STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES

GEOLOGY OF THE BLUE LAKE QUADRANGLE CALIFORNIA

BULLETIN 148
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DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO

STATE OF CALIFORNIA
EARL WARREN, Governor
DEPARTMENT OF NATURAL RESOURCES
WARREN T. HANNUM, Director

DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO
OLAF P. JENKINS, Chief

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GEOLOGY OF THE BLUE LAKE QUADRANGLE CALIFORNIA

By GEORGE A. MANNING
and
BURDETTE A. OGLE

LETTER OF TRANSMITTAL

To His Excellency
THE HONORABLE EARL WARREN
Governor of the State of California

SIR: I have the honor to transmit Bulletin 148, *Geology of the Blue Lake Quadrangle, California,* prepared under the direction of Olaf P. Jenkins, Chief of the Division of Mines, Department of Natural Resources. The most important part of this report is its accompanying geologic map printed as a lithograph in color. It covers an area of about 250 square miles, located in the north central part of Humboldt County.

The authors, George A. Manning and Burdette A. Ogle, prepared the report after mapping the geology of the quadrangle as a project of a research program with the University of California and in connection with graduate study. Much of the area is inaccessible to ordinary travel and is generally unknown to persons in developmental or scientific work. It is hoped that the publication of this new material will stimulate a general interest in this frontier and little known region of California.

Respectfully submitted,

WARREN T. HANNUM, Director
Department of Natural Resources

December 2, 1949

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ILLUSTRATIONS

GEOLOGY OF THE BLUE LAKE QUADRANGLE, CALIFORNIA †

By George A. Manning *
and Burdette A. Ogle **

ABSTRACT

The Blue Lake quadrangle, Humboldt County, California, is largely in the northern Coast Ranges but its eastern portion lies in the edge of the Klamath Mountain Province.

Three formations were mapped. The oldest, the Kerr Ranch schist, is a series of quartz-muscovite schists, green schists and semi-schists, formed by low grade regional metamorphism of sandstones, shales, conglomerates, cherts, interbedded volcanics and basic and ultra-basic intrusives. These rocks have been but slightly metamorphosed. The formation is pre-Franciscan in age and may be equivalent to the Abrams schist of the Klamath Mountains.

The Franciscan formation, of Upper Jurassic (Tithonian) age, is in fault contact with the Kerr Ranch schist. Franciscan rocks are predominantly dark gray, arkosic sandstones with interbedded volcanics, shales, conglomerates and cherts. Basic and ultra-basic rocks are intrusive into the sediments and volcanics and have locally caused metasomatic alteration. The Franciscan exposed in this area is lithologically similar to the lower part of the Franciscan-Knoxville group.

The Falor formation, in fault contact with the Franciscan, is composed of fine-grained, buff to gray sandstones, clays and minor conglomerates. Assemblages totaling forty-five molluscan and echinoid species indicate that this formation is lower Pliocene to lower middle Pliocene in age.

The area is characterized by complex, repeated faulting. All contacts are along faults. An eastern belt of schist is thrust over Franciscan; an eastern Franciscan belt is thrust from the northeast over a western schist belt; the western schist is thrust, with later possible normal faulting, over the Franciscan; and the Pliocene sediments occur as a down-dropped block, or blocks, in the Franciscan. Two major periods of faulting are apparent. Pre-Pliocene compressive deformation folded the Franciscan and started the thrusting. Normal faulting started at the end of the Pliocene. The general strike of the beds is northwest; the Kerr Ranch schist is highly contorted and forms isoclinal folds, while the Falor beds show a homoclinal dip to the northeast.

Mineral deposits of economic importance have not been found in this region, and there are but a few minor prospects.

INTRODUCTION

The Blue Lake quadrangle is located in northwestern California, in the north central part of Humboldt County. The area is bounded by lat. 40°45′ on the south, and lat. 41°00′ on the north, long. 123°45′ on the

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† Based upon dissertations submitted in partial satisfaction of the requirements for the degree Master of Arts in geology, University of California, Berkeley, 1947. Manuscript submitted for publication June 30, 1947.

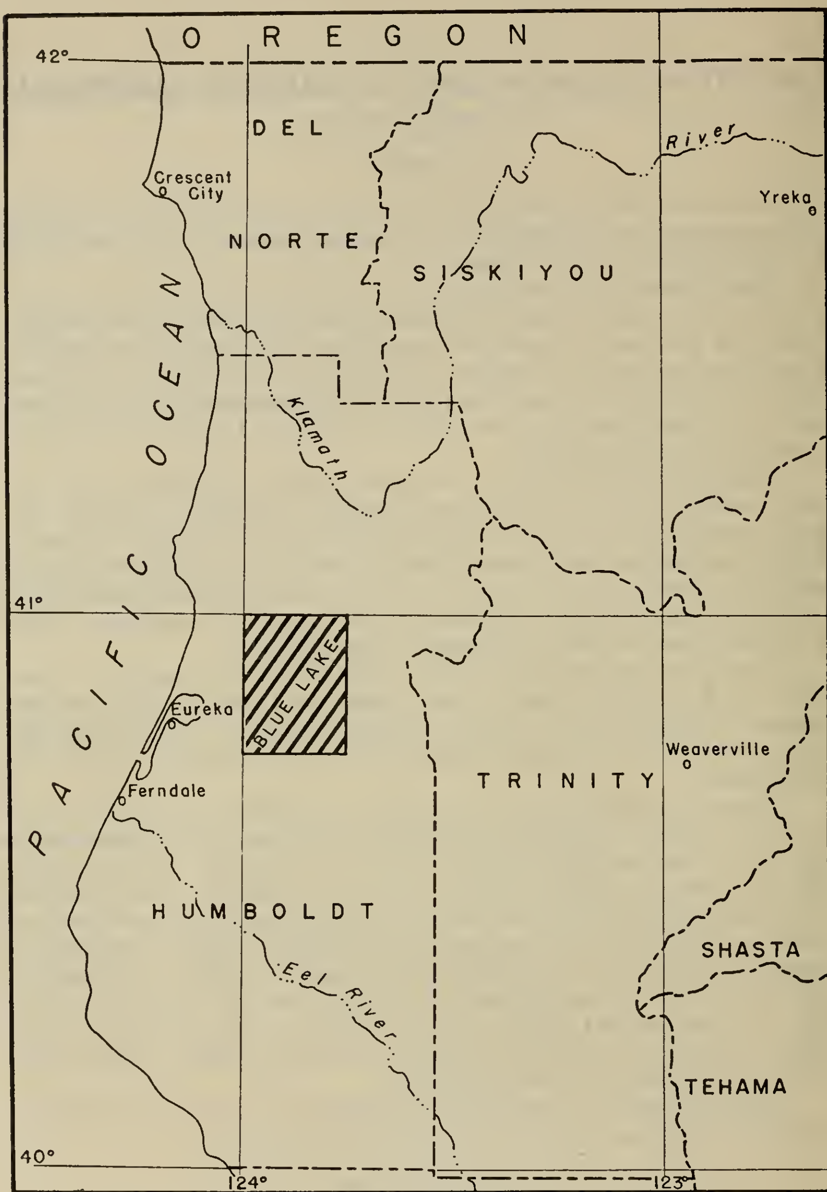

FIG. 1. Index map showing location of Blue Lake quadrangle.

east, and long. 124°00′ on the west. San Francisco is located about 300 miles to the south and Eureka, on Humboldt Bay, is 15 miles to the west. The quadrangle is named for the town of Blue Lake, which is situated in the west central part of the quadrangle. The area lies partly in the Coast Ranges and partly in the Klamath Mountains.

Little is known of the geology of northwestern California, other than that revealed in the reconnaissance mapping of Diller, Hershey, and Lawson in the period, 1894-1911.

The paucity of economic deposits and the lack of topographic base maps have retarded more detailed studies in recent years. Blue Lake quadrangle, which the authors used as a base map, was published by the U. S. Forest Service and Corps of Engineers, U. S. Army in 1943. It has a scale of 1:62,500 and a contour interval of 50 feet. Aerial photographs, with an approximate scale of 1 inch equals 2,000 feet, were also used by the authors. References to locations in this report apply to the standard grid coordinate system.

The quadrangle was mapped in two parts: the northern half by George A. Manning and the southern half by Burdette A. Ogle. This field work was done during the 3 summer months of 1946 and laboratory studies were completed in the spring of 1947.

All thin sections and rock specimens are on file at the University of California. References to thin sections are by University of California catalogue numbers. The fossil locality numbers used are those of the University of California Museum of Paleontology where the material is available for study.

ACKNOWLEDGMENTS

The writers are indebted to Dr. N. L. Taliaferro for encouragement and helpful guidance in the field work; to Dr. F. J. Turner for aid in petrography, for continued encouragement and for reading the manuscript; to Dr. C. M. Gilbert for assistance with mechanical analyses and mineral determinations; to Dr. Leo Hertlein of the California Academy of Science who was invaluable in identifying the Pliocene fossils; and to Dr. Howel Williams for his interest and aid.

Dr. Harry D. MacGinitie of Humboldt State College encouraged the work and did great service in locating several fossil localities.

The writers are grateful to all the landowners in this area, whose cooperation made the field mapping possible. The Northern Redwood Lumber Company, the California Barrel Company, Dr. and Mrs. William J. Kerr, Guy B. Kerr, Myers Gundersen, Mr. and Mrs. George Partout, Mr. and Mrs. Rudy Mora, and Mr. and Mrs. Loftus Grey, were especially helpful.

Financial aid from the Research Council of the University of California is gratefully acknowledged.

Mrs. B. A. Ogle, a constant source of encouragement, helped collect many of the fossils, and performed the arduous task of preparing the collection for identification.

GEOGRAPHY AND TOPOGRAPHY

Accessibility and Industry

U. S. Highway 299, a good hard-surface, all-weather road, crosses the northern part of the quadrangle in a general east-west direction.

Another paved road connects Blue Lake and Korbel. All others are graded gravel, graded dirt, or poorly maintained, dry weather dirt roads. Logging roads are abundant, but most of them are temporary and are not shown on the map. The following graded routes are usually fairly well maintained: Korbel to the Carson Ranch, via Bald Mountain; Korbel to the Wiggins Ranch and from the Wiggins Ranch to the Archibald Ranch; the road from U. S. 299 to the Redwood Creek Ranch; the branch going north from Redwood Creek Ranch along Redwood Creek; and the branch going from Redwood Creek Ranch to the Hoopa Indian Reservation to the northeast.

A railroad operates between Korbel and Arcata, but at present carries only freight and mail. Many trails made either by man, horse, or deer cover the mountainous areas. Some, such as the Hyampom Trail which connects the Russ Ranch with Hyampom Valley in Trinity County, are maintained by the county.

The region is sharply divided into two topographic subdivisions; the bottom land, represented by the area around Blue Lake and the fertile valley to the west, and the mountains that occupy the rest of the area. The bottom land supports intensive truck farming, dairying, and the growing of grasses and alfalfa.

Redwood *(Sequoia sempervirens)* and Douglas fir forests grow in the mountains and lumbering is the principal industry of this area. This industry reached its height 20 to 30 years ago when Korbel, a company town, was booming and a mill at Riverside was operating. Many camps, such as Camp 4 on the Mad River, were in full swing. Small logging railroad lines operated on both sides of Mad River, and the farming population in the surrounding area prospered by selling produce to the lumber companies. The mill at Korbel was closed in the 1930's and has only recently reopened. In the spring of 1947, a mill at the mouth of Boulder Creek was operating and there are many small mills running west of Blue Lake. The redwood timber south of Korbel has now been largely cut and redwood logging at present is confined to the northern part of the area. In the mountains of the central and eastern part of the quadrangle, there is extensive cutting of Douglas fir and to a lesser extent, yellow pine. Second growth brush has rapidly covered cut over areas and many regions that were large open forests, or even old logging railroad right-of-ways, are now nearly impassable. The cutting of tan oaks for tan-bark is a minor yet important lumbering operation in this area.

Cattle and sheep grazing is second in importance to lumbering in the mountainous area. Several large ranches are operated profitably and many small landowners make a comfortable living. The climate in this upland region is warm and dryer than the bottom land area in summer, and is cold with abundant rain and snow in the winter.

Climate

The climate is, in general, moist, and the rainfall increases coastward. The greatest amount of rainfall occurs from November to May. In the lowland regions and for considerable distances up many of the larger streams, fogs are persistent during the winter and throughout most of the summer months.

An annual rainfall of 100 inches may take place at 4000 feet as compared with 40 inches at sea level. U. S. Weather Bureau records [1] show the precipitation at Eureka, from 1887-1937, averaged 39.04 inches per year and the precipitation at China Flat, on the Trinity River in the quadrangle to the east, averaged 43.37 inches for the same period. Both of these areas are below 500 feet elevation. Local inhabitants estimate the average annual precipitation at the eastern Kerr Ranch to have been 90 inches per year, over a period of 30 years.

Temperatures in the mountains, above 2000 feet, fall below freezing (10° to 20° F.), for short periods during the winter months and reach as high as 100° F. in the summer. At these higher elevations considerable snow falls during these colder periods. In the western lowland area, the temperature is mild; the low rarely reaches freezing and the high is never above 80° F.

Vegetation

Variation in vegetation apparently is controlled more by differences in climate, altitude, and porosity and thickness of the soil cover than by lithologic differences in the bed rock. Grassy areas seem more common on Franciscan rocks, but are not restricted to them.

Chemical weathering of all formations in the area yields similar soils. The high humidity and dense vegetation have produced a soil cover that, in many parts of the quadrangle, is 5 to 10 feet thick. Locally, where the rock is more resistant, outcrops stand out.

Altitude is an important vegetation control. At the higher elevations around the Snow Camp Mountains, cedars, white fir, yellow pine and sugar pine are common. Below about the 4,000-foot elevation, Douglas fir forests are dominant.

Redwood forests, with few exceptions, are confined to the valley of the North Fork of the Mad River. Their presence seems to depend on a deep soil and proximity to the fog belt.

Topography

The ridges and major streams of the area trend generally northwest. The principal streams, from west to east, are Mad River, North Fork of the Mad River, and Redwood Creek. The Mad River provides water for Eureka, and is used for irrigation on the bottom land. The ridges are nearly continuous. The major ridge lines, from the southwest to the northeast, are Fickle Ridge, Tip Top Ridge, Snow Camp Mountain-Bald Mountain Ridge, Redwood Mountain Ridge, (the ridge east of Redwood Creek), and Indian Field Ridge. These major stream and ridge lines follow the general strike of the structure of the formations in this area.

The major streams are chiefly subsequent, but portions of the North Fork of the Mad River, and Mad River appear to be superimposed. The minor streams are generally consequent or obsequent, although many follow lines of weakness produced by small cross faults.

Mad River is a mature stream throughout most of this region, but in localities such as that southwest of the Falor Ranch, where it cuts through resistant Franciscan volcanics, the river appears youthful. The North Fork of the Mad River, and Redwood Creek are youthful streams. The

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[1] U. S. Weather Bureau, Annual reports, California section: 1937.
Baker, F. S., Mountain climates of western United States, Ecological Mon., vol. 14, pp. 223-254, April, 1944.

small streams form a dendritic to sub-trellis drainage pattern. Relief in the area ranges from 1000 feet near Blue Lake to 4625 feet at Snow Camp Mountain.

GEOMORPHOLOGY

The terrain of the Blue Lake region, as viewed from the higher peaks, shows the following prominent features:

1) Essential parallelism of all the major streams and ridges, not only in this quadrangle, but to the southwest and northeast. East of the Trinity River the drainage pattern is irregular.

2) The nearly even tops of the long parallel ridges and the general similarity of elevation of the major ridges southwest of Redwood Creek. The ridge line to the east of Redwood Creek is higher in elevation.

3) Broad, higher, older valleys and narrow, younger, inner valleys of the major streams (Redwood Creek and Mad River) with successive steplike breaks of slope from stream to crest.

The flat-topped ridges have been explained as remnants of an old peneplain which has been subsequently elevated. A multistage elevation is shown by the shapes of the valleys. Diller [2] discussed the topographic development of the general region of northwestern California and postulated several stages of post-Eocene peneplanation and uplift. The ridge to the northeast of Redwood Creek, according to Diller, is a remnant of the peneplain developed in the Klamath stage which he dated as probably lower Miocene. He also states, ". . . . the divide between Mad River and Redwood Creek is in the Coast Ranges and its flat crest is part of the Bellspring peneplain." He dated this peneplain as probably mid-Miocene. Lawson,[3] in discussing the geomorphology of the northern Coast Ranges, (to the south of this area), mentions ". . . the development in Pliocene time of a great coastal peneplain with correlative accumulation of of marine sediments," and with later progressive uplift of this peneplain.

The peneplains in this area cannot be dated accurately. The Klamath peneplain may be older, but the age is uncertain. The so-called Bellspring peneplain may have developed in Pliocene time while marine sediments of the Boulder Creek formation were being deposited in a shallow trough.

Though the age of some of the events is uncertain, the present features suggest the following history:

1) Formation of the Klamath peneplain in the eastern part and Bellspring peneplain in the western part of the area. The degree of flatness of these peneplains is not evident but they must have been old, or subdued land surfaces.

2) Several uplifts and development of the older broad valleys, the terraces of which indicate that they were cut in at least two cycles. During this time Pliocene sediments were block-faulted downward.

3) Another uplift, and subsequent erosion, and cutting of the narrow inner valleys.

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[2] Diller, J. S., Topographic development of the Klamath Mountains: U. S. Geol. Survey Bull. 196, 1902.

[3] Lawson, A. C., The geomorphogeny of the coast of northern California: Univ. California, Dept. Geol. Sci., Bull., vol. 1, pp. 241-271, 1894.

4) Deposition of terrace gravels at elevations of from 50 feet to 350 feet above the present stream bed. This suggests several additional minor uplifts.

The ancestral Mad River must have formerly flowed over the soft Pliocene sediments. Meanders developed, then after faulting and subsequent uplifts and erosion, the river was superimposed on the hard Franciscan rocks in the southern part of the area. The river was then deviated in various directions by the differences in hardness and resistiveness of the many rock types. Mad River, therefore, twists through the resistant Franciscan and only touches the soft Pliocene in several places before it reaches its lower valley.

PREVIOUS LITERATURE

Diller [4] in 1902 was the first to mention the geology of the area now included in the Blue Lake quadrangle. Near Korbel, he noted the Pliocene beds along the Mad River, and made several geomorphologic observations. Hershey, in a contemporaneous study of the Klamath Mountains, mentions parts of the quadrangle in several papers. He states that a ". . . belt of schist, chiefly Abrams mica schist which forms the South Fork Mountains . . . is prolonged northwestward to and probably across the Klamath River. The sandstones of the Coast Range region adjoin this schist belt on the west . . ." [5] Hershey [6] later recognized this contact as a fault and proposed the name Redwood Mountain fault. Diller, who first noticed this fault along South Fork Mountain to the south, did not name it.

The terraces along Mad River and Redwood Creek have also been mentioned by Hershey.[7]

STRATIGRAPHY AND PETROGRAPHY

Kerr Ranch Schist[8]

The name Kerr Ranch schist is proposed by the writers for the schists that occur in two belts of nearly identical lithology. The type locality is near the Kerr Ranch in the southeastern part of the quadrangle.

The rock types of the Kerr Ranch schist include muscovite-quartz-albite schists, quartz-muscovite schist, semi-schists that contain abundant relict sedimentary grains, slates, meta-conglomerates, green schists (actinolite schists, chlorite schists, etc.), meta-cherts, and glaucophane schists.

Muscovite-quartz-albite schists comprise about 70 percent of the formation. Typically, these schists are foliated, fine-grained, light-gray to dark-gray rocks with a pearly silky sheen to the foliated surface. Other rock types are green schists of two kinds: 1) green platy schists derived from flows, and 2) dark-green hard massive meta-intrusives composed of metamorphic minerals such as pumpellyite, sphene, chlorite, albite, and with some relict pyroxenes; semi schists (meta-sandstones that show the first slight orientation of the intergranular

[4] Diller, J. S., op. cit.

[5] Hershey, O. H., Metamorphic formations of northwestern California: Am. Geol., vol. 27, pp. 225-245, 1901.

[6] Hershey, O. H., Some western Klamath stratigraphy: Am. Jour. Sci., 4th ser., vol. 21, pp. 58-63, 1906.

[7] Hershey, O. H., Certain river terraces of the Klamath region, California: Am. Jour. Sci., 4th ser., vol. 16, pp. 240-250, 1903.

[8] The name "Redwood Creek" schist, used by the authors in unpublished masters' theses, University of California, 1947, and by B. A. Ogle in a talk before the Le Conte Club at Stanford University on December 4, 1948, is replaced by "Kerr Ranch" schist because of prior use of the term "Redwood formation."

AGE	FORMATION	COLUMN	THICKNESS FT.	DESCRIPTION
RECENT	TERRACES ALLUVIUM		0-100	Gravel, sand and silt.
PLIOCENE	FALOR FORMATION	FAULT CONTACT	750-2,000	Poorly consolidated marine sandstones, clays, silts and conglomerates. Contains some fossils and abundant plant debris. Upper 200 feet are red beds.
UPPER JURASSIC	FRANCISCAN GROUP	FAULT CONTACT	10,000-12,000	Dark-colored, well-indurated, arkosic sandstones. Dark-colored shales. Minor lenses of radiolarian chert, conglomerate and limestone. Basic volcanics. Basic and ultrabasic intrusives which have locally converted the sediments to glaucophane, chlorite and actinolite schists near their contacts.
PRE-FRANCISCAN	KERR RANCH SCHIST		?	Quartz-muscovite schists with subordinate semi-schists, slates, meta-conglomerates, green-schists and meta-cherts.

FIG. 2. Generalized stratigraphic section, Blue Lake quadrangle.

micaceous material), glossy dark-gray slates, and metaconglomerates. These schists are products of regional metamorphism of a low grade, equivalent to the green schist facies of Eskola.[8a] A few schists are found whose origin is not clear. These include glaucophane-chlorite-albite, glaucophane-chlorite-sphene-garnet (relict), and lawsonite-chlorite-albite-talc-actinolite schists. They outcrop near meta-intrusives and may be the result of some metasomatism. Due to the fine-grained character of these rocks a petrographic examination was necessary for their study.

Usually the micaceous schists are highly contorted, banded with alternating quartz-albite and micaceous·(muscovite-chlorite-graphite?) bands, and often veined with quartz.

The original rocks from which the Kerr Ranch schists were metamorphosed include sandstones, shales, chert, volcanics, and basic and ultra-basic intrusives.

Muscovite-quartz schist outcrops throughout the eastern belt and over most of the western belt except along Redwood Creek where semi-schists and slates are prevalent. The muscovite-quartz schist does not usually form prominent outcrops except where characterized by a high percentage of quartz which may occur either as granular bands or as veins that cut across the schistosity.

Stratigraphic Correlation. Previously mapped schists in northwestern California and southwestern Oregon either do not correspond in grade of metamorphism to the Kerr Ranch schist, are not contiguous, or are poorly defined and described. The authors, therefore, propose the new formation name. No fossils have been found in the formation and any correlation must necessarily be on lithologic similarity, geographic location, or stratigraphic position.

In many respects the Kerr Ranch schist resembles the Abrams schist in Trinity County as described and named by O. H. Hershey.[9] His description follows:

> "It is composed of thin folia of muscovite of dull colors, such as gray, light brown, yellow and dull red, separated by irregular layers of white quartz, representing the original laminae. Throughout it is very highly siliceous and doubtless portions of it would be called a micaceous quartz schist. In certain belts the silica predominates to such an extent as to cause it to outcrop like great veins of very glassy white and dark blue quartz."

The Abrams schist, he concludes, "is undoubtedly a highly metamorphosed sedimentary," probably of Algonkian age.

N. E. A. Hinds,[10] in a more recent study of the Klamath region, states that:

> "The Abrams formation consists for the most part of highly micaceous, white, pale gray, or dark gray schists, generally pink or red on weathered surfaces, and composed of colorless or black mica and varying amounts of quartz. In places the mica is green and gives to the rocks a blue-green or dark green color. These schists were apparently derived from clays and shales, much of which contained more or less quartz, and from shaly sandstones. These rocks are transitional into micaceous quartzites and pure quartzites, which were originally slightly impure standstone and almost pure quartz sandstone. There are also some beds of highly metamorphosed conglomerate, and numerous lenses of coarsely crystalline limestone and marble. Hornblende schists in zones ranging from a few inches to several hundred feet in thickness are present at many horizons."

[8a] Eskola, Pentti, Die metamorphen Gesteine, in Barth, T.F.W., Correns, Carl W., and Eskola, Pentti: Die Enstehung der Gesteine, pp. 357-359, Berlin, Julius Springer, 1939.

[9] Hershey, O. H., Metamorphic formations of northwestern California: Am. Geol., vol. 27, pp. 225-245, 1901.

[10] Hinds, N. E. A., Geologic formations of Redding, Weaverville district, California: California Div. Mines Rept. 29, pp. 77-122, 1933.

"Rocks of the Abrams," Hinds states, "are thoroughly recrystallized so that none of the original sedimentary types remain. . . . The schistosity in general parallels the original bedding of the sediments so that initial metamorphism was accomplished without much deformation and probably was of the load type." The Abrams, Hinds believes, is definitely pre-Devonian and probably pre-Silurian.

Thin sections collected by Hinds have been studied by the authors who conclude that the Abrams rocks range from Eskola's,[11] green-schist facies to the lower part of his amphibolite facies. The schists are crystalline, some rather coarsely so, and range from platy to nearly granulose in the higher grade amphibolite schists. Typical mineral assemblages are: albite-chlorite-epidote-calcite-quartz, muscovite-biotite-albite-quartz, oligoclase-muscovite-epidote, muscovite-garnet-oligoclase-epidote, and actinolite-oligoclase-garnet.

These assemblages represent a higher grade of metamorphism than any observed in the Kerr Ranch schist, in which no brown biotite has been found by the writers. No glaucophane has been reported from the Abrams formation; but it is present in several specimens of the Kerr Ranch schist collected by the writers. Except for these differences the two schists are similar, both have been regionally metamorphosed, and the original rocks were also similar. The original rocks, however, were as much like the present unmetamorphosed Franciscan of the Coast Ranges as they were like one another. In fact, the types represented are common the world over in rocks of widely different ages.

Neither of the schist belts within this area have been reported as contiguous with any of the Abrams schists in the vicinity of the Weaverville quadrangle or other parts of the Klamath mountains. Hershey[12] describes the schists of South Fork Mountains to the south as ". . . another belt of schist, chiefly Abrams mica schist, which forms South Fork Mountain and is prolonged northwestward to and probably across the Klamath River near Wichiper (Weitchpec). The sandstones of the Coast Range Region adjoin this schist belt on the west." Diller[13] describes these rocks more fully:

". . . The principal rock of South Fork Mountain is a gray or greenish-gray, more or less silky, mica-schist in which the mica is sericite. Although in well defined folia and fibres giving the mass a decided schistose structure, the mica is not well crystallized in distinct scales. The quartz is generally in excess of the mica and the mass is full of quartz veins. Another type occurs along lower South Fork Mountain. The rock is greenish, more or less schistose and composed chiefly of quartz and epidote. The occasional presence of blue hornblende in this rock suggests that it may be the result of contact metamorphism, but the field relations as far as known are not decisive."

Hershey[14] studied the mica schists at Weitchpec and named them the Weitchpec schist. He stated:

"The schistose slates of the Paleozoic formations have been converted into distinct micaceous schists. These differ from the more ancient schists of the Abrams formation in that the bedding planes are totally destroyed and the texture is finer. The Abrams formation was crystallized by thermo-metamorphism and these Paleozoic schists were altered by shearing. They are strongly developed along the trail between Hoopa Valley and Weitchpec at the mouth of the Trinity River."

[11] Eskola, Pentti, op. cit.
[12] Hershey, O. H., Metamorphic formations of northwestern California: Am. Geol., vol. 27, pp. 225-245, 1901.
[13] Diller, J. S., Klamath Mountain section, California: Am. Jour. Sci., 4th ser., vol. 15, pp. 342-362, 1903.
[14] Hershey, O. H., The Bragdon formation in northwestern California: Am. Geol., vol. 33, p. 357, 1904.

REDWOOD CREEK VALLEY FROM BALD MOUNTAIN
The flat-topped ridges are remnants of old land surfaces.

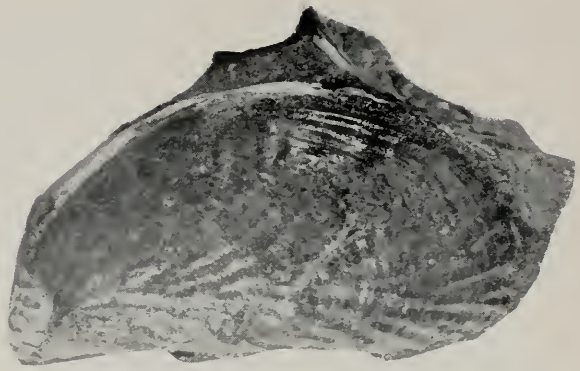
AN EXPOSURE OF THE KERR RANCH SCHIST ON BALD MOUNTAIN

FRANCISCAN PILLOW LAVA IN THE QUARRY AT THE TOP OF BALD MOUNTAIN RIDGE
On U. S. Highway 299 (pick handle approximately 18 in.).

PECTEN OREGONENSIS HOWE VAR., LEFT VALVE

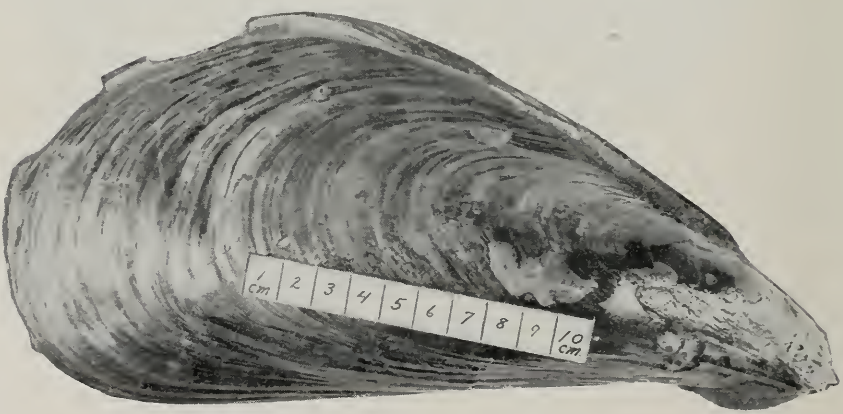
Loc. A4233, No. 1. This specimen resembles *P. oregonensis* closely, but the left valve has the prominent lamellar frills characteristic of *P. dilleri*. Dr. Hertlein suggests listing it as a variety of *P. oregonensis*. Howe, (1922), described only the right valve of his *P. oregonensis*, and it may be that they have close affinities. The shell is medium sized, of nearly circular outline. It has valves of low convexity, the right valve being moderately arched. Ribs on this specimen total 21 on the right valve, and 18 on the left valve. Ribs on the right valve are square and wider than the interspaces, sometimes showing a medial sulcus, growth lines are prominent; on the left valve the ribs are squarish with prominent lamellar frills. Ears are nearly equal in length, practically without scupture; byssal notch moderately deep. Dimensions: altitude, 81mm.; length, 89mm.; length of hinge, 29mm.; diameter of the two valves, 5mm.

PECTEN OREGONENSIS HOWE VAR., RIGHT VALVE
Loc. A4233, No. 1.



A, MYTILUS AFF. *M. MIDDENDORFI* GREWINGK,
NEW SPECIES
(NATURAL SIZE)

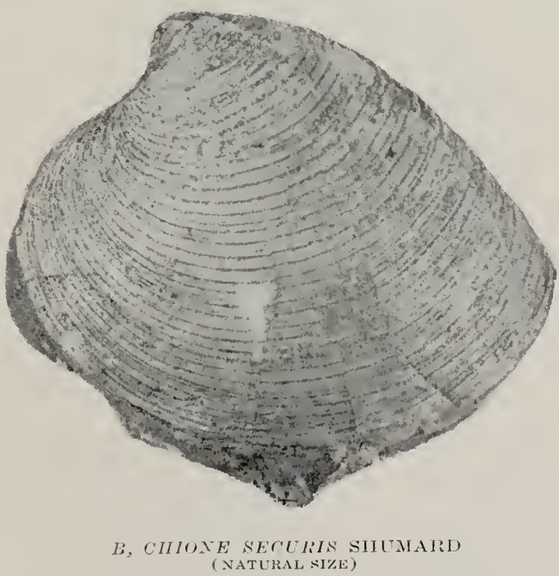
Loc. A4234, No. 3. This specimen may be similar to "*Mytilus condoni* Dall" which was mentioned in an early publication of the Nautilus, (1911?), by Dall as occurring in Oregon. No description or figures of "*M. condoni*" are available; thus the name remains a nomen nudum. It has affinities to *M. middendorfi* which has been found in Alaska. It differs from other Tertiary and Quarternary species in having plications on the distal portion of the valves. The shell is curved, thick, and the beaks are pointed. Dimensions: length, 54mm.; width, 22mm.; diameter of one valve, 19mm.



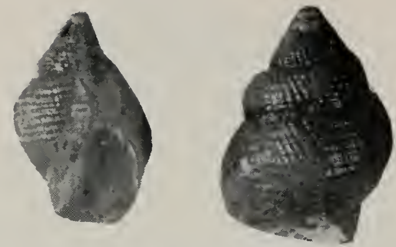
B, MYTILUS EDULIS LINNAEUS VAR.

Loc. A4233, No. 2. This specimen appears to be similar to *M. edulis* except for the huge size of this variety. All fossils found were of this same general size; thus the appearance of the young of this variety is unknown. *M. edulis* is the common mussel found along the Pacific Coast at present and is too well known to need a full description, the concentric undulations and dark color being particularly noted. Dimensions: length, 235mm.; width, 100mm.; diameter of both valves, 63mm.

A, CARDIUM (CERASTODERMA) MEEKIANUM GABB
(NATURAL SIZE)
Loc. A4234.



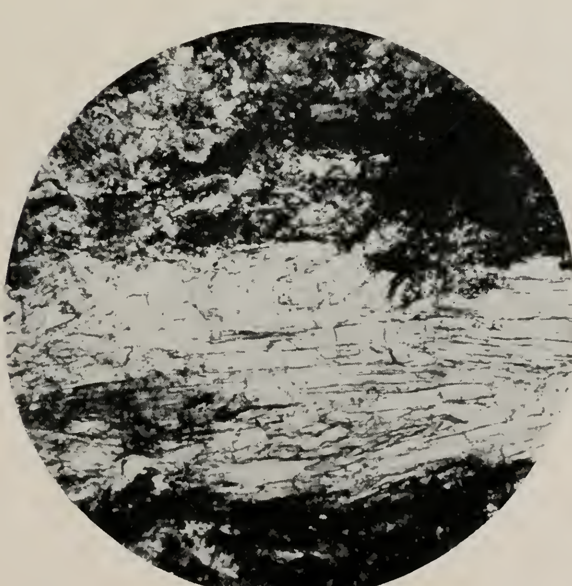
B, CHIONE SECURIS SHUMARD
(NATURAL SIZE)
Loc. A4233.



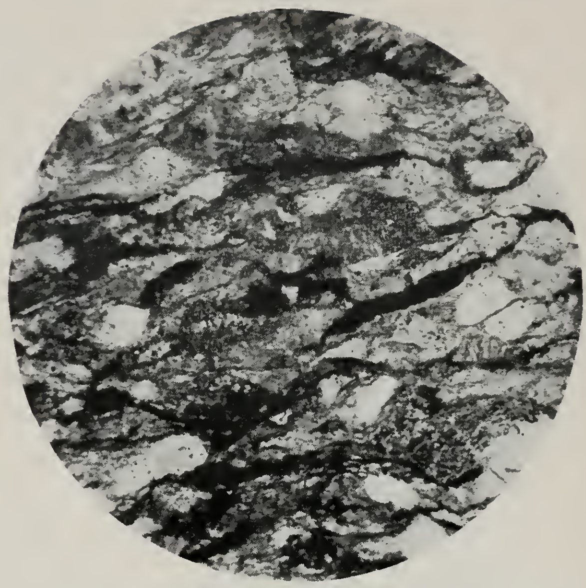
A, NASSARIUS MORANIANUS (MARTIN)
(NATURAL SIZE)
Loc. A4233.

B. GYRINEUM LEWISII CARSON
(NATURAL SIZE)
Loc. A4233.

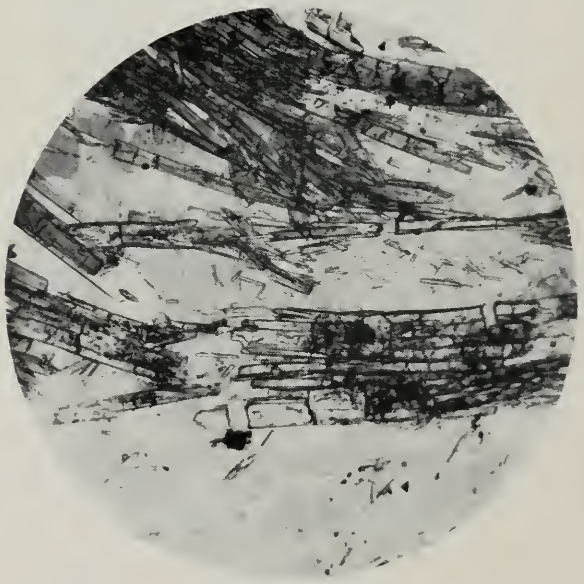
A, Muscovite-quartz-albite schist (Kerr Ranch schist). Note alternating bands of quartz and muscovite-chlorite-graphite (?). Under crossed nicols, x50.



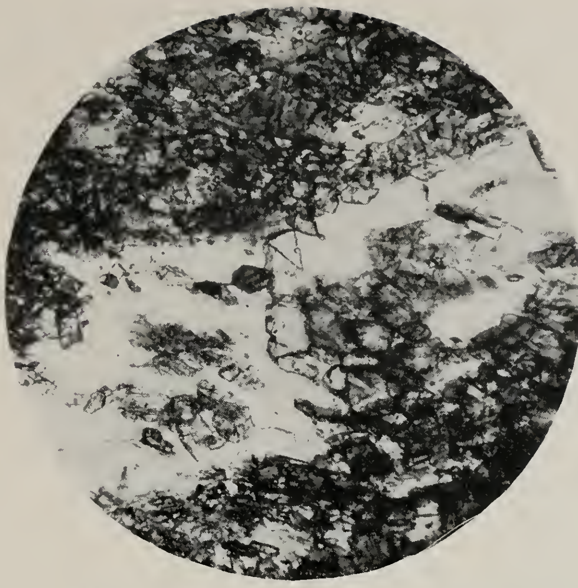
B, Glaucophane-chlorite-albite schist (Kerr Ranch schist). Bands of glaucophane prisms alternate with chlorite-graphite (?) -albite. Under crossed nicols, x50.



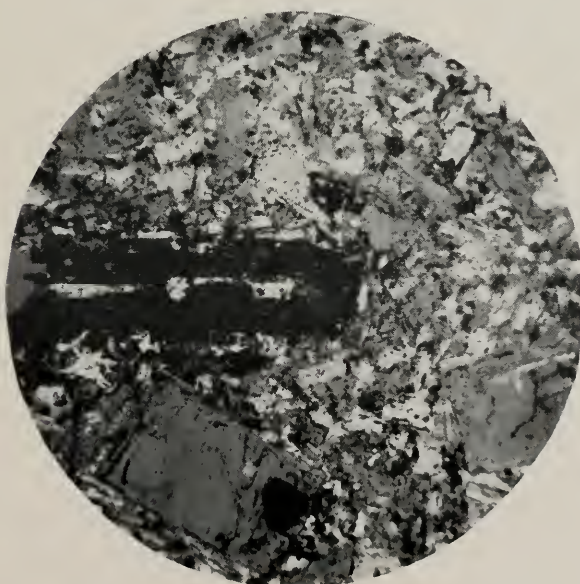
A. Semi-schist (Kerr Ranch schist). Clastic grains of oligoclase, quartz, etc. with tiny schistose intergranular flakes of muscovite, chlorite, and carbonaceous material. Under crossed nicols, x50.



B. Quartz-glaucophane-muscovite schist, Franciscan formation. Large prisms of glaucophane, irregular quartz grains and minor magnetite. Under crossed nicols, x50.



A. Actinolite-glaucophane-pumpellyite-muscovite-chlorite schist (Franciscan formation). Note large pumpellyite crystal in center; other minerals are quartz, and chlorite, actinolite, glaucophane and muscovite in the indistinguishable background. Ordinary light, x50.



B. Anorthoclase trachyte, Tertiary (?). Large phenocrysts of anorthoclase and basaltic hornblende are set in a trachytic groundmass of anorthoclase laths, tiny biotites, amphiboles, and iron ores. Under crossed nicols, x50.

He further states that "the Weitchpec schists resemble the most highly metamorphosed Calaveras schists."

In 1911, Hershey [15] on a reconnaissance map of Del Norte County and a small portion of northern Humboldt County, shows the Weitchpec schists in contact with the Franciscan on the west along the Redwood Mountain fault. He had earlier described the Redwood Mountain fault as the thrust fault running from South Fork Mountain along Redwood Mountain and extending northward to the Klamath River. To the east he shows a belt of serpentine and metagabbro, then a belt of the Galice formation (slates) equivalent to Mariposa, Upper Jurassic. The Weitchpec schists, Hershey concludes, are mainly highly metamorphosed portions of the Galice formation.

Maxson [16] in mapping the northern and central part of Del Norte County notes quartz mica schist and implies it is equivalent to the Abrams schist. Hershey mapped the same formation in 1911 as Weitchpec schist. Maxson's description noted that: ". . . quartz mica schist is subordinate to interbedded phyllite and slate," and that "the formation represents a dynamometamorphosed series of shales and argillaceous sandstones."

Diller, in 1903, described and named the Colebrooke schist.[17] His description follows:

"The rocks are in part mica-schists intermingled with slates in which the cleavage is highly developed but without definite crystalline structure visible to the unaided eye. The rocks are always fine grained, with decided schistose structure, and where most highly metamorphosed have much fine silky mica (sericite) on the foliated surface, so that they may be more definitely designated sericite-schists, or phyllites. They are much folded and crumpled. The schistose structure varies a great deal in direction, but the strike usually lies between north and west, with a vertical dip. On the south end of Brushy Bald Mountain the phyllite is so fine that its micaceous nature can be discovered only under the microscope. It looks in places like roofing slate and is composed chiefly of sericite and quartz, the former containing a multitude of minute rutile needles. Farther north on Brushy Bald Mountain it becomes coarser and fragmental, indicating its origin in sedimentary rocks. Quartz is the chief constituent, but there is some plagioclase feldspar and much sericite. On the summit of Brushy Bald Mountain the schist is coarser and the schistosity is so wavy as to apparently give a rough fibrous structure to the mass. Fine granular quartz largely predominates over the sericite which marks the structure, and is most prominent on the cleavage faces. . . . On Lobster Creek, a few miles below the trail crossing, black glossy slates (phyllites) are common. They contain much sericite, with fine granular quartz, and a large amount of dark carbonaceous matter which gives color to the mass. They are decidedly crumpled, giving the cleavage face a decidedly wavy profile. The rocks contain many small veins of quartz, which on weathering yield numerous fragments of quartz, to the soil.

As to the geologic age of these rocks, we have no decisive evidence in the Port Orford Quadrangle, except that they are pre-Cretaceous. Elsewhere in the Klamath Mountains, however, there is evidence that the Colebrooke schist is possibly of pre-Devonian age."

This quotation is given because it describes rocks that are similar to the Kerr Ranch schist.

From the foregoing descriptions, it is apparent that the earlier writers believed that the schists in the western Klamath Mountains were of a lower metamorphic grade than the eastern type section of Abrams schists. Hershey believed that the degree of metamorphism was an indication of age, and stated that the Abrams schist was probably Algon-

[15] Hershey, O. H., Del Norte County geology: Min. Sci. Press, vol. 102, p. 468, 1911.

[16] Maxson, J. H., Economic geology of portions of Del Norte and Siskiyou Counties, northwestern California: California Jour. Mines and Geology, vol. 29, nos. 1, 2, pp. 123-160, January and April, 1933.

[17] Diller, J. S., U. S. Geol. Survey Geol. Atlas, Port Orford folio, (no. 89), 1903.

kian,[18] and later thought the Weitchpec schist was Galice age (Upper Jurassic). Though Diller's description of the schists indicates a low grade metamorphism he followed Hershey's original designation and included them in the Abrams.

Hershey believed the Redwood Mountain fault separated Franciscan on the west from schist on the east in the area from South Fork Mountain to southern Del Norte County. The schist, therefore, by his description, would be Algonkian at South Fork Mountain [19] and Upper Jurassic at Weitchpec.[20] Hershey's papers were often written while in the field and he was probably unable to check his previously published statements.

The writers believe that this belt of schist, east of the Redwood Mountain fault, may be continuous from South Fork Mountain to at least southern Del Norte County and possibly farther north. Large gaps between South Fork Mountain, the Blue Lake quadrangle, and the Weitchpec locality together with the confused state of nomenclature seems to necessitate the introduction of the name Kerr Ranch schist. Future work may prove either that all of the northwestern California-southwestern Oregon mica schists are the same formation with varying degrees of metamorphism, or that there are several formations of different ages which have been metamorphosed to somewhat similar grades.

The writers conclude that the Kerr Ranch schist must be older than the Franciscan, an opinion based on the lack of regional metamorphic effects in the Franciscan and absence of gradational contacts between the rock types of the two formations. If the Kerr Ranch is a lower grade equivalent of the Abrams, it is pre-Devonian.

Franciscan (Upper Jurassic)

The Franciscan, long a subject of controversy, has been variously placed anywhere from Permian to Cretaceous in age. Taliaferro has placed the Franciscan and the overlying Knoxville in the uppermost Upper Jurassic [21] and has related the Franciscan to other Jurassic formations of California and Oregon.[22] He has treated the Franciscan and Knoxville as lithologic units, and has found that the Knoxville of any area always lies above the Franciscan of that same area but that it may be contemporaneous with a part of the upper Franciscan elsewhere.

A Franciscan designation has been given the rocks west and east of the Pliocene sediments, and between the two belts of Kerr Ranch schist. These rocks are lithologically similar to each other and to Franciscan rocks of other parts of the state. All contacts between this formation and either the Falor formation or the Kerr Ranch schist are faults. The Kerr Ranch schist has been regionally metamorphosed, while the Franciscan rocks are unmetamorphosed except for pronounced compaction, local strong deformation, and some metasomatism. There is no evidence of a a gradation from normal Franciscan sediments to Kerr Ranch schist.

No fossils were found in the Franciscan of Blue Lake quadrangle. Dr. H. D. MacGinitie of Humboldt State College, however, has found a

[18] Hershey, O. H., Metamorphic formations of northwestern California: Am. Geol., vol. 27, pp. 225-245, 1901.

[19] Hershey, O. H., Metamorphic formations of northwestern California: Am. Geol., vol. 27, pp. 225-245, 1901.

[20] Hershey, O. H., Del Norte County geology: Min. and Sci. Press, vol. 102, p. 468, 1911.

[21] Taliaferro, N. L., The Franciscan-Knoxville problem: Am. Assoc. Petroleum Geologists Bull., vol. 27, pt. 1, pp. 109-219, 1943.

[22] Taliaferro, N. L., Geologic correlation of the Jurassic of southwestern Oregon and California: Geol. Soc. America Bull., vol. 53, pp. 71-112, 1942.

fossiliferous limestone in a belt of Franciscan rocks in the Trinidad quadrangle. This belt of Franciscan can be traced into the Blue Lake quadrangle. The most distinctive species in this limestone is *Aucella pioche,* a Tithonian (Upper Jurassic) form common in the Knoxville. It is probable that this form is also characteristic well down into the Franciscan.

Taliaferro[23] described four stages of the Franciscan-Knoxville group, based mainly on varying conditions of depositions and igneous activity. Franciscan of the Blue Lake area, consists principally of sandstones with minor shales and some basaltic flows and plugs. This lithology corresponds most closely with all of the first and part of the second stage (lower Franciscan, and lower upper Franciscan) as recognized by Taliaferro.

The thickness of the Franciscan, though not measured accurately because of the lack of exposures, probably exceeds 12,000 feet in the western part of the area.

The Franciscan of the Blue Lake quadrangle is composed of arkosic sandstones (including graywackes), dark sandy shales, dark-gray clay shales, pebbly conglomerates, dark-gray limestone (very minor), red, green and gray chert, pillow lavas, vesicular basalts, minor agglomerates, and tuffs. These are intruded by basaltic plugs, ultra-basic intrusives, (often converted into serpentine), and gabbroic intrusives. Associated with the ultra-basic intrusives are the products of metasomatism: glaucophane and actinolite schists, and in some cases the steatitization of the intrusives themselves.

Sandstone. This is the predominate rock type, composing well over 50 percent of the formation. It is a massive, dark greenish gray to dark gray, arkosic sandstone or graywacke which weathers to light gray, reddish brown or buff. This rock is composed of fine to coarse, angular to subangular grains. It is usually very hard, well indurated and well cemented with a siliceous or, less commonly, calcareous or argillaceous cement. Dark-gray shale fragments, some of which are quite large, are common. These shale particles are largely responsible for the dark color of the sandstone. Volcanic material is locally sufficiently abundant to produce a tuffaceous sandstone or sandy tuff.

Thin section studies and mechanical analysis of a series of grab samples indicate that the sandstone, in general, is composed of 85 to 90 percent light minerals and 1 to 2 percent heavy minerals, the remainder being rock fragments. The lights are about 50 percent quartz, 45 percent feldspar and 5 percent muscovite. Most of the feldspars are too badly sericitized to determine. Those identified range from intermediate oligoclase to intermediate andesine with some microcline. Sericitization is considerably more extensive than in most specimens of Franciscan the writers have seen from other areas.

Of the heavy minerals apatite, biotite, chlorite, epidote, hornblende and iron ores are the most abundant, tourmaline is less common, and allanite (?) and brookite are rare. The rock fragments are volcanics, chert, and shale. No Kerr Ranch schist fragments could be definitely recognized.

A very light gray to white, fine-grained arkosic sandstone interbedded with thin, dark-gray, slaty shale occurs near the Christie Ranch. Some of these rocks have dark laminae parallel with the bedding; these

[23] Taliaferro, N. L., The Franciscan-Knoxville problem: Am. Assoc. Petroleum Geologists Bull., vol. 27, pt. 1, pp. 109-219, 1943.

are very small compared with the white layers. The dark laminae are formed by concentrations of biotite and other ferromagnesian minerals. There are no shale chips or volcanic debris in these sandstones.

These sandstones have angular to sub-angular fragments, are fairly well sorted and are hard, compact, and well cemented. They commonly weather to a buff or light brown, and are more resistant than the gray-green sandstone. The white sandstones are locally interbedded with cherts, and are underlain and overlain by the gray-green sandstone.

Taliaferro[24] states that the Franciscan sediments were derived from a high, rugged landmass under rigorous climatic conditions and were deposited in shallow marine waters in a slowly sinking basin. The sediments, he believes, were carried down by great rivers with high gradients. He also states that the source of most of the detritus was a land mass to the west which contained granodiorite, crystalline schists, quartzites, re-crystallized chert, and much intrusive quartz-feldspar porphyry. Part of the Franciscan debris is reworked Franciscan locally upwarped at the borders of the geosyncline. Nothing to dispute Taliaferro's general concept was found in the Blue Lake quadrangle. Some of the material, however, may have come from Kerr Ranch or Abrams schist, granodiorites or slates of the Klamath Mountains. A quartz-albite schist may have been a source rock of the white sandstone. The volcanic debris in the tuffaceous varieties indicates contemporaneous volcanism.

Conglomerates. These, though not plentiful, are widespread as comparatively thin lenses that apparently occur throughout the section. Conglomerates seem to be more extensive in the most easterly belt of Franciscan. In the northeast corner of the area, along the Horse Mountain road, striking bold outcrops of fine grit to pebble conglomerates grade into coarse sandstones. The pebbles are similar in all exposures. The most abundant pebbles are pink to gray to white quartzites, black cherts, and quartz porphyries; minor types are old volcanics, granitic rocks, quartz, and limestone. The fragments range in size from grits to small cobbles, with diameters of about ½-1 inch the most abundant. They are sub-angular to angular, and occasionally well-rounded. None seem to have been derived from the Kerr Ranch schist or other schists. These foliated and micaceous formations, however, disintegrate into small fragments which would only be noticed in the finer sediments.

Shales. The shales interbedded with sandstones are dark gray or dark brown and weather buff or gray; some of the shales are interbedded with chert and are either green or red. They are quite hard and are locally slaty. Composition ranges from fine clay to rather coarse silts, the more silty shales being most common. Near chert or limestone lenses they may be siliceous or limy. Carbonized plant fragments are plentiful but they are too small and poorly preserved to identify.

The distribution of these shales is wide but their relative percentage is small. They occur mainly as occasional thin beds in the massive sandstone. Where interbedded with the white sandstone, as in exposures along Mad River and near Christie Ranch, they form an appreciable percentage of the section.

Cherts. Cherts are not abundant. There are red, very pale green, and some variegated yellow, green, and red types. Usually the cherts occur in beds an inch or two in thickness and are interbedded with thin

[24] Taliaferro, H. L., The Franciscan-Knoxville problem: Am. Assoc. Petroleum Geologists Bull., vol. 27, pt. 1, pp. 109-219, 1943.

red or green shales. Lensing is common and the beds are often quite contorted. Quartz veins produce a network of welts on the cleaved surfaces of many of the cherts. Manganiferous cherts a few feet in thickness, occur locally along Fickle Ridge.

Radiolaria are a minor constituent of both the red and green cherts.

The petrography and origin of chert have been discussed by Davis [25] and Taliaferro.[26]

Limestone. A few very small lenses of thoroughly recrystallized, hard, dense, dark gray limestone occur in the Franciscan.

Volcanics. Volcanics are next to sandstones in the order of abundance. They include pillow basalts, vesicular (often amygdaloidal) basalts, spilitic basalts, tuffs that contain an appreciable amount of clastic materials, some rocks that are probably altered olivine basalts, and some andesites. The feldspars are usually too badly altered for accurate identification.

The most common type is the vesicular basalt. It is deep greenish-black and highly fractured; all fracture surfaces weather to a purplish-red brown. The individual fragments are very hard and angular. This rock commonly is amygdaloidal, the amygdules consisting of chlorite, quartz, and calcite.

The rocks classed as tuffs are interbedded with normal clastic sandstones, and in all cases contain up to 10 per cent clastic grains. They grade into the tuffaceous sandstones. Microscopic examination of a typical thin section of tuff reveals a heterogeneous assortment of tiny plagioclase laths, large well-formed plagioclase crystals, volcanic rock fragments, and sand grains of quartz, feldspar, and opaque minerals. Irregular masses of chlorite are abundant throughout the rock and there is some sphene and ilmenite-leucoxene. There are many quartz and calcite veins, and some openings filled with chlorite, quartz, and calcite. The plagioclase is altered but appears to range from oligoclase to andesine.

Basic and Ultra-Basic Intrusives. Throughout the Franciscan in this area there are numerous basic and ultra-basic intrusives that appear to be mostly plugs and dike-like bodies. Near the Beckstine Ranch, at peak 1706, and near Canon Creek these intrusives form prominent bold outcrops and often stand as great pillar rocks above the surrounding countryside. The intrusives range in composition from basic basalt plugs, through gabbroic types to serpentinized ultra-basics. Many have been metamorphosed. In some cases, as at peak 1706, the serpentine and gabbro are closely associated and apparently have no sharp boundary. The writers believe the gabbro is a differentiation product. Gabbroic bodies were not seen cutting the ultra-basics. Along the west contact of the eastern belt of Franciscan with the Kerr Ranch schist several intrusives appear to be part of the schist formation, and are mapped as such. They may be altered Franciscan ultra-basics, however.

From evidence in other parts of California, Taliaferro [27] has shown that similar intrusives were confined to late Upper Jurassic.

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[25] Davis, E. F., Radiolarian cherts of the Franciscan group: Univ. California, Dept. Geol. Sci., Bull., vol. 2, pp. 235-432, 1918.

[26] Taliaferro, N. L., Relation of volcanism to diatomaceous and associated siliceous sediments: Univ. California, Dept. Geol. Sci., Bull., vol. 23, pp. 48-49, 1933.

[27] Taliaferro, N. L., The Franciscan-Knoxville problem: Am. Assoc. Petroleum Geologists Bull., vol. 27, pt. 1, pp. 109-219, 1943.

Schists. In the following section the term schist includes metamorphosed rocks which do not have a schistose structure but which are composed of metamorphic minerals. None of these rocks is extensively exposed and all seem to have been affected by metasomatism. Ultra-basic igneous rocks are closely associated with each, a condition common in the glaucophane schists of California. Fluids causing metasomatism probably originate in the late magmatic emanations of the ultra-basic magmas. Taliaferro [28] has discussed the formation of these schists. They are interbedded or associated with unmetamorphosed sediments and igneous rocks, and all the metamorphic minerals are low temperature, low pressure types that fall within the green-schist facies. Some rocks have been locally sheared. Minerals in the schists include actinolite, albite, relict grains of stilpnomelane, augite, chlorite, chloromelanite, clinozoisite, epidote, glaucophane, muscovite, quartz, pumpellyite, talc, and zoisite.

Falor[29] Formation

The name Falor formation is proposed for Pliocene beds composed of poorly cemented gray to buff sandstone, gray to tan clay, lenticular limestone, thin red beds, and pebbly conglomerate. The type locality is the section along Maple Creek near the Falor Ranch (733.5-2039.0). It is exposed in an area that extends from near Blue Lake, along the eastern slopes of the Mad River basin, south through the Falor Ranch to the southern border of the quadrangle near Boulder Creek where it continues to the south. Along Boulder Creek, near the Wiggins Ranch, this formation contains an abundant molluscan fauna. The beds are marine with the possible exception of the upper 200 feet of red-brown clays and gravels exposed northwest of Korbel; these may be continental. The clays, sandstones, and conglomerates lense rapidly and grade into each other, and no members were mapped.

The sandstones are characteristically fine-grained, usually gray to buff, poorly cemented and compacted, and well sorted. Size analyses indicate that approximately 70 percent of the grains have diameters between $\frac{1}{4}$ mm. and $\frac{1}{16}$ mm. Cementing material is dominantly argillaceous, but calcareous cement is also common.

Plagioclase commonly composes 60 percent of the light minerals, but quartz, orthoclase, and chlorite are also present. The heavy mineral percentage varies greatly; the most abundant are hornblende, actinolite, tremolite, epidote, sphene and magnetite. Ilmenite-leucoxene, augite, clinozoisite, garnet, rutile, hypersthene, zircon, zoisite, tourmaline, glaucophane and basaltic hornblende were also identified.

Faunal evidence indicates that these beds are equivalent to a part of the Wildcat Series as described by Lawson.[30] The type section is located near Ferndale about 30 miles to the southwest. The portion of the Wildcat to which these beds are equivalent has not been definitely determined. Hertlein believes the fauna most resembles that of the upper Wildcat as described by Martin.[31] Hertlein believes further that the

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[28] Taliaferro, N. L., The Franciscan-Knoxville problem: Am. Assoc. Petroleum Geologists Bull., vol. 27, pt. 1, pp. 109-219, 1943.

[29] The name "Boulder Creek" formation, used by the authors in unpublished masters' theses, University of California, 1947, is replaced by "Falor" formation because of prior use of the term "Boulder formation."

[30] Lawson, A. C., The geomorphogeny of the coast of northern California: Univ. California, Dept. Geol. Sci., Bull., vol. 1, pp. 241-271, 1894.

[31] Martin, Bruce, Descriptions of new species of fossil mollusca from the later marine Neocene of California: Univ. California, Dept. Geol. Sci., Bull., vol. 8, pp. 181-202, 1914.

Falor beds are probably upper lower Pliocene and extend into lower middle Pliocene. Faunal similarities also indicate a correlation with part of the Empire formation near Coos Bay, and part of the Merced near San Francisco Bay.

The contacts with the Franciscan on both sides of the formation are along faults, thus it is difficult to tell how much of the section has been faulted out. The beds have a fairly constant strike of approximately N. 40° W., and dip homoclinally about 20° to the northeast. A section measured near Maple Creek shows an exposed thickness of 2000 feet; a section measured from map coordinates 731-2042.5 to 732.5-2043.5 [32] shows a thickness of 2460 feet. The section north of Korbel is only about 750 feet thick.

A faunal assemblage of 44 species was collected in this formation. Four localities yielded recognizable species. Unidentifiable broken shell fragments and soft crumbly shells occur in many other localities. Most of the fossils collected were found in limey concretionary portions of a fine-grained, poorly compacted and cemented, buff to gray arkosic sandstone. The formation is not fossiliferous throughout, and faulting has made the localities difficult to locate stratigraphically. Not enough forms were found at each locality to allow zoning of the beds.

The fossils in the following assemblages are listed by localities and were determined by Dr. Leo G. Hertlein and B. A. Ogle:

Locality A4233: near the bridge crossing Boulder Creek, adjacent to the Wiggins Ranch, (approximately 739.3-2036.2). The fossils are found in the stream banks for a distance of 300 yards along Boulder Creek. Part of this locality has since been submerged in a mill pond.

Echinoidea

Anorthoscutum oregonense quaylei Grant and Hertlein

Pelecypoda

Anadara trilineata (Conrad)
Cardium (Cerastoderma) meekianum Gabb
Chione securis (Shumard)
Hinnites sp.
Macoma sp.
Mytilus edulis, new variety
Panope generosa Gould
Pecten caurinus Gould
    oregonensis Howe var.
    sp.
Schizothaerus nuttallii (Conrad)
Solen sicarius Gould
Spisula albaria (Conrad)
    brevirostrata Packard
    catilliformis Conrad
    voyi (Gabb)
    sp.
Yoldia scissurata var. strigata Dall

Gastropoda

Calyptraea mamillaris Broderip
Crepidula princeps Conrad
Gyrineum lewisii Carson
Nassarius moranianus (Martin)
Natica russa Gould
Neptunea eurekaensis (Martin)
    recurva Gabb
Olivella biplicata (Sowerby)
Turris perversa (Gabb)

[32] See plate 1.

Cirripedia
Balanus cf. B. tintinnabulum var. coosensis Dall

Locality A4234, on the Mad River road, near the mouth of Canon Creek. The fossils are in high, vertical, sandstone bluffs. (729-2045.3).

Pelecypoda
Cardium (Cerastoderma) coosense Dall
(Cerastoderma) meekianum Gabb
(Clinocardium) nuttallii Conrad
Lucina cf. excavata Carpenter
Macoma astori Dall
inquinata (Deshayes)
nasuta (Conrad)
secta (Conrad)
Mya japonica Jay
Mytilus highoohiae Mandra
Sanguinolaria nuttallii Conrad
Saxidomus nuttalli Conrad
Semele cf. S. sylviaensis Weaver
Thracia sp.

Locality A4235, on a tributary of Boulder Creek, (736.6-2035.7).

Pelecypoda
Schizothaerus nuttallii (Conrad)

Gastropoda
Thais lamellosa (Gmelin)
ostrina (Gould)

Locality A4236, along road to Garner Ranch, at (731.2-2044).

Pelecypoda
Macoma inquinata (Deshayes)

All of these forms have been previously described or figured except *Pecten oregonensis* Howe var., *Mytilus edulis* new variety, and *Mytilus* new species.†

The environment ranges from depths of about 50 fathoms to shoreline conditions. Hertlein states,[33] "This is a cool water fauna similar to that living off the coast of Humboldt County today." He further states, "These are shallow water forms that probably lived in an embayment which was fairly open to the sea. There are no great number of bay forms and no brackish water forms to indicate estuarine conditions. Instead, the fauna indicates that marine conditions existed."

Plant remains occur in many of the sandstones and clays. These are usually small fragments, poorly preserved, which, according to H. D. MacGinitie, and R. W. Chaney are unidentifiable. Small conifer cones tentatively identified by MacGinitie as spruce cones[34] were found on Maple Creek Road near B.M. 999. Fairly well preserved leaves in poorly fissile clayey shales were found east of the post office at Korbel. At 732.7-2040.2, on Mad River, are abundant chunks of carbonized wood imbedded in the gray clay beds. Some of these are 4 feet long and 2 feet in diameter, and some have the appearance of being stumps which include part of the larger roots. Where exposed to weathering, the outer surfaces are friable. On a fresh-broken surface, the wood is a glittering black, with a suggestion of wood growth rings. Lignite from a small abandoned coal mine on Maple Creek near B.M. 456 is reported to have commonly had wood structure. Many freshly exposed clays and silts in this formation

† Ed. note: Since this paper was written, Mytilus n. sp. has been described as Mytilus highoohiae by York T. Mandra in J. Paleontology, January, 1949.
[33] Hertlein, Leo, Oral communication, March, 1947.
[34] MacGinitie, H. D., Oral communication, July, 1946.

have a characteristic fetid, swampy odor. The abundant plant remains suggest a rapid, near-shore deposition and a moist climate.

The greater part of this formation is marine, but the upper portion, best exposed north of Korbel, may be in part continental. The basin of deposition must have been relatively narrow and long. It was fairly shallow, though deep and wide enough at the open sea end to support typical marine instead of estuarine life.

Conglomerates are less abundant than either clays or sandstones. They usually occur as thin lenses and beds but near 735.5-2037.2 they reach thicknesses of from 30 to 50 feet and grade into interbedded pebbly sandstone. These conglomerates are usually well cemented and resistant. The conglomerate pebbles are set in a matrix of fine-grained buff sandstone. Most of the conglomerate material is of pebble size but some range to cobbles and boulders. The pebbles are poorly sorted and sub-angular to sub-rounded. The average pebble is about .5 to 1 inch in diameter. Franciscan debris, the most abundant material, includes, in order of abundance, sandstone, red chert, basalt, dark-green serpentine, and green chert. Pebbles of Kerr Ranch muscovite-quartz schist follow the Franciscan sandstone and chert in relative abundance. Minor constituents include well-rounded pebbles of quartz porphyry, black quartzite, white quartzite and dark igneous rocks, probably reworked from the Franciscan. At 733-2040.2 the mica schist is the most common pebble, in contrast to all other locations noted. At fossil locality A-4235, some of the fossils are in pebble conglomerate. The conglomerates must have been deposited in a shallow water environment. The local variation of grade and material is probably due to deposition from different drainage sources into a somewhat restricted basin.

The clays, second in abundance to the sandstones, are light gray to buff and grade to fine siltstones. Only locally, where filled with abundant leafy remains, are they shaly. They are interbedded and lens into the sandstones. A mineral and chemical analysis of these clays should be made to investigate possible economic use.

The continental beds are well exposed northwest of Korbel along U. S. Highway 299, but elsewhere their extent is concealed by dense vegetation and terrace gravels. They are composed of reddish-brown soft clays, poorly sorted ''rotten'' pebble conglomerates, and small lenses of reddish silt-stones. Sorting is poor and all rock types grade into each other rapidly. They may be as thick as 200 feet and are stratigraphically higher than the definite marine beds to the south. No evidence of continental origin has been found. The source of the sediments is certainly fairly local. The pebbles and sand minerals suggest that the Franciscan formation and Kerr Ranch schist were the principal source rocks. The altered feldspars and the floral remains indicate a moist seasonal climate similar to that of coastal Humboldt County today. Chemical weathering was probably pronounced. The fine-grained material suggests an area of moderately low relief. Sedimentation must have been rapid to preserve the plant remains. These sediments probably had their source in positive areas both to the northeast and southwest. Local differences in depositional conditions favored rapid lateral variation of the sediments. Many of the clays were possibly laid down as shallow mud flats in which stumps of trees were buried. Finally, there may have been a gradual recession of the sea in the northwestern part of the basin, possibly due to a slight uplift, followed by continental deposition.

Anorthoclase Trachyte of Undetermined Age (Tertiary?)

A pale buff to nearly white porphyritic anorthoclase trachyte is exposed in a single, small outcrop in the northwestern part of the area at 723.5-2048.4. To the west, in the Eureka Quadrangle, this rock forms several prominent knobs, on one of which it has been quarried for fills and road metal. The shape of the outcrop suggests a plug-like intrusive into Franciscan rocks. It apparently does not cut the Falor beds at the one locality where the two are in contact. The rock is much fresher and less fractured than typical Franciscan volcanic rocks, and no rocks of this type have been described from the Franciscan. A pre-Pliocene and post-Franciscan age is probable. Emplacement was possibly contemporaneous with Miocene volcanism of the Coast Ranges farther south.

In the hand specimen, the rock is buff to nearly white, has phenocrysts of feldspar and amphibole as large as eight mm. in length, is hard, rough to the touch, and has some tiny openings.

Microscopic examination reveals abundant anorthoclase and minor basaltic hornblende phenocrysts that average about one mm. in diameter. These are set in an intergranular groundmass of small feldspar laths, and tiny biotite and amphibole crystals. Anorthoclase phenocrysts which compose approximately 85 percent of the rocks, often show a faint ghost twinning and some zoning.

Quaternary Terrace Gravels

Terrace gravels have been deposited at several levels along Mad River, Maple Creek, Boulder Creek and to a lesser degree along Redwood Creek. They are usually unsorted gravels, sands, boulders and finer debris. They range in thickness from a few feet to as much as 50 feet. Their most striking occurrence is along the Pacific Gas and Electric Company power line, east of Christie Ranch. Here, between Mad River and Maple Creek, there are three principal terrace levels: two on the Mad River slope, one at the crest of the small divide, and two corresponding ones on the Maple Creek slope. The lowest level is 100 feet above the stream, the second is 150 feet, and the crest terrace is 300 feet.

The age of these terrace gravels is indeterminate; but they are fairly flat, lying over all older rocks and post-date the faulting.

Alluvium

The only alluvium, mapped as such, is the stream bed material. The present channel of the Mad River is about 10 feet below the general land surface. Many of the streams, especially Mad River, have broad gravel and sand covered stream channels which are filled only during exceedingly high water.

Landslides

Landslides, though not mapped, are common. Franciscan rocks, especially serpentine areas, are commonly slumped. Along the steeper parts of Redwood Creek Canyon, there are many slides of Kerr Ranch schist. Water soaked clays and soft sands of the Falor formation give way readily and produce great slumps and slides, an example of which occurs north of the Falor Ranch.

STRUCTURE

This region is characterized by a complex fault system and strong, early folding. The metamorphic rocks of the Kerr Ranch schist show the evidence of strong directed stress, but structures are difficult to detect. Along Redwood Creek the principal schistosity parallels the original bedding. Elsewhere the attitudes were taken on what seemed to be the principal plane of schistosity and the relation of original bedding to present schistosity was not determined. Two steep-flanked anticlinal structures in the schist, one along Redwood Creek, and one running through High Prairie, have been mapped. Other folds could not be delineated due to poor exposures. However, it is possible that isoclinal folding may characterize structure in the Kerr Ranch schist.

The Franciscan rocks have been folded and faulted, probably in several cycles; dips and strikes often vary widely in local areas. Part of the local contortions are due to faulting, and part are probably due to folding of sediments against more rigid intrusives which act as buttresses. Though accurate attitudes were difficult to obtain, the central belt seems to be a large syncline, and the eastern belt apparently is the eastern limb of a faulted anticline. Kerr Ranch schist forms the upwarped core of this structure.

The Falor formation has been down-faulted and uniformly tilted to the northeast with a dip of from 15° to 20°. Locally, near faults, this general attitude is changed.

Faulting

Seven major faults occur in this area. In some places their traces have been offset by cross faulting. The normal faults, from west to east, are the Falor, Blue Lake, Crawford and Korbel faults. These bound down-dropped blocks of the Falor formation. The Bald Mountain fault probably was originally a thrust along which there has been later movement. The Crogan fault thrusts Franciscan westward over Kerr Ranch schist. The Redwood Mountain fault barely enters the quadrangle, but extends both northwest and southeast for great distances. Hershey [35] named the Redwood Mountain fault and listed it as one of the four important members of the thrust faulting system of the Klamath Mountains. He also noted the fault at Bald Mountain but did not describe or name it.

The innumerable cross-faults which offset the main faults are difficult to explain. They seem to be later than the main faults and are possibly tensional effects, or are a response to stress in a direction oblique to the original compressive forces.* Small streams usually mark their trace. At many places, as at 736.7-2036.2, there is abundant fault gouge and a badly fractured zone. A sandstone from this locality is thoroughly mashed and brecciated and recemented with calcite.

Faults bound several Franciscan masses around which Falor beds have dropped. In each case, the main mass of the "island" is made up of

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[35] Hershey, O. H., Some western Klamath stratigraphy, Am. Jour. Sci., 4th ser., vol. 21, pp. 58-63, 1906.

* Since this paper was written, B. A. Ogle has found from field work in the Humboldt Bay-Eel River Tertiary-Quaternary basin, immediately to the west, that late structures have a general eastward trend. At least one major fault thrusts Pliocene beds over Pleistocene gravels. It is probable that the late cross-faults of this area are of a similar age and may be the dying-out of the major diastrophism to the west.

Franciscan igneous rocks and schists. Apparently the faults were governed by the location of intrusive bodies in the heterogeneous Franciscan mass.

GEOLOGIC AND STRUCTURAL HISTORY

The Kerr Ranch sediments were deposited in a sinking basin prior to late Upper Jurassic, possibly in pre-Cambrian time. Contemporaneous volcanism contributed the interbedded basic volcanics. Prior to metamorphism and possibly during deposition, the sediments and volcanics were intruded by basic and ultra-basic igneous rocks. Conglomerates and coarse clastic grains in the semi-schists suggest a relatively close source area of moderate relief.

Following deposition but apparently before formation of the Franciscan basin, this series was folded and subjected to regional metamorphism. The recrystallized Kerr Ranch and unaltered Franciscan are in sharp contrast, though the rocks, as originally deposited, were similar. Uplift and erosion followed metamorphism and overlying unmetamorphosed material, if present, was stripped off.

The area was again submerged in late Upper Jurassic. The great Franciscan geosyncline was initiated as a result of the Nevadan orogeny.[36] Franciscan deposition resulted in a section of at least ten thousand feet of shallow water sediments and submarine volcanics. Rarity of fossils may have been due to the rapid rate of deposition. Introduction of the basic and ultra-basic intrusives accompanied part of the sedimentation, and the sediments and volcanics were metasomatized to glaucophane and associated schists in the neighborhood of the contacts.

The coarseness and predominance of the clastic material at the base suggests a source area of rather high relief not far from the basin of deposition. The abundance of organic material indicates that this highland was well wooded. Taliaferro's reference to a western source is, in general, borne out, but at least a small amount of material must have come from Kerr Ranch exposures to the east. The much greater abundance of shale and chemical sediments near the top of the formation suggests reduction in relief of the source areas.

Franciscan deposition was followed by folding and faulting, probably in several stages, and the Redwood Mountain fault, the Crogan fault and probably the Bald Mountain fault were initiated. The area was uplifted and eroded to expose the Kerr Ranch schist which with the Franciscan furnished sediments for the Falor formation. The minor, local volcanism in the western part of the area belongs in this period, possibly in the Miocene.

In the upper lower Pliocene the area subsided, an arm of the sea entered the wide ancestral Mad River valley, and sediments from the near-by, heavily wooded land area were deposited. A molluscan shallow-water fauna flourished. The uppermost beds may represent continental deposition.

The end of the Pliocene was marked by uplift and normal faulting, followed by strong cross faulting and recurrent movement along old faults. There may also have been some compressional stress at an oblique angle to early stresses. During Quaternary time faulting continued and

[36] Taliaferro, N. L., Geologic correlation of the Jurassic of southwestern Oregon and California: Geol. Soc. America Bull., vol. 53, pp. 71-112, 1942.

the present topography was formed. Several Quaternary uplifts are indicated by terraces and by narrow lower stream valleys that contrast with the broad upper valleys.

ECONOMIC GEOLOGY

No mineral deposits are currently exploited in the area. There are a few minor prospects that have been worked from time to time. One property, the Horse Mountain Copper mine, to the east of the east boundary of the quadrangle, has yielded copper, and at one time employed several hundred men. The following data were obtained principally from a report of the California Division of Mines.[37]

Barite

A small vein of barite occurs in Franciscan sandstone on the Ford Ranch at Liscombe Hill. At present this vein is covered by soil, but float is abundant for about one-half mile along the strike. It is reported to be about 10 inches thick and parallel with the attitude of the sandstone.

Chromium

Several hundred tons of chromite were removed from the Horse Mountain Copper mine during World War I. It occurred in an ultrabasic igneous intrusive altered to serpentine. There may well be chromite in the ultra-basics of the Blue Lake quadrangle, but none was observed.

Clay

Near Hungry Hollow, section 20 (?), T. 6 N., R. 3 E; on this map, 731.2-2049, some small lots of clay usable for pottery making have been obtained by R. H. Jenkins for pottery making in his classes at Humboldt State College, Arcata. This clay is in the Franciscan formation and is a very small local deposit which was being worked in the summer of 1946, when the writers visited it. The clays in the Falor formation may be of value but no data are available.

Coal (Lignite), Maple Creek Deposit

An early patent for coal was granted for 80 acres in sections 20 and 29, T. 5 N., R. 3 E., H. M., on Maple Creek; on this map 734.6-2038.8. A seam of tough brownish-black lignite is reported to dip 45° NE. The width is not known, but it is thought to be 3 to 4 feet. In 1946, the mine area was completely overgrown. Mr. Myers Gundersen, an old resident, states that coal was dug about 30 years ago, but that it did not burn well.

Copper

Two miles to the east of the northeastern part of this area (sections 33 and 34, T. 6 N., R. 4 E., H. M.), there is an economic deposit of copper ore. There are 60 unpatented claims here under the group name of Horse Mountain Copper Glance Consolidated (Horse Mountain Copper Company). The last work was done in 1929; production was small and the property has since been abandoned. The country rock is serpentine and

[37] Averill, C. V., Mineral resources of Humboldt County: California Div. Mines Rept., vol. 37, pp. 499-527, 1941.

there are numerous hornblende gabbro pegmatite veins adjacent, some having crystals of plagioclase and hornblende 3 inches in diameter. A sample of ore obtained from a dump showed chalcocite, pyrrhotite, and chalcopyrite, in polished section.

Limestone

The few very small lenses of limestone in the Franciscan are not of commercial importance.

Manganese

Manganese stains Franciscan chert that is exposed near the Allard Ranch. Further investigation of this region may lead to the discovery of a commercial quantity of manganese.

Road Metal

Small quarries in which Franciscan basalt is being obtained for road metal are located along the Maple Creek Road, near the Barr Ranch, and on U. S. Highway 299 at the crest of Bald Mountain-Snow Camp Mountain Ridge. The rock, a brownish green, hard, and highly fractured variety, is loaded with a steam shovel and hauled by truck to roads in the vicinity. Some gravel, obtained along accessible reaches of Mad River, is used for concrete work or road metal.

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U. S. Weather Bureau

Annual Reports, California Section, 1937.

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* Prepared by Beth Collins

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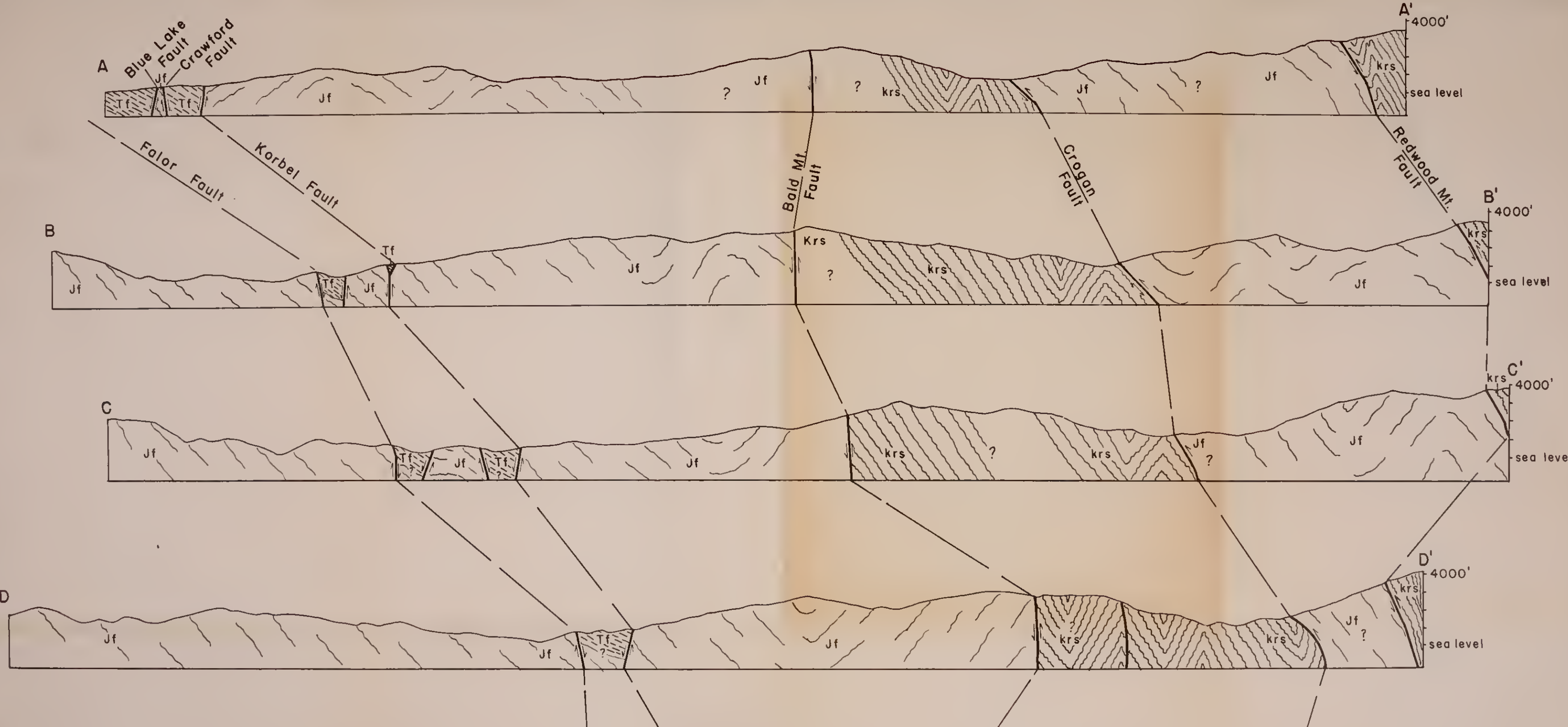
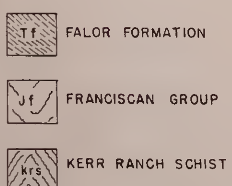




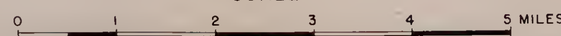
STATE OF CALIFORNIA DEPARTMENT OF NATURAL RESOURCES DIVISION OF MINES

GEOLOGIC STRUCTURE SECTIONS ACROSS BLUE LAKE QUADRANGLE, CALIFORNIA

ACCOMPANYING REPORT BY

G. A. MANNING AND B. A. OGLE

SCALE



DIVISION OF MINES
OLAF P. JENKINS CHIEF

STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES

BULLETIN 148 PLATE 1

LEGEND

QUATERNARY — *Recent*

Qal — Alluvium
(River sands and gravels)

Qt — Terraces
(Gravels, sands, and silts, poorly sorted)

TERTIARY — *Pliocene*

Tf — Falor formation
(Marine arkosic sands, clays, and conglomerates, upper red bed member)

Upper Jurassic (?)

Jf — Franciscan group
(Well-cemented arkosic sands, shales, cherts, conglomerates, basic volcanics, and basic and ultra-basic intrusives, local glaucophane schists)

Pre-Franciscan

pJkr — Kerr Ranch schist
(Muscovite-quartz schist, quartz-muscovite schist, green schists, and semi-schists and slates)

IGNEOUS ROCKS

TERTIARY (?)

Tt — Anorthoclase trachyte
(Shallow plug-like intrusive, porphyritic, acidic volcanic)

SYMBOLS

Contacts

Alluvium and terrace boundaries

Fault, known

Fault, inferred

Strike and dip of beds

Strike and dip of schistosity

Vertical schistosity

GEOLOGIC MAP OF THE BLUE LAKE QUADRANGLE, CALIFORNIA

By G. A. Manning and B. A. Ogle

Scale $\frac{1}{62500}$

Miles
Kilometers

Contour interval 50 feet
Datum is mean sea level

Manning
Ogle

Geology surveyed in 1946-47

DIVISION OF MINES
OLAF P. JENKINS CHIEF

STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES

BULLETIN 149 PLATE 2

LEGEND

QUATERNARY — *Recent*

Alluvium
(*River sands and gravels*)

Terraces
(*Gravels, sands, and silts, poorly sorted*)

TERTIARY — *Pliocene*

Falor formation
(*Marine arkose sands, clays, and conglomerates, upper red bed member*)

Pre-Franciscan Upper Jurassic (?)

Franciscan group
(*Well-cemented arkosic sands, shales, cherts, conglomerates, basic volcanics, and basic and ultra-basic intrusives, local glaucophane schists*)

Kerr Ranch schist
(*Muscovite-quartz schist, quartz muscovite schist, green schists, and semi-schists and slates*)

IGNEOUS ROCKS

TERTIARY (?)

Anorthoclase trachyte
(*Shallow plug-like intrusive, porphyritic, and/or volcanic*)

SYMBOLS

Contacts

Alluvium and terrace boundaries

Fault, known

Fault, inferred

Strike and dip of beds

Strike and dip of schistosity

Vertical schistosity

ECONOMIC MAP OF THE BLUE LAKE QUADRANGLE, CALIFORNIA

By G. A. Manning and B. A. Ogle

Scale 1/62500

Miles

Kilometers

Contour interval 50 feet
Datum is mean sea level

Manning

Ogle

Geology surveyed in 1946-47