N. E. ¼ SHOSHONE QUADRANGLE

GEOLOGY OF THE N.E. QUARTER OF THE SHOSHONE 15' QUADRANGLE CALIFORNIA

by

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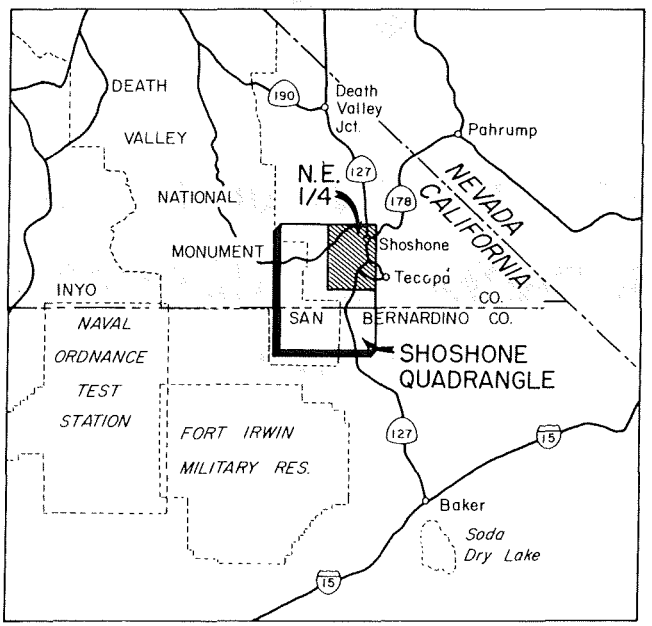

Index map showing location of
Shoshone Quadrangle, California.

INTRODUCTION

The northeast quarter of the Shoshone 15-minute quadrangle includes an area of about 65 square miles in the southeastern part of Inyo County, about midway between the Death Valley trough in California and the California-Nevada boundary. The rocks that crop out in the quadrangle range in age from Precambrian to Holocene. They include granite gneiss of Precambrian age; intermixed beds of marine limestone, shale, sandstone and quartzite of Early and Middle Cambrian age; quartz monzonite, lava flows and tuffs of Late Tertiary age; lava flows and lacustrine sediments of Quaternary age; and Holocene allluvium. All of these rocks, with the exception of the Precambrian gneiss and Quaternary lacustrine deposits, are well exposed in the Dublin Hills, just west of Shoshone. Fossil remains consist of camel bones in Quaternary volcanic ash interbedded with lacustrine sediments, algal forms in Lower and Middle Cambrian limestone, and trilobite casts and molds in Middle Cambrian shale.

The several types of faults in the area, especially normal and lateral faults, have played a major role in the development of the Dublin Hills.

ROCK UNITS

Precambrian Rocks

The oldest rock in the area is Precambrian granite gneiss which comprises the nose of an eastward-tapering ridge in the southwest corner of the mapped area. It is in fault contact with Stirling Quartzite. The granite gneiss is foliated, coarse grained, and is characterized by porphyroblasts of pink microcline and clots of biotite flakes. It is intruded by dikes of porphyritic rhyolite (Tertiary?) and dark diorite (Precambrian). In nearby regions granite gneiss lies unconformably beneath (younger) Precambrian and Cambrian sedimentary rocks.

Diorite intrudes the Precambrian granite gneiss. The diorite occurs as dikes, of which the largest is several tens of feet wide and can be traced along its strike length for about 3,000 feet. The rock is greenish-gray in color, medium grained and consists principally of much-twinned plagioclase (An_{45-50}) and greenish-brown hornblende. The diorite appears to have been weakly metamorphosed, but not by the same deformation which formed the granite gneiss, which the diorite intrudes. The diorite is similar in composition to metadiorite

which crops out extensively in the Funeral Peak quadrangle, some 20 miles northwesterly from the southwestern corner of the mapped area. Drewes (1963, p. 9–10) assigns an Early Precambrian age to the metadiorite, and on the basis of similarity of the composition of the diorite to the metadiorite, the diorite is considered also to be of Early Precambrian age.

Upper Precambrian-Cambrian Rocks

An almost complete succession of uppermost Precambrian to Middle Cambrian marine sedimentary rocks is exposed in the northeast quarter of the Shoshone quadrangle, including the Noonday Dolomite, Johnnie Formation, Stirling Quartzite, Wood Canyon Formation, Zabriskie Quartzite, and Carrara and Bonanza King Formations.

Noonday Dolomite is the lowermost formation of the sedimentary succession in this area. It is well exposed in the southwestern corner of the quadrangle where it forms bold, prominent exposures. The dolomite is massive, poorly bedded, light creamy-gray to cream colored, and weathers to a pale buff color. The rock is largely an algal dolomite, but locally contains coarse grit and fine gravel composed of well-rounded pebbles of red and brown colored jasper, black chert and white quartz.

Unidentified algal forms are the only suggestion of fossils found in the Noonday Dolomite. Because of the position of the dolomite at the base of an unbroken sedimentary sequence of known Late Precambrian-Early Cambrian age, the Noonday Dolomite has long been assigned a Precambrian-Cambrian age and is so considered herein.

The *Johnnie Formation* crops out in the southwestern corner of the quadrangle where it occurs in fault contact with the Noonday Dolomite and the Stirling Quartzite. Its conformable position between the Noonday Dolomite and the Stirling Quartzite is clearly established in adjacent areas. The Johnnie Formation is here subdivided into three units: A lower unit of quartzite and dolomite; a middle unit of quartzite and and shale; and an upper unit of shale, quartzite, and dolomite. The lower unit is chiefly interbedded quartzite and siliceous dolomite. The quartzite ranges from massive thick bedded to platy and is gray to brownish-red in color. The sandy dolomite is fine grained, strongly crossbedded, and contains varying proportions of angular quartz sand grains and well-rounded pebbles in a massive dolomitic matrix. A bed of oolitic limestone, 2 to 8 feet thick, occurs between two dolomite layers in the southwest corner of the mapped area.

The ooliths are siliceous, red and white in color, and from 1.5 to 2 mm in maximum dimension. The middle unit consists largely of gray to brown, massive quartzite beds and minor thin interbeds of shale. The quartzite beds are as much as two feet thick and consist of clear, well-rounded grains of quartz, some feldspar grains, and pale mica flakes. The interbeds of shale are light tan to brown in color when fresh and dark brown when weathered. Near the top of the middle unit are a few beds of sandy dolomite and thin interbeds of greenish-gray shale. The upper unit shows distinct lateral variation in lithology in which buff dolomite and maroon shale grade into greenish-gray shale. It consists of interbedded greenish-gray shale, fine-grained, dark-brown quartzite and buff-colored dolomite with individual beds ranging up to one foot in thickness.

The Johnnie Formation is unfossiliferous, but on the basis of lithologic characteristics it is readily correlated with portions of the Johnnie Formation described by Hazzard (1937, p. 303–306) in the Nopah-Resting Spring Ranges further east. The Johnnie Formation originally described in the Spring Mountains of Nevada (Nolan, 1929, p. 461–463) and later in the Nopah and Resting Spring Ranges has been included by Hazzard (1937) in the Lower Cambrian; the Johnnie Formation in the northeast quarter of the Shoshone 15-minute quadrangle, though more than 1,000 feet below the earliest Cambrian fossils, is considered by Mason (1948) as Precambrian-Cambrian.

The *Stirling Quartzite* is best exposed in the southwestern corner of the mapped area. There it is in fault contact with the underlying Johnnie Formation and lies conformably beneath the younger Wood Canyon Formation. Stirling Quartzite also crops out on the north flank of the Dublin Hills where it is in fault contact with the Wood Canyon Formation or lies completely surrounded by Quaternary alluvium. The Stirling Quartzite, although almost wholly composed of quartz grains, has been subdivided into three units: A lower unit of quartzite and shale; a middle unit of shaly quartzite; and an upper unit of quartzite. The lower unit consists principally of light gray, dense, fine to coarse-grained, locally-crossbedded quartzite. The beds are distinct, platy, and may be as much as six feet thick in individual beds. Greenish-gray and purplish shale partings are common. The middle unit is greenish-gray to red, shaly to platy quartzite. Locally, the quartzite is micaceous, and in places contains poorly preserved ripple marks. The upper unit consists of medium- to coarse-grained, light-gray massive quartzite. Crossbedding is common and beds are as much as four feet in thickness.

The Stirling Quartzite is considered as Precambrian-Cambrian in age on the basis of its conformable relationship with the overlying Wood Canyon Formation and its close similarity in lithology to the Stirling Quartzite exposed in the Spring Mountains of Nevada (Nolan, 1929, p. 463).

Wood Canyon Formation is well exposed in the southwestern corner of the mapped area and in the Dublin Hills. In the Dublin Hills, where at least the upper 2,000 feet of the formation are exposed, the base of the Wood Canyon Formation was not observed, but a conformable contact with the overlying Zabriskie Quartzite is readily observable at a number of places. The Wood Canyon Formation can be subdivided into three units: A lower unit of sandstone, shale, and quartzite; a middle unit of quartzite, sandstone and shale; and an upper unit of shale, quartzite and dolomite.

The sandstone of the lower unit is fine- to coarse-grained, gray to reddish-brown in color, and occurs in beds that range in thickness from a few inches to three feet. The sandstone differs from the quartzite only by being less firmly cemented and consolidated. Thin lenticular pebble beds, consisting of well-rounded pebbles of reddish jasper in a sandy matrix, are interbedded with the sandstone. The shale occurs as interbeds in the sandstone and is generally greenish-gray in color. About 500 feet above the base of the lower unit maroon-colored shale occurs in beds up to five feet in thickness. Scattered throughout the sandstone are layers of buff-colored, clayey dolomite as much as twenty feet in thickness. Quartzite makes up the upper portion of the lower unit. The quartzite is gray and weathers to a reddish-brown color. It is dense, well bedded, and ranges in sand grain size from coarse to fine. Crossbedding is common in the quartzite.

The middle unit consists largely of quartzite, but contains minor amounts of sandstone and shale. It is reddish-brown in color, fine-grained and consists largely of angular quartz grains. Interbedded with the quartzite are thin layers of greenish-gray, micaceous shale. Casts of trilobite fragments and brachiopod shells are preserved in sandstone associated with the quartzite.

The upper unit of the Wood Canyon Formation consists of shale, quartzite, and dolomite. The shale is greenish-gray in color, fine-grained, fissile and cleaves easily into thin plates. The quartzite is brownish in color, fine grained and platy. Dolomite is common in the upper unit. It is dense, dark gray and commonly weathers to a dirty brown color. The dolomite contains noticeable amounts of angular quartz grains.

A maximum of 2,100 feet of Wood Canyon Formation was measured in the southern part of the Dublin Hills. A tentative

age assignment of the Wood Canyon Formation to Lower Cambrian has been based upon sand casts of trilobites found in the middle unit, and upon its gradational relationship with the overlying Zabriskie Quartzite which contains *Mesonacis fremonti* Walcott and *Paedumias clarki* Resser, both well-established Lower Cambrian fossils.

The *Zabriskie Quartzite* was proposed as a member of the Wood Canyon Formation by Hazzard (1937, p. 309) for a 160-foot thick sequence of quartzite exposed in the Resting Spring Range immediately east of Shoshone. In 1948, Wheeler (p. 26) designated formational rank for the Zabriskie Quartzite which, on the basis of its conformable relationship to the underlying Lower Cambrian Wood Canyon Formation and the overlying Middle Cambrian Carrara Formation, is considered to be Early Cambrian in age.

The Zabriskie Quartzite crops out prominently in the Dublin Hills, especially in the western part of the hills where an almost continuous, yet faulted, belt of pink-weathering quartzite may be traced for 2½ miles. Complete sections of the Zabriskie Quartzite crop out at several places in the southwestern part of the Dublin Hills. The upper 100 feet of the formation consist of massive, fine- to medium-grained, light gray to pinkish-gray and distinctly crossbedded quartzite. Quartz, in rounded grains, is the principal mineral present. The remainder of the formation below the massive quartzite is well bedded, reddish-brown shaly quartzite which locally is conglomeratic. The basal 10–15 feet of the Zabriskie Quartzite is light gray, reddish-brown-weathering, massive quartzite in which occur vertical tube-like structures whose origin is not definitely known, but which resemble sand-filled burrows of forms like *Scolithus*. The Zabriskie Quartzite has a maximum thickness of 165 feet in the Dublin Hills.

The *Carrara Formation,* named for an abandoned mining camp near Beatty, Nevada (Cornwall and Kleinhampl, 1961), is well exposed in the northern and southwestern portions of the Dublin Hills where it conformably overlies the Zabriskie Quartzite and grades upward into the overlying Middle Cambrian Bonanza King Formation. The Carrara Formation includes all of Hazzard's Cadiz Formation (1937, p. 314) and that portion of the Wood Canyon Formation of Hazzard which lies above the Zabriskie Quartzite. A typical section at least 1,300 feet thick measured in the eastern part of section 3, T. 21 N., R. 6 E., S. B. M., includes interbedded micaceous, greenish-gray, sandy shale and sandstone at the bottom, grading upwards through dark brown quartzite, greenish-gray, micaceous sandy shale, greenish-gray, glauconitic shale and thin-bedded, gray to brown limestone into well-bedded,

yellowish-brown, locally nodular limestone with thin interbeds of mottled mudstone at the top. Algal *(Girvanella)* limestone beds occur near the bottom of the formation, and on the basis of trilobite remains found in the shale zones throughout the formation, the age of the Carrara Formation is considered to be Early and Middle Cambrian.

The *Bonanza King Formation* has the greatest exposed areal extent of all the Cambrian formations in the area mapped. It forms dark gray somber cliffs on the east side of the Dublin Hills which are easily visible from points on California Highway 127 south of Shoshone. The formation consists principally of massive dolomite and incompletely dolomitized limestone in beds ranging in thickness from a few inches to 10 feet. The dolomitized limestone ranges in color from light gray to dark gray. The Bonanza King Formation, as mapped in the Dublin Hills, is at least 1,800 feet thick. The age of the Bonanza King Formation is considered to be middle Upper Cambrian. It correlates well on a lithologic and stratigraphic basis with the Bonanza King Formation in the Nopah Range (Palmer and Hazzard, 1956, p. 2495) and at Bare Mountain, Nevada (Cornwall and Kleinhampl, 1961). It has a gradational contact with the underlying Carrara Formation which has been dated as Early and Middle Cambrian.

Tertiary Rocks

Quartz monzonite, lamprophyre, dacite, andesite, rhyolite, perlite, vitrophyre, tuff and tuff breccia of Cenozoic age are exposed in the northeast quarter of the Shoshone quadrangle.

The oldest of these Tertiary rocks is a body of quartz monzonite which is well exposed in the southern part of the Greenwater Range. This rock is medium gray in color, medium grained, moderately porphyritic, and locally has an aplitic texture. An age of 18.8 $\pm$ 1.2 million years has been assigned to this rock on the basis of one sample by the K-Ar method of dating (Geochron Laboratories, Inc., 1963). Although this age differs from the calculated age of 30 $\pm$ 10 million years assigned by Drewes (1963, p. 19) to a lithologically similar quartz monzonite in the Funeral Mountains about 12 miles west of the Greenwater Range, it falls within the broad range of time for intrusion and subsequent uplift and erosion of the quartz monzonite before the deposition of the overlying Tertiary lavas and pyroclastic deposits.

Dikes of lamprophyre, ranging in (width) thickness from less than one foot to several feet, occur in the quartz monzonite of the southern part of the Greenwater Range.

The lamprophyre is dark gray to dark greenish-gray in color, porphyritic and contains phenocrysts of dark green hornblende enclosed in a holocrystalline groundmass composed of hornblende, andesine and minor biotite.

Layers of tuff and tuff breccia interbedded with flows of rhyolite are common in the Dublin Hills. One layer of tuff breccia which appears to represent an early period of volcanic activity, is well-exposed in the northern part of the Dublin Hills where it underlies the other lava flows and pyroclastic rocks. The early tuff breccia is massive, yet shows well-defined bedding. It consists principally of angular and subrounded fragments of finely vesicular, grayish-white pumice as much as four inches in maximum diameter and moderate amounts of angular fragments of brown andesite, dark brown basalt, and gray and pink rhyolite all enclosed in a moderately consolidated matrix of gray ash. Other pyroclastic rocks, primarily tuffs of later periods of volcanic activity, are lacking in the basalt fragments, are less massively bedded, and are in general finer grained. Some of these tuffs exhibit bedding, whereas others are devoid of bedding.

Dacite, a porphyritic to non-porphyritic rock containing sodic plagioclase (An_{15-20}), golden-brown biotite and glassy quartz in a groundmass of small feldspar laths and minor augite, occurs as flows and dikes near the western margin of the mapped area. The dacite flows rest conformably upon light-colored tuff beds and are overlain, in turn, by a conglomerate layer about 75 feet thick. The conglomerate contains well-rounded pebbles and cobbles of dacite and quartzite, and it appears to have been derived, in part, from the dacite and from the Stirling Quartzite upon which it rests.

Rhyolite and associated glassy rocks, including perlite and vitrophyre, are very common and widely distributed in the Dublin Hills and the southern end of the Greenwater Range. The rhyolite occurs generally in flows, although dikes, sills, and small dome-like masses are not rare. Rhyolite flows are as much as several tens of feet in thickness, and at one place in the eastern part of section 27, T. 22 N., R. 6 E., S. B. M. in the eastern part of the Dublin Hills, an aggregate thickness of 150 feet of rhyolite can be seen. The rhyolite is generally pink to light gray in color, fine-grained and weakly porphyritic. Flow banding is distinct and generally contorted.

Both perlite and vitrophyre are closely associated with the rhyolite and represent the glassy tops and bottoms of rhyolite flows and sills. Small bodies of perlite completely enclosed within rhyolite represent local glassy phases of the rhyolite. Complete gradations of rhyolite into perlite and vitrophyre are common. The perlitic phases range in thickness from a

subordinate sands. The pebbles and boulders are well-rounded and are derived from the various rock sources exposed in the neighboring hills and mountains. In addition to being well-rounded, those clasts that are exposed at the surface are coated by desert varnish.

Alluvial fans flank the Dublin Hills and the ridges that extend eastward from Sheephead Mountain, and alluvium covers much of Greenwater Valley. The fans contain gravel and as they approach the valley bottoms, they grade into sand and fine silt. The alluvial covering at the bottom of Amargosa Valley is fine-grained sand and silt and contains appreciable amounts of sodium chloride and sodium sulfate. The white sodium salts are particularly noticeable along the course of the Amargosa River and along State Highway 127 between the ruins of the Amargosa borax works and Shoshone.

STRUCTURE

Faults are abundant in the northeast quarter of the Shoshone quadrangle. Minor folds can be found in the Quaternary lacustrine sediments south of Shoshone.

Normal faults are numerous in the Dublin Hills and are probably related to buried normal faults which were responsible for uplift of the hills, which are part of the Basin-Ranges Province of California. Although many of the normal faults are transverse to the general trend of the Dublin Hills, several are parallel to the trend of the hills. One of these latter faults is just east of the west side of the Dublin Hills, and it has been responsible for down-dropping the westernmost block composed of interbedded lava and pyroclastic deposits. Most of the normal faults have displaced the north and east blocks upward; and this has, in general, extended the rocks in the Dublin Hills in east-west and north-south directions.

Low-angle faults and thrust faults are among the oldest faults in the area. Two low-angle faults occur in the southern part of the Dublin Hills. The low-angle fault on the west side of the hills dips eastward and is present at or near the contact between the Bonanza King and Carrara Formations. Northward, the fault plane cuts across the Carrara Formation and still further north, the Carrara Formation is cut out, and the fault plane forms the contact between the Bonanza King Formation and the Zabriskie Quartzite. The low-angle fault of lesser importance on the east side of the Dublin Hills dips 10 degrees westward in its northern part; probably intersects another low-angle fault at depth and places uppermost Bonanza King on top of lower Bonanza King Formation. This

fault continues northward about one mile and is cut by several westerly-striking transverse faults whose displaced blocks are up on the north.

A segment of the Amargosa thrust fault appears in the southwest corner of the mapped area where fault-bounded masses of upper Precambrian-Cambrian Johnnie Formation and Stirling Quartzite lie upon Precambrian granite gneiss. Traces of the Amargosa thrust fault are not known north of the west-northwest trending fault which crosses the Ibex Hills and extends several miles to the northwest.

Lenticular masses of brecciated dolomite of the Bonanza King Formation occur interbedded with flows of rhyolite and layers of tuff breccia on the north flank of the Dublin Hills. The largest of these masses of monolithologic breccia rests upon a rhyolite flow and is, in turn, overlain by well-bedded tuff and basalt. Because of the lack of fault contacts between the bodies of breccia and the volcanic rocks, it is concluded that the masses of brecciated Bonanza King dolomite are sedimentary in origin and do not represent the forward edges of a thrust fault.

MINERAL DEPOSITS

Borax was one of the earliest mineral commodities to be mined in the northeast quarter of the Shoshone 15-minute quadrangle. From 1882 to 1890 borax was recovered by the evaporation of spring waters at the Amargosa borax works whose remains are alongside State Highway 127 about six miles south of Shoshone.

Pumicite (volcanic ash) has been mined extensively from the uppermost volcanic ash layer which is well exposed in the low terraced hills immediately west of Shoshone. The ash layer can be traced on the surface for several miles, and pumicite has been mined from it at two localities. One is just a few hundred yards southwest of Shoshone and the other is in a shallow gully about a quarter of a mile southeast of the southern end of the Dublin Hills.

Bentonite was mined by open pit methods from a clay deposit located about a quarter of a mile west of Shoshone. The bentonite was derived from the volcanic ash through alteration by spring waters.

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