Economic Geology of the
Darwin Quadrangle
Inyo County, California

California Division of Mines
Special Report 51
COVER—Darwin surface plant, Darwin Mines. Maturango Peak, highest in the Argus Range, is in the background.

Photo by Mary R. Hill, 1957.
ECONOMIC GEOLOGY OF THE
DARWIN QUADRANGLE
INYO COUNTY, CALIFORNIA

By WAYNE E. HALL and E. M. MACKEVETT

With a Section on the
DARWIN SILVER-LEAD DISTRICT
By W. E. Hall, E. M. Mackevett, and D. L. Davis

and on the
TUNGSTEN DEPOSITS
By W. E. Hall, E. M. Mackevett, and D. M. Lemmon

Prepared in Cooperation with the
CALIFORNIA STATE DIVISION OF MINES

Price $2.50
**OUTLINE OF REPORT**

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**Illustrations**

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3. Geologic map of the Christmas Gift mine area, Inyo County ... In pocket

4. Geologic maps of the underground workings of the Christmas Gift mine, Inyo County ... In pocket

5. Geologic maps of the Darwin mine area, Inyo County ... In pocket

6. Geologic maps of the Defiance workings of the Darwin mine, Inyo County ... In pocket

*Illustrations*
The Darwin quadrangle comprises 225 square miles in the west-central part of Inyo County and includes parts of the Argus Mountains, Coso Range, and Darwin Hills. Dollar value of the mine production through 1951 is estimated at $37,500,000. The principal commodities are lead, silver, molybdenum, nickel, and tungsten, and small amounts of antimony and zinc. The Paleozoic rocks range in age from the Devonian to the Permian in an essentially conformable sequence more than 1,500 feet thick. Silurian and Ordovician rocks are predominantly cherty; Devonian rocks are limestone, dolomite, shale, and quartzite. Mississippian and younger Paleozoic rocks are predominantly shale. The Paleozoic strata are intruded by the batholith of Hunter Mountain in the northeastern part, and by many small stocks. Most of the northern half of the quadrangle is covered by basalt flows and andesite of late Cenozoic age.

Structurally the area is on the west limb of a major syncline where the Paleozoic strata strike predominantly north and dip gently to the west. Within 2 or 3 miles of the margin the structure is much more complex; the beds are tightly folded and faulted, and much of the bedding is overturned. Inverted anticlines and synclines are common.

The mineral deposits are concentrated along the margin of the batholith in the Coso Range. The Darwin silver-lead district is in the Darwin Hills on the east side of the Coso Range. Lead-silver-zinc deposits are mainly on the western side of the Coso Range. The Darwin Hills and tungsten deposits are on the eastern side of the Coso Range. The deposits are in the Tecopa Hills at the north end of the batholith. Limestone—altered to calc-hornfels and talc—is the host rock for most of the lead-silver-zinc deposits and the tungsten deposits. Dolomite and talc deposits are in the Tecopa Hills at the north end of the batholith. Fractures have controlled the deposition of most deposits.

**Introduction**

**Purpose and Scope**

The present investigation of the Darwin quadrangle is part of a long-range program by the U. S. Geological Survey, in cooperation with the California Division of Mines, to study the geologic factors relating to the lead-silver-zinc deposits in a belt extending from the Coso Mountains southeastward to the Resting Springs district in the Tecopa quadrangle, a distance of about 120 miles. The Cerro Gordo, Ubehebe, Darwin, Modoc, Panamint, and Resting Springs districts were described in several previous reports. The study of the Cerro Gordo district and a report of the investigation is under preparation, and J. F. McAllister (1955, 1956) mapped the Ubehebe Peak quadrangle.

The Darwin quadrangle, which lies southeast of the New York Butte quadrangle and south of the Ubehebe Peak quadrangle, was mapped in 1952 and 1953, and the minor deposits were studied during 1954. The quadrangle contains some of the most important lead-silver-zinc deposits in the State, the largest lead-silver-zinc-producing area in the State, and significant tungsten deposits.

The report is divided into two parts. The first part briefly describes the rocks and structure of the Darwin quadrangle. The second part is a description of the mineral resources, including the deposits in the Darwin lead-silver-zinc district, the zinc hill district, the Lee district, and the Tecopa Hills. Emphasis is given to descriptions of the lead-silver-zinc deposits. The talc deposits are described only briefly, as detailed mine description have been published recently by Page (1951). The talc
deposits were mapped in 1941 and 1942 by a U. S. geologic Survey party under D. M. Lemmon, and their are published herein.

Location and Accessibility
Darwin quadrangle is in central Inyo County in southeastern part of California 35 miles southeast of Whitney and 40 miles west of Death Valley between longs 117°30' and 117°45' W. and parallels 36°15' and 6°30' N. (Fig. 1). The southern end of the Inyos, the northeastern flank of the Coso Range, and northwestern flank of the Argus Range lie within the quadrangle. Darwin, a small mining town of several residents, is the only town within the quadrangle. The Anaconda Company maintains a large mining camp about a mile northwest of Darwin, and a few mines are at some of the mines and springs.

36°15' Highway 190, which connects U. S. Highway 6 Lone Pine with Death Valley, traverses easterly the central part of the quadrangle. Abundant dirt roads branch off from the State Highway and lead good access. The nearest railroad is 13 miles by northwest of the Darwin quadrangle at Keeler, the end terminus of Southern Pacific's narrow-gauge road from Keeler to Laws, Calif. Lone Pine, the principal supply center, is 26 miles by paved highway north of the Darwin quadrangle.

Climate and Vegetation
The climate is characterized by scant rainfall, a prevalence of wind, and by a considerable diurnal and annual range in temperature. The closest weather station is 14 miles southwest of the Darwin quadrangle at Haiwee at an altitude of 3,830 feet. The U. S. Weather Bureau's publication Climatological Data for 1948 lists the normal annual rainfall at Haiwee as 6.06 inches. The average January temperature is 40.4°F, and the average July temperature is 81.7°F. The extremes in recorded temperature for 1948 are a high of 102°F and a low of 14°F. Except at the lower altitudes near Panamint Valley where the summer temperatures are uncomfortably hot, the figures listed above are probably typical of most of the area in the Darwin quadrangle.

Vegetation is sparse, consisting of scattered creosote bush and some cacti and Joshua trees. An impressive stand of Joshua trees is growing at Lee Flat. Pinon pines and junipers grow in some places at altitudes above 6,000 feet, except where the bedrock is basalt.

Topography and Water Supply
The Darwin quadrangle is in the western part of the Basin and Range physiographic province, in which parallel mountain ranges trending N. 10°-20° W. rise above intermontane plains. Narrow, deeply incised, easterly
trending canyons are prominent topographic features in the eastern part of the quadrangle. Altitudes range from 1,960 feet in an unnamed canyon 2 miles north of Rainbow Canyon to 7,731 feet in the Inyo Mountains.

Drainage is into two enclosed basins, the Panamint Valley to the east and Owens Lake to the west. About four-fifths of the quadrangle drains into Panamint Valley, principally through Darwin Wash, Santa Rosa Flat, and Lee Flat. The remaining area in the southwestern part of the quadrangle drains through Lower Centennial Flat into Owens Lake.

Darwin Wash and Darwin Canyon provide the principal water supply in the quadrangle. The drainage from an area of 165 square miles, which includes the Darwin Hills, the west flank of the Argus Range, and the north-east flank of the Coso Range in the Darwin quadrangle and the northern half of the Coso Peak quadrangle, is fanned into Darwin Canyon. Wells and springs in the canyon provide the water supply for the Darwin Mines, the Miller-Warnken tungsten mill in Darwin Canyon, a mill and residence at China Garden Springs, and the motel at Panamint Springs. The town of Darwin receives its water supply through a pipe line from a spring in the Coso Range 8 miles to the southwest. Water is hauled from Darwin or Lone Pine to the Santa Rosa mine and the mines in the Tule City Hills and Santa Rosa Hills.

Previous Work and Acknowledgments

Early mining activity near Darwin is described by Raymond (1877, p. 25-30), Burchard (1884, p. 163-164), and in reports of the State Mineralogist (Goodyear, 1888; Aubury, 1902 and 1908). Knopf (1914) wrote on the geology and ore deposits of the Darwin lead-silver district, and Kelley (1937; 1938) mapped the Darwin Hills and made large scale maps of some of the mines. Hopper (1947) mapped about 90 square miles in the southern part of the Darwin quadrangle in his reconnaissance study of a strip from the Sierra Nevada to Death Valley.

Commodity studies carried on by the U. S. Geological Survey during World War II covered some of the mineral deposits. Preliminary reports were made available to the writers on the lead-silver-zinc deposits by C. W. Merriam and L. C. Craig and on the tungsten deposits by D. M. Lemmon and others, B. M. Page (1951) and L. A. Wright studied the tude deposits during World War II and T. E. Gay, Jr. and L. A. Wright (1954) mapped the geology of the Tule City area.


The writers wish to express their gratitude to the mining people in the area for their wholehearted cooperation. The Anaconda Company furnished maps of many of the mines owned by them in the Darwin district and extended many other courtesies to the writers. Especial thanks are due D. L. Davis, John Eastlick, M. B. Kildale, and F. E. Tong. E. H. Snyder of Combined Metals Reduction Company furnished production data and a map of the upper workings of the Zine Hill mine.

Many other individuals supplied production data, and are credited under individual mine descriptions.

J. F. McAllister and C. W. Merriam of the U. S. Geological Survey were of great help with stratigraphic and structural problems. E. H. Bailey, district superintendeat geologist for the U. S. Geological Survey, provided valuable suggestions during the preparation of the report. Field work was benefited by discussions with M. Billings of Harvard University and C. E. Stewart of Tufts University. Many geologists provided capable assistance for periods ranging from 2 weeks to 3 months. These include L. A. Brubaker, Santi das Gupta, J. J. Hanañez, Victor Mejia, E. H. Pampyan, D. L. Pi, H. G. Stephens, and D. H. Thamer. The cartography is done under the direction of Esther T. McDermott.

GENERAL GEOLOGY

Rocks in the Darwin quadrangle include sedimentary rocks of Paleozoic age, plutonic and hypabyssal rocks of late Mesozoic age, and volcanic rocks and sediments of Cenozoic age. The stratigraphic sequence is summarized in table I. Paleozoic rocks range in age from Early Ordovician to Permian in a sequence approximately 14,200 feet thick. Formation contacts are conformable except for local unconformities in the Pennsylvanian and Permian series. Pre-Mississippian rocks are mainly dolomite; Mississippian and younger rocks are predominantly limestone. Similar Paleozoic sections have been described in adjacent areas by McAllister (1952), and Merriam (1954).

The Paleozoic rocks in the quadrangle are intruded by the batholiths of the Coso Range in the southwestern part of the quadrangle, the batholith of Hunter Mountain in the northeastern part, and by several small plutons in the Darwin Hills and Argus Range. Volcanic rocks and sediments of late Cenozoic age unconformably overlie the Paleozoic and Mesozoic rocks.

The distribution of the rocks and the location of ore deposits are shown in plate 1. The purpose of the map is to show the distribution of the mineral deposits with respect to lithology and nearness to igneous contacts. The geology has been simplified and the faults not shown. The distribution of the mineral deposits about the margin of the batholith of the Coso Range is a restriction of tuff deposits to a dolomite and quartz host rock of Devonian or older age, and the concentration of lead-silver-zinc and tungsten deposits in limestone of late Paleozoic age is the principal geologic feature shown on the map.

Sedimentary Rocks of Paleozoic Age

Pogonip Group

The Pogonip group of Early and Middle Ordovician age is the oldest rock sequence exposed in the quadrangle. It crops out in isolated or fault-bounded segments along the southwestern edge of the Tule City Hills and at the end of the hills west of the West Virginia claim (pl. 3). Although the base of the sequence is unexposed, most of the Pogonip group is exposed west of the West Virginia claim by a section 1,570 feet thick.

The group consists predominantly of light-gray, medium- to thick-bedded dolomite, but includes limestone, shaly limestone, and siliceous limestone in the
Table 1. Stratigraphic section of the Darwin quadrangle.

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<tr>
<th>Age</th>
<th>Lithologic unit</th>
<th>Thickness (feet)</th>
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<tr>
<td>Recent</td>
<td>Alluvium, including fluvial deposits, and minor lake beds</td>
<td>0-600</td>
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<tr>
<td>Pleistocene</td>
<td>Olive-olive flows, fluvial deposits, and Darwin Wash lake beds of Hopper, 1947</td>
<td>600</td>
</tr>
<tr>
<td>Pleistocene or Pliocene</td>
<td>Coso formation of Schultz, 1937</td>
<td>910+</td>
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<tr>
<td>Pliocene (?)</td>
<td>Andesite, basaltic pyroclastics, basalt flows, and pumice</td>
<td></td>
</tr>
<tr>
<td>Cretaceous (?)</td>
<td>Hypabyssal rocks—andesite porphyry and alkali-basalt dikes</td>
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</tr>
<tr>
<td>Cretaceous</td>
<td>Batholith of Hunter Mountain, batholith of the Coso Range, and related intrusive rocks—mainly quartz monzonite but includes granodiorite, syenodiorite, gabbro, leucogranite, and aplite</td>
<td></td>
</tr>
<tr>
<td>Pennsylvanian</td>
<td>Lower member—mainly fine-grained calcareous; some thick limestone lenses, shale, and siltstone</td>
<td>1,700</td>
</tr>
<tr>
<td>Permian</td>
<td>Lower member—mainly fine-grained calcareous; some thick limestone lenses, shale, and siltstone</td>
<td>2,600</td>
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<td>Permian and Pennsylvanian</td>
<td>Upper member—calcilitic and fine-grained calcareous with lesser shale and limestone-pebble conglomerate</td>
<td>1,700</td>
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<tr>
<td>Pennsylvanian (?)</td>
<td>Lower member—thick-bedded limestone with interbedded limestone-pebble conglomerate</td>
<td>2,300±</td>
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<td>Pennsylvanian (?) and Mississippian</td>
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<td>Mississippian</td>
<td>Perdido formation—limestone and banded chert</td>
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<tr>
<td>Devonian</td>
<td>Lost Burro formation—coarse-grained white and light-gray marble; dolomite and limestone in lower part of formation; minor quartzite and shale</td>
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<td>Devonian and Silurian</td>
<td>Hidden Valley dolomite—light-gray, massive dolomite</td>
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<tr>
<td>Ordovician</td>
<td>Ely Springs dolomite—dark-gray dolomite with chert beds and lenses; some light-gray dolomite</td>
<td>1,770±</td>
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<tr>
<td>Ordovician</td>
<td>Eureka quartzite—light-gray to white vitreous orthoquartzite</td>
<td>1,570±</td>
</tr>
<tr>
<td>Ordovician</td>
<td>Pogonip group—light- and medium-gray thick-bedded dolomite; some thinner-bedded dolomite and limestone</td>
<td>1,000±</td>
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Eureka Quartzite

Eureka quartzite is abundantly exposed in the Tale City Hills, where it forms distinctive, glistening white, outcrops. It is on both flanks of the overturned syncline at the northwest end of the Tale City Hills 1,600 feet northeast of the White Swan mine and at the Hard Scramble talc prospect. Isolated patches of the Eureka crop out between the Alliance talc mine and the Cactus Owen prospect. Most contacts of the Eureka are faults, and isolated blocks of Eureka quartzite as much as several hundred feet long are common in fault zones in the Pogonip group and Ely Springs dolomite.

The Eureka quartzite is 440 feet thick in an unfaulted section on the ridge 2,000 feet N. 30° E. of the northernmost workings of the White Swan tale mine (pl. 2). The formation consists almost entirely of white vitreous quartzite, but brown-weathered, in part platy quartzite crops out locally above the basal contact. Individual quartz grains are mostly of coarse silt size. Cross-bedding is common in the basal part of the formation.

The age of the Eureka is Middle Ordovician. It lies above Middle Ordovician fossils near the top of the Pogonip group and below the fossiliferous Ely Springs dolomite of Late Ordovician age.

Ely Springs Dolomite

Exposures of Ely Springs dolomite are confined to the Tale City Hills. The formation crops out mainly in the northwestern part of the hills on both flanks of an overturned syncline (pl. 2). Other exposures are at the Trinity tale mine, in two bands extending west from the Alliance tale mine, and on the hill 1 mile east of the Viking tale mine. The contact of the Ely Springs dolomite with the underlying Eureka quartzite is marked by abrupt lithologic and color differences and forms the most conspicuous formational boundary in the Paleozoic section. The sharp change from the white vitreous quartzite of the Eureka to the dark-gray, thick-bedded dolomite of the Ely Springs may be readily distinguished even at a distance of a mile.

A complete section of Ely Springs dolomite on the ridge, 3,500 feet N. 6° E. of the northernmost workings of the White Swan mine is 920 feet thick. The lower part of the formation consists of dark-gray, thick-bedded dolomite with irregular lenses and nodules of chert. It grades upward through medium-gray to massive, light-gray dolomite. A bed of dark-gray dolomite, 50 feet thick, is present at most places at the top of the formation.

The formation has been dated as Late Ordovician in age by C. W. Merriam of the U. S. Geological Survey based on fossils collected from the lower part of the Ely Springs on the ridge southeast of the Hard Scramble prospect.

Hidden Valley Dolomite

Hidden Valley dolomite crops out for 1 1/2 miles along the crest of the ridge 1,400 feet west of the Hard Scramble prospect, and other smaller outcrops are present north of the Alliance tale mine, 700 feet south of the Tale City mine, and 300 feet north of the Trinity tale mine. The formation consists entirely of massive, buff to light-gray dolomite. The dolomite is recrystallized, and
very little bedding is preserved. The entire section of the Hidden Valley is not exposed at any one locality within the quadrangle. Approximately 1,000 feet of Hidden Valley dolomite is exposed along the ridge between the White Swan coal mine and the Hard Scramble prospect, although the upper part of the formation is eroded.

Only meager, indeterminate fossil remains were found in the Hidden Valley dolomite in the Tale City Hills. McAllister (1932, p. 16) dated the Hidden Valley dolomite as Silurian and Early Devonian in age in the Quartz Spring area.

Lost Burro Formation

The Lost Burro formation crops out in the Santa Rosa Hills underlining the hill at the Silver Reid prospect, in the Tale City Hills at the Cactus Owen, Homestake, and Tale City mines, and on the west flank of the Darwin Hills. No complete section of the Lost Burro is exposed in the quadrangle, but the thickness is probably greater than 1,700 feet and a composite section may be as thick as 2,400 feet. The accuracy of this estimate is somewhat impaired by minor faulting and folding. The formation consists of light-gray dolomite, quartzite, sandy limestone, shale, and chert in the lower part and white to light-gray marble with local thin quartzite beds in the upper part. The lower part of the formation is exposed at the Tale City mine. It consists of 65 feet of interbedded brown-weathering quartzite, sandy limestone, and chert and is correlated with the Lippincott member (McAllister, 1932, p. 12). This lower part is overlain by about 600 feet of light-gray mottled dolomite that, in turn, is overlain by light-gray limestone and shale. The upper part of the formation is exposed in the Santa Rosa Hills at the Silver Reid prospect, and it consists of white to light-gray marble with minor thin quartzite beds. The marble is finely banded with alternating white and medium-gray layers. Some medium-gray limestone beds within the white marble contain abundant Cladopora and Stromatopora. The age of the Lost Burro is Devonian.

Tin Mountain Limestone

Tin Mountain limestone crops out for 4 miles along the crest of the Santa Rosa Hills, and smaller exposures are at the Lee mine and locally along the west flank of the Darwin Hills. The formation is 435 feet thick at the south end of the Santa Rosa Hills. The dominant rock type is medium- to dark-gray, fine-grained limestone in beds 1/2 to 12 feet thick. Chert lenses and nodules and crinoidal debris are common throughout the Tin Mountain limestone. At the south end of the Santa Rosa Hills the Tin Mountain limestone is bleached and in part recrystallized to marble, so that it resembles marble of the Lost Burro formation. Elsewhere a sharp color contrast distinguishes the dark limestone of the Tin Mountain from the underlying coarse-grained white marble of the Lost Burro formation.

The Tin Mountain limestone is the most fossiliferous formation in the quadrangle and contains numerous corals, brachiopods, bryozoans, and crinoidal stems. Several collections of fossils from the Tin Mountain of the Santa Rosa Hills were examined by Helen Dunne and by Mackenzie Gordon, Jr., of the U. S. Geological Survey, who summarized his findings of the brachiopods as follows:

“The three collections appear to represent approximately same faunal assemblage. The small narrow Spirifer sp. A, with rather long dental plates and about 5 ribs on each side of a narrow sinus in the pedicle valve, occurs both in collection F-1 and along with poorly preserved horn corals that have a general Old Missouri aspect, according to Miss Duncan. Cyrtina and Leptaena are genera that range through Silurian and Devonian rocks and into the lower Mississippian. In western United States Leptaena analoga (Phillips) is typical of the rocks of Madison age and is not definitely known to range higher. In the mid-continent this species and several cyrtinas are known in rocks of Kinderhook and Osage age and are not known to range as high as uppermost Osage, Rhipidomella oswelli (Haime) with which several partly crushed silified specimens are compared is a widespread lower Osage form. The presence of large productid, though too poorly preserved to identify even as genus, precludes a Devonian age for the assemblage. The rest of the specimens are not well preserved or entire enough to add evidence to that discussed above.

In summary, the fossils can be said to represent an easterly Madison (Osage) fauna. In terms of mid-continent stratigraphy they are believed to be not younger than Osage in age and may be Kinderhook in age.”

Perdido Formation

The Perdido formation is present mainly in the Santa Rosa Hills conformably overlying Tin Mountain limestone and locally at the south end of the Tale City Hills and on the western flank of the Darwin Hills. The formation is approximately 325 feet thick in the Santa Rosa Hills. It consists predominantly of limestone, silty limestone, and chert. Thin-bedded, medium-gray limestone with thin layers of medium-chert characteristic of the lower part of the formation. Chert is much more abundant in the upper part of the formation where it is present in beds as much as 60 feet thick at the south end of the Santa Rosa Hills. The lithology of the lower part of the Perdido formation and the upper part of the Tin Mountain limestone is similar and the contact between the two is placed at the base of the lowermost bedded limestone in the Perdido formation.

The Perdido formation is much thinner in the Darwin quadrangle than in the Quartz Spring area where McAllister (1952, p. 23) measured a section about 610 feet thick. The Perdido formation in the Darwin quadrangle is similar in lithology to the lower part of the Perdido formation in the Quartz Spring area, although the upper part of the Perdido is missing. The age of the Perdido formation, according to McAllister (1952, p. 24), is Mississippian based on fossils in the Ubehebe Peak quadrangle and the Quartz Spring area.

Lee Flat Limestone

The Lee Flat limestone is named here for exposure near Lee Flat, a Joshua-tree-studded, alluviated arroyo east of the Santa Rosa Hills. The type section trends south from near the top of the prominent hill nine tenths of a mile S. 36° E. of the main shaft of the Lee mine. The formation is exposed for 1½ miles along the north side of the Santa Rosa Hills, and it forms the prominent hill 3,000 feet south of the Lee mine. Smaller outcrops of Lee Flat limestone are in the southern part of the Tale City Hills and along the west flank of the Darwin Hills.

The predominant rock type is thin-bedded, medium to dark-gray limestone. Locally the generally uniform
ance of the limestone is broken by thin, sandy
drain parts or by thin beds and lenses of chert.
lee Flat limestone is at least 520 feet thick at the
ality where it conformally overlies the Perdido
ion. The upper part of the limestone is covered by
n. The formation is estimated to be more than
et thick on the hill 3,000 feet south of the Lee
out the top of the formation is covered by basalt
uvium, and faulting in the exposed section vitiates
mate.
only fossils found in the Lee Flat limestone are
fragments; consequently the age of the forma-
derived from its stratigraphic position. The for-
alies conformably on limestone and chert that are
ated with the lower part of the Perdido formation
Ubehebe Peak quadrangle, where the lowest beds
bably Early Mississippian. (See Helen Duncan in-
ister, 1952, p. 24.) The top beds of the Perdido
ion in the Quartz Spring area are of Chester age
Mississippian) (McAllister, 1952, p. 24). The Lee
mestone occupies the same stratigraphic position
the upper part of the Perdido formation and the
pring shale occupy in the Quartz Spring area and
pee Peak quadrangle (McAllister, 1952, pl. 2).
ugh there are no fossils to show equivalence of age,
lee Flat limestone probably correlates with the
art of the Perdido formation of Late Mississip-
ge and all of the Rest Spring shale of Pennsyl-
Vania (?) age. It then represents a facies change
m section of siltstone, shale, and minor limestone
Ubehebe and Quartz Spring areas to fine-grained
one in the Darwin quadrangle.
he Darwin Hills the Lee Flat limestone is overlain
the Keeler Canyon formation, which ranges in age
probable Atoka or Des Moines (Pennsylvanian) to
probable late Wolfcamp (Permian) according to L. G. Hen-
best and R. C. Douglass of the U. S. Geological Sur-
svey. Fusulinids are the most abundant fossils, but in
any the internal structures are impaired by silifica-
tion to such an extent that assured identifications are
unobtainable.
A report by Lloyd G. Henbest of the U. S. Geological Survey concerning a collection of fusulinids from near the base of the Keeler Canyon formation in the Santa Rosa Hills 1.58 miles S. 77° W. of the Lee mine is given below.

F-8591 Pennsylvanian, Atoka or Des Moines age.
Solenopoid Algae
Climacoc Squista, sp.
Endothyra sp.
Müllerella ? sp.
Fusulinella sp. or Wodekindella sp.
Fusulinella sp. or an early form of Fusulina.

"Most of the specimens show massive deformation and poor
preservation. The fusulinids are identified generically with fair
assurance. The age indicated is Atoka or very early Des Moines.
The foraminiferal association gives support of very limited value
to this age determination. The species of solenopoid Algae is a
fossil of common occurrence in the Rocky Mountain region. In
my experience, it is limited to rocks of Atoka and of approxi-
ately the first half of Des Moines age. By the fusulinids
alone, in this state of preservation, I could not definitely prove
that they are not of early Permian age. The assemblage and
especially the peculiar solenopoid all agree in indicating Atoka
or early Des Moines age."

Two collections of fusulinids were made at the top of the
upper member of the Keeler Canyon formation at the
north end of the Darwin Hills northeast of the Dar-
win Antimony mine. These collections were examined by
R. C. Douglass of the U. S. Geological Survey in 1954,
and his reports are given below.

F-9748 "At north end of Darwin Hills in sec. 35 (projected),
T. 18 S., R. 40 E., at elevation 5,290 feet. Located
3.92 miles N., 73° E. from road junction of State
highway 190 and Darwin turn off and 1.20 miles N.
33° W. of VARM 5079. In thinly bedded blue-gray, fine-grained limestone.”

Climacium sp.
Tetraaria?
Endothyra?
Schwagerina sp.
One aff. S. compacta (White)

“Evidence on the age of this sample is inconclusive. The sample is probably of Wolfcamp age, possibly middle to late Wolfcamp.”

F-3749 “At north end of Darwin Hills at elevation 5,400 feet. Located in gully 600 feet north of VARM 5079 and 4.39 miles N. 80° E. of junction of State highway 190 and Darwin turn off. In 3-foot thick limestone bed interbedded in pink fossil shale.”

Calcitornells
Climacium sp.
Triticites sp.
Schwagerina sp. (possibly 3 species)
One aff. S. dierciformis Dunbar & Skinner
Another aff. S. linearis Dunbar & Skinner
Pseudoschwagerina sp.
Paraschwagerina?

“This assemblage contains elements common to the uppermost Wolfcamp and lower Leonard formations. It can probably be correlated with this boundary zone with fair certainty.”

Owens Valley Formation

The name Owens Valley formation is defined by Merriam and Hall (1957, p. 7) as a sequence of limestone and shale exposed extensively on the western slope of the Inyo Range; the type locality is in the foothills between Union Wash and the Reward mine, about 3 miles southeast of Independence. The formation is abundantly exposed in the Darwin quadrangle. It underlies Conglomerate Mesa (pl. 1) and the low group of hills at the head of Santa Rosa Flat in the northwestern part of the quadrangle, and it is in the southeastern part of the quadrangle on the east side of the Darwin Hills, in Darwin Canyon, and on the west flank of the Argus Range.

The Owens Valley formation is more than 3,200 feet thick and consists of interbedded calcarenite, silty limestone, pure limestone, siltstone, and shale. For convenience of description, it is divided informally into 3 members. The lower member is about 2,800 feet thick and consists of calcarenite, shaly limestone, lenses of pure limestone, shale, and siltstone and will be referred to as the lower limestone member. Lenses of bluish-gray, pure limestone as much as 40 feet thick and several thousand feet long are characteristic of the lower member, and cross-bedded calcarenite is abundant. A contact between the Keeler Canyon formation and the lower member of the Owens Valley formation is 4,500 feet east of the Darwin antimony mine. A brown-weathering siltstone 450 feet thick is at the base of the formation, and this is overlain by interbedded calcarenite, pure limestone, and shaly limestone. It was not possible to correlate details of lithology in the Keeler Canyon formation and lower member of the Owens Valley formation in the Darwin Hills to those in the group of low hills at the head of Santa Rosa Flat in the northwestern part of the quadrangle. A gradational contact between these two formations in the northwestern part of the quadrangle is 3 miles east of the northwest corner of the quadrangle. The Owens Valley formation to the west contains abundant lenses of pure limestone in calcarenite while the underlying Keeler Canyon to the east contains abundant interbedded pink shale and silty limestone. No siltstone bed similar to the one in the Darwin Hills was 1 foot thick at the contact, but another siltstone bed 250 feet thick is in the upper member of the Keeler Canyon formation, 1,200 feet below the contact.

The middle shale member of the Owens Valley formation is exposed only in the northwestern part of the quadrangle along the foot of Conglomerate Mesa, approximately 200 feet thick, but the incompetent beds and poor outcrop preclude an accurate measurement of the thickness. The middle member consists of ponderantly of shale but includes subordinate siltstone and limestone. Most of the shale is brick red or yellow-brown on both fresh and weathered surfaces, but it is dark gray or greenish-gray.

The upper limestone conglomerate member forms resistant capping and cliff exposures of Conglomerate Mesa. It has a minimum thickness of 180 feet in the Darwin quadrangle, and consists of limestone conglomerate, siltstone, and sandstone. The contact with the underlying middle shale member is disconformably on the adjacent Ubehebe Peak quadrangle the limestone conglomerate in the stratigraphic equivalent upper part of the Bird Spring (?) formation has a maximum thickness of 600 feet (McAllister, 1955, p. 14). The conglomerate contains fragments of gray limestone and siltstone mostly 1 inch to 4 inches in diameter sand-sized matrix of limestone and chert. In places conglomerate has been nearly completely stilified.

The age of the Owens Valley formation ranges in late Wolfcamp (Permian) to probably Guadalupian (Mississippian). The lower limestone member ranges in age to late Wolfcamp (Permian) into Leonard (Permian). The faunal assemblage includes fusulinids, corals, brachiopods, ammonites, and gastropods.

Two collections from near the base of the Owens Valley formation in the northwestern part of the quadrangle were studied by R. C. Douglass of the U. S. Geolo Survey and were determined as probably late Wolfcamp age. Collection P-9645 is 2.85 miles S. 86° E. of northwest corner of the quadrangle; collection P-9646 is 2.20 miles S. 80° E. of the northwest corner. The descriptions by Douglass are given below.

F-9645 Permian
California, Inyo County, Darwin quadrangle
Schubertiella sp.
Triticites sp.
Schwagerina sp.
Pseudoschwagerina? sp.

“The material in this collection is fractured and siltific of Permian age, probably upper Wolfcamp.”

F-9648 Permian
California, Inyo County, Darwin quadrangle
Schwagerina sp. advanced forms
Pseudoschwagerina sp.

“This sample is of Permian age, probably upper Wolfcamp.”

Two collections were made at the top of the lower member of the Owens Valley formation. Collected P-9650 of fusulinids was from a limestone lens 40 feet thick in silty limestone 1.20 miles S. 71° E. of the northwest corner of the quadrangle. Collection P-119 is 3 miles S. 58° E. of the northwest corner. It is a collection of gastropods, corals, brachiopods, and bryozoa from craggy limestone lens 84 feet thick that is stratigraphically a few feet below collection P-9650.
There are many small forms in this collection most of which are immature individuals of the following genera, but of which may be Endothyra and Schubertella. 

Nos. Steele Williams of the U. S. Geological Survey summarized results of paleontological studies of glossoïd assemblage collected from locality F-119 the top of the lower limestone member as follows: 

- *tenodiscus* sp. indet. (no close age significance)
- *tietycostostus* sp. indet. large form
- *tietycostostus* sp. indet., related to *D. ivesi basi* McKee
- *tietycostostus* sp. indet., possibly related to *D. ivesi* (Newberry)
- *mecella* sp. indet.

Several specimens of gastropods were reported on separately by Ellis and R. B. Borchers. 

The large *Dietycostostus* in the above list is crushed and indeterminate but as nearly as one can tell it is probably a *D. ivesi vesta* McKee. The smaller one is related to *D. ivesi vesta* as restricted by McKee but it appears to have ser costae and a deeper sulcus than are typical of that l es. 

The species of *Mecella* in mature individuals is larger than *Parafusulina* Pennsylvanian. On these rather slender grounds believe that the collection is probably of Leonard or younger. 

It is not the typical Orenyo fauna but appears to be older than that fauna. I do not believe it is as old as *D. mielckii.* It may however be an unusual facies of one of these faunas.

Fossils were found in the middle shale member of the middle limestone conglomerate member of the Owsency formation. The middle shale member is probably Leonard or later Pennsylvanian as it conformably overlies the lower member, the upper part of which contains slates that are considered by James Steele Williams to be Leonard or later Pennsylvanian as cited above. 

On bed of Orenyo fauna and fossils from time-equivalent rocks in the New York Butte quadrangle, Merriam res the limestone conglomerate member is Permain, digitally Guadalupian.

Plutonic Rocks of Mesozoic Age 

Plutonic rocks are exposed at the surface over approximately 10 percent of the quadrangle, and possibly 10 percent underlie a thin cover of basalt or alluvium. 

Inclines include the batholith of Hunter Mountain in the eastern part of the quadrangle, the batholith of the Range in the southwestern part, and the stocks in Darwin Hills, Tale City Hills, and at Zinc Hill. Most of the plutonic rocks fall into two lithologic types-e-hornblende quartz monzonite and leucocratic a-z monzonite. Small bodies of leucogranite, aplite, and pegmatite are common at the border of bodies of quartz monzonite and as thin dikes intruding them.

**Biotite-Hornblende Quartz Monzonite**

Biotite-hornblende quartz monzonite is the predominant rock type in the batholith of Hunter Mountain, in the batholith of the Coso Range, and in the stock in the central part of the Darwin Hills. Biotite-hornblende quartz monzonite crops out in the batholith of Hunter Mountain in steep, east-trending canyons where the rock has been exposed by faulting or by erosion of the overlying basalt. This batholith extends northward into the Ubehebe Peak quadrangle where it has been described as the Hunter Mountain quartz monzonite by Meallister (1956). In the Darwin Hills and the Coso Range, biotite-hornblende quartz monzonite is the most easily weathered rock, and forms gentle slopes that commonly are grossly covered. Locally resistant leneocratic differentiates crop out that do not reflect the composition of the gross-covered areas.

**Petrography**

The biotite-hornblende quartz monzonite is a light-gray rock that has a speckled appearance produced by a scattering of dark ferro-magnesian minerals. The texture ranges from equigranular, with an average grain size of 2 to 3 mm, to porphyritic, with 10 to 20 percent phenocrysts of pinkish potassium feldspar as much as 1 1 2 cm long in a finer grained light-gray equigranular groundmass. The uncontaminated rock is predominantly quartz monzonite in composition but ranges from granodiorite to quartz monzonite. Essential minerals are quartz, potassium feldspar, and plagioclase; commonly at least five percent hornblende and biotite are present. Feldspar makes up 60 to 75 percent of the rock; plagioclase and potassium feldspar are in about equal quantities. Plagioclase is calcic oligoclase or andesine of composition *An* 25 to *An* 30, and it is commonly normally zoned. The potassium feldspar is microperthitic; some of it has microcline twinning. Quartz makes up as much as 30 percent of the rock. It is more abundant in the quartz monzonite from the batholith of the Coso Range than that from the batholith of Hunter Mountain. The mafic minerals include biotite, hornblende, and, in the batholith of Hunter Mountain, augite, and they range in volume percent from 8 to 30. Hornblende is predominant in the quartz monzonite from the Coso Range and from the batholith of Hunter Mountain, and biotite is predominant in the quartz monzonite underlying the low hills west of Darwin. Minor accessory minerals are sphene, apatite, magnetite, and tourmaline. Tourmaline is particularly abundant in the satellite bodies south of the Santa Rosa Hills.
The Darwin stock is an heterogeneous intrusive composed predominantly of biotite-hornblende quartz monzonite and granodiorite similar to that in the Coso Range, but the rocks are deeply weathered and few unaltered specimens were found for study. Near the Defiance and Thompson workings of the Darwin mine the intrusive is contaminated and consists largely of granodiorite, quartz diorite, and diorite.

Megascopically the biotite-hornblende quartz monzonite from the batholith of Hunter Mountain, the batholith of the Coso Range, and the least contaminated parts of the stock of the Darwin Hills are similar in color and texture. However there are some overall differences between quartz monzonite from the different plutons. The quartz monzonite in the batholith of the Coso Range contains more quartz and less mafic minerals than the batholith of Hunter Mountain. Augite is a common mafic mineral in the batholith of Hunter Mountain but was not observed in the batholith of the Coso Range. These differences are believed to be due mainly to assimilation of limestone by the batholith of Hunter Mountain rather than to a difference in the parent magmas. The central part of the batholith of Hunter Mountain in the Ubehebe Peak quadrangle (McAllister, 1956) is also relatively low in quartz, and it is probable that the exposures of the batholith are closer to the former roof than the exposures of the batholith of the Coso Range.

Border Facies. The border facies of quartz monzonite of the batholith of Hunter Mountain are quartz-poor rocks that include monzonite, syenodiorite, and gabбро. Generally the border facies rocks are slightly coarser grained and are darker than the typical quartz monzonite, but in some exposures the two are nearly indistinguishable. Except for the low quartz content, monzonite is similar to quartz monzonite in mineralogy and texture. Syenodiorite megascopically also is similar, but in thin section it is seen that some of the amphibole is hastingsite instead of hornblende. The syenodiorite that contains hastingsite also contains minor tourmaline and scapolite in veinlets transecting and replacing plagioclase.

Leucocratic Quartz Monzonite

Distribution

Leucocratic quartz monzonite is present in the stock in the Tale City Hills and in the stock at Zinc Hill in the Argus Range. Most slopes underlain by the stock in the Tale City Hills are gross covered and only a few shallow gullies expose relatively unweathered rock. The stock at Zinc Hill is in an area of rugged relief and is well exposed.

Petrography

Leucocratic quartz monzonite is a medium- to coarse-grained, light grayish-pink rock that at most places contains less than five percent mafic minerals. The texture ranges from equigranular to porphyritic; locally the rock contains pink feldspar crystals as much as 1 cm long in a medium-grained equigranular groundmass. Dark fine-grained discoidal inclusions less than 1 inch long are sparsely disseminated through the stock in the Tale City Hills. The leucocratic quartz monzonite is lighter colored and coarser grained than the more widespread biotite-hornblende-quartz monzonite.

Essential minerals in the rock are quartz, plagioclase, and orthoclase. Feldspars constitute 70 to 75 percent of the rock and are present in about equal quantities. Plagioclase is nepheline and commonly forms phenocrysts that poikilitically enclose all the other minerals. Orthoclase is sodic oligoclase. Biotite is the predominant mafic mineral and generally constitutes less than five percent of the rock, although as much as seven percent has been observed; it is in part altered to chlorite. Hornblende may be present in small quantities. Minor accessory minerals are allanite, apatite, magnetite, pyrite, and sphene.

Other Intrusives

A body of diorite, gabbro, epidote amphibolite, and amphibolite described briefly by Hopper (1947, p. 29) crops out in Darwin Canyon in the vicinity of Darwin Falls. This diorite and amphibolite body grades into hornfels of the Owens Valley formation and is nonformably overlain by olivine basalt of late Cenozoic age. The amphibolite is a heterogeneous, fine-grained, grayish-green rock cut by stringers and lenses of epidote amphibolite and quartz-poor diorite. Numerous dioritic dikes cut the surrounding hornfels close to its contact with the main diorite body. In places the bedding of the adjacent hornfels extends into the dike and amphibolite body and is preserved in it. Contacts between the diorite and hornfels are gradational over distances of 10 to 20 feet. The diorite is believed to have formed from the alteration of impure limestone of Permian age by hydrothermal solutions from a basic intrusive.

Age

In the Darwin quadrangle the age of the granite rocks can be determined only as younger than Permian and older than late Cenozoic. In the Inyo Mountains the granitoid rocks intrude shale and volcanic rocks of Triassic age (Knopf, 1918, p. 60). David Gottfried (oral communication, 1955) of the U. S. Geological Survey reports that in the Hunter Mountain quartz monzonite to be 99 million years old (middle Cretaceous) based on zircon determination by the Larsen method of a sample collected by writers from the southeast part of the Ubehebe Peak quadrangle. This is about the same age as that determined for the Sierra Nevada batholith (Faul, 1955, p. 265).

Hypabyssal Rocks

Hypabyssal rocks include dikes of andesite porphyritic diorite, and alaskite. Andesite porphyry dikes are widely distributed in the rocks of Paleozoic age and are uniformally overlain by volcanic rocks of late Cenozoic age. The dikes are 2 to 6 feet thick and strike about N. 70° E. and dip nearly vertically. They are greenish-gray in fresh surfaces and weather to shades of brown. The andesite porphyry dikes are highly altered and consist of plagioclase phenocrysts with saussuritic alteration of fine-grained plagioclase groundmass composed mainly of albite, epidote, chlorite, calcite, and stilbite. An albite porphyry dike crops out half a mile east of Ophir Mountain. This dike contains phenocrysts of albite and quartz, 2 to 4 mm long in a cryptocrystalline groundmass composed of albite, quartz, and minor epidote and chlorite. The dike is Cretaceous or younger in age. The andesite porphyry dikes.
They made Tentsch Schultz (1937, p. 98), on the basis of vertebrate fossils found west and southwest of the Darwin quadrangle, believes that the formation was formed during the transition period between Pliocene and early Pleistocene.

Erosional fans are marginal to the Inyo Mountains and to the Argus Range. The tuff of the south end of the Inyo Mountains contains fragments of dolomite, limestone, and quartzite of Ordovician to Devonian age in a clay and silt matrix. It probably is the same age as the nearby Coso formation of Schultz.

The tuff of the west slope of the Argus Range consists of fragments of Pennsylvanian and Permian limestone, quartz monzonite, agglomerate, and olivine basalt in a predominantly sandy matrix. The fans are overburdened by, and in part interflow with, the Darwin Wash lake beds of Hopper (1947). The tuff of the Argus Range dips 4° to 6° W., but it has been tilted locally to low east dips.

Conspicuous white lake beds crop out in Darwin Wash east and southeast of Lane Mill. The essentially horizontal beds have a maximum exposed thickness of 58 feet, but the base is unexposed. The lake beds consist of white, fine-grained pumiceous ash, silt, clay, and diatomaceous earth in beds half a foot to 4 feet thick. The lake beds have been dated as middle to late Pleistocene in age by K. E. Lohman (written communication) on the basis of diatoms.

The upper part of the tuff from the Argus Range interfingers with the Darwin Wash lake beds of Hopper and is therefore middle to late Pleistocene in age and is younger than the Coso formation of Schultz of late Pliocene or early Pleistocene age.

**Volcanic Rocks**

Voleanic rocks, which cover about 30 percent of the quadrangle, include basalt, andesite, basaltic pyroclastics, and minor pumice. Basaltic pyroclastics are the oldest volcanic rock. Andesite and pumice are interbedded near the top of the pyroclastics. Olivine basalt is the youngest rock and is the resistant capping that forms mesas and plateaus in the Inyo Mountains and on Darwin Plateau.

Pyroclastic rocks are widely distributed throughout the northern half of the quadrangle and are best exposed in the Inyo Mountains at the Santa Rosa mine and in the basin a mile and half southwest of the Santa Rosa mine. The section has a maximum thickness of 910 feet near local vents. Pyroclastic rocks rest nonconformably on Paleozoic rocks and granite rocks. The pyroclastics are unconformably overlain by olivine basalt flows. Most of the pyroclastics dip less than 25°, but dips as much as 41° were measured beneath nearly horizontal basalt, indicating a period of tilting prior to the extrusion of the basalt.

The pyroclastic rocks consist of agglomerate, tuff-breccia, lapilli-tuff, scoria, volcanic cinders—all of basaltic composition—and locally, thin layers of pumice. The lower part of the pyroclastic section contains of well-bedded light-brown and yellowish-brown basaltic tuff and tuff-breccia. The upper part is poorly bedded and consists mainly of red or reddish-brown agglomerate, cinders, volcanic breccia, tuff-breccia, and scoriaceous basalt.
Andesite is exposed over an area of about 3 square miles south and southeast of the Santa Rosa mine. This andesite crops out in bold reddish cliffs and forms a broad dome interbedded in the upper part of the pyroclastics. It is a red or gray porphyritic rock containing phenocrysts and clusters of plagioclase as long as 10 mm and euhedral phenocrysts of hornblende as long as 4 mm in an aphaniitic groundmass. The gray variety is light gray on fresh surfaces and weathers dark gray; the other variety is red to reddish gray on fresh surfaces and weathers reddish brown. The red andesite owes its color to oxyhornblende and hematite.

Petrographically, the andesite consists of plagioclase of composition An46 to An34, hornblende or oxyhornblende, biotite, volcanic glass, and minor amounts of euhedral quartz, orthoclase, augite, apatite, and zircon.

Olivine basalt covers a large part of the northern two-thirds of the quadrangle, and it is present in several isolated patches in the southern one-third of the quadrangle. It is in flows 10 to 100 feet thick with a maximum aggregate thickness of about 600 feet. Thin basalt dikes, some representing feeder dikes for the flows, are abundant near volcanic vents. The basalt is generally gray on fresh surfaces and weathers dark yellowish brown to brownish-black desert-varnished surfaces. Vesicles are abundant near the tops and bottoms of the flows and in some of the dikes. The basalt is finely porphyritic with 1- to 2-mm phenocrysts of olivine, and a few smaller phenocrysts of plagioclase and augite, in a fine-grained groundmass consisting of plagioclase, olivine, augite, biotite, and volcanic glass. Secondary minerals are iddingsite, antigorite, goethite, calcite, and chaledony. Minor embayed quartz fragments, probably xenocrysts, are in some of the basalt. The plagioclase is labradorite of composition An37 to An10.

**Age**

The age of the volcanic rocks is only tentatively given in table 2 as their relationship with known Cenozoic deposits is not well established. The basaltic pyroclastic rocks are probably Pliocene in age. Fragments of basaltic agglomerate and scoria that are probably time equivalents of the basaltic pyroclastics in the Inyo Mountains are abundant in the Coso formation of Schultz on the west side of the Coso Range east of Haiwee Reservoir. If the pyroclastics are equivalents, they are older than the Coso formation of Schultz of late Pliocene or early Pleistocene age.

The andesite south of the Santa Rosa mine is interbedded in the upper part of the pyroclastics and is identical to the andesite in the Coso Range east of Haiwee Reservoir. The Coso Range andesite apparently is interbedded with the lower part of the Coso formation below the fossiliferous beds described by Schultz (1937, p. 98). The Coso formation of Schultz on the west flank of the Coso Range contains fragments of andesite, but beds identical in lithology to the Coso formation of Schultz and with contiguous outcrop underlie the andesite in the Coso Range at Cactus Flat 3 miles east of Haiwee Reservoir. The andesite is probably late Pliocene in age.

Olivine basalt flows overlie the Coso formation of Schultz (1937) in the Haiwee Reservoir quadrangle (Hopper, 1947, p. 417) and in the southwestern part of the Darwin quadrangle, and olivine basalt flows over fanglomerate in Darwin Canyon near Darwin Flat. They must be early Pleistocene or younger in age.

**Recent Alluvial Deposits**

Recent alluvial deposits cover about one-fourth of the quadrangle and are particularly abundant in Los Centennial Flat, Santa Rosa Flat, and Lee Flat. They are largely alluvial fan deposits, but include some playa deposits and lake beds.

**Structure**

The Darwin quadrangle is on the west limb of the major anticlinorium, the axis of which trends approximately N. 15° W. near the crest of the Panamint Range about 15 miles east of the quadrangle. The Paleozoic rocks are folded and faulted. Bedding strikes predominantly north to N. 30° W. and dips southwest, except in the Tule City Hills where the strike is N. 60°-80° E. as a result of deformation by forearc intrusion of the batholith of the Coso Range. Thrust faults and step faults, some probably with large strike-slip displacements, were formed during the late Mesozoic orogeny. Basin and Range faults of Cenozoic age are important in forming the present topography.

The only major unconformity truncates the Paleozoic rocks and the Cretaceous plutonic rocks. Minor unconformities are represented in the Pennsylvaniaian a Permian strata by recurrent limestone-pebble conglomerates and by local angular discordances. Pronounced differences in lithology between formations of Paleozoic age may represent minor hiatuses.

The Paleozoic rocks are deformed into broad open folds with moderate dips at distances greater than several miles from a major intrusive. The trend of the fold is north to N. 20° W. Within 2 to 3 miles of the batholith of the Coso Range in the Darwin Hills and Tule City Hills folding is much more intense and bedding overturned. Inverted anticlines and synclines are common, and faults are abundant. The structure of the Darwin Hills is an overturned syncline with an axial plane that strikes N. 15° E. and dips about 50° W. along the eastern margin of the hills. The rocks range in age in a conformable sequence from Devonian to Permian on the east. Bedding, which is overturned, strikes north and dips predominantly to the west, except locally on limbs of minor folds. The structure in the Tule City Hills is also synclinal; Devonian and Silurian rocks are in the core and Ordovician rocks on the flanks of the syncline (pl. 2).

Two general periods of faulting are recognized—a late Mesozoic period of faulting and late Cenozoic faulting producing the present basin-and-range topography. Late Mesozoic faults include thrust faults and steep faults that have mainly a strike-slip displacement. The major thrust fault is in the Tule City Hills where rocks of Devonian to Ordovician age have been thrust toward the northeast over limestone of predominantly Pennsylvanian and Permian age. The stratigraphic throw on this fault is 5,900 feet, and the net slip is estimated to be 3.6 miles. The Davis thrust is an important ore controlling structure in the Darwin Hills.
strike-slip faults are common in the Darwin Hills and the Santa Rosa Hills. The Darwin tear fault is the major fault in the Darwin Hills. It is a left-lateral transcurrent strike-slip fault with a displacement of 2,200 feet, the slip vector. Strike-slip faults in the Santa Rosa Hills are also left lateral, but the net slip is not known. Faults of late Cenozoic age account for many of the significant topographic features. These faults strike north-south and dip steeply. Most of them are normal faults with an en echelon pattern. A swarm of Basin-Range faults in the northeastern part of the quadrangle is responsible for the escarpment on the west side of Panamint Valley. Some of the faults are normal faults with their down-dip side to the east, but some are reverse faults with their down-dip side to the west. The Basin-Range faults are less conspicuous in other parts of the quadrangle.

ORE DEPOSITS

The Darwin quadrangle is best known economically for its deposits of lead-silver-zinc ore, but in addition, tungsten, antimony, copper, and gold have been mined, and vast deposits of limestone and dolomite are known. The total value of the ore produced from 1904 to 1952 is approximately $37,500,000. Production in the Darwin district has accounted for $29,000,000 of this amount. Most of the silver, lead, and zinc was mined from the Darwin Hills. Smaller deposits have been developed in the Zinc Hill area, the Lee district, and the Santa Rosa mine. Steatite-grade talc has been produced continuously since 1917 from the Tale City Hills, east of the Tale City mine. The only other modality exploited in any quantity is tungsten, which first produced in 1941 from mines on the east side of the Darwin Hills, and intermittent production has maintained itself since then.

History

Kidized silver-lead ore bodies were discovered at Darwin in November 1874 (Chalfant, 1933, p. 274), and between 1875 and 1880 the rich near-surface ores were worked extensively. The town of Darwin was reported to have a population of 5,000 people by 1880 (Kelley, 1921, p. 507). Between 1875 and 1877 three smelters were built near Darwin—the Cuervo with a capacity of 100 tons per day, the Defiance with a capacity of 60 tons per day, and the New Coso with a capacity of 100 tons per year, 1888, p. 226).

May 1875 the New Coso Mining Company pur chased the Christmas Gift and Lucky Jim mines, then in prospect, and under the management of L. L. Wilson the company recovered 226,672 ounces of silver, 4,120,261 pounds of lead by April 1877, (Robin, 1877, p. 38) with a total value of $410,350. By 1883, $1,280,000 in bullion had been recovered, but the prop erty was idle at that time (Burchard, 1884, p. 164). The Defiance and Independence mines were in production by 1875 as reported in the Coso Mining News December 24, 1875, and by 1883 they yielded bullion worth $1,280,000. The district was nearly dormant by 1888 owing to the exhaustion of the easily mined, high-grade, near-surface ores (Goodyear, 1888, p. 226), and properties were operated only intermittently by lessees until World War I.

The history from World War I until 1945 is quoted from Norman and Stewart (1951, p. 60).

... As these surface ores [of the Darwin district] were exhausted, however, the isolation of the district and unfavorable price fluctuation of metals allowed only intermittent operation until World War I, during which some of the principal mines, the Lucky Jim, Promontory, Lane, and Columbia, were operated by the Darwin Development Company, the Darwin Lead-Silver Development Company, and finally by the Darwin Silver Company. The Darwin Silver Company consolidated the Defiance and Independence mines with the others.

In 1919, the brokerage firm of W. W. Wagner and Company gained control of the properties, and under the management of W. A. Kirby, installed surface equipment, prepared some of the properties for production, and regraded the property. In 1921 the Wagner Company went bankrupt, and the Wagner Assets Realization Corporation, a creditors' organization, was formed to take charge of the assets. From 1922 to 1925, W. A. Kirby operated the properties on a lease. In 1925, C. H. Lord obtained a lease and bond on the properties and operated them as C. H. Lord, Trustee, until 1927. He then formed the American Metals, Incorporated, and continued operations until the end of the year. The Wagner Assets Realization Corporation then attempted to regain possession of the properties, but certain legal difficulties were not straightened out until 1936. Two of C. H. Lord's financial backers formed the Darwin Lead Company, obtained a lease and bond on the properties, and commenced operations in the fall of 1936 and continued until the summer of 1938. The Imperial Smelting and Refining Company, Mr. Sam Mosher and Ralph Davies and associates began operating the property in 1940. Later Mr. Davies withdrew, and Mr. Mosher and an association of officers of the Signal Oil Company continued operations as the Imperial Metals, Incorporated. In March 1943, Arthur J. Theis and associates took over the operation under the name Darwin Mines, although Imperial Metals, Incorporated retained an interest. The Anaconda Copper Mining Company purchased the property on August 1, 1945.

The Anaconda Company has operated the Darwin mines since 1945, except for brief shutdowns in 1948 and from March 1954 to January 1955. Most of their production has come from the Defiance, Essex, Independence, and Thompson mines. The Lucky Jim mine was rehabilitated in 1948, but no ore has been mined from it since then.

Talc was first mined in the Tale City Hills sometime prior to 1919. Waring and Huguenin (1919, p. 126) described operations at the Tale City mine—then called Simonds tale mine—in their biennial report for 1915-1916. In 1918 the Simonds tale mine was purchased by the Inyo Talc Company, which later became known as the Sierra Talc and Clay Company. The Sierra Talc and Clay Company operated the Tale City mine and several smaller deposits continuously since 1918.

Scheelite was recognized in the eastern part of the Darwin district during World War I and was mentioned by Kelley (1938, p. 543), but no deposits were developed until 1940. The principal production of tungsten was in 1941 and 1942 by the Pacific Tungsten Company.

Distribution

Deposits of lead-silver-zinc are widely distributed throughout the Darwin quadrangle. The largest deposits are in the southern part of the quadrangle in the Darwin Hills north and east of the town of Darwin. Other de-
deposits have been mined at Zinc Hill 6 miles northeast of Darwin, in the Lee district at the south end of the Santa Rosa Hills, at the Santa Rosa mine in the Iryo Mountains, and at a few small deposits in the Tale City Hills (Pl. 1).

**Ore Controls**

Most of the lead-silver-zinc deposits are in calc-hornfels close to an intrusive contact. The deposits in the Darwin Hills are in calc-hornfels of the lower member of the Keeler Canyon formation of Pennsylvania and Permian age. The Santa Rosa mine is in calc-hornfels of the lower member of the Owens Valley formation of Permian age. A few small deposits are in marble or limestone.

No individual formation can be considered as particularly favorable for ore deposits, although within mineralized areas certain beds are favorable. In general, all formations consisting of limestone seem to be favorable for lead-silver-zinc deposits, and formations of dolomite and quartzite appear unfavorable. The deposits in the Lee district are in the Lost Burro formation of Devonian age and the Tin Mountain limestone of Mississippian age. The Cactus Owen prospects and the Homestake mine in the Tale City Hills are in a limestone unit of the Lost Burro formation. Deposits in the Zinc Hill district are mainly in Mississippian limestone. The Silver Dollar mine is in limestone of Pennsylvanian age near a thrust fault contact with older dolomite. Dolomite and quartzite in the Tale City Hills contain talc deposits, but only the limy parts of the formations contain lead-zinc deposits.

The generalization that limestone is favorable for lead-silver-zinc deposits and dolomite is unfavorable is also true in the Cerro Gordo area northwest of the Darwin quadrangle. However, the major lead-silver mines in the Ubehebe Peak quadrangle, the Lippincott and Ubehebe mines, are mainly in dolomite (McAllister, 1955, p. 20).

Within mineralized areas, certain beds in a formation are more favorable than other beds. In the Darwin district a medium-grained wollastonite-garnet-idocrase calc-silicate rock formed from a fairly pure limestone is favorable, but dense, gray or greenish-gray calc-hornfels formed from silty limestone is unfavorable. At the Zinc Hill mine all the known ore bodies are in one favorable marble bed 200 feet thick, while other limestone beds are only slightly mineralized.

Individual deposits occur within favorable horizons as replacement bodies along faults, as bedded replacements commonly near the crests of folds, and as steep irregular or pipelike ore bodies. A fault control is apparent for nearly all the deposits, although it may be only one of several controls instrumental in localizing ore. In the Darwin district, most of the ore bodies are in favorable beds in or close to steep-dipping strike-slip faults striking N. 50°-70° E. that served as feeder channels for the ore solutions. The ore is in the N. 50°-70° E. faults at the Christmas Gift, Lucky Jim, and Rip Van Winkle mines. At the Thompson mine the ore is in north-striking fractures that are close to the N. 50°-70° E. faults, and the fractures are progressively less mineralized away from the northeast-striking faults. An exception is the Essex ore body, which is in a fault that strikes N. 65° W.

Bedded replacement bodies are at the Defiance, Independence, Jackass, Custer, Promontory, and Empress-Zinc Hill mines. At both the Defiance and Independence mines the bedded replacement bodies are at the ends of gentle folds close to a granodiorite sill. The body at the Defiance mine becomes progressively thinner outward along bedding away from the northeast-trending Defiance fault.

The largest steep pipelike ore body is at the Defiance mine; this ore body has been developed from the 1,000-foot level to the 1,000-foot level. It is adjacent to the Defiance fault and is localized in a zone broken up by numerous small fractures that strike northerly from the Defiance fault.

In the Lee district, ore bodies are localized in lying fractures between major steep-dipping faults. Flat fractures may parallel bedding or transsect beds. A similar structural environment at the Ubehebe mine has been described by McAllister (1955, p. 27) and has been observed by the writers about 11 miles southeast of Darwin at the Defense mine in the Argus Range.

The ore bodies range in size from small pods to contain a few tens of tons of ore, as in the Lee mine, to the large bedded replacement bodies of the Independence mine or pipelike ore body of the Defiance mine in the Darwin district. The bedded ore body at the Independence mine is mineralized, although not all of it is grade, for a maximum strike length of 500 feet, a thickness as much as 160 feet, and a distance of 700 feet down the dip. The pipelike ore body of the Defiance mine has been developed 700 feet vertically from 125 feet above the 400-foot level to the 1,000-foot level, but its total vertical extent is not delimited. The mineralized area is approximately 5,000 square feet in cross section, but it is not all ore.

**Mineralogy**

The minerals identified in the lead-silver-zinc deposits in the Darwin quadrangle are listed below.

**Hypogene minerals**

<table>
<thead>
<tr>
<th>Ore and sulfide minerals</th>
<th>PbAgSbS6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andorite...</td>
<td>PbAgSbS6</td>
</tr>
<tr>
<td>Argentite...</td>
<td>AgS</td>
</tr>
<tr>
<td>Arsenopyrite...</td>
<td>FeAsS</td>
</tr>
<tr>
<td>Bismuth (?)...</td>
<td>Bi</td>
</tr>
<tr>
<td>Bornite...</td>
<td>CuFeS</td>
</tr>
<tr>
<td>Chalcopyrite...</td>
<td>CuFeS</td>
</tr>
<tr>
<td>Enargite-fannaminite (?)</td>
<td>CuAsS6.CuSbS6</td>
</tr>
<tr>
<td>Fraskeite...</td>
<td>PbSbSnSbS</td>
</tr>
<tr>
<td>Galena...</td>
<td>FeS</td>
</tr>
<tr>
<td>Guanajuatite (?)...</td>
<td>BiS</td>
</tr>
<tr>
<td>Maltidite...</td>
<td>AgSbS</td>
</tr>
<tr>
<td>Pyrite...</td>
<td>FeS</td>
</tr>
<tr>
<td>Pyrrhotite...</td>
<td>FeS-As</td>
</tr>
<tr>
<td>Scheelite...</td>
<td>CaWO4</td>
</tr>
<tr>
<td>Sphalerite...</td>
<td>ZnS</td>
</tr>
<tr>
<td>Stannite...</td>
<td>CuFeSnS4</td>
</tr>
<tr>
<td>Tetrahedrite-tennantite</td>
<td>(Cu,Fe)10SbS6.Si12(Cu,Fe)20AsS6</td>
</tr>
<tr>
<td>Unknown lead-bismuth-zeo-</td>
<td></td>
</tr>
<tr>
<td>nium sulfosalts...</td>
<td></td>
</tr>
</tbody>
</table>

**Canga minerals**

| Barite...                | BaSO4     |
| Calcite...               | CaCO3     |
| Chaledony...             | SiO2      |
| Dewellite...             | MgSiO3.6H2O |
| Diopside...              | CaMgSiO3  |
| Fluorite...              | CaF2      |
| Garnet sp. andradite...  | Ca3(Al,Fe)SiO4 |
| Graphite...              | C         |
| Idocrase...              | CuAl(OF,OH)Al2(SiO4) |
| Jasper...                | SiO2      |
| Kaolinite...             | H2Al2SiO5  |
| Montmorillonite...       | (OH)Al2SiO5.12H2O |
The minerals of the pyrogenic ore and sulfide minerals consist principally of galena, sphalerite, pyrite, pyrrhotite, and chalcopyrite with minor tetrahedrite, scheelite, andorite, andorite, tennantite, enargite-famatinite, matildite, th(A) and an unidentified lead-bismuth-selenium salt. Argentiferous galena is the principal ore mineral. It ranges in texture from coarse crystalline to fine-grained steel galena. Corroded inclusions of tetrahedrite, pyrrhotite, and chalcopyrite are common in galena. Some of the steel galena from the Essex contains tiny lamellar inclusions oriented along planes that are probably matildite that has been converted to galena. The inclusions are similar in appearance to reflectivity of galena and are distinctly anisotropic from light to dark gray. The galena with inclusions has a bismuth and silver peaks on the x-ray spectrometer. Some galena from Essex mine distinct selenium peaks on the x-ray spectrometer may be clausenthalite. Sphalerite is common in all the primary ore and is the dominant pyrogenic mineral at the Zinc Hill. It is commonly in coarse crystalline masses with faces 1 to 2 inches in diameter. Pyrite is abundant in the lead-zinc deposits except at the Lee mine, also widely distributed through the country rock. The Harvard mining district is characterized by coarse tetrahedrite, pyrrhotite, and chalcopyrite in the ore bodies. Chalcopyrite is a minor constituent ore and occurs as corroded inclusions in sphalerite.

Of the primary lead-zinc ore contains scheelite, chalcopyrite, and chalcedony crystals 1/2 to 1/2 inch diameter, and many euhedral crystals have been redblood embedded in oxidized ore (Davis and

*Photo 1. Specimen from Thompson mine showing subhedral scheelite crystals (s) embedded by galena (g).* Peterson, 1948, p. 2). Similar crystals of scheelite surrounded and embayed by galena have been found in the deep levels of the Thompson mine (photo 1).

Franckeite, andorite, bismuth, stannite, and enargite-famatinite (?) were identified by Charles Milton of the U.S. Geological Survey from a silver-rich ore body in the 534 stope above the 400 level of the Thompson mine. Franckeite is in the silver-rich primary ore bodies that contain little galena. It is in thin, tabular, banded crystals as much as 1/2 inch long that are prominently striated. In polished section, tiny irregular white inclusions are visible irregularly distributed through the franckeite. The inclusions may be guanajuatite (Bi₂Se₄), as both bismuth and selenium were indicated by the x-ray spectrometer. Andorite is associated with the franckeite and may account for the high silver content where sulfantimonides are present. It is in thin tabular crystals similar in appearance to franckeite, but the presence of both minerals was verified by x-ray diffraction pattern by J. M. Axelrod of the U.S. Geological Survey. An unidentified lead-bismuth-selenium sulfosalts that may be a new mineral is associated with franckeite in the Thompson mine. The sulfosalts is a silver-white tabular mineral that is prominently striated. The x-ray diffraction pattern does not agree closely with any known sulfide mineral. The presence of bismuth, lead, and selenium was indicated by the x-ray spectrometer.

The gangue minerals consist principally of calcite, fluorite, garnet, and jasper with minor barite, clay minerals, diopside, idocrase, orthoclase, quartz, and wollastonite. Both calcite and fluorite are directly associated
with ore minerals. Calcite is very coarsely crystalline at some of the deposits in the Darwin Hills. Dark calcite rhombohedrons 2 to 6 inches long are abundant at the surface workings of the Defiance mine. It is also particularly abundant at the Custer mine where rhombohedrons as much as 24 inches long make up most of the vein, and the lead minerals form pockets or chimneys interstitial to the calcite. Fluorite is commonly intergrown with galena, and the miners have used it as an indicator of ore. It ranges in color from colorless to light green, light blue, or rose, and was noted at nearly all the mines in the Darwin district. Garnet, idocrase, diopside, and wollastonite were formed by recrystallization of the limestone to silicate minerals before the period of metallization, and they are in part replaced by ore minerals. Jasper is in some of the ore bodies formed in major fault zones. It is particularly abundant as a gangue mineral at the Santa Rosa mine. Only small quantities of barite are found in the Darwin district, but it is an abundant gangue mineral at the Lee mine and Silver Reid prospect in the Lee district.

**Supergene Minerals**

The zone of oxidation at most places in the Darwin quadrangle is deep. The ore is largely oxidized except where protected from oxidation by an impermeable layer or in the deeper levels of the Darwin mine. The oxidized ore is a porous, crumbly mass composed mainly of limonite, hemimorphite, and cerussite with some unaltered relics of galena. At the Defiance mine the ore was mainly oxidized to the 400-foot level, and both oxide and primary ore extend from the 400-foot level to the 1,000-foot level. At the Lucky Jim mine, only small relics of primary sulfide minerals extend down to the deepest workings on the 920-foot level. Anglesite forms a thin alteration halo around some of the galena. Hydrozincite, plumbojarosite, pyromorphite, and smithsonite are less abundant in the oxidized ore. At some places, secondary copper minerals accompany the secondary lead and zinc minerals. Aurichalcite, azurite, bronchonite, caledonite, chrysocolla, linarite, and malachite have been identified from the Darwin district. Some of the oxidized near-surface ore mined during the early history of the Darwin district is reported to have contained as much as 950 ounces of silver per ton (Raymond, 1877, p. 30). Native silver, cerargyrite, and sooty argentite are reported in the oxidized ore at Darwin (Kelley, 1938, p. 546; Davis and Peterson, 1948, p. 2; and Carlisle and others, 1954, p. 46). Euhedral crystals of cerargyrite were identified from the Lee mine. Other minerals found in small quantities in the zone of oxidation are bindheimite, creedite, crocoite, goiartite, jaroite, melanterite, pyrolusite, sulfur, vanadinite, and wulfenite. Small quantities of chalcocite and covellite are in some of the sulfide ore.

**Primary Zoning**

The hypogene mineralization within the Darwin area shows a general zonal distribution, which probably can be correlated with an overall temperature gradient at the time of ore deposition. In general the near-surface ore contains more lead and silver, but with depth the zinc-to-lead content increases and the silver content decreases. The Defiance workings of the Darwin mine will be used as an example. The near-surface primary ore in the bedded deposits consisted mainly of galena with above-average content of silver. The gangue minerals are largely calcite, fluorite, and jasper. The upper portion of the steep pipe-like Defiance ore body consisted predominantly of galena that had a lower content of silver than the overlying bedded deposits. Some sphalerite is present in this ore. With increasing depth in the Defiance body the proportion of zinc to lead shows a definite increase and the silver content of the ore shows a decrease. Pyrite also shows a marked increase in deeper levels of the mine. The gangue minerals predominantly consist of garnet, wollastonite, and calcite. It should be emphasized, however, that there are many local variations within this general zonal distribution.

Zoning is also evident between the lead-silver bodies and the tungsten ore bodies on the east side of the stock of the Darwin Hills; the lead-silver ore bodies are farther out along the same faults that control the tungsten ore bodies.

Scheelite with little or no associated galena is found in the quantity and care-fulls in the Fernando adit for a distance of 600 feet from the portal west to the contact of the stock of the Darwin Hills. Lead-silver ore is 450 N. 70° E. of the tungsten ore—farther from the stock—in the Fernando fault at the old Fernando workings. Similarly at the St. Charles No. 3 workings scheelite ore is close to the stock of the Darwin Hills and the ore at the Custer mine is localized by the same fractures but farther from the intrusive Lane Canyon, scheelite is found in tactite along the rest of the contact of intrusive but lead-silver ore at the Lane and Santa mines to the east is still farther from the intrusive.

The Jackass mine, where both scheelite and lead-silver ore are found within a few feet of each other, is exception to the zoning on the east side of the stock. Scheelite is disseminated in tactite while the lead-silver ore with no scheelite is in a bedding plane fault at the footwall contact of the tactite with care-fulls found an undoubtedly later.

**Darwin Silver-Lead-Zinc District**

by W. E. Hall, E. M. Mackevett, and D. L. Davis*

The Darwin silver-lead-zinc district, which is in the southern part of the Darwin quadrangle, is within the New Coso mining district. The Darwin district is extensive with the Darwin Hills. The district is 39 by paved road from Lone Pine, the nearest supply center. The nearest railroad is at Keeler, the southern terminus of the Southern Pacific Railroad Company's rail gauge line from Keeler to Laws, Calif. The Anaconda Company maintains a modern mining camp, including housing, grocery store, and recreational facilities, 10 miles north of Darwin.

The Darwin district can be divided into two parts: Lead, zinc, and silver are the principal commodities mined in the western part, while tungsten is the principal commodity mined in the eastern part. Most of the mines in the western part of the district have been solidated under one management since World War I, they are commonly referred to as the Darwin mines. The Darwin mines consist of the Berron, Column, Defiance, Driver, Essex, Independence, Lane, Libra, 

* Former resident geologist, The Anaconda Company, Darwin M
Table 3. Ore produced from the Darwin silver-lead-zinc district.*†

<table>
<thead>
<tr>
<th>Year</th>
<th>Gold (oz)</th>
<th>Silver (oz)</th>
<th>Copper (lbs)</th>
<th>Lead (lbs)</th>
<th>Zinc (lbs)</th>
<th>Operator or Mine</th>
</tr>
</thead>
<tbody>
<tr>
<td>1875</td>
<td>1,571,000</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>DEFANCE MINE</td>
</tr>
<tr>
<td>23.51</td>
<td>-</td>
<td>26,759</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>CHEYENNE MINE</td>
</tr>
<tr>
<td>7.26</td>
<td>-</td>
<td>70,095</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>CUSTER MINE</td>
</tr>
<tr>
<td>21.9</td>
<td>-</td>
<td>20,362</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>CUSTER MINE</td>
</tr>
<tr>
<td>64</td>
<td>-</td>
<td>5,517</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>CUSTER MINE</td>
</tr>
<tr>
<td>56</td>
<td>-</td>
<td>54,800</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>CUSTER MINE</td>
</tr>
<tr>
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* Defiance Mine, New Coso Mining Co.
† Phoenix Mine
- Custer Mine; J. A. McKenzie; H. Mettler; Phoenix Mine
- Christmas Gift Mine; Henry Mettler
- Custer Mine; J. A. McKenzie; Henry Mettler
- J. A. McKenzie and W. W. Bowwall
- R. C. Troeger
- Custer Mine; Last Chance Mining Co.; J. A. McKenzie; Phoenix Mine
- W. W. Bowwall; J. A. McKenzie; Phoenix Mine
- J. A. McKenzie; Phoenix Mine
- J. A. McKenzie
- Inyo County Mining and Dev. Co.; J. A. McKenzie
- Christmas Gift Mine; Inyo County Mining and Dev. Co.
- C. G. Bradford; Inyo County Mining and Dev. Co.; New Coso Mining Co.
- New Coso Mining Co.
- New Coso Mining Co.
- Christmas Gift Mine; New Coso Mining Co.; S. H. Reynolds
- New Coso Mining Co.; S. H. Reynolds
- Christmas Gift Mine; Independence Mining Co.; New Coso Mining Co.
- Christmas Gift Mine; Custer Mine; New Coso Mining Co.; J. C. Rooper; M. J. Summers
- New Coso Mining Co.
- Christmas Gift Mine; Darwin Development Corp.; Theo Peterson
- Christmas Gift Mine; Darwin Mines Corp.
- Christmas Gift Mine; Custer Mine; Darwin Mines Corp.; Theo Peterson; M. J. Summers
- A. A. Belin; Custer Mine; Darwin Silver Co.; A. G. Kirby; Rooney and Bradford
- Custer Mine; Darwin Silver Co.; Theo Peterson; M. J. Summers
- Custer Mine; Darwin Silver Co.; Theo Peterson; M. J. Summers
- Darwin Silver Co.; A. G. Kirby
- A. A. Belin; L. D. Foreman and Co.
- American Metals Inc.; Christmas Gift Mine; L. D. Foreman and Co.
- American Metals Inc.; Christmas Gift Mine; L. D. Foreman and Co.
- American Metals Inc.
- Custer Mine
- Custer Mine; Darwin Keystone Ltd.; Darwin Lead Co.; Louis Warnken, Jr.; J. B. Anthony
- Custer Mine; Theo Peterson
- Imperial Metals, Inc.
- Imperial Metals, Inc.; L. D. Foreman and Co.
- Darwin Mines
- Darwin Mines; L. D. Foreman and Co.; Wonder Mine
- The Anaconda Co.; L. D. Foreman and Co.
- The Anaconda Co.; L. D. Foreman and Co.
- The Anaconda Co.; L. D. Foreman and Co.; Wonder Mine
- The Anaconda Co.; Custer Mine; L. D. Foreman and Co.; Keystone Mine; St. Charles Mine
- The Anaconda Co.; Custer Mine; Keystone Mine
- The Anaconda Co.
- The Anaconda Co.; Custer Mine; Keystone Mine
- The Anaconda Co.
- The Anaconda Co.; Union Bell; Lane; Promontory

The production from 1875 to 1883 was estimated by the writers from smelter returns listed in the report to the stockholders in 1877 by the New Coso Mining Company, and from value of production given in early descriptions of the district in the Coso Mining News and by Burchard (1884, p. 164). The production data from 1888 to 1942 for the Darwin mines were compiled by the Mineral Production and Economics Division of the U. S. Bureau of Mines. The production figures for the other mines in the district are from annual records from the U. S. Bureau of Mines, Metal Economics Branch, San
Francisco office. All production figures are published with the permission of the mine owners. The production of lead, zinc, and silver from 1943 through 1951 is from the Minerals Yearbook.

No record of production was found for some of the smaller mines. Possibly their production was combined with shipments from other properties, and they did not receive recognition for their ore.

Grade of Ore

Before 1942 mainly high-grade oxidized silver-lead ore with some relict galena was mined from shallow workings at the Darwin mine. Smelter returns of the New Coso Mining Company prior to April 1877 show that 29.5 percent lead and 47 ounces of silver per ton of ore were recovered from its furnaces (Robinson, 1877, p. 38). Burchard (1884, p. 164) reports that ore from the Defiance and Independence mines averaged 30 percent of lead and $40 (31 ounces) of silver per ton. The grade of ore must have been very erratic as Raymond (1877, p. 30) reports ore at the Defiance mine assayed up to $1,225.29 (950 ounces) of silver per ton and 56 percent lead.

Production data compiled during World War II by the U. S. Bureau of Mines, Metal Economics Branch, indicate that 102,524 tons of ore was mined from the Darwin mines from 1902 through 1942. The average recovery from this ore was 0.03 ounces of gold per ton, 8.7 ounces of silver per ton, 0.2 percent copper, and 7.3 percent lead. The zinc content of the ore is not known, and probably little zinc was recovered.

Since 1942, production of sulfide ore from the Darwin mine has exceeded that of oxide ore. The grade of sulfide ore averages approximately 6 percent lead, 6 percent zinc, and 6 ounces of silver per ton. A considerable tonnage of high-grade ore containing approximately 20 to 30 percent lead was produced and direct-shipped from 1944 through 1952.

Geology

The rocks in the Darwin district are marble, limestone, silty limestone, shale, and siltstone in an overturned section that ranges in age from Devonian at the northwest end of the Darwin Hills to Permian on the east side. A stock intrudes the Pennsylvanian and Permian rocks along the east side of the Darwin Hills. The Paleozoic rocks strike northerly and dip predominantly to the west. Within 4,000 feet of the stock the sedimentary rocks are mostly altered to calc-hornfels, marble, and tactite.

The Lost Burro formation of Devonian age is the oldest formation present. It crops out on the west side of the Darwin Hills 3,700 feet N. 47° W. of Ophir Mountain. It is about 600 feet thick and consists of banded white and light gray coarsely crystalline marble and minor gray limestone. The marble is correlative with the Lost Burro formation on the basis of stratigraphic succession, lithology, and very poor fragmentary fossils that resemble *Cladopora*.

The Tin Mountain limestone of Mississippian age crops out in a band east of the Lost Burro formation. The formation is about 300 feet thick and consists of thinly to medium-beded gray limestone that locally is bleached white. Fragmentary solitary corals and *Syringopora* are present. The Tin Mountain limestone is in fault contact with the Lost Burro formation, but the bedding-plane fault probably has little displacement, and almost all the formation is believed to be present.

The Perdido formation of Mississippian age crops on the west side of the Darwin Hills in a band approximately 350 feet thick adjacent on the east to the Mountain limestone. It consists of thinly bedded medium-gray limestone, bedded chert, and siltstone. Bedded plane faults of small displacement separate the Perdido formation from the Tin Mountain limestone on the west and from the Lee Flat on the east. The previously described formations—the Lost Burro, Tin Mountain, Perdido—are present only at the north end of the Darwin Hills northwest of Ophir Mountain, and they pass into alluvium in the vicinity of the Darwin mine.

The Lee Flat limestone of Mississippian and Pennsylvanian (?) age is the oldest formation in the Darwin mine area. It crops out from the north end of the Aconda Company mining camp to the north of the Darwin Hills. The formation consists of thin-to-medium-beded gray limestone that contains thin beds of chert and iron-stained hornfels. Locally the limestone is bleached white and is recrystallized to marble. The formation is about 500 feet thick, but part of the section may be cut out by faulting.

The Keeler Canyon formation of Pennsylvanian age underlies most of the Darwin Hills, and is the host rock for most of the ore deposits in the Darwin district. It crops out along the crest and slope of the Darwin Hills north of the Darwin mine and constitutes all of the Paleozoic rocks in the Darwin Hills south of the Darwin mine. The formation is about 4,000 feet thick and consists of bluish-gray limestone, silty limestone, sandy limestone, pink shale, and siltstone. The lower part of the formation is mostly limestone, and the upper part contains abundant shale and interbedded limestone. The unaltered formation is what is exposed north of the Darwin tear fault in the vicinity of the Darwin Antimony mine. South of the Darwin tear fault the formation is mostly altered to calc-hornfels and tactite.

The Golfball horizon, which is thin-beded bluish-gray limestone with ⅓- to ⅓-inch spherical chert nodules and which locally contains sparse tiny fusulinids, crops out along the western contact of the limestone sequence between Ophir Mountain and the Darwin mining camp. This horizon is characteristic of the base of the formation throughout the Darwin, New York Butte, Panamint Butte, and Ubehebe Peak quadrangles.

The Owens Valley formation of Permian age is present on the east side of the Darwin Hills 2,700 feet east of the Darwin Antimony mine and 3,500 feet east of the Christmas Mine. It consists of light- to medium-light- to medium-beded calcarenite, siltstone, shale, and lenses of massive pure limestone. The calcarenite commonly is cross-beded.

The rocks of Paleozoic age are intruded by a stock along the central part of the Darwin Hills and by small concordant pluton on the west slope of Ophir Mountain. The batholith of the Coso Range crops locally along the west edge of the Darwin Hills.
structure

The northwest trending Darwin Hills are an overturned syncline with an axial plane that dips west; the syncline is bounded by the stock of the Darwin Hills along the east edge of the hills. The Paleozoic rocks west of the stock strike northerly and dip mainly 30° to 70° W. in an overturned section on the west limb of the overturned syncline. East of the stock the beds also dip west in an overturned section as far east as the Lucky Jim, Christmas Gift, Wonder, St. Charles, and Durham-Fernando shafts, that is, about 800 to 1,200 feet east of the stock. Evidence for the overturning is mainly on stratigraphic successions. The oldest beds are on the west side of Darwin Hills, and the rocks become progressively younger to the east. Bedding, however, dips predominantly west. Paleozoic rocks on the west side are similar to Devonian and Mississippian rocks elsewhere in the quadrangle, while fossiliferous Pennsylvanian and Permian rocks underlie the central and eastern parts of the Darwin Hills. The lithology of some formations is sufficiently distinctive to recognize that parts of some formations are to the west. The ball horizon is the best example. The faunal evidence is also suggestive of an overturned section, but is poorly preserved and the faunal evidence is conclusive except for fusulinids of late Wolfcamp (Permian) in many places along the east side of the quadrangle.

Locally the upper part of the Keeler Canyon formation and much of the Owens Valley formation is crossed by beds. Cross-bedding in the silty limestone of the upper Keeler Canyon formation 2,000 feet northeast of the Antimony mine corroborates the overturned section there.

East of the Lucky Jim, Christmas Gift, Wonder, St. Charles, and Durham-Fernando mines is a belt of highly iron-stained, dense calc-hornfels that is intensely folded. The belt of iron-stained calc-hornfels is the axis of the syncline and forms the transition between overturned beds to the west and right-side-up beds along the east edge of the hills (Photo 2).

In some places, bedding in this deformed belt is readily apparent and the folds are easily resolved, but in most places the rocks are fractured and their folded nature is not apparent except by close examination. The crests of folds, in particular, are commonly shattered. Fracture cleavage locally is well developed in this deformed belt and is an aid in determining tops of beds. In tight, overturned folds fracture cleavage is usually well developed on the right-side-up limb, but it is poorly developed on the overturned limb where it tends to be nearly parallel to bedding.

The folded beds are exposed in the canyon that drains east from the Lucky Jim mine and in the canyon to the north. At the Lucky Jim mine the overturned beds strike northerly and dip west. An overturned Minor syncline with an axial plane that dips west is about 600 feet northeast of the main shaft. If one continues east down the canyon from the mine, the beds may be seen to pass through several tight minor anticlines and synclines before passing into right-side-up beds with broad folds 2,200 feet east of the mine. The beds continue to dip gently east in Darwin Wash to Darwin Canyon, and the beds dip west on the east side of the canyon.

In the Durham-Fernando mine area the beds likewise are overturned and dip to the west. The axis of an overturned syncline crops out in the gully 500 feet N. 77° E. of the Durham shaft. (See pl. 9.) An open anticline is 30 feet east of the overturned syncline, and the beds pass through gentle folds with right-side-up beds continuing to the east.

At many places, although the exact nature of the transition from right-side-up to overturned beds is not evident because of inadequate exposures, some tight folds are recognized. At some places, as at the Custer mine,
The Paleozoic rocks are intersected by four sets of faults. The four sets are described under the subtopic "Darwin mine" as the faults are important in localizing ore. The largest fault is the Darwin tear fault, which is a left-lateral strike-slip fault that strikes N. 70° W. Displacement on the fault is 2,300 feet, the north block moving west.

**Belle Union Mine**

The Belle Union mine, owned by The Anaconda Company, is in sec. 12, T. 19 S., R. 40 E., at altitudes near 5,200 feet. It is one of the old mines in the district but in recent years has been inactive. Mine workings including three shafts are largely inaccessible and their size and extent are not known. The mine is in calc-hornfels of the Keeler Canyon formation near a salient of the Darwin Hills stock. The ore is in a near-vertical vein trending N. 58° E. Observed ore minerals on the dumps and in the highly iron-stained vein include galena, cerussite, and hemimorphite.

**Buckhorn Mine**

The Buckhorn mine, which is owned by Andrew Sundberg, is in sec. 31, T. 18 S., R. 41 E., at an altitude of 4,240 feet. The mine is developed by two shafts, one about 30 feet deep inclined northerly at 70°, and the other inclined to the northwest at 30°. Other workings include minor pits and open cuts south of the main workings. Production from the property is small.

The mine is in silt limestone of the lower member of the Owens Valley formation. Ore is a replacement of a fault zone that strikes N. 70° E. and dips 30° N. Another fault, which strikes N. 28° W. and dips 70° N., apparently cuts off and displaces the N. 70° E. fault. Ore minerals consist of cerussite, hemimorphite, and minor galena in an iron-stained quartz-calcite gangue. The size or grade of the ore body is not known.

**Christmas Gift Mine**

The Christmas Gift mine is 2$\frac{1}{2}$ miles north of Darwin in secs. 1 and 12, T. 19 S., R. 40 E., at an altitude of 5,440 feet. The property is accessible by a dirt road 2$\frac{1}{2}$ miles long that branches off the Darwin to Lone Pine highway 2.2 miles northwest of Darwin. The mine is owned by C. B. Skinner of Morro Bay, Calif.

The recorded production from the Christmas Gift mine since 1893 is given in table 4. The total production from 1875 to 1893 is not known. Both the Christmas Gift and Lucky Jim mines were owned by the New Coso Mining Company during the early history of the district and the production of both mines was lumped. Burchard (1884, p. 164) reports the production of the two mines by 1883 to be $750,000. The Christmas Gift mine was worked extensively in 1875 and early 1876 according to the annual report of 1877 to the stockholders, and 8,571 bars of silver were produced from the Christmas Gift during this period (estimated by the writers to contain 83,500 ounces of silver and 700,000 pounds of lead). Apparently most of the production between the spring of 1876 and 1883 came from the Lucky Jim mine.

**Table 4. Ore produced from the Christmas Gift mine since 1875.**

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* Published with the permission of the mine owners.

The mine workings consist of 5 shafts, several adit~

totaling more than 600 feet in length, and many cut~
s and shallow shaft. The Christmas Gift shaft is sunk on the vein to a depth of 250 feet, and a win extends 126 feet below the 250-foot level. These approximately 1,900 feet of levels from the shaft is winze. The Johnny John shaft is reported by Norm and Stewart (1951, p. 59) to be 250 feet deep, but was inaccessible. The other shafts are 90 to 100 feet deep. The Christmas Gift area is underlain by quartz monzonite and calc-hornfels and hornfels that is metamorphosed limestone and silt limestone of the lower member of the Keeler Canyon formation (pl. 3). The ore deposits are in calc-hornfels that relates with the uppermost part of the lower member of the Keeler Canyon formation (photo 3). The low member consists of white to light-gray dense calc-hornfels with 1- to 2-inch thick greenish-gray dense hornfels bands that are metamorphosed shale. The calc-hornfels of the lower member of the Keeler Canyon formation is intruded by small irregular bodies of quartz monzonite and granodiorite that line up in a north direction. The contact with the upper member of the Keeler Canyon formation is 370 feet northeast and 8 feet east of the Christmas Gift shaft. The upper member consists of dense greenish-gray hornfels that weather dark brown.

Bedding is overturned in the metasedimentary rock. It strikes predominantly north to N. 40° W. and dip 25° to 30° W. The rocks are cut by many faults that strike N. 30°-70° E. and dip steeply northwest. The displacement where recognized is left lateral. Nearly horizontal slickensides exposed underground confirm the strike-slip displacement on the fault through the Christmas Gift shaft.

Ore in the Christmas Gift mine is localized in fault that strike N. 30°-70° E. Seven faults have been projected, but most of the ore was mined from the Christmas Gift vein, which is exposed in the Christmas Gift shaft. Ore minerals are exposed along the Christmas Gift vein intermittently for a strike length of 700 feet and to depth of 334 feet, but only locally is the grade sufficient high to be ore. Most of the ore in the vicinity of the Christmas Gift shaft has been mined between the shaft and the No. 6 level, a vertical distance of 146 feet.
ore shoot strikes N. 40°-50° E. and dips 70°-80°; it rakes steeply to the southwest. Average thickness of the vein is about 3 feet.

The ore is oxidized in the deepest mine workings, where minor reliefs of galena remain. The vein is predominantly of limonite and cerussite in a bed of calcite and jasper and locally they contain green secondary copper minerals.

Structural control for ore shoots related to strike of fault zone seems evident. The ore is localized where faults strike approximately N. 45° E., and the faults only slightly mineralized where the strike is N. 65° E. As the faults had a left-lateral displacement, the ore zones were open where the strike is N. 45° E. — favorable for ore deposition—and tight where the strike is N. 65°-70° E. This is illustrated by the ore zone on the No. 10 level (pl. 4). The mineralization is restricted to the part of the fault southwest of the zone where it strikes N. 35° E. and dips 68° NW. The dip steepens unmineralized northeast of the winze where the dip changes to N. 70° E. and the dip steepens to approximately vertical.

A pocket of ore was mined from a shaft 670 feet N. 6° off the Christmas Gift shaft. The shaft is 98 feet deep with 5 short levels. Ore was stope from the bottom to the surface but the tonnage mined was small. Ore was also mined from shallow adits and open along the veins at the north end of the property.

Custer Mine

The Custer mine is in sec. 19, T. 19 S., R. 41 E., on the side of the Darwin Hills a mile N. 70° E. of Darwin, in the narrow canyon half a mile south of Lane mill at an altitude of 4640 feet. The mine is accessible by a 1 mile long that leads east from Darwin down the canyon past the St. Charles mine or by a road 1.1 miles long that heads southerly from Lane mill (see pl. 9).

The mine is owned by Harry R. Staples and Paul C. Staples of Oxnard, Calif. The property is developed by an inclined shaft 400 feet deep that bears S. 60° W. at -50°. The collar of the shaft is at an altitude of 4,641 feet and levels extend off the shaft at altitudes of 4,600 feet (50-foot level), 4,503 feet (200-foot level), 4,452 feet (250-foot level), 4,396 feet (300-foot level), and 4,308 feet (400-foot level). A winze extends 240 feet below the 400-foot level.

The recorded production from the Custer mine is 994 tons from which 96,614 pounds of lead and 10,492 ounces of silver were recovered. In addition, 6,123 ounces of silver were recovered during the 1890's from an unknown amount of ore. The total production is given below:

Table 5. Ore produced from the Custer mine.*

<table>
<thead>
<tr>
<th>Year</th>
<th>Tons</th>
<th>Gold (oz.)</th>
<th>Silver (oz.)</th>
<th>Copper (lbs.)</th>
<th>Lead (lbs.)</th>
<th>Zinc (lbs.)</th>
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<tr>
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<td>-</td>
<td>-</td>
<td>579</td>
<td>-</td>
<td>-</td>
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<td>198</td>
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<td>198</td>
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<td>251</td>
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<td>8</td>
<td>119</td>
<td>396</td>
<td>-</td>
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<td>2.00</td>
<td>165</td>
<td>416</td>
<td>2,674</td>
<td>72</td>
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<tr>
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<td>994</td>
<td>141.57</td>
<td>16,615</td>
<td>6,622</td>
<td>96,614</td>
<td>72</td>
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* Published with the permission of the mine owners.
PHOTO 4. View looking west at the east slope of the Darwin Hills showing the surface workings of the Darwin mine. The smooth slopes in the foreground are underlain by the stock of the Darwin Hills (Kqm) and the skyline is calc-hornfels of the Keeler Canyon formation (CPk).

PHOTO 5. View looking east at the Darwin mining camp and the west side of the Darwin Hills. The hills are composed mainly of an overturned section of calc-hornfels of the lower part of the Keeler Canyon formation (CPk). On the left side are remnants of the Lee Flat limestone (Cf) of Mississippian and Pennsylvanian (T) age in fault contact with the Keeler Canyon formation. The Copper fault and the parallel northeast-striking fault are one of the structural controls for ore.
the uppermost part of the lower member of the Ophir Canyon formation crops out in the mine area. It consists of anaphitic light-gray, greenish-gray, and gray calc-hornfels and beds of bluish-gray limestone which are in part altered to tectite. A fault contact between the lower and upper members of the Keeler Canyon formation is about 150 feet northeast of the inclined shaft. The upper member consists of anaphitic greenish-gray calc-hornfels that is characteristically highly iron stained on weathered surfaces.

The Keeler Canyon formation is intruded by a quartz monzonite dike 300 feet S. 65° W. of the collar of the adit. It strikes N. 50° to 70° E. and dips steeply either north or south. Displacement on the faults is slight.

The ore body at the Custer mine is in calc-hornfels and is parallel to bedding. The bedded deposit consists dominantly of coarse calcite and quartz with pockets of interstitial material composed of cerussite, galena, jarosite, pink and green fluorite, and locally amounts of malachite. The calcite is gray to white color and commonly occurs as rhombohedrons 12 to 15 inches in diameter. Some scheelite is exposed in the ore.

The ore body is inconspicuously exposed at the surface. On the 50-foot level it is approximately 60 feet long and 6 to 10 feet thick, and it is stope for about 30 feet above the level. The shape of the ore body is lenticular in plan view, and it has a long axis that pitches nearly right down the dip. The bedded deposit is strong on the 200-foot and 300-foot levels. On the 200-foot level it is 110 feet long and is terminated on the north by a pre-mineral fault that strikes N. 70° E. and dips 10° W. The thickness of the ore body is erratic. Within 5 feet it ranges from a few inches to 10 feet thick. The ore body is stope for about 70 feet above the level for 15 feet below the level. On the 300-foot level the material of the ore body has decreased, and the bedded deposit consists mainly of quartz and calcite. It is 60 feet long and a maximum of 40 feet wide. Locally it contains pockets of galena and cerussite. The calcite-quartz vein extends to the 400-foot level, but it carries very little lead at this depth except locally at the northwest end and Permian rocks along the east side of the Darwin Hills in the vicinity of the Defiance, Thompson, and Independence workings. The Lee Flat limestone of Mississippian and Pennsylvanian (?) age is the oldest formation in the mapped area. It crops out in a band along the west side of the Darwin Hills and at the top of Ophir Mountain (photo 5). It is a thin- to medium-bedded, medium- to dark-gray limestone. Locally the limestone is bleached white and recrystallized to marble close to its contact with the batholith of the Coso Range. The limestone is altered to massive, buff-colored dolomite 300 feet west of the Bernon workings (pl. 5). The dolomite resembles the Hidden Valley dolomite except for interbeds of the Lee Flat limestone.

The Keeler Canyon formation underlies most of the mine area. It is in fault contact with the Lee Flat limestone on the west side of the Darwin Hills and along the prominent ridge trending S. 60° W. from the top of Ophir Mountain. The lowermost part of the Keeler Canyon formation is exposed on the southeast side of the Ophir fault. The golfball horizon (limestone with spherical chert nodules) and limestone with sparse tiny fusulinids are in the prominent inverted syncline on the west flank of Ophir Mountain. Between the golfball horizon and the Davis thrust on the east side of the hills are interbedded bluish-gray thinly bedded limestone, thinly laminated, and minor siltstone. Much of the limestone is altered to a white, gray, brown, or greenish-gray dense calc-hornfels.

Nearly all of the ore is in the Keeler Canyon formation between the Davis thrust and the stock of the Darwin Hills. The formation in this interval consists of dense white calc-hornfels and white, fine- to medium-grained calc-silicate rocks. Idocrase crystals commonly 1/4 to 1/2 inch in diameter are characteristic of the calc-silicate rocks on the east side of the Davis thrust and are rare or absent in the calc-hornfels on the west side of the thrust. The idocrase-bearing calc-silicate rocks are west of the stock from the Independence workings south to the Susquehanna mine. This horizon also crops out north of Ophir Mountain as far as Belle Union mine.

The Keeler Canyon formation is intruded by the stock of the Darwin Hills in the vicinity of the Independence, Thompson, and Defiance workings, and by a nearly concordant intrusive on the southwest side of Ophir Mountain. The stock is made up of a heterogeneous mixture of diorite, granodiorite, quartz monzonite, and aplite. The intrusive rocks are deeply weathered, and north of the Defiance workings they are highly iron stained, which makes them easy to distinguish from the hard, lighter-colored calc-hornfels. The stock is composed predominantly of quartz monzonite and granodiorite. Granodiorite and quartz diorite are prevalent around the Defiance and Thompson workings but quartz monzonite and minor aplite are prevalent in the area extending from the Thompson workings to the Independence workings. Aplite also crops out south of the Defiance workings.

Quartz monzonite crops out on the west flank of Ophir Mountain as an essentially concordant intrusive 1,400 feet long and 600 feet wide. The sill is 1,100 feet east of the batholith of the Coso Range and is probably an offshoot from it. The south end of the sill is in contact with diorite and gabbro. Several small diorite and
gabro bodies are 200 to 700 feet west of the Bernon workings and are similar to the diorite at Darwin Falls, which is considered a granitized silty limestone.

Structure. The Paleozoic rocks in the mine area strike northerly and dip mostly 30° to 70° W. in an overturned section that ranges in age from Mississippian to Permian on the west limb of a major overturned syncline. The stock of the Darwin Hills intruded near the axis of the syncline. Several minor open folds are superposed on the overturned limb of the syncline. One of these folds on the west flank of Ophir Mountain is visible from the Darwin mining camp. The strata are folded into the form of an open anticline that plunges gently to the north, but younger strata are in the core and older rocks are on the flanks of the fold. Therefore, this fold, which commonly is referred to locally as the Ophir Peak anticline, is a minor inverted syncline according to the definition of White and Jahns (1950, p. 196). Similar inverted synelines are exposed in the Defiance and Bernon workings, in the Intermediate workings, and on the west side of the Darwin Hills adjacent to the Darwin mining camp.

The Paleozoic rocks are intersected by four sets of faults. One set strikes N. 50°-70° E. and dips steeply to the north. Displacement on the faults is left lateral with the north block moving west a few feet to 100 feet relative to the south block. The horizontal displacement is shown by offset of beds and by abundant nearly horizontal slickensides and mullion structure exposed at fault planes in underground workings. The N. 50°-70° E. faults are mineralized and many ore bodies are located in or close to them. The Defiance fault, Copper Falls fault, Water Tank fault, and Mickey Summers fault are this group.

A second set strikes N. 65° W. and dips steeply. They are parallel to the Darwin tear fault, which is a 10° to 20° lateral strike-slip fault. The Essex vein exemplifies this set.

The third set of faults are thrust faults that strike northerly and dip 30° to 40° W. The Davis thrust or
among the side of the hill above the Independence, x, and Bernon workings, and at the south end of
nine area it is exposed on the west side of the hills
e the mining camp at the water tanks. This fault is
exposed in the Essex workings and in the upper
pendence workings. Right-hand drag folds localized
ed to the fault plane indicate that the west block
upward toward the east relative to the east block
(5). The amount of displacement is not known. The
fault is west of, and parallel to, the Davis thrust,
the amount of displacement on it is small. The drag
associated with it are left-hand drag folds instead
right-hand drag folds like those along the Davis
st. Four parallel faults also are exposed between Ophir fault and the alluvium on the west side of the
win Hills. The writers believe that the overthrust
the Davis thrust broke along several parallel
es as it was moving and that each underlying block
ed slightly farther to the east than the overlying
x. Therefore, the overlying block on the west side
Ophir fault moved downward relative to the over-
block between the Ophir fault and the Davis
st. Thus, left-hand drag folds were formed along
Ophir fault while right-hand drag folds were form-
ing the Davis thrust.

The fourth set of faults strikes northerly and dips
dee steeply to the west. The displacement is small.
ual faults are mineralized, and many of the ore bodies
the district are localized among them.

4 Bodies. Ore in the Darwin mine occurs mainly
favorable stratigraphic zone more than 840 feet
close to pre-mineral feeder faults that strike
0°-70° E. and dip steeply to the northwest. Indi-
ore bodies occur as replacements of certain
able beds close to the N. 70° E. faults, as replace-
bodies in fault zones, and as irregular or pipelike
alc-hornfels. The bedded deposits have sharp
ets with the wall rock both stratigraphically above
below the favorable bed, although the ore within a
alized bed has a considerable range in grade and
blocks of low grade ore were left behind as stope

Description of ore bodies and ore controls of
workings is given below.

Bernon Workings. The Bernon workings adjoin
nce workings on the north and the Thompson
ings on the south. The workings are in white,
-grained calc-hornfels along the crest of a minor
ted syncline that extends southward to the De-
workings. The Paleozoic rocks are intruded by a
of quartz monzonite south of the 434 fault, and by
ke south of the Bernon fault. The rocks are cut by
-pre-mineral Bernon fault and the 434 fault, both of
strike N. 50°-60° E. and dip steeply to the north-
. The faults are cut off on the west by the Davis
st. All ore is in the Bernon fault in medium-grained
icate rock.

Defiance Workings. The Defiance workings are in
eastern part of the Darwin mine area 0.7 miles
h of the town of Darwin. Two bedded ore bodies
out along the crest of an inverted syncline
ere it is cut by the Defiance fault. The Blue vein is
in dense white calc-hornfels near the upper contact of a
granodiorite sill. The vein is 300 feet long and has been
ined 400 feet down the dip from the surface to the
215-foot level (fig. 2). The Red vein is in dense white
calc-hornfels 60 feet stratigraphically above the Blue
vein and 80 feet stratigraphically below an upper sill
of granodiorite. This vein is 460 feet long at the De-
urence tunnel level, 5 to 10 feet thick, and has been
ined 670 feet down the dip from the surface to the
400-foot level. Other smaller bedded ore bodies have
ed in the deeper mine workings. Both the Red
Blue veins lie between two sills of granodiorite
that are stratigraphically about 200 feet apart. Both
ills pinch out in depth. The upper sill does not extend
to the 110-foot level from the surface; the lower sill termi-
nates between the 570-foot and 700-foot levels. The lower
sill cannot be delimited on the surface as it merges with
the main Darwin Hills stock at the level of the present
erosion surface (fig. 2). The bedded ore in the Defiance
workings is approximately coextensive in depth with
the extent of the sills.

Below the 400-foot level the principal ore bodies
change from concordant veins to an irregular, vertical
replacement ore body that has been developed for 570
feet vertically to the 1,000-foot level. The ore is localized
close to the Defiance fault but extends outward from the
fault along closely spaced fractures for distances as
uch as 270 feet. On both the 800- and 900-foot levels
about 25 percent of the calc-hornfels over an area 200
feet by 270 feet is replaced by ore (pl. 6). Insufficient
exploration work has been done to delimit the ore on the
1,000-foot level.

Driver Prospect. The Driver prospect is 1,000 feet
S. 10° E. of the Defiance workings. The prospect is de-
served by several small open cuts, adits, and winzes. It
is in dense white calc-hornfels 30 to 50 feet west of the
contact with the stock of the Darwin Hills. Bedding in
the calc-hornfels strikes northerly and dips 35° to 53°
W. The Mickey Summers fault displaces the contact of
the quartz monzonite and calc-hornfels 75 feet, the north
side moving west relative to the south side. A parallel
fault cuts the calc-hornfels 230 feet south of the Mickey
Summers fault.

The calc-hornfels is highly iron stained parallel to
bedding close to the N. 70° E. faults. A belt of white calc-
hornfels 20 to 30 feet wide is highly iron stained 30 feet
west of the stock of the Darwin Hills and north of the
Mickey Summers fault. Gossan 1 to 2 feet thick is locally
distributed along a bedding-plane fault on the east side
of the iron stained zone. The calc-hornfels is similarly
heavy iron stained for 50 feet north of the fault that
is south of the Mickey Summers fault and parallel to it.
It is not known if any ore was mined from the shallow
workings.

Essex Workings. The Essex workings are 230 feet
southwest of the portal of the Independence workings
and 820 feet northwest of the portal of the Thompson
workings. The surface workings are in medium-grained
calc-silicate rock 50 feet east of the Davis thrust. Bed-
ding strikes northerly and dips 32° to 68° W. The calc-
hornfels is cut by the Essex fault, which strikes N. 70°
W. and dips vertically to very steeply south. The Essex
fault is cut off by the Davis thrust.
Figure 3. Longitudinal section of the Essex workings showing stope outlines.
re minerals are not conspicuous at the surface of the
Essex workings. The Essex fault is iron stained over a
th of 10 feet and contains jasper near the Essex
t. The open cut and short adits 40 feet northeast of
shaft are on a branch of the Essex fault, and they
ose only minor iron staining. The main ore body in
Essex workings does not crop out at the surface, but
below the Davis thrust in the Essex fault zone and
g steep north-striking fractures in calc-hornfels
es to both the Essex fault and an intrusive contact
3).
re has been mined from the Essex fault from 50 feet
ty to the 600-foot level, a vertical dis-
e of 780 feet. The ore is localized in the fault in cal-
cal-hornfels at the stock of the Darwin Hills and
Davis thrust. Between the surface and the 3 B level,
Davis thrust and the west contact of the stock are
roximately parallel and are about 360 feet apart. Ore
is continuous over this distance and has a maximum
ness of 30 feet. This is one of the few places in the
where ore extends up to the Davis thrust (fig. 3).
B the 3 B level the trend of the contact between the
silicate rock and the Darwin Hills stock dips verti-
cally or steeply to the east. As the distance between the
k and the Davis thrust becomes progressively greater
th depth, the amount of known ore is proportionately
ore along north-striking fractures is best developed
he 200- and 400-foot levels (see pl. 7, plan of 400-foot
level). On the 200-foot level ore extends 175 feet north
of the Essex fault, and on the 400-foot level it extends
400 feet north of Essex fault close to the intersection of
a steep north-striking fault and a sill of quartz mon-
zonite that dips 34° W. The ore is localized within 40
feet of the intrusive contact.

Independence Workings. The Independence workings
are at the north end of the Darwin mine 850 feet N. 25°
W. of the Thompson workings. Medium-grained cale-
silicate rock is exposed at the surface in most of the area
over a width of 130 feet from the stock of the Darwin
Hills west to the Davis thrust. Fine-grained gabbro and
diorite crop out southwest of the portal of the Inde-
pendence adit around the base of the mine dump. North
of the Independence workings the favorable cale-silicate
rock is cut off by the Davis thrust, and an unfavorable
overthrust block of dense greenish-gray cale-hornfels is in
contact with the stock. Gossan is exposed at the surface
in medium-grained cale-silicate rock along its contact
with the stock. The contact strikes northerly and dips
43° to 72° W. A prospect pit 30 feet deep 60 feet north
of the Independence adit exposes a highly iron stained
zone 10 feet thick along a fault contact between the
stock and cale-silicate rock. An open cut at the crest of
the ridge 250 feet N. 25° E. of the Independence adit
exposes gossan about 20 feet thick that dips 43° W. along
the cale-hornfels-intrusive contact.

Figure 4. Geologic section of the Independence workings showing stope outlines.
The underground workings show that the stock of the Darwin Hills terminates to the west in a series of sills that commonly are antclinal shaped and pinch out in depth to the west (fig. 4). Ore above the 100-foot level is in medium-grained calc-silicate rock above the uppermost sill and below the Davis thrust. The Davis thrust terminates the favorable cale-hornfels in the workings on both the Independence and 100-foot levels. The ore is an irregular bedded replacement body that has a strike length of 250 feet and a width of 120 feet on the Independence level. Approximately 30 percent of the calc-silicate rock over this area is replaced by ore. The ore is stopped from the 100-foot level to the surface. A sill of quartz monzonite is between the 100- and 200-foot levels.

The largest bedded ore body in the district is between the 200-foot and 3B levels over a lower antclinal-shaped quartz monzonite sill (fig. 4). Bedded ore has been stope d discontinuously between the quartz monzonite sills, a vertical distance of 160 feet, along the crest of the antclinal-shaped fold (an inverted syncline) for a maximum strike length of 500 feet on the 3B level. Ore has been mined westward down the dip above the upper contact of the lower sill for a distance of 700 feet to the 400-foot level.

Smaller bedded ore bodies are below the lower sill between the 400-foot and 600-foot levels (fig. 4). All the known ore is within 100 feet of the lower contact of the sill. The ore body on the west limb of the inverted syncline is 200 feet long and as much as 50 feet thick; it has been mined 280 feet down the dip below the 400-foot level. A smaller bedded ore body was mined on the east limb of the inverted syncline from the 400 level to 40 feet below the 500 level.

Rip Van Winkle Workings. The Rip Van Winkle workings are on the west side of the Darwin Hills above the Darwin mine camp. They include the workings on the Water Tank fault, the Mickey Summers fault, and the workings 680 feet N. 40° E. of the portal of the Radiore adit (pl. 5).

The shaft on the Water Tank fault 80 feet east of the water tanks is in cale-hornfels at the intersection of the Water Tank fault with the Davis thrust. The favorable medium-grained calc-silicate rock lies east of the Davis thrust and unfavorable dense, greenish-gray cale-hornfels is west of the thrust. An irregular plug of quartz monzonite crops out at the surface 300 feet northeast of the shaft. The Water Tank fault, which strikes N. 70° E. and dips 85° N., is highly iron stained at the surface.

The Radiore adit crosses the Water Tank fault in the favorable calc-silicate rock on the east side of the Davis thrust, and the fault is mineralized on this level along its strike for 360 feet (pl. 6).

The Mickey Summers fault strikes N. 74° E. and dips 80° SE. A parallel mineralized fault 60 feet north of the Mickey Summers fault is developed by two shafts 220 feet apart. Mineralization is continuous between the two shafts. Kelley (1938, p. 558) reports one of the vertical shafts to be 250 feet deep but inaccessible at the time of his fieldwork. He states the ore is highly pyritic but is reported to be unusually high in silver.

The inclined shaft 680 feet N. 40° E. of the portal of the Radiore adit is on a vein 6 feet thick that strikes N. 20° W. and dips 54° SW. parallel to bedding. The vein, which can be traced for about 50 feet on the surface in dense white to light-gray cale-hornfels 70 feet of a small outcrop of quartz monzonite. Only a small amount of ore minerals is exposed in the Radiore adit 218 feet below the collar of the shaft.

Thompson Workings. The Thompson workings 1,200 feet N. 25° W. of the Defiance workings near the western contact of the stock of the Darwin Hills. Quartz monzonite crops out at the portal of the Thompson adit and it extends 370 feet N. 67° W. into the adit and feet on the surface west of the adit. White medium-grained calc-silicate rock is exposed west of the quartz monzonite and extends over an outcrop width of 10 feet to the Davis thrust. Bedding in the calc-silicate rocks strikes north and dips 16° to 53° W. The Copper fault, which strikes N. 60° E. and dips steeply to the north, is exposed near the portal of the Thompson adit. Two parallel faults cut the calc-silicate rock 300 and 360 feet north of the Copper fault.

The ore in the Thompson workings is in medium-grained calc-silicate rock in the same stratigraphic horizon as in the Independence and Bernon workings. Gossan 1 foot to 6 feet thick is exposed in a surface stope in calc-silicate rock at the contact with quartz monzonite 250 feet S. 75° W. of the Thompson portal and 40 feet north of the Copper fault. Most of the mined underground was north of the gossan that exposed at the surface, and only minor mineralization is exposed on the 200-foot level 77 feet below the surface stope. The ore underground is in faults striking N. 57° E. in calc-silicate rock close to intrusive contacts and also in fractures in calc-silicate rock closely parallel to intrusive contacts. The 234 and 229 northerly striking faults are mineralized discontinuously for distances as much as 400 feet from a minor sill or dike quartz monzonite. Ore has been stope d along the 234 fault for as much as 190 feet along its strike. The thickness of ore ranges between 4 and 20 feet between the 200-foot and 3B levels, a vertical distance of 200 feet. Above the 200-foot level and below the 3B level the ore is nor striking faults between the 234 and 229 faults. The 2 fault has been less productive than the 234 fault, but has yielded ore for 135 feet along strike with a thickness of 10 feet between the 200-foot and 3A levels. A near horizontal sill cuts out the ore at the 3B level, but the faults and a little ore continue beneath the sill. In addition a considerable tonnage of ore has been mined from bedded replacement bodies between the 229 and 2 faults.

Fairbanks Mine

The Fairbanks mine is 3 miles north of Darwin, sixes 1 and 2, T. 19 S., R. 40 E., at an altitude of 5,6 feet. The mine is owned by Mrs. Marie Wilson of San Francisco. The workings consist of a shaft, reported to be 150 feet deep (Tucker and Sampson, 1938, p. 440) on a strand of the Darwin tear fault, and a number of open cuts and shallow shafts.

The host rock is the lower member of the Keeler Canyon formation and consists of thinly bedded bluish-gray limestone that is in part altered to cale-hornfels. Tectonic activity fractures across the north end of the mine area. It is a strongly sheared zone 50 to 100 feet wi
strikes N. 70° W. The Darwin tear fault is highly stained, but apparently contains little or no lead ores. Kelley (1938, p. 554) reports a small chimney vein was mined from a vertical vein that strikes north within the shear zone of the Darwin tear fault. The vein is 2 to 4 feet thick and consists of galena and sphalerite in a gangue of calcite and limonite.

**Jackass Mine**

The Jackass mine is in sec. 18, T. 19 S., R. 41 E., le N. 60° E. of Darwin and half a mile southwest of the Lane mill on the east side of the Darwin Hills at an altitude of 5,000 feet. A dirt road 1 mile long extends from Darwin to the mine. The property once had a patented claim owned by George F. Seeman, Fresno, Calif. It is developed by an inclined shaft 600 feet deep with about 150 feet of drifts. An inclined shaft about 35 feet deep with a short drift at the bottom is 600 feet N. 15° W. of this shaft.

No record was found of the production from the Jackass mine. Tucker (1921, p. 288) reports the mine to have been in operation at the time of his visit and that ore was carried to the Lane mill by an aerial tramway. The tram line has since been dismantled. George F. Seeman acquired control of the property in 1950. He mined 20 tons of ore from workings at the north of the property that he reports assayed 21 percent silver and 17 ounces of silver per ton (written communication, 1955).

The rocks in the mine area are brown-stained dense hornfels and bluish-gray limestone that is in part oxidized to tactite. The beds strike N. 20° W. and dip 78° W. The 140-foot inclined shaft is on a bedding-plane vein between a bluish-gray limestone and tactite bed 50 feet thick on the west and brown-stained, dense calcite-hornfels on the east. Open cuts at the surface expose the vein with a thickness of 1 to 4 feet over a length of 80 feet. The vein contains some galena and secondary copper minerals in a gangue of limonite and calcite.

On the 66-foot level a drift has been driven S. 38° E. for a distance of 75 feet along the vein and 70 feet N. 18° W. from the shaft. The vein south of the shaft is 1 to 2 feet thick, and ore in the vein is in pockets. The tactite contains a little scheelite disseminated through it over a thickness of 2 to 4 feet several feet into the hanging wall of the vein. North of the shaft a chimney of ore has been stopeed for 20 feet along the level to a height of 20 feet and a thickness of 10 feet.

The 35-foot shaft 600 feet N. 15° W. of the main inclined shaft is on a vein that strikes N. 63° E. and dips 77° SE. The vein is 3 feet thick at the surface and contains galena, cerussite, sphalerite, and pyrite in a gangue of calcite and limonite. The vein thins to 1 foot at the bottom of the shaft.

**Keystone Mine**

The Keystone mine is in secs. 19, 20, 29, and 30, T. 19 S., R. 41 E. It lies mainly on the east slope of the Darwin Hills about 1.75 miles southeast of Darwin. The mine is owned by Hilda Bickley, Helen Gunn, and Jess G. Sutleff of Independence, Calif.

The lower workings (fig. 5) include the Keystone adit 626 feet long, a drift 210 feet long, 120 feet of crosscuts,
a 175-foot steeply inclined winze, and small stopes. The upper workings consist of the McDonald adit, which is caved 145 feet from its portal, 135 feet of drifts, and minor crosscuts. A connecting raise and adjacent stopes between the lower and upper workings are largely inaccessible.

Production data are rather scanty. Tucker and Sampson (1938, p. 435) report that 800 tons of sorted ore was shipped from the lower winze and the zone between the lower and upper workings. This ore contained 15 percent lead, 28 ounces of silver per ton, and minor amounts of gold. Shipments during 1940 and the early part of 1941, according to the records of Mr. Sutleff, consisted of 205 tons of ore containing 0.04 ounces of gold per ton, 27.9 ounces of silver per ton, 25 percent lead, 0.6 percent zinc, and 20 percent iron.*

The mine is in folded and faulted rocks of the upper member of the Keeler Canyon formation (fig. 6). The rocks are brown-weathering silty limestone and blue-gray limestone. The limestones are partly altered to calc-hornfels, particularly in the western part of the mine area. The dominant faults trend between N. 70° E. and east and dip steeply.

Ore is in a poorly exposed vein 2 to 10 feet thick that strikes north and dips 60° W. to vertical. It has been exploited for a strike length of about 40 feet underground. The ore is highly oxidized and contains cerussite as the chief ore mineral with only minor relic galena. Gang minerals are limonite, jasper, and calcite.

Lane Mine

The Lane mine is 1.4 miles northeast of Darwin, sec. 18, T. 19 S., R. 41 E., on the east side of Darwin Hills at an altitude of 4,440 feet. The mine is adjacent to the Lane mill. The road from Darwin to Panamint Springs passes through the mill site. The Association of Seconda Company owns the property but has not operated it to date.

Development work consists of two vertical shafts 1,300 feet apart that are 600 and 800 feet deep with levels at 280, 350, 470, 610, and 700 feet according to an outdated old company assay map of the mine. Waring and Huguenin (1919, p. 98) report the shafts as 725 at 750 feet deep. Both shafts are inaccessible. Two other shafts 300 and 600 feet west of the main shaft are 200 feet deep. An adit reported by Kelley (1938, p. 59) to be 1,300 feet long and now accessible for about 1,000 feet trends S. 85° W. from the gully just west of the shafts.

The mine was discovered early in the history of the Darwin district, but was not extensively developed until the early 1890's by the Inyo Mining and Development Company according to Crawford (1894, p. 24). The mine was not mentioned by Goodyear in the Eighth Annual Report of the State Mineralogist for 1888. By 1894 Crawford (1894, p. 24) reports shafts 30, 80, and 2

* Published with permission of the mine owners.
Table 6. Ore produced from the Lane mine.†

<table>
<thead>
<tr>
<th>Year</th>
<th>Ore (tonne)</th>
<th>Gold (oz.)</th>
<th>Silver (oz.)</th>
<th>Copper (Rb.)</th>
<th>Lead (Rb.)</th>
<th>Operator</th>
</tr>
</thead>
<tbody>
<tr>
<td>1899</td>
<td>706</td>
<td>4,927</td>
<td>2,077</td>
<td>3,200</td>
<td>2,042</td>
<td>W. W. Boswell</td>
</tr>
<tr>
<td></td>
<td>581</td>
<td>1,617</td>
<td>118</td>
<td>2,600</td>
<td>3,772</td>
<td>W. W. Boswell</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1</td>
<td>207</td>
<td></td>
<td>3,200</td>
<td>Inyo County Mining &amp; Dev. Co.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>118</td>
<td>1,176</td>
<td></td>
<td>3,772</td>
<td>Inyo County Mining &amp; Dev. Co.</td>
</tr>
<tr>
<td></td>
<td>41</td>
<td>23</td>
<td>1756</td>
<td>342</td>
<td>38,016</td>
<td>Silas H. Reynolds</td>
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<td></td>
<td>120</td>
<td>58</td>
<td>43</td>
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<td>38,016</td>
<td>Silas H. Reynolds</td>
</tr>
<tr>
<td></td>
<td>122</td>
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<td>6,780</td>
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<td>816</td>
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<td>3,484</td>
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<td>859</td>
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<td>7</td>
<td>10,123</td>
<td>5,215</td>
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<td>769</td>
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<td>38,016</td>
<td>L. D. Foreman &amp; Co.</td>
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<td>44</td>
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<td>Theo Peterson</td>
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<td>5,800</td>
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<td>649,495</td>
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<td></td>
<td>334</td>
<td>888</td>
<td>529</td>
<td></td>
<td>649,495</td>
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<td>579</td>
<td>5</td>
<td>3,804</td>
<td>1,962</td>
<td>649,495</td>
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<tr>
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<td>154</td>
<td></td>
<td>649,495</td>
<td>L. D. Foreman &amp; Co.</td>
</tr>
<tr>
<td>total</td>
<td>11,944</td>
<td>1,547</td>
<td>75,866</td>
<td>38,016</td>
<td>1,820,888</td>
<td></td>
</tr>
</tbody>
</table>

†Ores and dumps: Figures for 1900 through 1946 furnished by U. S. Bureau of Mines. Figures for 1899 through 1900 furnished with the permission of the mine owners.

The mine is in steeply dipping open folds of the syncline that trends southward just above the edge of the alluvium between the two deeper parts of the ore shoots. The rocks are intersected by several faults that displace the ore shoot so that the ore shoot is vertically divided into several shoots that dip steeply north. At the collar of the westernmost shoot the ore shoot is 12 feet thick and contains gossan and some copper minerals over a width of 30 inches. Crawford (1896, p. 32) reports that the main shaft extends along the vein to a depth of 300 feet and that the ore shoot is 100 feet long and plunges vertically. On the 300-foot level a cross vein is exposed that strikes north and averages 4 feet in thickness. The shaft is on this cross vein below the 300-foot level.

The ore is mainly cerussite with small pockets of relic galena in a gangue of calcite, jasper, and minor fluorite. A company assay map shows that some of the ore on the deeper levels locally contains 1 to 2 percent copper.

The long adit west of the main working is along the same shear zone that is in the shafts, but it exposes little lead-silver ore. Locally the shear zone is iron stained and contains pockets of calcite and jasper. Minor scheelite is in the adit between 700 and 800 feet from the portal.

**Lucky Jim Mine**

The Lucky Jim mine is 2.7 miles N. 3° W. of Darwin in sec. 1, T. 19 S., R. 40 E., at an altitude of 5,240 feet. The Anaconda Company owns the property. The mine was formerly one of the major producers in the district. Kelley (1938, p. 553) estimates the value of ore produced at $2,000,000.

Workings (figs. 7, 8) consist of a 320-foot vertical shaft, several shallower shafts, approximately 7,690 feet of level workings distributed among 12 levels, about 1,000 feet of winzes and raises, and large steep stopes. The deepest level is 860 feet below the collar of the main shaft. The Anaconda Company renovated the main shaft and most of the main levels in 1948, but most of the stopes and some of the levels are still inaccessible. A view of the main workings is shown in photo 6.

The mine is in strongly faulted calc-hornfels and quartz monzonite host rocks (fig. 9). The calc-hornfels is correlated with the lower member of Pennsylvanian and Permian Keeler Canyon formation and has been divided into a light unit and a dark unit. The light unit is a light-gray to white, fine-grained, diopside-rich rock with minor, quartz and calcite. Its bedding is generally
Modified map of the Anacortes Company by W.E. Hall and E.M. Mackinl, 1954. Published with permission of mine owners.

Figure 7. Geologic maps of the underground workings of the Lucky Jim mine.
FIGURE 8. Composite map and longitudinal projection of the Lucky Jim Mine.
Figure 9. Geologic map of the Lucky Jim Mine.
Table 7. Partial ore production from the Lucky Jim mine.*
given in report on Darwin Mines by Ira Joralemon (1940):

<table>
<thead>
<tr>
<th>Year</th>
<th>Dry tons</th>
<th>Average grade</th>
<th>Metal content</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Au</td>
<td>Ag</td>
</tr>
<tr>
<td>5-1929</td>
<td>11,592</td>
<td>.0177</td>
<td>36.0</td>
</tr>
<tr>
<td>7-1929</td>
<td>28,866</td>
<td>.0095</td>
<td>11.3</td>
</tr>
<tr>
<td>Total</td>
<td>40,460</td>
<td>.0118</td>
<td>18.39</td>
</tr>
</tbody>
</table>

Table includes data furnished by the Anaconda Company. *Crude ore includes dump ore. Includes 2,850 tons of dump ore.

* Data supplied by the Anaconda Company, 1936, and published with their permission.

Darwin Quadrangle

Table 8. Ore produced from the Promontory mine since 1911.*

<table>
<thead>
<tr>
<th>Year</th>
<th>Dry tons</th>
<th>Average grade</th>
<th>Metal content</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Au</td>
<td>Ag</td>
</tr>
<tr>
<td>1911</td>
<td>21</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>1916-1919**</td>
<td>1,932</td>
<td>0.086</td>
<td>37.4</td>
</tr>
<tr>
<td>1937†</td>
<td>87.6</td>
<td>.053</td>
<td>24.0</td>
</tr>
<tr>
<td>Total</td>
<td>2040.6</td>
<td>.08</td>
<td>37.0</td>
</tr>
</tbody>
</table>

* Data supplied by the Anaconda Company, 1936, and published with their permission.
** Data from report on Darwin Mines by Ira Joralemon, 1940.
† Crude ore.
ally has been reported with that of the Darwin Silver
oup. The average grade of ore that has been shipped is not
own. According to records in the San Francisco office
the U. S. Bureau of Mines, however, 1,116 ounces
silver and 5,667 pounds of lead were recovered from
21-ton shipment of ore in 1911 by C. A. Bradford and
42 ounces of silver and 17,738 pounds of lead were
covered from 82 tons of ore shipped in 1918 by the
Darwin Development Company. The average grade of
is ore is 21 ounces of silver per ton and 11.3 percent

The lower member of the Keeler Canyon formation of
nsylvanian and Permian age crops out in the mine
area. It consists of light-gray dense calc-hornfels with
some relics of limestone and light-gray dense calc-horn-
fels with interbedded chert and hornfels. The beds strike
northerly and dip 33° to 55° W. in an overturned section.
The beds in the mine area are cut by three faults that
strike N. 70°-80° E. and dip steeply south and by a
fault 240 feet west of the main shaft that strikes north-
erly and dips 82° W. (fig. 10).

The ore occurs as a bedded replacement of limestone and
light-gray calc-hornfels close to faults that trend
N. 70° E. Three mineralized beds are exposed in the open
cut at the main inclined shaft. The westernmost vein is
a replacement of a bluish-gray limestone bed that is ex-
posed in the collar of the shaft. Gossan is also exposed
in light-gray calc-hornfels 12 feet and 40 feet farther

[Map and diagrams of the underground workings of the Promontory mine.]

**Figure 11.** Geologic maps of the underground workings of the Promontory mine.
east of the shaft. The veins can be traced on the surface for only a few feet north of the open cut.

The most extensive ore exposed in the mine is on the 180- and 210-foot levels. On the 180-foot level ore is exposed discontinuously for 180 feet as a replacement of 3 or 4 thin beds (fig. 11). The veins range from a few inches to 5 feet thick. On the 210-foot level one vein is exposed for 133 feet that ranges in thickness from a few inches to 8 feet. Mineralization below the 210-foot level is weak.

Gossan is exposed in several shallow workings south and southeast of the main inclined shaft. A shallow surface stope 52 feet long, 350 feet S. 10° W. of the inclined shaft exposes gossan 2 to 4 feet thick parallel to bedding and a shallow inclined shaft has been sunk on gossan 210 feet S. 54° E. of the main inclined shaft.

The ore consists of cerussite and minor wulfenite, plumbojarosite, and hydrozoicite in a gangue of jasper, iron oxides, and calcite. Kelley (1938, p. 561) reports some siderite in the gangue also.

Santa Ana Mine

The Santa Ana mine is in sec. 18, T. 19 S., R. 41 E., on the east slope of the Darwin Hills at an altitude of 4,560 feet. According to claim notices the mine was located by P. D. Owen in July 1926, sold to Alex Ruona in February 1927, and subsequently deeded to the present owners, Hilma Ruona of Huortana, Finland, and Marie Ruona Wilson of San Francisco. According to Kelley (1938, p. 559) the mine probably was worked during the nineties. The main workings consist of a 200-foot vertical shaft with drifts at the 75-, 150-, and 200-foot levels and with a 30-foot winze from the lowest drift. Other workings are an inclined shaft about 30 feet deep and shallow surface pits.

The country rock is blue limestone and greenish-gray, brown-weathering calc-hornfels of the upper member of the Keeler Canyon formation. The main workings are on a vein striking N. 42° E. and dipping 85° SE. The vein ranges from 1 foot to 6 feet in thickness at the surface, and Kelley (1938, p. 559) states it is as much as 10 feet thick where exposed in underground workings. The vein is highly iron stained and contains jasper and coarse gray calcite. Galena and cerussite are the chief ore minerals.

Standard Group

The Standard Group includes several claims in the eastern part of sec. 13, T. 19 S., R. 40 E., and in the western part of sec. 18, T. 19 S., R. 41 E. The claims were explored and mined mainly during the early 1920's by Alex Ruona. They are now owned by Mrs. Marie Wilson of San Francisco and Hilma Ruona of Finland. A small mine camp in the canyon north of Lane Canyon was largely demolished by a cloudburst. The mine workings consist of many adits and open cuts. No record of production was found.

Workings of the Standard Group are near the irregular eastern border of the stock of the Darwin Hills, mainly in calc-hornfels of the Keeler Canyon formation, but locally within granitic rocks. Bedding strikes north and dips mainly west except for minor open folds, one of which is well exposed near the old mining camp. Two nearly vertical branches of a N. 60°-80° W.-trending fault zone near the old campsite are the most conspicuous structural features. These faults, which are parallel, the Darwin tear fault, are marked by iron-stained breccia and gouge zones 10 to 40 feet thick with pockets of jasper, calcite, and minor pyrite, chalcopyrite, and chalcocite. These faults have been extensively explored by adit work but little ore has been found. The ore-bearing vein, which are 1 foot to 4 feet thick, strike N. 50°-75° E., dip from 70° NW. to vertical. The most important of these veins are the Standard vein, the Standard Extension vein, and an unnamed vein, possibly a faulted segment of the Standard vein, north of the northwest-trending fault zone.

The Standard vein is exposed for about 1,000 feet the northeast part of sec. 13. Workings on the vein consist of a vertical shaft 70 feet deep, adits 100 and 5 feet long, and extensive surface workings. The vein strikes N. 60°-70° E., a dips from 75° NW. to vertical. A salient of the stope of the Darwin Hills is adjacent to the western extremities of the vein. Away from the stock the vein cuts into the calc-hornfels of the Keeler Canyon formation. The vein averages 2 feet in thickness and is composed of coarse calcite, quartz, jasper, and limonite with lesser amounts of galena, cerussite, pyrite, chrysocolla, and anglesite in a gangue of highly iron-stained jasper, and fluorite.

The Standard Extension vein crops out for about 6 feet in secs. 13 and 18, about 600 feet south of the Standard vein. Workings on the vein consist of three shall about 100 feet deep, two adits, and drifts, and minor surface workings. The vein strikes N. 60°-70° E., a dips from 75° NW. to vertical. A salient of the stope of the Darwin Hills is adjacent to the western extremities of the vein. Away from the stock the vein cuts into the calc-hornfels of the Keeler Canyon formation. The vein averages 2 feet in thickness and is composed of coarse calcite, quartz, jasper, and limonite with lesser amounts of galena, cerussite, hemimorphite, and chrysocolla.

A possible faulted segment of the Standard vein crops out near the extreme northeast corner of sec. 13 nor a strong northwesterly trending fault. This vein is explored by a northeast-trending adit and by surface workings. The vein, which is 2 feet thick, strikes N. 60° E., and dips 75° NW. It is similar to the Standard vein in mineral content.

The strong northwest-trending faults in the mine area are explored by long adits, but apparently lack ore. Small quantities of ore minerals are local and distributed on steep minor subsidiary faults that strike between N. 25° W. and N. 25° E.

Susquehanna Mine

The Susquehanna mine is in sec. 24, T. 19 S., R. 40 E., between The Anaconda Company mining camp and Darwin at an altitude of 4,880 feet. The property is owned by the Mickey Summers estate, and it is leased to Mr. Finley and Mr. Vignich of Darwin. The mine is accessible by hard-surfaced roads both from Darwin and from The Anaconda Company mining camp. It is developed by an inclined shaft 43 feet deep that bears S. 20° E. at −70°. A drift at the bottom of the shaft heads 50°-70° E. for approximately 870 feet with a few crosscuts from it. Little stoping was done. Local residents state the mine has had a small production, but no record of it was found.

The lower member of the Keeler Canyon formation, Pennsylvanian and Permian age rocks out in the mine area. The rocks near the collar of the shaft consist of...
anic light-gray and greenish-gray calc-hornfels. The
ris thrust fault is exposed about 300 feet east of the
ft. East of the Davis thrust and extending to the
end of the Darwin Hills, 800 feet east of the shaft, the
ks are aphanitic white and light-gray calc-hornfels.
calc-hornfels east of the Davis thrust is cut by a
tical fault that strikes N. 50°E. A bedding-plane
ature can be traced for about 100 feet north of the
50°E. fault.
both the N. 50°E. fault and a bedding-plane fracture
feet northeast of the shaft are mineralized locally.
50°E. fault is iron stained and locally contains
or amounts of malachite through a thickness of 8
A vertical shaft 30 feet deep on the fault exposes
ore. The bedding-plane fracture is limonite stained
ough a thickness of 3 feet and contains minor jasper.
inclined shaft bearing S. 70°W. at minus 39° ex-
ss no ore.
the Davis thrust fault is exposed in the underground
ings about 300 feet northeast of the main inclined
it. On the east side of the thrust fault, the drift is
ing a fault that strikes N. 50°E. and dips 50° SE.
the intersection of the two faults the sheared calc-
fels is highly iron stained and is reported to have
ained some ore. The N. 50°E. fault away from the
section is only slightly mineralized.

Wonder Mine

The Wonder mine is in sec. 18, T. 19 S., R. 41 E., on
south side of Lane Canyon 3,000 feet west of Lane
at an altitude of 4,720 feet. The Wonder No. 1
m is on the north side of Lane Canyon adjacent on
orth to the Wonder claim. The Anaconda Com-
y owns the property, which has been idle for many
rs. The mine was first described by Knopf (1914, 6)
briefly by Kelley (1938, p. 559).

e Wonder claim is developed by an adit about 100
long trending S. 20°E., an inaccessible inclined
it reported by Tucker (1926, p. 465) to be 100 feet
, and several surface pits. The Wonder No. 1 claim
developed by an inclined shaft, reported by Tucker
6, p. 465) to be 225 feet deep.

The rocks in the mine area are calc-hornfels and
ly tactite at the top of the lower member of the
ler Canyon formation. Between the workings on the
nder and Wonder No. 1 claims the rocks are inter-
ed by a number of N. 70°E. fractures that are part
the Lane fault. Bedding south of the Lane fault
kes north and dips 55°W. North of the fault the
ings are along the crest of an open antilinal-shaped
l that may be an inverted syncline.

The ore in the Wonder claim is along a vein that
kes N. 27°W. and dips 55° SW. A steep N. 70°E-
uding fault cuts the vein in the adit about 60 feet
on the portal and offsets the southern segment ap-
imately 8 feet to the west. The vein is 2 to 6 feet
k and consists predominantly of coarse gray calcite,
nte, and garnet with local pockets of galena, cerus-
, fluorite, pyrite, quartz, oxidized copper minerals,
minor scheelite.

imilar ore is exposed along the crest of an antilinal-
pold at the collar of the inclined shaft on the
nder No. 1 claim. The ore extends down the west
limb of the fold as a bedding-plane vein 4 to 6 feet thick
that strikes N. 10° W. and dips 55° SW.

Mines and Prospects in the Argus Range
Darwin Zinc Prospect

The Darwin Zinc prospect is in sec. 2, T. 19 S., R. 41
E., on the west slope of the Argus Range at altitudes
of about 3,700 feet. Workings include a crosscut adit 174
feet long trending N. 74°E., a 20-foot raise from the
it, and northwest-trending surface pits and trenches
on the slope above the adit. An ore chute about 120 feet
long connects the surface workings with the access road
near the portal of the adit. Additional older workings
are accessible from the canyon north of the new workings
and consist of a S. 15°W.-trending open stope 70 feet
long and an 87-foot long adit that trends S. 12°W. The
portal of a caved north-trending adit is on the north
wall of the canyon.

The workings explore a major N. 10°-30° W.-trending
fault zone that is marked by numerous fault surfaces
and steep parallel brecciated and shattered zones. Fossi-
lerous silty limestone of the lower member of the Owens
Valley formation of Permian age is west of the fault and
Mississippian marble lies to the east. The marble appears
identical to much of the marble at the Empress and Zinc
Hill mines. Minor amounts of hydroxizine in the open
stope constitute the only identified ore mineral. Iron
staining is locally abundant throughout the fault zone,
and in places coarse calcite crystals coat some of the
brecciated rock.

Empress Mine

The Empress mine includes four unpatented claims in
sec. 2, T. 19 S., R. 41 E., on a precipitous west slope of
the Argus Range at altitudes about 4,500 feet (pl. 1).
The mine is connected to the Darwin Canyon road by a
steep narrow road about 1.2 miles long. The property is
operated by W. E. McCulley of Darwin, Calif. The mine
production, which is from records of the U. S. Bureau
of Mines, is given in the following table.

Table 9. Ore produced from the Empress mine.*

<table>
<thead>
<tr>
<th>Year</th>
<th>Crude Ore (t)</th>
<th>Gold (oz)</th>
<th>Silver (oz)</th>
<th>Copper (lbs)</th>
<th>Lead (lbs)</th>
<th>Zine (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1946</td>
<td>79</td>
<td>1</td>
<td>530</td>
<td>2,038</td>
<td>34,901</td>
<td>12,359</td>
</tr>
<tr>
<td>1947</td>
<td>89</td>
<td>2</td>
<td>1,450</td>
<td>2,483</td>
<td>60,403</td>
<td>8,141</td>
</tr>
<tr>
<td>1948</td>
<td>136</td>
<td>2</td>
<td>2,824</td>
<td>5,880</td>
<td>62,254</td>
<td>22,300</td>
</tr>
<tr>
<td>1949</td>
<td>91</td>
<td>1</td>
<td>726</td>
<td>3,099</td>
<td>39,329</td>
<td>12,358</td>
</tr>
<tr>
<td>1950</td>
<td>None recorded</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1951</td>
<td>25</td>
<td></td>
<td>170</td>
<td>199</td>
<td>13,209</td>
<td>1,670</td>
</tr>
<tr>
<td>1952</td>
<td>430</td>
<td>5</td>
<td>5,700</td>
<td>14,264</td>
<td>216,186</td>
<td>57,008</td>
</tr>
</tbody>
</table>

* Production figures furnished by the U. S. Bureau of Mines and published with the permission of the owner.

Mine workings consist of 412 feet of level workings, less
than 100 feet of winzes and raises, small stopes, and
minor surface pits and trenches (fig. 12).

The Empress mine is in an unfaulted block of Cre-
taceous quartz monzonite and a roof pendant of Missis-
sippian limestone that is cut by minor quartz diorite,
aplite, and basalt dikes (fig. 13). The limestone beds
are 1 foot to 2 feet thick and contain numerous 1- to 4-
inches thick chert lenses. The limestone is similar to the
Figure 12. Cross section and geologic map of the underground workings of the Empress mine.
EXPLANATION

Quartz diorite

Peridotite

Formation

Gray limestone with chert lenses, white marble and light-colored calc-hornfels. Cal, mainly tectite and dark-colored calc-hornfels. Cal

Contact approximately located

Concealed contact

Fault showing dip

(Dashed where approximate)

Strike and dip of beds

Vesicular showing dip

Lithostatic alteration

Olistonic alteration

Portal of tunnel or adit

Portal and open cut

Small prospect pit or open cut

Outline of underground level

Figure 13. Geologic Map of the Empress mine.
Perdido formation of Mississippian age and is tentatively correlated with it. Where unaltered, the limestone is medium gray and the chert is light gray. Most of the limestone is metamorphosed to white marble, light-colored calc-hornfels, and dark-brown tactite; the chert is bleached white. The marble consists predominantly of coarse-grained white calcite, but locally it contains minor amounts of antigorite. Wollastonite is the predominant mineral in the light-colored calc-hornfels. The dark-brown tactite, which attains a maximum thickness of about 70 feet, is generally contiguous to quartz monzonite. It consists of garnet and epidote with lesser amounts of quartz, calcite, pyroxene, limonite, antigorite, and very minor amounts of scheelite and chrysotile.

The quartz monzonite is a medium-grained, pinkish-gray rock containing quartz, orthoclase, oligoclase, and biotite with minor amounts of pyrite, apatite, and sphene. The quartz diorite is a fine-grained, dark-gray speckled rock made up of hornblende, biotite, quartz, and plagioclase with a lesser quantity of apatite and opaque minerals. It occurs in irregular dikelike masses as much as 20 feet thick that are cut by a few aplite dikes 1 inch to 4 inches thick. An altered, grayish-brown basalt dike 3 to 4 feet thick strikes N. 20° W. across the mine area. The dike is intermittently exposed, as its upper limits only locally reach the present erosion surface. The dike consists predominantly of labradorite and olivine. Secondary minerals are calcite, limonite, chlorite, epidote, and iddingsite. Dolomitic alteration of limestone and iron staining are abundant in or near the ore horizon and adjacent to some faults.

Three sets of steep faults cut the rocks in the mine area. These faults strike N. 20°-30° W., N. 70°-80° W., and N. 50°-60° E. Most of the faults can be traced for only short distances. They have little displacement and appear to be closely associated with ore deposition. The ore horizon cuts across some of the faults, but in others the faults displace the ore horizon slightly, a probable attribute to minor movement on the faults after ore deposition.

Bedding mainly strikes nearly east and dips 15° to 40° N. Aberrant southerly dips are near intrusive contacts and in a minor flexure in the east-central part of the mine area.

Ore at the Empress mine is a bedded replacement of limestone and a continuation as a flat-lying quartz vein in quartz monzonite. The ore zone in limestone is well exposed on the surface for about 400 feet where it ranges from a few inches to about 6 feet thick. In places local bifurcations give rise to two separate and generally thinner veins. Extensive iron stains and some dolomite mark the ore horizon in limestone. Most of the early workings exploited the north end of the vein within quartz monzonite near the contact with the limestone. The ore in the southern part of the mine is lower grade and consists of thin discontinuous galena-bearing stringers in a heavily iron-stained and dolomitized host rock. Both limestone and chert of the host rock were replaced by ore.

The primary ore consists of pockets of argentiferous galena, sphalerite, and chalcopyrite in a quartz-rich gangue. Secondary ore minerals are cerussite, anglesite, azurite, malachite, chrysocolla, hemimorphite, and very little wulfenite. The gangue consists mainly of quartz and chaledony with lesser calcite, limonite, pyridinite, and gypsum. The same minerals are in quartz veins that cut quartz monzonite, and the minerals generally occur as irregular replacement of the vein.

Anomalous radioactivity was measured in the workings. Local radioactivity ranged from 0.04 to 12 MR/hr in the A-15 and A-17 workings; the background count averaged 0.02 MR/hr (fig. 12). In the A-14 workings radioactivity averaged about 0.03 MR/hr. The source of the radioactivity is not known.

Wynog Prospect

The Wynog prospect is in sec. 11, T. 19 S., R. 41, at an altitude of about 4,080 feet on the west slope of the Argus Range. The prospect is 2,000 feet S. 15° E. of the Empress mine. It is accessible by a trail 1,000 feet long from the sharp bend in the road to the Empress mine. According to claim notices W. W. Tice and H. R. Quinn of Darwin located the prospect on March 26, 1919. No production has been recorded, and the prospect currently idle. The main workings consist of a 50-foot adit trending N. 15° W., a 44-foot drift trending near east, and a surface trench 500 feet long about 110° N. 60° E. of the portal.

The prospect is in an upfaulted area underlain by marble and tactite metamorphosed from Mississippian limestone and by irregular salients of biotite-quartz monzonite. Garnet and epidote are the most abundant constituents of the tactite.

Ore is in a quartz vein 1 inch to 12 inches thick that strikes northeast and dips about 35° SE. The host rock in the main workings is marble. The vein cuts the quartz monzonite where explored by the trench, and it apparently pinches out in the intrusive rock north of the trench.

Three nearly vertical faults trending N. 20° W. of the vein and each elevates the east side 1 foot to 6 ft. relative to the west side. The vein is truncated by the southernmost of these faults about 10 feet south of the portal of the main workings.

The ore minerals include galena, cerussite, chrysocolla, and minor quantities of chalcopyrite, cuprite, and azurite. Quartz is the dominant gangue mineral associated with minor calcite, barite, hematite, and limonite. The ore minerals are in small pods an inch or two long that are irregularly distributed in the quartz vein. Parts of the vein are slightly radioactive and have about twice the background count.

Zinc Hill Mine (Utacala Group, Colorado Group)

The Zinc Hill mine is 51 miles northeast of Darwin, sec. 2, T. 19 S., R. 41 E., at the north end of the Argus Range at an altitude of 3,875 feet. The mill site of an abandoned mining camp is on the old State Highway 1 between Darwin and Panamint Springs. The mine is accessible by a pack trail 4,400 feet long that leads north from the mill site. A small jeep can negotiate the trail.

The property consists of five unpatented claims owned by the Combined Metals Reduction Company of Salt Lake City, Utah. The early history of the mine is completely unknown. The mine was not mentioned by Wari and Huguenin in the 15th Annual Report of the St
The property is developed by numerous open cuts, surface stopes, and short adits into a steep hillside. Workings develop four separate mineralized areas, here are no interconnecting workings between them. There are designated workings A, B, C, and D, for convenience in writing. The ore from the westernmost worked was brought up to the end of the pack trail by an inclined tramway, and that from the upper workings was brought down by an aerial tram line.

The rocks in the mine area are marble and limestone of Mississippian age faulted against silty limestone of Permian age (fig. 14). The sequence of rocks is given below:

<table>
<thead>
<tr>
<th>Age</th>
<th>Stratigraphic unit</th>
<th>Lithology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cretaceous(?)</td>
<td></td>
<td>6. Diorite dike</td>
</tr>
<tr>
<td>Permian</td>
<td>Owens Valley formation</td>
<td>5. Silty blue-gray limestone</td>
</tr>
<tr>
<td>Fault</td>
<td>contact</td>
<td></td>
</tr>
<tr>
<td>Pennsylvanian(?)</td>
<td>Lee Flat (?) limestone</td>
<td>4. Marble, white</td>
</tr>
<tr>
<td>and Mississippian</td>
<td></td>
<td>130+</td>
</tr>
<tr>
<td>Mississippian</td>
<td>Perdido (?) formation</td>
<td>3. Blue-gray limestone with bedded chert</td>
</tr>
<tr>
<td>Mississippian</td>
<td>Tin Mountain (?) limestone</td>
<td>2. Ore horizon. Marble. Contains bedded chert near top. Lower part probably Tin Mountain limestone. 120+</td>
</tr>
</tbody>
</table>

The oldest rock in the mine area is thinly bedded blue-gray limestone that is locally bleached and recrystallized to marble. It is overlain by a 200-foot-thick marble bed that contains all the known ore bodies. Most of the mineralization is in the upper half of this ore horizon. It is overlain by 130 feet of gray to bluish-gray limestone with 1- to 4-inch-thick beds of chert, which is in turn overlain by marble. The above units lithologically resemble the Mississippian formations found elsewhere in the quadrangle, and Hopper (1947, p. 409) found Mississippian fossils in limestone that is probably about the same stratigraphic horizon 4 miles to the southeast. The lithology is similar to that of the Lee Flat limestone, Perdido formation, and Tin Mountain limestone.

The Mississippian limestones are faulted on both the east and west sides of the mine area against silty bluish-gray limestone of the Owens Valley formation of Permian age.

A fine-grained diorite dike 1 foot to 2 feet thick cuts the Mississippian rocks in the southern part of the mine area. It strikes N. 65° W. and dips vertically. The dike has been stoped at the surface for 250 feet along strike, but the nature of the ore removed is not known.

Faulting is the main structural feature in the mine area. The mine is in a horst of Mississippian limestone that has been faulted up against the Owens Valley formation by steep north to N. 20° W. -trending faults. Beds within the horst strike northwest to west and dip 10° to 30° N.; those in the Permian limestone strike northeast to east and dip 35° to 80° N.

The Zinc Hill fault bounds the horst of Mississippian limestone on the west and has a stratigraphic throw of over 2,700 feet. It is displaced 150 feet, north side west, by 3 northwest-trending faults that are locally dolomitized. Many discontinuous north- to northeast-trending faults are near the ore bodies. They are important in localizing ore bodies, although they have only a few feet of displacement. A major fault striking N. 20° W. bounds the horst on the east. It also has a stratigraphic throw of over 2,700 feet.
GEOLOGIC MAP OF THE ZINC HILL MINE, INYO COUNTY, CALIFORNIA

Figure 14. Geologic map of the Zinc Hill mine.
Figure 15. Geologic maps and section of the upper workings in Area A, Zinc Hill mine.
The faults must have had several periods of movement. Many of the northwest- and northeast-trending faults are mineralized or dolomitized, yet the northwest-trending faults apparently displace the Zinc Hill fault, which has had late Tertiary or Quaternary displacement. The ore occurs as replacement bodies parallel to bedding and to a lesser extent along faults where they cut a favorable stratigraphic horizon (fig. 14). The favorable ore horizon crops out for 1,500 feet in a northwesterly direction, and it is cut off by faults at both ends. Mineable ore bodies are in four localities within this favorable horizon. The ore in areas A and D is mainly parallel to bedding, while the ore bodies in areas B and C are mainly along steeply dipping faults (fig. 14).

Ore in the upper workings in area A is mainly in bedded replacements in what is called the Colorado bed by the Combined Metals Reduction Company (written communication). The Colorado bed is at the top of the favorable ore horizon. As the ore within the Colorado bed was mined out when the mine was mapped, det within the bed were not evident. The Colorado bed described by L. G. Thomas (written communication geologist for Combined Metals Reduction Company) follows:

"The deposit is a replacement type composed of at least 3 possibly 4 distinct beds intercalated between ribs or part within the Colorado bed and adjacent to a feeder fissure, called Herbert fissure, which strikes N. 35° E. and dips 60° to 75° the northwest. The sequence within the Colorado bed is in ger as follows:"

<table>
<thead>
<tr>
<th>Upper bed No. 4</th>
<th>Ore, 2+ feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limestone parting</td>
<td>Waste, 6 feet</td>
</tr>
<tr>
<td>Bed No. 3</td>
<td>Ore, 4 to 6 feet</td>
</tr>
<tr>
<td>Limestone parting</td>
<td>Waste or low grade, 3-4 feet</td>
</tr>
<tr>
<td>Main bed No. 2</td>
<td>Ore, 5-8 feet</td>
</tr>
<tr>
<td>Limestone parting</td>
<td>Waste or low grade</td>
</tr>
<tr>
<td>Bottom bed No. 1</td>
<td>Ore, 3-4 feet</td>
</tr>
</tbody>
</table>
Here in the upper workings in area A was mined from stope (fig. 15). The lower stope is approximately 25 feet long, 60 feet wide, and 10 to 16 feet high. Ore beds Nos. 1 and 2 were mined from this stope. Approximately a third of the ore removed from this stope is primary ore and the rest oxidized ore. The upper ore is approximately 25 feet long, 25 feet wide, and 4 to 7 feet high. It apparently contained only oxidized ore. The Royal Wright winze was sunk 22 feet from the lower stope on oxidized ore 4 to 7 feet thick with some sphalerite and galena along fractures striking N. E. and dipping 37° NW. These fractures are continuous between the upper and lower stopes. Two bedded bodies each about 30 feet long, 25 feet wide, and much as 10 feet thick were mined in area B. This ore beally cut by faults, and oxidized ore extends a short distance along the faults.

Stalactite ore bodies are localized along faults in B and C. In area B, ore is stope discontinuously a distance of 200 feet along a fault zone striking N. W. and dipping 30° to 50° NE. (fig. 16). The ore is 10 feet thick and is stope about 50 feet down the Oxide ore is still exposed on the lower level (fig. 16). at the east end of the open stope in area B termi- nates against a mineralized fault that strikes N. 30° W. dips 65° SE. Ore 1 to 12 feet thick was mined 50 along strike and 40 feet down dip; ore 2 to 4 feet thick is exposed at the bottom of the stope.

Small, discontinuous ore bodies both parallel to bedding and along faults were mined in area C. The largest body is a bedded deposit that strikes east and dips N. It is stope 40 feet along strike and 30 feet down dip; it has a thickness of 3 to 6 feet. Other small sizes of ore occur along faults.

The primary ore contains sphalerite, galena, pyrite, chalcopyrite in order of decreasing abundance in argue of calcite, jasper, gyspum, and quartz. Sphal- erite is the predominant primary ore mineral. It is brownish-yellow and has a resinous luster. The size is 4 to 4 mm in diameter. Galena is only locally abundant. It commonly has a bluish color due to a thin film containing copper. Pyrite and chalcopyrite are present in minor quantities.

Most of the ore that remains in the mine is oxidized ore. It is a crumbly, porous, brownish-colored mass that consists mainly of hemimorphite, hydrozincite, and smithsonite, and lesser amounts of cerussite, anglesite, thsosinite, and some blue and green secondary copper minerals.

Hemimorphite is the principal supergene mineral, and must have made up nearly 100 percent of the oxide that was mined. The hemimorphite forms crumbly masses of colorless, white, or cream-colored crystals that are admixed with limonite. Locally the crystals are red pink, red, or deep green. Hydrozincite is con- tent near the borders of oxidized zinc ore bodies, particularly in area C. It forms a white, powdery coating on chalcedony and on vugs and is admixed and shed with clay minerals. Smithsonite is rare. It is in veins away from the zinc ore bodies and has been asported farther than the other supergene zinc minerals.

Cerussite and anglesite are present in small quantities where observed are always near relict galena. Angle-
the early Lee mine ore probably was milled in Mill Canyon at the site marked by the ruins of an old mill about 7 miles northeast of the Lee mine. Water was obtained from Lee pump about 8 miles northeast of the mine. DeGroot (1890, p. 213) mentions that the Lee district was waning by 1888.

The available production data probably account for only a minor part of the total output. During 1937, 250 tons of ore was shipped that averaged 449.00 per ton in silver (Tucker and Sampson, 1938, p. 443). Louis Warnken, Jr., shipped 226 tons of dump material in 1938 that contained 750 ounces of silver and 2 ounces of gold (production records of the U. S. Bureau of Mines). Recent production data are summarized below.

Table II. Recent ore production from the Lee mine.*

<table>
<thead>
<tr>
<th>Year</th>
<th>Tons</th>
<th>Copper (percent)</th>
<th>Lead (percent)</th>
<th>Zinc (percent)</th>
<th>Silver (oz/ton)</th>
<th>Gold (oz/ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1951</td>
<td>41</td>
<td>0.4</td>
<td>2.4</td>
<td>16.3</td>
<td>61.3</td>
<td>0.025</td>
</tr>
<tr>
<td>1952</td>
<td>35</td>
<td>0.25</td>
<td>1.5</td>
<td>17.6</td>
<td>48.0</td>
<td>0.025</td>
</tr>
<tr>
<td>1953</td>
<td>40</td>
<td>0.45</td>
<td>1.5</td>
<td>17.5</td>
<td>40.0</td>
<td>0.035</td>
</tr>
<tr>
<td>1954</td>
<td>42</td>
<td>0.24</td>
<td>7.9</td>
<td>17.7</td>
<td>49.6</td>
<td>0.025</td>
</tr>
</tbody>
</table>

* Published with the permission of the mine owner.

Accessible workings in the main mine consist of more than 1,000 feet of levels and inclines and several thousand square feet of stopes (fig. 17). In addition, numerous inaccessible shallow workings adjoin the main workings on the northwest. The West Workings consist two short adits and an inaccessible shaft.

The Lee mine area is underlain predominantly by Tin Mountain limestone of Mississippian age (pl. 17). The Lost Burro formation of Devonian age is exposed the northern part of the mine area and conforma underlies the Tin Mountain limestone. The Perdido formation conformably overlies Tin Mountain limestone in the southern part of the mine area and is overlain by thin flow of olivine basalt.

The Lost Burro formation exposed in the mine white, medium- to coarse-grained marble with thin beds of dark-gray marble. Some of the marble exposed in the deepest mine workings may be part of the Lost Burro formation, although it is more likely bleached Tin Mountain limestone. The Tin Mountain limestone is a medium gray, fine-grained limestone in beds half a foot to 2 ft thick. Dark-gray chert nodules and lenses are moderately abundant throughout the formation. The limestone contains sparsely distributed tremolite crystals. All known ore deposits at the mine are within the lower part of the Tin Mountain limestone. The Perdido formation consists of medium-gray limestone interlayered with beds of dark-gray chert.

The Paleozoic rocks lie in a concordant sequence that strikes generally between N. 70° W. and west and dips predominantly 20° to 40° SW. Most faults in the area strike parallel with bedding; the most conspicuous dips steeply northeast. Examples are the West fault and the large faults along the 5,210 and 5,250 levels (fig. 1). Where evidence is obtainable, these faults can be sho
Figure 18. Geologic maps of the underground workings of the Lee mine.
Figure 19. Geologic sections of the Lee mine.
The normal faults. The cumulative dip slip of the West fault and two similar faults south of it is about 50 feet. Three less prominent fault set strikes parallel with the bedding and dips steeply southwest. Minor bedding-related faults are present locally.

The rocks are brecciated and shattered in the vicinity of the main workings. Some of the brecciated rocks are anhydrous and have a long vertical dimension; for example, the breccia at the inaccessible shaft 100 feet S. E. of the main shaft is at least 70 feet long in vertical dimension. Well-stratified surplanted material ranging in size from fine sand to pebbles occurs at two places in the mine in vertical pipe-like bodies about 7 feet in meter circumscribed by near-vertical slickensides. Ore fragments are in the breccia. Both the chimney-breccias and the detritus-filled chimney-like bodies believed to be formed by the solution of limestone along a period of abundant rainfall and the subsequent rise of the overlying rock. The well-stratified material was deposited in the solution cavities prior to the pipe.

Ore occurs as discontinuous, flat-lying bodies that are partly controlled by bedding or bedding-plane fractures. The size and shape can best be inferred from the enlargements of the old stopes (figs. 18, 19). The largest pipes are about 1,400 square feet in area, about 16 feet maximum height, and 6 feet in average height. Ore bodies exploited in recent years were considerably larger, and, in general, yielded between 50 and 100 tons per pipe.

Most of the ore is oxidized and only relicts of the primary minerals remain. Hemimorphite is the most abundant ore mineral. It is in radial and divergent aggregates light-gray to colorless crystals associated with cerarite, which economically is probably the most important ore mineral. The cerarite is in euhedral olivine-granular crystals that are cubes 0.2 mm on a side modified by octahedral faces. In addition auralite, azurite, bindheimite, cerussite, chrysocolla, and native copper have been tenebros.

Galena is the most abundant primary ore mineral. It is present as relicts 1 inch to 4 inches in diameter surrounded by oxidized ore minerals. Cerussite and anglesite relicts are found only where ore is evident. Minor units of sphalerite, pyrite, and tetrahedrite are in primary ore. The sphalerite is in irregularly shaped grains as great as an inch in maximum dimension in a resinous light brown. Barite, quartz, calcite, and cedony are the principal gangue minerals and gypsum and clay minerals are in small quantities.

The most important ore bodies are near fault zones and the rocks are in part brecciated and shattered. Most ore bodies are shallow dipping and gently conform to bedding, locally they steepen and angularly transect bedding. Some of this steepening may be a drag effect of post-ore faulting. The favorable ore body occupied by the discontinuous ore bodies plunges steeply to the southeast (see fig. 19, section A-A').

Here steep northeast-dipping faults, such as the West fault, are mineralized, they contain abundant quartz, fite, yellow and brown ochreous iron oxides, and cedony, but they contain little ore minerals. Movement on the steep faults was probably instrumental in forming open fractures parallel to bedding that served as loci for ore bodies, but the steep fractures served only as channelways for the ore solutions. Slickensided selvages and local shattering indicate some post-ore movement. The northeast-dipping fractures in places offset the shallow-dipping ore bodies of the main workings.

Santa Rosa Mine

The Santa Rosa mine is in secs. 26 and 35 (projected), T. 17 S., R. 39 E., in the southern part of the Inyo Mountains at an altitude of 6,500 to 7,100 feet. The mine is described in detail by Mackevett (1953), and his report is summarized here.

Workings consist of the 352-foot Hesson inclined shaft, several shallower shafts, about 1,500 feet of drifts and crosscuts, and extensive stopes. In addition, an 1,800-foot westerly trending crosscut adit was driven in 1953 to explore the known veins at greater depth.

The mine is the eighth largest lead producer in the State. From the time of its discovery in 1910 until 1950 the mine produced 36,854 short tons of ore containing 11,990,792 pounds of lead, 487,347 pounds of copper, 4,105 pounds of zinc, 426,543 fine ounces of silver, and 478.7 fine ounces of gold (Mackevett, 1953, p. 4). Lessees have mined some ore from the new deeper workings since 1953.

The mine is within an inlier of the lower limestone member of the Owens Valley formation of Permian age that has been metamorphosed to calc-hornfels. The inlier is approximately 2,000 feet long and 600 feet wide. It is encircled by Tertiary and Quaternary volcanic rocks consisting of olivine basalt, tuff, tuff-breccia, agglomerate, and andesite. The calc-hornfels is a dense, fine-grained rock that is greenish-gray on fresh surfaces and weathers brown. It consists mainly of calcite, quartz, and diopside and minor amounts of zoisite, garnet, epidote, limonite, and opaque minerals. Minor beds of silicified bluish-gray limestone that are locally fossiliferous are interbedded with the calc-hornfels.

Andesite porphyry dikes, which were called syenoidiorite porphyry by Mackevett (1953), are 2 to 6 feet thick, strike N. 70° E., and dip nearly vertical. These dikes cut the Owens Valley formation of the inlier but do not cut the adjacent volcanic rocks. Northeast-trending, steeply dipping basalt dikes 2 to 16 feet thick cut both limestone and volcanic rocks.

The inlier of calc-hornfels is structurally a horst. The Santa Rosa fault bounds the inlier on the east, and another steep fault forms part of the western boundary of the inlier. The Santa Rosa fault is a north-trending normal fault that dips about 80° E. The east block has been downfaulted probably at least 250 feet. Rocks of the inlier strike N. 10°-20° W. and dip 30°-70° NE. Faults of prevolcanic age within the inlier contain the ore-bearing veins. The most important faults strike parallel with bedding and dip 30° to 60° SW. Some of the ore-bearing faults strike parallel with bedding and dip 55° to 80° NE. or strike about east and dip nearly vertically.

Ore is in veins within prevolcanic faults. At least 12 veins are exposed. They range from less than 10 feet to 700 feet in length and average between 3 and 4 feet in thickness. West-dipping veins are the most abundant and productive. Fissure filling was the dominant process involved in the emplacement of the veins.
EXPLANATION

Dibl, fine grained medium-gray limestone; Dibm, marble

Contact, approximately located

Vertical fault

Fault showing dip

Dashed where approximate

Strike and dip of beds

Vein showing dip

Outcrop of vein

Vertical shaft

Open cut or prospect pit

Dump

Fossil locality

Geology by L.A. Brubaker, May 195 and W.E. Hall, June 195
Topography by E.M. Mackevey 195

Figure 20. Geologic map of the Silver Reid prospect.
veins are highly oxidized and consist chiefly of sylvite and hemimorphite in an iron-stained silica- and siderite-gangue. The primary ore is composed mainly of sphalerite, galena with subordinate arsinite and chalcopyrite. The grade of ore within a mile of the Hesson vein, ecologically the most important vein, was from a shoot mined gently north of the property.

The develop ment of the production from the Hesson vein, ecologically the most important vein, was from a shoot mined gently to the north.

The adit was driven under the mine workings by the Hesson Company to explore the veins at depth. The adit was driven westerly 1,800 feet at an altitude of 6,580 feet from the sharp bend in the road at the tramway from Upper Sanger workings. (See Bend, 1953, pl. 2.) The adit is completely calc-silicate. The ore showings in the adit are sparse. Most veins have pinched out above the level of the tramway.

Lost Burro Prospect

Silver Reid prospect is 12.5 miles north of Darwin, southeastern part of the Santa Rosa Hills in sec. 11, T. 17 S., R. 40 E. The prospect is above a dirt road that leads from the Saline Valley 1 mile east to the Lee mine; the property adjoins the Lee mine on the north. The surface geology was mapped by L. A. Brubaker and E. M. Mackevett in May 1951 and additions were made by W. E. Hall in July 1953.

The Silver Reid prospect was staked in 1924 by W. A. Reid, and it is now owned by his widow, Mrs. Agnes Reid of Panamint Springs, Calif. The property has been prospected intermittently since 1924, and by 1951, development work consisted of about 25 shallow pits and shafts and several near-surface stopes. No production has been recorded from the property, but a small production may have been lugged with that of the Lee mine.

The Lost Burro formation of Devonian age crops out in the prospect area (fig. 20). It is conformably overlain by Tin Mountain limestone of Mississippian age south of the prospect at the Lee mine, and it is unconformably overlain by flat-lying basalt of Tertiary or Quaternary age and by alluvium to the west and north of the prospect. A section 1,500 feet thick of the Lost Burro formation is exposed in the area. It consists of white, medium- to coarse-grained marble that is characteristically banded parallel to bedding and contains streaks and thin beds of dark-gray marble less than an inch thick. Quartzite lenses are locally in the white marble. Fine-grained, medium-gray limestone beds as much as 50 feet thick are interbedded with the white marble in the northeast part of the prospect area near the base of the exposed section of Lost Burro. Thin

---

EXPLANATION

Lost Burro formation (mainly white marble)

Contact, approximately located, showing dip

Fault showing dip (Dashed where approximate)

Vein containing quartz, calcite, barite, and minor galena

'Stoped vein

Open cut and outline of stope

---

Figure 21. Geologic map of the main stope of the Silver Reid prospect.
chert interbeds are abundant in the medium-gray limestone near the base of the exposed section.

Bedding in the Lost Burro formation strikes N. 45° W. to west and dips southwest to south from 35° to 87° except for local steep northeast dips near the crest of the hill. Two sets of faults are evident in the mine area. One set strikes about N. 70° W., approximately parallel to the strike of bedding, and dips steeply either to the north or south. The other set strikes N. 20°-70° W. and dips gently southwest. The flat faults have no appreciable displacement and are probably fractures formed by differential movement along the steep major faults. The major faults strike parallel to bedding, but in general dip more steeply than bedding. They are believed to have mainly a strike-slip displacement.

Ore is localized in small bodies in flat-lying faults near major steeply dipping faults striking N. 60°-80° W. Most of the steep faults are only slightly mineralized. The largest known ore body has been stoped over an area 40 feet long and 20 feet wide, and it has an average thickness of 2 feet (fig. 21). At least five other flat veins are exposed on the surface or in shallow prospect shafts (fig. 20) to the northwest of the main stope, but they are extensively developed.

At a few places the steep N. 60°-80° W. faults locate the vein material. At the west side of the Silver Hill prospect an inclined shaft has been driven to a depth of 56 feet on a N. 70° W.-striking fault. At the surface the fault shows little mineralization, but a 30-foot section at the bottom of the inclined shaft exposes a vein 1 to 3 feet thick, and a winze has been driven on the fault to a depth of 10 feet below the level. The steeply-dipping vein is similar in mineralogy to the flat-lying veins.

The veins consist of minor galena and pyrite in a gangue of quartz, calcite, and barite. Secondary copper minerals and a yellow antimony mineral, probably bismuthinite, are present locally. No silver minerals were s
Little data are available about the grade of the ore. H. R. Glenn (oral communication, 1954), lessee of the mining Lee mine, sampled the dump near the Main pit and reports the sample assayed 18 ounces of silver.

S and Prospects in the Tale City Hills
Cactus Owen (Midway) Prospect

The Cactus Owen prospect is in sec. 25 (projected), T. 18 S., R. 39 E., on an isolated hill 1½ miles N., 70° W. of Tale City mine, at an altitude of 5,000 feet. The prospect has no recorded production. Workings consist of inclined shafts 40 and 200 feet deep, a short adit, and at 300 feet of levels.

Limestone and quartzite of the Lost Burro formation are found in the prospect area (fig. 22). Limestone is a light-gray, bleached rock in beds 1 to 4 feet thick. It is recrystallized and shows evidence of intense deformation. Several quartzite beds 1 to 12 feet thick are interbedded with the limestone. The quartzite is medium-gray on fresh surfaces and shows light brown coloration.Some of the quartzite rocks strike N., 80° W. to west and are steeply dipping. They are cut by a steep fault that lies N., 20°-30° E. The fault is marked by an iron-stained breccia zone about 10 feet thick. Other faults are lenticular or nearly parallel to bedding. They are iron-stained and in some places have local pockets of quartz calcite. Workings have mainly developed the bedding-plane faults.

The only ore minerals observed were found on the surface and consisted of a few scattered galena fragments associated with quartz and minor quantities of pyrite specular hematite. Calcite commonly coats veins and is associated with quartz. A minor gossan is exposed in a few places but appears barren of ore minerals.

Homestake Mine

The Homestake mine is 2,000 feet northwest of the Tale City mine in sec. 30 (projected), T. 18 S., R. 40 E., at an altitude of 5,520 feet. The mine is owned by Edith Hart and George Koest. Workings at the Homestake mine consist of inclined shafts 50 feet deep and workings on the adjacent Homestake numbers. The claim includes a 45-foot adit trending S., 33° W., and a 30-foot drift trending N., 45° W.

The country rock is thin-bedded bluish-gray limestone. The Lost Burro formation that strikes N., 70° W. and 70° SW. The mine workings follow major shear planes, and the major structure at the Homestake number 1 consists of a shear zone 2 to 10 feet thick that strikes N. W. and dips 70° SW. The upper workings are on iron-stained shear zones as much as 6 feet thick that strike N., 45° W. and N., 33° E. and dip steeply south. Sheared limestone is iron stained and is locally replaced by dolomite. In places the shear zones are replaced by pockets of quartz and minor calcite, erussite, morphite, and oxidized copper minerals.

Silver Dollar (Domingo) Mine

The Silver Dollar mine is 2,600 feet east of the Tale City mine in sec. 29 (projected), T. 18 S., R. 40 E., in the eastern part of the Tale City Hills at an altitude of 3,000 feet. It is owned by Edith S. Sickhart and George Koest, mailing address Darwin, Calif. Early mining operations were for lead and silver, but in recent years the mine has been exploited on some of the claims. Production data from the files of the U.S. Bureau of Mines, San Francisco office, for the metalliferous deposits are given below. These data are given under the name Domingo, a former name of the mine. George Koest provided much of the following historical information.

<table>
<thead>
<tr>
<th>Year</th>
<th>Gold (oz)</th>
<th>Silver (oz)</th>
<th>Copper (lbs)</th>
<th>Lead (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1910</td>
<td>——</td>
<td>5,360</td>
<td></td>
<td>107,000</td>
</tr>
<tr>
<td>1911</td>
<td>1.79</td>
<td>12,247</td>
<td></td>
<td>320,578</td>
</tr>
<tr>
<td>1915</td>
<td>1.45</td>
<td>1,117</td>
<td>229</td>
<td>35,374</td>
</tr>
</tbody>
</table>

*Production figures furnished by the U.S. Bureau of Mines and published with the permission of the mine owners.*

Ore was first discovered on the property in 1910 at the site of the main pit and all the recorded production was made during the ensuing five years. During late 1910 and early 1911 a shaft, sunk to a reported depth of 90 feet, explored a vertical vein on the south side of the main pit. During the next four years, lessees enlarged the main pit and drove short drifts along a vein dipping to the northeast, backfilling the original shaft. This northeast-dipping vein was followed for 100 feet down the dip before work was abandoned in 1915. During the late 1930's the present owners sunk a 130-foot shaft 100 feet east of the main pit. Crosscuts were driven from the bottom of the shaft to points under the main pit, but no ore was found. The main ore workings consist of a 75-foot inclined shaft with several hundred feet of drifts and crosscuts.

The Silver Dollar mine is in a complexly faulted area underlain by the Lost Burro formation of Devonian age and the Keeler Canyon formation of Pennsylvanian and Permian age (fig. 23). Minor Rest Spring shale of Pennsylvanian age crops out in faulted zones. The Lost Burro formation consists mainly of massive light-gray dolomite but includes some medium-bedded, light-grayish gray limestone and minor quartzite. The Rest Spring shale is a dark-brown fissile shale that is localized along a thrust plane. Bluish-gray thin-bedded cherty limestone of the Keeler Canyon formation is the host rock for the lead-silver ore.

The Devonian rocks are thrust over the Rest Spring shale and the Keeler Canyon formation. The best exposure of the thrust fault is about 300 feet north of the main pit where the Lost Burro formation overlies the Rest Spring shale. Numerous steeply dipping faults that strike about N. 50° W., approximately parallel to bedding, displace the thrust fault. Some of the northwest-trending faults contain dragged and shattered quartzite. Rocks in the thrust plane are strongly folded. The contact of limestone and dolomite 175 feet southeast of the main pit is parallel to bedding, and the structure is a faulted inverted syncline.

Ore from the main pit probably accounts for almost the entire mine production. The ore is in limestone of Pennsylvanian and Permian age in a fault zone that strikes N., 55° W. and dips steeply northeast.
in the size and shape of the main pit, the main ore body was about 35 feet long, 30 feet thick, and extended feet down dip. Little ore remains in any of the works, but many faults in the mine area are strongly iron and contain quartz, calcite, and jasper. A confluence of abundant local faulting and shattering and favorable host rock probably accounts for the localization of ore at the main pit. No data are available regarding the tenor of the ore.

The tale deposits are within dolomite of the Last Formation 650 feet northwest of the lead-silver. The tale is in strongly sheared masses in a fault that strikes N. 20° W. and dips 70° SW. The deposits were not mapped. The tale is pale green and is thinly laminated by shearing. Locally it contains some brite. Several of the N. 70° W.-trending faults in the chert part of the map area contain tale and they have been explored by small pits (fig. 23).

Tungsten Deposits

by W. E. Hall, E. M. Mackevett, and D. M. Lemmon

Tungsten in the mineral scheelite has been recovered the Darwin quadrangle principally from mines in 18 and 19, T. 19 S., R. 41 E., in the east part of Darwin Hills 1 mile to ½ mile east and northeast Darwin. Stolzite has been reported by Tucker and apson (1941, p. 567). However, D. M. Lemmon submitted similar material to Jewel Glass of the U. S. Geological Survey as that from which stolzite was reported, and the material was identified as scheelite mixed with other minerals but it contained no stolzite. Some scheelite is present in the Thompson mine of the Darwin up, but it is intimately associated with galena and fault metallurgical problems have discouraged efforts to recover it except from local high-grade concentrations that were mined selectively and given special metallurgical treatment. A small amount of scheelite has been mined from deposits on the northeast slope of the Coso Range about 8 miles west and southwest of Darwin. All one of these deposits, the Lone Pinyon, which lies in the quadrangle in sec. 26, T. 19 S., R. 39 E., are nth of the Darwin quadrangle (pl. 1).

Some of the deposits in the Darwin district contain high scheelite and lead-silver minerals or scheelite and other minerals. The Custer, Defiance, Fairbanks, Jack Lane, Promontory, and Thompson, and Wonders mines have both lead-silver and tungsten minerals. These properties, which were developed mainly for their lead-silver ore, are described under the heading, “lead-silver deposits”.

Story and Production

Although scheelite was recognized in the Darwin lead district during World War I, the deposits remained undeveloped until 1940. At this time Frank Atkins purchased a group of patented claims on the west side of the Darwin Hills at a tax sale, relocated litional claims, and with C. W. Fletcher and others organized the Darwin Consolidated Tungsten Company to develop the tungsten. In 1941 the E. L. Cord interests der the name Pacific Tungsten Company leased 23 mining claims from the Darwin Consolidated Tungsten Company, and during the ensuing twelve months they produced 30,940 tons of ore that averaged about 1 percent WO₃ (Wilson, 1943, p. 544). The ore was treated at a mill near Keeler owned by the West Coast Tungsten Corporation. This production was principally from the Durum, Fernando, St. Charles, and Hayward claims. Possibly 25,000 tons of tungsten ore has been mined in the district from 1944 to 1955.


The scheelite in the Thompson mine of the Darwin group normally is not recovered except from local concentrations of high-grade ore that are mined selectively. Davis and Peterson (1948, p. 2) report that several hundred tons of high-grade scheelite ore containing 10 to 15 percent WO₃ have been mined, and scheelite was being stockpiled at the Darwin mine in March 1955. This high-grade ore was shipped to Tooele where it was fused with sodium carbonate and then leached with hot water for recovery of WO₃.

Some deposits about 1 mile east and southeast of Darwin were located originally in the 1890’s for their copper showings, but they were operated briefly during World War II for tungsten. These include the Alameda and Toga claims. The Alameda claim is mentioned as a copper prospect by Aubury (1908, p. 313) under the name Richardson group, and part of the Toga claim is probably part of the Kingman claim described by Aubury (1902, p. 245).

Acknowledgments and Previous Work

The eastern part of the Darwin Hills, where the tungsten deposits are located, was mapped by Kelley (1938, pl. 7) as part of his study of the Darwin silver-lead district. He identified scheelite on the Bruce claim. A U. S. Geological Survey party under D. M. Lemmon studied the tungsten deposits from Nov. 3, 1941 to March 4, 1942. They mapped the Durum-Fernando-St. Charles area on a scale of 1 inch equals 200 feet and made larger scale maps of the underground workings. Their maps are published in this report, and with additional data supplied by Lemmon serve as the basis for the description of the tungsten deposits. The writers mapped the recent workings in the Fernando and St. Charles mines. The U. S. Geological Survey party under D. M. Lemmon also mapped the tungsten prospects in the Coso Range in Feb. 1942.

L. K. Wilson (1943, p. 543-560), geologist for the Pacific Tungsten Company, described the tungsten deposits in the Darwin district, their genesis, and the operations of the Pacific Tungsten Company from 1941 to 1943. The U. S. Bureau of Mines under D. W. Butner (1949, p. 2), project engineer, trenching, and sampled nine properties in the Darwin district in 1941-42. Most of this work was done at the Silver Reef mine, owned by Mickey Summers’ estate, at the south end of the
Figure 24. Geologic map of the underground workings of the Durham and Fernando mines.
Figure 25. Geologic map of the underground workings of the St. Charles mine.
Darwin Hills south of the Darwin quadrangle, but some work was done on all the principal tungsten showings in the Darwin Hills.

Deposits in the Darwin District

Geologic Setting

Most of the tungsten deposits in the Darwin district are within metamorphosed rocks of the upper part of the lower member of the Keeler Canyon formation of Pennsylvanian and Permian age close to the eastern contact of the stock of the Darwin Hills. The rocks consist of calc-hornfels, marble, and tactite that are metamorphosed equivalents of interbedded silty and sandy limestone, limy shale, and pure limestone. The metamorphosed zone extends about 3,000 feet east of the stock. The calc-hornfels is derived from limy shale and silty and sandy limestone. The relatively pure limestone beds are in part unmetamorphosed, but in most places they are recrystallized to marble or altered to tactite.

Calc-hornfels is the predominant rock type. It is a light-gray to greenish-gray dense rock with a wide range in mineralogy depending upon the original composition of the rock. In general, the calc-hornfels is composed of diopside and wollastonite with lesser amounts of garnet, olivoclase, scapolite, tremolite, and relict calcite. The pure limestone beds are partly recrystallized to a gray, medium-grained marble. Locally the marble and limestone are replaced by tactite within a few hundred feet of an intrusive contact close to the intersection of faults. Most of the tactite is a garnet- or idocrase-rich rock, but some contains epidote, diopside, wollastonite, and calcite. The garnet is andradite.

The eastern contact of the stock of the Darwin Hills is very irregular. Many small dikes and sills extend as far as 1,500 feet east of the main intrusive body, and the tungsten deposits are localized close to these offsets. A group of dikes and small, irregular intrusions extend east of the main stock on the St. Charles claims. A sill of quartz monzonite is 160 feet east of the Durham glory hole, and an irregular intrusion crops out along the ridge between the Durham and Chipunk mines (pl. 9).

The Paleozoic rocks have been tilted into an overturned section that strikes north and dips 30° to 78° W. as described under the subtopic "Geology" in the section on the Darwin lead-silver-zinc district. Numerous faults that strike N. 60° E. to east and dip steeply either north or south cut the rocks, but the displacement along the faults is small. Slickensides are nearly horizontal, and the displacement is predominantly left lateral.

Ore Bodies

Scheelite ore bodies are found as replacements of pure limestone and tactite beds close to the intersection with N. 70° E.-striking faults and with the N. 70° E. faults mostly where the wall rock is pure limestone or tactite. Most of the ore is found within 3 limestone beds locally known as the Durham, Prisco, and Alameda beds (pl. 9). Only the Durham ore body is known to extend more than 60 feet vertically (fig. 24). The Durham and Alameda ore bodies are replacements of pure limestone and tactite beds close to the intersections with the Fernando shear zone. The Durham ore body is a replacement of the footwall of the Durham limestone bed where it contact with calc-hornfels. The ore body is expose 350 feet at the surface and has been mined to a depth of 350 feet where the ore body is only 30 feet long (fig. 14). Its thickness ranges from 2 to 35 feet.

Three ore bodies that are replacements of the Alamedan bed near N. 70° E. faults have been mined. Two are the intersection of the Alamedan bed with the Fernando shear zone; the third is 1,000 feet northwest of the Alamedan bed. The largest of these ore bodies is at the intersection of the Alamedan bed and the Fernando shear 950 feet S. 80° W. of the pit of the Fernando adit. It has been developed by an open pit 50 feet long parallel to the strike of the enclosing calc-hornfels, 60 feet wide, and about 20 feet deep. A drift was driven in 1955 under the pit to develop ore remaining at the bottom.

The ore in the St. Charles-Hayward area is in N. 70° E. faults that dip steeply to the northwest (pl. 9). The largest ore body is developed by the St. Charles workings (fig. 25). The ore shoot was 140 feet long and 10 feet thick, and was mined from the surface to an average depth of about 30 feet. Most of the scheelite is associated in the St. Charles No. 2 and St. Charles workings is in thin veins or streaks along N. 70° E. faults, and no scheelite is disseminated in the wall rock between faults (fig. 25). The streaks range from a width of 0.1 to 6 inches thick and can be mined by highly selective methods where fractures are closely spaced so that several can be mined together. Some of the trends contain ores of 10 to 30 percent WO₃, but the ore of over a mining width would probably average about 0.2 to 0.3 percent WO₃.

Grade

The grade of ore mined from the district has averaged about 0.75 percent WO₃. Wilson (1943, p. 558) reported that from 1941 to 1942 approximately 32,000 tons of ore averaging more than 1 percent WO₃ was mined from the Darwin Hills. The ore at the Durham mine averaged 1 percent WO₃ over an average width of 15 feet of 200-foot and 300-foot levels (Wilson, 1943, p. 558). The grade of ore at the St. Charles No. 1 mine was high, ranging from 2 to 10 percent WO₃. Ore mined since averaged about 0.5 percent WO₃.

Submarginal ore is present at the Fernando mine to a lesser extent at the St. Charles No. 3 mine. The marginal ore at the Fernando mine is exposed in the main Fernando adit along the Fernando shear zone (fig. 24). Scheelite is localized along fractures over a length of 610 feet and a width up to 50 feet; some parts of the area are estimated to contain 0.2 to 0.5 percent WO₃.

Ore Controls

The ore controls for scheelite are both stratigraphic and structural. Pure limestone, and tactite formed from alteration of it, are more favorable for ore than calc-hornfels. However, the dense calc-hornfels can be eliminated as a possible host rock as some ore has been mined from it. The bedded replacement body at the Durham mine selectively replaced tactite and pure limestones. Most other occurrences of scheelite in the district along N. 70° E.-striking faults, and scheelite ma
whether the wall rock is tectite, limestone, or hornfels. Commonly the scheelite zone is widest a fault cuts tectite and thins to a narrow stringer the fault cuts calc-hornfels. In both the St. Charles workings and in the Hayward mine, ore has been from veins where the wall rock is calc-hornfels. At hayward mine the ore is widest where the wall rock tite, and the vein thins to a thin stringer to the east the wall rock is calc-hornfels. The ore body rakes west parallel with bedding.

dritic rocks must be close by in order to form either or scheelite. The most favorable places for ore are small satellite intrusive bodies crosscut structure. Etie and scheelite do not necessarily form adjacent intrusive rocks, but are within a few hundred feet rusive rocks and commonly are localized by faults.

**Alamed 63**

**Alameda Mine**

The Alameda mine is 4,200 feet N. 80° E. of Darwin in sec. 19, T. 19 S., R. 41 E., at an altitude of 5,000 feet. The property was originally developed as a copper prospect by Charles Richardson in the early 1900’s and he sunk an inclined shaft 103 feet deep (Aubury, 1908, p. 313). Very little drifting or crosscutting were done.

A pocket of scheelite ore was reported in the shaft at a depth of 95 feet by Wilson (1943, p. 557). This pocket was mined by the Pacific Tungsten Company during World War II, and an additional small tonnage was mined in 1953 by W. E. Schmidt who had a sublease on the property from Howard Miller and Louis Warpen, Jr. The total tonnage of tungsten ore mined is small, because the stope at the bottom of the shaft is only about 25 feet long, 6 to 10 feet wide, and 9 feet high.

The rocks in the mine area are marble, calc-hornfels, and tectite of the Keeler Canyon formation and are intruded 290 feet west of the inclined shaft by the stock of the Darwin Hills. Bedding strikes N. 18° W. and dips 71° SW. The shaft is sunk in marble on a bedding-plane vein 3 feet thick. The vein contains a small amount of secondary copper minerals in a gangue of calcite and limonite. Scheelite has been mined from a small stope at the bottom of the shaft where the N. 18° W. vein is intersected by a small fault that strikes N. 20° E. and dips 77° SE. Only a small amount of scheelite remains along the cross fault.

**Bruce Mine**

The Bruce mine is 6,000 feet N. 28° E. of Darwin in sec. 18, T. 19 S., R. 41 E., on the north side of Lane Canyon at an altitude of 4,800 feet. A steep dirt road leads to the property from the road in Lane Canyon. The mine is owned by The Anaconda Company and was leased to A. J. Pouch and “Frenchie” Lingsley of Dar- win in 1955. The workings consist of 2 adits about 80 and 100 feet long and an open cut 50 feet long, 10 feet wide, and 5 to 15 feet deep.

The rocks in the mine area are calc-hornfels and tectite that are folded into an open anticlinal-shaped fold that is an inverted syncline. The fold axis is approximately 350 feet east of the stock of the Darwin Hills. The rocks are correlated with the upper part of the lower unit of the Keeler Canyon formation of Pennsylvanian and Permian age. The crest of the anticline is mineralized along the surface for a distance of about 400 feet. In the open cut the vein is 2 to 6 feet thick along the crest of the anticline, and ore extends down the west limb of the anticline as a bedding-plane vein that strikes N. 25° W. and dips 67° SW. The vein contains calcite, quartz, limonite, chrysocolla, cuprite, malachite, garnet, and scheelite. The grade or continuity of the deposit down the dip is not known because of insufficient development. Samples cut by D. L. Davis on surface exposures averaged 0.40 percent Cu and approximately 1 percent WO<sub>3</sub>; the vein shows only scattered ore minerals where cut by the lower adit.

**Chimpunk Claim**

The Chimpunk claim, owned by W. E. McCully of Darwin, is 6,000 feet S. 75° E. of Darwin in sec. 19, T. 19 S., R. 41 E., at an altitude of 4,700 feet. The claim is 850 feet S. 15° W. of the Darwin open cut. A dirt road
that branches off from the Durham road leads south to the property. Mine workings consist of an adit 115 feet long and several open cuts and short adits.

The rocks in the mine area are eale-hornfels and taelite that are correlated with the top of the lower member of the Keeler Canyon formation. Overturned bedding strikes north and dips 65° to 80° W. A steep fault that strikes N. 70° E. cuts through the portal of the main adit, which trends S. 15° W. along another steep fault.

Scheelite is exposed along the N. 70° E. fault for a distance of 70 feet. Only a few specks of scheelite were seen in the adit along the steep N. 15° E. -striking fault.

Darwin Group

Some of the lead-silver stopes of the Thompson workings have local concentrations of scheelite, although most of the ore contains no scheelite. Davis and Peterson (1948, p. 2) report several hundred tons of lead-silver ore containing 10 to 15 percent WO₃ was mined from oxidized ore. Euhedral crystals of scheelite are found loosely embedded in a matrix of eussite, limonite, jarosite, gypsum, and wulfenite. Primary ore has also been found in the deeper levels that contain euhedral crystals of scheelite surrounded and slightly embayed by galena (photo 1). Small amounts of scheelite are in fractures in or near the Water Tank fault near the crest of the ridge east of the Darwin mine camp and on the Bermen claim (pl. 5). All are too low grade to be ore.

Durham Mine

The Durham mine is 5,500 feet east of Darwin in sec. 19, T. 19 S., R. 41 E., at an altitude of 4,640 feet. The property is accessible by a hard-surfaced road leading south from Lane mill. Development work consists of an inclined shaft 250 feet deep with 4 levels totaling 1,100 feet of drifts and crosscuts (fig. 24). The 100-foot level connects with the bottom of the Fernano shaft.

The rocks in the mine area consist of limestone, marble, eale-hornfels, and taelite of the Keeler Canyon formation and are intruded by a sill of quartz monzonite 170 feet east of the Durham shaft. Overturned bedding strikes north and dips 50° to 67° W. The rocks are intersected by a series of strike-slip faults that trend east to N. 70° E.

The ore body extends south from the Fernano shear along the footwall of a limestone bed 40 feet thick that is in part recrystallized to marble and altered to an idocrase- and garnet-rich taelite. The taelite is in the basal part of the limestone bed in the upper mine workings and in the central part of the bed below the 200-foot level. Many small cross fractures cut the limestone and taelite.

The ore body is 350 feet long at the surface, and the ore mined by the Pacific Tungsten Company in 1941 to 1943 ranged in thickness from 4 to 20 feet. The lower grade wall rock has been mined by subsequent lessors so that the glory hole now has a maximum width of 44 feet. The ore body extended to a depth of 350 feet (fig. 24). On the 0 and 100 levels, the best grade of ore is on the footwall of the limestone bed where it is altered to taelite. On the 200-foot and 300-foot levels the footwall is barren, and the ore is in the middle of the limestone and taelite bed.

Scheelite occurs irregularly through much of the taelite, but the mineralization is more intense where fractures are abundant, and scheelite extends out the main ore body into taelite along these cross fractures.

Fernano Mine

The Fernano mine consists of two patented claims that lie adjacent to the Durham mine on the north. Both properties are accessible by the same road. The workings. The Fernano mine was worked for its lead-silver values. The old workings are 500 feet N. 70° E. of the portal of the Fernano adit, and consist of an inclined shaft 125 feet deep paral bedded and several levels driven from the shaft. (1938, p. 561) reports that on the 100-foot level mineralization along the Fernano shear zone is 30 to 40 feet wide and the ore consists of galena, eussite, and a roque in a gangue of limeonite, calcite, and jasper. The recorded production of lead-silver ore was in 1919-1920 when the mine was operated by Theo Peterson.

The tungsten ore is along the Fernano shear zone in feet S. 70° W. of the old Fernano workings. The zone is prospected and developed by three adits. Fernano or zero level totals 1,550 feet of drifts and crosscuts, and a winze extends 40 feet below this level. The intermediate level, 230 feet above the zero level, the Alameda glory hole has 310 feet of drifts and cuts. An inclined shaft 130 feet deep near the portal the Fernano adit connects with the 100-foot level of the Fernano adit.

Tungsten ore in the Fernano mine is of low grade and has been worked successfully only by solo mining and sorting or by screening. Scheelite is erratically distributed along fractures in the Fernano zone, which strikes east and dips steeply south, and is not sufficiently abundant to be ore except at the intersections of the Fernano shear with pure limestone taelite beds. The largest ore shoot was mined from an open cut at the intersection of the Alameda bed and the Fernano shear zone. The ore shoot was 90 feet long, parallel to bedding, 46 feet wide, and was mined at depth of 50 feet.

Considerable prospecting has been done on the level along the Frisco bed, but only a small amount of ore was found. A winze was sunk on ore on the Frisco bed to a depth of 40 feet along a fracture at N. 70° E. and dips 55° SE. On the zero level the shoot is 55 feet long and 2 to 10 feet thick, but scheelite is exposed at the bottom of the winze (fig. 24). Low-grade scheelite containing less than half a percent WO₃ is within the Fernano shear zone at its intersection with the Frisco bed (fig. 24). Low-grade scheelite is exposed for 200 feet and is a few inches to 15 feet thick. The vertical extent has not been prospected. A stringer of scheelite is exposed in the crosscut of the Frisco bed 340 feet south of the Fernano shear. Scheelite stringer is 1 inch to 6 inches thick along a fracture that strikes N. 77° W. and dips 66° SW. No cutting has been done along the fracture. Some ore is also mined at the portal of the Fernano adit near the intersection with the Durham bed, but no ore was found.
Hayward Mine

The Hayward mine is 1 mile N. 78° E. of Darwin in sec. 19, T. 19 S., R. 41 E., 300 feet east of the portal of St. Charles No. 1 adit. The mine is accessible by a road down the canyon past the St. Charles mine. Development work consists of an open pit 50 feet long, 30 feet wide, and 20 feet deep. A 50-foot vertical shaft sunk at the east end of the open pit.

The ore consists of many narrow seams of scheelite-bearing fractures in a shear zone striking N. 65° E. and dipping 72° SE. in dense hornfels. The size of the ore is outlined by the dimensions of the pit. The fault extends northeast onto the Custer claim where it has been prospected by a vertical shaft 50 feet deep that has exposed a zone of 3 to 4 feet thick which contains minor scheelite and secondary copper minerals. In 1955 an adit was being driven to prospect the depth of about 50 feet.

Lane Mine

Some scheelite is exposed in the Lane mine 700 to 800 feet within the portal of the Lane adit and a raise was driven 70 feet above the level by the Imperial Metalspany to explore the scheelite-bearing zone. The scheelite is in hornfels along fractures in a fault zone that strikes N. 72° E. The U. S. Bureau of Mines sam-pled the raise and the adit at 10-foot intervals from 633 to 70 feet from the portal between Nov. 17, 1941, and Jan. 19, 1942 (Butner, 1949, p. 6). Thirteen samples of the adit assayed a trace of WO₃ and one sample yed 0.09 percent WO₃. Four samples were taken in raise. Two assayed a trace of WO₃, one assayed 0.49 percent WO₃ over a width of 5.5 feet, and one 0.8 percent WO₃ over a width of 4.7 feet.

St. Charles Mine

The St. Charles mine is 4,500 feet S. 72° E. of Darwin in sec. 19, T. 19 S., R. 41 E., at an altitude of 4,750 feet. The mine is southwest of the Custer mine. Three areas prospected by separate workings known as the St. Charles No. 1, No. 2, and No. 3 workings (fig. 25). The Charles No. 1 area is developed by an inclined shaft 280 feet north of the St. Charles shaft, consist of an adit 97 feet long and two short crosscuts; the No. 3 workings 230 feet 15° W. of the St. Charles shaft consist of three unconnected adits with several short crosscuts, all of which are 600 feet in length.

The ore body in the St. Charles No. 1 workings is in a vein that strikes N. 65° E. and dips 70° NW (fig. 25). The ore shoot was 140 feet long and 2 to 10 feet thick; it was mined from the surface to an average depth of 30 feet. The ore extended only 10 to 15 feet below the adit level, and the bottom 105 feet of the shaft is in sub-marginal ore or barren rock. The ore from the stope averaged 2 to 8 percent WO₃. The scheelite was localized in two narrow high-grade veins separated by 5 to 8 feet of low-grade ore. Southwest of the ore shoot the 2 high-grade veins diverged to a horizontal separation of 20 feet, and the amount of scheelite in each vein decreases. Some ore has been mined from the northernmost split for a stope length of 33 feet, a width of 3 to 4 feet, and for a maximum distance of 55 feet down the dip. Work was being done in this part of the mine in March 1955.

At the St. Charles No. 2 workings, scheelite is exposed in the adit 50 feet from the portal, along fractures trending N. 65° E., but the showings are thin and low grade (fig. 25).

At least three veins have been prospected in the St. Charles No. 3 workings, but ore was mined only from the lowest adit. Thin seams of scheelite are exposed in many places in the lowest adit in fractures trending N. 65° E., but only two small shoots have been mined. A high-grade seam of scheelite 40 feet long and a maximum of 6 inches thick was mined between 25 and 65 feet within the adit, and a raise has been driven to the surface on a shoot of ore 10 feet long in the same structure 90 feet within the adit. At 65 feet within the portal 2 thin seams of high-grade scheelite are exposed, but the hornfels between seams is barren, making the average grade over a mining area of 3 feet less than 0.3 percent WO₃. The 2 upper adits exposed only a small amount of scheelite in thin fractures and none is of ore grade.

Toga Mine

The Toga mine is 4,500 feet S. 82° E. of Darwin in sec. 19, T. 19 S., R. 41 E., along the crest of the ridge overlooking Darwin Wash (pl. 9). The property is accessible by a road from Darwin. The C. W. Fletcher owns the claim.

The property is developed by several short adits and raises to the crest of the ridge at the end of the road to the Toga mine and by an adit 370 feet long that was driven from the gulley 270 feet east of the raises. Some scheelite was mined by Fletcher in 1943 from the workings along the crest of the ridge.

The rocks in the mine area are limestone and calc-hornfels of the lower member of the Keeler Canyon formation and quartz monzonite of the stock of the Darwin Hills. The stock crops out 60 feet southwest of the workings at the crest of the hill and a dike offshoot from the stock is 60 feet to the east. The mine workings intersect a fault that strikes N. 70° E. and dips 80° SE.

A small scheelite ore body was mined from the workings at the crest of the hill. The ore was localized in the N. 70° E. fault at the intersection with one of the Alamedal limestone beds. The fault zone is 8 feet thick in the mine area and locally contains scheelite in a highly limonitic groundmass. Scattered scheelite is exposed in the fault zone in the 390-foot adit on the property.
Deposits in the Coso Range

A few small tungsten deposits are on the northeast slope of the Coso Range 8 to 10 miles southwest of Darwin. Most of the deposits are south of the Darwin quadrangle, and only the Lone Pinyon prospect, which is near Black Springs, lies within the quadrangle and is described here. The deposits are within roof pendants or screens of metasedimentary rocks in quartz monzonite of the batholith of the Coso Range. None have proved to be extensive.

Lone Pinyon (Black Rock) Prospect

The Lone Pinyon prospect is in the Coso Range 8 miles S. 80° W. of Darwin and 2,400 feet east of Black Springs in the SW¼ sec. 26, T. 19 S., R. 39 E., at an altitude of 6,200 feet. The prospect is accessible from Darwin by a dirt road that crosses Lower Centennial Flat. Clyde E. Hanbury and associates developed the property in 1941 and 1942. Little or no work has been done since then. The property is opened by an adit 140 feet long bearing S. 31° W. and a few surface pits and trenches. D. M. Leumon and J. H. Wiese of the U. S. Geological Survey mapped the property in February 1942 and most of the data here are from their investigations.

Quartz monzonite is the predominant rock type in the mine area. It contains many small screens or roof pendants of limestone that are in part altered to tactite and calc-hornfels. The main tungsten showings are in a screen that is 100 feet long in a N. 30° E. direction and 30 feet wide that has been prospected by the adit. Bedding strikes N. 80° E. and dips 50° SE.

Scheelite-bearing tactite crops out at the surface 100 feet S. 30° W. of the adit portal and 60 feet higher at the contact with quartz monzonite over an area 20 feet long and 10 feet wide. The ore did not extend to the adit.

For the first 40 feet the adit is in tactite that contains a small amount of scheelite. The tactite is composed of garnet, epidote, calcite, limonite, and quartz. The remainder of the adit is in hornfels and marble with only a few narrow streaks of scheelite-bearing tactite.

Antimony Deposits

Darwin Antimony Mine

The Darwin Antimony mine is in the Darwin Hills. 2 miles north of Darwin in sec. 2, T. 19 S., R. 40 E. The mine is on one of three unpatented claims located in 1942 by F. E. Groover of Balboa, Calif. The production of antimony from the mine is reported by Norman and Stewart (1931, p. 29) as, "50 to 100 tons of ore assaying more than 30 percent antimony." The workings consist of shafts, drifts, and crosscuts totaling 550 feet. The lower shaft, reported by Norman and Stewart (1931, p. 29) to be 100 feet deep with 50 feet of crosscuts east and west from the bottom, is inaccessible. The shaft has an inclination of 65° W. The upper or main shaft, about 350 feet deep north and 68 feet higher at the collar, is 150 feet deep and has an inclination of 65° in a S. 78° W. direction. At the 100-foot level, 12-foot drifts extend north and south from the shaft. At the bottom of the shaft, 50-foot drifts extend north and south. From the south end of the south drift, crosscuts extend 50 feet west and 30 feet east. A stope in the east crosscut produced all the antimony ore shipped from the mine.

The Darwin Antimony mine area is underlain by bedded medium-gray limestone of the lower member of the Keeler Canyon formation of Pennsylvanian and mian age, which is about 1,000 feet thick, in the view of the mine. Bedding in the Keeler Canyon formation is overturned. It strikes north at the main shaft and 62° to 65° W. The limestone is sheared and fractured near the main shaft, and limonite and calcite fill many of the fractures. A bedding-plane fault that strikes N. 10° E. and dips 65° W. is exposed in the main shaft. It is off by the Darwin air shaft at the position of the last shaft.

Ore in the Darwin Antimony mine is localized along a bedding-plane fault exposed in the main shaft. The fault is traceable along strike for about 1,000 feet. S. nitre is exposed intermittently at the surface and in underground workings over a strike length of about 100 feet near the main shaft and probably was in the last shaft 350 feet farther south. The vein consists of siltite with minor secondary antimony minerals in sheared limestone. Limonite and calcite are the chief gangue minerals. The vein ranges in thickness from a few inches to about 3 feet. All the ore was mined from a stop of the footwall between the 100- and 150-foot levels at about 40 feet south of the main shaft. Small discontinuous seams and pods of stibnite less than an inch thick are exposed in the north drifts on the 100- and 150-foot levels.

Many other bedding-plane faults, also having a northeast strike, are exposed in the west crosscut, but are not realized. Several faults with approximately N. 60° E. strikes and steep northwest dips intersect the main north trending fault in the east crosscut of the 150-foot level and are mineralized at some of these intersections.

At least three shallow prospect pits were cut into vein at the surface not more than 100 feet north of the main shaft, but no ore was produced from them.

Copper Deposits

Copper minerals are associated with practically all the lead-silver-zinc ores and with some of the scheelite deposits. In a few deposits copper minerals are the principal ore mineral, and only these deposits will be described here. The deposits are the Giroux mine and adjacent prospects near Darwin and the Whipple prospect near the east border of the quadrangle (pl. 29). Mines of the Darwin group account for most of the copper production in the quadrangle, but the Santa R. Lane, and Custer mines also produced some copper.

Mining activity on the copper prospects was not confined to the late 1890's and the first few years of the century. Most of the deposits are described by Aub (1902, 1908). A blast furnace was built at the Lane mine in 1889, and some copper matte was recovered (Warren and Huguenin, 1919, p. 99).

Geology

Copper minerals are in the lead-silver-zinc deposit and locally along fractures in some tectites. Most of the copper minerals are in oxidized ore. Chrysocolla is the prevalent copper mineral—occurring in almost every copper-bearing deposit. Antlerite, aurichalcite, azurite, brochantite, caledenite, chalcantite, cuprite, linarite, malachite, and tenorite are the less common second
other minerals found in the quadrangle. The primary copper minerals are chalcopyrite, enargite(?), tetrahedrite, and tennantite. Small amounts of supergene chalcocite and covellite are also present.

(Jerio, Rio Tinto) Mine

The Giroux mine, which is owned by the C. W. Cher estate, is in sec. 24, T. 19 S., R. 40 E., about a mile east of the town of Darwin. The main mine workings consist of a lagged two-compartment vertical shaft 203 feet deep with a 95-foot crosscut and a 70-foot shaft inclined 42° SE. about 150 feet S. 32° E. of main shaft. Most of the workings were made prior to 1908 when the mine was owned by Joseph Giroux of Angeles (Aubury, 1908, p. 313). No production data available.

The mine is along a contact between iron stained porphyry and the stock of the Darwin Hills to the east and calc-hornfels of the Keeler Canyon forma-
to the southwest. A garnet-rich tactite zone 1 foot thick is locally along the contact. The workings stop small oxidized veins and irregular iron stained zones. A 2-foot thick vein exposed by the inclined shaft es N. 55° W. and dips 42° SW. parallel to bedding in the calc-hornfels. Minor cross fractures cut this vein due to negligible offsets. Another vein is exposed in a narrow belt S. 43° W. of the main shaft. This vein es N. 80° W. and dips 40° SW. It is 3 feet thick and is traced for 30 feet on the surface.

The ore minerals consist of secondary copper minerals, chalcopyrite, enargite, and covellite, with minor cuprite, malachite, and chrysocolla. Veins are heavily iron stained and limonite pseudomorphs after pyrite pyritohedrons are abundant. Au-
(1902, p. 245) reports chalcopyrite and minor amounts of gold and silver in the ore.

Man Prospect

The old Kingman copper prospect is in sec. 19, T. 19 S., R. 41 E., about 1,000 feet S. 66° E. of the Giroux mine. Workings consist of 2 adits each about 100 feet long that trend S. 5° W. and an open pit 40 feet long, maximum of 20 feet wide, and 20 feet deep. The prospects are in calc-hornfels and tactite of the Keeler Canyon formation near the contact of the stock of the Darwin Hills. Copper minerals are in two iron stained veins 1 to 4 feet thick and in smaller quantities as fracture veins in tactite. One of the veins strikes N. 20° W. and dips 70° NE., and the other strikes N. 85° E. and 75° SE. The prevalent copper mineral is chalcopyrite with some cuprite, malachite, and aurichalcite(?). Au-
(1902, p. 245) reports chalcopyrite and small amounts of gold and silver.

Whipperwill Prospect

The Whipperwill prospect is in sec. 35 (projected), T. 7 S., R. 41 E., in a canyon near the eastern border of the quadrangle. Workings consist of an inclined shaft 40 feet deep and short drifts. Copper minerals are in a sheared zone 6 to 20 feet thick that cuts the hornfels and tactite country rock. The shear zone is N. 20° W. and dips 70° SW., approximately parallel to bedding. The shear zone contains chrysocolla gangue of sheared, iron-stained calc-silicate min-

Gold Prospects

Gold prospects are distributed through the granitic rocks in the southwestern part of the quadrangle, particularly in the low rolling hills west of the Darwin Hills (pl. 1). A few prospects are in the extreme northwestern part of the quadrangle, the southern part of the Santa Rosa Hills, and in the Argus Range. The prospects are all small, and it is doubtful if any produced more than a few tons of ore. Most of them were located during the 1930’s and show little indication of recent work.

The numerous prospects in the low hills west of Darwin and those in the northern part of the Coso Range are on iron-stained and local quartz-rich fractures cutting granitic rocks of the batholith of the Coso Range. The fractures strike about N. 30° W. and dip steeply. They can be traced for as much as several hundred feet. Commonly the fractures are tight and locally contain small quartz lenses and veins a maximum of 1 foot thick. Most of the quartz veins and lenses are iron-stained and contain minor amounts of calcite, pyrite, and secondary copper minerals. No gold was seen.

The prospects in the northeastern part of the quadrangle are in the shale member of the Owens Valley formation. They explore small gash veins filled with coarsely crystalline quartzite. The veins are 10 to 30 feet long and a few inches thick. Shallow workings for gold in the southern part of the Santa Rosa Hills are on northwest-trending, steeply dipping mineralized faults cutting Mississippian limestone. The principal workings are on the West vein at the Lee mine on an iron-stained quartz-calcite vein (pl. 8). At the Granite claim in the Argus Range a short adit follows a steeply dipping fracture in quartz monzonite that locally contains quartz.

Nonmetallic Commodities

Nonmetallic commodities include talc, light-green chlorite which is locally called “pyrophyllite,” limestone, dolomite, and quartzite. Only talc and “pyrophyllite” are important commercially at present. The great distance to marketing centers is the chief factor inhibiting the development of the vast quantity of limestone and dolomite.

Talc Deposits

Talc deposits are confined to Devonian and older rocks in the Talc City Hills (pl. 2). Only a brief description of the deposits is given here as the deposits are described by Page (1951) and the reader is referred to his report for detailed mine descriptions. Gay and Wright (1954, map sheet no. 12) mapped the surface geology of the Talc City Hills Mines in the Talc City Hills have been one of the nation’s major sources of steatite-grade talc, but in recent years production has been small. The Sierra Talc and Clay Company owns most of the large mines.

The Talc City Hills are underlain by sedimentary rocks of Early Ordovician to Permian age and Cretaceous quartz monzonite. The Silurian and Ordovician sedimentary rocks are predominantly dolomite; the Mississippian and younger rocks are predominantly limestone. The older part of the Devonian rocks is predominantly dolomite and the younger part is limestone and shale.
The Devonian and older rocks are thrust over younger Paleozoic rocks. The Devonian and older rocks in the thrust plate are tightly folded and cut by many steep faults. Overturned bedding and inverted structures are common.

**Geology**

The talc deposits are replacements of dolomite and quartzite near or within shear zones peripheral to the stock of the Tale City Hills. Dolomite of the Lost Burro formation is the principal host rock for tale, but deposits are also in quartzite and dolomite of pre-Devonian age. Some tale has replaced felsite dikes and silts in the Frisco mine. No deposits are in limestone. Most of the dolomite is normal in the regional stratigraphic section, but some dolomitized limestone is present locally near most of the mines. The dolomite is recrystallized and nearly all evidence of original bedding has been obliterated so that original dolomite does not look like its analogue in unaltered equivalent sections. The prevalent tale-controlling shears strike northwesterly and dip nearly vertically.

The steatite is grayish green, pale green, or dull white. It commonly is highly sheared. The larger steatite deposits are irregular elongate pods as much as 600 feet long and 50 feet thick. Most of the deposits are small irregularly shaped bodies a few inches to a few feet thick and are exposed for 10 to 20 feet along shear zones. Some of the deposits contain large residual masses of the host rock.

Except for a few thin dikes and silts of felsite the nearest intrusive rock is quartz monzonite of the stock which crops out in the southern part of the Tale City Hills. The deposits near the stock are larger than those farther away from the stock.

**Alliance Mine**

The Alliance mine is in secs. 29 and 30 (projected), T. 18 S., R. 40 E., at an altitude of 5,400 feet. Edith Lockhart and George Koest, mailing address Darwin, Calif., own the mine. The main workings consist of a northeast-trending glory hole about 200 feet long, 50 feet in maximum width, and 30 feet in maximum depth, an inclined shaft 70 feet deep that connects with about 500 feet of level underground workings and stopes, and several minor adits and pits. Page (1951, p. 12) reports a total production between 5,000 and 10,000 tons.

The tale deposits are in or near shear zones in dolomite and quartzite of Ordovician and Silurian age. The dolomite and quartzite are thrust over limestone of Pennsylvanian and Permian age; the thrust contact is exposed at the south end of the mine (photo 8). Locally the contact is steep on the Irish lease. Here, the thrust is apparently displaced a small amount by a later steep fault. The main workings are on a N. 70° E.-trending shear that dips about 47° NW. Eureka quartzite is in the footwall of the shear and Hidden Valley dolomite in the hanging wall. Tale is in an alteration zone as much as 30 feet thick that can be traced about 200 feet. Much of the material of this zone is a dark-gray chloritite rock, but tale is in irregularly shaped bodies in gradational contact with the chlorite. According to Page (1951, p. 22) two types of tale were mined—a white to gray, commonly mottled tale and a dark-gray to black tale.

The easternmost workings are on a shear zone 4 feet thick that strikes N. 48° E. and dips 75° NW. The host rock is dark-gray Ely Springs dolomite. Tale is main on the hanging wall of the shear zone.

**Apex Prospect**

The Apex tale prospect is in sec. 29 (projected), T. 14 S., R. 40 E., bordering the Tale City mine on the north. Tale occurs locally along a N. 80° E.-striking vertical shear zone and along a north-striking vertical shear zone, which is developed by a 40-foot shaft and a adit 100 feet long. The country rock is light-gray dolomite and minor bluish-gray limestone of the Lost Burro formation.

**Bobcat Claims**

The Bobcat claims are in secs. 29 and 32 (projected T. 18 S., R. 40 E., in the eastern part of the Tale City Hills. Tale is along two near-vertical shear zones. The major zone strikes N. 75° W. and the other N. 25° E. Page (1951, p. 30) reports the ore body, which is mined out, was more than 100 feet long and was 5 to 10 feet thick. The host rock is light-gray dolomite of the Lost Burro formation. Blue-gray limestone of the Lost Burro formation crops out south of the northwest-trending shear zone.

**Frisco Mine**

The Frisco mine is 4,000 feet southwest of the Tale City mine in sec. 31 (projected), T. 18 S., R. 40 E. The mine is owned by the Sierra Tale and Clay Company. The deposit is developed by two inclined shafts 60 to 65 feet deep and three pits, the largest approximated 350 feet long, 100 feet wide, and 50 feet deep. Light medium gray dolomite of the Pogonip group is the principal host rock. Gray limestone of the Pogonip is exposed in parts of the mine area but does not serve as host for the tale. Some sills and dikes of chloritite and felsite are exposed in one of the pits. Slivers of quartzite locally distributed in the shear zones are believed to be Eureka quartzite fault-dragged into the Pogonip. Although the mine produced significant quantities of steatite, a large part of the production consisted of massive green chlorite, locally called "pyrophylite." The easternmost inclined shaft and two of the large open pits are on a chlorite-rich shear zone that strike N. 20° E. and dips 70° NW. Chlorite is abundantly exposed in the largest pit along near-vertical shear zone 2 to 15 feet thick striking N. 70° W. and N. 20° E. Pag (1951, p. 30) gives the chemical analysis of the chlorite as follows:

<table>
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<tr>
<th>Component</th>
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The identification of chlorite was confirmed by an x-ray diffraction pattern.
PHOTO 8. View looking north at the Alliance talc mine showing the Talc City thrust with the Eureka quartzite (Oe) and Ely Springs dolomite (Oes) of Ordovician age thrust over the Keeler Canyon formation of Pennsylvanian and Permian age (CPk).
Photo 9. Talc City mine. Talc is in shear zones in massive dolomite of the Lost Burro formation of Devonian age.
The westernmost shaft and smaller pits are on a N. 70°
ending shear zone that dips 70° NW. Tale bodies 5

5 feet thick are distributed locally along this shear.

A adit north of the western-most shaft is along a shear

6 to 8 feet thick striking N. 75° W. and dipping

SW. that contains a zone of chlorite 2 feet thick.

**Hard Scramble Prospect**

The Hard Scramble prospect is in sec. 13 (projected),

8 S., R. 39 E. Tale is sporadically distributed along

dip north zone that strikes N. 10° W. and dips 70 NE.

A shear is developed by an inclined shaft about 60 feet

6 and by some short adits. The country rock is mainly

Eureka quartzite and the tale formed as a replacement

quartzite adjacent to Ely Springs dolomite.

**Irish Lease**

The Irish lease is in secs. 29 and 30 (projected), T.

8 S., R. 40 E., adjoining the southern boundary of the

ance mine. Workings consisting of a short adit and

dip shaft about 65 feet deep are on a shear zone

N. 63° W. and dipping to the north. The shear

ranges from 4 to 30 feet thick and separates Eureka

quartzite to the north from silty limestone of the Keeler

yon formation to the south. Tale is in irregular

 zones within the sheared and altered rock. Page (1951,

2) reports the tale-bearing zone is at least 250 feet

and that the tale replaced a quartzose rock—the

Eka quartzite.

**Talc City Mine**

The Talc City mine is in secs. 29 and 32 (projected),

8 S., R. 40 E. (pl. 2). The mine is owned by the

Eka Tale and Clay Company and has been the largest

dolomite source of steatite-grade tale in the United

production from the Talc City mine from 1915 to

is shown below. This table, which may include some

duction from the Trinity mine, was compiled by the

or California State Division of Mines.

The extensive mine workings consist of three large

y holes, several thousand feet of underground level

ings, stopes, several shafts, inclined underground

ings, and numerous shallow surface workings (photo

Many of the underground workings are caved, and

large open fractures are visible at many places on, the

surface.

The mine area is in highly folded Devonian rocks con-

sisting mainly of light-gray faintly mottled massive dol-

omite, with lesser silty, brown-weathering limestone,

and light-gray quartzite. A quartz porphyry dike 2 feet thick

that strikes generally northwest and dips gently north-

east is exposed in the central part of the mine area. This dike

is highly altered and consists mainly of quartz, sericite, and
calcite, with subordinate iron oxides and pyrite. Quartz appears to be the chief primary mineral
both as phenocrysts and in the groundmass. Most of the
other primary minerals are completely altered.

The major tale deposits are in four large shear zones

that strike about N. 20°-30° W. and dip southwest. The

main ore bodies are the West ore body, Central body,

East ore body, and Evening Star ore body (Page, 1951,

p. 16). Numerous smaller exposures of tale are in the

mine area, commonly localized in N. 70°-80° W.-trending

steep shear zones.

The West and Central ore bodies accounted for most

of the production. The West ore body is 550 feet long

on the surface and 5 to 60 feet thick. It thins with depth

and about 100 feet below the surface it is manifested by
two salientlike prolongations. The Central ore body is

680 feet long on the surface and 70 feet thick. It has

been mined for a vertical distance of almost 400 feet

below the surface, but its downward extensions are ap-

parently discontinuous along strike.

The East End ore body is 2 to 15 feet thick and devel-

oped for more than 180 feet along strike and 100 feet
down dip. Workings in the adjacent hills southeast of

the East End shaft and access road are probably on the

same ore-controlling structure as the East End ore body.

The Evening Star ore body is irregularly shaped and
crops out for almost 200 feet in length and has a maxi-
mum thickness of 50 feet.

Most of the tale deposits are within massive light-gray
dolomite. Many are in the proximity of quartzite, and a few
are near brown-weathering silty limestone. Character-
istically the tale is fine grained and pale greenish gray.
In places it is strongly sheared and foliated. Most
of the tale is of steatite grade, and some of it is of excep-
tional purity.

**Trinity Mine**

The Trinity mine is 4,000 feet west of the Talc City

mine in sec. 30 (projected), T. 18 S., R. 40 E. It is

owned by the Sierra Tale and Clay Company. Tale was

mined mainly from a northwest-trending glory hole 150

feet long, 50 feet wide, and 50 feet deep. Other workings

include an inclined shaft about 100 feet deep, several

adits, a vertical shaft, and numerous drifts, crosscuts,

and stopes. Many of the underground workings are
caved and inaccessible.

The country rock is light-gray dolomite of the upper

part of the Ely Springs dolomite. Dolomite of the Pogo-
nip group is in fault contact with Ely Springs dolomite

in the southern part of the mine area and Eureka quartz-

ite is present locally along this fault. Tale is mainly in a

N. 72° W.-trending, gentle southwest-dipping shear

zone. The tale is fine-grained, pale green variety of stea-
tite grade.

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**Table 13. Tale produced from the Talc City mine.**

<table>
<thead>
<tr>
<th>Year</th>
<th>Short tons</th>
<th>Year</th>
<th>Short tons</th>
</tr>
</thead>
<tbody>
<tr>
<td>1930</td>
<td>300</td>
<td>1932</td>
<td>3,438 (est.)</td>
</tr>
<tr>
<td>1933</td>
<td>428</td>
<td>1934</td>
<td>3,402</td>
</tr>
<tr>
<td>1931</td>
<td>620</td>
<td>1935</td>
<td>3,560</td>
</tr>
<tr>
<td>2,000</td>
<td>7,398</td>
<td>1936</td>
<td>6,667</td>
</tr>
<tr>
<td>1937</td>
<td>7,087</td>
<td>1938</td>
<td>9,829</td>
</tr>
<tr>
<td>1939</td>
<td>4,300</td>
<td>1940</td>
<td>8,800</td>
</tr>
<tr>
<td>1941</td>
<td>5,352</td>
<td>1942</td>
<td>7,640</td>
</tr>
<tr>
<td>5,585</td>
<td>5,202</td>
<td>1943</td>
<td>9,691</td>
</tr>
<tr>
<td>1944</td>
<td>4,517</td>
<td>1945</td>
<td>5,890</td>
</tr>
<tr>
<td>1946</td>
<td>5,462</td>
<td>1947</td>
<td>12,600</td>
</tr>
<tr>
<td>6,275</td>
<td>5,275</td>
<td>1948</td>
<td>15,226</td>
</tr>
<tr>
<td>6,195</td>
<td>5,263</td>
<td>1949</td>
<td>13,325</td>
</tr>
<tr>
<td>6,370</td>
<td>5,275</td>
<td>1950</td>
<td>14,900</td>
</tr>
<tr>
<td>5,561</td>
<td>4,398</td>
<td>1951</td>
<td>11,113</td>
</tr>
</tbody>
</table>

Notes: Figures furnished by California State Division of Mines and published with permission of the Sierra Tale and Clay Company.
Victory Mine

The Victory mine is in sec. 19 (projected), T. 18 S., R. 40 E. (pl. 1). The mine is owned by Edith Lockhart and George Koest. The main workings consist of a northeast-trending adit 170 feet long and a shallow shaft. Talc is irregularly distributed in an altered shear zone within Hidden Valley dolomite near the contact with Ely Springs dolomite. The shear zone strikes N. 44° E., dips 60° NW., and has a maximum thickness of 8 feet.

Viking Mine

The Viking mine is in secs. 23 and 24 (projected), T. 18 S., R. 39 E. (pl. 1). The mine is owned by Edith Lockhart, Ida Nelson, and George and Helen Knight. Production was from the Viking number 1 and Viking number 4 claims. The Viking number 1, the easternmost of the claims, is developed by a shaft less than 100 feet deep, two drifts, and minor trenches. Talc is mainly along a N. 33° E.-trending minor shear zone cutting Eureka quartzite and Ely Springs dolomite.

The Viking number 4 claim is on a shear zone striking N. 75° W. and dipping 80° SW. The mine is worked by two shafts and two adits. Ely Springs dolomite is south of the shear zone and Eureka quartzite to the north. The Eureka quartzite forms a wedge-shaped, fault-bounded outlier.

White Swan Mine

The White Swan mine includes several claims in sec. 23 (projected), T. 18 S., R. 39 E., at the northwest end of the Tale City Hills. The mine is owned by Mrs. Edna M. Towers. Workings, which for descriptive purposes are grouped as the North workings and the South workings, are on many shear zones in the mine area. The North workings include an adit about 100 feet long and a pit about 50 feet long, 30 feet wide, and 20 feet deep, on a N. 83° W.-trending shear zone in Ely Springs dolomite. Tale surrounds fragments of brecciated dolomite within the shear zone. Another shear zone, about 50 feet to the south in Ely Springs dolomite, strikes N. 60° E. and dips 74° SE. The shear zone is 8 feet thick and contains a talc-bearing border zone about 6 inches thick on the footwall. Other smaller workings expose small lenses of tale.

The South workings consist of 2 adits, a shaft, and surface cuts on a N. 80° W.-striking shear zone that dips 80° NE. Dolomite of the Pogonip group is north of the shear zone and dolomite and limestone of the Lost Burro formation are to the south. Tale is irregularly distributed in small pods in the thick shear zone.

Iceland Spar

Coarse calcite crystals are a common accessory mineral in many of the lead-zinc-silver deposits in the quadrangle, but they are generally discolored by iron oxides and other impurities. Only one deposit has been developed for Iceland spar. This is the Iceland prospect in sec. 3, T. 19 S., R. 40 E., in the northern part of the Darwin Hills. The property is owned by the estate of W. R. Wallace. Workings consist of an open cut 60 feet long, with small irregular underground workings near its northwest end, a vertical shaft 40 feet deep, and minor surface cuts. Calcite occurs as cavity fillings between coarse limestone fragments in a N. 45° trending, vertical fault zone. The coarse calcite rhombodons are a maximum of 4 inches across, clear fragments. The quality of the Iceland spar is impure by imperfect transparency due to iron oxide discoloration and local fracturing. No production is recorded from the property.

Limestone and Dolomite

The Darwin quadrangle is a large potential source of limestone and dolomite, but their development is hampered by distances from markets. Limestone of Devonian and younger Paleozoic rocks probably could be used in the manufacture of cement. The Tin Mount limestone and the upper part of the Lost Burro formation are the most likely sources. Minor shallow drill work was done a few hundred feet north of the Lee Flat in the Santa Rosa Hills by operators who contemplated quarrying Tin Mountain limestone for ornamental building stone, but no limestone was mined.

Massive dolomite in the Devonian and older rocks abundant in the Tale City Hills. The massive light-gray dolomite probably would be a suitable formation for commercial exploitation.

Quartzite

The upper part of the Eureka quartzite is exceptionally pure and is a potential source of silica for refractory silica brick. The Eureka quartzite crops out at north end of the Tale City Hills at the Hard Scraper mine and north of the White Swan mine.

LITERATURE CITED


Burchard, H. C., 1884, Report of the U. S. Director of the Census upon the statistics of the production of precious metals in the United States for the calendar year 1883.


Simplified geologic map of the Darwin quadrangle showing the location of mines and prospects.
GEOLOGIC MAP OF THE LEE MINE AREA