NEVADA BUREAU OF MINES

MAP 28
STILLWATER RANGE, NEV.

PRELIMINARY GEOLOGIC MAP OF A PART OF THE STILLWATER RANGE, CHURCHILL COUNTY, NEVADA

By Ben M. Page

INTRODUCTION

That part of the Stillwater Range which lies in Churchill County is largely composed of Upper Triassic strata and a remarkable succession of post-Triassic volcanic and intrusive rocks. It contains important thrust faults, one of which may have resulted from gabbroic intrusion. There are many later normal faults, and recent movements on some of them have caused earthquakes.

Background information is available concerning the adjacent Mount Tobin 30' quadrangle (Muller, Ferguson, and Roberts, 1951), and the Buffalo Mountain 15' quadrangle (Wallace and others, 1959). Both quadrangles lie north of the area of this report. The geology of the Sand Springs Range to the south is described in a report for the Atomic Energy Commission by the University of Nevada (1962).

Most of the writer's field work was carried out in the summers of 1956-1958 and 1961, but some was done at other intervals. The Stanford University class in Field Geology made detailed geologic maps in the Sand Springs district in 1946, 1947, and 1951. The writer is indebted to the students and instructors, and to Prof. R. R. Compton in particular. Chapman Young (1963) studied an area extending north from White Cloud Canyon and this work has been very helpful. Important identifications of fossils from the Stillwater Range have been made by Prof. S. W. Muller and by Mr. N. J. Silberling. In recent years, Mr. R. C. Speed studied a gabbroic complex and related thrust faulting in the northern part of the Stillwater Range as well as the ranges to the west and east. He has been an invaluable source of ideas, encouragement and helpful criticism, and has kindly read this manuscript.

The writer wishes to thank the Geological Society of America and the Shell Companies Foundation for generous financial support.

ROCK UNITS

SEDIMENTARY ROCKS OF PALEOZOIC OR MESOZOIC AGE

Quartzites (qtz on map) of unknown stratigraphic position are found near Cox Canyon and north of IXL Canyon. The quartzite at Cox Canyon is almost wholly quartz sand with local interstitial calcite, it is free of shale intercalations, and it is several hundred feet thick. In these respects it resembles the Jurassic(?) quartzite of Cottonwood Canyon (see below), but it differs in being slightly coarser, less uniform in grain size, and in containing more smoky, rounded grains.

Various limestones (ls) and metasedimentary rocks (ms) occur in klippen and in small remnants engulfed in the gabbroic complex of the northern part of the map area.

TRIASSIC ROCKS

Metasedimentary rocks (TRms)

Metasedimentary rocks adjacent to U. S. Highway 50 east of Sand Springs may represent more than one system. Included are: black chiastolite- and chloritoid-bearing phyllite; graphitic schist; metamorphosed silty, calcareous sediments; limestone, marble, and calc-silicate rocks; schistose sandy siltstone and graywacke; "stretched-pebble" conglomerate; quartz-muscovite schist; and schistose tuffaceous(?) material. The only fossils found in these rocks were collected in a single locality 1.2 miles west-northwest of the Summit King mine. They were identified as Myophoria sp. and Alectryonia(?) by S. W. Muller (oral communication, 1946), who suggests a probable Late Triassic age. The rock types of the vicinity contrast markedly with the Upper Triassic slates to the north, implying local depositional differences or tectonic transport.

Upper Triassic slate and phyllite (TRsl)

Slate derived from marine muds is the most prevalent rock in the central part of the mapped area. Most is gray-black, weathering to pale gray, greenish gray, or light tan. The slaty cleavage is approximately parallel with the bedding except in the axial parts of folds where it is parallel with the axial planes. Recrystallization is generally only incipient, but in the vicinity of granitic bodies the rock contains chiastolite porphyroblasts .02 to 2 inches long. In a few areas phyllite prevails over slate.

Some of the slate sequence includes abundant fine-grained feldspathic quartzite interbeds 1 to 35 inches thick. These beds display a fascinating variety of sole marks, including flute casts, fillings of organic trails, and assorted convexities of unknown origin. Some quartzite beds show small-scale crossbedding, and the upper surfaces of many are covered with crescentic undulations that are thought to be linguloid ripple marks. All of these features are useful in determining tops and bottoms of folded strata. Generally the quartzite beds are thin and widely spaced, but just south of Shanghai Canyon, in lower Hare Canyon, and in a few other localities, there are rock sequences 50 to 300 feet thick in which quartzite predominates over intercalated slate.

Parts of the slate succession are interrupted at intervals by gray-weathering limestone beds 1 to 60 inches thick. More rarely, limestone occurs in prominent units 1 to 50 feet thick. Many of the carbonate rocks are calcarenites, and some contain limestone conglomerate and bioclastic material. Certain thin, lenticular carbonate beds are ferruginous and weather orange-brown.

The lower part of the section, just above the Cox Canyon thrust zone, differs from the bulk of the overlying slate, although it is not distinguished on the map. It is mainly lavender-weathering silty shale that locally contains black flinty streaks and nodules. Many thin black to gray limestone beds occur in this unit.

The stratigraphic thickness of the slate, phyllite, and interbedded rocks cannot be measured because of complex deformation, but it is estimated to be 5,000 to 10,000 feet, of which less than 10 percent is quartzite and limestone. The lavender silty shale member at the bottom of the exposed section is about 500 feet thick.

The slate and associated rocks, including the lavender silty shale, are Late Triassic in age, probably representing part of the Karnian and all of the Norian stages. This is indicated by poorly preserved fossils identified by S. W. Muller and N. J. Silberling, as summarized in the table below. It is concluded that parts of the slate sequence are chronologically equivalent to much of the Grass Valley, Dun Glen, Winnemucca, and Raspberry Formations of the Mount Tobin and Winnemucca quadrangles to the north (Muller, Ferguson, and Roberts 1951; Ferguson, Muller, and Roberts 1951; Silberling and Roberts, 1962).

FOSSILS FROM SLATE AND INTERCALATED STRATA (TRsl),
STILLWATER RANGE, CHURCHILL COUNTY, NEVADA 1/

Fossil		Probable Stratigraphic Position	Area of occurrence* 1	2	3	4	5	6
Hydrozoan:	Heterastridium sp.	U. Triassic; u. Norian		x				
Coral:	Isastrea sp.	U. Triassic		x			x?	
Pelecypods:	Halobia sp.	U. Triassic; Karnain or Norian	x	x	x?	x?		x?
	Monotis sp. (locally, M. subcircularis Gabb)	U. Triassic; Norian		x		x		
	Plicatula?	U. Triassic?		x				
Ammonites:	Arcestes sp.	M. or U. Triassic	x	x				
	Juvavites?	U. Triassic		x				
	Choristoceras?	U. Triassic; u. Norian	x					
	Paratibetites?	U. Triassic; Norian		x				
	indet. trachyceratid	M. or U. Triassic			x		x	
	Malayites?	U. Triassic; top of lower Norian		x				
Belemnite:	Asteroconites sp.	U. Triassic; Norian		x				

*Area 1. Lavender silty shale 0.5 to 1 mile south of Cox Canyon.
2. Main slate terrain, Cox Canyon to White Cloud Canyon.
3. Slate area surrounding Hare Canyon.
4. Slate area near Fortieth Parallel, W. side of range.
5. Slate area near Fortieth Parallel, E. side of range.
6. Slate area between Mountain Well Rd. and Eleven Mile Canyon.

Note: Question mark after genus means identification is not certain. If identification is erroneous, the indicated stratigraphic position (middle column) may not apply.
Question mark after "x" in righthand columns means the indicated generic identification is not certain in that particular area because of poor fossil preservation.

1/ (Specimens collected by B. M. Page, and identified by S. W. Muller and/or N. J. Silberling, mainly 1956-1964).

The Upper Triassic sedimentary rocks of the region to the north of the mapped area are believed to have been deposited as part of a delta in a shelf sea, of which the shoreline lay to the east and southeast (Silberling and Roberts, 1962, p. 37; Silberling, oral communication, 1963). In the Stillwater Range, the features of the Upper Triassic slate and interbeds of quartzite seem to fit this hypothesis.

Undifferentiated limestones (TRls)

A large sheet of black to gray Upper Triassic limestone forms much of the upper plate of the La Plata thrust between Mountain Well Road and Eleven Mile Canyon. Surprisingly few fossils are present, but three localities yielded the following, kindly identified by N. J. Silberling: Halobia sp., Monotis sp., Placites sp., and Metasibirites sp. All denote a Late Triassic age, and the strata containing Placites are referred to the middle or upper part of the Norian stage. Therefore the limestone is the same general age as part of the Upper Triassic slate sequence upon which it rests tectonically, implying significant lateral transport of rocks deposited in a different environment from that of the slate.

Other limestones labeled "TRls" on map are known to be Triassic, and may possibly belong to the formation just described. Perhaps some of the limestone klippen of unknown age, labeled "ls" are similarly related.

JURASSIC ROCKS

Lower Jurassic limestone and shale (Js)

An unnamed formation in the Hughes Canyon (which extends from the adjacent Buffalo Mountain quadrangle into the northernmost part of the mapped area), is characterized by tan-weathering, platy, silty limestone and calcareous shale. It also includes a few relatively pure limestone beds. N. J. Silberling identified psiloceratacid ammonites from the silty limestone, and considers these to represent the Hettangian or Sinemurian stages of the Lower Jurassic. He found Upper Triassic fossils (Monotis Subcircularis, Halorites sp., Placites sp., and Rhabdoceras sp.) in rocks a few tens of feet distant. It is likely that the lowermost part of the silty limestone formation is Upper Triassic, but the bulk of it is certainly Lower Jurassic. The relationship of this formation to the Upper Triassic slate is doubtful. The contact may be a thrust fault, but the writer is inclined to think it is depositional. If the contact is depositional, the Hughes Canyon section is overturned, as the Jurassic beds dip toward the Triassic terrain and Monotis locally occurs above the Jurassic strata.

Jurassic rocks like those of Hughes Canyon are found in a small area in White Cloud Canyon, but are omitted from the map. Similar rocks are seen at the mouth of Fondaway Canyon. A more important occurrence 1 to 2 miles north of White Cloud Canyon has been carefully studied by Young (1963), who believes that the Jurassic section he examined is in depositional contact with the Upper Triassic slate. He found the following ammonites, which were identified by S. W. Muller: Waehneroceras sp. (indicative of Hettangian stage), Euphyllites sp. (Hettangian), Caloceras(?) sp. (Hettangian), Arietitidae (Sinemurian - L. Pliensbachian), Phylloceras sp. (Sinemurian - Valanginian), Dactylioceratidae(?) (L. Pliensbachian - Toarcian), Hildoceratidae(?) (U. Pliensbachian - Toarcian), and Harpoceratinae(?) (U. Pliensbachian - Toarcian). The Lower Jurassic Hettangian and Sinemurian stages are definitely represented, the Pliensbachian may be present, and the Toarcian is strongly indicated. Young points out that the maximum stratigraphic thickness is only 200 to 500 feet, and this, coupled with the phosphatic nodules observed in some beds, suggests slow deposition during a long time span. J. Corvalan (1962) found 1600 feet of Lower Jurassic strata in the Westgate area 40 miles to the south.

Jurassic(?) metavolcanic rocks (Jmv)

Between La Plata Canyon and Mountain Well Road is a sequence of altered and locally schistose rocks of which at least half are volcanic and the remainder sedimentary. The following are included: fine-grained slaty andesitic tuffs, schistose andesitic tuff-breccias, breccias, thin andesite flows, graphitic slate, quartzite, calcareous sandstone, and thin conglomerate lenses. The volcanic members retain few, if any, original minerals but show indicative relict textures. The presumed andesitic composition is not certain. Although the sedimentary members are better preserved, they are unfossiliferous. The formation is probably marine, at least in part, and it is more than 5,000 feet thick.

The metavolcanic rocks appear to rest unconformably upon allochthonous Upper Triassic limestone (TRls). A "basal" breccia 25 to 100 feet thick, lies upon, and occupies fissures in, the limestone. However, the clasts of the breccia are obscure, white, altered material of probable volcanic origin rather than detritus from the underlying formation. The contact might possibly be a thrust fault; if it is not, the metavolcanics are post-Upper Triassic, but are older than the Late Jurassic orogeny which resulted in metamorphism and deformation. The Lower Jurassic silty limestone described in the preceding section is missing, as are Lower Jurassic rocks similar to those of the Westgate area (Corvalan, 1962) and the Pershing district (Wallace and others, 1959). Perhaps Lower Jurassic sediments were removed by erosion prior to the deposition of the metavolcanics. More probably, however the metavolcanics were carried in with the underlying limestone as a part of the La Plata thrust sheet, and may therefore represent a distant stratigraphic section.

Rocks somewhat similar to those just described occur 15 miles to the north near lower Cox Canyon, and are believed to belong to the same formation despite a great difference in structural relations. The northern metavolcanics structurally underlie, rather than overlie, the Upper Triassic rocks.

Jurassic(?) quartzite (Jqc)

A distinctive allochthonous quartzite occurs in remnants of the Boyer thrust sheet at the mouth of Cottonwood Canyon and elsewhere. It varies from black to white and from thin-bedded to massive, but in other respects it is remarkably uniform. The sand is well sorted, fine to very fine grained, and is mainly angular to subrounded. Quartz predominates to the exclusion of all other clastic components except rare specks of tourmaline and zircon. Interstitial carbonate, chalcedonic silica, and chlorite are locally present, and some of the rock is calcareous sandstone rather than quartzite. The formation is at least 500 feet thick and is not interrupted by shale intercalations. The age is not definitely known because fossils are lacking, but R. C. Speed (personal communication, 1964) recently found Jurassic basalt apparently resting concordantly on the quartzite 3 to 4 miles north of Dixie Meadows. This suggests, but does not prove, a Jurassic age for the quartzite.

Jurassic basalt (Jba)

North of the latitude of Dixie Meadows, Jurassic basalts occupy large areas. They occur as flows (locally amygdaloidal), lithic lapilli tuffs, tuff breccias, and breccias. These rocks are generally altered, and commonly contain chlorite and epidote which impart a greenish color. They have previously been regarded as andesites, but R. C. Speed (oral communication, 1964) finds that the composition is basaltic. He reports that the flows contain labradorite phenocrysts or microphenocrysts, some contain clinopyroxene, and a few have talc pseudomorphs after olivine. The groundmass of the flow rocks includes lineate plagioclase laths and alteration products of pre-existing clinopyroxene and glass. Speed notes that many of the flow rocks are petrographically identical with rocks of similar occurrence in the west Humboldt Range, where an analyzed specimen showed 52.92 percent SiO_2 (by weight) and normative plagioclase of composition An_{52}.

The rocks just described are found in the area of the Upper Jurassic gabbroic and dioritic complex and are not recognized with certainty beyond that area. They are more prevalent near the center of the complex than near the margins, and are intruded by some facies of the complex. It is likely that the intrusive and extrusive rocks are genetically related and almost contemporaneous.

Gabbroic and dioritic rocks (Jdg)

The northern quarter of the mapped area is dominated by the Jurassic basalts and by gabbroic and dioritic intrusives. The intrusives have been examined by R. C. Speed, who has made a detailed study of correlative rocks in the West Humboldt Range (Speed, 1962a, 1962b, and 1963). The rocks form a gabbroic suite consisting of hornblende gabbro, diorite, picrite, anorthosite, dolerite, keratophyre, and gabbroic pegmatite. The earliest parts of the suite are locally strongly differentiated and layered, and occur mainly along the margins of the intrusion. Speed considers the complex to be a tabular mass emplaced at shallow depth, probably less than 2500 feet. In places it may have erupted to form the associated basalts. Speed obtained a potassium-argon age determination from primary biotite in a gabbro specimen from the West Humboldt Range. The indicated age is 150± 3 million years; accordingly, the complex is probably Late Jurassic.

Commonly the gabbroic and dioritic rocks have been profoundly altered. For example, some of the rock is albitized and bleached white, and some is dolomitized, lacking original minerals and texture, and weathering yellow-brown.

CENOZOIC OR MESOZOIC ROCKS

A number of nonmarine rock units, chiefly volcanic, overlie Upper Triassic or Lower Jurassic formations and underlie Miocene(?) volcanics. They contain no fossils, and their age(s) may be either Late Jurassic, Cretaceous, or early Tertiary.

Landslide breccia (T-Jbr)

An interesting but limited lithified breccia near the south fork of Cox Canyon is more than 500 feet thick and is almost unstratified. It consists of blocks and fragments of three or four lithologic types. The basal part contains abundant Triassic slate fragments as well as fragments of Jurassic(?) metavolcanic rocks. The latter predominate in most of the mass, but a few horizons are chiefly composed of quartzite blocks, and others of limestone blocks. Most of the features suggest a landslide origin. The accumulation is overlain by devitrified welded tuff, and is intruded by porphyritic basaltic andesite and by white aphanitic felsite.

Latite flows, tuffs, and breccias (T-Jl)

Latite which weathers lavender or pale blue-gray is prevalent in the vicinity of Job Peak and southward to upper Eleven Mile Canyon. The only megascopic minerals are minute, sparse K-feldspar phenocrysts. These are scattered in a groundmass of microscopic feldspar laths that are sodic plagioclase in part. The groundmass is sprinkled with extremely fine brown specks. There are rare, tiny chlorite pseudomorphs after hypersthene(?), but no other vestiges of mafic silicates.

Some of the latite shows fine flow layering, limited horizons are spherulitic, and others are amygdaloidal. Columnar jointing is occasionally discernible. Some tuffs (including thin, stratified rhyolite crystal tuffs) and latite breccias accompany the flows. The total thickness is 2,000 to 6,000 feet.

The latite is intruded by Oligocene or Lower Miocene granite in the vicinity of Coyote Canyon, and is darkened and microscopically recrystallized.

Devitrified welded tuff (T-Jwt)

Remarkable welded tuffs resembling prophyries occur between Mountain Well Road and Cox Canyon. They compose Job Peak and much of the southern half of the mapped area. These rocks are not to be confused with younger welded tuffs included under "Tv" on the map. They are dull colored, weathering gray to brown, and are so completely compacted and uniform that joint systems and topography are not influenced by original structures. The welded tuffs are hard, dense, and crowded with euhedral feldspar crystals, and there is no megascopic indication of pyroclastic origin except the common presence of scattered angular lithic fragments such as Triassic slate, lavender latite, and various volcanic rocks. However, thin sections show fine "fluidal" banding and wispy relict structures faintly suggesting flattened shards and collapsed bits of pumice. All the former glass has given place to a microcrystalline, mosaic-like texture that has almost effaced the original features.

A number of different rock units are included here under "devitrified welded tuff". In all of them, the larger mineral grains are megascopic (0.5 to 2 mm.) and numerous, and include euhedral crystals and angular fragments of plagioclase (commonly andesine), orthoclase, perthite, and quartz. Quartz is very scanty to very abundant and the rock compositions probably range from latite through dacite to silica-rich rhyolite. No original mafic minerals are present, but chlorite pseudomorphs after biotite are common.

The devitrified welded tuff rests unconformably upon Upper Triassic slate, Upper Triassic limestone, and Jurassic(?) metavolcanic rocks; and its basal part locally contains fragments or boulders of the underlying formations. Near Coyote Canyon and elsewhere, it rests upon latite (T-Jl), and in places members 100 to 200 feet thick consist of latite blocks and fragments in a rhyolitic matrix. The total thickness of devitrified welded tuff is commonly greater than 2,000 feet, and may possibly attain 10,000 feet.

Some of the devitrified welded tuff outcrops show a faint planar structure expressed by short greenish streaks and platy lithic inclusions. Oddly, this structure generally dips 45° to 90°, whereas the base of the formation, where exposed, is less steeply inclined. The tuff was deposited on an uneven surface, and may have had an initial dip that was increased by downhill slumping while the mass was hot and soft. The dips were further increased by subsequent tectonic folding.

The devitrified welded tuff, unlike the younger volcanics (Tv), has been intruded by white felsite dikes and by Oligocene or early Miocene granodiorite and granite. The granitic rocks and the welded tuff may be genetically related; that is, after magma erupted to form the welded tuff, additional magma from the same source may have intruded the volcanic products. If this hypothesis is correct, the devitrified welded tuff is Oligocene or early Miocene.

Undifferentiated rhyolitic volcanic and intrusive rocks (T-Jvi)

An area northwest of Job Peak is underlain by a poorly exposed assemblage of extrusive and intrusive rhyolites. This assemblage probably includes some units that are designated elsewhere as "T-Jwt", "T-Jf", and "Tv", but it also includes various unfamiliar rocks. Because of complexity and inadequate exposures, it was not feasible to map the units separately.

Porphyritic basaltic andesite (T-Jpa)

The devitrified welded tuff and older formations are intruded by greenish gray porphyritic basaltic andesite. This rock has prominent plagioclase phenocrysts (calcic andesine to labrodorite) in a groundmass of felted plagioclase, -- apparently oligoclase to andesine. Chlorite, epidote, and calcite have formed pseudomorphs after pyroxene and biotite.

Extrusive basalts and andesites (T-Jba)

A number of rock units, perhaps of different ages, are grouped under "T-Jba". Volcanic flows and breccias 2 to 4 miles *south of* Cox Canyon have a mineral composition similar to that of the intrusive rocks described in the preceding section, *and are probably* extrusive equivalents. They appear to be 8,000 feet thick. These rocks are fractured, chloritized, and epidotized at the expense of original *features*, but two or three stratified tuff members 20 to 30 feet thick suggest an extrusive origin.

Altered basaltic andesite containing orthopyroxene, forms flows, breccias, and tuffs that rest unconformably upon Upper Triassic slate 2 to 5 miles north of Alameda Canyon. The basal material locally contains blocks, rounded pebbles, and cobbles of volcanic rocks, slate, granodiorite, and microgranite.

Certain peaks between Fondaway and White Cloud Canyons are composed of andesitic breccia, tuff-breccia, and tuff. There are members of dense (welded ?) andesitic tuff with streaky planar structure and columnar jointing. The andesitic rocks, up to 1900 feet thick, postdate the Early Jurassic sedimentary rocks and predate Miocene(?) volcanics (Tv).

Basalt that is older than the Miocene(?) volcanics occurs on both sides of U. S. Highway 50 near the Summit King mine. It is locally strongly altered and bleached. Much of the basalt is distinctive because of its numerous thin, broad, scale-like labradorite phenocrysts. The groundmass consists of andesine or labradorite laths. Some varieties of the basalt show vestiges of small pyroxene crystals, and some contain pseudomorphs, probably after olivine. The basalt covers a thrust fault affecting Upper Triassic rocks, and is believed to be intruded by Late Cretaceous granodiorite, so its age is probably Jurassic or Early Cretaceous. Silicified wood from beneath the basalt was identified as Cupressanoxylon sp., by Virginia M. Page (oral communication, 1964).

Felsic porphyries and aphanitic intrusive rocks (T-Jf)

White felsite with no megascopic grains occurs as prominent dikes and irregular intrusive bodies. One such body south of Cox Canyon is 1 1/2 miles long and 1 mile wide, but despite its size, has extremely fine texture. Many aphanitic-porphyritic dikes and sills of various ages are also included under "T-Jf". A striking swarm of east-west felsic dikes cuts the devitrified welded tuff in a large area around Eleven Mile Canyon. Some felsic dikes are spatially and petrologically related to granitic plutons. Some are younger than the plutons but older than, or contemporaneous with, the Miocene and Pliocene volcanic rocks (Tv). Many of the younger dikes have phenocrysts of quartz and fresh feldspar in an aphanitic groundmass sprinkled with fresh biotite.

GRANITIC PLUTONS

A mass of Late Cretaceous granodiorite and porphyritic granite (Kg) dominates the Sand Springs Range and extends into the southernmost part of the mapped area. It is locally somewhat foliated, but otherwise does not differ greatly from the Tertiary granitic rocks farther north. According to a recent report (Nevada Bureau of Mines, 1962, p. 17), biotite from the granite and granodiorite gave potassium-argon ages of 79.6 (± 2.0) and 76.0 (± 2.0) million years, respectively. These rocks intrude Upper Triassic(?) metasediments about 1 mile south of U. S. Highway 50.

Granodiorite and quartz *monzonite (both marked "Tg")* near the *center of the mapped area invade* latite and devitrified weld*ed tuff of* probable Cretaceous or early Tertiary age. Biotite from a sample obtained in IXL Canyon gave a potassium-argon age of 28 ± 2.0 million years (R. C. Speed, oral communication, 1964). Evidently the rock is Oligocene or Early Miocene, depending upon the varying usage of these terms. The "dated" granodiorite is intruded by a younger coarse granite 1.5 miles south of Mud Spring. In fact, the terrain labeled "Tg" encompasses several successive intrusions, but they are not shown separately.

The granitic plutons labeled "TKg" near La Plata, Alameda, and White Cloud canyons are of unknown age.

Intrusion of the granitic mass in the area south of U. S. Highway 50 accentuated and coarsened the fabric of the invaded foliated rocks, and induced the growth of porphyroblasts (chiefly chiastolite and chloritoid). It produced marble and skarn in some adjacent limestones. The granitic mass near IXL Canyon had similar effects. A small intrusion 1 mile north of U. S. Highway 50 transformed limestone to a plagioclase-hornblende rock. Most of the other granitic plutons produced aureoles of black hornfels or chiastolite-bearing phyllite and minor amounts of quartzite and marble. Some plutons gave rise to white felsite dikes which cut the Triassic and Jurassic rocks.

Only the upper parts of the granitic bodies are exposed, judging from internal features and metamorphic environment. The pluton of the Sand Springs Range is somewhat more deeply exposed than the others.

ROCKS YOUNGER THAN THE GRANITIC PLUTONS

Miocene(?) volcanic rocks (Tv)

Extensive post-granitic volcanic rocks include silicic tuffs, welded tuffs, tuff-breccias, breccias, and flows. Some associated andesite is included. Although alteration is locally intense, many parts of the silicic suite retain fresh biotite and glass, unlike the earlier volcanics. Some units are white or brightly colored, few dikes cut the rocks, and in places the attitudes of the various members may be deduced from topographic expression. These characteristics are lacking in the Pre-Miocene volcanics. The total thickness is 1,800 feet in some eroded sections and might attain 3,000 to 4,000 feet in restored sections.

Some younger (Pliocene ?) white rhyolitic tuffs have been included with the foregoing rocks on the map.

Pliocene(?) basalt (Tb)

Near Mountain Well Road and La Plata Canyon, about 75 feet of basalt locally lies beneath the Pliocene sedimentary rocks and the youngest rhyolitic tuffs. The rock is sprinkled with square feldspar phenocrysts and fine crystals of augite and olivine. Some of the basalt is columnar.

Pliocene(?) non-marine sedimentary rocks and tuffs (Ts)

Dissected pediments and low hills commonly show exposures of poorly consolidated gravels, sands, clays, fissile white siliceous shales, and light colored tuffs. The sediments are fluvial and lacustrine, and locally interfinger with subaerial crystal and vitric ash. Near Eleven Mile Canyon the sequence is 650 feet thick, and near Mountain Well Road it is perhaps 1,500 feet thick. Fossils obtained to date do not have a restricted range. Silicified wood of Quercus(?) cf. chrysolepis, Salix sp., and Sequoia(?) sp. was identified by Virginia M. *Page* (written communication, 1959). *Impressions of grass and willow leaves and a fragment of a small fish skeleton were found in siliceous* shales. A thin lacustrine limestone yielded Ostracoda that B. E. B. (Cameron tentatively identifies as "Pseudoeucypris Pagei" Swain. The last-named species is reported from the Green River Formation (Eocene) near Sunnyside, Utah. However, the sediments described here are younger than the Oligocene or Miocene granitic intrusives. They seem roughly comparable to beds which are elsewhere called "Truckee" and "Esmeralda".

Plio-Pleistocene basalt and basaltic andesite (Qba)

The Stillwater Range is partly capped by olivine basalt in flows from 20 to 100 feet thick, aggregating 1,600 feet in some places. Locally the flows rest upon bright red scoriaceous material or gray ash. Northwest of Mountain Well 1,000 feet of breccias and flows of porphyritic pyroxene andesite lie upon folded and eroded Pliocene sedimentary rocks.

STRUCTURE

The structural features are shown in cross sections A-A' B-B', and C-C'. The various thrust faults, which are rather inconspicuous on the geologic map, may be found by referring to the INDEX MAP OF THRUST FAULTS, located to the upper left of the geologic map.

MESOZOIC FOLDS AND THRUST FAULTS

Folds in Upper Triassic slate

The slate between Cox Canyon and Fondaway Canyon is intricately folded in places. Intervening parts are nearly homoclinal, but about half the homoclinal sections are overturned. Although there are many exceptions, most beds that dip steeply south or southwest are overturned (cross sections). This indicated differential movement of the upper part of the body of slate toward the north or northeast with respect to the deeper part of the mass. The configuration of drag folds supports this interpretation. Many contorted beds are disrupted by low-angle displacements where folding gave way to minor thrust faulting. Folds in the Upper Triassic slate are transected by, and are therefore earlier than, the Boyer thrust of Late Jurassic age.

Cox Canyon thrust zone

Where the structural base of the slate body is exposed just south of Cox Canyon, the lavender shale member rests discordantly upon quartzite of unknown age. As much as 10 feet of brecciated shale occurs at the contact, and sheared shale overlying the breccia contains tectonic augen or lenses of limestone. Although the contact with the quartzite is locally very steep, on the whole it appears to be a thrust fault.

The quartzite south of Cox Canyon forms a tectonic, wedge-shaped mass which has been overridden by the slate and which in turn has overridden Jurassic(?) metavolcanics. Moreover, the metavolcanics have been thrust over a limestone of unknown age. Therefore the several rock units south of Cox Canyon appear to be tectonic slices in an imbricate thrust zone, as shown in Cross Section B-B'.

The extent of the Cox Canyon thrust zone is unknown, but it may underlie the entire slate terrain of the Stillwater Range (Page, 1959). The amount of "tectonic transport" is also unknown, and the direction and sense of relative movement are uncertain. The writer tentatively believes that the major folds in the slate formed at the time of thrusting; if this is so, the slate mass and the imbricated wedges moved north and northeast with reference to the underlying rocks. The time of thrusting was probably Middle or Late Jurassic, but may have been Cretaceous. In any case, it antedated various intrusions, including the Tertiary pluton of IXL Canyon, inasmuch as the intrusive rocks have invaded and obliterated the east extension of the thrust zone.

Boyer thrust

In the northern third of the map, there are several exposures of a remarkable thrust fault structurally higher than the Cox Canyon thrust zone. It is easily seen north of Cottonwood Canyon near Boyer Ranch Here and in other typical localities, distinctive fine-grained quartzite of unknown age has been thrust over Upper Triassic slate. Locally the quartzite has overridden Lower Jurassic rocks. There is a striking association between quartzite and intrusive diorite and gabbroic rocks in the upper plate, whereas the intrusive rocks are lacking (except for narrow dikes) in the slate beneath the thrust. The dioritic and gabbroic rocks clearly accompanied the quartzite at the time of transport, and R. C. Speed believes (as does the writer) that the igneous rocks were partly molten during this episode; in fact, the intrusion may have propelled the quartzite thrust sheet (Speed and Page, 1964).

The upper plate of the Boyer thrust is part of a sheet of gabbroic rocks and intruded metasediments extending from the West Humboldt Range to the Clan Alpine Range and occupying an area of 500 square *miles. The parts exposed near White Cloud Canyon and near Dixie* Meadows probably moved south with respect to the underlying rocks. The latter are little disturbed in most places, but in some localities seem to show a reversal of the earlier northward overturning. However, *this interpretation is only tentative.*

R. C. Speed (Speed and Page, 1964) has determined that one of the gabbroic intrusive bodies is Late Jurassic. If the intrusive complex is syntectonic, the thrusting is also of that age.

La Plata thrust

In the vicinity of Eleven Mile Canyon and La Plata Canyon, a sheet of allochthonous Upper Triassic limestone rests discordantly upon Upper Triassic slate. The tectonic base of the sheet is undulating and generally gently dipping. Both the limestone and the slate are strongly folded near the contact, and the latter is bordered by 1/2 to 15 feet of breccia. Jurassic(?) metavolcanics exposed near the head of La Plata Canyon, which apparently overlie the limestone unconformably, are probably a part of the thrust sheet rather than a later deposit, but are not seen in contact with the footwall rocks. Both the allochthonous limestone and the footwall slate are intruded by quartz monzonite, which (in view of the later dikes that transect it) may be Late Cretaceous rather than Tertiary. In this case, the La Plata thrust would probably be Late Jurassic or Early Cretaceous. The direction of transport is thought to be north or north-northeast, based on small folds near the thrust surface, but the evidence is inconclusive.

Sand Spring thrust

Several conspicuous limestone klippen occur in an east-west array just south of U. S. Highway 50. They may be remnants of the La Plata thrust, or they may belong to a different sheet. The limestone is gray, slightly recrystallized, barren of fossils, and of unknown stratigraphic horizon. It is distinctly bedded and is folded into a simple east-trending syncline. It rests in thrust-fault contact upon Upper Triassic(?) phyllite and schist which dip steeply but are almost undisturbed by the thrusting. No indication of the direction of thrusting has been found. The thrust fault is partly covered by later basalt flows which appear to be intruded by granodiorite of Late Cretaceous age; hence the thrusting was probably Late Jurassic or Early Cretaceous.

CENOZOIC STRUCTURES

Cenozoic folds

The early volcanic rocks such as the devitrified welded tuff, (T-Jmt), were folded along north-south axes prior to the emplacement of Oligocene or Early Miocene plutons. Volcanic rocks (Tv) later than the plutons were also folded along north-south axes, but only mildly. Some of the rhyolitic and dacitic units labeled "Tv" show unsystematic dips suggesting that gravitative slumping, sliding, and tilting has occurred. The Pliocene sediments are moderately folded along north-south axes, and slumping has accentuated some of the dips. The Pliocene-Pleistocene basalts are generally tilted rather than folded, and rarely dip more than 12°. A very gentle, open syncline modified by block faulting extends north-northeastward into the basalt terrain from the vicinity of Sand Springs.

Cenozoic normal faults

Much of the Stillwater Range is a horst sliced into narrow north-south trending blocks by normal faults. Some tilting has accompanied the block faulting; this is apparent in the Pliocene-Pleistocene basalts. The normal faulting involved an east-west extension of the crust, and probably it was induced by a reduction of confining pressure in that direction. Indeed, it looks as though the range sloughed off narrow subsidiary blocks during and after its uplift above the adjacent basins, mainly in response to gravity. Probably many normal faults also underlie the alluvium alongside the mountains.

Some normal faults in the interior of the range extend to the flanks and continue as marginal faults bounding the range. This condition may be seen at two widely separated places on the east side, at Coyote Canyon and at a point 9 miles southwest of Cottonwood Canyon.

Fault movements in the present century

Some of the normal faults in the vicinity are active, and have been responsible for earthquakes. In 1903, a fault displacement in the Louderback Mountains, adjacent to Dixie Valley on the southeast, broke the ground surface and caused the Wonder earthquake (Slemmons and others, 1959). In 1915, marginal faults along the flanks of the Tobin Range, China Mountain, and Sou Hills (all north of Dixie Valley) underwent sudden displacements responsible for the severe Pleasant Valley earthquake (Jones, 1915; Page, 1935). At this time, an internal north-south fault high in the Stillwater Range was reactivated, forming a fresh scarp 1 to 3 feet high. This fault is 5 to 7 miles north of the area shown on the accompanying map.

In July and August of 1954, faulting occurred along the east base of Rainbow Mountain, just west of the southern Stillwater Range. This created the Fallon-Stillwater earthquakes, of magnitude 6.8 on the Richter scale (Byerly, 1956; see also other reports on following pages of this volume). The fault displacements reached the ground surface.

On December 16, 1954, the Dixie Valley-Fairview Peak earthquakes (Tocher, 1957; see also other reports on following pages of this volume) originated from displacements on a number of separate faults in a zone extending from Dixie Meadows to a point 60 miles south of the east foot of Slate Mountain (see fold-out map in Slemmons, 1957). The two most important displacements occurred along the east base of Fairview Peak (southeast of the area mapped in this report) and along the east base of the Stillwater Range. The Fairview Peak fault movement produced an earthquake of magnitude 7.1 (Romney, 1957, p. 305). About 4 minutes and 20 seconds later, movement along the juncture of the Stillwater Range and Dixie Valley produced a second earthquake of magnitude 6.8. Romney's (1957, p. 306) analysis of seismic data placed the focus of the second earthquake at lat. 39.8° N., long. 118.1°W., depth approximately 40 km. This location falls under the eastern part of the range near the mouth of Hare Canyon. Probably the actual focus was on the marginal fault which bounds the range, somewhat east of the surface trace of the fault, inasmuch as the latter dips 45 to 75° E. The depth of focus may have been a good deal less than 40 km.

The fault movements of December 16, 1954 displaced the surface of the ground, as described by Slemmons (1957), leaving steep scarps *that are marked by hachures on the accompanying map. The scarps are 1 inch to 12 feet high, but commonly surmount miniature graben,* and therefore tend to exceed the net vertical displacement. Neglecting the miniature graben, the net vertical displacement is about 7 feet maximum. No significant strike slip occurred at the surface, although right lateral slip was observed in other parts of the region, especially along the east base of Fairview Peak south of U. S. Highway 50. Most of the 1954 faulting within the map area occurred at the immediate foot of the Stillwater Range. However, some displacements took place on the alluvial slopes at distances of 1 to 3 miles from the base of the mountains, where low late Pleistocene scarps were increased in height by a small increment, usually less than 3 feet. Everywhere along the foot of the mountain the west side of the faults rose relative to the east side. Displacements far out in the alluvium are mainly in the same sense, but are locally contrary. Most of the scarps shown on the map probably mark the traces of normal faults which dip in the direction of the relatively downthrown block.

Geodetic measurements of ground movements are summarized by Whitten (1957). Relative to points about 40 miles to the east and to the west, the Stillwater Range seems to have remained almost stationary, but Dixie Valley may have dropped as much as 7 feet (e.g., near IXL Canyon). Two triangulation stations on the east side of Dixie Valley, near Horse Creek and Wonder, moved southeast 3.4 feet and 3.7 feet respectively, relative to Job Peak. This probably represents elastic rebound subsequent to long-term regional movements of comparable magnitude. Whitten (1957, p. 323) notes that the disparity between the azimuth of crustal movement and the strike of the faults indicates a component of east-west extension, which would be consistent with displacement on north-south normal faults.

The recent faulting is a continuation of Quaternary vertical adjustments in response to gravity, caused by reduction of pressure in the east-west direction. Superimposed on these adjustments is a northwest-southeast right lateral component, most clearly evidenced south of Dixie Valley. This type of horizontal movement characterizes strain in coastal California, and now appears to affect the earth's crust inland at least as far as the region discussed here.

Crustal characteristics and block faulting in west-central Nevada, including the Stillwater Range, are discussed by Thompson (1959), with emphasis upon gravity data. The same author (1960) suggests that the east-west distension of the crust and the consequent normal faulting may result from a phase change near the boundary between crust and mantle.

MINERAL DEPOSITS

Copper

The Coppereid camp (now abandoned) in White Cloud Canyon, produced minor amounts of copper in the last century, and briefly supported a small smelter about 1893 (Lincoln, 1923, p. 13). Copper sulfide and secondary minerals occur in contact-metamorphosed limestone with erratically developed skarn and local masses of specularite and pyrite (Ransome, 1909, p. 59-61; Vanderburg, 1940, p. 52-53). A few carloads of copper ore were mined from deposits in diorite in Copper Kettle Canyon (Lincoln, 1923, p. 2). Copper is recorded from the nickel deposits of Cottonwood Canyon and in small showings between Cottonwood Canyon and White Rock Canyon 8 miles to the southwest. These showings, which are chiefly chalcopyrite and oxidation products in Jurassic basalt, are described by Carpenter (1911) and Vanderburg (1940, p. 47). Reportedly, they yielded a few wagon-loads of ore in 1861. Recurrent attention is accorded the "Bradshaw property" in altered Jurassic basalt in White Rock Canyon 10 miles north of Dixie Meadows. Copper minerals are found in limestone and lime-silicate rocks in the Sand Springs district 1 mile north of U. S. Highway 50, and in mine workings just west of the Summit King gold mine.

Fluorspar

Several hundred tons of fluorspar have been mined from small veins in limestone interbedded with slate near Cox Canyon (Horton, 1961, p. 9). The deposits border a mineralized normal fault 1 mile northeast of the mouth of the canyon. Other occurrences are reported from contact zones of granitic plutons. Fluorite is mentioned as a minor gangue mineral near the copper deposits of White Cloud Canyon, and occurs in a prospect in limestone near quartz monzonite in La Plata Canyon.

Gold

One of the few successful gold mines in the area was the Summit King, on U. S. Highway 50, where gold and silver were recovered from a vein of lamellar quartz. The vein strikes east-west, transecting Upper Triassic(?) schist and highly altered post-Triassic basalt. This mine was among the 10 largest producers of gold and silver in the State in 1948-49.

Small veins in Triassic slate and interbedded quartzite formerly attracted much unsuccessful prospecting in the Shady Run district encompassing Fondaway, Shady Run, Shanghai, and Mill canyons (Lincoln, 1923, p. 9; Vanderburg, 1940, p. 43). A small amount of gold and silver was produced from quartz and calcite veins in limestone in IXL Canyon, and prospects have been opened on the other side of the range in the watershed of Cox Canyon (Vanderburg, 1940, p. 32-35).

The Dixie Comstock mine at the east foot of the Stillwater Range near Humboldt Salt Marsh yielded a small amount of gold and silver from a vein in the marginal fault zone, but hot water was encountered (Vanderburg, 1940, p. 48) and the mine was closed. Gold is said to accompany albitic dikes in altered diorite in Corral Canyon (Ferguson, 1939, p. 18-19).

Iron

High grade magnetite ore has been successfully mined from deposits of small to moderate size in the Buena Vista Hills (Reeves, and Kral, 1955), and has been found in less accessible deposits in the Stillwater Range between lat. 39°50' and 40°02'N. In nearly all cases, the ore is in altered Jurassic basaltic or gabbroic rocks and is genetically related to the latter.

Nickel

Nickel and cobalt were mined in Cottonwood Canyon for 8 years in the 1880's, and briefly thereafter. Annabergite, $Ni_3As_2O_8H_2O$, and various other nickeliferous minerals occur with iron oxide in small stringers. Some of the stringers are in highly altered "aplite" (albitized rock?) near a fault close to the contact between extrusive Jurassic basalt and intrusive diorite. Other stringers are in highly altered basalt near the diorite contact. (Ferguson, 1939. See also Ransome, 1909, p. 55-58).

Quicksilver

Traces of cinnabar occur in the tungsten ore of Fondaway Canyon (see below), and have been reported elsewhere in the district. There has been little or no successful exploitation of quicksilver, however.

Silver

Silver was briefly mined near the main forks of La Plata Canyon in the early 1860's, and a small town and stamp mill were established. La Plata was the county seat from 1864 to 1868. Reportedly the main deposit was a quartz vein in granite, but other veins in the district are in limestone or slate near intrusives. There is no evidence of substantial production (Vanderburg, 1940, p. 38-39).

The most important silver output has come from the Summit King mine, described under "Gold". This mine ranked among Nevada's three largest producers in the period 1948-1951.

Minor amounts of silver accompany whatever gold is present in the various unproductive prospects of the region.

Titanium

Certain late-stage albitic members of the Upper Jurassic gabbroic and dioritic complex are highly titaniferous, and have been examined for possible titanium ore. One of the best known localities is Corral Canyon, about 5 miles southwest of Cottonwood Canyon. It is reported that anatase, TiO_2, is contained in white, altered, albitic dikes which transect diorite (Hand, 1955; Beal, 1963, p. 8-9). Similar deposits are reported between Corral Canyon and Cottonwood Canyon along the east flank of the range (Beal, 1963, p. 11). No titanium production has been realized so far.

Tungsten

In the 1950's, a small amount of high grade scheelite ore was mined from a narrow vein alongside a dike in the allochthonous limestone of lower Fondaway Canyon. No skarn is present. Other scheelite showings of high grade but small size occur in skarn adjacent to granodiorite 1 mile south of U. S. Highway 50 in the Sand Springs district. Scheelite occurs 1 mile north of the same highway in somewhat different deposits in limestone. Mineralized skarn is conspicuous at the north margin of the Tertiary quartz monzonite in the vicinity of IXL Canyon, but no appreciable amount of tungsten has been found there as yet.

REFERENCES

Beal, L. H., 1963, Investigation of titanium occurrences in Nevada: Nevada Bur. Mines Rept. 3.

Byerly, Perry, 1956. The Fallon-Stillwater earthquakes of July 6, 1954 and August 23, 1954 Historic introduction: Seismol. Soc. America Bull., v. 46, p. 1-40.

Carpenter, A. H., 1911, Boyer copper deposits, Nevada: Mining and Scientific Press, v. 103, p. 804-805.

Corvalan, J. I., 1962, Early Mesozoic biostratigraphy of the Westgate area, Churchill County, Nevada: unpublished Ph.D. thesis Stanford Univ.

Ferguson, H. G., 1939, Nickel deposits in Cottonwood Canyon, Churchill County, Nevada: Nevada Univ. Bull., v. 33, no. 5, Geol. and Min. Ser. no. 32.

Ferguson, H. G., Muller, S. W., and Roberts, R. J., 1951, Geology of the Winnemucca quadrangle, Nevada: U. S. Geol. Survey, Geol. Quad. Map GQ-11.

Horton, R. C., 1961, An inventory of fluorspar occurrences in Nevada: Nevada Bur. Mines Rept. 1.

Hand, David, 1955, Geology of the Corral Canyon area, Churchill County, Nevada: unpublished M.A. thesis, Univ. of Nevada.

Jones, J. C., 1915, The Pleasant Valley earthquake of October 2, 1915: Seismol. Soc. America Bull., v. 5, p. 190-205.

Lincoln, F. C., 1923, Mining districts and mineral resources of Nevada: Nevada Newsletter Pub. Co., Reno, Nev.

Muller, S. W., Ferguson, H. G., and Roberts, R. J., 1951, Geology of the Mount Tobin quadrangle, Nevada: U. S. Geol. Survey, Geol. Quad. Map GQ-7.

University of Nevada, 1962, Geological, geophysical, and hydrological investigations of the Sand Springs Range, Fairview Valley, and Fourmile Flat, Churchill County, Nevada: Report to Atomic Energy Commission for Shoal Project, Vela Uniform Program, 127 p.

Page, B. M., 1935, Basin-Range faulting of 1915 in Pleasant Valley, Nevada: Jour. Geology, v. 43, p. 690-707.

Page, B. M., 1959, Tectonic record of the Stillwater Range, western Nevada (abs.): Geol. Soc. America Bull., v. 70, p. 1739.

Ransome, F. L., 1909, Notes on some mining districts in Humboldt County, Nevada: U. S. Geol. Survey Bull. 414.

Reeves, R. G., and Kral, V. E., 1955. Iron ore deposits of Nevada. Part A, Geology and iron ore deposits of the Buena Vista Hills, Churchill and Pershing Counties, Nevada: Nevada Bur. Mines Bull. 53, 37 p.

Romney, Carl, 1957, Seismic waves from the Dixie Valley - Fairview Peak earthquakes: Seismol. Soc. America Bull., v. 47, p. 301-319.

Silberling, N. J., and Roberts, R. J., 1962, Pre-Tertiary stratigraphy and structure of northwestern Nevada: Geol. Soc. America Spec. Paper 72, 58 p.

Slemmons, D. B., 1957, Geological effects of the Dixie Valley - Fairview Peak, Nevada, earthquakes of December 16, 1954: Seismol. Soc. America Bull., v. 47, p. 353-375.

Slemmons, D. B., Steinbrugge, K. V. Tocher, Don, Oakeshott, G. B., and Gianella, V. P., 1959, Wonder, Nevada, earthquake of 1903: Seismol. Soc. America Bull., v. 49, p. 251-265.

Speed, R. C., 1962a, Humboldt gabbroic complex (abs.): Geol. Soc. America Spec. Paper 73.

______, 1962b, Scapolitized gabbroic complex, West Humboldt Range, Nevada: unpublished Ph.D. thesis, Stanford Univ.

Speed, R. C., 1963, Layered picrite-anorthosite gabbro sheet, West Humboldt Range, Nevada: Mineralog. Soc. America Spec. Paper 1, p. 69-77.

Speed, R. C., and Page, B. M., 1964, Association of gabbroic complex and Mesozoic thrusts, west central Nevada [abs.]: Geol. Soc. America Spec. Paper 82, p. 278-279.

Thompson, G. A., 1959, Gravity measurements between Hazen and Austin, Nevada: A study of Basin-Range structure: Jour. Geophys. Research, v. 64, p. 217-229.

Thompson, G. A., 1960, Problem of Late Cenozoic structure of the Basin Ranges: Internat. Geol. Cong., 21st, Copenhagen 1960, pt. 18, p. 62-68.

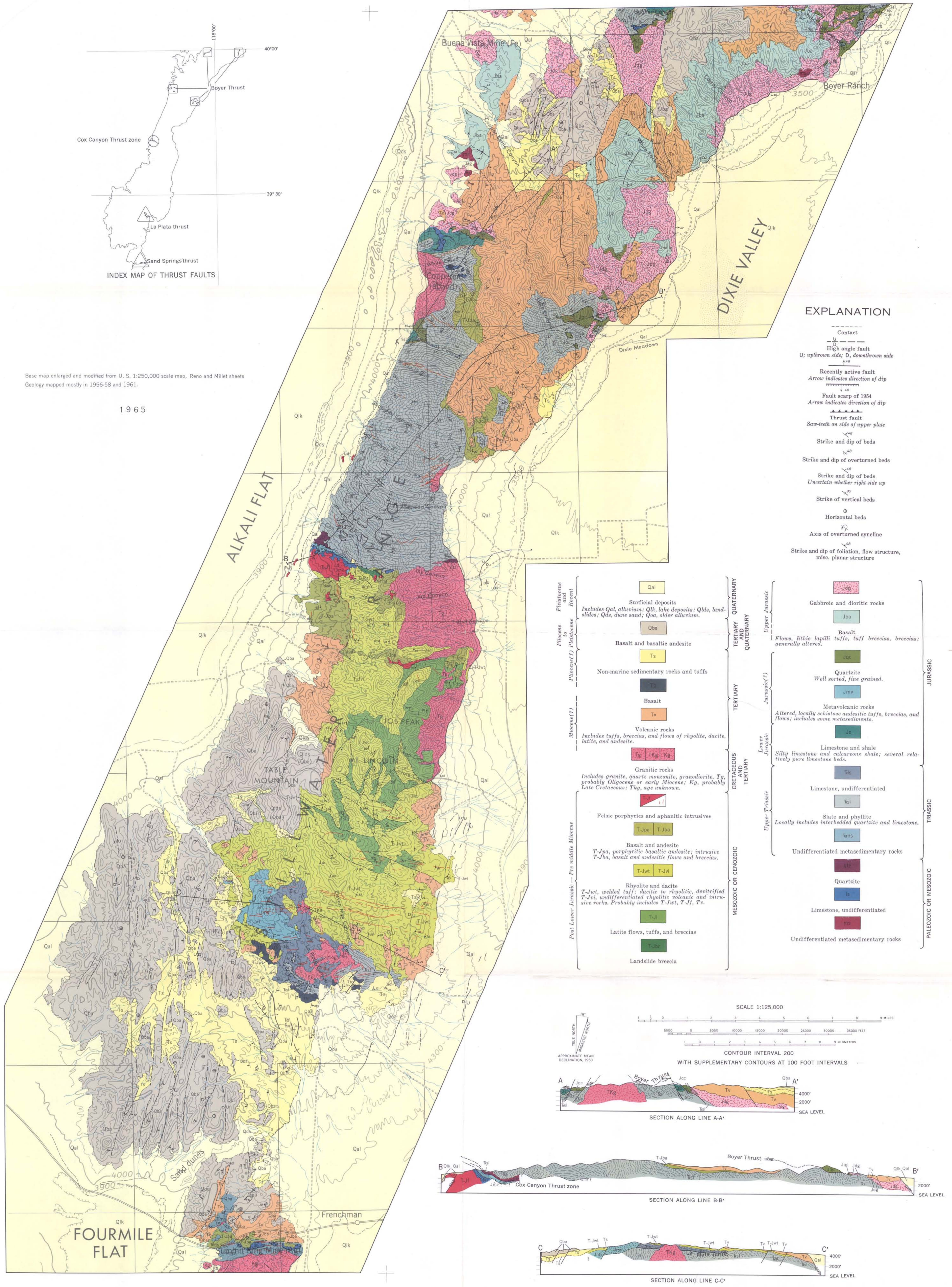
Tocher, Don, 1957, The Dixie Valley - Fairview Peak earthquakes of December 16, 1954: Introduction: Seismol. Soc. America Bull., v. 47, p. 299-300.

Vanderburg, W. O., 1940, Reconnaissance of mining districts in Churchhill County, Nevada: U. S. Bur. Mines Inf. Circ. 7093.

Wallace, R. E., Silberling, N. J., Irwin, W. P., and Tatlock, D. B., 1959, Preliminary geologic map of the Buffalo Mountain quadrangle, Nevada: U. S. Geol. Survey Mineral Inv. Field Studies Map MF-220.

Whitten, C. A., 1957, Geodetic measurements in the Dixie Valley area: Seismol. Soc. America Bull., v. 47, p. 321-325.

Young, Chapman, 1963, The geology north of White Cloud Canyon, Stillwater Range, Nevada: unpublished M.S. thesis, Stanford, Univ.



INDEX MAP OF THRUST FAULTS

Base map enlarged and modified from U. S. 1:250,000 scale map, Reno and Millet sheets
Geology mapped mostly in 1956-58 and 1961.

1965

EXPLANATION

Contact

High angle fault
U; upthrown side; D, downthrown side

Recently active fault
Arrow indicates direction of dip

Fault scarp of 1954
Arrow indicates direction of dip

Thrust fault
Saw-teeth on side of upper plate

Strike and dip of beds

Strike and dip of overturned beds

Strike and dip of beds
Uncertain whether right side up

Strike of vertical beds

Horizontal beds

Axis of overturned syncline

Strike and dip of foliation, flow structure, misc. planar structure

QUATERNARY — Pleistocene and Recent
- Qal — Surficial deposits. *Includes Qal, alluvium; Qlk, lake deposits; Qlds, landslides; Qds, dune sand; Qoa, older alluvium.*

TERTIARY AND QUATERNARY — Pliocene to Pleistocene
- Qba — Basalt and basaltic andesite

TERTIARY — Pliocene(?)
- Ts — Non-marine sedimentary rocks and tuffs
- Tb — Basalt

TERTIARY — Miocene(?)
- Tv — Volcanic rocks. *Includes tuffs, breccias, and flows of rhyolite, dacite, latite, and andesite.*

CRETACEOUS AND TERTIARY
- Tg, TKg, Kg — Granitic rocks. *Includes granite, quartz monzonite, granodiorite. Tg, probably Oligocene or early Miocene; Kg, probably Late Cretaceous; Tkg, age unknown.*

MESOZOIC OR CENOZOIC — Post Lower Jurassic — Pre middle Miocene
- T-Jf — Felsic porphyries and aphanitic intrusives
- T-Jpa, T-Jba — Basalt and andesite. *T-Jpa, porphyritic basaltic andesite; intrusive T-Jba, basalt and andesitic flows and breccias.*
- T-Jwt, T-Jvi — Rhyolite and dacite. *T-Jwt, welded tuff; dacitic to rhyolitic, devitrified T-Jvi, undifferentiated rhyolitic volcanic and intrusive rocks. Probably includes T-Jwt, T-Jf, Tv.*
- T-Jl — Latite flows, tuffs, and breccias
- T-Jbr — Landslide breccia

JURASSIC — Upper Jurassic
- Jdg — Gabbroic and dioritic rocks
- Jba — Basalt. *Flows, lithic lapilli tuffs, tuff breccias, breccias; generally altered.*

JURASSIC — Jurassic(?)
- Jqc — Quartzite. *Well sorted, fine grained.*
- Jmv — Metavolcanic rocks. *Altered, locally schistose andesitic tuffs, breccias, and flows; includes some metasediments.*

JURASSIC — Lower Jurassic
- Js — Limestone and shale. *Silty limestone and calcareous shale; several relatively pure limestone beds.*

TRIASSIC — Upper Triassic
- TRls — Limestone, undifferentiated
- TRsl — Slate and phyllite. *Locally includes interbedded quartzite and limestone.*
- TRms — Undifferentiated metasedimentary rocks

PALEOZOIC OR MESOZOIC
- qtz — Quartzite
- ls — Limestone, undifferentiated
- ms — Undifferentiated metasedimentary rocks

SCALE 1:125,000

CONTOUR INTERVAL 200
WITH SUPPLEMENTARY CONTOURS AT 100 FOOT INTERVALS

SECTION ALONG LINE A-A'

SECTION ALONG LINE B-B'

SECTION ALONG LINE C-C'