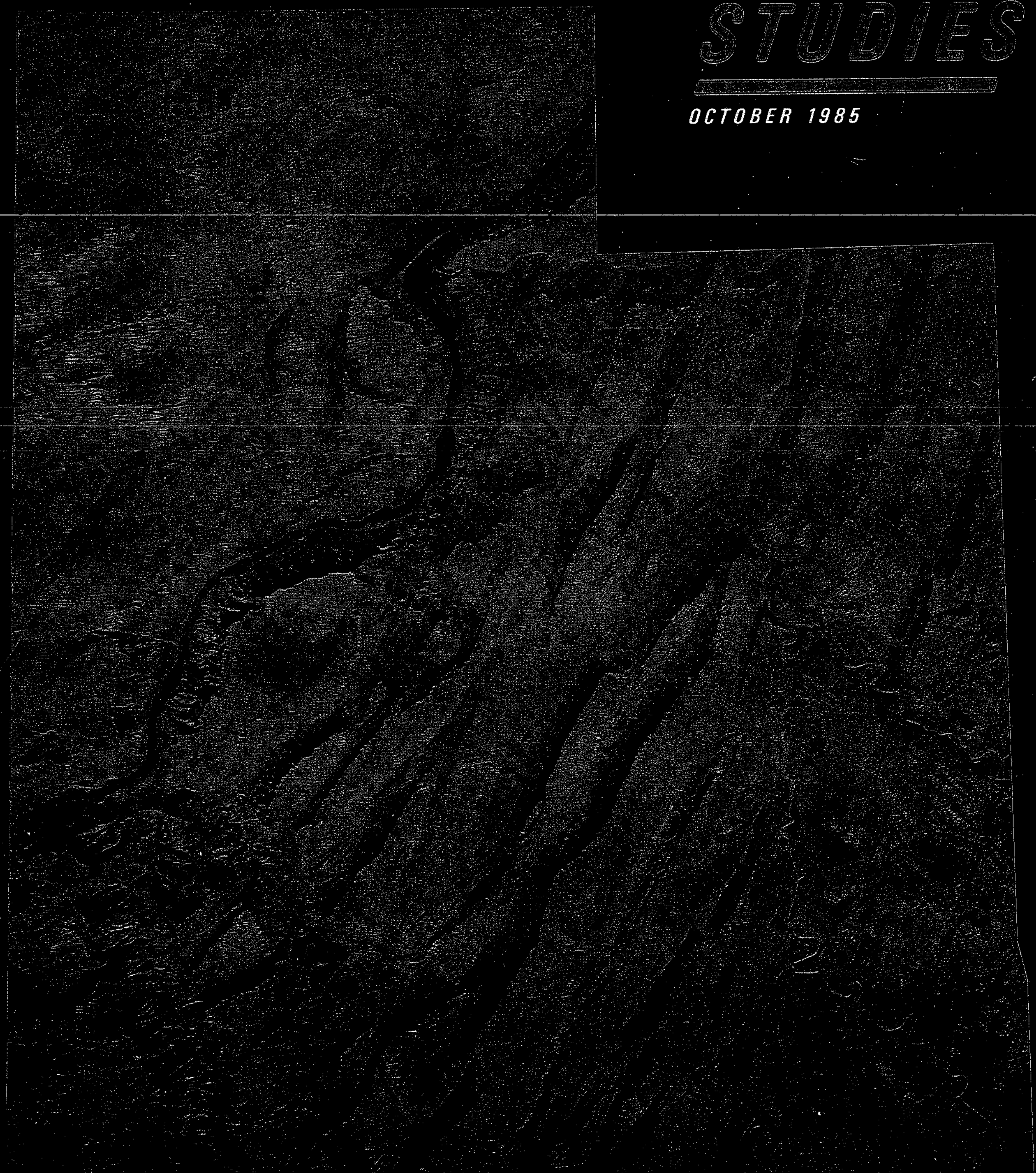
BRIGHAM YOUNG UNIVERSITY GEOLOGY STUDIES

OCTOBER 1985



VOLUME 32, PART 1

BRIGHAM YOUNG UNIVERSITY GEOLOGY STUDIES

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CONTENTS

THE GLORY OF GOD IS INTELLIGENCE

A publication of the
Department of Geology
Brigham Young University
Provo, Utah 84602

Brigham Young University Geology Studies is published by the Department of Geology. This publication consists of graduate student and faculty research within the department as well as papers submitted by outside contributors. Each article submitted by BYU faculty and outside contributors is externally reviewed by at least two qualified persons.

Cover: High-altitude infrared aerial photograph of block faulting in the Permian Cutler-Rico formations near the junction of the Green and Colorado Rivers, Utah. Fall 1983. U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service. Salt Lake City, Utah: Aerial Photography Field Office.

ISSN 0068-1016
Distributed October 1985
10-85 600 76925

CONTENTS

Geology and Ore Deposits of the Reveille Mining District, Nye County, Nevada*

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ABSTRACT

The Reveille district in central Nevada was mapped in order to describe its geology and evaluate its mineral potential. The stratigraphic column in the district consists of a thick sequence of Ordovician–Mississippian carbonates and quartzites surrounded and, in part, overlain by Tertiary welded tuffs and volcanic flows. The Paleozoic rocks have been thrust over conglomerates, sandstones, and carbonate mudstones of possible Pennsylvanian–Permian age which are exposed in a fenster near the New Deal claims.

Rocks of the area are cut by four sets of normal faults: an east–west-trending set, a northwest-trending set, a northeast-trending set; and a north–south-trending set. The east–west and north–south sets generally have large displacements whereas displacements on the other two sets are minor. The eastern boundary of the district is marked by a north–south-trending left lateral strike-slip fault.

Seven types of alteration are recognized in the district: argillization, sericitization, chloritization, pyritization, silicification, and bleaching. Alteration type often reflects rock type and is more extensive in volcanic than in sedimentary rocks.

Ore consists of silver-bearing stibnite, tetrahedrite, and silver-bearing oxides. There are three types of ore bodies in the district: fissure-filling, high-grade irregular replacements, and low-grade replacements. The richest ore bodies occur along faults where carbonates or quartzites abut welded tuffs. The strongly fractured quartzites and carbonates provide an inviting host rock for the ore. The tuff is highly fractured and altered but appears not to have been chemically favorable to ore deposition. Faults have provided both migration paths and depositional sites. The richest deposits occur in areas where northwest- and northeast-trending faults crosscut east–west-trending faults. Economic potential in the district consists of low-grade replacement deposits with localized pods of high-grade ore.

INTRODUCTION

The Reveille mining district has been the site of sporadic mining activity since its discovery in 1866. Exploration and mining coincided with periods of high metal prices. From 1978 to 1979 exploration reached a peak and led to exploitation of small, low-grade ore bodies. No large high-grade deposits have been located in the district since the early 1900s. This study was undertaken to identify and define the geologic controls on the emplacement of the district's ore deposits. In order to delineate these controls, the study includes a description of the stratigraphy, structure, hydrothermal alteration, and nature of the ore bodies.

LOCATION AND ACCESSIBILITY

The Reveille district, sometimes called the Old Reveille district, is one of three mining districts located in the northern Reveille Range (fig. 1). The Arrowhead district, just to the north, and the New Reveille district, immediately to the south of the Reveille district, were not included in this study. The district, located in northern Nye County, Nevada, lies 32 km south of Warm Springs and 282 km north of Las Vegas, Nevada. Improved dirt roads, which are passable by passenger car in favorable weather, provide access from Nevada 395 (formerly Nevada 25). Roads within the district itself are best traveled with high-clearance, four-wheel-drive vehicles.

*A thesis submitted to the Department of Geology, Brigham Young University, in partial fulfillment of the requirements for the degree of Master of Science, August 1983.

METHODS AND PROCEDURES

Fieldwork in the Reveille district began in May of 1979 and was completed by March 1980. It included geologic mapping, measurement of stratigraphic sections, mapping of hydrothermal alterations, and sample collecting. Detailed geologic mapping was done on aerial photographs at 1″ = 650′ and transferred to topographic base maps at a scale of 1″ = 500′. Stratigraphic sections were measured with steel tape and Brunton compass, and hand samples were collected for additional study in the laboratory. Petrographic thin sections of igneous rocks and mineralized zones were prepared and their mineral percentages estimated. Minerals that could not be identified in the field were identified by optical properties and X-ray diffraction. Gold Creek Mining Corporation provided silver assays on selected samples.

HISTORY AND PRODUCTION

The mineral deposits of the Reveille district were reportedly discovered by Indian Jim in 1866 (Lincoln 1923). The district, organized that same year, was named in honor of the *Reese River Reveille*, an Austin, Nevada, newspaper (Browne 1868). Production has been sporadic and limited in volume. The initial discovery period lasted four years, from 1866 to 1870. Production came from discontinuous, rich, shallow pockets of ore in the carbonate rocks (Raymond 1869). After this initial period, the district was dormant until 1875 when a new discovery was made on one of the New Deal claims (Raymond 1875). Production on this property, which was renamed the Gila Mine, came from the Eureka quartzite. Reportedly, the Gila Mine produced 6,128 tons of silver, lead, copper, and gold ore, which made it the largest producer in the district (Couch and Carpenter 1943). After the Gila Mine closed in 1891, sporadic production came from the Antimonial Mine, Kietzke Mine, Lost Burro Mine, and reworking of the Gila dumps. Starting in 1972, several companies reevaluated the district; and in 1978, claim owners in the district organized several development companies which contracted Gold Creek Corporation of Las Vegas, Nevada, to develop the properties. Three small open-pit mines, developed in 1979 and 1980, produced over 60,000 tons of low-grade ore. The ore was placed on gravel pads where silver removal by acid leach was attempted (Bob Johnson, Gold Creek Corporation, personal communication). Falling silver prices halted the project in 1981. At this writing, no mines are presently operating within the district.

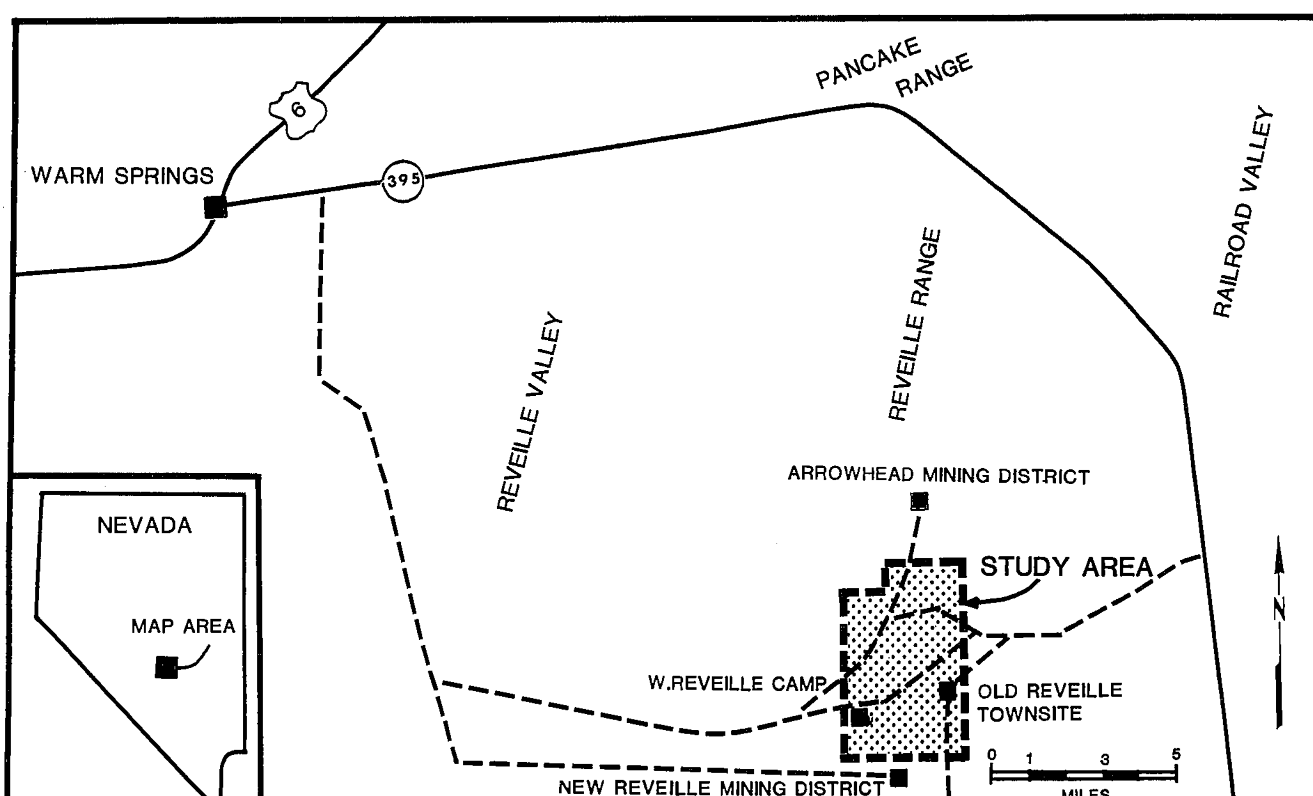

FIGURE 1.—*Index map showing location of the Reveille district.*

PREVIOUS WORK

Browne (1868), Stedfedt (Raymond 1869), Gilbert (1872) and Degroot (Raymond 1875) each made early reconnaissance studies of the district and gave brief descriptions of the ore deposits and general geology. Spurr (1903) and Ball (1907) made the first attempts to place the sedimentary rocks into a stratigraphic sequence. Ekren and others (1973b) mapped the Reveille Quadrangle at a scale of 1:48,000 and extended the existing nomenclature of both the sedimentary and igneous rocks from central Nevada into the area. Unless otherwise noted, the author uses the nomenclature proposed by Ekren and associates. Lawrence (1963) described and mapped the geology of the Antimonial Mine. Several mining companies have conducted reconnaissance studies of the district; however, the results were unavailable to the author with the exception of one unpublished study by Runnels and Grauberger (1972). Geochemical work has been done in selected areas, but the data were unavailable to the author.

GEOLOGIC SETTING

The Reveille Range, located in the central Great Basin, is typical of the basin's ranges. It is a horst bounded on the east and west by normal fault zones. As shown on plate 1, the western boundary fault lies within the district; however, the eastern boundary fault zone lies some 5 km (3 mi) east of the district proper. Much of the Reveille Range is made up of Tertiary welded tuffs and volcanic flows (Stewart and Carlson 1978). The Reveille district, however, is located in an area where two patches of Paleozoic sedimentary rocks are exposed beneath volcanic rocks. The igneous rocks are part of a belt of tuffs 34 to 17 million years old that extends across central and south central Nevada and Utah (Silberman and others 1976). Several collapsed caldrons have been postulated in the area around the district (Ekren and others 1976). Basalts related to the Lunar Crater volcanic field are found in patchy outcrops to the east, west, and north of the district; however, none are found within the district proper.

ACKNOWLEDGMENTS

The author would like to express his appreciation to Dr. Kenneth C. Bullock for his helpful suggestions and direction in the course of this study. Gratitude is also expressed to Drs. Lehi F. Hintze and Willis Brimhall for their help as members of the thesis committee. Funds for this project were provided by Mr. Einar Erickson of Las Vegas, Nevada; Mr. Dennis Campbell of Denver, Colorado; and the general thesis fund of Brigham Young University Geology Department. Dave Keller and Blaine Rowley assisted with portions of the fieldwork. The author would also like to thank Drs. Myron Best, Jess Bushman, Dana Griffen, and Harold Bissell for helpful criticism. Gratitude is expressed to Joe Owens for his suggestions and support and to Bob Johnson and all of the employees of Gold Creek Corporation for their hospitality and assistance. The author is indebted to Paula Landon for assistance in editing and typing and to Pauline Baird Jones for assistance in typing as well as providing encouragement during the study.

SEDIMENTARY ROCKS

The sedimentary outcrops at Reveille are more than 64 km (40 mi) from the nearest sedimentary rocks. Because of their isolated nature, correlation with other sequences has been difficult. For example, Spurr (1903) correlated the Reveille sequence with Cambrian rocks in the Eureka, Nevada, area whereas Ball (1907) thought the sequence to be Pennsylvanian in age. The confusion was resolved by the work of Ekren and others (1973b). They correlated the Reveille sequence with Ordovician-to-Mississippian rocks of central Nevada. Unless otherwise noted, the author uses the nomenclature proposed by Ekren and his associates. The author measured five sections in the district. Lithologic descriptions given herein supplement those given by Ekren and others (1973b). Because of faulting, the stratigraphic sequence exposed in the district is incomplete (fig. 2).

ORDOVICIAN SYSTEM

Antelope Valley Limestone

In the Reveille district, the Antelope Valley Limestone (Nolan and others 1956) forms a ledgy slope at the mouth of Gila Canyon. The sequence was described by Ekren and associates (1973b) as dolomite and limestone with minor quartzite beds. The author divides the formation differently than Ekren and others (1973b) into four informal members (fig. 2): (1) The lowest member (A) consists of 35 m of fine-grained, medium gray, thin to medium wavy-bedded packstone. The limestone weathers dark bluish gray with splotches of limonite stain. This member contains 1–7-cm-thick interbeds of pink, papery, calcareous shale that weathers dark bluish gray. (2) The second informal member (B) consists of 24 m of fine-grained, black to medium gray limestone (grainstone) which contains abundant skeletal debris and networks of irregular silt partings. Similar "chicken-wire" patterns were described in the Belted Range to the south (Ekren and others 1971). (3) The third informal member (C) is 53 m thick and resembles the second but contains 0.5-to-3-m-thick interbeds of tan to red, calcareous siltstones and gray to maroon, calcareous, papery shales. (4) The upper member (D) consists of 105 m of medium gray,

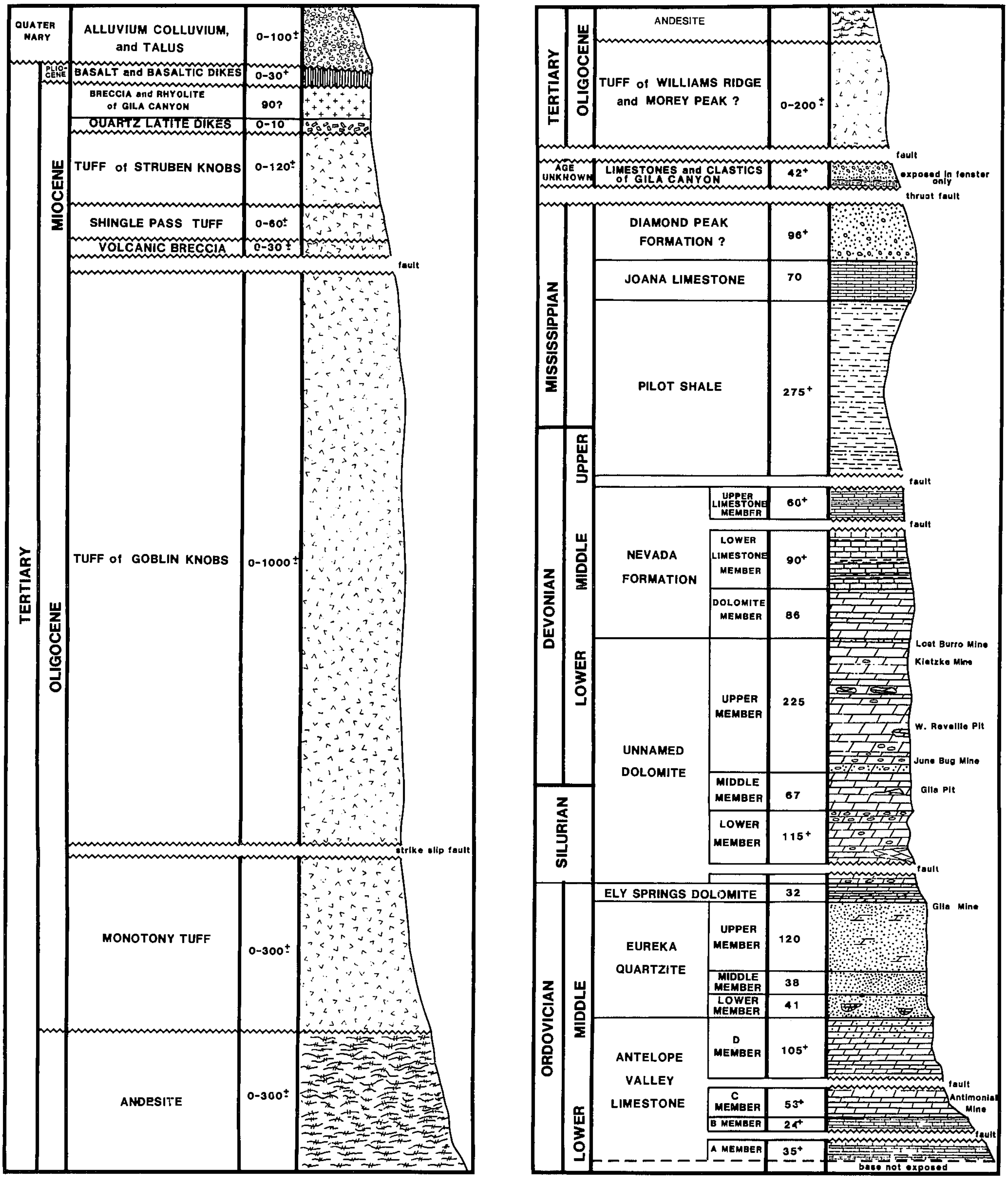

FIGURE 2.—*Generalized stratigraphic column of the Reveille district.*

saccharoidal dolomite which contains discordant masses of dolomite breccia up to 1 m across in the lower 10 m. Some beds in the upper two-thirds contain up to 20% quartz, and others have a speckled appearance caused by spots of white spar up to 5 mm in diameter.

Eureka Quartzite

The 149-m-thick Eureka Quartzite (Hague 1883, Kirk 1933) forms cliffs on the east side of the Reveille Range and conformably overlies the Antelope Valley Limestone. The well-sorted, well-rounded, medium-grained, white to light gray, massive-appearing orthoquartzite is brittle, highly fractured and jointed. Because of its fractured nature, reliable strikes and dips are hard to obtain. The quartzite contains cross-beds up to 8 cm wide. Ekren and others (1973b) divided the formation into a lower slope-forming member, a middle member, and an upper member. The reader is referred to their map for lithologic descriptions. The author found quartz-rich, pinkish white to white, fine-grained dolomite lenses up to 0.5 m long and 0.3 m wide in the lower member. Just north of the Gila Mine these lenses have been silicified and are almost undistinguishable from the quartzite. Two white-weathering bands in the upper member of the quartzite are easily distinguishable on aerial photographs and make good marker beds.

Ely Springs Dolomite

Conformably overlying the Eureka Quartzite is the 32-m-thick Ely Springs Dolomite (Westgate and Knopf 1932), which forms a ledgy slope. The dolomite consists of two distinct members: a dark gray, fine-grained, sucrosic, medium-bedded, lower dolomite member containing abundant chert nodules and a light gray, fine-grained, poorly bedded upper dolomite member which contains no chert (Ekren and others 1973b). However, the author noted that locally bleaching and dolomitic replacement of the chert causes the lower member to resemble the upper one. The upper contact of the Ely Springs Dolomite with the overlying dolomites was defined by Ekren and others (1973b) as the zone where the chert nodules begin to reappear. However, this contact is not always easily distinguishable owing to the replacement of chert nodules with dolomite, the silicification of localized areas, and, in some places, the absence of chert altogether.

SILURIAN–DEVONIAN SYSTEM

Unnamed Dolomite

Over 400 m of massive, mostly unfossiliferous dolomites conformably overlie the Ely Springs Dolomite. No distinctive fossil assemblage has been identified so the age of these dolomites is unknown. Ekren and coworkers (1973b) placed a Silurian–Devonian age on the sequence because of its stratigraphic position. The Silurian–Ordovician boundary is probably at or near the base of the sequence, and the Devonian–Silurian boundary lies at some unknown position within the dolomites. To help define the age of the dolomites, the author made unsuccessful attempts to find conodonts.

The dolomites crop out along the crest of the Reveille Range. Dolomitization obscures most bedding features. The dolomite is massive in appearance, has a sucrosic texture, forms ledgy slopes to cliffs, and weathers with "pit and spire" surfaces. The entire sequence contains scattered, irregular, planar to discordant bodies of dolomite breccia; and in areas where these breccia bodies are not easily recognizable, close inspection often reveals breccia ghosts healed by dolomite infilling. Because of fracturing and jointing, reliable strikes and dips are often difficult to measure. Commonly chert and calcite stringers fill the fractures.

Ekren and others (1973b) mapped two members which they tentatively correlated with the Roberts Mountain and Lone Mountain Formations of central Nevada. Mapped by the author were three informal members. The author's lower member corresponds to the lower member mapped by Ekren and others (1973b) which they describe as medium to dark gray, medium-grained, thick-to-thin-bedded dolomite which contains beds rich in echinoidal debris. As defined on their map, a 30-m zone of chert nodules marks the base of this member, and a 15-m zone of chert nodules marks the top. Because of the partial to complete replacement of the chert by dolomite, the author found these zones locally difficult to define in areas north of the Gila Mine. The author measured 115 m of lower member which represents an incomplete section because of faults. The middle member consists of 67 m of light gray, medium-to-fine-grained, thick-to-thin-bedded dolomites which contain only occasional chert nodules. The dolomite mapped as the upper member is color banded, light to dark gray to black, fine to medium grained, thin to thick bedded (Ekren and others 1973b). The author measured 255 m of the upper member in the district and noted the black and dark gray dolomites are high in carbonaceous material and give off a characteristic hydrocarbon smell when broken. The black dolomites are often spotty rather than forming distinct bands. A bed 40–30 m from the top of the member was found by the author to contain poorly preserved brachiopods and corals which are partially replaced by dolomite. Chert nodules are occasionally found throughout the member but are plentiful in the lower 40 m. West of the Combination claims, 1-m-wide brown-weathering lenses of quartz-rich dolomite occur 15 m from the base of the member. North of the New Deal claims the upper member contains irregular pockets (up to 0.3 meter across) of coarse, crystalline dolomite.

Stratigraphic position in the unnamed dolomite can be roughly determined on the basis of color changes and marker beds mentioned above; however, bleaching, dolomitization, and patchy silicification obscure the marker beds in local areas. Areas where differentiation was not possible were mapped as unnamed dolomite undifferentiated.

DEVONIAN SYSTEM

Nevada Formation

In the Reveille area, Ekren and others (1973b) divided the Nevada Formation (Hague 1833, Merrian 1940) into an upper and lower member. The author mapped three members, with the author's lower member corresponding to the lower one mapped by Ekren and others (1973b). It consists of 86 m of black to dark gray, fine-grained, sucrosic dolomite which contains lenses of dolomite breccia (Ekren and others 1973b). The author noted that this member is thick bedded at the base and becomes thinner bedded upward. The formation forms spectacular dark-colored hogbacks along the west side of the range. The middle member consists of medium-to-thick-bedded, dark gray to medium gray, fine-to-medium-grained limestone (packstone and grainstone) interbedded with laminated to thin beds of medium to light gray micrite and gray to pink calcareous shale. This member weathers to a ledgy slope with characteristic purplish pink color. The author measured 95 m of the middle member; however, because of faulting, the top is not exposed. The upper member consists of thin-to-medium-bedded, black to light gray limestone that contains lenses of breccia up to 1 m across and displays parallel to lenticular bedding. Grainstone and packstone dominate, but some beds contain recrystallized limestone. Because of faulting, neither the base nor top of the member is exposed; however, 60 m were measured.

MISSISSIPPIAN SYSTEM

Pilot Shale, Joana Limestone, and Diamond Peak Formation

Near the west mouth of Lost Burro Canyon lie several outliers that contain the only outcrops of Mississippian rocks in the district. The oldest of these rocks is the Mississippian–Devonian Pilot Shale which consists of shale and siltstone grading upward to siliceous shale and chert (Ekren and others 1973b). The Pilot Shale is more than 275 m thick, weathers a characteristic yellowish brown color, and is easily recognizable on aerial photographs. The Joana Limestone which consists of 70 m of dark gray, fine-grained, laminated to thin-bedded, lenticular limestone conformably overlies the Pilot shale. Overlying the Joana Limestone are reddish brown quartzite and quartzitic conglomerates of the Diamond Peak Formation. For more detailed lithologic descriptions of these three formations, the reader is referred to Ekren (1973b).

PENNSYLVANIAN–PERMIAN ? SYSTEM

Sedimentary Rock of Gila Canyon

West of the old Gila Mine is a small outcrop of sedimentary rocks of possible Pennsylvanian–Permian age referred to herein as the sedimentary rocks of Gila Canyon. This 42-m-thick sequence crops out in a fenster in the sole of a thrust fault. Both the rocks and fenster were first recognized by Ekren and others (1973b), who described the lithologies in the window as conglomerates, sandstones, and carbonate mudstones. The author measured this sequence in detail and divided the sequence into nine units as shown in figure 3. Neither the base nor the top of the sequence is exposed. Unit 1, the lowest exposed, is made up of 8.2 m of flaggy, gray to pink, argillaceous and silty carbonate mudstone which displays medium to laminated bedding. These beds are covered by colluvium except where exposed in a small excavation. Unit 2 consists of 0.7 m of buff to pink, sandy limestone and sandstone. The next 0.6 m is composed of pink to buff, fine-grained, sandy limestone which grades into unit 4, 3.7 m of buff and red, well-sorted, laminated to medium-bedded calcareous siltstone and sandstone. Unit 5 represents the transition zone between units 6 and 4 and consists of red, laminated, well-sorted, well-rounded, calcareous rocks with occasional pebbles and pebble beds. Unit 6 is made up of 4.3 m of well-sorted, cross-bedded red conglomerate. Unit 7 resembles unit 6 but is buff in color and 4.2 m thick. Overlying unit 7, unit 8 is composed of 4.6 m of buff, massive-weathering, poorly sorted, well-rounded conglomerate which contains 0.3-to-0.5-m-thick lenses of red to buff, well-sorted, moderately rounded, cross-bedded, friable sandstone. The uppermost unit, 9, consists of 12.3 m of medium gray, brown-weathering, poorly sorted conglomerate. The well-rounded conglomerate clasts consist mostly of dolomite, quartzite, and limestone which resemble the Ordovician to Devonian rocks in the district. The sequence is probably nonmarine and was deposited near a highland area.

No fossils were found in the sequence though the author made attempts to extract conodonts and spores from the mudstones. The sequence crops out only in the fenster, and no stratigraphic relationships are visible. The lack of knowledge about the sequence's stratigraphic relationships, coupled with lack of paleontological data, makes age assignment difficult. Since the conglomerate contains clasts from the Ordovician-to-Mississippian lithologies found in the district, the sequence must be late

Mississippian–Pennsylvanian or younger. The sequence is similar in lithology to a Pennsylvanian–Permian sequence found in the Tybo Quadrangle 48 km (30 mi) northwest of the Reveille district (Quinlivan and Rogers 1974). The Tybo sequence is thought to correlate in part with the Permian Diablo Formation of western Nevada (Kleinhampl and Ziony 1968).

TERTIARY SYSTEM

Carbonate Breccias

Several areas of carbonate breccia formed by tectonic processes are present in the district. Two areas of breccia were large enough to be mapped separately. Near the Lost Burro Mine, along the road on the west side of the Reveille Range, an outcrop of limestone breccia represents part of the Nevada Formation brecciated by the movement of the Reveille Fault. Also mapped is a circular outcrop of dolomite breccia southeast of the Lost Burro Mine. This breccia pipe is thought to have formed because of upward movement or "belches" of volcanic gases.

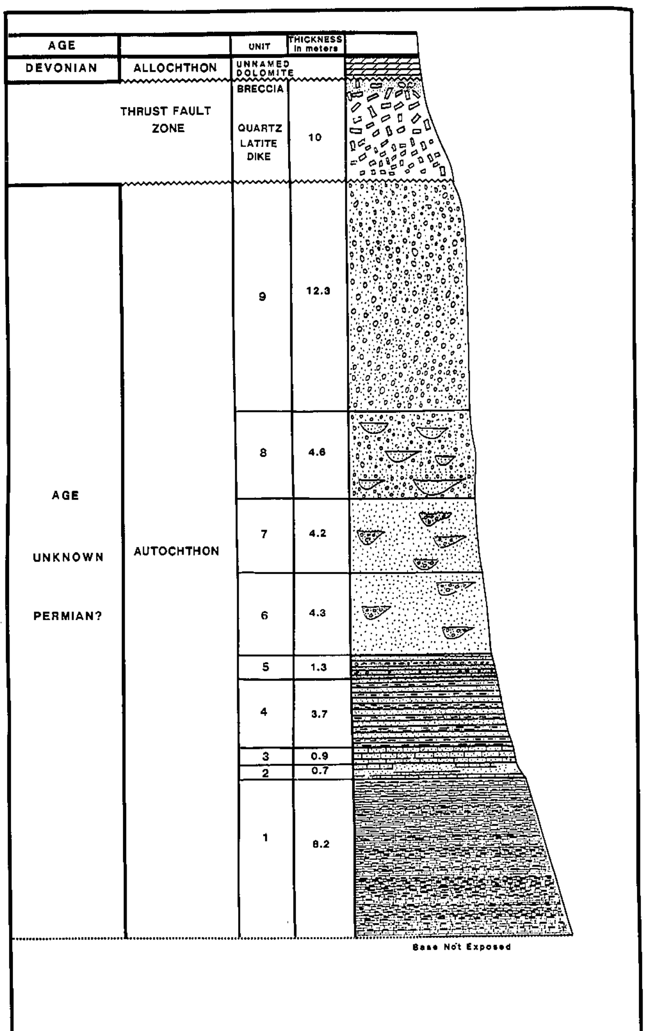

FIGURE 3.—*Stratigraphic column of the sedimentary rocks of the New Deal area. Nine units were identified in this outcrop which is of possible Pennsylvanian-Permian age. The thrust fault zone has been intruded by a quartz latite dike of Miocene age.*

IGNEOUS ROCKS

TERTIARY VOLCANIC ROCKS

The sedimentary outcrops are completely surrounded by volcanic rocks. Age relationships are difficult to determine because very few contacts between volcanic units are visible. The volcanic rocks in the district are moderately to intensely altered; this alteration makes absolute age determinations tentative. Spurr (1903) described the volcanic rocks as Tertiary rhyolites. Runnels and Grauberger (1972) divided the Tertiary volcanic rocks into rhyolitic crystal tuffs and porphyritic dacite. The U.S. Geological Survey has mapped the volcanic rocks in several quadrangles around the district. Ekren and others (1973b), using the nomenclature and regional relationships developed in the surrounding region, differentiated the district's volcanic rocks into seven units. Unless otherwise noted, the nomenclature and ages assigned by Ekren and others (1973b) have been used in this paper. The reader is referred to papers by Ekren and his coworkers (1967, 1971, 1973a, 1973b) to find the descriptions of unaltered volcanic units in the area. To facilitate field recognition, this paper emphasizes the appearance of altered outcrops. Descriptions are based on field observations in combination with laboratory evaluations of hand samples and 52 thin sections.

Tuff of Williams Ridge and Morey Peak

Ekren and others (1973b) tentatively identified the densely welded, intensely altered tuff which crops out in the graben south of the Gila Canyon east of the Combination claims and in isolated patches throughout the district as the tuff of Williams Ridge and Morey Peak. On the basis of regional relationships, they assigned the formation an Oligocene age. The author applied the same name and age to this formation. The tuff weathers to form rolling hills which are subdued in comparison to the rugged Paleozoic outcrops in the district. Limonite stains give the tuff a characteristic yellowish brown cast. Flow layering accented by limonite staining is visible in some outcrops.

Before alteration, it appears that the tuff contained up to 30% biotite, plagioclase, alkali, feldspar, and quartz phenocrysts in a pumice-rich matrix. The relative abundance of quartz phenocrysts varies horizontally and vertically over short distances. The phenocryst, except quartz, and the matrix have been partially to completely altered throughout the district. Feldspars were altered to clay and sometimes to sericite, and the biotites were altered to clay and iron oxides. Locally, limonite and hematite occur in bands. The limonite, abundant in the tuff, comes from the alteration of biotite and from the oxidation of hydrothermally introduced pyrite. The appearance of the tuff changes locally because of the hydrothermal addition of one or a combination of the following: cryptocrystalline quartz, calcite, and chlorite. These occurrences are discussed in greater detail later in the alteration section.

Altered Tuff

Just south of the Gila Project leach pad, an outcrop of tuff which lies between two branches of the Old Reveille fault has been almost entirely altered to clay. The bentonitic clay ranges in color from lavender to red to white to gray. The tuff is so intensely altered that assignment of the unit to any of the district's volcanic sequences is impossible. For this reason, the author mapped the altered tuff as a separate unit.

Red Volcanic Breccia

A 1-to-4-m thick bed of red volcanic breccia which lies within the altered tuff was also mapped as a separate unit. Subangular to angular clasts of tuff from 2 mm to 5 mm compose the breccia. Red, earthy hematite stains the outcrop and, along with silica, cements the breccia. The bed is stratiform and appears to be a flow unit.

Volcanic Breccia of the Hulse Area

A triangular-shaped, poorly exposed outcrop of breccia is located just to the west of the stone ruins in the area of the Hulse claims. Angular fragments of argillized tuff cemented by limonite-stained silica make up the breccia. The outcrop is 70 m by 45 m with the tuff of Williams Ridge and Morey Peak surrounding it on three sides; however, the contact is obscured by rubble. No similar breccias were found interbedded with the tuff. The breccia appears to be a vertical pipe made up of fragments of tuff of Williams Ridge and Morey Peak brecciated by an explosion of volcanic gas.

Andesite

Ekren and others (1973b) identified the rocks overlying the tuff of Williams Ridge and Morey Peak as andesite. It crops out along northern and western edges of the district. On the west central edge of the area the andesite is mostly unaltered and matches the description of Ekren and others (1973b). Here it forms low, black hills easily recognizable on aerial photographs. It also has altered appearances that were found by the author. Just east of the June Bug Mine, along the northern margin of the district and south of Struben Knob, the groundmass is commonly partially altered to clay and stained with limonite, and the plagioclase phenocrysts are altered to clay. This alteration gives the andesite a brownish yellow appearance which, at a distance, causes it to resemble the ash flow tuff. In the northwestern corner of the district, just south of Struben Knob, the andesite's groundmass has been altered to chlorite and calcite, and the feldspar phenocrysts have been altered to clay. In another area just south of Struben Knob in a small isolated outcrop just west of the Kietzke Mine, the entire rock is altered to purple clay. The transition from unaltered andesite to each of the alterations described above is visible south of Struben Knob.

Monotony Tuff

The Reveille district lies near the center of a circular area about 160 km (100 mi) in diameter in which the Monotony Tuff crops out (Ekren and others 1971). In the Reveille Quadrangle, Ekren and others (1973b) divided the tuff into two members: the tuff of Goblin Knobs and a "typical" quartz latitic tuff. They also noted that some of the "typical" Monotony Tuff was pumice rich. The author used this nomenclature to map three members of the tuff in the district: (1) a pumice-rich sequence, (2) a pumice-poor sequence, and (3) the tuff of Goblin Knobs. For further descriptions of these sequences, the reader is referred to Ekren and others (1973b). The three members have suffered only minor alteration in the district. The tuff of Goblin Knobs crops out in the district only on the east side of the strike-slip fault that cuts through the old town of Reveille. The pumice-poor sequence is limited to a few small outcrops on the west side of the district, south of the Reveille camp, and the pumice-rich sequence crops out north of the camp. Locally, the pumice-rich tuff has been replaced by red jasperoid accompanied by argillization of the pumice fragments and the feldspar phenocrysts.

Other Volcanic Rocks

Three other volcanic units found extensively in the area outside the district crop out in limited areas within the district. These volcanics, identified by Ekren and others (1973b), do not occur near mineralized areas and have little economic significance. A devitrified, densely welded outcrop of Miocene Shingle Pass tuff (Cook 1965) and a small outcrop of volcanic breccia (Ekren and others 1973b) made up of chaotic blocks of Monotony Tuff occur in the area surrounding the Reveille Camp. In the extreme northwest of the geologic map (plate 1) is the southernmost exposure of the tuff of Struben Knob. Descriptions of these volcanic rocks are given by Ekren and others (1973b).

TERTIARY INTRUSIONS

GENERAL STATEMENT

Five types of intrusive bodies are exposed in the district. The age of these intrusions is hard to determine since alterations make absolute age determinations tentative at best. Crosscutting relationships were used where possible to place the intrusions into the district's geochronologic framework.

PEBBLE PIPES OF THE KIETZKE AREA

Runnels and Grauberger (1972) reported an outcrop of green volcanic conglomerate located south of the Kietzke Mine. The author mapped two nearly circular outcrops of this volcanic conglomerate, each being about 90 m in diameter. Both bodies are cut by faults, at least on one side. The conglomerate consists of well-rounded, subangular, sedimentary rock clasts ranging from 3 mm to 200 mm in diameter in an altered, chlorite-rich matrix. The clasts consist of dark gray to black limestone (15%), brown limestone (5%), gray to black dolomite (30%), green quartzite (5%), and dark brown quartzite (5%). The matrix (40%) was probably volcanic material and now has been altered to chlorite crystals up to 1 mm in diameter. A roadcut on the easternmost outcrops shows the vertical contact between the tuff of Williams Ridge and Morey Peak conglomerate. These volcanic conglomerates are pipelike and intrude the tuff. A 1-to-2-m zone around the easternmost pipe is altered to coarse chlorite crystals. This zone, in turn, grades into a 1-m-wide zone of tuff that has been sericitized, chloritized, and silicified.

Runnels and Grauberger (1972) described these pipes as diatremes. This classification was based on the vertical contact seen in the bulldozer cut. The author agrees that the two outcrops could be alloclastic breccia formed by the expulsion of volcanic gases and molten rock. The author suggests that the circular outcrop patterns, the presence of altered border zones in the host rock, and the presence of clasts of rock types not seen at the surface are further evidences supporting the diatreme hypothesis.

ALTERED INTRUSIVE ROCK OF THE KIETZKE AREA

Southwest of the Kietzke Mine, a possible intrusive body forms two prominent low hills on the west side of the range. The extremely altered body was identified as an intrusion by Runnels and Grauberger (1972). On the west side of the body, three prospects examined by the author show an intrusive relationship between the igneous rock and the upper member of the Nevada Formation. The contact zone is marked by red, sugary, hematite-rich calcite, but no skarn was found.

The igneous rock itself is extremely altered with most of the primary minerals replaced. The rock has a porphyritic-aphanitic texture. Phenocrysts make up 20% of the rock of which 70%, probably originally feldspar, have been replaced by clay. In thin section, the clay replacements often show rims of sericite. Another 5% of the phenocrysts have been altered to sericite and iron oxides. Only 25% of the phenocrysts, quartz, is unaltered. The groundmass consists of quartz, sericite, clay, iron oxides and, occasionally, apatite crystals. The iron oxides give the rock a dark pink color on fresh surfaces. The quartz phenocrysts show quartz overgrowths, and the groundmass is often completely replaced by quartz. The rock weathers a dark reddish brown, and the removal of the clay pseudomorphs after feldspar gives the rock a pseudovesicular texture.

QUARTZ LATITE DIKES

Ekren and others (1973b) mapped four dikes within the district that they classified as being quartz latite. The author mapped four additional dikes which are lithologically similar to those described by Ekren and his co-workers. These porphyritic dikes contain quartz (10–20%), plagioclase (40–60%), sanidine (10–30%), and biotite (10–15%) in a quartz- and feldspar-rich matrix. The phenocrysts vary in size and abundance from dike to dike. The degree and type of alteration also varies between dikes.

The district's eight dikes are shown on the geologic map (plate 1). The northernmost dike, which intrudes the andesite, strikes east–west and measures 1,410 m long and up to 40 m wide. The rock contains up to 25% phenocrysts, which range up to 5 mm in size. The feldspars in the rock are partially altered to clay. The dike is weathered and poorly resistive, and it forms a rounded, long, low hill. The second dike lies to the southeast and is the only northward-striking dike in the district. The 15-mm-wide, 600-m-long dike in the tuff of Goblin Knobs has an appearance similar to that of the first dike described. The third dike is located south of the first dike and has intruded along an east–west-striking fault which marks the contact between the andesite on the footwall and the unnamed dolomite on the hanging wall. Talus covers the central portion of the 1,300-m-long, 10-m-wide dike, so only the western and eastern ends are exposed. The east end is only moderately altered and resembles the first two dikes, and the west end is strongly silicified and contains veinlets and irregular replacements of red jasperoid. This portion of the dike is resistive and forms a ridge. Feldspar phenocrysts which range in size up to 10 mm have been altered completely to clay, and subsequent weathering out of the clay gives the rock a pseudovesicular texture at the outcrop. The fourth dike, only partially shown on the map, lies almost directly east

FIGURE 4.—*Bands of hematite and limonite staining in dike. The photo shows bands in a dike in the New Deal area.*

of the third dike; however, there is no surface connection between them. The 10-m-wide, 1,450-m-long, east–west-striking dike displays spheroidal weathering which makes it easily distinguishable at a distance from the andesite it intrudes. The dike has a 5-to-9-m-wide core that contains sanidine phenocrysts up to 50 mm long, and the margins are marked by a 0.3-m-wide zone of fine-grained rock. A fifth dike, intruded along a northeast-trending fault in the unnamed dolomites on the mountain north of the New Deal claims, is 600 m long and 5 m wide. The groundmass of the dike rock is silicified, and the feldspar phenocryst, up to 10 mm long, has been altered to clay. The sixth dike lies in the canyon just south of the fifth dike in the area of the New Deal claims. The east–west-trending dike is 8 m wide and 460 m long. The rock is made up of 70% silicified matrix, 10% quartz phenocrysts, and 20% feldspar phenocrysts which have been argillized. Limonite and hematite form colored bands throughout the dike (fig. 4). The seventh dike is found on the floor of the gully just north of the Gila Mine. The east–west-striking, 20-m-long, 2-m-wide dike has been intruded along a fault in the Eureka Quartzite. The seventh dike resembles the sixth dike. The eighth dike is located on the east side of the district south of Lost Burro Canyon. The 1.5-m-wide, 15-m-long dike is best exposed in a prospect pit. The rock resembles the description given for the fifth dike.

BRECCIA AND RHYOLITE OF GILA CANYON

Ekren and others (1973b) described the rhyolite and breccia which form a circular outcrop 300 m in diameter just southwest of the Gila Mine (fig. 5). The author mapped the breccia, which is composed of rhyolite and tuff clasts up to 1 m in diameter, and the rhyolite as two separate units. Ekren and others (1973b) postulated that the outcrop represents a vent breccia intruded by rhyolite dikes. In a small prospect pit on the southeast side of the outcrop, the author observed a horizontal contact between the breccia and the rhyolite. Since the breccia appears to be lying upon the rhyolite, the author suggests that the outcrop may represent a rhyolite dome with an

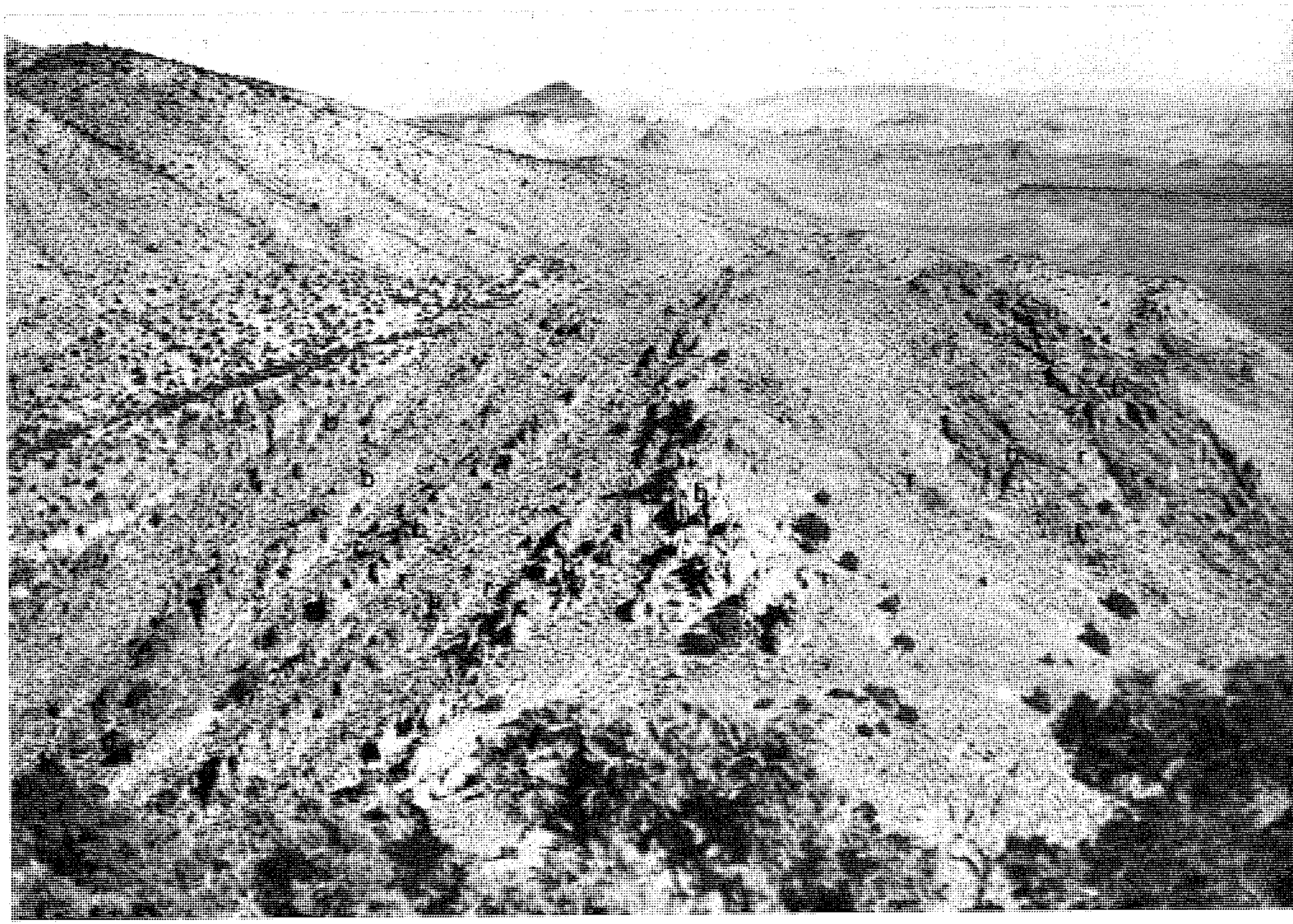

FIGURE 5.—*Breccia and rhyolite of Gila Canyon. The photo is a northward-looking view of the probable rhyolite dome. The breccia (b) appears to overlie the flow-layered rhyolite (r).*

autoclastic breccia envelope formed by breaking up cooled intrusive and host rocks during intrusion. The outcrop is moderately silicified, argillized, and stained by hematite. The iron staining gives the outcrop a brownish red color.

QUATERNARY DEPOSITS

Two types of unconsolidated Quaternary deposits occur in the district: alluvium and colluvium. Thickness varies but probably does not exceed 40 m.

UNDIVIDED ALLUVIAL DEPOSITS

Two types of alluvial deposits were recognized in the district. Stream deposits are seen in the major canyons in the range and in the valleys on both sides of the range. Also mapped as alluvium were alluvial fan deposits along both sides of the range. Some fans on the west side have been dissected because of recurrent movements along the major fault system on the west side of the range.

COLLUVIUM DEPOSITS

Talus is abundant beneath the cliffs all around the range and in Lost Burro Canyon. Also mapped as colluvium are pediment gravels and slope wash found on the lowest slopes at the base of the range.

TALUS APRON

One talus unit was mapped separately: a talus apron around the rhyolite dome in Gila Canyon. This apron is composed of angular clasts of the breccia and covers the slopes around the outcrop.

STRUCTURE

GENERAL STATEMENT

The structural history of the Reveille district is complex. The folding of the sedimentary rock is broad and relatively simple, and faulting is extensive and complex. Joint systems and local breccia pipes are also well developed. Dolomites and quartzites are intensely fractured whereas the limestone behaved plastically.

FOLDING

Both Gilbert (1875) and Spurr (1903) described the structure of the district as a homocline. Hogbacks of well-bedded dolomite members of the Nevada Formation overlying the massive, poorly bedded, unnamed dolomites give the illusion that all beds dip westward at the same angle. In fact, the dip changes from 15° to 45° from east to west across the district. The strike and dip also vary on either side of the east–west-trending faults as shown on the geologic map (plate 1). The folding could be described as the west limb of a faulted anticline or monocline.

Drag folds and small second-order folds are found in the district. These folds are restricted to the Antelope Springs, Nevada, and Joana Limestones. The limestones seem to have reacted plastically to the stresses to which they were subjected.

Foliations of the igneous rocks are shown on the geologic map (plate 1). The folia in the volcanic rocks on the east side of the Reveille Range dip toward the east, and those on the west side dip to the west. In the graben between the Combination Fault and the Reveille Fault, the folia in the volcanic rocks dip toward the center of the graben.

FAULTS

General Statement

Six sets of faults are present in the district: (1) a thrust fault, (2) east–west-trending normal faults, (3) northeast-trending normal and reverse faults, (4) northwest-trending normal faults, (5) north–south-trending basin-and-range faults, and (6) a strike-slip fault system (fig. 6). These faults will be discussed in the order listed above. The faults are generally expressed by valleys; but locally

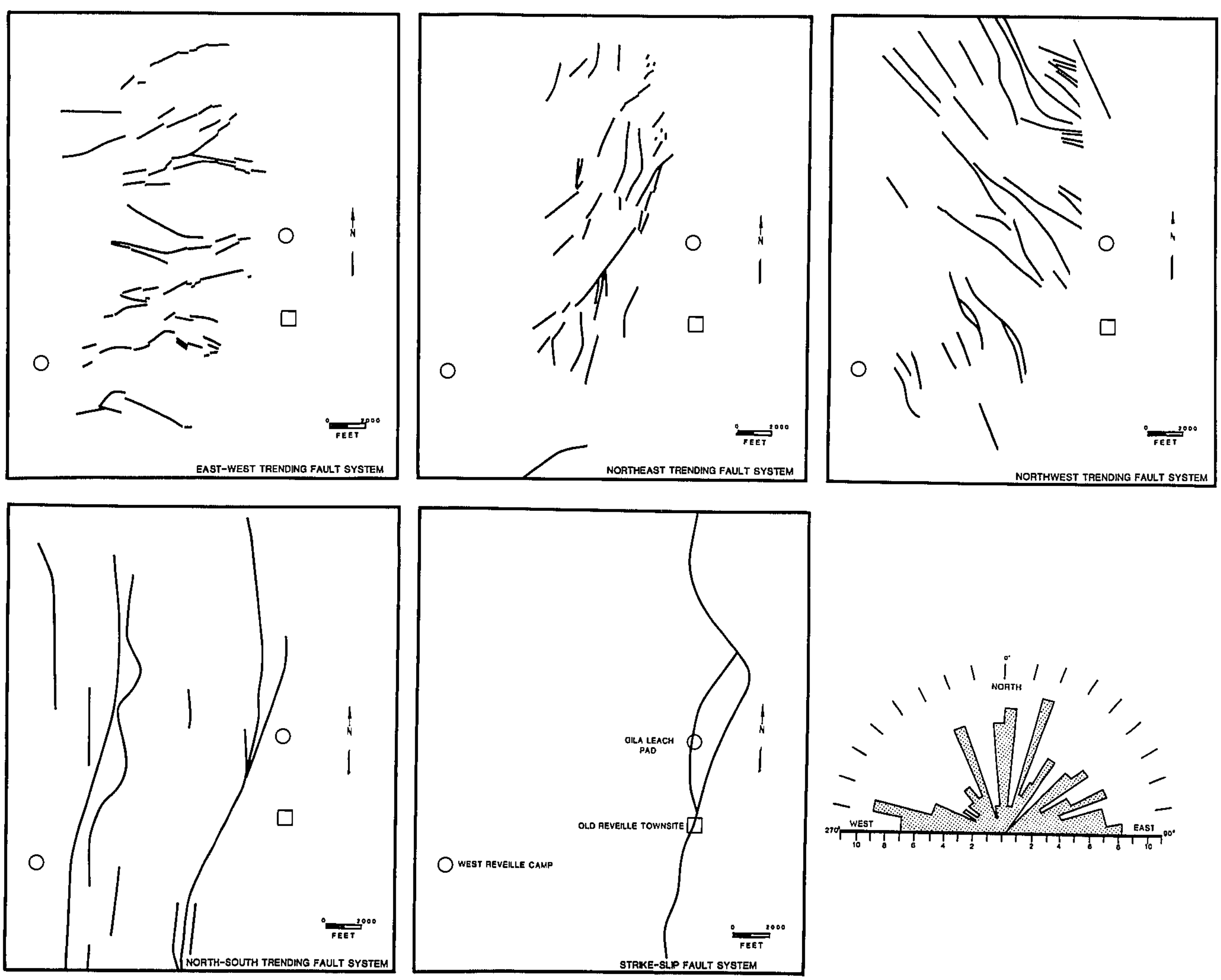

FIGURE 6.—*Fault systems of the Reveille district. Four sets of normal faults and one strike-slip fault system were identified in the district. The rose diagram in the lower right-hand corner shows strikes of the faults as measured in the field.*

where the fault breccia is silicified, the fault trace may be expressed by ridges or highs. Because talus, soil, and zones of argillic and silicic alterations obscure many of the fault contacts, fault attitudes are often hard to determine. The combination of weathering and alteration makes faults difficult to trace across the volcanic outcrops.

Thrust Fault

The oldest fault in the district is a thrust fault which was the result of compressions during one of the post-Mississippian orogenies in central Nevada. It is exposed in a small fenster in the New Deal area. The fenster, first recognized by Ekren and others (1973b), reveals Ordovician–Devonian rocks thrust over the sedimentary rocks of the New Deal area. Rocks in the allochthon strike N 30° E and dip westward at 35° while the rocks in the autochthon vary in strike from S 80° W to S 60° W and dip eastward at 17°. The author found that the sole of the fault is marked by a 15-m-thick zone of breccia. The northernmost part of the thrust zone is intruded by a quartz latite dike (fig. 3). The fenster, though extremely limited in extent, provides the only evidence for the thrust fault in the district.

East–West-Trending Normal Faults

A system of major normal faults having strikes from N 55° E to S 70° E cuts across the Reveille Range. These faults bound four east–west-trending grabens in which volcanic rocks often crop out. The thickness of the volcanic rocks within the grabens can be only roughly estimated; therefore, the total fault displacements are likewise rough estimates. Displacements along these faults probably range from 50 m to 100 m. Minor faults along the same trend north of the New Deal claims have displacements from 10 to 40 m. Attitudes of these faults range from 40° to 90°. Mining in the West Reveille Pit revealed that the Kietzke Fault steepens with depth. The fault traces are marked by 3-to-10-m-wide zones of silicified and pyritized breccia which commonly contain silicia boxworks and quartz-filled vugs. The east–west faults are often mineralized and are, in turn, displaced by three other sets of normal faults.

Northeast-Trending Faults

A set of normal and reverse faults striking between N 10° E and N 45° E cut the entire district. Maximum displacements range from 50 m to less than 10 m. The vertical to nearly vertical fault zones are marked by silicification, areas of earthy limonite, and occasional slickensides. One of these faults, the Gila Mine fault, terminates in a horsetail near the Gila Mine and is mineralized.

Northwest-Trending Faults

A set of faults striking between N 50° W and N 30° W cut all other normal fault sets in the district, with the exception of the north–south-trending fault set. The faults show displacements from a few to 30 m. The nearly vertical normal faults are most common in the north half of the district. The fault traces are marked by 0.5-to-2-m-wide zones of silicified, limonite-stained breccia. Figure 7 shows a northwest-trending fault offsetting a major east–west-trending fault.

North–South-Trending Faults

The youngest fault set trends north–south and is related to basin-and-range faulting. A fault system, herein named the West Reveille Fault zone, bounds the west side of the district. The fault is mostly covered by alluvium, but the sharp line marking the boundary between the Reveille Range and the Reveille valley gives a good indication of its location. The zone consists of several faults. In the area of the Kietzke mine the strike changes from north to N 15° E. The east side of the district is likewise bounded by a normal fault system, herein named the Antimonial Fault. The fault splays into three faults near the Antimonial Mine. Like the West Reveille Fault system, the southern portion of the fault trends northward while the northern portion strikes northeastwardly. In the sedimentary rocks the faults are marked by zones of silicified breccia. In other areas of the New Deal and Combination claims, the silicified breccia has been rebrecciated by postalteration movement of the fault. Aragonite often infills these late breccias in mammillary masses.

Strike-Slip Faults

A major strike slip, first recognized by Ekren and others (1973b), is located along the eastern edge of the district. The left lateral fault brings the tuff of Williams Ridge and Morey Peak in contact with the tuff of Goblin Knobs. The fault trace is generally marked by an alluvium-filled valley. In the area north of the Reveille townsite, the fault bifurcates, and the area between the two segments is filled with alluvium and, just south of the Gila leach pad, with extremely altered tuff. The two segments rejoin in the area east of Lost Burro Canyon. The rocks along the fault are severely sheared and contain areas replaced by clay and earthy red hematite. Extensive silicification is found along the southern end of the western segment just south of the Gila Project leach pads.

Detachment Blocks

In Lost Burro Canyon, a block consisting of the upper member of the unnamed Silurian–Devonian dolomite and the dolomite member of the Nevada Formation has

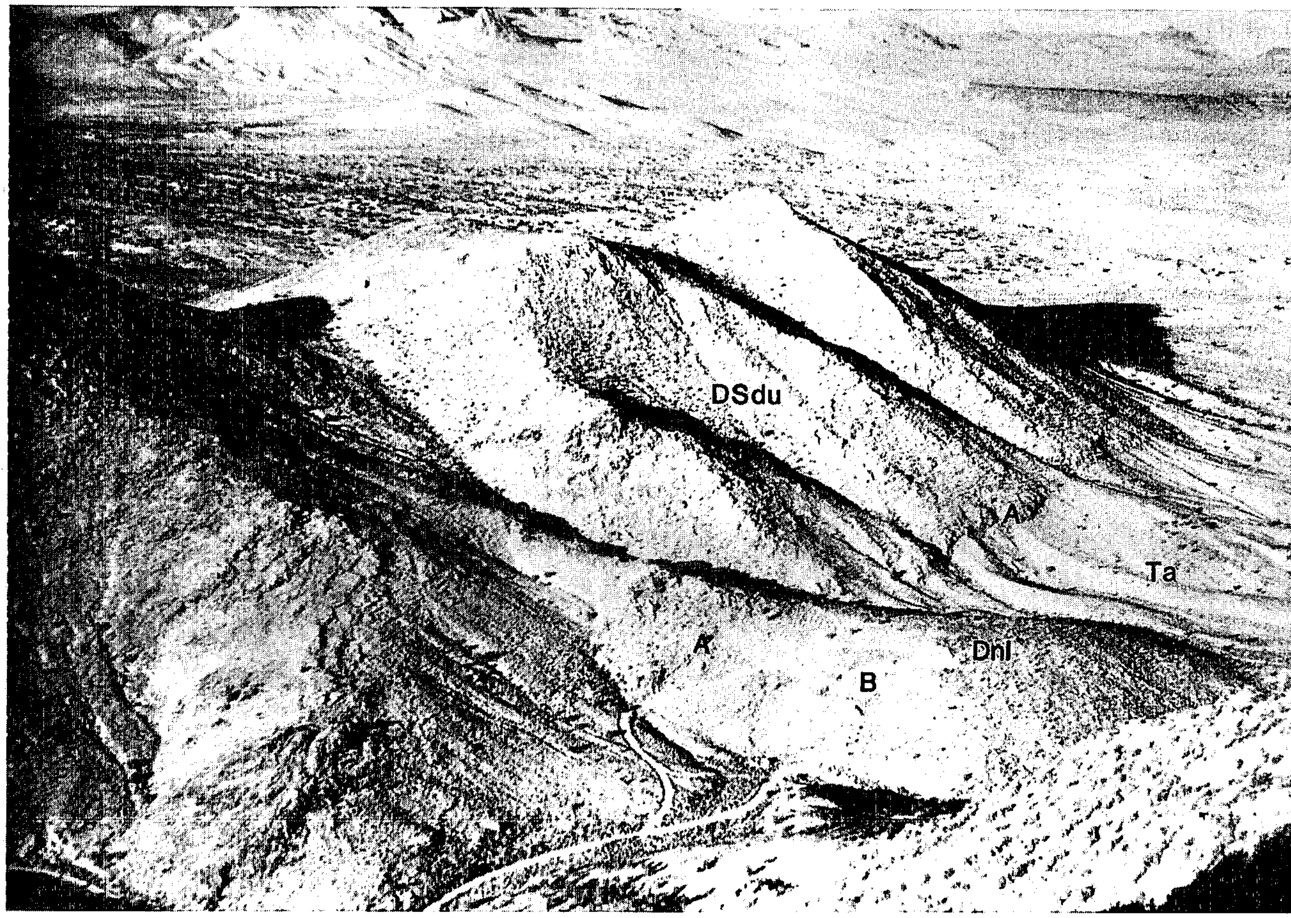

FIGURE 7.—*The June Bug Fault. This northeastward-looking view was taken from the ridge on the south rim of Lost Burro Canyon. The June Bug Fault (A) separates the upper member of the unnamed dolomite (DSdu) on the upthrown side from andesite (Ta) on the downthrown side. The June Bug claims (B) lie where a northwest-trending fault (C) crosscuts the June Bug Fault. The mine lies in the lower member of the Nevada Formation (Dnu).*

apparently been detached from outcrops nearby and has slid down into the canyon. A 5-to-8-m-thick bed of breccia marks the base of the block. The rock in the block itself displays some brecciation, breccia ghosts, and silica boxworks that have formed around some of the breccia. The block dips to the south and was probably detached from the mountain to the north. It has a maximum displacement of about 300 m. The block is cut by northwest- and east–west-trending faults. Detachment occurred before silicification.

JOINTING

Paleozoic quartzites and dolomites are intensely jointed. The joints generally belong to four sets that parallel the major fault trends. In some outcrops of Eureka Quartzite and unnamed Silurian–Devonian dolomite, jointing is so extensive that reliable strikes and dips cannot be obtained. In localized areas the joints are silicified; the joints may also be mineralized near mineralized fault zones.

BRECCIA PIPES

Two areas of semicircular to circular pipes were found in the district. The largest is a breccia pipe 10 m in diameter located on the mountain south of the Lost Burro Mine. The pipe is semicircular in shape and has smooth walls. The breccia shows no addition of volcanic material. Along the east side of the range south of Lost Burro Canyon lies an area containing several smaller breccia pipes. They range from 1 to 4 m in diameter. Silica boxworks have been formed around the dolomite clasts. The pipes in both areas are interpreted as being the result of gaseous volcanic explosions. The autoclastic breccias are similar to those found in the Spor Mountain district in western Utah (Bullock 1981).

CONCLUSIONS

The east–west-trending faults have affected form and emplacement of igneous intrusives in the district. The graben between the Combination and Kietzke Faults has been the site of two igneous intrusions. Several of the east–west faults have been intruded by quartz-latite dikes. The strikes of basin-and-range faults change from north to northeast in the area where they intersect the Combination and Kietzke Faults. The change in strike of these faults is possibly due to their intersection with the east–west faults.

ALTERATION

GENERAL STATEMENT

The complex alteration in the district does not display clear zonal changes around the ore bodies. The type of hydrothermal alteration differs from volcanic to carbonate rocks. These changes represent boundaries between different rock types rather than zonal changes related to the ore bodies. The variance in alteration types is an expression of varying chemical environments between the different rock types. More extensive alteration in volcanic and intrusive rocks than in the carbonate rocks may be due to one of two factors: (1) the geothermal fluids may have had greater chemical contrast with the igneous rocks than with the sedimentary rocks, (2) the igneous rock may have had better porosity and permeability due in part to cooling cracks and flow laminations. Weathering is partly responsible for the altered appearance of the igneous rocks. In some areas, weathering processes strongly overprint the hydrothermal alterations, making it difficult to distinguish between the effects of two processes.

Seven types of alteration are recognized in the district: (1) argillization, (2) sericitization, (3) chloritization, (4) pyritization, (5) silicification, (6) calcification, and (7) bleaching. Distribution of alteration is shown on the alteration map (plate 2). The altered character of the igneous rocks has been previously discussed in this paper. The following discussion will focus on the extent and location of the various types of hydrothermal alteration.

ARGILLIZATION

Both the igneous and carbonate rocks in the district display argillic alteration. In the igneous rocks, argillization is widespread and variable in its intensity. Most commonly the feldspar phenocrysts, matrix feldspar, and glass shards found in the tuffs, andesite, and intrusive rocks have been altered to clay. This alteration is shown as moderate argillic on the map. In localized areas, intense argillization has completely altered volcanic rocks to clay. South of the Gila Project leach pads, the tuffs have been altered beyond recognition to bentonitic clay. Similar intense alteration in local areas west of the West Reveille Fault has converted andesites to a purple clay. In the tuff of Williams Ridge and Morey Peak, intense argillic alteration occurs in zones 0.3 to 6 m wide along major east–west faults.

Intense argillic alteration is not restricted to volcanic rocks but also occurs in the carbonates. Generally, it is restricted to a zone 0.2 to 6 m wide along the Kietzke, Combination, and Gila Mine Faults. These hematite- and limonite-stained clay zones are exposed in prospects and mine workings. Some of the best examples of this alteration are visible in the West Reveille Pit. Here clay envelopes have formed along a small fissure that intersects the Kietzke Fault. The clay is stained by oxides in color bands. The center of the fissure is marked by vuggy silicified boxworks. A similar argillic alteration zone occurs along the contact between the Nevada Formation and the Devonian–Silurian unnamed dolomite north of the Kietzke Mine.

SERICITIZATION

Sericitization is a common alteration in the tuff of Williams Ridge and Morey Peak, the andesites, the quartz latite dikes, and the altered intrusion of the Kietzke area. The intensity of sericitization varies. Commonly, waxy aggregates of sericite replace feldspar phenocrysts. In some cases, especially in the tuff of Williams Ridge and Morey Peak, clays have, in turn, replaced the sericite. As a result, sericite rims are visible in thin section around the clay. In advanced cases, sericite begins to replace the matrix and is shown on the map as advanced sericitization which is limited to the area just south and east of the old Gila Mine. In advanced cases, sericite is associated with granular quartz and pyrite usually altered to limonite. In other areas, sericite is associated with clay, limonite, and, in the tuff, chlorite.

CHLORITIZATION

Chloritic alteration is found in the pebble pipes of the Kietzke area, in localized areas of the tuff of Williams Ridge and Morey Peak, and in the andesite. In the andesite and pebble pipes, the matrix is altered to fine-grained chlorite. In the Gila Canyon area, the tuff of Williams Ridge and Morey Peak is altered to coarse-grained (up to 5 mm) chlorite, calcite, and sericite. In Lost Burro Canyon, the tuff has been replaced by a fine-grained aggregate of chlorite, chalcedony, limonite, and muscovite.

CALCIFICATION

Calcific alteration is expressed in four different ways: (1) Blebs of white and light pink calcite are often associated with chlorite in the tuffs. (2) Pink calcite replaces patchy areas of tuff south of Kietzke Mine. (3) On the west side of the altered intrusion of the Kietzke area, the Nevada limestone has been replaced by sugary pink calcite spar. Replacement was preferential along fractures. The recrystallized limestones have a spongy texture. (4)

Minor calcification of the dolomites has occurred along the Kietzke Fault, where spots up to 10 mm in diameter have been replaced by calcite. Calcite appears to be a late stage of alteration. It is not clear how much of the calcite is due to hydrothermal processes or is the product of circulating groundwater.

SILICIFICATION

Silicification is common in both the sedimentary and igneous rocks. Four types of silicification were mapped: (1) intense silicification, (2) patchy silicification, (3) weak to moderate silicification, and (4) red jasperoid. Massive silicification occurs in the dolomites, the quartz latite dikes, and the breccia of Gila Canyon. In the dolomite, the silicification is easy to recognize because the replacements are characteristically limonite stained and weather resistant. Silicified zones commonly form ledges or small ridges. Replacement generally occurs along faults where wall rock and breccia alike are replaced. These zones commonly have visible breccia ghosts. The igneous intrusions also have massive silica replacements that may or may not be iron stained.

Patchy silicification was mapped in areas where the dolomite has been only partially replaced. This type of silicification occurs in brecciated or fractured areas where the open spaces have been filled with cryptocrystalline quartz. The partial replacement of the breccia results in a boxwork lattice around unreplaced dolomite.

Weak to moderate silicification was mapped in areas where quartz aggregates make up part of the alteration. The tuff of Williams Ridge and Morey Peak, the altered intrusion of the Kietzke area, and the quartz latite dikes display this type of silicification. Quartz aggregates in the matrix and quartz overgrowths are common in these rocks. The quartz is commonly associated with sericite, clay, and limonite.

Red, hematite-stained jasperoid occurs as stringers and patchy replacements. The jasperoid occurs in three areas: (1) in the Monotony Tuff south of Lost Burro Canyon, (2) in the quartz latite dikes at the northern end of the dolomite outcrops, and (3) in the dolomite near the small quartz latite dike southeast of Lost Burro Canyon.

No silicification was mapped in the Eureka Quartzite. The quartzite displays quartz overgrowths throughout. The overgrowths are not thought to be hydrothermal in origin. However, near the Gila Mine some hydrothermal effects can be observed. Dolomite lenses in the quartzite have been silicified, and fractures in the quartzite have been partially healed. The extent and effect of silicic alteration in the quartzite is difficult to determine.

PYRITIZATION

Pyritization is extensive in the district. Pyrite crystals were found in highly silicified dolomite in the main tunnel of the Kietzke Mine. On the surface above the Kietzke Mine, the pyrite has been altered to limonite. Pyrite crystals are uncommon in surface outcrops because limonite has replaced the pyrite in the weathered zone; therefore, limonitized areas have been mapped as pyritic alteration. In volcanic rocks the weathering of mafic minerals has also contributed to the amount of limonite present. Limonite staining is common in the silicified dolomite, the tuff of Williams Ridge and Morey Peak, and the andesite. Limonite and hematite are found in colored bands in the quartz latite dikes in the New Deal area. Hematite stains were also mapped as pyritic alteration. Hematite is found in the jasperoid zones and in the altered intrusion of the Kietzke area. Earthy hematite occurs in the red volcanic breccia south of Gila leach pads and just west of the old Reveille townsite. Whether the location of the limonite and hematite is the exact location of pyritization is questionable in some cases. Iron oxides formed in the weathering zone can be mobilized and carried for some distance from their sites of formation.

BLEACHING

In several areas, dark dolomites and limestones have been bleached. Bleaching usually affects areas between intersecting faults. In bleached areas, differentiation of the carbonate rocks is difficult. Bleaching occurs along the Kietzke and Lost Burro Faults.

ECONOMIC GEOLOGY

MINERALOGY

General Statement

Most of the mining prior to 1970 was of high-grade oxidized ores. Reportedly, the minerals mined were cerrusote, cerargyrite, antimony-oxides, argentite, azurite, malachite, pyrite, arsenopyrite, chalcopyrite, galena, stibnite, tetrahedrite, molybdenite, quartz, calcite, gypsum, and "silver-copper glance" (Brown 1965; Raymond 1869, 1875). Mining has removed most of these rich ores. Some of the minerals mentioned above were not found in the district by the author. The following section will describe those minerals that were found.

Primary Ore Minerals

The two most common primary ores encountered in the study were tetrahedrite-tennantite and stibnite. Quartz veinlets containing dark metallic grains of tetrahedrite are most abundant on the western side of the district and were collected in the West Reveille Pit along the west end of the Combination fault, in the South Reveille Pit, and in the Lost Burro area. The tetrahedrite-bearing ore is silver rich. Assays showed values up to 100 ounces of silver per ton.

Large-bladed crystals of stibnite are found in pods and intergrown with quartz in the Gila Pit and the Antimonial Mine. It also occurs less commonly disseminated in silicified dolomite in the area of the Gila Pit. Assays showed that the stibnite contains up to 60 ounces of silver per ton.

Small blebs of sphalerite in oxidized ores were found in ore samples taken from a small dump west of the Old Gila Mine. The author found neither galena or pyrargyrite.

Primary Gangue Minerals

Quartz is the most common gangue mineral found in the district. Quartz occurs as vein-filling in vugs and in "cockscomb" structures. Drusy quartz vugs are often filled in the center with various oxides. Microcrystalline quartz occurs as a replacement in dolomites and in boxworks.

Calcite is a common gangue which occurs as dogtooth spar in vugs and fissure fillings and as rhombohedral masses in fissure fillings. Aragonite occasionally occurs as mammilary, fine-grained masses in open space fillings along veins.

Large (up to 60 mm wide) clear pseudorhombohedral crystals of barite are found in boxworks and as encrustations in quartz veins. Barite was found near the New Deal fault south of the Old Gila Mine and along the June Bug fault north of Lost Burro Canyon.

Pyrite cubes from less than 1 mm to 3 mm in length were found decimated in silicified dolomites in the Kietzke Mine. Pyrite was probably once plentiful but has mostly been altered to various iron oxides.

Minor amounts of white fluorite were found in prospect on the ridge just south of the Lost Burro Mine. Fluorite is not abundant in the district.

Secondary Ore Minerals

A variety of lead, silver, copper, and antimony oxides are found in the district. Smithsonite is found in black dense masses along the west side of the district. Cerrusite appears as white-bladed clusters to brown earthy masses throughout the district. Anglesite is found in very limited quantities in samples taken from small prospects south of the New Deal area. Yellow antimony oxides are common as haloes around stibnite crystals. Bladed sprays of hemimorphite were observed in thin section. Chalcocite rims were seen in polished sections around tetrahedrite. Because of their bright blue and green colors, the most obvious of the secondary ores are chrysocolla and the copper carbonates: malachite, azurite, and rosasite. These minerals occur as rims around tetrahedrite crystal or as brittle films or veinlets in brecciated rocks. Least obvious of the secondary ores is ceragyrite which is found in grayish white to black earthy masses in most of the ore zones.

Secondary Gangue Minerals

Secondary gangue minerals are mainly hematite and limonite, and a mixture of manganese oxides. The manganese oxides were identified by Runnels and Grauberger (1972) as manganosite, hausmannite, and hetaerolite. The author found sulfates to be common in the oxidized zone with jarosite being most common. In the area of barite mineralization, gypsum commonly occurs. The Kietzke tunnel contains small veinlets of recently deposited fibrous, blue vitreous melanterite ($FeSO_4$ $7H_20$). Upon removal from its natural environment within the mine, melanterite dehydrates to a white powder, rozenite ($FeSO_4$ $4H_2O$). Thin veinlets and irregular patches of opal were found in samples taken from the Gila Mine, the Gila Pit, and the West Reveille Pit.

FORM AND LOCATION OF ORE BODIES

General Statement

Ore bodies in the district are hydrothermal deposits and can be classified in two groups: fissure fillings and irregular replacements. Ore bodies are usually found near the intersection of major faults. The fissure veins are usually chambered and discontinuous. Irregular replacements are found within 100 m of the fissure deposits. Most of the productive mines lie along or in the area between the Kietzke and Gila Canyon Faults. This productive area is herein referred to as the Gila-Kietzke Trend. The following section deals with the form and location of ore bodies in the major mines and prospects of the district.

Antimonial Mine

The Antimonial Mine, located near the mouth of Gila Canyon, is the easternmost mine along the Gila-Kietzke Trend. The Antimonial Mine has been described in detail by Lawrence (1963, p. 135–37). The mine consists of an adit, shaft, and prospect pits. The mine is located where the Antimonial Fault cuts the Gila Canyon Fault. Both faults bring the Antelope Valley Limestone on the hanging wall in contact with the tuff of Williams Ridge and Morey Peak on the footwall. The Antelope Valley Limestone has been silicified to the extent that Lawrence (1963) called it quartzite. The structure is further complicated by an intersecting northwest-trending fault. Fissure-filling deposits occur along all three faults. The ore found on dumps and ore piles consists of quartz with small blebs and pods of stibnite. Yellow antimony oxides commonly form rims around the stibnite crystals. The ore dips along with the faults to the east at about 50°.

Gila Mine

Gila Mine is historically the largest producer of high-grade ore in the district. It is located in Gila Canyon at a major fork in the drainage and consists of three shafts, two adits, several prospect pits, and an open cut. Several shafts and prospects are found on the hill just west of the mine. At the surface, the workings are visible through an open cut on the north side of the mine. The author inspected the upper level, but safety considerations prevented the examination of lower levels. The mine is located at the intersection of the Gila Canyon Fault and splays of the Gila Mine Fault. In the mine, the footwall of the Gila Canyon Fault is the tuff of Williams Ridge and Morey Peak, and the hanging wall is Eureka Quartzite. South of its intersection with the Gila Canyon Fault, the footwall of the Gila Mine Fault is made up of tuff. On the surface, the hanging wall is also composed of tuff; however, 10 m below the surface in the mine workings, the footwall is Eureka Quartzite. The Gila Mine Fault structure is complicated. The structure can be seen in the open cut on the north side of the mine. The fault shows horsetails which are nearly horizontal at the top of the cut and quickly become almost vertical with depth. The ore follows this fault pattern. The ore bodies are best described as sheeted veins. The Eureka Quartzite is brittle and fractures, and the ore has filled up some of the small fractures in the quartzite close to the faults. The ore apparently occurred in discontinuous fissure fillings along the faults. What is left in columns and pockets in the upper level is a mixture of black oxides with no discrete minerals visible. A sample of the oxides assayed by Gold Creek Mining Company for the author had 25 ounces of silver per ton. The vein along the Gila Canyon Fault and related veins dip at between 70° and 90° to the east.

Prospects South of the Gila Mine

On the hill south of the Gila Mine are several prospects and shafts. None of the workings are open. The prospects lie along a faulted area where the New Deal Fault and another fault that parallels it intersect the Kietzke Fault. The area is made up of horsts of Eureka Quartzite and Ely Springs Dolomite caught up between the two northwest-trending faults. No ore minerals were found, but barite and gypsum were found on the northernmost dump.

Gila Pit

The Gila Pit was opened in 1979 by Gold Creek Mining Corporation. The mine, one of three open-pit mines in the district, is located at the head of Gila Canyon southwest of the Gila Mine. Mining in the main pit occurred on four levels. Three benches were developed on the hillside west of the main pit. The mine lies in an area where a northeast-trending fault and a northwest-trending fault intersect the Kietzke Fault where the hanging wall is Silurian–Devonian unnamed dolomite. The dolomite is bleached but probably consists of the upper and middle members. The footwall of the Kietzke Fault is made up of tuff of Williams Ridge and Morey Peak. Discontinuous fissure-filling ore bodies are found along the faults. Two types of replacements are found near the fissure fill. Located within 50 m of the faults are 0.5-to-3-m-wide pods of stibnite which contain 20 to 50 ounces of silver per ton. Fractures may have played a role in the localization of the ore pods. The second replacement type is low-grade replacement that occurs within 100 m of the faults. The ore grade is spotty and varies from less than $\frac{1}{4}$ ounce per ton to 12 ounces of silver per ton. No minerals are visible in the low-grade replacements, and the ore zones are identifiable by assay only. The cross section in figure 8 shows the relationship between the ore bodies in the mine. Calcite and quartz are the most common gangue minerals. The vein fillings are partially oxidized, and the irregular replacements show no signs of oxidation.

West Reveille Pit

Located just west of the Gila Pit, the West Reveille Pit was opened in 1978 by Gold Creek Mining Corporation. The pit is long and linear, follows the trend of the Kietzke Fault, and was developed on twelve levels. The pit is located in an area where three small faults intersect and offset the Kietzke Fault. The Kietzke Fault brings the tuff of Williams Ridge and Morey Peak in contact with the upper member of the Silurian–Devonian unnamed dolomite. The Kietzke Fault and portions of the intersecting faults contain breccia-filling ore deposits. Open spaces have been filled with 5-cm-wide quartz veinlets which commonly have tetrahedrite-tennantite crystals in the center.

Irregular replacements are found along the fissure filling in a 10-to-20-m-wide zone. As shown on the assay map, ore in the fissure veins and replacements are patchy (fig. 9). Oxidized ore is found in the fissure fillings. The low-grade ore can be identified only by assay.

Kietzke Mine

The Kietzke Mine, the last major mine in the Gila-Kietzke Trend, is located on the west side of the range. The mine consists of an upper tunnel 18 m long, a lower tunnel 670 m long, and several prospect pits on the dolomite hill just to the north of the mine. The author inspected the upper tunnel and the first 305 m of the lower tunnel. Unsafe ground and partial collapses prohibited inspection of the rest of the lower tunnel. The mine is located along the Kietzke Fault where it is intersected by crosscutting faults. The ore bodies mined were the fissure-fill type. Crosscutting faults set up shear zones filled with high-grade silver halides and oxides. Silver halides and oxides also fill the fissure along the Kietzke Fault in discontinuous pockets. High-grade ore assayed by Runnels and

Grauberger (1972) contained up to 100 ounces of silver per ton. The unnamed dolomite on the hanging wall may contain low-grade deposits similar to those mined in the West Reveille Pit. The Kietzke Fault and the main vein dip at 50° to 70° to the south.

South Reveille Pit

The only open pit mine not in the Gila-Kietzke Trend is the South Reveille Pit. Opened by Gold Creek Mining Corporation in 1980, the mine lies on the western end of the Combination Fault. The ore body is located where a small northeast-trending fault cuts the Combination Fault. The tuff of Williams Ridge and Morey Peak lies north of the fault. On the south side of the fault, the upper member of the unnamed dolomite crops out. The ore body, as in the West Reveille Pit, is mostly low-grade, patchy ore around discontinuous breccia fill. Some high-grade pockets of tennantite and quartz are found in the low-grade ore. Unlike the West Reveille deposits, the South Reveille ore body trends along the strike of the northeast-trending fault, not the strike of the major east–west fault.

Combination Claims

The Combination claims are located on the eastern side of the Reveille Range east of the South Reveille Pit. The property contains a collapsed shaft, a prospect pit, and an adit. The mine lies in an area where the Combination Fault is crosscut by a north–south-trending fault. The pit is developed in a brecciated silicified zone along the north–south fault. Rejuvenation of the fault has caused the silicified zone developed along the fault to be brecciated. Ore was not found on the dumps or in the pit.

Lost Burro Mine

The Lost Burro Mine is located in the west end of Lost Burro Canyon. The mine consists of two shafts and an adit. The mine workings open to the surface in holes at the top of the high ridge to the south of the shafts. The author did not enter the workings because of safety considerations. The mine is developed in an area where a northwest-trending fault and northeast-trending fault crosscut the Lost Burro Fault, where unnamed dolomite on the hanging wall contacts tuff of Williams Ridge and Morey Peak and the upper member of the Nevada Limestone on the footwall. The ore apparently occurred as fissure filling along the faults. The dump contains quartz crystals in cockade-and-comb structures which were sometimes filled with blue and green oxides. Fluorite, azurite, malachite, and cerussite were also found on the dumps.

June Bug Claims

The June Bug claims lie along the road in eastern Lost Burro Canyon. The mine is located at the intersection of three faults: the June Bug Fault, a northeast-trending fault, and a northwest-trending fault. Stratigraphically,

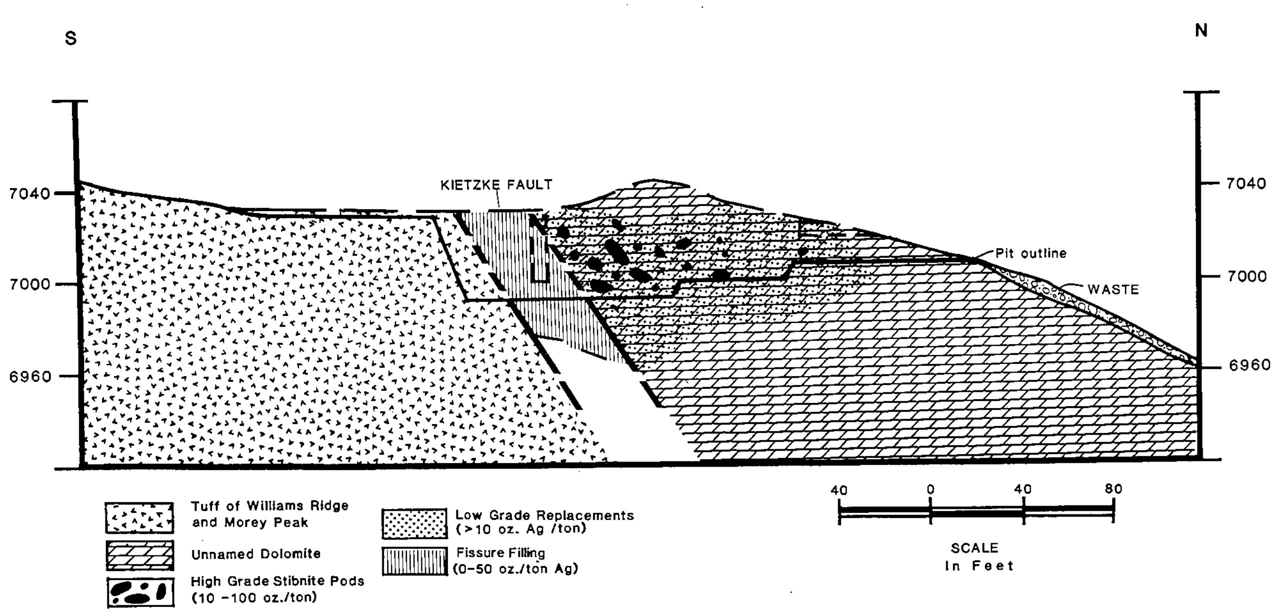

FIGURE 8.—*Generalized cross section of the Gila Pit. The main section of the Gila Pit has three levels. The cross section shows the location of fissure filling, high-grade irregular replacements of stibnite, and the low-grade replacements. The tuff of Williams Ridge and Morey Peak is altered but unmineralized.*

the mine lies in the unnamed dolomite and the Nevada Formation. Andesite is found on the footwall of the northwest-trending fault. The workings were not explored, but boxworks and cockade structures on the dumps suggest the ore, at least in part, filled fissures.

Prospects in the Northeast Corner of the District

Northeast of the June Bug Mine is a series of prospect pits and caved adits. The prospects lie along the intersection of small northwest-trending faults and the June Bug Fault. Along the June Bug Fault, unnamed dolomite on the hanging wall contacts andesite on the footwall. The dumps contained silica boxworks, quartz, and barite crystals. No other minerals were found on the dumps.

Prospects near the Old Reveille Townsite

The only area with extensive prospect pits entirely in the volcanic rocks lies in a shear zone along the Old Reveille Fault on the western edge of the old Reveille townsite. The pits and adits are located along a hematite-stained clay zone in the tuff of Williams Ridge and Morey Peak. Red dumps make the prospects easy to locate. No ore minerals were found on the dumps.

Other Prospects and Workings

Several other prospect pits and adits are found scattered throughout the district. Most of the prospects lie on or near faults or in areas where dikes or igneous rocks contact the carbonates.

ORE CONTROLS

GENERAL STATEMENT

From the previous discussion on the district's mines, it is demonstrated that both stratigraphic and structural conditions controlled the ore deposition.

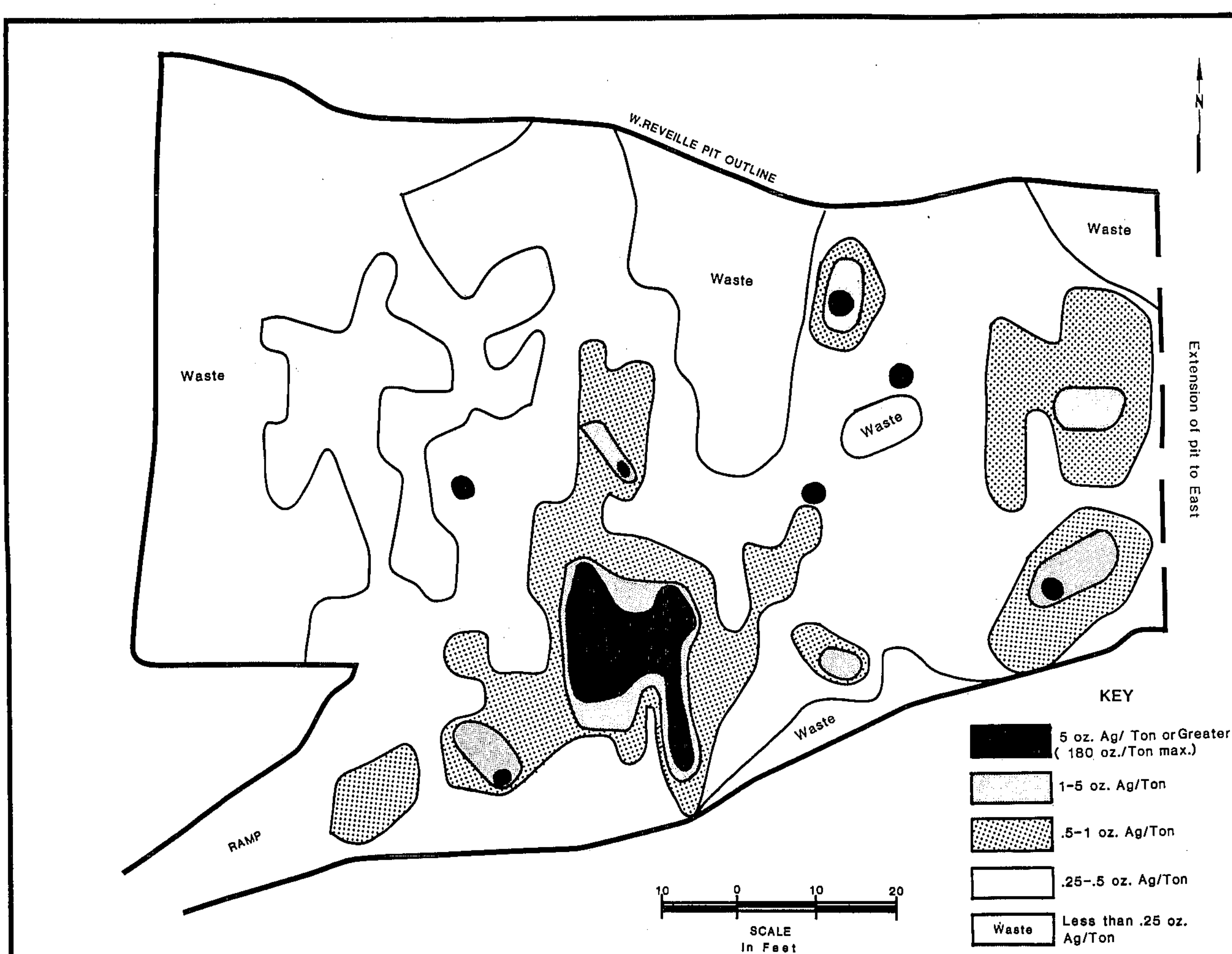

FIGURE 9.—*Assay map of the West Reveille Pit. The map shows assay values from core holes drilled on a six-foot spacing on the seventh level of the West Reveille Pit. Assay information was provided by Gold Creek Mining Corporation.*

Stratigraphic Controls

Ore deposits have been found in every Ordovician to Devonian formation. The richest ore, however, occurred in breccia fillings in the Eureka Quartzite. Four observations can be made on the stratigraphic controls on ore deposition:

1. The richest ore occurs along faults where Ordovician to Devonian sedimentary rocks on the hanging wall lie against the tuff of Williams Ridge and Morey Peak or andesite on the footwall.
2. Irregular replacements occur only in carbonate rocks.
3. The strongly fractured quartzite provides a permeable breccia-filling environment.
4. The tuff of Williams Ridge and Morey Peak, for the most part, is not mineralized. The tuff is highly fractured and altered. The contact, however, between the sedimentary rocks and the tuff appears to have been favorable for ore deposition.

Structural Controls

Four structural factors controlled the deposition of ore:

1. Most ore bodies in the district are all or in part fissure fillings. Faults have provided depositional sites and migration pathways for hydrothermal fluids.
2. The richest deposits occur in areas where northwest- and northeast-trending faults crosscut the east–west-trending faults.
3. The horsetailing along the Gila Mine Fault that helped provide open spaces for ore deposition may have occurred in other deposits also.
4. Jointing and fracturing helped create small open spaces that were filled by ore.

ZONATION

As previously mentioned, stibnite, tetrahedrite, and barite do not occur together. There appears to be a cruder zonation within the district. Copper minerals occur on the west side of the range and at the Gila Mine. Stibnite- and antimony-rich ores formed east of the copper-rich zones. Barite is found in a zone on the easternmost part of the district. No detailed work was done on geochemical zonation.

GENESIS OF THE ORE

Three possible sources exist for the ore: the altered intrusion in the Kietzke area, quartz-latite dikes, or the rhyolite dome and breccia in the Gila Canyon. The author found no feeder veins leading from any of the locations. None of the intrusions have visible mineral deposits. The age of the mineralization was probably late Miocene and most likely postdates the strike-slip faults and intrusions.

FUTURE POTENTIAL

The district has the potential for new discoveries of small, low-grade silver (probably less than 10 ounces of silver per ton) and antimony deposits. These potential deposits could be irregular replacements or fissure fillings. The district potentially contains other low-grade irregular replacements near already exploited fissures. These ore bodies would probably contain scattered high-grade pockets similar to those found in the West Reveille Pit (fig. 9). Future ore bodies should be explored, with the previously outlined ore controls as a guide. One untested potentially economic location of ore bodies is along the sole of the thrust fault, especially where it contacts the volcanic rocks across normal faults; however, the depth at which this contact occurs is not known.

CONCLUSIONS

In summary, the ore deposits of the Reveille district are hosted in Ordovician-to-Devonian carbonates and quartzites. The Reveille district has a complex structural history. A major thrust fault is exposed only in the fenster in the New Deal area. Paleozoic strata in the district dip to the west from 40° to 50°, but dips gradually decrease to the east to less than 20°. Four sets of normal faults cut the district: east–west-trending faults, northeast-trending faults, northwest-trending faults, and basin-and-range faults. The strike of the basin-and-range faults bounding the Reveille Range on either side change where they intersect the Kietzke-Gila Canyon fault system. A strike-slip fault is found on the eastern edge of the district. Movement along this fault may have been the cause of gravity slide detachments found in the district. Alteration in the district consists of sericitization, argillization, calcification, chloritization, silicification, pyritization, and bleaching. Alteration types not only reflect the distance from the ore body but also host rock type. Alteration and weathering are more extensive in the volcanic rocks. Three types of ore bodies containing silver, antimony, and copper ores are fissure fillings and low- and high-grade irregular replacements. The richest ore bodies occur along faults where dolomite or quartzite on the hanging wall abuts against welded tuffs on the footwall. The strongly fractured quartzite and carbonate rocks provided an inviting host rock for the ore. The tuff is also highly fractured and jointed but appears not to have been favorable for the deposition of ore. The interface between the sedimentary rocks and the tuffs seems to have been the most inviting environment for ore deposition. The best-developed ore bodies occur in areas where east–west-trending faults are crosscut by other fault sets. Economic potential in the district is for low-grade replacement deposits with localized pods of high-grade ore. The ore deposits at Reveille are considered to be mesothermal and of probable late Miocene age.

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