NEVADA BUREAU OF MINES

Vernon E. Scheid, Director

BULLETIN 71

GEOLOGY OF PARTS OF THE WADSWORTH AND CHURCHILL BUTTE QUADRANGLES, NEVADA

By

Robert L. Rose

MACKAY SCHOOL OF MINES
UNIVERSITY OF NEVADA

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FOREWORD

In 1958 Dr. Robert L. Rose, then Assistant Economic Geologist with the Nevada Bureau of Mines, made a mineral resources and geological survey of some lands in Storey and Lyon Counties, Nevada, owned by the Curtiss-Wright Corp. of Wood-Ridge, New Jersey. Later Dr. Rose restudied a portion of the area of his earlier report and expanded it to encompass all the land within the southern half of the Wadsworth quadrangle and the northern half of the Churchill Butte quadrangle in order to produce the present report, "Geology of Parts of the Wadsworth and Churchill Butte Quadrangles, Nevada." The additional field work necessary to complete these later field studies was done by Dr. Rose in the period 1959–1966, during summer vacations from his duties at San Jose State College, San Jose, Calif., where he is now Professor of Geology.

This report describes an area that during the Tertiary Period of earth history was transitional between a region of volcanic outpourings to the west, and the region to the east in which deposition of sediments in land-locked basins was more prevalent. The area is of interest because of its proximity to the State's most productive silver district, the Comstock Lode, in the adjacent Virginia City quadrangle. The Nevada Bureau of Mines is pleased to publish Bulletin 71, "Geology of Parts of the Wadsworth and Churchill Butte Quadrangles, Nevada," as a contribution to our knowledge of the mineral resources and geology of Nevada.

VERNON E. SCHEID, *Director*
Nevada Bureau of Mines

January, 1969
Mackay School of Mines
University of Nevada, Reno

GEOLOGY OF PARTS OF THE WADSWORTH AND CHURCHILL BUTTE QUADRANGLES, NEVADA

By Robert L. Rose

ABSTRACT

The area described in this report is centered about 30 miles east of Reno, Nev., and is partly in Storey, Lyon, and Washoe Counties. Cenozoic volcanic and sedimentary rocks are present in about 90 percent of the area. The oldest exposed rocks are Jurassic metasediments and metavolcanics which have been intruded by Jurassic(?) dioritic and Cretaceous(?) granitic rocks. The Mesozoic rocks are unconformably overlain by a thick sequence of Tertiary volcanic and sedimentary rocks, the oldest of which is an Oligocene (pre-Hartford Hill) lacustrine unit consisting mainly of claystone. Overlying this is the early Miocene Hartford Hill Formation, locally about 2,000 feet thick and composed of welded to semiwelded rhyolitic tuff. The Alta Formation, predominantly andesitic and trachybasalt lava flows, conformably succeeds the Hartford Hill Formation. In the Truckee Canyon the Alta is overlain by a sequence of rhyolitic tuffs and lacustrine sediments which have been assigned to the Old Gregory Formation on the basis of lithologic similarity to the type section. About 2,000 feet of basaltic lavas and interbedded sediments of the Chloropagus Formation succeed the Old Gregory Formation. This is followed by the Desert Peak Formation which consists of intermediate volcanic rocks and diatomaceous and tuffaceous sediments. These strata are succeeded by a transgressive Pliocene unit, the Kate Peak Formation, which consists mainly of dacitic and rhyodacitic lavas and breccias and dacitic to rhyolitic intrusive rocks. Much of this sequence has been more or less argillized or propylitized and locally mineralized.

In the southeastern part of the area the Kate Peak Formation is conformably overlain by several hundred feet of tuffaceous and diatomaceous sediments of the Coal Valley Formation. Small intrusive masses of pyroxene andesite in the east-central part of the area have been tentatively correlated with the Knickerbocker Andesite of the Virginia City area. In the southern and eastern parts of the area many of the higher ridges are capped by thin lava flows of basalt and trachybasalt of the Lousetown Formation. The Pleistocene Mustang Formation which consists of trachyandesite lavas is present in a small area near Clark. The youngest volcanic unit is the McClellan Peak Basalt, which forms two cinder cones and two thin lava flows on the east-central margin of the area. Unconsolidated sediments belonging to three stratigraphic units—older alluvium, Lake Lahontan sediments, and alluvium—are widespread in the lower portion of the Truckee Canyon. Alluvium is also widespread in other topographically low areas. The Tertiary rocks of the area have been folded into a series of gentle folds most of which trend approximately east-west. These are broken by numerous high-angle faults, including normal, reverse, and oblique slip faults. Many of the east-west-trending faults have a left-lateral component of movement. Unconformities and stratigraphic relationships indicate that tectonic activity was more or less contemporaneous with the Cenozoic volcanism.

The area has been extensively prospected for gold, silver, uranium, iron, and diatomite. Past mineral production includes gold and silver from Ramsay and Talapoosa, but the only current mineral production is diatomite mined near Clark.

INTRODUCTION

LOCATION AND ACCESSIBILITY

The area covered in this report is located in west-central Nevada and is centered about 30 miles east of Reno (see fig. 1). It includes the southern half of the U. S. Geological Survey Wadsworth 15′ quadrangle and the northern half of the Churchill Butte 15′ quadrangle. Most of the area is in Storey and Lyon Counties but the northern portion is in Washoe County.

The only population center of the region is the town of Fernley, which with the neighboring town of Wadsworth had an estimated total population of 750 in 1967. Elsewhere there are a few ranches along U. S. Route 50 in the southern part of the area and in the Truckee Canyon in the north. Eagle-Picher Industries, Inc. has an office and diatomite mill in the northwestern part of the area at Clark, and a few miners are generally in residence at the Gooseberry gold mine a few miles south of Clark. The mining communities of Talapoosa and Ramsey in the southern part of the area have long been deserted.

U. S. Route 40 (Interstate 80) is the main access route to the northern part of the area. This is supplemented by an unpaved road along the Truckee Canal between Derby Dam and Fernley, the road from Clark to the Celatom mine, and various jeep trails. Access to the eastern and southern parts of the area is by various dirt roads from U. S. Routes 95 and 50. Ramsey and the central part of the region are reached by the unpaved road that extends from Clark to U. S. Route 50 just west of Silver Springs. The west central part of the area can be reached by an unimproved road from Virginia City and by jeep trails from U. S. Route 50.

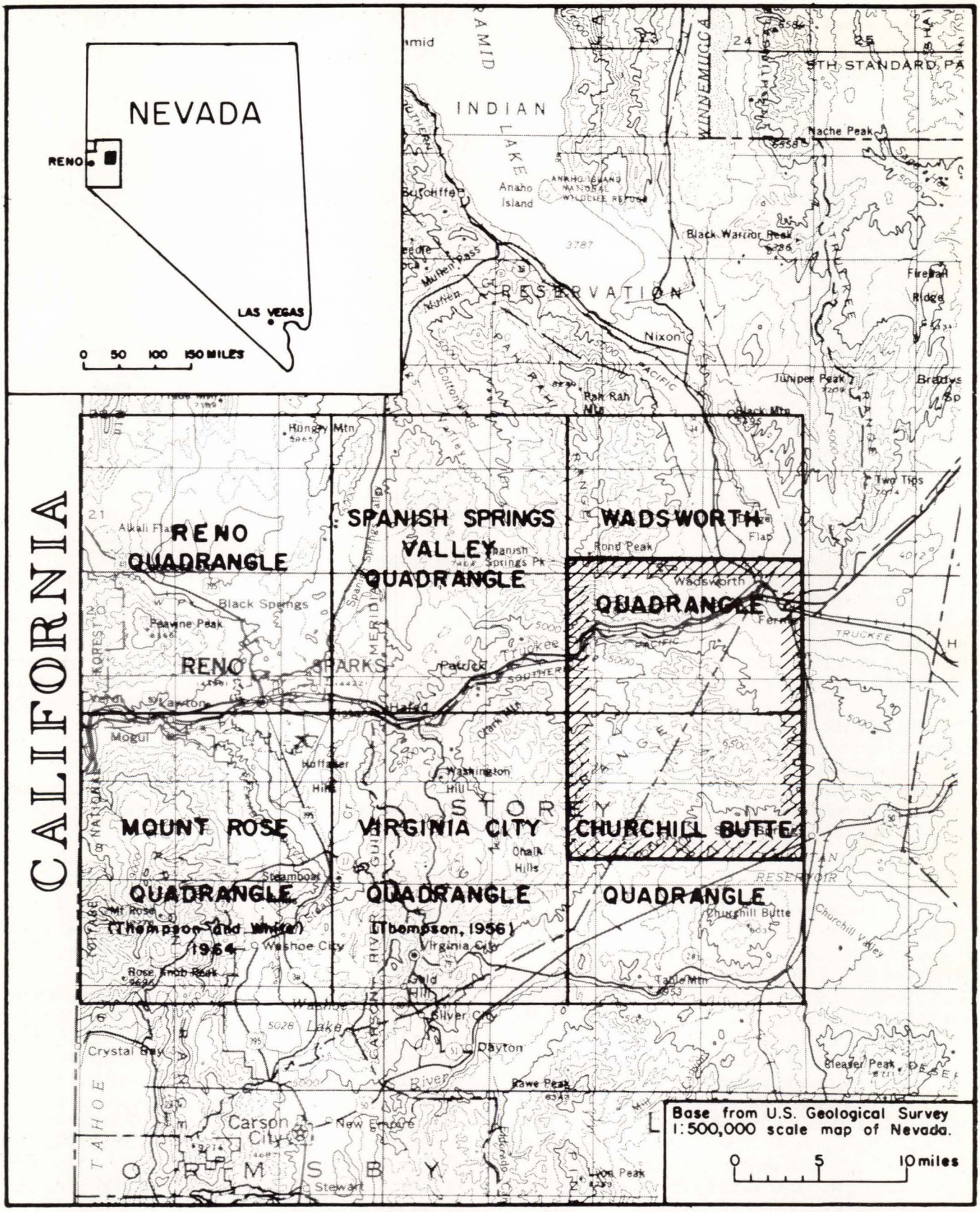

Figure 1. Index map showing location of mapped area.

PHYSICAL FEATURES

The area is a rugged mountainous region, situated in the northeastern part of the Virginia Range and in portions of the Pah Rah Range and Virginia Mountains to the north of the Truckee River. The maximum elevation is approximately 7,260 feet near the center of the area. The lowest point, 4,065 feet, is in the Truckee Canyon near the northeastern part of the map area. Topographic relief is thus slightly more than 3,000 feet.

The northern part of the area is transected by the canyon of the Truckee River, which is rather narrow and steep walled in the western part but relatively broad and open to the east near Fernley. Churchill Valley in the southeastern part of the area and the region around Fernley are the only extensive areas of low relief. Water is very scarce in most of the region, although a few springs are present, particularly in the southern part of the area just north of U. S. Route 50 and along the eastern border. Most of the streams have flowing water only as a result of heavy rainstorms or spring runoff. The only perennial stream is the Truckee River.

CLIMATE AND VEGETATION

The climate varies from arid to semiarid. Most of the lower region has an annual rainfall of less than 5 inches, whereas the average precipitation above 6,000 feet is probably in excess of 10 inches. Most of the precipitation falls as snow during the winter months with minor amounts of summer rain due to thunderstorms. The summers are hot and dry with occasional daytime temperatures in excess of 100° F. The winters are cold with temperatures sometimes reaching 20° below zero.

Vegetation in the area is sparse, especially at lower elevations. Sage, salt grass, shadscale, and greasewood are the principal plants at lower elevations. Piñon pine and juniper are locally abundant in the higher regions. Desert peach, wild rose, willow, cottonwood, and aspen occur in some of the major canyons but the larger trees are most abundant in the Truckee Canyon.

FIELDWORK AND ACKNOWLEDGMENTS

Most of the fieldwork for this project was done between January 1958 and September 1959, and during the summers of 1960 and 1961, with additional fieldwork during the summers of 1963, 1965, and 1966.

The initial objective was to study the mineral resources and prepare a geologic map of property owned by the Curtiss-Wright Corp. in the Virginia Range exclusive of the Virginia City quadrangle. Fieldwork for this project was completed in 1958, and a report and geologic map were completed in March of 1959. Subsequently, it was decided to refine the previous mapping and extend the work to cover all of the southern half of the Wadsworth quadrangle and the northern half of the Churchill Butte quadrangle.

During the early stages of the fieldwork, mapping was done on aerial photographs scaled at 1:20,000. Much of the work completed after March 1959 was on photographs at a scale of about 1,000 feet to the inch. Data was then transferred to a topographic base of 2,000 feet to the inch and subsequently reduced to 4,000 feet to the inch for publication (see pl. 1).

The initial part of this project (1958 and early 1959) was financially supported by the Curtiss-Wright Corp. All subsequent work was financed by the Nevada Bureau of Mines. During the summer of 1958 the writer was assisted in the field by Larry Godwin, a graduate student of the Mackay School of Mines, who is responsible for much of the mapping in the southwestern part of the area. The writer is indebted to numerous staff members of the Nevada Bureau of Mines and the Mackay School of Mines for various types of assistance and numerous helpful discussions; D. B. Slemmons, E. R. Larson, and Alex Volborth were particularly helpful. Norman Silberling of the U. S. Geological Survey indentified Mesozoic fossils from the area. D. I. Axelrod of the University of California at Los Angeles identified plant fossils collected by the writer and gave many suggestions concerning the stratigraphy of the area. J. F. Evernden and his co-workers at the University of California, Berkeley, determined the potassium-argon dates for two samples of the Hartford Hill Formation. Others who aided the writer includes James Moore of the U. S. Geological Survey, George Thompson of Stanford University, and Lawrence Beal of Phelps Dodge Co. The writer is particularly grateful to Vincent P. Gianella, Professor Emeritus of Geology at the University of Nevada, for introducing the writer to the Virginia City area and for many helpful suggestions and discussions.

STRATIGRAPHY AND LITHOLOGY

The rock units of this area form three natural groups: a Mesozoic sequence of metamorphic and igneous rocks, a Tertiary sequence of volcanic and sedimentary rocks, and a Pleistocene unit of volcanic and sedimentary rocks. The Mesozoic rocks are restricted to less than 10 percent of the area and consist of Jurassic metasediments and metavolcanic rocks, Jurassic(?) dioritic rocks, and Cretaceous(?) granitic rocks. The Tertiary succession includes a thick, complex, and extensive series of volcanic rocks and associated sediments that have been folded, faulted, and more or less hydrothermally altered and mineralized. The Pleistocene rocks are relatively undisturbed and unaltered and consist of lacustrine and fluvial sediments and volcanic rocks. The general stratigraphy is summarized in table 1.

MESOZOIC ROCKS

Metasedimentary Rocks

The oldest rocks of this region are metasedimentary rocks which are exposed in three areas: in the Truckee Canyon about 5 miles west of Fernley, between Ramsey and U. S. Route 50, and near the Blackhawk mine in the southwestern part of the map area.

The metasediments are most extensive near Ramsey

where they consist mainly of slate with thin interbeds of metasandstone and dolomitic limestone. The slates are dark bluish gray with poor to moderately well-developed cleavage apparently parallel to original bedding. Adjacent to granodiorite the slate grades into a fine-grained dark-gray hornfels devoid of conspicuous foliation and occasionally containing small porphyroblasts of andalusite. The limestone interbeds are dark gray, finely crystalline, and seldom more than a few feet in thickness. Some beds show relic clastic textures and contain small pebbles of volcanic rocks. Near contacts with granodiorite the carbonate rocks have been converted to calc-silicate hornfelses which are typically light colored and wollastonite bearing. Wollastonite-diopside-grossularite hornfels is the most common calcareous hornfels immediately adjacent to the granodiorite.

In the Truckee Canyon the metasediments occur as a small mass between granodiorite and metavolcanic rocks. Garnet-diopside-wollastonite hornfels is the main rock type, but epidote-rich hornfelses and garnetiferous skarn are also present.

Near Blackhawk the metasediments form inclusions

TABLE 1. Generalized stratigraphic section in the Wadsworth and Churchill Butte quadrangles, Nevada.

Age	Formation	Lithology	Approx. Max. Thickness
Recent	Alluvium	Gravel, sand, and silt.	50′
Pleistocene	Lake Lahontan deposits	Sand, silt, gravel.	125′
	Older alluvium	Gravel and sand.	35′
	McClellan Peak Basalt	Olivine basalt flows and cinders.	35′
	Mustang Andesite	Hornblende-pyroxene trachyandesite flows.	350′
	Lousetown	Basalts, andesites, and trachyandesites—mostly lava flows —some intrusives.	350′
	Unconformity		
Pliocene	Knickerbocker(?) Andesite	Pyroxene andesite dikes and plugs.	.....
	Coal Valley	Sandstone, rhyolite tuff, shale, and diatomite.	500′
	Kate Peak	Dacite and rhyodacite flows, flow breccias, some interbedded rhyolite tuff, and diatomite. Dacitic to rhyolitic intrusives.	1,500′
	Unconformity		
	Desert Peak	Upper part: sandstone, shale, and diatomite. Lower part: dacite and rhyodacite flows and flow breccias.	3,000′?
	Chloropagus	Basaltic and andesitic flows with interbedded rhyolitic tuffs and sediments. Basaltic intrusives.	3,000′
	Unconformity		
Miocene	Old Gregory	Mainly rhyolitic tuffs, some shale and andesitic lava.	1,200′
	Alta	Andesitic and basaltic lavas, breccias, and intrusives.	1,000′
	Hartford Hill	Rhyolitic ash flow tuffs.	2,500′
	Unconformity		
Oligocene	Pre-Hartford Hill	Olive green claystone.	300′
	Unconformity		
Jurassic		Metamorphic dioritic and granitic rocks.	?

in the plutonic rocks but many occurrences are too small to show on the map. Marble, calc-silicate hornfels, actinolite, and actinolite-magnetite granofels are the main rock types in this area. The actinolite-magnetite rocks may represent metasommatically altered dolomites but the other rocks are thermally metamorphosed rocks.

Fossils have been found at two localities in the metasediments. Poorly preserved molluscs were found in a pebbly limestone in the SW¼ sec. 23, T. 18 N., R. 23 E. about 3.5 miles south of Ramsey. According to N. J. Silberling of the U. S. Geological Survey (personal communication, 1960), these are marine pelecypods, possibly Pinna sp., and indicative of a Mesozoic age. D. I. Axelrod and V. C. Gianella collected an ammonite from the north-central part of this same section. According to Silberling, this ammonite is an Arietited type and is indicative of an Early Jurassic age (Moore, 1960, p. 288). From the above data the metasediments are considered to be Early Jurassic in age.

Metavolcanic Rocks

Metavolcanic rocks are associated with the metasediments in the three areas of pre-Tertiary rocks. In the Truckee Canyon they are mainly dark-gray to black hornblende-plagioclase and hornblende-biotite-plagioclase hornfelses. Volcanic textures of these rocks have been obliterated by metamorphism but mineral content indicates basaltic and andesitic composition. Similar hornblende hornfelses occur as inclusions in the dioritic complex at Blackhawk but are too small to show on the map.

Just south of Ramsey hornblende hornfelses occur adjacent to the granodiorite. In part, these are metamorphosed intrusive rocks, possibly metamorphosed diabases. Dark-gray and greenish metabasalts and meta-andesites occur as inclusions in the Kate Peak intrusive rhyolites in this same area but the most extensive metavolcanics are in the main canyon south of Ramsey. Here the metabasalts and meta-andesites are only slightly metamorphosed.

The lower part of this unit near Ramsey consists mainly of dark-gray and greenish-gray aphanitic metabasalts, which are only partly reconstituted and contain variable amounts of calcite, epidote, albite, chlorite, and actinolite. Stratigraphically above these are greenish to reddish-brown meta-andesites which are porphyritic with abundant phenocrysts of plagioclase (andesine) in an aphanitic matrix. Most of the meta-andesites orginally had pyroxene phenocrysts, now represented by antigorite, or a mixture of antigorite and magnesite(?) often with epidote. Calcite, albite, epidote, chlorite, and actinolite are commonly present in the groundmass, and the plagioclase phenocrysts are usually partly altered to albite and calcite. These metavolcanic rocks are unconformably overlain by the Hartford Hill Formation and appear to be stratigraphically above the metasediments. However, intrusive rhyolites obscure the relationship of the metamorphic rocks. The regional setting suggests that the metavolcanic rocks are probably of Late Jurassic Age.

Dioritic Rocks

Diorites and microdiorites are the main rock types near the Blackhawk mine. They are poorly exposed and more or less covered by a veneer of rubble, so their relationships are uncertain.

The microdiorites are dark gray to black and are composed chiefly of plagioclase and hornblende. Locally they have thin pegmatitic streaks consisting of feldspar and hornblende. The diorites are generally medium grained, hypidiomorphic granular and range from dark-gray hornblende-biotite diorites to light-green quartz-bearing actinolite diorites. Thin veins of quartz or quartz and calcite, often with pyrite and occasionally chalcopyrite and galena, are present in the dioritic rocks at Blackhawk.

The age of the diorites is uncertain. They intrude metamorphic rocks of probable Jurassic Age and are intruded by dikes of aplite and microgranite of probable Cretaceous Age. These relationships suggest the diorites are possibly Late Jurassic in age.

Cretaceous(?) Granitic Rocks

Plutonic rocks ranging from granite to quartz diorite intrude the Mesozoic metamorphic rocks. In the Truckee Canyon outcrops of granitic rocks are limited to a small area about 6 miles southwest of Wadsworth. They vary from coarse-grained muscovite granite to hornblende-biotite quartz diorite. Medium-grained biotite granodiorite is probably the most abundant rock type exposed.

In the Ramsey district granodiorite crops out over an area of about 1 square mile. Exposures are poor and the rock is more or less altered; typically it is a medium-grained, biotite-hornblende granodiorite, with large poikilitic microcline crystals. Secondary chlorite, epidote, calcite, and sericite are generally present and partially replace the mafic minerals and plagioclase; allanite is a minor constituent of some of the granodiorite. Thin aplite and pegmatite dikes are locally present, but none are extensive nor contain any unusual minerals. The granodiorite discordantly cuts the metamorphic rocks and has produced a narrow zone of thermal metamorphism up to the hornblende hornfels facies.

A small mass of biotite granodiorite is present about 1.5 miles east of the Blackhawk mine. Thin aplite dikes and dikes of porphyritic microgranite locally intrude the dioritic rocks; these are not shown on the map.

The age of the granitic rocks is uncertain, but the regional relationships suggest they are probably of Cretaceous Age.

CENOZOIC ROCKS

Pre-Hartford Hill Sediments

The oldest Cenozoic unit recognized in this area is a lacustrine sedimentary unit that unconformably overlies metamorphic rocks south of Ramsey. It is best exposed on the west side of the gulch in the NW¼ sec. 23, T. 18

N., R. 23 E., where it is unconformably overlain by the Hartford Hill Formation. The formation has a maximum thickness of about 300 feet and consists mainly of claystone with minor thin interbeds of sandstone and limestone.

The claystone is dark olive green, well indurated, and well bedded with thin, silty interlayers. Lithic feldspathic sandstones with abundant bleached biotite and slate fragments occur sparingly as interbeds up to 15 inches in thickness. They are light gray to buff, medium grained and more or less cemented by calcite. A few feet of conglomerate are present locally near the base of the formation but are poorly exposed and of uncertain thickness. They appear to consist mainly of subrounded clasts of metavolcanic rocks.

Fragments of silicified wood are locally abundant in the associated colluvium but none were found in their original position; however, leaf fossils are rather common in the claystone. According to D. I. Axelrod (written communication, 1961), the flora indicates a late Oligocene age.

Hartford Hill Formation

The Hartford Hill consists mainly of welded to semiwelded rhyolitic ash flow tuffs. It is a hard, resistant unit forming bold outcrops in the Truckee Canyon and the Ramsey district. It also occurs in a small area south of the canyon and in several places near Blackhawk.

In the Truckee Canyon the formation has a thickness of at least 2,000 feet but elsewhere it is much thinner. Generally the Hartford Hill rests unconformably on Mesozoic rocks; however, in the Ramsey area it locally overlies the pre-Hartford Hill sediments with a small angular discordance. The rhyolites are mostly light colored and gray, green, pink or brownish, but locally they are brick red or purplish. For the most part they are crystal rich (10 to 30 percent) with conspicuous small crystals of quartz, sanidine, sodic plagioclase, and biotite enclosed in a devitrified matrix. The semiwelded rocks, particularly near the top of the section, usually show an obvious clastic texture with lithic rhyolite fragments and/or partly collapsed pumice fragments up to 3 or 4 inches in length. The clastic features of the highly welded rocks are often apparent only microscopically. The rhyolites are more or less altered with secondary quartz sericite, calcite, or clay minerals which partially replace the phenocrysts or groundmass.

In previous literature the formation has commonly been reported as Eocene in age; however, recent radiometric dating by Evernden and Curtis (Evernden and James, 1964, p. 966) on samples collected by the writer from the type area and the Truckee Canyon indicate an early Miocene age (22.7–22.8 million years).

Alta Formation

In the Truckee Canyon and the southern part of the Ramsey district the Hartford Hill Formation is conformably overlain by a series of andesitic and basaltic lavas that are equivalent to the Alta Formation of the Virginia City area. In the mapped area the Alta has a maximum thickness of about 800 feet and consists mainly of lava flows and flow breccias with minor intrusive rocks, clastic sediments, and rhyolite tuff. Outcrops on the north side of the Truckee Canyon are disconformably overlain by the Old Gregory Formation, but outcrops south of the canyon are unconformably overlain by the Chloropagus Formation, and near Ramsey the Kate Peak Formation unconformably overlaps the Alta.

The upper two-thirds of the section near Ramsey consist mainly of porphyritic gray to greenish hornblende-pyroxene and pyroxene andesite which are holocrystalline with small to medium-size phenocrysts of plagioclase and mafic minerals in an aphanitic matrix. Thin veins of secondary minerals (calcite, quartz, and fibrous zeolites), are common, and the rocks are more or less propylitized with variable amounts of calcite, celadonite, antigorite, chlorite, epidote, quartz, and pyrite. Hypersthene is invariably replaced by antigorite or celadonite with or without magnesite(?). Trachybasalts form the lower third of the Ramsey sequence.

Rock types similar to those at Ramsey are present in the Truckee Canyon section, but there most of the section consists of dark-gray to black olivine trachybasalt. The lower third of the two outcrops of Alta Formation just south of the Truckee Canyon, in contrast, consists of trachybasalts.

The trachybasalts are moderately to coarsely porphyritic with large tabular plagioclase and small altered olivine phenocrysts in a microcrystalline matrix. Locally plagioclase phenocrysts are half an inch or more in length and constitute up to 30 percent of the rock. The trachybasalts are more or less propylitized and contain veinlets of various secondary minerals such as quartz, calcite, and laumontite (see fig. 2). The tops of flows are moderately vesicular and are locally amygdaloidal with amygdules composed of a zeolite (generally laumontite), calcite, or celadonite, or a mixture of these. Microscopically the rocks are porphyritic, with phenocrysts of plagioclase (labradorite) and altered olivine in a matrix consisting mainly of sodic labradorite, augite, alkali feldspar (sanidine?), magnetite, apatite, and variable amounts of calcite, celadonite, antigorite, bowlingite, and magnesite(?). Olivine is invariably replaced by the secondary minerals. Alkali feldspar (usually 10 to 20 percent) occurs as interstitial grains and rims on plagioclase.

The clastic sediments in the Alta Formation are mainly gray to green andesitic sandstones and brown silty shales. Usually these occur as thin interbeds but locally on the south side of the Truckee Canyon the shales are at least 20 feet thick.

Three thin interbeds of rhyolite tuff, 5 to 20 feet thick, were found in the Alta, one near the middle of the section in the Truckee Canyon, and two about 300 feet above the base of the alta near Ramsey. These rocks

Figure 2. Vein of laumontite and calcite in altered andesites of Alta Formation in roadcut along U.S. Route 40 west of Fernley, Nevada.

are white to light gray, lithoidal, and more or less silicified. They contain a few crystals of biotite, quartz, and altered feldspar, but are thoroughly devitrified. Originally they were probably vitric tuffs.

Alta intrusive rocks occur as small dikes and plugs that are lithologically similar to the andesitic lavas. The largest intrusive is the irregular body near the base of the Alta Formation in the Truckee Canyon, a propylitized hornblende-pyroxene andesite that contains occasional xenoliths of granite and hornblende diorite.

The age of the Alta Formation has been variously quoted as Miocene or Oligocene on the basis of leaf fossils from the Sutro member near Virginia City (Axelrod, 1958, p. 96). However, the early Miocene radiometric age determinations on the Hartford Hill Formation indicate the Alta is no older than early Miocene; probably it is early to middle Miocene in age.

Old Gregory Formation

Disconformably overlying the Alta Formation in the Truckee Canyon is a stratigraphic unit about 600 feet thick consisting mainly of rhyolite tuff with minor sediments and a few thin flows of basalt. This unit is herein referred to as the Old Gregory Formation on the basis of lithologic and stratigraphic similarity to the type Old Gregory Formation near Fallon, Nev. (Axelrod, 1956, p. 137).

The rhyolite tuffs are light gray to pale green, massive to moderately well bedded and moderately to strongly indurated. Typically the tuffs contain about 10 percent

reddish-brown lapilli, pumice fragments up to an inch in length, and about 10 percent small crystals all in a devitrified clastic matrix. The crystals are mainly plagioclase and quartz with rare biotite. Calcite is commonly present in small amounts as a cement.

Locally the tuff grades into a coarse tuff breccia with an abundance of angular to subrounded clasts of granitic and volcanic rocks. Many of the volcanic clasts are types found in the Alta Formation, including coarsely porphyritic olivine trachybasalt, but some are lithologically unlike rocks known from this or the adjacent region. Microscopically a typical tuff sample shows a vitroclastic texture with lithic fragments, pumice, and crystal fragments of partly albitized plagioclase (sodic andesine and oligoclase), quartz, and altered biotite in a matrix of devitrified glass shards. Calcite is present in variable amounts and partly replaces the plagioclase, pumice fragments, and glass shards and acts as a cement. The coherence of the rock is partly due to devitrification and partly to cementation by calcite or quartz.

The sediments are best developed near the base of the section where they locally reach a thickness of 50 feet or more. Brown porcelanitic shale and silty mudstones are occasionally present, and greenish to black chert is a minor constituent. Locally the clastic sediments are interbedded with the rhyolite tuff.

Thin interlayers of basalt are present in the Old Gregory Formation; some of these are sills from the overlying Chloropagus Formation, but at least one is a lava flow. This flow is a greenish propylitic olivine basalt about 35 feet thick. It is highly altered and contains thin quartz and calcite veinlets. The top of the flow is amygdaloidal with composite amygdules up to half an inch in diameter consisting of chlorite, calcite, chalcedony, and a zeolite, probably heulandite. The basalt is porphyritic with small serpentinized olivine phenocrysts enclosed in an intersertal matrix consisting mainly of chlorite, calcite, a zeolite, and albite. Plagioclase is partly replaced by calcite, albite, and a zeolite. Mafic minerals and glass have been replaced by chlorite.

Much of the Old Gregory Formation appears to have been deposited in either a fluvial or lacustrine environment. Part of the tuff was probably deposited as a pumice lahaar, and the tuff breccias appear to have a lahaaric origin.

According to Axelrod (1956, p. 138), the type Old Gregory is late Miocene in age. A flora from the basal part of the Truckee Canyon section is currently (1967) being studied by Axelrod.

Chloropagus Formation

The Chloropagus Formation consists mainly of basaltic and andesitic lava flows and breccias with interbeds of rhyolitic pyroclastic rocks, sediments, and numerous intrusive masses similar to the lavas. It is extensively exposed in and north of the Truckee Canyon and along the eastern side of the Virginia Range southwest of Fernley.

The maximum thickness of the formation is at least 2,500 feet. It unconformably overlies the Old Gregory Formation and overlaps the Alta and locally the Hartford Hill Formation. Correlation with the type section of the Chloropagus in the Hot Springs Mountains northeast of Fernley (Axelrod, 1956, p. 95) is on the basis of lithologic similarity and stratigraphy.

The Chloropagus lavas are dark gray, greenish gray, black, or locally brownish to brick red. Typically they are aphanitic or inconspicuously porphyritic with minute phenocrysts of olivine and/or plagioclase. The tops of the flows are moderately to strongly vesicular and commonly amygdaloidal with amygdules of chalcedony or celadonite. Locally calcite, quartz, or a zeolite (natrolite, chabazite, or analcite) are present in composite amygdules. Chalcedony amygdules, .5 to 2 inches in diameter, are not uncommon and locally they weather out of the lavas and litter the slopes. The flows vary in thickness from a few feet to about 50 feet; often the tops and bottoms of the flows are brecciated.

Microscopically the rocks are commonly microporphyritic with phenocrysts of partly iddingsitized olivine and/or plagioclase in an intersertal or intergranular matrix consisting mainly of plagioclase, clinopyroxene, and magnetite. The andesitic rocks tend to be hemihyaline with variable amounts of brownish glass clouded with finely divided magnetite. The glass is often partly altered to palagonite, nontronite(?), or calcite. Chemical analyses of the rocks show they are somewhat rich in potash (2 to 3 percent) and approach trachyandesite or trachybasalt in composition, but alkali feldspar is rarely observable in any of the rocks.

A few layers of coarse, basaltic tuff breccia are present in the formation southwest of Fernley. These are seldom more than 50 feet in thickness and rarely seem to have any lateral extent. Their unsorted nature and other features suggest they probably originated as mud flows.

Numerous rhyolite tuff interbeds are present throughout the Chloropagus Formation (fig. 3). They are laterally discontinuous and mostly less than 100 feet in thickness. Only the more conspicuous and thicker tuffs are shown on the map. The most continuous tuff member is present on the south side of the Truckee River near the top of the formation. It is mostly about 150 feet in thickness but just north of Clark the same tuff is about 800 feet in thickness.

Typically the tuffs are white to light gray and pumiceous-vitric with clasts of perlite, obsidian, and lithic-banded rhyolite lapilli grading in size up to 4 inches or more in diameter. Locally they grade into tuff breccia. Small crystals of plagioclase, biotite, and quartz usually comprise 5 to 10 percent of the tuff. The tuffs vary from massive to well bedded and often contain thin interbeds of impure diatomite and/or tuffaceous sandstone. Most of the tuff appears to have been water deposited, and probably much of it represents ash-fall

Figure 3. Vitric rhyolitic tuff in the Chloropagus Formation east of the Celatom diatomite mine, near Fernley, Nevada.

material that was water transported into local depositional basins.

Gray to light-brown tuffaceous sandstone interbeds from a few inches to several feet thick are present in the Chloropagus. Where they are overlain by lava flows their upper portions are often brick red. The sandstones associated with the rhyolite tuffs generally contain much rhyolitic pumice and glass shards. Those interlayered with lava flows generally contain an abundance of gray, black, and red andesitic and basaltic grains.

Dark-gray or greenish-gray shale is occasionally present in the sequence. Generally it is tuffaceous or diatomaceous and often contains plant remains. The shales are seldom more than 20 feet in thickness.

Impure diatomite and diatomaceous shale occur throughout the section but are most abundant south of Fernley. Commonly these rocks are more or less silicified especially adjacent to faults and intrusive rocks. In some places the diatomite has been converted to opaline chert.

Limestone is rare in the Chloropagus section but thin beds are present in a few places south of Fernley. An oolitic limestone with an abundance of small molluscs is exposed in a small area about 3 miles southwest of Fernley. It is light gray and has a maximum thickness of about 2 feet.

Basaltic and andesitic intrusive rocks of the Chloropagus Formation are present at numerous places in and adjacent to the Truckee Canyon where they intrude the Chloropagus Formation and older rocks. They occur mainly as dikes (fig. 4) and plugs and occasionally

as sills. Undoubtedly they are more common than shown on the map as they are difficult to recognize except where they intrude rocks that are distinctly different in appearance. The assignment of these intrusives to the Chloropagus is mainly on the basis of lithologic similarity to the Chloropagus extrusive rocks. However, these intrusives are somewhat variable; some of the larger ones have cores of microgabbro, many of the thin dikes are vesicular, and some are even amygdaloidal with chalcedony-celadonite amygdules. Where these intrusives are situated in pumiceous tuffs they are generally bordered by narrow zones of dark glass which is sometimes perlitic. These glass zones were evidently produced by local fusion of the pumiceous tuff adjacent to the intrusives.

According to Axelrod (1956, p. 113), the age of the Chloropagus Formation is late Miocene to early Pliocene. A radiometric date for an andesitic tuff in the upper part of the type section of the Chloropagus has yielded a late Miocene Age of 13.9 million years (Evernden and James, 1964, p. 970).

Desert Peak Formation

Unconformably overlying the Chloropagus Formation is a 3,000-foot complex sequence of volcanic and sedimentary rocks herein assigned to the Desert Peak Formation. This unit differs somewhat in lithology from the type Desert Peak Formation on Desert Peak in the Hot Springs Mountains, about 20 miles northeast of Fernley (Axelrod, 1956, p. 97), the main difference being the presence of a moderately thick sequence of intermediate volcanic rocks in the lower part of the local section. Rather than assign a new formational name to this volcanic unit, it is herein considered a local member of the formation. The formation crops out as a broad, irregular, northwest-trending band across the northern half of the mapped area.

The lower or volcanic member has a maximum thickness of about 1,200 feet and consists mainly of lava flows and flow breccias that range from olivine-augite andesite to biotite-hornblende rhyodacite. Typically these rocks are medium gray or reddish brown and porphyritic with medium to large phenocrysts of plagioclase and small mafic phenocrysts enclosed in an aphanitic groundmass. Locally the more siliceous rocks are vitrophyric. The mafic phenocrysts vary from one rock to another; in the andesitic rocks they are usually pyroxene and olivine; in the dacites, hornblende and clinopyroxene; and in the rhyodacites they are hornblende and biotite. Xenocrysts of quartz are common,

Figure 4. Rhyolite tuff in the Chloropagus Formation just north of U.S. Route 40 about 5 miles west of Fernley, Nevada. Note two faults dipping toward left of photo (north) with northside down in each case; each fault has a thin basaltic dike lithologically correlative with the Chloropagus Formation.

and some of the larger plagioclase and biotite crystals may also be xenocrysts. Rounded inclusions of microdiorite up to several inches in diameter are not uncommon in many of these rocks, even in the olivine andesites. Cristobalite is a common groundmass constituent of most of these rocks; in the rhyodacites it is abundant.

The tops of the lava flows are usually brecciated and/or finely vesicular with small irregular distorted vesicles that are often lined with minute tridymite crystals or opal.

Brownish-gray, lithic, feldspathic sandstone up to 30 feet in thickness is present in the volcanic sequence near Clark. Generally the sandstone is massive to thick bedded and uncemented or poorly cemented. Locally it is pebbly with subangular clasts of various volcanic rocks.

At the base of the Desert Peak Formation near Derby Dam and to the east is a pumiceous tuff breccia that locally reaches a thickness of 50 feet. The breccia is typically pale brown with pumice fragments up to an inch in diameter in a vitric-lithic tuffaceous matrix. Small crystals of biotite, hornblende, and plagioclase are also present and some portions of the breccia are relatively coarse with lithic fragments up to 10 inches in diameter. The unit varies from massive to well bedded and locally cross bedded. The lithic constituents are partly Chloropagus andesite and basaltic debris and partly dacitic rocks resembling the Desert Peak volcanics. The textural features indicate that most, if not all, of this unit was deposited in water.

The upper or sedimentary member of the Desert Peak Formation has a maximum thickness of about 3,000 feet and consists largely of diatomaceous and tuffaceous sediments with some pyroclastic rocks, an andesite flow, and several thin flows of basalt. The lower thousand feet of the section interfinger with the underlying volcanic rocks.

Near the Celatom mine the lower several hundred feet of section consist of commercial-grade diatomite which is well bedded with occasional thin interbeds of gray vitric tuff and tuffaceous sandstone.

Just west of the Celatom mine about 300 feet of brownish-gray basaltic tuff are present. Typically, the tuff is well bedded, fine to coarse grained with thin interbeds of basaltic-lapilli tuff and occasional interbeds of tuff breccia. The larger clasts in this material are mainly dark gray to black vesicular basalt; reddish basaltic fragments and bombs are common in the tuff breccia. The tuffs and the matrix of the breccia consist mainly of angular fragments of basaltic glass, plagioclase (labradorite), fragments of diatomite, and clinopyroxene. Biotite and hornblende are minor constituents in some layers and fragments of dacite and rhyodacite are locally present.

Extensive exposures of the upper member of the formation 3 miles southeast of Clark consist mainly of impure diatomite and diatomaceous shales. Typically these are white to pale colored, well bedded, and platy. The diatomaceous shales contain variable amounts of clay (chiefly montmorillonite), bleached biotite, and plagioclase. Thin interbeds of brownish mudstone, silty shale, and tuffaceous sandstone are fairly common in this section. The diatomaceous sediments are more or less silicified and locally they have been converted to opaline chert, particularly along faults or adjacent to intrusive rocks.

The diatomaceous sediments near Clark grade upward to medium- to coarse-grained tuffaceous sandstone with with some interbedded shale and pebble conglomerate. The sandstones are light gray to bluish gray and moderately well bedded. The finer sandstones consist largely of rhyolitic glass and pumice fragments, whereas the coarse and pebbly sandstones contain an abundance of basaltic debris often with fragments of dacite, and rhyodacite lithologically like the underlying Desert Peak volcanics. Plagioclase is a common component of all of the sandstones, and biotite and hornblende are locally important. Rounded fragments of diatomite are common in the coarser sandstones and are often conspicuous in the pebbly sandstones.

On the eastern margin of the area about 1.5 miles from Talapoosa the upper 300 feet of the section consist of devitrified rhyolitic tuff. This material is well bedded, hard, resistant, and more or less silicified and partly zeolitized. Previously this unit has been considered correlative with the Valley Springs Formation of the Sierra Nevada (Axelrod, 1956, p. 141). However, the regional relationships and recent radiometric dates indicate this tuff is much younger than the Valley Springs Formation and that the Hartford Hill Formation is correlative with the Valley Springs.

In the vicinity of the Talapoosa Triangulation Station the upper part of the formation consists mainly of pale-colored tuffaceous sandstone which is well bedded but poorly sorted and often gritty to pebbly. Pumice fragments, rhyolitic glass, clasts of intermediate volcanic rocks, and fragments of diatomite are the main constituents of the sandstone. It is mostly soft and friable but locally it is strongly cemented and partly replaced by quartz. The silicified sandstone forms conspicuous rocky outcrops often stained by iron oxides. The lower part of the Desert Peak sedimentary section in this area consists of interbedded tuffaceous sandstone, impure diatomite, diatomaceous shales, bentonitic mudstone, and platy siliceous shales.

Both andesitic and basaltic lavas are present in the sedimentary section near the Celatom mine. The basaltic flows are thin and short and are associated with basaltic tuffs. The andesite is exposed at the Celatom mine and immediately west it has a maximum thickness of about 100 feet but is not very extensive.

The andesite is a black porphyritic rock with phenocrysts of zoned labradorite in a hemihyaline groundmass consisting mainly of plagioclase, clinopyroxene, and glass ($n = 1.520$).

The best evidence for the age of the Desert Peak Formation is the Fallon flora from the lower part of the

formation near Fallon, Nev. According to Axelrod (1956, p. 191), the Fallon flora is early Pliocene in age.

Kate Peak Formation

The Kate Peak Formation is extensively exposed in the southern part of the area where it extends westward to the type locality in the Virginia City quadrangle (Gianella, 1936). The formation has a maximum thickness of at least 1,500 feet and consists mainly of lava flows and breccias with some interbedded sediments and numerous intrusive masses ranging from andesite to rhyolite. Generally the Kate Peak Formation unconformably overlies the Desert Peak Formation with a small angular discordance, locally as much as 25°; but near Ramsey it overlaps the older Tertiary formations and locally rests on pre-Tertiary rocks. In the southeastern part of the area the upper part of the Kate Peak interfingers with the overlying Coal Valley Formation.

The lava flows and breccias are mainly dacites and rhyodacites, but andesite flows are locally present, especially in the southwestern part of the area. Generally the dacites and rhyodacites are gray, pinkish, or brown and conspicuously porphyritic with an abundance of medium to large stubby plagioclase phenocrysts and smaller mafic phenocrysts, usually hornblende and pyroxene and/or biotite. Rhyodacites are characterized by phenocrysts of basaltic hornblende, biotite, hypersthene, and a few phenocrysts of quartz, whereas dacites typically have phenocrysts of augite, hypersthene, and strongly resorbed hornblende. Andesites are much like the dacites but contain a higher percentage of mafic minerals in the groundmass. Most of the Kate Peak rocks have an aphanitic matrix, but some of the rhyodacites are vitrophyric with a matrix of gray perlitic glass with pinkish sperulites. The tops of flows are generally finely vesicular with small irregular vesicles that are often lined with tridymite, cristobalite, or opal. Rounded inclusions (autoliths?) of hornblende–microdiorite ranging up to several inches in diameter are commonly present in most of the dacites and rhyodacites but are often absent from the andesites.

Black pyroxene andesite flows ranging in thickness to about 100 feet are fairly common in the southwestern part of the area. These rocks are porphyritic with medium to small phenocrysts of plagioclase, hypersthene, and augite in a hemicrystalline matrix consisting mainly of plagioclase, pyroxene, and glass. Locally dacitic and rhyodacitic flows grade into flow breccias consisting of large angular blocks more or less cemented by vesicular laval (fig. 5). Tuff breccias up to a hundred feet or more in thickness are common throughout the section. Usually they consist of angular to subangular blocks of dacite or rhyodacite in a tuffaceous matrix lithologically similar to the large clasts. These breccias are massive to

Figure 5. Coarse dacitic breccia near base of Kate Peak Formation near Corral Spring.

vaguely stratified and are often associated with tuffaceous sandstone and diatomite. Many of the tuff breccias are probably of mudflow origin. Tuffaceous sandstone, impure diatomite, and vitric pumiceous tuff occur interlayered with lavas and breccias in the southwestern part of the area. Locally they have an aggregate thickness of more than 250 feet.

Altered Kate Peak rocks

In the vicinity of Ramsey, Talapoosa, and the Gooseberry mine, the Kate Peak Formation is more or less altered: either argillized, silicified, or propylitized. Propylitic alteration is most common and varies from weak to moderate in intensity. The propylitized rocks are dull greenish with chalky-white feldspar phenocrysts. Finely disseminated pyrite is commonly present along with thin veinlets of quartz or calcite. Calcite partly replaces plagioclase, and the mafic minerals and chlorite, antigorite, and sericite are present in varying amounts. Epidote is locally present in veinlets, joint coatings, or as a replacement of plagioclase.

Silification is locally important especially near the Talapoosa mine. In some cases opal is the predominant mineral but quartz and chalcedony are generally more important. Some of the altered rocks at the Talapoosa mine contain adularia and jarosite.

Bleached, argillized rocks are common throughout the altered areas. They are very irregular in distribution and seem to be due to weathering of pyrite-bearing rocks. However, local occurrences along faults suggest that some of the argillization may be due to hydrothermal alteration. Most of the altered rocks are in the lower part of the Kate Peak Formation, and are spatially related to Kate Peak intrusive rocks which are commonly more or less altered. In much of the region the upper limit of alteration seems to be approximately parallel to the layering in the Kate Peak rocks. Locally, however, it is strongly transgressive.

Intrusive rhyolites

Dikes, plugs, and irregularly shaped intrusives of rhyolite are present throughout the area but are most abundant near Ramsey. They intrude the lower part of the Kate Peak Formation and older rocks, but locally they are intruded by Kate Peak rhyodacites. These and other relationships indicate the rhyolites were emplaced during Kate Peak volcanic activity and therefore belong to that sequence.

Typically the rhyolites are light colored or white and aphanitic with a few inconspicuous phenocrysts of plagioclase. In the Ramsey area they commonly contain minute pyrite crystals or cubic holes due to the removal of pyrite by weathering. Thin quartz veinlets are common and the rocks are more or less silicified. Microscopically the rhyolites appear to be holocrystalline with small phenocrysts of sodic plagioclase, generally albite, in a microgranular matrix consisting mainly of quartz and potash feldspar. A few rhyolites contain phenocrysts of biotite. Sericite is commonly present in some of the rhyolites and locally replaces much of the feldspar.

Just east of the Celatom mine, rhyolite occurs with intrusive Kate Peak rhyodacite to form several composite dikes along the Celatom fault. The rhyolites are younger than the rhyodacites and form thin margins to the dikes. Rhyodacite xenoliths, and xenocrysts of minerals from the rhyodacite, are present in the rhyolite and thin apophyses of rhyolite penetrate the rhyodacites.

Dacitic and rhyodacitic intrusives

Intrusive rocks of Kate Peak lithology ranging from andesite to rhyodacite are present throughout the area but are particularly abundant in the vicinity of Ramsay (fig. 6). They occur as dikes, plugs, and domes a few feet to a mile or more in length. No sills were observed but they are probably present and undoubtedly many intrusives are present that have not been recognized. Many of the smaller dikes in the Truckee Canyon are present along faults, elsewhere most of the intrusives show no obvious structural control.

Lithologically the intrusive rocks are very similar to the Kate Peak extrusive rocks. They resemble also some of the volcanic rocks in the lower part of the Desert Peak Formation and some of the intrusives situated in rocks older than the Desert Peak Formation, but they have not disturbed the intrusive rocks. Thus these intrusives appear to be younger than the Desert Peak Formation.

Typically these rocks are conspicuously porphyritic with an abundance of medium to large phenocrysts of plagioclase and lesser amounts of medium-size biotite and hornblende phenocrysts. Augite and/or hypersthene are common as microphenocrysts and many of the rocks contain a small percentage of small quartz phenocrysts. Most of these rocks have an aphanitic matrix but a few of the dikes have vitrophyric margins.

In the northern part of the area most of these rocks are unaltered or only slightly altered; however, many of the intrusives in the southern part of the region have been more or less altered, propylitized, koalinized, silicified, or alunitized. In some cases the alteration is marginal; elsewhere it appears to involve the entire rock unit.

In the vicinity of Ramsey there are numerous occurrences of Kate Peak rhyodacite that have been partly replaced by alunite. These alunitized rocks commonly form narrow ridges and elongated masses up to several hundreds of feet in length. They are hard, resistant rocks and are commonly stained red or brown by iron oxides or black by manganese oxide minerals. They appear to be steeply dipping tabular masses or elongated pluglike structures. Many of the less altered rocks have steeply dipping planer structures and are vaguely columnar with near-horizontal columns. These features, together with their discordant relationship with the adjacent extrusive rocks, indicate that these alunitized rocks are intrusive in origin, hence they have been grouped with the Kate Peak intrusives on the accompanying map. The early prospectors were attracted to these conspicuous rocks,

Figure 6. Dike of hornblende-biotite dacite of the Kate Peak Formation, intrusive into the Alta Formation about 2.5 miles south of Ramsey.

which resulted in numerous prospecting excavations in and adjacent to them.

Microscopically the alunitized rocks appear to consist mainly of a fine-grained mixture of alunite and quartz, often with some diaspore. Relic porphyritic textures are shown by the presence of quartz phenocrysts and plagioclase "ghosts" preserved by fibrous alunite. The structural and textural features indicate that these rocks orginally were rhyodacite. Possibly the alunitization was produced by near-surface hydrothermal alteration that accompanied the emplacement of the rocks.

Age of the Kate Peak Formation

No radiometric or paleontologic dates are available for the Kate Peak Formation in this area. However, the regional stratigraphic relationships and radiometric dates for the Coal Valley Formation and other formations indicate the Kate Peak is Pliocene in age, possibly ranging from early to late Pliocene.

Coal Valley Formation

In the southeastern part of the area the Kate Peak Formation is conformably overlain by a series of fluviatile and lacustrine sediments that are correlated with the Coal Valley Formation of Axelrod (1956, p. 29–32). The formation has a maximum thickness of about 750 feet and consists mainly of tuffaceous siltstone and sandstone with thin interbeds of silty shale, diatomaceous shale, pebble conglomerate, and vitric-pumiceous tuff. All of these rocks are rich in siliceous volcanic debris which is present as pumice fragments, glass shards, and lithic fragments. In some of the more finely grained rocks the glassy fragments appear to be partly replaced by a weakly birefringent mineral, possibly the ziolite clinoptilite. Pebbly sandstones and pebble conglomerate commonly contain dacitic and rhyodacitic clasts resembling the Kate Peak Formation, but basaltic debris is uncommon. The sandstones are quite variable; typically they are only a few inches to a few feet in thickness and are poorly indurated and friable. Locally they are well cemented by a carbonate mineral, commonly calcite but occasionally dolomite. Crossbedding is common and suggests that the transporting medium was flowing in a southerly direction.

Diatoms are present in the finer sediments and poorly preserved ostracods were found in a calcareous mudstone just north of Silver Springs. Elsewhere the Coal Valley is known to be Pliocene in age on the basis of vertebrate fossils, plant fossils, and radiometric dates.

Knickerbocker(?) Andesite

A series of dikes and plugs of pyroxene andesite in the east-central part of the map area is provisionally

correlated with the Knickerbocker Andesite of the Virginia City area on the basis of lithologic similarity and relative age.

The andesite is a black porphyritic rock with large glassy plagioclase phenocrysts in a subvitreous aphanitic groundmass. Most of the intrusives have columnar jointing and some have thin siliceous veinlets along joints perpendicular to the columns.

Microscopically the andesite is porphyritic with large complexly zoned plagioclase phenocrysts (labradorite-andesine) and small andesine crystals in a hemicrystalline matrix of andesine, clinopyroxene, hypersthene, glass, magnetite, and apatite. Also present are a few altered olivine crystals, magnetite-pyroxene "ghosts" after hornblende, and a few quartz xenocrysts.

The age of the Knickerbocker Andesite in the type locality is somewhat uncertain. Thompson (1956) considered it to be younger than the Kate Peak Formation and probably older than the Lousetown Formation. The age of the Knickerbocker(?) in this area is also uncertain. The Knickerbocker(?) intrusives cut the Desert Peak Formation but have not been observed in contact with the Kate Peak or younger rocks. These intrusives are closely associated with lava flows of the Lousetown Formation but appear to have been truncated by the erosion surface on which the Lousetown flows are situated. Thus they are probably older than the Lousetown Formation, younger than the Kate Peak Formation, and possibly of late Pliocene Age.

Lousetown Formation

In the vicinity of Talapoosa and between Talapoosa and the Celatom mine the Kate Peak and Desert Peak Formations are unconformably overlain by a series of basaltic to intermediate lavas with a maximum thickness of about 350 feet. These lavas and their associated intrusive rocks, minor pyroclastics, and gravel are part of the Lousetown Formation as defined by T. P. Thayer (1937). The Lousetown also occurs near Cinder Mountain and in a small area south of Ramsey.

Most of the Lousetown lavas and intrusive rocks are medium to dark gray, finely porphyritic olivine basalts, olivine trachybasalts, and pyroxene andesites. However, conspicuously porphyritic pyroxene dacite is present near the Celatom mine.

The basaltic and andesitic rocks tend to be holocrystalline with small phenocrysts of plagioclase and olivine or augite in an intergranular to subophitic groundmass. The trachybasalts contain 10 to 15 percent alkali feldspar, probably sodic sanidine, which occurs as minute interstitial grains or thin rims on plagioclase crystals. Small amounts of cristobalite or tridymite are commonly present especially in the andesitic rocks, but glass is important only in the vesicular rocks, scoria, and rare volcanic bombs. All of the rocks are relatively unaltered except for partial replacement of olivine by iddingsite. The tops of flows are conspicuously vesicular and locally show ropy structure. Individual flows appear to be relatively thin, usually less than 50 feet in thickness.

Dark-gray pyroxene dacite is present as lava flows, breccia, and an irregularly shaped intrusive mass just east of the Celatom mine. Typically the dacite is porphyritic with moderately large plagioclase phenocrysts and minute clinopyroxene phenocrysts enclosed in a hemicrystalline matrix consisting mainly of plagioclase, clinopyroxene, and glass. Xenocrysts of quartz, biotite, and hornblende are present in small amounts. Locally the dacite is holocrystalline with an abundance of cristobalite. Much of the dacite immediately east of the Celatom mine is a coarse extrusive breccia with angular dacite fragments up to 3 feet in diameter. Fragments of diatomite occur in the breccia and locally much of the matrix appears to be fragmented diatomite. The adjacent intrusive Lousetown is largely composed of similar breccia and may be the source of the extrusive dacite.

Dark-gray basaltic tuff and tuff breccia commonly occur at the base of the Lousetown in the Talapoosa area (fig. 7). Generally this material is only a few feet thick and is poorly exposed. However, in a small area just south of the Talapoosa Triangulation Station well-bedded tuff and tuff breccia is present with irregular dips up to 45° or 50°. The exposures are rather limited but the general relationships suggest that this may mark the location of an eruptive center for some of the Lousetown lavas.

A thin layer of gravel is present at the base of the Lousetown in the area southeast of Clark. It is largely obscured by talus and only locally is extensive enough to be mapped. The main constituents of the gravel are subangular to subrounded fragments of dacite, rhyodacite, and diatomite apparently derived from the Desert Peak Formation. The gravels are of fluvial origin and apparently mark the drainage channels that existed at the beginning of Lousetown volcanism in this area.

Gravels questionably assigned to the Lousetown are present at several levels on the hills north of Clark. Evidently these gravels were deposited by the ancestral Truckee River. The assignment to the Lousetown Formation is highly uncertain and is based mainly on geomorphic relationships. The highest gravels are about 1,000 feet above the bottom of the adjacent Truckee Canyon and indicate a deepening of the canyon by that amount since deposition of the gravels, perhaps a million years ago.

Probably more than five eruptive vents participated in supplying the Lousetown lavas but their locations are not precisely known. One must have been located near Cinder Mountain, another one may be marked by the dike associated with the small Lousetown flow south of Ramsey, and the Lousetown extrusive rocks near the Celatom mine possibly came from vents now marked by the nearby Lousetown intrusives. Lavas near Talapoosa and the adjacent area apparently came from vents near the Talapoosa Triangulation Station as they seem to radiate away from this area. The previously mentioned occurrence of steeply dipping tuff may mark one of the vents in this area.

The age of the Lousetown in this area is uncertain,

but Lousetown lavas near Truckee, Calif., have yielded radiometric age dates of 1.2 to 2.3 million years (Birkeland, 1966, p. D5). On the basis of this and the local geological setting, it is thought that the Lousetown in this area is Pleistocene, as currently defined by Quaternary geologists.

Mustang Formation

The type locality of the Mustang Formation is on Clark Mountain in the Spanish Springs Valley quadrangle just west of Clark (Thompson, 1956, p. 59). Within the area mapped in the present report, the Mustang is present in a small area just south of Clark, and on the ridge north of the Truckee Canyon.

South of Clark the Mustang occurs as a thick flow of hornblende-augite trachyandesite in an old, broad valley cut in the Kate Peak and Desert Peak Formations. The flow has been considerably dissected by erosion, and talus and alluvium obscure much of its details. Fresh surfaces of the trachyandesite are medium gray, but weathered surfaces are dark brown or black due to iron oxide coatings. Typically the rock is porphyritic with an abundance of small to medium-size phenocrysts of hornblende and small inconspicuous plagioclase crystals in an aphanitic groundmass.

Microscopically the rock appears to be holocrystalline with an intergranular groundmass of andesine, augite, cristobalite, sanidine(?), apatite, and magnetite. Hornblende phenocrysts are largely replaced by iron oxide minerals and many plagioclase phenocrysts have thin discontinuous rims of alkali feldspar. The rock is designated a trachyandesite because of the abundance of alkali feldspar and a potash content of 2.65 percent (Volborth, 1963, p. 72). The occurrence northeast of Clark is lithologically similar to that at Clark and the correlation is based on lithologic features and geomorphic relationships.

The youngest rock unit overlain by the Mustang in this area is the Kate Peak Formation, but in the type area the Mustang Formation locally overlies the Lousetown Formation, and water-worn clasts of Mustang are present in gravels beneath the McClellan Peak Basalt (Thompson, 1956, p. 60). These relationships indicate that the Mustang Formation is Pleistocene in age.

McClellan Peak Basalt

The youngest volcanic unit recognized in this area is the McClellan Peak Basalt, which occurs as lava flows and cinders. The basalt forms two prominent cinder cones in the southwestern part of the area, Cinder

Figure 7. Base of the Lousetown Formation, showing a thin fragmental layer between the Lousetown and the underlying Kate Peak Formation just north of Talapoosa, Nevada.

Mountain and the adjacent peak to the south, each with an associated lava flow. The flow from Cinder Mountain is widespread in the adjacent Virginia City quadrangle. A small part of the southern flow is exposed in the area of the present report. Both flows are about 25 feet thick and consist of dark-gray to black olivine basalt with conspicuous fresh olivine phenocrysts and sparse augite and plagioclase phenocrysts. Tops of the flows are highly vesicular and hemicrystalline. The interiors of the flows are holocrystalline and contain about 12 percent olivine, 30 percent titanaugite, and 50 percent plagioclase. Chemical analyses indicate that the northern flow corresponds to alkali basalt with a small amount of normative nepheline (Thompson and White, 1964, p. A8).

The cinder cones consist mainly of scoriaceous fragments ¼ to ½ inch in diameter, with many fragments 1 foot or more in length and well-formed bombs and fragments of bombs as much as 5 feet long. Some of the larger bombs contain inclusions of Kate Peak dacite or olivine gabbro.

The type McClellan Peak Basalt near McClellan Peak south of Virginia City has yielded a radiometric age date of 1.14 million years and has a reversed remanent magnetism (Birkeland, 1966, p. D5). However, the northern flow of this area has a normal remanent magnetism. It is therefore slightly younger than the type McClellan Peak Basalt. The normal remanent magnetism places this lava flow in the Brunhes normal polarity epoch, consequently it is less than 0.85 ± 0.15 million years old (Birkeland, 1966, p. D5). Presumably the southern flow and the two cinder cones are about the same age as the northern flow.

Older Alluvium

The older alluvium consists mainly of alluvial fan and pediment gravels. The unit is present throughout the map area but is most extensive in the southern part of the region just north of U.S. Route 50. It is also important in the Truckee Canyon and the area just east of the Gooseberry mine.

The gravels are coarse and unsorted, and consist largely of subangular to subrounded cobbles and boulders up to 6 feet in diameter enclosed in a sandy matrix. Generally the unit is poorly exposed and occurs as loose unconsolidated gravel that mantles bedrock surfaces. The composition varies with location, but generally the gravels consist mainly of locally derived volcanic debris. The older alluvium is apparently younger than the Mustang Formation and older than the Lake Lahontan deposits, but some of the gravels may be contemporaneous with the Lahontan or even younger.

Lake Lahontan Deposits

Lake Lahontan sediments are extensively exposed in the Truckee Canyon and are especially widespread in the vicinity of Fernley. They are also present in two small areas in the southeastern part of the map near U.S. Route 50. About 300 feet of section is exposed just west of Fernley, but the section is much thinner near Clark. The upper limit of the Lahontan is approximately 4,380 feet, and no evidence was found to indicate any offsetting or warping of this level.

The Lahontan deposits consist mainly of sand with minor amounts of gravel, silt, and tufa. The sand is white to pale buff, well bedded, and generally well sorted to size. It varies from fine to coarse grained and occasionally it is pebbly.

Gravel occurs as interbeds in the sand especially near the base of the section. Typically it consists of well-rounded pebbles up to 3 inches in diameter enclosed in a sandy matrix. Generally the larger clasts are mainly granitic and volcanic rocks that appear to have a Sierran source. In a few places coarse gravel interbeds are present that consist mainly of subangular fragments of volcanic rocks of local derivation. A small tufa dome about 10 feet in diameter is present at an elevation of about 4,360 feet on the hillslope, approximately 2 miles west of Fernley. Elsewhere, dendritic tufa is present as thin coatings on bedrock below the 4,380-foot elevation where the clastic Lahontan sediments have been removed by erosion. In the northeastern part of the area Lahontan-age sand has been reworked by wind to form a considerable area of sand dunes.

Alluvium

Unconsolidated gravel and sand occur throughout the area along stream courses and in local basins. Typically they are only a few feet thick and consist mostly of locally derived rock debris, mainly volcanic material. However, alluvium along the Truckee River commonly contains much coarse volcanic and granitic debris that appears to have been derived from the Sierra Nevada. In the northeastern part of the area much of the alluvium has been derived from Lahontan deposits and from older alluvium, so it is often difficult to separate these units.

STRUCTURAL GEOLOGY

The general structural pattern of this area is dominated by a more or less east-west trend of folds and faults in the Cenozoic rocks. North-south to northeast-southwest structural features are locally present but these are subordinate to the east-west features. Structural details of the pre-Tertiary rocks are uncertain due to their limited distribution. Field relationships, however, indicate that the Mesozoic metamorphic rocks were deformed prior to emplacement of the granitic rocks, presumably in mid-Cretaceous time.

All of the Cenozoic rocks older than the Pleistocene Lousetown Formation have been folded and faulted. The folding is most obvious in the older Tertiary rocks, and the uncomformable relationships indicate that

deformation was more or less progressive during Tertiary volcanism. In the northern part of the area the folds are essentially east-west trending, and generally plunge westward. Transgressive relationships of the Chloropagus Formation, and the steeper plunges of folds in pre-Chloropagus rocks, suggest the possibility of a westward tilting of the Old Gregory Formation and older rocks in late Miocene prior to Chloropagus volcanism.

The manner in which the Kate Peak Formation transgresses the older rocks indicates that the main folding occurred after deposition of the Desert Peak Formation and prior to Kate Peak volcanism, that is, after early Pliocene time. Further evidence for pre-Kate Peak folding is demonstrated in the vicinity of Ramsey. Here, the spatial relationships indicate the formation of an anticlinal structure in the Alta and older rocks prior to Kate Peak time. This structure was subjected to extensive erosion prior to Kate Peak time, resulting in partial removal of the older rocks. The thinning of the Kate Peak across this structure indicates the presence of a topographic high in this area at the beginning of Kate Peak volcanism.

Some weak folds can be recognized in the Kate Peak Formation, but structure is less obvious than in the older rocks. In part, this is due to the irregularity of flow banding in the Kate Peak lavas and the general lack of reliable attitudes. In the southwestern part of the area the Kate Peak structures have a northeast-southwest trend but just north of Ramsey the Kate Peak has been folded into a gentle east-west-trending syncline. Folding of the Kate Peak and Coal Valley Formations occurred prior to Lousetown volcanism, because the Lousetown shows little evidence of any deformation other than minor tilting and dislocation along faults.

Faulting apparently occurred contemporaneously with the Cenozoic volcanism. Most of the faults are high-angle faults (60° to 80°). Both normal and reverse faults are present but some of the east-west faults seem to be oblique slip faults, with left lateral displacements.

Faulting in the Truckee Canyon is difficult to understand largely because of the uncertainty of correlating faults across alluviated areas. The Derby fault is one of the most problematic. It appears to be a pivotal or rotational fault, the north side near Derby Dam having been displaced upward about 1,000 feet, while the north side in section 15 about 3 miles to the northeast was displaced downward at least 1,000 feet. This fault also appears to have some left lateral strike-slip displacement, possibly several thousand feet, but this is highly conjectural.

The "102" fault north of Clark appears to be a high angle reverse fault with the north side down. This fault apparently branches and dies out to the east.

The "46" fault in the central part of the area is a high-angle reverse fault with an apparent throw of about 1,200 feet on the top of the lower (volcanic) part of the Desert Peak Formation. However, displacement relative to the base of the Kate Peak Formation is small, indicating that most movement occurred prior to deposition of the Kate Peak.

The oldest recognizable faulting in the area is shown by a group of normal faults with small displacement in the Chloropagus Formation about 7 miles west of Fernley. These faults are considered to be contemporaneous with Chloropagus volcanism because, although they offset Chloropagus rocks, undisturbed Chloropagus dikes are present along the faults. Faulting also occurred during the interval between the deposition of the Desert Peak Formation and Kate Peak volcanism. This is best indicated by relationships along the Celatom fault near the Celatom mine. This fault offsets Desert Peak rocks but contains dikes of Kate Peak rhyolite and rhyodacite. Still other faults offset Kate Peak rocks but appear to be older than the Lousetown Formation. The Crest fault in the central part of the area is the best example of this category.

Some of the faults, particularly in the southeastern part of the area, are younger than the Lousetown Formation, but the youngest recognized fault is a small fault in the northwestern part of the area, about 2 miles north of Clark. This fault brings alluvium in fault contact with Chloropagus lavas. It appears to be an oblique slip fault with a few feet of left lateral displacement.

The north-south-trending fault in the northeastern part of the map is concealed by alluvium but its presence is indicated by the relationship of the Chloropagus Formation and Hartford Hill Formation in this area. The eastern side of this fault has moved down with respect to the west. Apparently the fault intersects the Celatom fault in the alluvium along the Truckee River with the result that the block northeast of the intersection has been downdropped several hundred feet relative to the adjacent area.

Two "trap door" faults are present in the south-central part of the area. Both involve Mesozoic rocks that are surrounded by much younger rocks. Evidently the Mesozoic rocks have been pushed up from below, probably by intrusive magma.

ECONOMIC GEOLOGY

The area covered in this report has been extensively prospected for various mineral materials. Numerous prospect pits, trenches, shafts, and adits are present throughout the area wherever the rocks are altered or have the least indication of containing a valuable mineral deposit.

The earliest prospecting was for gold and silver, but later the area was searched for iron, tungsten, mercury,

copper, diatomite, and uranium. Although the area has been extensively explored, the only current mineral production is the diatomite mined near Clark by Eagle-Picher Industries, Inc.

GOLD AND SILVER

Most of the rocks older than the Kate Peak Formation have been prospected for gold and silver, but such prospecting has been most extensive in the altered Kate Peak rocks, particularly near Ramsey, Talapoosa, and the Gooseberry mine south of Clark. Although countless prospecting excavations are present in these areas, especially near Ramsey, only two mines, the Ramsey-Comstock and Talapoosa, have any record of production.

In 1966 the only active gold-silver prospect in this area was the Gooseberry Mine in sec. 25, T. 19 N., R. 22 E. about 5 miles south of Clark. The mine is owned jointly by C. D. Martin, J. D. Martin, and Mrs. E. L. Martin of Fresno, California. It consists of a 1,000-foot shaft and several thousand feet of workings at various levels. The ore consists of a quartz-calcite vein with minor amounts of pyrite, chalcopyrite, tetrahedrite (argentiferous), and variable amounts of silver and gold. Samples collected from the dump and analyzed by the Nevada Mining Analytical Laboratory of the University of Nevada showed up to 1.14 ounces of gold and 69 ounces of silver per ton, but the ore probably averages only about $10 per ton. At the surface the vein ranges from a few inches to several feet in width, and strikes about N. 70° W. and dips about 80° to the south. According to Mr. C. D. Martin, manager of the mine, the vein is thicker below the 400-foot level than at the surface. The wall rock of the vein is a pyritic propylitized dacite of the Kate Peak Formation that is more or less argillized at the surface. Secondary gypsum and jarosite are fairly common in the argillized areas near the mine and minor quartz veins are not uncommon. Although the deposit was discovered in 1906, the Gooseberry mine has no record of production. Currently the underground workings are being extended to explore the deposit, and during the past few years several hundred feet of crosscuts and drifts have been made on the 1,000-foot level.

The Talapoosa mining district, in the southeastern part of the area about 10 miles south of Fernley and 3.5 miles northwest of Silver Springs, has the largest recorded gold production of the entire area. Although gold was discovered in this area in 1864 the production was very small prior to 1938. The principle mine of the area, the Talapoosa, produced 7,530 tons of ore valued at $304,151, mainly in gold but with minor amounts of silver values, from 1939 to 1942 (Stoddard and Carpenter, 1950, p. 83).

The Talapoosa district is in silicified, argillized, and propylitically altered rocks of the Kate Peak Formation. The ore consists of gold-bearing silicified dacite with quartz veins along east-west-trending faults and along north-south cross fractures. The quartz is fine grained, commonly drusy, and is locally accompanied by adularia. According to Mr. Fred DeLongchamps, who operated the mine from 1939 to 1942, much of the richest ore was found along low-dipping cross fractures. Silver was a minor constituent of most of the ore, but according to DeLongchamps, one shaft on the property encountered mineralized rock with ruby silver minerals. Although all of the known high-grade ore has been mined, apparently there is considerable low-grade material remaining in the mine.

A few miles west of the Talapoosa district, and nearly midway between Clark and Silver Springs, is the Ramsey mining district, an area of several square miles, where prospecting for gold and silver has been very extensive. Although there are countless prospecting excavations in the area, only one mine, the Ramsey-Comstock mine in sec. 34, T. 19 N., R. 23 E., has a record of production of gold and silver. The Ramsey-Comstock ore was discovered in 1906, and from 1906 to 1911 the mine is credited with about $80,000 production, mainly of gold with some silver (Lincoln, 1923, p. 130). From 1933 to 1937 the production was $35,891 (Stoddard, 1950, p. 80); apparently the property has been idle for many years.

The northern and main part of the Ramsey district, including the Ramsey-Comstock mine, is in altered rocks of the Kate Peak Formation which are mainly propylitized and argillized dacites and rhyodacites. Locally the Kate Peak rocks are partly silicified with small quartz veinlets. Near the Ramsey-Comstock mine are numerous occurrences of steeply dipping, tabular masses of alunitized rhyodacite, most of which appear to be of intrusive origin. Many of the prospecting excavations are located in or adjacent to these masses. The Ramsey-Comstock deposit is in similarly altered rock, although it is uncertain whether it was originally intrusive or extrusive.

The Ramsey-Comstock ore is a tabular body of quartz-diaspore-alunite rock about 10 feet thick that strikes about N. 65° E. and dips northward about 55°. Near the surface the hanging wall is a light-colored gouge about 3 feet thick. Slickensides and stria in the gouge suggest that the latest movement along this zone was probably left lateral strike-slip movement, but this movement was evidently post mineralization. Production records show that the ore produced during 1933 and 1934 averaged $74.70 per ton, while the ore produced during 1936 averaged slightly less than $6 per ton. Evidently the best ore was near the surface, and tenor of the ore decreased with depth. The property has been inactive since 1937.

TUNGSTEN

Although several tungsten prospects are present near Blackhawk and in the metamorphic rocks south of Ramsey, the only significant occurrence of tungsten mineralization in this area is in the Truckee Canyon

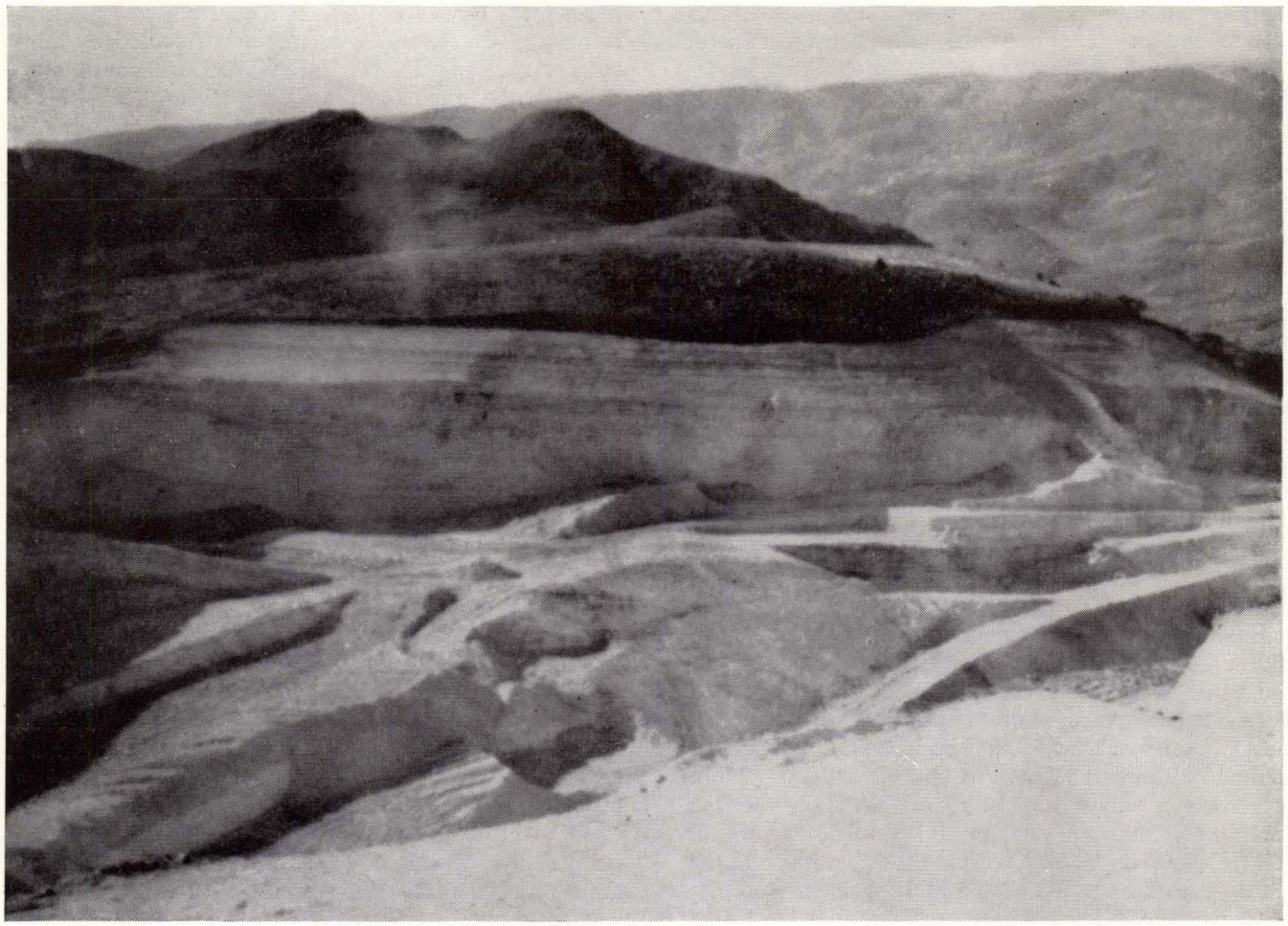

Figure 8. Main pit of the Celatom diatomite mine, looking northwest (1959).

about 5 miles west of Wadsworth in sec. 13, T. 20 N., R. 23 E., adjacent to U.S. Route 40. This occurrence was discovered in 1940 by John M. Heizer and later developed by Rare Metals Corp. (Overton, 1947, p. 72), but only a small amount of ore has been removed from the property. The ore consists of scheelite in calc-silicate hornfels and garnetiferous skarn adjacent to intrusive granitic rocks.

COPPER

Small amounts of copper minerals occur at several localities in the Mesozoic rocks and in the andesitic rocks of the Alta Formation. All of the occurrences are erratic and none appear to have commercial possibilities. The occurrences in the pre-Tertiary rocks consist of bornite and/or chalcopyrite often with secondary malachite or chrysocolla. Most of these occurrences are in contact metamorphic rocks or in the adjacent intrusive rocks near the Blackhawk mine and south of Ramsey.

Small amounts of malachite and chrysocolla occur in several places in the Alta Formation south of Ramsey but the most interesting occurrence of copper minerals in this area is in zeolitic andesitic rocks near the top of the Alta Formation just north of U.S. 40 in the Truckee Canyon. Here thin veins of laumontite contain small amounts of native copper, cuprite, tenorite(?), and malachite. The copper minerals occur in the central portions of the veins and are later than the laumontite.

IRON

Iron mineralization is present at a number of places in the metamorphic rocks near the Blackhawk mine in the southwestern part of the area. Most of these occurrences consist of magnetite streaks and masses in actinolitic metamorphic rock. The only occurrence that seems to have any commercial possibility is the Black Eagle prospect in the SE¼SE¼ sec. 25, T. 18 N., R. 22 E. Here low-grade magnetite ore occurs in actinolite-magnetite granofels associated with microdiorite. A considerable quantity of low-grade ore, possibly averaging about 20 percent iron, is present at this location. In 1966 this property was reportedly under lease to the Utah Construction and Mining Co. which now controls the Dayton iron prospect about 1.5 miles to the south.

URANIUM

During recent years the area has been extensively prospected for uranium, and numerous claims have been located in rhyolitic rocks of the Hartford Hill Formation in the Truckee Canyon and south of Ramsey. Most of the claims have been abandoned and there apparently has been no production from any of the properties.

MERCURY

Minor amounts of mercury mineralization are present in the area at several localities, but the only significant occurrence is in the Desert Peak Formation at the Taylor-Branch prospect in the SW¼ sec. 35, T. 20 N., R. 22 E., about 1 mile southwest of Clark. According to E. H. Bailey (1944, p. 188) the deposit consists of cinnabar in altered tuff. Only a small amount of mercury has been produced, and in 1966 the property was inactive.

VOLCANIC CINDERS

Volcanic cinders of good quality form the bulk of the two cinder cones of the McClellan Peak Basalt in the southwestern part of the area. A small amount of cinders has been mined from pits on Cinder Mountain but the property was inactive in 1966.

DIATOMITE

Diatomite occurs at various places throughout the area in the Coal Valley, Kate Peak, Desert Peak, and Chloropagus Formations, but the only place it is present in sufficient quantity and quality for production is at the Celatom mine about 6 miles east of Clark (fig. 8). Here a deposit about 300 feet thick occurs in the basal part of sedimentary rocks of the Desert Peak Formation. Minor thin interbeds of rhyolitic tuff and sandstone are present in the diatomite, but the bulk of the material is commercial quality and is being produced at a rate of more than 100 tons per day by Eagle-Picher Industries, Inc.

The diatomite is mined in open pits and trucked to Clark where it is processed and loaded on freight cars for transport to market. In mid-1966 about 50 persons were employed in the operation. Reserves are large enough to maintain the operation for many years.

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