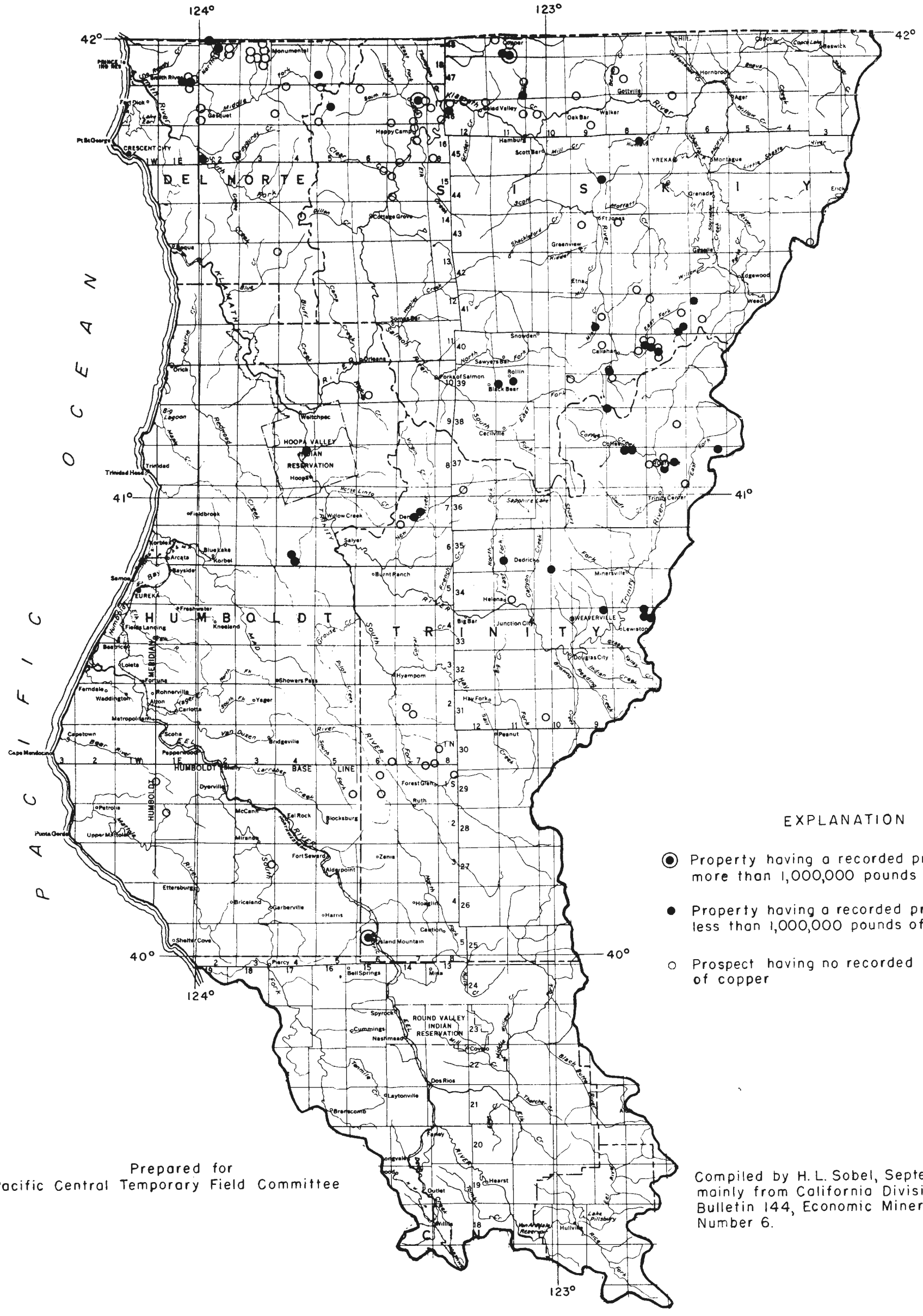

EXPLANATION

- ◉ Property having a recorded production of more than 1,000,000 pounds of copper
- ● Property having a recorded production of less than 1,000,000 pounds of copper
- ○ Prospect having no recorded production of copper

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Compiled by H. L. Sobel, September 1952 mainly from California Division of Mines, Bulletin 144, Economic Mineral Map Number 6.

FIGURE 6
MAP OF NORTHWESTERN CALIFORNIA SHOWING LOCATION OF
COPPER DEPOSITS

0 10 20 30 40 MILES

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through 1957. The output reached its peak during two periods--before 1875 to 1880, and from 1895 to 1913. During 1957 only 23 flasks of quicksilver valued at $5,681 were produced.

Productive quicksilver deposits occur in several small districts in the Klamath Mountains province (figure 7), and a few unproductive deposits have been found in the eastern part of the northern Coast Ranges. The Altoona mine in northeastern Trinity County accounts for the only significant production, having produced more than 30,000 flasks of quicksilver. This mine recently has been reactivated. The quicksilver deposits in northwestern California are associated with bodies of ultramafic rock. Panning of stream gravels by members of the Geological Survey indicates that the quicksilver ore minerals are more widespread in the area than the distribution of known deposits suggests and that new discoveries are likely.

In the past, because of the uncertainty in prices, and the irregular character of the deposits themselves, developed ore reserves have never been substantial. Ore bodies are mined as they are encountered, and at times of declining prices known ore is removed and the mine is allowed to cave without any search for new ore bodies. The average grade of ore which can be mined economically today is much lower than in the years of peak production owing to more efficient operations and the increased price of mercury. Therefore, it is quite probable that in the near future, some of the success attained in the region under the Government supported price schedule, which expired

December 31, 1958, will stimulate the exploration that will uncover other new deposits. Production of mercury may again make a substantial contribution to the mineral industry of the area and would provide a new source of employment.

Manganese.--Manganese ore has accounted for slightly less than 1 percent of the area's recorded mineral production, but in 1957 no manganese ore was produced in the area. The mining of manganese ore has been sporadic, and most of the activity resulted from wartime demand and Government purchases, which provided a market at relatively high prices. During normal times very little manganese has been mined.

Manganese is used chiefly in the manufacture of steel, which consumes over 90 percent of all manganese used in the United States. Lesser amounts are used in the manufacture of chemicals and dry-cell batteries, and in the glass, ceramic, and paint industries.

Deposits of manganese are scattered throughout northwestern California (figure 7), but are most abundant and productive in the northern Coast Ranges province, where they occur in small masses in chert beds in the central band of Franciscan rocks. Of the nearly 200 recorded prospects in the area, only four have yielded more than 1,000 tons of ore; the greatest production from a single mine is only 5,000 tons.

The higher quality manganese deposits are of the oxide minerals that occur near the surface and extend downward only a short distance. This occurrence of ore makes for small reserves, and such deposits are

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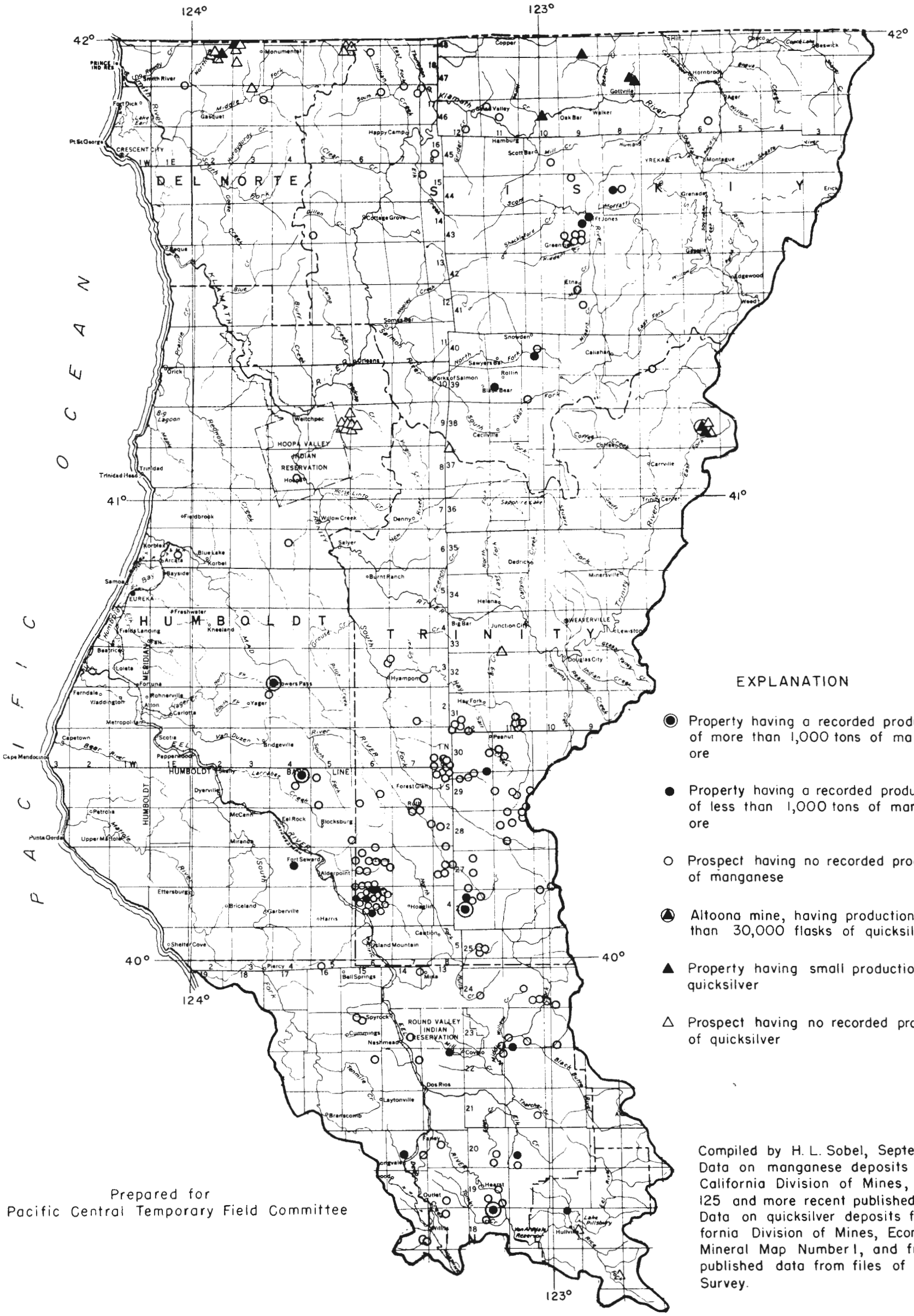

EXPLANATION

- ◉ Property having a recorded production of more than 1,000 tons of manganese ore
- ● Property having a recorded production of less than 1,000 tons of manganese ore
- ○ Prospect having no recorded production of manganese
- ◭ Altoona mine, having production of more than 30,000 flasks of quicksilver
- ▲ Property having small production of quicksilver
- △ Prospect having no recorded production of quicksilver

Compiled by H. L. Sobel, September 1952. Data on manganese deposits from California Division of Mines, Bulletin 125 and more recent published literature. Data on quicksilver deposits from California Division of Mines, Economic Mineral Map Number 1, and from unpublished data from files of Geological Survey.

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FIGURE 7
MAP OF NORTHWESTERN CALIFORNIA SHOWING LOCATION OF
MANGANESE AND QUICKSILVER DEPOSITS

0 10 20 30 40 MILES

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rapidly depleted. The principal reserves of manganese are contained in the carbonate or silicate ores that underlie the oxide ore and extend downward to greater depths. Most of the ores that form these reserves, however, are low in grade and require beneficiation to be commercial. They also are not readily amenable to mechanical concentration and only a few shippers have been able to meet the present specifications of metallurgical manganese ores. The extractive metallurgical processes now practiced are either not adapted to these ores or the product of beneficiation is obtained at an excessive cost and thus is not marketable under existing prices. Utilization of the fairly large deposits of low-grade manganese ore depends upon metallurgical advances.

Miscellaneous metals.--Deposits of antimony, iron, lead, molybdenum, nickel, tungsten, and zinc have been found (figure 8), and small amounts of several of these metals have been produced as by-products during the recovery of other metals. The total value of this production, however, is negligible from a regional viewpoint, and with the exception of nickel it is doubtful that these metals will ever prove important to the economy of northwestern California.

Nickel is presently being mined from areas of high-level, old land surfaces on bodies of ultramafic rocks in southern Oregon, and production from these deposits may ultimately prove to be substantial. Similar old land surfaces are known in Del Norte County, and may occur elsewhere in northwestern California. Major metal-mining companies

are currently investigating the possibility of mining nickel in northwestern California.

Nonmetals

The production of nonmetallic commodities in the northern Coast Ranges province is many times greater than that of metallic commodities; in the Klamath Mountains province the production is about a third that of metallic commodities. Production from the Cascade Range province is solely that of nonmetallics in California.

The nonmetallic commodities generally are of low unit value relative to metallic commodities, and the source of supply must of necessity be near the consumer. Sand and gravel is by far the most important nonmetallic product in the northern Coast Ranges and Klamath Mountains provinces. With the exception of mineral fuels, the major nonmetallics are used for construction purposes, and the important deposits are near centers of population or along major transportation routes.

Miscellaneous stone.--Under this heading are included sand and gravel, crushed rock, rubble, and riprap. During the period 1880-1957 the value of miscellaneous stone production was approximately 23 percent of the basins' recorded mineral output, or an annual average of $474,000. In 1957 the output of miscellaneous stone constituted about 76 percent of the mineral yield of the area for that year, or $6,003,000. Its production, transportation, and use in roads, ballast, fills, and concrete construction has resulted in the employment of such substantial numbers of persons as to be of considerable economic

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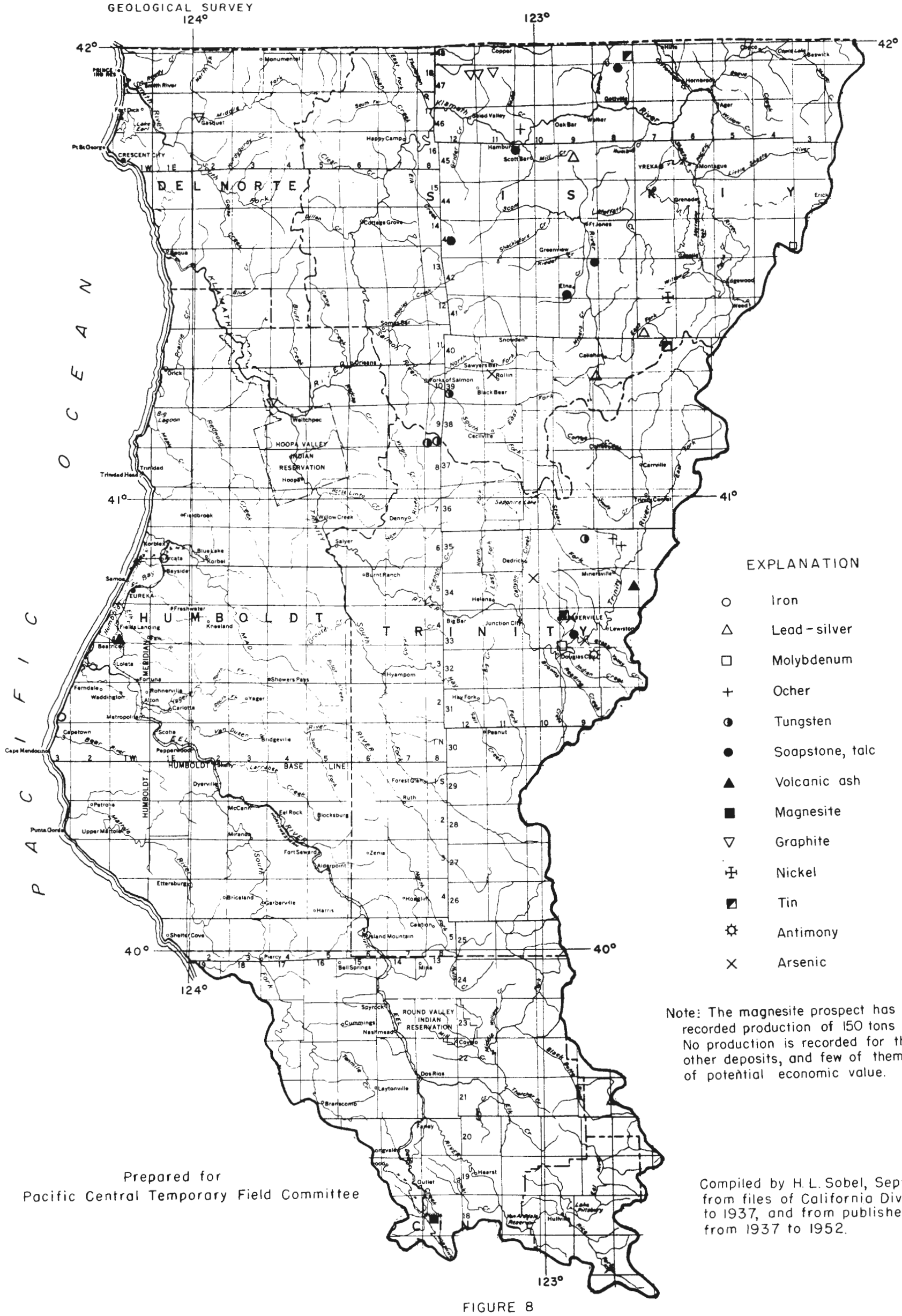

EXPLANATION

○	Iron
△	Lead – silver
□	Molybdenum
+	Ocher
◑	Tungsten
●	Soapstone, talc
▲	Volcanic ash
■	Magnesite
▽	Graphite
✢	Nickel
◩	Tin
☼	Antimony
×	Arsenic

Note: The magnesite prospect has a recorded production of 150 tons of ore. No production is recorded for the other deposits, and few of them are of potential economic value.

Prepared for
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Compiled by H. L. Sobel, September 1952 from files of California Division of Mines to 1937, and from published literature from 1937 to 1952.

FIGURE 8
MAP OF NORTHWESTERN CALIFORNIA SHOWING LOCATION OF
DEPOSITS OF MISCELLANEOUS MINERAL COMMODITIES

0 10 20 30 40 MILES

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importance to the area. Although the production of miscellaneous stone may vary considerably over periods of time, a steady increase in population, industrial expansion, road and dam construction, railroad ballast needs, and many other factors will doubtless result in increased production.

Sand and gravel are obtained from river, terrace, and beach deposits, and the reserves of such material are large. Greenstone and chert are widely used as road metal on secondary roads, particularly in the northern Coast Ranges, and deposits of these rocks are so abundant and widespread as to be practically inexhaustible.

Limestone.--The total recorded production of limestone and marble through 1957 is approximately $91,880. The last recorded production of limestone was in 1945, and that of marble in 1915.

Deposits of limestone are found in many places in the area, but are largest and most numerous in the Klamath Mountains province (figure 9). Several of the deposits had a small production, mainly for agricultural use and the manufacture of quicklime. Many of the deposits in the Klamath Mountains province are thought to be suitable for the manufacture of cement, but those in the northern Coast Ranges probably are not as desirable. Most of the limestone has been recrystallized, and a small quantity has been quarried as marble for dimension stone.

Lime kilns were operated in the area until 1931, but since that time the basins' requirements have been filled by shipments from

lime-producing districts elsewhere in California and Oregon. Should the population and industrial establishments of the area and adjacent territory grow to such proportion that lime and cement requirements would be sufficient to support lime and cement industries, limestone--the basic material for both commodities--is available. Until then, any sizable production of limestone would of necessity be marketed in consuming areas under competitive conditions.

Clays.--Clay production accounted for about $338,000 of the recorded mineral production of $153,964,000 from 1880 through 1957. No clay was produced in 1957. The last production was in 1955.

Deposits of clay have been mined principally in the vicinity of Eureka for the manufacture of brick and tile, and other deposits having a small production are near Scott Valley. The future of the clay mining industry in the area will reflect the trend of construction activity in specific localities, as throughout California and Oregon common brick and heavy tile products are fabricated largely from local clays.

Asbestos.--Asbestos is one of the strategic minerals that the United States imports in large amounts. The short-fiber chrysotile variety has many uses, such as for heat insulation, as a fabric, for pipe and boiler insulation, for steam packing, for brake linings, for roofing material, and in cement and paint. Such short-fiber asbestos has been found in bodies of ultramafic rocks at several localities in northern California (figure 5), and a few of these deposits have been

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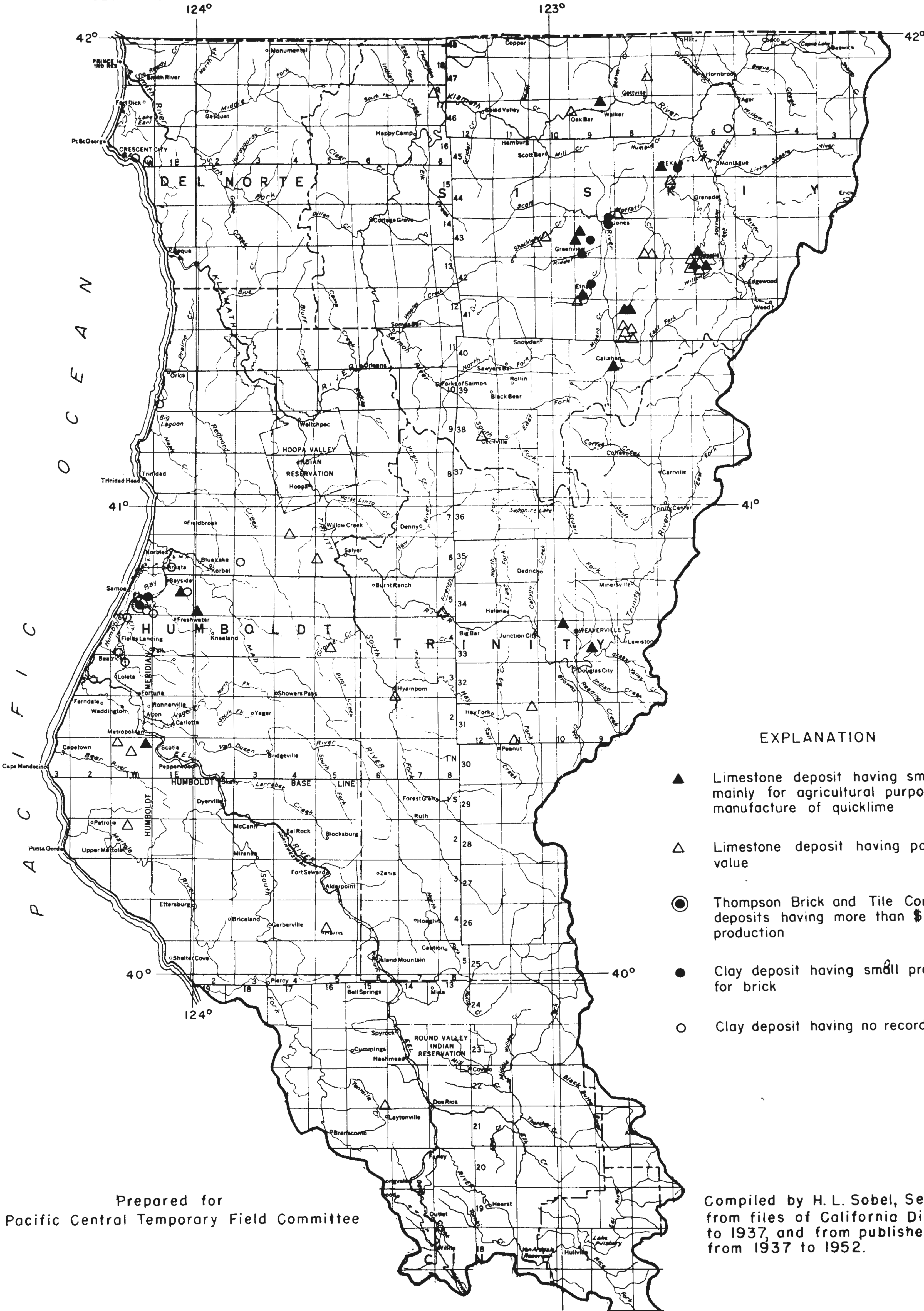

EXPLANATION

▲ Limestone deposit having small production, mainly for agricultural purposes and manufacture of quicklime

△ Limestone deposit having potential economic value

◉ Thompson Brick and Tile Company clay deposits having more than $ 50,000 production

● Clay deposit having small production, principally for brick

○ Clay deposit having no recorded production

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Compiled by H. L. Sobel, September 1952 from files of California Division of Mines to 1937, and from published literature from 1937 to 1952.

FIGURE 9
MAP OF NORTHWESTERN CALIFORNIA SHOWING LOCATION OF
LIMESTONE AND CLAY DEPOSITS

0 10 20 30 40 MILES

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exploited on a small scale. Some of them have been drilled extensively by major asbestos-producing companies and their potential is accurately known. The best deposits that have been found are in the Klamath Mountains province, but none has proved commercially important. Much of the area has not been thoroughly examined, however, and significant deposits may yet be found.

Pumice and volcanic cinders.--Pumice and volcanic cinders are principally of value as lightweight aggregate for construction purposes. Deposits of these rocks have been worked in Humboldt and Trinity Counties, but the principal productive deposits in northwestern California are in Siskiyou County outside the region in the young volcanic rocks of the Cascade Range province. Past production in the region has been small, but production probably will expand as the population of the area increases.

Sandstone.--The past output of sandstone is valued at about $42,000, and the last recorded production was in 1927.

Sandstone has been quarried as dimension stone in Siskiyou County, and was used for buildings and for railroad culverts. An extensive revival of sandstone quarrying is not anticipated, as the use of dimension stone for building purposes is on the wane.

Ornamental and gem stones.--California (California jade)--a very compact, massive green vesuvianite which takes a high polish and closely resembles jade--is found in a deposit in Siskiyou County. Rhodonite

from the same county has been sold as a semiprecious stone. Jade has been mined from deposits at Leech Lake Mountain in Mendocino County.

The recorded production of gem stones through 1957 is valued at approximately $31,200. In 1957, the value of gem stones sold was $1,928. Any activity in this commodity will not be of great importance economically in the area.

Tube-mill pebbles.--During the years 1934-1939, tube-mill or grinding-mill pebbles valued at $17,100 were produced in Siskiyou County. There has been no production since 1939. The pebbles were obtained from stream gravels by experienced handsorters.

Although grinding can be done most efficiently in grinding mills with iron and steel liners, balls, and rods, natural pebbles are used in mills having block or brick grinding surfaces where contamination by metal (mainly iron) must be avoided. The requirements for such pebbles are rigid and imported pebbles which meet the specifications are preferred. Because the market is limited and gathering the pebbles has become costly, it is not anticipated that grinding pebbles will be produced in the basins in appreciable quantity except in the advent of the loss of the current source of imported supply.

Granite.--The recorded production of granite in the area through 1957 is valued at approximately $17,400. Most of this output was in years prior to 1904, and no granite was produced in 1957.

Large masses of granite occur in Siskiyou, Trinity, and Del Norte Counties, but most of it is not suitable for dimension stone.

Future production of granite will be restricted by requirements for broken stone in retaining fills and in jetties, since the use of cut stone for heavy construction has lessened.

Mineral Fuels

Petroleum and natural gas.--The value of petroleum and natural gas produced in the basins has been about 2 percent of the total value of the basins' mineral production. The production of oil and gas in the basins, however, has been fairly recent, and the value of natural gas extracted in 1957 amounted to about 7 percent of the value of the basins' mineral production of that year. For the years 1909 through 1957 the annual average volume of natural gas withdrawn and utilized was about 441,200,000 cubic feet, compared with the withdrawal of 2,086,723,000 cubic feet in 1957. The trend of the natural gas production in the area since 1939 has been one of gradual ascendency.

In general, the results of considerable exploratory drilling have been disappointing, but several oil companies are continuing exploration. The only production of natural gas and oil has been from western Humboldt County (figure 10). A minor quantity of natural gas was withdrawn for local consumption near Briceland during the period 1909-1938, but the greatest production has been from the Tompkins Hill field near Fortuna. A small quantity of oil was produced near Petrolia in 1953 and 1954, the only recorded production of oil in the basins.

Mineral Commodities

From the standpoint of gas and oil production, the areas of principal interest in the basins are those underlain by marine sedimentary rocks of Tertiary age. The largest area is in western Humboldt County. The rocks range from Miocene to early Pleistocene in age, and probably attain a thickness in excess of 12,000 feet. They form a west-trending syncline that is modified by subparallel faults and secondary anticlines. The submarine, offshore extent of the rocks is not known.

The Tompkins Hill gas field near Fortuna was discovered in 1937, and is the only commercially productive area at present. Ten wells were completed to the end of 1957. During 1957 about 2,086,723,000 cubic feet of gas was produced. The total production of the field to the end of 1957 was 21,181,569,000 cubic feet. The California Department of Natural Resources, Division of Oil and Gas, estimated the reserve of this field to be about 12,000,000,000 cubic feet of gas as of January 1, 1958. The field is on a small anticline on the northeast limb of the Eel River syncline. The gas is produced from sands of Pliocene age at a depth of approximately 5,000 feet.

Coal.--The recorded coal production for the area during the period 1880-1952 was approximately 4,000 tons valued at $21,160.

Coal of Cretaceous and Tertiary age has been found in significant quantity at several localities (figure 10) in the northern Coast Ranges and Klamath Mountains. Although the coal is low in both rank and grade, a small amount has been produced commercially

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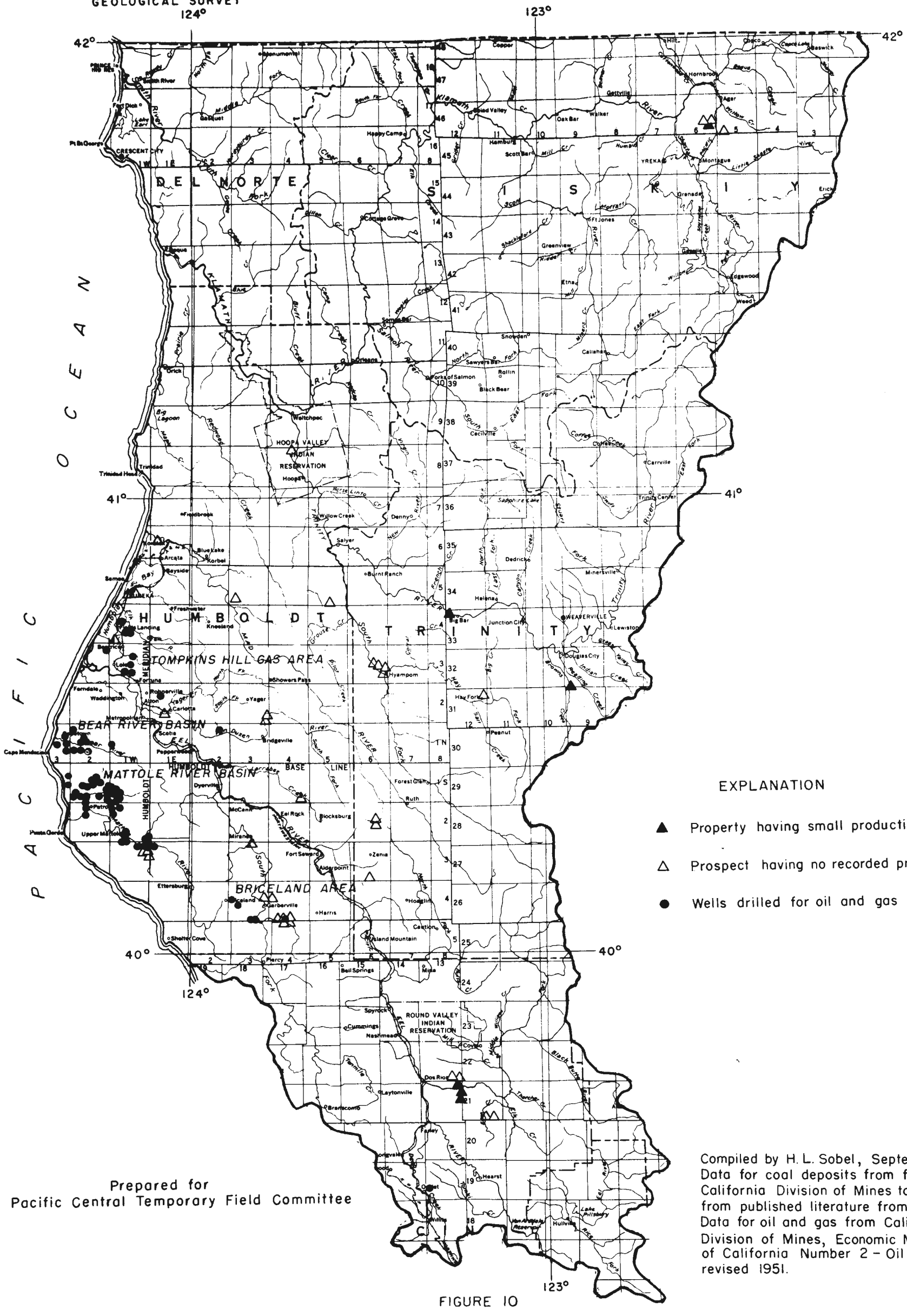

EXPLANATION

- ▲ Property having small production of coal
- △ Prospect having no recorded production of coal
- ● Wells drilled for oil and gas

Prepared for
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Compiled by H. L. Sobel, September 1952. Data for coal deposits from files of California Division of Mines to 1937, and from published literature from 1937 to 1952. Data for oil and gas from California Division of Mines, Economic Mineral Map of California Number 2 – Oil and Gas, revised 1951.

FIGURE 10

MAP OF NORTHWESTERN CALIFORNIA SHOWING LOCATION OF
COAL DEPOSITS, AND WELLS DRILLED FOR OIL AND GAS

0 10 20 30 40 MILES

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from deposits in Mendocino, Siskiyou, and Trinity Counties. Production ceased in Mendocino County in 1925, in Siskiyou County in 1926, and in Trinity County in 1945. Coal has not been considered an important commodity in the area since the use of petroleum and natural gas became widespread.

Nonfuel natural gas.--Carbon dioxide gas was withdrawn from a well in the Hopland field, Mendocino County, over a period of many years. The gas was used largely as a source of "dry ice". Water reported as containing a boron mineral seeped from the well and allegedly destroyed the nearby vegetation. It became necessary to correct this situation to continue production of carbon dioxide. An estimate of the cost involved proved to be prohibitive and the well was shut down in 1956. It was not reopened.

REFERENCES

Averill, C. V., 1931, Preliminary Report on Economic Geology of the Shasta Quadrangle, California: Dept. Nat. Res., Div. of Mines, State Mineralogist Rept., v. 27, no. 1, p. 2-65.

Cater, F. W., Jr., and Wells, F. G., 1954, Geology and Mineral Resources of the Gasquet Quadrangle, California-Oregon: in Contributions to Economic Geology 1953-54, U. S. Geol. Survey Bull. 995-C, p. 79-133.

Hershey, O. H., 1901, Metamorphic Formations of Northwestern California: Am. Geol., v. 27, p. 225-245.

Hershey, O. H., 1904, The Bragdon Formation in Northwestern California: Am. Geol., v. 33, p. 248-256 and 347-360.

Hinds, N. E. A., 1932, Paleozoic Eruptive Rocks of the Southern Klamath Mountains, California: Calif. Univ. Pub. Bull. Dept. Geol. Sci., v. 20, no. 11, p. 375-410.

Hinds, N. E. A., 1933, Geologic Formations of the Redding-Weaverville District, Northern California: Calif. Jour. Mines and Geology, v. 29, nos. 1, 2, p. 77-122.

Lawson, A. C., 1894, The Geomorphogeny of the Coast of Northern California: Calif. Univ. Pub., Dept. Geol. Bull., v. 1, no. 8.

Manning, G. A., and Ogle, B. A., 1950, Geology of the Blue Lake Quadrangle, California: Calif. Dept. Nat. Res., Div. of Mines, Bull. 148, 36 p.

Maxson, J. H., 1933, Economic Geology of Portions of Del Norte and Siskiyou Counties, Northwesternmost California: Calif. Dept. Nat. Res., Div. of Mines, State Mineralogist Rept., v. 29, nos. 1 and 2, p. 123-160.

Ogle, B. A., 1953, Geology of the Eel River Valley Area, Humboldt County, California: Calif. Dept. Nat. Res., Div. of Mines, Bull. 164, 128 p.

Rynearson, G. A., and Smith, C. T., 1941, Chromite Deposits in the Seiad Quadrangle, Siskiyou County, California: U. S. Geol. Survey Bull. 922-J, p. 281-306.

Wells, F. G., and others, 1946, Geologic Investigations of Chromite in California: Calif. Dept. Nat. Res., Div. of Mines, Bull. 134, pt. 1, p. 6.

References

Wells, F. G., Hotz, P. E., and Cater, F. W., Jr., 1949, Preliminary Description of the Geology of the Kerby Quadrangle, Oregon: Oregon Dept. of Geol. and Mineral Industries, Bull. no. 40, 23 p.

Williams, Howel, 1949, Geology of the MacDoel Quadrangle, California: Calif. Dept. Nat. Res., Div. of Mines, Bull. 151.

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