GEOLOGY OF THE WESTERN SISKIYOU MOUNTAINS

by

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PLATE 1 Northwest Face of Preston Peak from the south slope of Young's Peak

TABLE OF CONTENTS

LIST OF PLATES

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Figure 1 Index map showing location of the area in the northwestern corner of California

Summary of Thesis

The results of the research in the western Siskiyou Mountains may be grouped in three principal categories, all of which represent original investigation. The first category deals with the land forms or physiography. Three distinct provinces, the coastal belt, the Klamath oldland, and the Siskiyou upland, are herein described in detail. The coastal province near the California-Oregon line exemplifies emergence and in this process the large terrace, on which Crescent City is situated, was formed. The Klamath oldland, a sub-aerial erosion surface, is found to have been developed in late Pliocene time and later uplifted 1000 to 3000 feet. The Siskiyou upland is fretted with mountain peaks of igneous rocks and has been subjected to Pleistocene glaciation.

The second phase of the study, stratigraphy (and petrology) was concerned with the physical characters of the rocks exposed and with defining their position in the geologic sequence of the northwestern Klamath Mountains.

The third major problem attacked is the crustal structure of this mountainous region. The principal fault, known as the Orleans fault, is reverse in nature and of large throw. By movement along it the Siskiyou upland has been lifted above the Klamath oldland to the west. The Crescent City fault has outlined the coastal pattern south of that community. By displacement on it the Crescent City terrace has been depressed with respect to the Klamath oldland to the east. The results of folding, intrusion, metamorphism, and faulting give eloquent witness to Klamath Mountains orogeny and indicate the circumferential compression of the group.

INTRODUCTION

Location, Relief, and Size of Area

The Siskiyou Mountains constitute an east-west range of peaks rising to a height of over 7000' above sea level along the California-Oregon border. They form one of the northwesternmost units of that scattered group of ranges extending over the major portion of northwestern California which were designated the Klamath Mountains by Major J. W. Powell.[1] The term was appropriately derived from the large antecedent river of that name which flows through the heart of the mountainous area.

The adjacent mountains of the coastal region of Oregon have received the self-explanatory name of Rogue River Mountains. To the south across the Klamath River rise the Trinity Mountains and progressively to the east the Salmon Mountains, the Marble Mountains, and farther to the south the Yolla Bolly Mountains and Bully Choop Mountains. Although not named these groups are indicated in Figure 1 which illustrates the position of the area considered. As compared to the lofty Sierra Nevada the Klamath group possesses a very moderate elevation, the highest portions of the Salmon-Trinity Alps scarcely exceeding 8000' while the general average for the group would approximate 5000'.

The key position of the group at the northern termini of the Sierra Nevada and the Coast Range of California and at the southern termini of the Oregon Coast Ranges and the Cascade Mountains endows the geologic history of the Klamath Mountains with more than usual interest. Early cursory investigations readily established that the group although geographically allied to the Coast Ranges is nevertheless petrologically related to the Sierra Nevada Range.

[1]Powell, J. W., Physiographic Regions of the United States, Monograph, Nat. Geographic Soc. p. 96 (1895)

The area embraces the northern halves of the Crescent City and Preston Peak Quadrangles, the former a compiled map with sketch topography, the latter the result of a 1915 survey of the United States Geological Survey. On the west this district reaches the Pacific Ocean while to the east the high western peaks (Preston Peak 7310') of the Siskiyou Mountains are included.

The area occupies the northwesternmost corner of California. Its north-south extent in Del Norte County is about 20 miles while the east-west distance along the California-Oregon border is about 48 miles. The area approaches 800 square miles.

Previous Investigations

Unlike other portions of the Pacific coastal belt the Klamath Mountains as a whole and particularly the Siskiyou Range escaped the attention of geologists. The late J. S. Diller of the United States Geological Survey carried out extensive explorations in the Klamath Mountains but touched only the coastal margin of the area under consideration, the results being published as Bulletin 196 of the United States Geological Survey, "The Topographic Development of the Klamath Mountains" in 1902. Mr. O. H. Hershey published a sketch map and note on Del Norte County geology embodying results of a reconnaissance in 1907.

Petrologic studies by A. N. Winchell of Josephine County, Oregon, have been published by the Oregon State Bureau of Mines and Geology. The same organization also sponsored work of a general and descriptive nature by G. M. Butler and G. J. Mitchell in Curry County. Both of the regions discussed are contiguous to the area being considered in this report. Other work having an important bearing on the general geology of the region has been done by H. W. Hoots of the United States Geological Survey near Eureka in Humbolt County. Studies are being made of the mineral deposits of south-

western Oregon by J. T. Pardee of the United States Geological Survey. N. E. A. Hinds of the University of California is investigating the geology of the Weaverville Quadrangle.

Purpose

The object of the present paper is to outline the essential facts in the geological history of the area studied in Del Norte County. Of great interest to the writer was the physiographic development of the region, involving as it does the coastal area with associated phenomena of marine erosion an old, elevated and partially dissected land surface, and the Siskiyou peaks with subalpine topography profoundly modified by glaciation. The attempt was made to map the areal geology in as much detail as time, natural obstacles and the scale of the map permitted. It was believed that the area studied would furnish a comprehensive stratigraphic and structural section from the sea to the core of the Siskiyou Range. However, in view of the natural difficulties of studying this region, difficulties of transportation, inaccessibility, vegetation, relief, and multiplicity of rock types, all of which will receive further comment, it is felt that the areal mapping could not be otherwise than general in nature.

The paleontology of the region was investigated only from a stratigraphic point of view. The preponderance of igneous rocks would furnish an excellent opportunity for making detailed petrographic study particularly in regional metamorphism. Although this may be undertaken at some future time, in this report the igneous rocks have been given a general classification and their genetic sequence has been briefly discussed.

Mineral deposits of many varieties are common in the region although as yet they are of minor industrial importance. For the sake of completeness the modes of occurrence, sources, and compositions of the most important min-

eral groups are briefly discussed.

Method of Investigation

Within the Preston Peak Quadrangle the topographic map of the United States Geological Survey afforded an adequate base. The contour interval of 100' and the scale of two miles to the inch preclude detailed mapping. Although as a whole remarkably accurate, occasional errors as well as generalization of topography make precise location impossible. This fact taken into consideration along with the difficulties of getting over ground due to excessive forest and brush cover, rugged relief, lack of trails, and intricacies of igneous contacts, would not justify the time required for tracing of contacts afoot. Contacts were located at trail crossings and at points adjacent to trails or roads by means of triangulation from topographic eminences with Brunton compass and by use of an aneroid barometer with 100' divisions. Continuation of contacts between points of definite location was usually done by observation from favorably situated prominences. In this connection it may be noted that distance involved and the masking effect of forest were frequently major difficulties.

In the Crescent City Quadrangle no usable map was available. Hence the 1928 survey of the United States Coast and Geodetic Survey with topography along the coast, together with maps of the Forest Service, Del Norte County, and the United States Army Engineer Corps, were utilized in compiling a new base map. Topography was sketched by taking Land Office, U.S.C.& G.S., and aneroid elevations of principal peaks and ridges, roads and trails for vertical control. Observations in the field and from the air were useful in correlating results. The map makes no pretense to accuracy but it is believed by the writer that the rough expression of topography justifies itself in clarifying physiographic as well as structural relationships.

PHYSICAL CONDITIONS

Culture

Crescent City, the county seat of Del Norte County, is the only large organized community in the area proper, and it had, according to the 1930 census, a population of 1715. Del Norte, "of the north" county of California has an area of 992 square miles of which 714 square miles or 71% is in the Government-owned Siskiyou National Forest. Its 1930 population was 4734.

The principal industry of the district is lumbering, the normal annual export of redwood lumber being 16-18 million feet. It is shipped to San Francisco and San Pedro. During the first half of 1930 the export total dropped to about 5 million feet. The second industry in importance is dairying which produces an annual income of about $1,000,000, some 1½ million pounds of butter being the principal item. Fishing is the third industry of importance, large amounts of salmon being canned each year at Requa at the mouth of the Klamath River.

One of the closest neighbors is Eureka, county seat of Humbolt County, about 90 miles to the south. Grants Pass, a city of 4659 and county seat of Josephine County, Oregon, is about 60 miles to the northeast.

In carrying out the present problem, two settlements were utilized as bases, Crescent City, California, and Takilma, Oregon, the latter being located near the ghost mining town of Waldo and adjacent to the California line. Takilma is a small community existing through agricultural activities in the upper Illinois Valley and the mining of copper at the Queen of Bronze and Cowboy Mines. These are owned by John Hampshire and Company of Grants Pass. Near Waldo is an active gold placer property, the Llano de Oro, operated by G. M. Esterly.

Transportation and Commerce

Existing on a narrow coastal platform with an immense wooded hinterland, Crescent City's earliest developed channel of communication was by sea. A poor road connected it with the Rogue River Valley of Oregon. Much of the stream of immigration into southwestern Oregon passed around the Horn and up the Pacific Coast to Crescent City whence the distance was short to the gold fields and farming lands.

It is difficult to realize the great strides which have been made in road-building in the northwest. Of paramount importance is the great surfaced and graded Redwood Highway, formally completed on July 11, 1928. Extending from the San Francisco Bay region to Grants Pass where it connects with the Pacific Highway, it has opened a new era in northern California. Crescent City has naturally felt the advantages of both tourist traffic and improved shipping facilities. Trucking and stage lines operate daily.

From Orick on the highway south of the mouth of the Klamath a highway, completed in 1924, extends over the Bald Hills to the mouth of the Trinity River whence it follows the Klamath River to the Pacific Highway near Hornbrook. Communication in the interior region was further improved in 1928 by the opening of the Salmon River road between Somes Bar on the Klamath and Yreka via Etna Valley. These highways are excepting short stretches adapted to one way traffic. Stage lines are functioning.

Crescent City not only is served by the Redwood Highway but is the ~~southern terminus of~~ the Roosevelt Highway extending north along the Oregon coast to Coos Bay. It was opened in 1929.

The interior mountain area is traversed by a few Forest Service roads and by a network of trails. Here horses and pack trains are as necessary as in the earliest days of settlement.

Figure 2 Field party of 1930 in Twin Valley

A short railroad, the California and Oregon Coast Railroad, belonging to the city of Grants Pass is 14.6 miles in length and extends southwest of Grants Pass. It is now being profitably managed by a receivership and it is the intention ultimately to build to tidewater at Crescent City. The railroad's right of way has been followed by the Redwood Highway but an agreement exists whereby the railroad may reoccupy the right of way by satisfactorily moving the highway where necessary at its own expense. This railroad is important to mining interests in both northwestern California and southwestern Oregon. Its significance is illustrated by a segregation of freight handled in 1929.

	Cars	Tons
Copper ore	41	2067.5
Cont. equip.	7	182.5
Lumber	281	7526.6
Logs	385	9178.5
Road Oil	42	1622.4
Limestone	1418	73170.0
Wood	37	1130.0
	2211	94878.5

Excepting a short lumber road there are no railroads in Del Norte County. The nearest connections are at Grants Pass which lies 60 miles away on the Shasta Route of the Southern Pacific and at Eureka, the northern terminus of the Northwestern Pacific which was recently acquired by the Southern Pacific. (added in '31)

There are no cable or telegraph lines to Crescent City, telegrams being transmitted by telephone to Grants Pass and relayed. The telephone system in northwestern California and southwestern Oregon is, however, nothing short of remarkable. Excepting the line between Crescent City and Grants Pass, it is largely owned and maintained by the United States Forest Service. Remote mountain tops and diverse settlements in the forests are in this way connected. While long distances and leakage along lines weaken voice transmission, the process of relaying is quite satisfactory and in the whole of the region there is a pronounced willingness to cooperate.

While recent developments in land communication have been great, the marine commerce is still most important. Crescent City is served by two steamship lines and has two wharfs. The usual draft limit for loaded vessels is 16 feet which has been a distinct handicap to shipping. Moreover, exposure to the open sea has necessitated loss of time in putting out to sea during storms and in some instances was responsible for loss of life and property. At present a breakwater is being constructed by the Federal Government for strategic purposes which is expected ultimately to provide an adequate and protected harbor. Thus shipping will be much stimulated.

The following table shows the tonnage and values transmitted through the harbor in recent years.

Year	Tonnage	Value
1921	29,639	1,278,700
1922	38,894	2,560,878
1923	48,260	3,472,500
1924	50,146	4,202,712
1925	68,609	5,332,903
1926	68,315	5,869,449
1927	81,915	6,920,205
1928	75,961	5,369,199

The outgoing commerce consists principally of lumber and dairy products and the incoming commerce of petroleum products and general merchandise.

Climatic Conditions

The climate in this part of California is essentially humid and temperate. Snow rarely falls along the coast and in but small amounts. Back from the coast the climate is different, there being an increase in temperature and humidity and comparatively little wind. The temperature is controlled largely by altitude. During the summer, temperatures in the interior valleys sometimes exceed 100. Nights, however, are cool. Winter temperatures below zero are uncommon although some have been recorded.

Precipitation Data[1]

Crescent City (Del Norte County)	Mean	annual	(1885-1923)	74.8 in.
Happy Camp (Siskiyou County)	"	"	(1915-1923)	39.9 in.
Monumental (Del Norte County)	"	"	(1904-1910)	109.1 in.
Orleans (Humbolt County)	"	"	(1885-1923)	48.6 in.

At the abandoned settlement of Monumental occurred the maximum recorded annual precipitation in California, 139.2 inches in 1907. The greatest precipitation is seen to occur over the area of the elevated land surface back from the coast. Farther inland as at Happy Camp the north-south ridges of the Siskiyous have caused a diminution on precipitation.

[1]Day, P. C., Climatological Data, Sect. 16, U. S. Dept. Agric. Weather Bureau

Snowfall:			
Monumental	Mean	(1905-1910)	126.2 in.
Weitchpec	"	(1909-1917)	51.5 in.
Youngs Valley[1]		(1916-1917)	316 in.
Temperature:			
Crescent City	Mean annual	(22 years)	52.1
	" Max.		60.2
	" Min.		44.0
	Highest		102
	Lowest		23
Orleans	Mean annual	(18 years)	59.4
	" Max.		73.8
	" Min.		45.2
	Highest		117
	Lowest		18

These figures illustrate the general increase in temperature inland. At Happy Camp[2] the maximum temperature is about 112, the minimum about 4.

Fogs are common at Crescent City, which is second only to Eureka in average number of days with .01 inch or more of precipitation. The average for 24 years is 111 days out of the year with .01 inch or more. The prevailing wind direction at Crescent City over 24 years is south in all months excepting March, April, May, and June, when it is northwest, a fact to be borne in mind in consideration of the coastal platform sand dunes.

Vegetation

A great proportion of the region is clothed with forest trees and brush. The extreme variety of climate from the balmy coastal plains to the sub-alpine peaks of the interior fosters a myriad of plant species. Thus there is an ideal merging for floras of northern and southern provinces. Groves of redwood (Sequoia sempervirens) occurring on the Crescent City platform are near the northernmost range of this important tree. From the north have come the Alaskan cedar (Chamaecyparis nootkaensis) and the dwarf juniper (Juniperus sibirica). The occasional occurrence of the latter on the

[1]Hoofer, A. C., blueprint
[2]Sutcliffe, E. M., District Ranger, Personal communication

higher peaks marks the southern limit of this typically arctic species.

On the river flats and at lower elevations oaks (Quercus) are common. Both here and at moderate elevations yellow pine (Pinus ponderosa) and sugar pine (Pinus lambertiana) stands occur. In most of the higher districts of the Siskiyou peaks are scattered stands of mixed types including Douglas fir (Pseudotsuga taxifolia), Port Oxford cedar (Chamaecyparis lawsoniana), western hemlock (Tsuga heterophylla), white pine (Pinus monticola), white fir (Abies concolor), noble fir (Abies nobilis) and occasional Brewer (weeping) spruces (Picea breweriana). This latter is found only in the Klamath Mountains. Among the many bushes of this region are rhododendron, manzanita, mountain balsam, snowbrush, and sandalwood oak.

In the extensive burned areas closely spaced lodgepole pines (Pinus contorta) and knobcone pines (Pinus attenuata) are clustered. Well nigh impassable thickets of manzanita and other bushes are characteristic. Huckleberry, Oregon grape, and thimble berry plants are common.

The thick vegetation of this region is of unusual importance. In the first place the fidelity of detail on the topographic map is impaired by groves of Douglas fir. The individual trees are from 100 to 150 feet tall and by their concentration in depressions they tend to obliterate relief. This condition is accentuated by the fact that the contour interval is 100 feet.

In the second place the vegetation is a serious, well nigh insurmountable impediment to cross-country travel. Thickly matted brush areas make progress painfully slow. Lastly vegetation effectively masks contacts and exposures of bedrock in most places.

Fauna[1]

In view of the relative lack of importance of man and man's work in the more inaccessible hinterland, it is interesting to note briefly the indigenous mammalian assemblages. Among the smaller forms the rodents are omnipresent. There are the meadow mouse (Microtus mordax mordax), the white-footed mouse (Peromyscus m. rubidus), the dusky-footed woodrat (Neotoma fuscipes) which usually builds a large brush nest at the foot of trees, and the western bushy-tailed wood rat (Neotoma occidentalis) which makes its home in hollow trees or to the traveler's inconvenience, in deserted cabins. Several members of the squirrel group are present including the Douglas pine squirrel (Sciurus douglasii), the silver gray squirrel (Sciurus griseus), and the Douglas ground squirrel (Citellus beecheyi douglasii) which makes itself a great nuisance when any camp equipment or food is left unprotected. Siskiyou chipmunks (Eutamias townsendii siskiyou) are found universally and are quite tame. In some favored localities are found the beaver (Castor canadensis) and the porcupine (Erithizon dorsatum dorsatum).

Fur-bearing carnivores frequently attract the attention of trappers and thus provide an intermittent vocation to cursory inhabitants of the back country. These include the Pacific fisher (Martes pennanti pacifica), the northwestern martin (Martes caurina), the California weasel (Mustela xanthagenys), the Pacific mink (Mustela vison energumenos), the Pacific raccoon (Procyon p. pacifica), the little spotted skunk (Spilogale latifrons), and the large striped skunk (Mephitis occidentalis).

Other important smaller carnivores are the ring-tailed cat (Bassariscus astutus raptor), Townsend's gray fox (Urocyon c. townsendi), and the coyote (Canis lestes) which is frequently encountered and more often heard in the late evenings or early mornings.

[1]In part from Stanley G. Jewett, U. S. Geological Survey

Among the larger mammals the most numerous and most important is the black-tailed deer (Ododoileus columbianus) which is daily encountered throughout the region. Elk, formerly numerous, were reported a few years ago in an isolated locality near Poker Flat. The black Bear (Ursus) is a very commonly encountered denizen of the wooded tracts. Their colors sometimes vary to a reddish-brown but all are wild and avoid human beings.

Bobcats (Lynx pallescens) are quite numerous though rarely seen. Del Norte County is famed for its unusually large numbers of the most respected carnivor of the West, the cougar or mountain lion (Felis oregonensis). From these last strongholds of this formidable animal dozens of pelts are secured annually by semi-professional hunters. Subsisting largely on deer they may be found anywhere in the area but though signs of their presence are fairly numerous it is rare that they are seen by man unless treed by dogs. During three months in the field in 1929 the writer observed but one in the open daylight, in the perenially deserted Rattlesnake Meadow below Preston Peak.

Advance Summary of Geomorphic Features of Northwesternmost California

In order to simplify the complicated physiographic history, the district will be divided into three separate provinces, the division being based on structure and geologic history. These provinces are, however, interrelated. Since Cretaceous and post-Cretaceous rocks do not enter into the deformation of the Klamath Mountains or occur save at the coastal belt, we may infer that the region underwent profound erosion in the early Tertiary. There is at present no way of recognizing interruptions of these earlier cycles of erosion. By the middle of the Tertiary a system of north-south striking faults had become active and the later history of the blocks thus formed becomes legible.

In the first decipherable history of the Crescent City platform, a surface of low relief extended considerably beyond the present Point St. George. Movement along the bounding fault to the east led to submergence and deposits correlated with the Empire beds of Coos Bay were laid down. These are presumably lower Pliocene. An uplift and slight tilting of the block to the northeast exposed a low-lying marine terrace to the action of the waves. Erosion of the shoreline and progression of marine planation brought the point of attack to the scarp of the fault to the east of Crescent City. This retreated a short distance but the new shoreline bore the linear outline imparted by the fault. Stacks were developed in the resistant sandstone at the back of the platform. This shoreline may be followed northward into Oregon where it lies about 100 feet above sea level and close to the present shoreline. In a late stage of this planation occurring in the Pleistocene, a thin veneer of sands was deposited. Again movement on the fault occurred and tilted the block to the northeast so that the southern margin emerged from the sea while the northern portion became an embayment. The

most recent history of the platform is concerned with the filling of this embayment. This proceeded through the increment of stream gravels from the Smith River on the inner margin and through progradation of the beach on the outer margin. As a result of this progradation two fresh water lakes lying parallel to the shoreline have been enclosed. Vigorous wave attack is at present cutting back the southwestern shoreline leaving terrace remnants and stacks.

The Klamath oldland province now varies in elevation from 1400 feet near the ocean to over 3000 feet near the Siskiyou escarpment to the east. On the Klamath oldland block a region of extremely low relief, which may be called the Siskiyou peneplain, was developed before upper Miocene time. Submergence of this surface in the upper Miocene was followed by accumulation of Wimer beds on the extreme western margin. This relationship convinced Diller of the pre-Wimer development of his underlying "Klamath peneplain". The present study confirms the former determination of these beds as upper Miocene. Among the forms present in the fauna, Pecten discus is particularly indicative. The fundamental question raised by this determination is whether this sub-Wimer surface is really part of the general Klamath surface or whether the Klamath surface is younger and passes over the Wimer beds. These beds are thin surficial accumulations hence projection of the Klamath erosion surface from the east to the west with its attendant error will give no indication of true correlation. Moreover, the beds are nearly horizontal, thus beveling is not demonstrable. Outside evidence is necessary. This is afforded by continuation of the Klamath surface to the south, varying here and there in elevation because of local deformation. In the vicinity of the Eel River near Eureka the surface bevels the folded Pliocene Wildcat beds. Surfaces appearing at two elevations here were interpreted by Diller

as representing separate cycles. It seems probable that the lack of accordance is due rather to later displacement on faults.

While two nearly accordant surfaces of differing ages can be recognized in the Crescent City quadrangle it is difficult to ascertain the line of their juncture. The underlying Siskiyou peneplain has been partly exhumed. The Wimer beds may have extended over nearby level areas of the margin, but to the east a marked relief on the remnants without evidence of deformation indicates the presence of an oldland rather than a peneplain. No remnants of Wimer beds have been found on the oldland to the east of the margin. Instead stream gravels occur in shallow valleys not accordant with present drainage or relief.

We may then summarize the physiographic history of the oldland area by pointing out first, the development of a pre-upper Miocene peneplain, second, submergence with deposition of the Wimer beds, third, differential uplift with the Wimer beds remaining near base-level and escaping removal while the back country was degraded over large areas to low relief corresponding to advanced old age. The truncation of the folded lower Pliocene Wildcat beds points to an upper Pliocene age for this period of erosion. The most recent history of the surface has been concerned with its uplift in the Pleistocene and Recent times. First, a broad upper valley was cut. Then a more pronounced and rapid uplift with rejuvenation of the streams led to production of steep walled inner valleys. Finally, a recent uplift and envigoration of the streams has developed narrow gorges in favorable places.

The Siskiyou Range itself may be termed an upland for it has been elevated several thousand feet higher than the oldland to the west by movement along the Orleans reverse fault. The extensively eroded scarp forms a clear cut physiographic boundary. The upland itself is cut on crystal-

line intrusives and schists, all of the rocks being relatively resistant save serpentine which commonly serves as the floor of valleys and passes. A relief of over 4000 feet exists. Streams are subsequent throughout the upland. Persistent uplift of this region has led to deep denundation. During the Pleistocene the valleys of the subsequent streams were occupied in part by glaciers. Meager evidence for an early and very extensive glaciation may be found in the lower reaches of the valleys. Signs of a much more recent and less extensive glaciation are found in the U-shaped cross-section of many valleys. The tarns of this stage are now filled and covered by meadows. The last and very recent glaciation led to the development of glaciers only on the higher peaks. These were cliff-glaciers. The lakes of this stage are still open and polished rock surfaces persevere. The most recent event has been uplift probably regional and correlated with the uplift of the Crescent City platform and gorge-cutting in the oldland area.

Previous Physiographic Study

Diller[1] in discussing the physiographic history of the Klamath Mountains notes sixteen distinct stages of development. To what extent his sequence deduced for the whole of northwestern California corresponds with that in the Crescent City and Preston Peak quadrangles will be clear through comparison with the writer's deductions.

For comparative purposes it will be necessary to take up his sequence stage by stage:

1. Klamath stage. Erosion from Eocene to Miocene reduced Klamath region to a peneplain. The Coast Ranges were receiving Miocene deposits. (Deposits in northern Coast Ranges Pliocene as far as known.)
2. Post-Klamath faulting. Uplift.
3. Bellspring Stage. Truncation of the "Miocene" beds of the northern Coast Ranges to form Bellspring peneplain, "practically continuous with the peneplain of the adjacent Klamath Mountain district". (Bellspring peneplain considered as identical with Klamath oldland in this paper.)
4. Post-Bellspring uplift. Differential uplift greater toward the crest of the Klamath Mountains.
5. Sherwood stage. Five hundred feet lower than the Bellspring peneplain, the Sherwood peneplain was developed principally on "softer beds of Miocene age". (Sherwood peneplain not recognized in this paper, lower levels locally ascribed to faulting.) Diller recognized this surface particularly from the Chetco River south and states that where the rocks were hard broad valleys are only

[1]Diller, J. S., U. S. G. S. Bull. 196

development. The broad upper valley of the Smith River does not warrant use of the term.)

6. Post-Sherwood uplift. Differential uplift.

7. Garberville stage. Broad valleys developed in valleys or plains of the Sherwood stage. (Garberville too far removed from area considered to admit of correlation with later uplifts.)

8. Post-Garberville subsidence.

9. Hay Fork stage. Valley filling, estuarine deposits "containing shark's teeth and Miocene leaves". (This is far removed in the Trinity drainage and no evidence is found near Smith River.)

10. Post-Hay Fork uplift. Elevation of 1,500' bringing land 600' higher than at present.

11. Continental broder stage. Erosion of the now submarine Miocene border deposits during unusually high stand of the land. (Diller points to an unconformity between Miocene and Pliocene at Battery Point. Due to conditions mentioned in the discussion of stratigraphy, it is no longer possible to verify the presence of sediments of Pliocene age near Battery Point. Sediments of Miocene age are lacking here. Quaternary sands rest directly on Mesozoic Dothan.)

12. Post-continental border stage. Subsidence to below the present level.

13. Battery Point stage. "The fossiliferous Pliocene San Diego beds of Battery Point near Crescent City were deposited during this stage."

14. Post-Battery Point subsidence. Subsidence to level of Sherwood peneplain.

15. Marine terrace uplift stage. Uplift with terraces developed at 1,500', 1,000', 100'. (It appears to the writer that duplication exists because of separate treatment of coast and hinterland valleys. Stages in the recent uplift are reflected both at the shore line and in the interior.)

16. Coos Bay subsidence.*

Lawson's[1] paper on the Geomorphogeny of the coast of northern California presents a sequence of events in the Eel River region and which is therefore not in all respects accordant with the sequence farther to the north in Del Norte County.

1. Development in Pliocene time of a great coastal peneplain with correlative accumulation of marine sediments. (The Wimer upper Miocene beds were, of course, unknown.)
2. The orogenic deformation of parts of this peneplain and the folding of Pliocene strata, the general altitude of the peneplain where not so disturbed, remaining the same.
3. The reduction of the soft upturned Pliocene strata to base-level, and the limited extension of the peneplain in between uplifted blocks of other disturbed areas.
4. The progressive uplift of this peneplain, with its residual monadnocks, to an elevation for the plain of from 1,600' to 2,100', the adjacent mountainous tracts participating in the same movement.
5. Advance in the new geomorphic cycle to a stage of late adolescence or early maturity.
6. A very recent local sag or depression of about 100 miles of coast

*But one of these stages, the Coos Bay subsidence, is recognized by Diller as being local in character

[1]Lawson, A. C., Univ. Calif. Publ. Bull. Dept. Geol. 1:241-272 (1894)

adjacent to the Golden Gate and the consequent flooding of the stream valleys by the ocean.

Abstract of Coastal Physiography

Along the coast of northern California extends an oldland now lying at elevations from 1400 to 3000 feet. It has been warped and faulted locally and dissected to a stage of late youth. Great V-shaped valleys have been cut by vigorous streams. The mightiest river of them all, the Klamath, which rises southeast of Crater Lake in Oregon has its mouth some thirty miles south of the California-Oregon border. To the south of this mouth the coast has sunk, permitting the drowning of several creek systems. North of the mouth of the Klamath River the shoreline is determined by a fault. The landward block has been upthrown, while the seaward block has been downthrown. Marine erosion has caused some retrogradation of the shoreline but the height of the seaward facing escarpment (over 1000 feet in places) and the resistance of the rocks has made the progress slow.

The platform on which Crescent City is situated has undergone a complicated series of movements involving both uplift and subsidence. This platform rises to a maximum height of 75 feet at the base of the linear escarpment to the east which is in line with the shoreline to the south. The physiographic history of the platform may be summarized:

1. Development of pre-Upper Miocene peneplain on resistant metamorphic rocks, extending to the seaward of Point St. George.
2. Submergence, deposition of veneer of Upper Miocene marine sands.
3. Faulting along Crescent City fault begun or renewed.
4. Differential uplift of the back country, the amount increasing to the east, inaugurating a new cycle of erosion.
5. Deposition of thin and scattered Pliocene marine sediments on the

on the Crescent City platform.

6. Reduction of the back country to low relief, the Klamath oldland. Uplift on Crescent City and coastal faults 500 to 1000 feet. Late Pliocene.

7. Crescent City block slightly lifted and tilted to the north. Marine planation across softer beds of platform to escarpment with development of stacks there. Shoreline north of Sinestia Peak to the Oregon boundary driven inland from ½ to 1 mile east of present shoreline. Deposition of Pleistocene shoreface terrace materials. Possibly delta sandstones and conglomerates occurring in gap in ridge northeast of Crescent City deposited by Smith River at this time.

8. Uplift of mainland block about 100 feet. Uplift of Crescent City block with tilting to the north. Emergence of the southern portion from the sea.

9. Deposition of delta materials by Smith River in embayment over northern portion of the platform.

10. Progradation of the western shoreline by longshore drifting and beach drifting with enclosure of two freshwater lakes parallel to the strandline. Progradation of the shoreline between Battery Point in Crescent City and the mainland block.

11. Retrogradation of the southwestern shoreline where portions of the former marine bench are visible. Isolation of stacks.

12. Dune drifting with partial anchorage by vegetation.

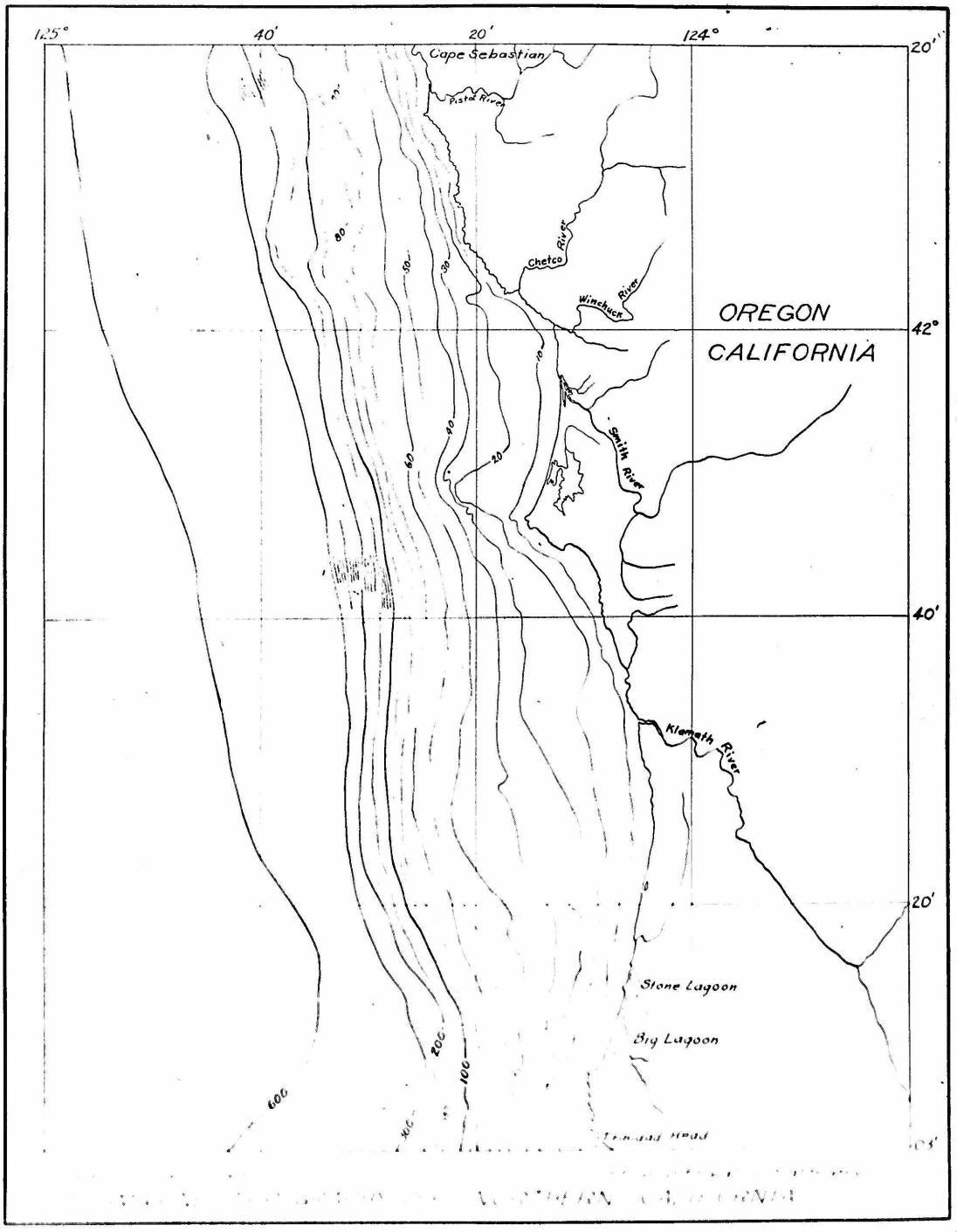
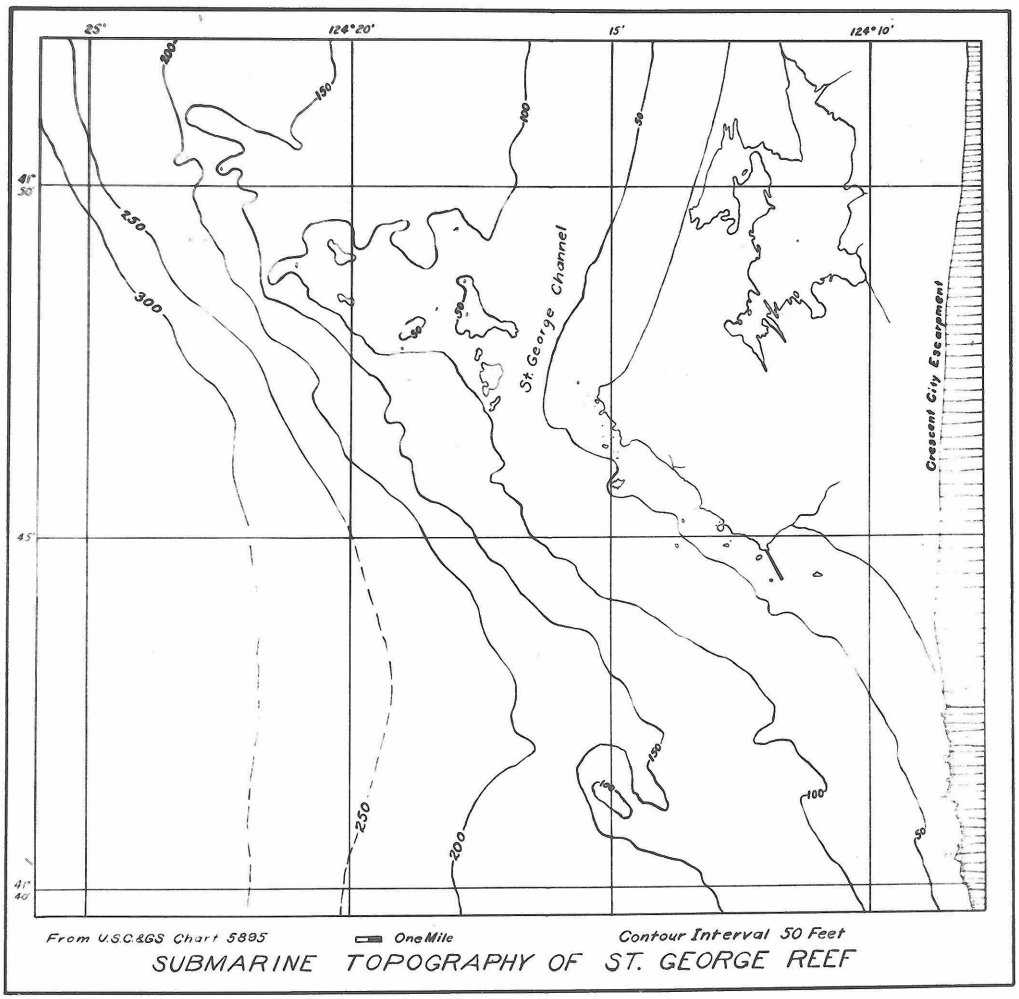

125°
40'
20'
124°
20''
Cape Sebastian
Pistol River
Chetco River
Winchuck River
OREGON
CALIFORNIA
42°
Smith River
40'
Klamath River
20'
Stone Lagoon
Big Lagoon
Trinidad Head
60
80
30
10
90
20
200
100
600

Figure 3


25'
124°20'
15'
124°10'
41°
50'
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250
300
250
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150
100
50
St George Channel
Crescent City Escarpment
From U.S.C.&G.S. Chart 5895
One Mile
Contour Interval 50 Feet
SUBMARINE TOPOGRAPHY OF ST. GEORGE REEF

Figure 4

The Shoreline of Northern California

Introduction

The coastline of northern California and southern Oregon is one of remarkable boldness and though cremulated in detail it is regular taken as a whole. A few prominent headlands project so as to disturb the somewhat rectilinear outline. No great estuaries or embayments indent the land. From Point Conception to Cape Blanco there are but three major projections. To the north of Eureka and the mouth of the Mad River, Trinidad Head extends about two miles to the seaward of the general coastline. Some fifteen miles south of the California-Oregon line is Point St. George, from which a reef of rock projects about seven or eight miles into the Pacific. To the north of the border there is a broad, general prominence reaching from Cape Ferrelo to Cape Sebastian. Along the greater part of this shoreline high cliffs front on the ocean and are broken here and there by a valley mouth with a stream.

From Trinidad Head north 65 miles to the Oregon boundary the rocks are remarkably uniform in type and attitude. The Dothan formation, which is correlated with the Franciscan formation of supposed late Jurassic age, consists largely of metamorphosed gray sandstones. Minor shales, cherts, and intrusive bodies are also present. The rocks strike in general northwesterly and dip steeply east.

While rock structures and differential erosion are responsible for the position of the shoreline in detail, it is believed that the regularity and linear outline of the shoreline north of the Klamath River is determined by a fault. One must, however, use care in postulating relationship between faults and lineaments of earth features in view of extreme emphasis by Hobbs[1].

[1]Hobbs, W.H., Lineaments of the Atlantic Border Region, Bull,Geol.Soc.Am. 15:483-506 (1904)
Earthquakes, New York (1907)

Johnson[1] has cast doubt on the too liberal extension of the fracture theory of earth lineaments to coast lines.

Mention should be made of the topographic development of the back country. During the Pliocene an extensive sub-aerial erosion surface of low relief was developed over the northern Coast Ranges of California and fringing the Klamath Mountain group of northwestern California and southwestern Oregon. This surface was characteristic of the old age stage. For this reason the writer refers to it as an oldland. This region has been uplifted from 1000 to 1500 feet along the coast and dissected to a stage of late youth. In figure the different physiographic provinces are delineated. The Crescent City platform as a portion of the coastal province will be treated in this section of the thesis. For convenience the coastal physiography may be discussed in three sections, one concerning the subsided coast south of the Klamath River, another the upfaulted coast north from the Klamath River to the Crescent City platform, and the other related to the complicated events of both uplift and subsidence affecting the anomalous Crescent City platform itself.

The Area of Subsidence

Just to the north of Trinidad Head and Patrick's Point in northern Humbolt County, California, the submarine contours swing markedly toward the land in a way suggestive of depression of the continental shelf. The shoreline itself exemplifies subsidence. The debouching subsequent streams have a trellis pattern adjusted to the northwest striking structure previously mentioned. They have dissected much of the country adjacent to their lower reaches to maturity, their headwaters alone extending to the region where

[1]Johnson, D.W., New England Acadian Shoreline pp. 43-57 (1925)

small remnants of the Klamath oldland still exist. The Bald Hills of Humbolt County are typical of these remnants.

The largest and in many ways the most striking embayment in this region is Big Lagoon which lies immediately north of Patrick's Point. Here the mouth of Pitcher Creek-Maple Creek drainage system has been invaded by the sea. A striking feature of the embayment is its breadth and rather short inland extension. This may indicate rapid accentuation of the foundering near the shoreline. It can also be accounted for on the basis of more effective lateral planation of the streams as they approached closely to the former base-level. The broad coastal valley would when drowned give the condition found today. The lagoon is asymmetric, the bayhead being located to the southweast, because of structural control.

Figure 5 Big Lagoon, looking south along a ria shoreline of submergence in the stage of middle youth of the shoreline cycle.

The embayment is closed by a broad, sandy, and straight baymouth bar of asymmetric cross-profile, the seaward slope being pronounced, the bayward slope being gentle, intersecting the water's surface in sweeping arcs.

The bar is given this cross-profile by over-wash during storm periods. Much wood and debris accummulates on the bayward slope. Near the north end of the bar is a tidal inlet which is open during exceptionally high tides.

The seaward projecting spurs have been truncated by wave attack and are beautiful examples of cliffed headlands. Their regularity in seaward extension may not only be due to characteristic wave erosion but also to faulting. In this case the shoreline would not be one of simple subsidence but rather a compound shoreline, a neutral shoreline with subsidence.

In this connection a peculiarity of the bayhead region may be mentioned, notably the minor development of waste accumulations. Bayside beaches are practically non-existent. The bayhead delta and marsh is relatively small. If faulting had in part determined the position of the headlands a later stage of youth would be stimulated than actually exists. However, one must not overlook the fact that the creeks themselves are small.

Stone Lagoon, the drowned mouth of McDonald Creek to the north of Big Lagoon, is longer and narrower in its proportions. Its long axis also

Figure 6 Stone Lagoon, looking southeast toward the bayhead delta and the mouth of McDonald Creek

also extends northwesterly. In the presence of barrier bar and bayhead marsh it resembles Big Lagoon. Another smaller though similar lagoon, Freshwater Lagoon, lies immediately to the north. The shoreline in this vicinity is in the youthful stage of the shoreline cycle.

North of Freshwater Lagoon is the mouth of Redwood Creek whose course is in general northwesterly. It receives the waters of Prarie Creek which flows southward closely paralleling the shoreline to the north from a mile and a half to two miles inland. This coastal area is known as Gold Bluff. Prarie Creek receives most of the drainage of the entire coastal area for the streams which drain down the sea cliffs are few and insignificant. The mouth of this creek system has been silted up, presumably through diminution of gradient because of subsidence. Gold Bluff itself although the result of former uplift, probably on a fault, may have shared in recent subsidence because the mouth of the great Klamath River to the north is drowned.

The Klamath River rises inland in the drainage basin feeding the Klamath Lakes of Oregon and flows through most of its course in a steep-walled canyon. The Klamath Mountains flank it on either side. The writer believes it to be antecedent through this region. This is significant in accounting for such a large stream having its mouth on such a mountainous coast. Some deference, however, is shown to structure and in the stretch from the mouth of the Trinity River to the Klamath's mouth at Requa it has the northwest strike of the smaller streams. The last two miles of its course is definitely embayed and a number of sandy islands testify to it diminished transporting power. The embayment is closed by a baymouth bar having a tidal inlet near its southern extremity.

Thus from Trinidad Head north to the mouth of the Klamath River the most recent movement of the coast is one of subsidence.

The Uplifted Coast North of the Klamath River

From the mouth of the Klamath River northward into Oregon the most recent movement appears to have been uplift. The exceptionally rugged coast extending northward to the Crescent City platform is due to the compound effect of uplift and marine erosion. The sea cliff where it reaches an elevation of 1000 feet forms an imposing scarp. From physiographic and structural evidence noted about the Crescent City platform it would appear that the cliff face was once a fault scarp which has since its formation been profoundly modified by marine planation.

Figure 7 Looking south along the precipitous northern California coast line. Flat-topped surface in left foreground 1000 feet above the sea.
Airplane photo by writer from altitude of 4000'

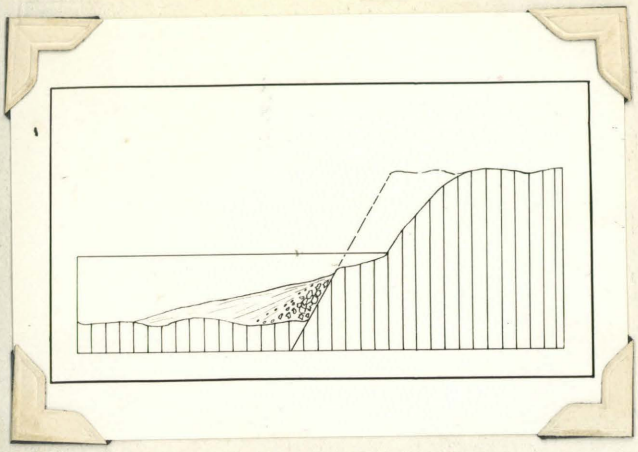

Figure 8 Profile of a fault shoreline. Modified after Johnson

The cross profile of the coast line accords well with that developed in the accompanying figure 8, illustrating a neutral shoreline of faulting. The fault surface in the present instance has been obliterated by marine erosion and weathering. In detail a crenulated pattern is developed. This is illustrated by figure 7 on the previous page. Rocks lie immediately off the strand line. Slides are continually carrying down portions of the cliff to the sea. This feature has been annoying in many instances to those maintaining and using the Redwood Highway which follows the cliff for some distance. Immediately inland from the cliff remnants of the Klamath oldland occur. This surface must neces-

Figure 9 Looking east at the sea cliff three miles south of Crescent City from an elevation of 4000 feet over the Pacific Ocean Airplane photo by writer

sarily have been developed near baselevel and its present elevation of 1400 feet in places gives an idea of the magnitude of recent uplift.

North of Endert's Beach at the mouth of Nickel Creek south of Crescent City a stream terrace, in part rock cut, is developed at an elevation of 50 feet. Refer to figure 10 on the next page. Extension of the terrace at its present slope would project the former creek mouth at least 700 feet, a distance which the alignment of the scarp behind the Crescent City platform does not justify. The position and slope of this terrace indicate that the mouth of the stream has either been uplifted with consequent dissection of the terrace by the rejuvenated stream or that the mouth was once a considerable distance seaward. The former alternative would imply movement on fault while the latter would involve extensive marine planation. However, the propositions are not mutually exclusive. Indeed, marine planation is necessarily significant in view of the fact that the inferred fault is offshore. Yet, as has been shown, this process could not have solely given rise to the elevated terrace. The truncation and dissection of the terrace are thus due to the combined uplift of the seacoast and marine planation.

Approaching Crescent City the Redwood Highway follows along the face of the sea cliff. When the Crescent City platform comes into view it is seen that the sea cliff does not curve to the northwest with the beach but swings northwesterly and meets the shoreline near Sinestia Peak. The platform itself is a unique feature of the northern California and southern Oregon coast and will be taken up in considerable detail subsequent to a brief review of the coast to the north.

Beyond Sinestia Peak to the north the major sea cliffs do not front on the present shoreline. Rather a marine terrace lying at an elevation running up to 100 feet above sea level and varying from $\frac{1}{8}$ to $\frac{1}{4}$ mile in width

Figure 10 LOOKING NORTH TOWARD CRESCENT CITY PLATFORM

intervenes. On this rock-cut bench are occasional stacks. This former strandline is correlated with that along the east of the Crescent City platform which will be discussed later. The terrace perseveres at constant elevation to a point some seven miles north of the California line and beyond Brookings in Curry County, Oregon. At a number of places along the terrace kitchen middens occur.

The Crescent City Platform

The anomalous Crescent City platform is a sub-rectilinear marine terrace varying from the ocean's level to about 75 feet above. The mean for the whole platform would be about 25 feet. The southern margin is fringed by the hard, olive green to gray sandstones of the Dothan formation. These project seaward as a strike reef, the St. George Reef.

Figure 11 Looking down on Pt. St. George from an altitude of 1500 feet. Note the stacks to the right and the diminishing height of the sea cliff to the left

The relationship of the platform to the submarine topography about Point St. George is graphically illustrated in the accompanying chart, figure 4. While the northern portion of the platform is composed of stream gravels the southern portion is largely an emerged marine terrace sand which has in part been reworked by the wind. Forests of redwood at one time blanketed the platform and remnants are still found. Dunes at Pt. St. George bear large kitchen midden deposits.

As is demonstrated in other portions of this thesis, the early Tertiary history of the Klamath region is one of uplift and denudation. How many cycles of erosion were completed or interrupted in this long period cannot now be determined. It is known, however, that during a long period of quiet preceding the upper Miocene a peneplain was developed. This surface extended over the Crescent City platform. Subsidence at this time was followed by deposition at least on the oldland block of the upper Miocene Wimer marine beds. On the platform these beds or correlatives either were never deposited or were subsequently swept away. Faulting must have been begun or renewed at this time along the Crescent City fault for we can distinguish the subsequent histories of the regions to the east and the west. On the Crescent City platform scattered Pliocene marine beds were deposited while none have been found on the oldland block. The Georgian formation which is possibly lower Pliocene lies on a northeastward sloping erosion surface which may be observed at various places along the southern margin of the platform. On a sea cliff at Point St. George these Tertiary beds may be seen dipping northerly. Their northward extension under the surface of the platform and under Pelican Bay to the west of it is indicated by fossiliferous fragments carried by the waves up to the Talawa barrier beach. This structural and stratigraphic dissimilarity between the Klamath oldland block and the Crescent City platform is conclusive evidence of faulting.

Either at this time or somewhat later the Smith River had its mouth near the middle of the present escarpment east of the platform and south of its present debouchement. Here a delta deposit accumulated. Much of this should be at the present time buried on the nearby portions of the Crescent City platform. Associated materials have been preserved in the old channel followed by the Redwood Highway as it leaves the platform. Renewed uplift led to slipping off and adjustment to the northwest striking structure.

Figure 12 Looking southeast from Pt. St. George. Note the gentle northeast tilt and the accordance of the surface with Castle Rock to the right

The platform was uplifted somewhat to the north so that wave action subsequently beveled both the metamorphosed sandstones and the soft Tertiary rocks. See Plate 5 in pocket. These rocks because of their weakness readily succumbed to wave attack and were part swept away. Ultimately the sea came to attack the scarp to the east of the platform developed in the previous large uplift of the oldland block. Along the coast north of Sinestia Peak the shoreline was not driven so far inland, a feature to be explained by the

Figure 13 Looking north along the Crescent City platform from stack near Pt. St. George. Shoreline in foreground retrograding in Dothan shales and sandstones, shoreline in background prograding from lake area. Platform of marine planation in foreground, dunes in distance

superior resistance of the Dothan sandstones. With the passage of the Pleistocene the Crescent City fault plane was completely eroded away and the cliff face receded a distance not definitely known at present, presumably a few hundred feet.

Sub-aerial erosion resulted in degradation of the angular margins of the escarpment and in the incision of numerous ravines in the coastal face. That these ravines did not completely obliterate evidences of faulting on the platform is due to still another structural detail, namely, that the triangular region east of the face, with the apex at or near the point of debouchement of Smith River and legs along the coastal face and along the Bald Hills, was so tilted to the northeast that all the drainage of the block save that of the coastal face itself was diverted into the Smith River. The small streams down the western face have been incapable of extensively modifying

the topography. As a consequence the face possesses a due north and south trend up to the debouchement of Rowdy Creek on the platform. There the face is directed northwest. The angularity of this deflection is probably in part due to lateral planation of Rowdy Creek. The face as a whole makes an angle to the strike of the Dothan sandstone. As may be noted in photograph, figure 14, the linear outline of the escarpment is very pronounced from the air.

Figure 14 Looking east over the Crescent City platform from an elevation of 2500 feet. Note linear character of escarpment

Some facetting of interstream spurs has taken place as a result of marine erosion. Evidences of this process affecting the escarpment are definite and unmistakable. In addition to the testimony of the Quaternary marine terrace deposits extending to the face and the truncated spurs with small local terraces, there are a number of isolated stacks immediately adjacent to the face. An excellent example of one rising 75 feet above the old sea floor is shown in figure 15 on the next page.

Figure 15 Looking north along the former shoreline and sea cliffs at the back of the Crescent City platform (east). In the foreground is seen the sloping littoral area. The tree covered hillock in the center is a former stack composed of typical green Dothan sandstone with included black shale pebbles.

Lenses of broken mollusc tests incorporated in the terrace capping at Battery Point in Crescent City indicate the Pleistocene age of this transgression.

Following the attack on the escarpment to the east of Crescent City the platform was elevated slightly and tilted to the north. The general uplift of the oldland correlated with this movement has led to gorge cutting by streams. The tilting of the platform resulted in emergence of the southwestern corner from the sea and possibly the whole southern margin. However, much filling took place in the southeastern corner because from Battery Point to the cliffs on the east the shore is low and sandy. In this low-lying filled area drainage is disorganized. Streams terminate haphazardly in swamps and outflow is by seepage to the nearby ocean or it is carried by distributaries.

Smith River began to fill the embayment to the north with its gravels. In this manner the shoreline was prograded seaward. Deposits in cuts, natural or otherwise, in this region are clearly fluviatile. In many cases they lie nearly at the level of the sea. Along the seaward region from Sinestia Peak south and from Point St. George north, debris was easily gathered from the soft Tertiary and Quaternary sediments and was distributed by longshore currents and beach drifting. In this way it is believed that the Lake Earl area was enclosed partially by spits. At this time the mouth of

Figure 16 Looking north over Lake Earl

Smith River may have been located at this embayment judging from the position of Talawa Slough at the north of Lake Earl and from the depth of the channel communicating with Lake Talawa. A slight uplift reflected in a 15' terrace northeast of the present Smith River led to the exposure of a new area to wave action with the result that a barrier bar of sand was thrown up enclosing a second body of water, Lake Talawa. Shifting of the mouth of Smith River to the north and modification of the barrier by longshore currents led to approximately the present outlines of the lakes. Principal recent changes have been in the nature of accretion to mudflat

areas by minor platform tributaries and alteration of the shoreline by wind blown sand.

The present lakes are very shallow. Large areas of mudflat and tule' marsh lie between the open water and the low featureless shore. Lake Earl probably does not exceed 15' in depth while Lake Talawa is even shallower. At the narrows between the two lakes the channel reaches a depth of 20'. The barrier beach which protects Lake Talawa diminishes in width to the south until it becomes about 50' wide. A gradual interchange of waters is permitted. While the lakes have no large tributaries spring excesses in precipitation may so raise the level of the lakes as to flood adjacent fields. Hence the farmers about Lake Earl are accustomed at this time of year to excavate a trench across the barrier.

The western shoreline is being prograded at present. The load being discharged at the mouth of the Smith River is distributed alongshore.

Figure 17 Looking down on the mouth of Smith River from altitude of 1500 feet

The lower alluvial flats of the river are marked here and there by sloughs reminiscent of former channels.

The retrograding southwestern shoreline about Pt. St. George has been figured in the early discussion of the Crescent City platform. It remains to point out another factor in the changing topography of the platform, namely, the wind. Sand is plentifully afforded to the northwest winds and it is piled up in drifting dunesover large areas. Perfect Saharan scenes may be observed in this very humid climate but a few miles northwest of Crescent City. Near Pt. St. George a water filled depression between dunes is known as Dead Lake. Aeolian deposits are common over the southern half of the plat-

Figure 18 A view in the wind-swept dune country northwest of Crescent City. Looking northeast at a barchane of loose sand with well developed ripple marks. Profile indicates prevailing winds from the northwest.

form and may have been largely developed in the time following uplift of the platform above sea level when abundant supplies of loose material would be at hand but before the forest cover could gain a foothold. The present free moving dune areas are largely restricted to south and west and north and west of Lake Earl, the remaining dune country being anchored with brush and trees.

The Crescent City platform being itself in the youthful stage of the cycle chronicles the most recent constructive geological events in this portion of California. The back country to which it is intimately related, in its more recent history, chronicles a period of profound erosion. We must go back into the Tertiary for the story of its construction.

The Klamath Oldland

The Klamath oldland of the area under consideration occupies the region lying between the Pacific coast escarpment and the Siskiyou escarpment to the east. The latter is not a simple straight line but is frequently arcuate. It marks a definite topographic break which coincides with a lithologic break and is interpreted as a fault. Remnants of the Klamath surface do not occur to the east of it although some high lying areas occur to the west. The present elevation of the surface varies from 1400' west of the Bald Hills to 3500' along the Siskiyou escarpment. These figures do not represent original differences in elevation, for no part may be said to be undisturbed. Moreover there has been post-Klamath tilting to the west. In contradistinction to Diller's broad use of the term "Klamath-peneplain", the erosion surface herein designated "Klamath oldland" is restricted to the region above mentioned which is the type locality.

For convenience the discussion will be divided into two parts, one of which will concern a small fault segment with a somewhat different history, while the other will treat on the features of the principal area.

The Mill Creek Segment

Between the Bald Hills and the coastal escarpment is a large area which shows on the average of less than 500' relief. Its elevations run from 1000' to 1400' and appears to have been considered by Diller as a part of his Sherwood peneplain. The low relief stands in contrast to the cus-

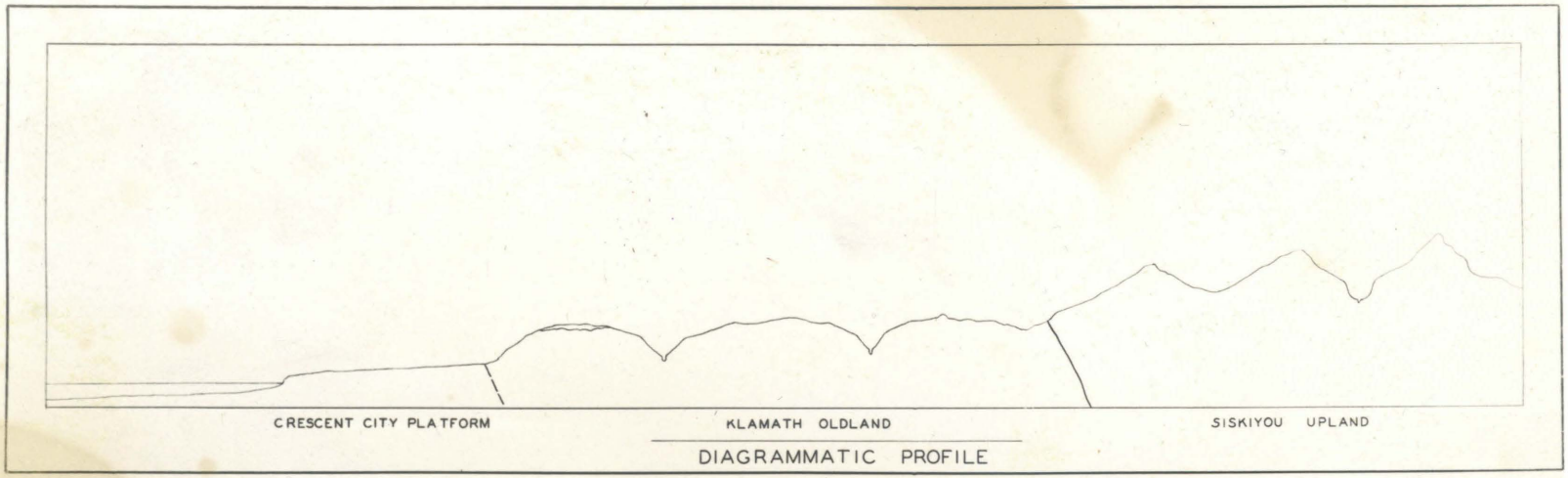

Figure 19 Profile showing bathymetric distinction between physiographic provinces. Wimer beds shown capping margin of oldland. Characteristic valley cross-profiles indicated.

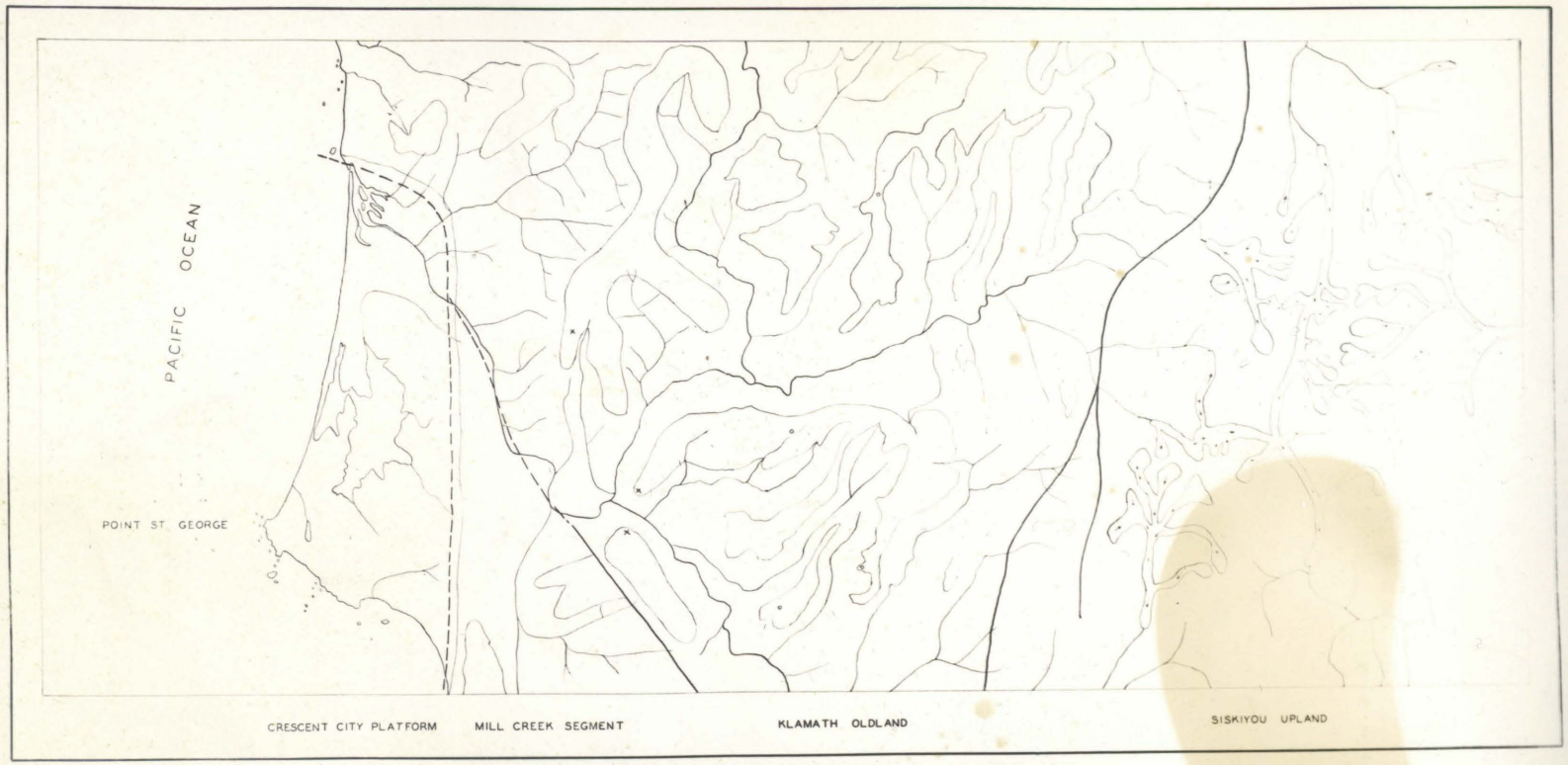

Figure 20 Illustrating boundaries between physiographic provinces. Remnants of the Klamath oldland are outlined in that province, crosses indicating patches of the Wimer upper Miocene sandstones, circles indicating oldland gravels. Pleistocene glacier system of the inherited dendritic type depicted in the Siskiyou upland province.

tomary 1500' to 2000' relief toward the interior. Moreover, the principal stream, Mill Creek, pursues a general north-northeasterly course whereas the Dothan sandstones strike northwesterly. It thus appears hardly possible that this should be primarily a subsequent stream. Its anomalous direction could hardly be derived from superimposition in view of the fact that no soft overburden occurs over the Mesoxoic rocks as remnants. As a matter of fact we might reasonably assume that the drainage was originally (i.e. during the last stages of oldland development) from the area of high relief directly to the ocean. Instead of this east to west trend the western tributaries of Mill Creek carry the water from the very crest of the Pacific Ocean escarpment. An example of this is noted in traveling over the Hobbs, Wall & Company lumber railroad shown on the Crescent City Quadrangle. Water that is less than a mile from the sea must flow tortuously around through Mill Creek into the Smith River and thence northerly to the northwest corner of the platform. In view of the conditions just cited Mill Creek must be reagrded as essentially a consequent stream whose course on the oldland surface was determined by the slope given the fault block. Additional physiographic evidence for this fault will be taken up together with stratigraphic relationships under the subject of structure. It should also be added as confirmatory evidence that both from points of vantage on the ground and from the air the plane that would pass tangent to the hilltops would slope north by northeast. This plane is not determined by accidental degradation but lies at or very near the former land surface as shown by A. water rounded pebbles of the oldland cycle on the flat top of Child's Hill, elevation 2291', B. deeply weathered schist on low lying ridges of Bald Hill, and C. by large flats on these ridges at elevations of about 1400'.

The Klamath Oldland Proper

The Klamath oldland is a well developed erosion surface extending over a portion of northwestern California and southwestern Oregon. In the strict sense of the work it was not a peneplain as has been so frequently stated but rather a surface in the old age stage of the physiographic cycle. It possessed considerable relief amounting with certainty to 500' ro 600'. To the northwest it was hemmed in by the Rogue River group of the Klamath Mountains, to the east by the Siskiyou Mountains while between the two groups a portion of the oldland extended into the valley of the Illinois River and the Rogue River drainage system. The extent to the south is unknown to the writer although he believes that the Bald Hills of Humbolt County are a continuation of the Rattlesnake-Red Mountain series of surfaces. The accordant flat summits of the Coast Ranges occurring between 3000 to 4000' which are to be observed from Bear Ridge south of Ferndale on the Eel River appear to be a related surface.

The surface occurs over a larger area and is in a better state of preservation in the Preston Peak Quadrangle than in any other area mapped topographically. Here the north-south drainage has separated a number of broad flat-topped ridges. Toward the coast on the north the surface appears at High Divide at an elevation of 2200' and slopes gently to the south down Myrtle Creek Ridge to an elevation of 1800'. To the south of the Smith River the Bald Hills at 1920', Child's Hill at 22CO', Little Rattlesnake Mountain at 3000', Rattlesnake Mountain at 3600' and Red Mountain at 4305' continue the rise. To the east of this group and at the north of the sheet Pine Flat Mountain with an elevation of 2500' is a large typical plateau remnant with a perfectly flat top. Northeast of this across the North Fork of the Smith River, Oregon Mountain with an elevation of 3100' occurrs. To

Figure 21 Looking northwest over the flat top of Low Plateau from High Plateau Mountain

Figure 22 Looking south from the center of Low Plateau. A characteristic scene on the Klamath oldland. The gentle undulating topography completely obscures the 600' chasm of the present cycle between the foreground and the background

the south is Low Plateau at 2800' and High Plateau Mountain at 3400'. To the west of Pine Flat Mountain is Brushy Ridge at 2500'. Elk Camp Ridge at 3500' is part of the High Plateau system of heights. South of the Smith River, French Hill at 2000' is a pronounced remnant. Lower Coon Mountain at 2700' and Haines Flat at 2200' lie to the south. Easterly the surface rises. Fordon Mountain with an elevation of 4170' must have been a pronounced elevap tion on the oldland. Upper Coon Mountain adjacent to the north at 3700' is on the surface. To the south of Gordon Mountain the ridge drops in elevation and immediately above Madrone Camp a flat-topped spur at 2500' is covered with a sprinkling of rounded gravels. A small flat remnant likewise occurs directly east of Madrone Camp at an elevation of 3500'.

Northward into Oregon the surface rises and Keeps to the east of the high elevations in the region of Chetco Peak and northwest of Sanger Peak. The Baldface Creek Rdige remnants near the Curry-Josephine County line lie at an altitude of about 3300' while Rough and Ready Creek Ridge runs about 3500'. Josephine Mountain just north shows a development of the surface on its south slope at 4000'. Elsewhere in the Kerby Quadrangle as at Gold Basin, 4000' (123°52', 42°18') and at Swede Basin 3500' (123°41', 42°23') remnants near the same general level.

In the southwestern Curry County some accordant flat-topped ridges may be noted swinging southwest of Chetco Peak, as for example Packsaddle Mountain, but the area was not studied in detail because of the lack of a topographic map.

That these surfaces are indisputably erosion remnants of a former stand of the land is evident from their large areal extent and basin shaped tops, evidences which are not obliterated or minimized by the deep canyons which have been incised between them during the present cycle. We have then, not merely accordant ridge crests but accordant plateaus. In the region of

Figure 23 Looking west from High Dome over Klamath oldland. High Plateau, a prominence on the oldland, to the left, Low Plateau in center distance, Elk Camp Ridge in foreground. The general relief of the surface may be deduced from plateau remnants for deformation and faulting are not believed important in area viewed. The surface is not a peneplain but is rather an oldland.

Figure 24 Looking NW over Pine Flat Mountain from Low Plateau. Level character of surface emphasized. Brushy Ridge rises above level slightly in center background and beyond the Chetco Mountains.

oldland development, panoramas (see Figure 23) emphasize the gentle relief and indeed frequently minimize features of the present cycle.

Again the presence of rounded gravels on some of the surfaces is conclusive evidence of former drainage on the surface. While stream gravels would seem to be the most ephemeral appurtenances of a land surface in view of their positions in depressions first attacked after lowering of base-level, there are a number of such occurrences. On Child's Hill as has been mentioned waterworn pebbles are scattered on the top. A similar instance was noted on the ridge west of Madrone Camp. In both cases the constituents were derived from foreign rocks. On Elk Camp Ridge an isolated small patch of cemented conglomerate occurs at an elevation of 3300'.

Klamath Drainage

Actual stream channels are to be noted at the French Hill Mine which is carrying out placer operations in the old gravels. Here a southwest striking valley on the former land surface retains a remnant of valley stream debris. This is composed largely of cobblestones with frequent bowlders to a depth of some 50'. It is overlain with stream sands and fine gravels. In reports of the California State Mining Bureau by Watts and others the deposits are believed to be part of a series of Cretaceous shoreline deposits. Aside from the fact that the deposits are not marine, the impossibility of Cretaceous shoreline gravels persevering on the oldland surface will become apparent in the geologic history. This confusion presumably arose from erroneous correlation with the supposed Cretaceous shoreline conglomerates of the Waldo district in Oregon.

French Hill itself has little relief on top and is broken by low rolling hills. Toward the east end of the hill the old valley gives the surface a basin-shaped appearance. This southeast directed valley is actually a hanging valley. The break is not well marked because of some down-cutting on the hill itself but the gradient shows a somewhat sudden increase where the stream passes down the south side of French Hill and into Craigs Creek below. The valley is hanging by virtue of the superior corrading power of this rejuvenated important tributary. In the hanging valley the gravels have a dip to the southwest of 5 degrees. It much be borne in mind, however, that this angle may have been accentuated by post-depositional tilting. The gravels are cemented locally. They are of many rock types. Metaperidotite and serpentine gravels are so thoroughly weathered that they may be crumbled in the hand. They are usually saturated with water and when exposed to the sun they shrivel and break automatically. Diorites and related rocks are fairly plentiful. There is a considerable amount of jasper and chert.

Figure 25 French Hill Mine: Old Placer workings in Klamath oldland stream conglomerates, here seen dipping about 5° W.

In the old cut on the French Hill Mine property the sediments show marked directional tendencies. Shingling and various current arrangements may be observed. Lenses of sand and fine gravels occur between the massive sections of cobbles. Large bowlders are not unusual. The materials are strikingly heterogeneous. In places carbonized wood lies in horizontal position in the finer sediments and indicates the occurrence of local eddies and back-waters.

The reasons for believing in terrestrial origin may be summarized:

1. Confinement of the gravels to well defined channels
2. Banking of the gravels on turns
3. Distinct shingling
4. Pockety occurrence of gold as result of current irregularities
5. Great variety of rocks (In marine area receiving conglomerates

the more friable tend to be pulverized. Rocks such as serpentine could not exist long.)

6. Presence of wood (Although by no means conclusive, the occurrence of concentrations of wood favors terrestrial origin.)

7. Subangularity of gravels

On Haines Flat to the south of French Hill another southwest striking stream channel may be noted. Here the bedrock is dacite porphyry. The sediments occur in a broad depression and appear to have been 35-50' in thickness. At the bottom is fine gravel with some coarse material, then about 3' of cobbles followed by about 2' of sandstone which dips about 10 degrees to the southwest. A considerable thickness of sandstones and gravels have been

Figure 26 Looking North up old placer workings of Haines Flat. Stream alluvium of Klamath oldland

carried away by running water at this place on the depression. The sediments are finer than those of French Hill and seem to be fairly well sorted. All the larger stones are well rounded but no more so than in bars of the

present Smith River. All the types of rocks found in the neighboring territory are found in the gravels including metaperidotite, dacite porphyry, diorite, slate, and quartzite. One bowlder of rhyolite porphyry is somewhat hard to account for but it may have been derived from dikes of the Galice. The metaperidotite cobbles have a noteworthy peculiarity: they show a concentric ring of weathered material about $\frac{1}{2}$ inch in thickness on the outside separated by a veinlet of quartz from the inside. It is possible that this phenomenon was caused by processes of hydration, being continued for a certain length of time followed by mineralizing activity which filled the crevice beneath the expanded shell.

Conditions which perhaps oppose the terrestrial idea of origin are:

1. Roundness of bowlders (dubious)
2. Thickness
3. High angle of dip
4. Extension through range of elevations
5. Crossbedding not observed in sandstone

On the other hand:

1. Gravels are poorly cemented
2. Some bowlders are subangular (invalid)
3. Bedding is present although not sharply defined
4. Some tendency toward shingling
5. Presence of hornblende (altered) and decomposed feldspar in sands indicating short transportation
6. Sand grains angular, little quartz
7. Positions in depressions
   If estuarine with no major stream entering it, sediments would be fine
8. Only fossils heard of in any auriferous gravel occurrence of this cycle were in bowlders derived from earlier formations

9. Depth of weathering of bedrock in most places not attributable to post-gravel weathering

These two valley remnants (French Hill and Haines Flat) which have fortuitously survived the subsequent erosion are the only clews of the earliest drainage found by the writer. They indicate southwest flowing streams. Incongruity of present trunk drainage with this southwest drainage is apparent. It would thus appear that post-Klamath deformation has elevated the southern districts so as to impose a general westerly direction on the streams. This uplift is emphasized by the gorge of the Klamath River between Somes Bar and Orleans to the south.

Figure 27 Looking Northwest over Pine Flat Mountain from Low Plateau, Chetco Mountains in right background, Gorge of North fork Smith River right foreground. Terrace in center and upper valley.

Two cycles in the development of the post-Klamath surface drainage may be noted. The earlier led to the development of broad gentle valleys across the broadly warped oldland surface. The time given this stage was sufficient to form valleys from 200 to 300 feet in depth and a mile or so in width. While not evident on the topographic map a broad gentle upper

slope of the Smith River valley may be noted in the field. It is particularly well developed on the upper northern face of Coon Mountain. See illustration. But the most striking confirmation may be seen from the air. From above the hills back of the Crescent City platform a very broad upper valley with gentle sidewall slopes may be seen following the course of the Smith River.

A pronounced renewal of vigorous downcutting has led to the steep walled valleys and canyons of the present cycle. These features are emphasized by the sketch cross-profile shown below. A very recent trenching of the valley floor has taken place in many places probably in response to the very recent uplift of the Crescent City platform and the back-country as well.

Figure 29 View illustrating most recent gorge cutting. Looking east at junction of Middle Fork and South Fork of Smith River. Bench at extreme right rock cut and of about 50 acres area. Continuation on center tongue in background. Height of cliff 20 feet, depth of water 15 feet and over.

Age of the Klamath Oldland

Opinions differ concerning the age of the Klamath oldland. Lawson advanced the view that the surface was developed in Pliocene time while Diller held that it was developed in the Miocene and proposed a rather elaborate scheme of physiographic explanation involving over a dozen movements and stages. Since the days in which this work was done, ideas of antiquity of peneplains have been greatly modified. The upland erosion surface of the Sierra Nevada which was regarded by Turner, Lindgren and others as Cretaceous is now believed to be Pliocene. Blackwelder[1] has recently expressed the belief that no present topographic feature is as old as Miocene. Similarly physiographic concepts are being modified in the eastern United States. The old New England peneplain once regarded by Davis as Cretaceous is now regarded both by himself and others as late Tertiary. In general the great antiquity of existing surfaces is everywhere doubted in connection with Appalachian surfaces, Rocky Mountain surfaces, and Great Basin surfaces. Ashley[2], the State Geologist of Pennsylvania has asserted that no uncovered erosion surface is older than Miocene.

Naturally with this gradual change some of the more ardent proponents of extreme geologic youth of existing features have questioned the validity of Diller's views. In the present study certain data were obtained which are significant in the discussion, data which explain the deductions of former observers while to a certain extent reconciling and simplifying them. Thus the results obtained from study of the well-defined and classical yet little known erosion surfaces of the Klamath region have an importance to fundamental concepts of the science as a whole as well as to the analysis of a restricted area.

[1]Blackwelder, E., Abst. p. 14, 28th Ann.Meet.G.S.A. Cordilleran section (1929)
[2]Ashley, Abst. 43rd Ann.Meet.G.S.A. Toronto (1930)

Diller apparently pinned his faith in the Miocene age of the Klamath surface on the occurrence of the marine Wimer beds on the western margin of an erosion surface. If these beds were deposited on this peneplaned surface they must closely follow maximum development and therefore give the minimum of age possible. His best data of age provided by Dall and Knowlton indicated that the Wimer beds were Miocene. His dependence on this is indicated when he concedes: "If the Wymer beds should be Pliocene and the Hay Fork later than Miocene then the Miocene would be largely excluded from the sequence."[1]

In taking up this point the writer came across a new source of information, namely, the occurrence of Wimer beds on the northeast face of Bald Hill. Fortunately, they contain a fauna with a more restricted range than that at the type locality. One form particularly, Pecten discus Conrad (known also by a number of synonyms, Pecten (AEquipecten) andersoni Arnold, Pecten raymondi and var. pabloensis Clark) is confined to the Miocene. It is especially abundant in and characteristic of the San Pablo Group (upper Miocene) but is also reported in the Monterey (middle Miocene). The fauna at present known from the Wimer thus corroborates Dall and Knowlton. The field relationship of the Wimer beds is indisputable. They lie as Diller indicated in this and scattered patches on a relatively level surface. On Myrtle Creek Ridge which rises to the north the sediments are occasionally swept off the surface exposing serpentine or whatever the underlying rock may be. On the Bald Hills the beds have been protected to the west presumably by faulting against the serpentine of the hill and reach a thickness of about 200 feet. The contact surface is somewhat irregular indicating relief of about 100 feet. See plate 8, in pocket.

[1]Diller, J.S., U.S.G.S. Bull. 196 (1902)

These relationships verify Diller's view that a peneplain existed in this region before upper Miocene time. We may designate this as the Siskiyou peneplain since it is so far as known associated with the west flank of the Siskiyou Range. As will be indicated it is impossible to establish the former extent of the Siskiyou peneplain because of subsequent erosion.

The question of the age of the surface described in a preceding section of this paper as the Klamath oldland then depends upon correlation with this sub-Wimer surface. If they are the same as Diller believed the oldland is undubitably Miocene. In treating this point we must take up external proof since several circumstances preclude determination of whether the oldland surface represented by tablelands between the Siskiyou front and the westernmost, Wimer-capped ridges passes over or under the upper Miocene marine deposits. In the first place, undulations and relief of existing remnants do not furnish an adequate plane for projection. In the second place, the Wimer beds are so thin that they subtend an almost immeasurably small angle. Finally, the position of the beds themselves being almost horizontal deprives us of the conclusive evidence which inclination and truncation would present. So far as field evidence in this locality is concerned it is entirely possible if not probable that the oldland surface as a whole was developed over them. Diller apparently assumes the latter but does not appreciate the significance of his following statement: "The dislocation of the Miocene sediments brought them up to the sea level, but does not appear to have raised to any considerable extent the Klamath Mountains region, for the plain cut upon the soft, tilted, Miocene beds during a relatively quiet epoch immediately succeeding the tilting accords approximately with the Klamath peneplain".[1]

[1]Diller, J. S., U. S. G. S. Bull. 196, p. 48 (1902)

The external evidence is to be found in the Eel River country of Humbolt County where Lawson[1] described a surface as follows: "The base-levelling process continued (following post-Wildcat deformation) and the peneplain eas extended in between the bolder masses of the disturbed districts and completely over the region occupied by the soft rocks of the Wild-cat Series. After this interval of encroachment of the old peneplain between the new orogenic blocks, the general uplift was inaugurated and has proceeded by stages down to the most recent times, the uplift in northern California being from 1,500' to 2,100'". It is evident that if this surface may be correlated with the Klamath surface we have an important time check.

Since the writer differs from Diller in the correlation of surfaces, the latter's views will be scrutinized in the light of accumulated knowledge. Diller considered his Klamath peneplain as extending from Roseburg, Oregon to the south of the Klamath River where the surface becomes the "Bellsprings Peneplain". The Bald Hills of Humbolt County, a plateau area lying south of the Klamath River at an elevation of 3,000' is included by him in the "Bellsprings Peneplain". He confesses to some confusion in distinguishing these surfaces. "The only point near the coast in California where the two plains have been spearated is at the northern end of Bear Ridge, which is surmounted by an older plain of gentle relief at an altitude of about 2,500 feet, while on the north slope at 2,000 feet there is a well-marked plain cut upon the upturned edges of the Wildcat series. In Oregon north of Rogue River, although traces of the second plain have been recognized, they appear near the level of the Klamath plain and are scarcely distinguishable. It is possible, perhaps probable, that in some cases the lower plain is the same as the upper, the discordance in the elevations being due to faulting."[2] The

[1]Lawson, A. C., Univ. Calif. Publ. Bull. Dept. Geol. 1:270 (1894)
[2]Diller, J. S., U.S.G.S. Bull. 196 p. 22 (1902)

The recent work of Hoots[1] in the Eel River country strengthens this alternative. "The late Tertiary rocks of these areas appear to occupy dropped fault blocks, which have acquired their present position as a result of deformation since the Pliocene series was deposited. Post-Pliocene block faulting, accompanied by folding of the Tertiary rocks, is therefore believed to be largely if not entirely the agency determining the present distribution and structure of the Tertiary strata of this region."

When one takes cognizance of the foregoing conditions acceptance of two non-separable surfaces becomes difficult. The writer's observation of the surfaces does not incline him to accept separation of the Klamath surface from the Coast Range surface by any considerable time period. The topographic map of the Preston Peak Quadrangle shows flat topped ridges continuing southward, and gradually increasing in elevation. The Bald Hills of Humbolt County represent a continuation for the accordance of levels is marked. Bear Ridge just south of the Eel River and near its mouth offers another splendid view and the erosion surface is clearly defined to the eastward extending over the northern Coast Range of California at an elevation of 3,000 to 4,000'. The writer, therefore, believes that the surface extended from southern Oregon into northern California, skirting the high mountain areas of the Chetco Mountains, the Siskiyou Mountains, and the Salmon-Trinity Mountains. This latter differs from Diller's belief that the "Peneplain" extended to an elevation of over 6,000' near the head of the Salmon River. The writer does not ascribe the accordant ridges of the interior to the Klamath oldland, in fact he does not feel convinced that they are indicative of a former surface at all. Equality of interstream spacing has been discussed in connection with other areas and demonstrated to be accountable for accordant ridges.[2] The

[1]Hoots, H.W., Oil and Gas Exploration in Southwestern Humbolt County, Calif. U.S.G.S. Press Memorandum, Mar. 5, 1928
[2]Shaler, N.S., Bull. G.S.A., 10:245-76

fact that all the flat-topped remnants do not lie at a given absolute elevation is not considered as indicative of differing ages. Post-Pliocene deformation and faulting of considerable intensity is manifest through the retion and probably exaggerates the relief of the oldland. For example, we have the tilting of the surface seaward and uplift of the surface near the Klamath River leading to the development of the Klamath gorge below Orleans. Likewise, faulting has displaced surfaces in the quadrangles especially investigated. Examples are the down dropped Crescent City platform and the Mill Creek segment of the Klamath oldland which Diller thought represented part of his later "Sherwood peneplain".

The surface in the Eel River country truncates the Wildcat series which have a rich fauna. Dall's determination of the age as upper Miocene helped to mislead Diller as to the age of the surface just as Merriam's correct assignment to the Pliocene gave Lawson an advantage in his summary statement. The more recent work of Martin[1] closely correlated the upper and lower divisions of the Wildcat with other sections. The upper Wildcat is considered as equivalent to the Merced and upper Purisima while the lower Wildcat is closely correlated to the Etchegoin, part of the Purisima, and to the Empire at Coos Bay. The Klamath erosion surface which truncates these beds is therefore post-middle Pliocene.

A critical question to be determined is the relationship of the pre-Wimer Siskiyou peneplain to the post-Wimer, post-Wildcat Klamath oldland. The possibility that the Klamath oldland is merely the exhumed Siskiyou peneplain must be considered. Several facts militate against the latter supposition. In the first place, the only Tertiary marine deposits found on the surface are the Wimer beds which are restricted to a small marginal locality. Their light color, softness, and characteristic vegetation tend to

[1]Martin, B., Univ. Calif. Publ. Bull. Dept. Geol. 9:250 (1916)

make them conspicuous yet extensive field studies have failed to reveal any remnants anywhere on the oldland. (It should be here mentioned that Diller's Hay Fork locality was not visited.) The immense extent of the oldland in comparison with the tiny area of marine deposits supplements the view that marine beds were never deposited east of the margin. The second fact demonstrating the sub-aerial development of the Klamath oldland is the presence of stream gravels in the valleys of the former cycle, now hanging by virtue of trunk stream downcutting in the present cycle. If the marine deposits ever existed in these places (eastern French Hill, Haines Falt, etc.) the sub-aerial degradation was sufficient to obliterate all signs of the beds themselves and the nearly level surface beneath them. Hence the oldland is not an exhumed surface but is rather one developed much later by normal erosion in a humid climate.

The foregoing, it must be understood, applies to the Klamath oldland in general. In the Crescent City Quadrangle the Wimer beds were undoubtedly at one time somewhat more extensive. Perhaps they lapped farther to the east on French Hill than they do today and they may have occurred on Low Plateau. They were undoubtedly more extensive at one tome on the Bald Hills of Del Norte County and Myrtle Creek Ridge. The actual boundary must remain indefinite although subjected to the above-mentioned finite restriction.

Resume of Physiographic History

Bearing in mind the preceding discussion, the later physiographic history of northwesternmost California may be recounted. The last sediments involved in the Klamath Mountains deformation here are late Jurassic in age. The Cretaceous beds lap over unconformably and remain in places as outliers. A long period of degradation was inaugurated in the Cretaceous and sediments were shed to the Oregon Horsetown sea to the north. This condition was first recognized by Thomas Condon.[1] Erosion had presumably after many intermediate disturbances, principally of uplift, reduced the northwestern part of California and the southwestern part of Oregon to a peneplain (Siskiyou peneplain) before the upper Miocene. Submergence and deposition of the Wimer, upper Miocene beds took place. Slight elevation occurred in Del Norte County, the Wimer beds lying near base-level, while depression of southwestern Humbolt County was accompanied by the deposition of the Wildcat, lower Pliocene. In the Crescent City region faulting led to separation of the Crescent City platform which followed its own history (ante vide). About the middle Pliocene renewed uplift and deformation took place. In Del Norte County the hinterland was uplifted more than the coastal margin which remained near base-level. Degradation accompanied and followed crustal movement and progressed till the intermontane and coastal tracts of the region as a whole were reduced to an old age surface (Klamath oldland). This beveled the Wildcat series. During part of Pleistocene and Recent time uplift and concomitant dissection took place in three stages. During the first broad gentle walled valleys were carved. The second was rapid and pronounced so that streams carved deep V-shaped valleys. In the last stage uplift is causing a slight intrenchment in the valley floors.

[1]Condon, T., Two Islands

Correlation of the Klamath Oldland

Tertiary erosion surfaces have been recognized in many places throughout California. Many in the Great Basin have been exposed in section at least by block faulting. A number of scattered erosion surfaces of this sort form a stage in the sequence of Basin Range development and are termed by Davis, the Powell surface. Earlier deformation had produced the so-called King Mountains which were reduced by sub-aerial means to the Powell surface. Accumulations of sediments and lava took place. Later, in the Pleistocene, tensional faulting occurred producing a regular north-south pattern of mountains and intermont basins. While the indefiniteness of age of the Powell surface makes correlation with the Klamath surface purely speculative, this possibility may be suggested. The problem of the California erosion surfaces including the Sierra Nevadan surface, that of the Coast Ranges, the Mohave Desert, the San Bernardino Mountains -Big Bear Valley remnant, the Peris peneplain, and the San Diego oldland, while too far removed spacially to allow correlation and too intricate in relationship to permit specific statement in each case, nevertheless, suggest the general idea of reduction of the greater portion of the Cordilleran area to low relief during the Neocene.

Figure 30 Looking east at the Siskiyou escarpment from Prominence at the head of Stony Creek. Low regular ridge in the foreground is Elk Camp Ridge, whose crest represents part of the Klamath oldland. The distinction between provinces is obvious.

THE SISKIYOU RANGE

The Klamath oldland behind Crescent City terminates easterly against the higher peaks of the Siskiyous at an elevation of about 3,600'. A well marked topographic and structural break occurs here and to the east jagged peaks rising from 5000' to 7,310' above sea level are characteristic. Their topography is all attributable to sub-aerial and glacial erosion in adjustment to structure. The Orleans fault, a steep dipping reverse fault, separates the two physiographic provinces. To the west a few monadnocks of the acidic plutonics such as Higgins Mountain occur. To the east no remnants of the oldland are found unless the cut terrace on the west side of the Haystack near Sanger Peak at an elevation of 4,300' is a raised portion.

In the interior high lying area dioritic peaks rise above contact or serpentine floored valleys. Topography has a sub-alpine grandeur. The essential key to present day forms is long continued sub-aerial erosion and complete adjustment of streams to structure with subsequent modification by glacier action of the inherited basins. The post-glacial history is one of recent uplift and envigorated canyon cutting.

Pre-Glacial Topography

The features of the range antecedent to glaciation may be briefly summarized. In the first place, the complete adjustment to structure and the great relief indicate that the region had reached maturity in the normal cycle. From the fact that no post-Paleozoic sediments are found in the high country it may be suggested that the region has been subjected to intensive orogenic forces during most of later geologic time. It would thus form the stable, rigid rampart against which the circumlocated Mesozoic strata were compressed. More particularly the absence of Tertiary sediments indicates that the region has been high above base-level at least during the Tertiary

time. Continual rejuvenation of the streams resulted in persistent maximum of relief. Constant degradation naturally resulted in the excavation of the igneous and metamorphic complex to a great depth. Thus the Paleozoic argillites and lavas occur as isolated roof pendants and inclusions in the deeply degraded batholith. It was this rugged and elevated area that was subjected to Pleistocene glaciation.

Features of the Glaciation

Clear Creek Glacier

In the sub-alpine country of the Preston Peak Quadrangle many types of glaciers existed and have left widespread evidences of their tenancy. The principal glacier was that of Clear Creek Valley and it was of the inherited dendritic type. Fed by subsidiary glacierets and the Doe Creek glacier this body of moving ice profoundly modified pre-existing topography. The former V-shaped valley was rounded to its present U-shape while projecting spurs were eliminated. In the higher portions of the valleys of Clear Creek and Doe Creek there are grassy meadows, Young's Valley and Doe Flats, which point to the presence of blackslopes at one time. Young's Lakes to the northwest of El Capital are now in the last stage of filling while about them rise high precipices. Above the upper lake a considerable amount of debris seems to be in the process of solifluction. Morainal deposits have in the most places been removed from the valley. However, a large recessional moraine extends two miles down the valley from the lower Young's Lake. It is preserved as a rule along the eastern side of the valley while to the west it has been incised and reworked by Clear Creek. The till is composed of dioritic bowlders showing great variety of size, and interspersed gravels. One block, shown in Figure 32, is estimated to weigh 40 tons. A large erratic in the meadow of Young's Valley is likewise shown in an attached photograph, Figure 31.

Figure 31 Young's Valley in the spring. The glacial meadow is inclined to be swampy in the center, with pools during wet season. The stage of redissection has just been reached. Note the glacial erratic. The sharp line of demarcation between the trees and the meadow marks closely the contact of the fill and the bedrock or shallow soil. The fill contains too much water for vigorous tree growth.

Figure 32 Scene on the Clear Creek Valley recessional moraine. To the left some of the finer till may be seen. The large block is some 15' x 20' x 10'. It is apparent that Clear Creek is not responsible for its appearance here.

Figure 33 Looking N up Clear Creek Valley from N side Bear Mountain. Preston Peak out of view to right. A glaciated valley of the high Siskiyous.

Another area of glacial deposits exists on the east side of Clear Creek below Trout Camp. Some lateral moraines are evident extending below the mouths of tributary canyons. Here again Clear Creek has entrenched itself between the till and the bedrock to the west.

The plan diagram in the Siskiyou upland portion of figure 20 page illustrates the former glacier of Clear Creek Valley, and those in adjacent valleys.

East Fork Glacier

More obviously glacial in form is the upper valley of the east fork of the Illinois River. The southern four miles is without a turn or a jog, a straight, U-shaped valley with steep walls 1,500' in height. Large slides occur on the eastern wall at several places, the result of overdeepening of the valley. This valley is lower at its head than the southward directed Clear Creek Valley with which it is in alignment. The head of Young's Valley drops several hundred feet to the north into the Illinois Valley. Till has been thoroughly reworked by the stream in most places, although some huge erratics remain where they were deposited. Terraces at 50' elevation above the stream in places are indicative of post-glacial rejuvenation.

Poker Flat Glacier

Poker Flat, lying on the east side of the Siskiyou divide, is in a region that is locally rather low in relief. Headward working streams however are producing high relief about the margins of the pronounced glacial action. Feeding tributaries to the Poker Flat glacier along the spur to the south of Poker Flat have left a number of depressions and lakes including Kelly Lake as a record of their occupation. Moraines of a combined lateral and terminal nature occur along this spur, one to the east of Mud Lake, another in part retaining Kelly Lake. Elsewhere bare rock surfaces covered frequently with a litter of slate and basalt from Post-glacial weathering are characteristic.

To the southwest a tributary hanging valley lies at an elevation of 500' above Poker Flat. Its north-south direction is inherited from the streams which worked headward along north-south striking argillites and cherts. A glance at the sketch map of the Poker Flat glacier will show at once the general relationships.

South Fork Glacier

This glacier occupied the headwater area of the south fork of Indian Creek. Tributary basins of collection are scattered along the east slope of the north-south directed Preston diorite batholith and include those on the east side of Preston Peak, Copper Peak, El Capitan, and Lookout Mountain (Twin Valley). A number of small lakes occur in the highest reaches of the valleys. Evidences of sliding with accompanying slump holes in the serpentine are common on the south side of the ridge cumning east from Copper Peak.

Dunn Creek Glacier

Glaciers occupied the headwaters of Dunn Creek. Glacial sculpture is particularly evident about Lookout Mountain. To the northeast of Lookout Mountain is an un-named tarn which may be called Lookout Lake. This lake is relatively shallow and silted up.

Broken Rib Glacier

Glaciers having gathering grounds on the west side of Young's Peak, Snager Peak, and the east side of Broken Rib and Wounded Knee Mountains contributed to the formation of a glacier in the upper part of the present Sanger Creek. Sanger Lake is one of the most striking features of this area.

Glaciers about Bear Basin

Bear Basin is itself a shallow, southward facing glacial hollow. The ice gathered here evidently discharged into the present valley to the south, a valley also receiving ice from the vicinity of Island Lake. The east-west ridge extending from Bear Basin Butte to the west flank of Bear Mountain has precipitous northern slopes which are apparently the result of cirque formation to the north.

Classification of Glaciers as to Type

The previously mentioned valley glaciers were all of the inherited basin dendritic type. These were continuous streams of ice which filled their valleys to perhaps a fourth or a fifth of their depth. Shoulders, however, have been obliterated in the lower reaches. The movement must have been fairly rapid in consideration of high gradient and large mass. In the collecting basins themselves, movement was much slower and shoulders are preserved as at Twin Valley and Lookout Lake which indicate that a good third of the depth was filled.

The glacier which occupied the north slope of Broken Rib Mountain affords an example of the reconstructed type. A gathering basin occurs slightly to the east of the summit which fed to the whole north upper slope. On this, ice accumulated and together with that coming from above passed over the high precipices to be re-collected in the Sanger Creek glacier.

There were a number of small cliff glaciers of the hanging glacieret type. Some of them show the most clear evidences of recent existence. They may be compared with the Triest Glacier hanging above the Aletsch Glacier in Switzerland. It is found that they too occupy small circular depressions as a rule high above and feeding the valley glacier. There are numerous examples of this type in the western Siskiyou Mountains where they were developed in large measure by a later stage of glaciation of diminishing vigor. The Devil's Punchbowl on the north side of Bear Mountain illustrates a high, kettle-like, rock-bound basin of this type. Preston Lake, Buck Lake, and Sanger Lake also occupy basins formerly held by glacierets.

Figure 34 Looking southwest over Preston Lake with Twin Peaks on the horizon. A typical tarn perched high above Clear Creek Valley

Post-Glacial History of Backslopes

It is known that glaciers act more vigorously in their erosion at the bergschrund than elsewhere and that transverse crevasses at points of irregularity in the valley floor tend to duplicate conditions at the schrund line with the net result of producing glacial treads. In this area the glaciation of the late, recognizable stages has not been extensive enough to produce steps in the major valley floors. Albeit, the Devil's Punchbowl and the adjacent lakes on the north side of Bear Mountain form a pater noster of small size. Here elevations of a hundred to two hundred feet separate the tarns occupying the rock cut depressions.

The initial stage of the backslope immediately succeeding the glacial epoch is characterized by tarns, clear and frequently very deep. Talus and debris have just begun to fill the basin in the early stage. The more transitory evidences of glaciation are still conspicuous, including glacial scratches and glacial polish. The best example to be found (in this area) of a backslope in the early stage is the above-mentioned Devil's Punchbowl. Here the broad areas of roches moutonnees cut on Punchbowl diorite still appear fresh at the surface. Glacial polish was noted in a few places although it could not be expected to endure long in a position so exposed to large temperature fluctuations and consequent exfoliation. Striae are practically obliterated. Care must be exercised to avoid confusion with weathered systems of joint cracks. The lake is unusually deep, it being reported by natives that plumb lines 200' long failed to touch bottom. Another tarn in this stage is Island Lake where the writer observed vertical walls on the east of the island being lost to sight at a depth of about 60'. In all probability the lake has a maximum depth well over 100'. Buck Lake and Sanger Lake represent

progressively later portions of the early stage.

As weathering yields talus which is carried down by solifluction and rivulets during storms, the lakes are gradually filled. In the early part of this median stage the lakes are shallow, sometimes reaching a depth of 20' as is the case at Kelly Lake. Prescott Lake is filled with gravel and debris so that but 10' of water is present. The late portion of the median stage is typified by Whiskey Lake where the lake is under 3' in depth. The bottom is a fine muck with a high percentage of decaying vegetal materials. The surface is covered with water lilies and their large pads. Young's Lakes are in a similar stage of filling though they were originally

Figure 35 Glaciated rock surfaces below the Devil's Punchbowl

Figure 36 Looking east across Island Lake, a rock cut basin in Punchbowl diorite. South of Bear Mt. Youthful stage.

PLATE 2 Looking easterly across Kelly Lake, impounded by morainal material. Outlet to left

larger lakes. To illustrate the late median stage Mud Lake has been chosen. Here the encroaching matte of vegetation and soil has almost completed the occupation of the backslope. The fill does not reach the water-level of the

Figure 37 Mud Lake. A tarn showing encroachment of mud and vegetal material on lake surface. An early stage in the development of a glacial meadow.

initial stage for solution has lowered the outlet, in this case about 5'.

With the completion of the fill the ultimate or redissection stage is inaugurated. With a through drainage channel established the backslope is no longer an efficient settling basin and the point of overflow is subjected to vigorous corrasion during the rainy seasons. Young's Valley is an examplt of a meadow but little advanced in the redissection stage. As the process continues, the outlet is lowered across the bounding rock barrier. Poker Flat is advanced in the stage of redissection. Streams are

removing the fill and but few remnants of the median surface remain. In the last stage of redissection the evidences of prior existence of a backslope are being removed. The final chapter in this history is recorded when the valley again becomes V-shaped and the last definite evidence of glacial occupation is boliterated.

Figure 38 Looking north over rock bar at outlet Poker Flat. This bar forms the local base-level. Shows dissection of Poker Flat. Mount in center foreground and the terrace on which cabin is situated are remnants of former surface.

Stages of Glaciation

There were probably two and possibly three distinct stages of glaciation in the Siskiyou Mountains. The earliest and probably the most extensive stage of glaciation occurred when the stream developed valleys were continuous rivers of ice discharging into the broad valley of the Illinois River in Oregon, into the upper Smith River Valley, and toward the mouths of the Klamath River tributaries. The western wall of the Illinois River valley is relatively straight and the broad valley continues to where the Illinois River flows west of Eight Dollar Mountain. These features are in part at least due to the contact between serpentine on the west (Rough and Ready Ridge) and sedimentaries on the east in the valley. The outlines of the early glacial valley have, however, been largely obliterated by subsequent sub-aerial erosion. The till has been reworked and covered with alluvium. From the later gold-bearing gravels of southwestern Oregon a number of grinders and tusks of elephant have been obtained.

In the mountains themselves the evidences of this early extensive period of glaciation have disappeared. Renewed uplift of the Siskiyou block and canyon cutting produced a drainage adjusted perfectly to structure. The second stage of glaciation led to deepening and expansion of the mountain valleys to a U-shape, a shape that is retained in part at least to the present day. While not debouching from the mountains proper, the ice streams reached from the higher parts of the area down to an elevation of about 3,000' depending upon factors of rainfall and position with respect to the sun and prevailing winds. The valley glaciers belong to this stage. Their valleys lie below the limit of the last glaciation and their backslopes are usually in the redissection stage. Extensively dissected Poker Flat and incipiently dissected Young's Valley are examples.

The interval between the second and the last stage of glaciation does not appear to have been long geologically for evidences of the valley glaciers are yet clear and the line between the two would be difficult to place in some localities. Evidences for the last stage are usually fresh. Open tarns, in rock depressions backed by tremendous cirque wall cliffs, look over bare slopes of roches moutonnees. The best example is the Devil's Punchbowl, but Buck Lake, Island Lake, Preston Lake, and others are also worthy of notice. Glaciers of this stage merely filled the basins of the previous stage, lying as a rule above 5,000' and facing in a northerly direction. Without exception they belonged to the glacieret type. This stage must have been relatively recent. While there are no glaciers at present in this group of peaks, snowdrifts lie throughout the year on the north face of Preston Peak and some tiny glaciers exist in the higher Salmon-Trinity Range to the south.

No conclusion as to age of the stages other than relative was reached by the writer. Hence it is interesting to compare observations with those of O. H. Hershey[1] in the region to the south. There he observed evidences of three glacial stages which may be summarized as follows:

1. Earliest stage at least ten times and perhaps twenty-five times as old as the last stage. In this stage glaciers had maximum length and extended far down the valleys. Drift of this stage is largely in the lower reaches of valleys and is covered with alluvium. It was a low altitude glaciation and in age was at least as old as the Illinoian and perhaps as old as the Kansan glaciation.
2. The intermediate glacial stage was about three times as long ago

[1]Hershey, O. H., Jour. Geol. 11:5:431-458 (1903)

as the last and is correlated with the Iowan.

3. The deposits of the last glacial stage in the Klamath Mountains fully represents the Wisconsin glaciation. This was a high altitude glaciation and indicates an uplift of from 2000' to 3000' between the first and last stages.

In general correspondence may be noted in conditions and relative ages of glaciation with the Siskiyou area under consideration.

Post-Glacial History

The post-glacial history of the Siskiyou region is largely concerned with continued down cutting of the streams. Recent uplift has led to entrenchment of 25 to 50 feet. This movement appears to have affected the whole of the quadrangles studied for gorges of this nature are found in the valleys of streams at present dissecting the oldland. This uplift is probably contemporaneous with the uplift of the Crescent City platform itself. The streams of the present day Siskiyous are typical of a mountainous tract. They have many rapids and falls and are actively corrading their channels.

Broader Features of the Peak Area

The peak area is impressive in its ruggedness and grandeur. Connected chains of peaks form the sides of the valley of Clear Creek which flows south to the Klamath River and those of the northward flowing Dunn Creek-East Fork of the Illinois River drainage. As is more clearly pointed out in the section on structure there is complete harmony of land form with rock types. The dioritic mass of Preston Peak-El Capitan rises 3000' above the serpentine floored Clear Creek Valley. Preston Peak is a beautiful example of a horn. Glaciers have attacked all its sides and given to it a pyramidal outline. Jointing has principally controlled the faces of the

Figure 39 Stream erosion in hornblende schist (Salmon) on Doe Creek in the high Siskiyous.

Figure 40 Pothole with tool on Doe Creek. Characteristic cleavage of Salmon Schist in background.

Figure 41. Panoramic view looking easterly over the valley of Clear Creek, taken from ridge extending south from Young's Peak.

Features numbered from left to right: 1. Young's Peak, 2. Black Butte, 3. Lookout Mountain, 4. Lightning Gap, 5. El Capitan, 6. Cyclone Gap, 7. Copper Peak, 8. Preston Peak, 9. White's Meadow, 10. Upper end of valley of East Fork of Illinois River, 11. Young's Valley, 12. "The Chromite" Prospect, 13. Preston Lake, 14. Rattlesnake Meadow.

PLATE 3 Looking southwest at Bear Mt. and the Devil's Punchbowl from the south slope of El Capitan

pyramid. Thus the north face is essentially a joint plane. The mass itself is nothing but a pile of joint blocks still in the main lying in their original position. Where sapped by the action of the ice, great talus slopes have accumulated.

It is readily noted from the panoramic illustration, figure 41, that the typical sawtooth or sierra ridge has been produced. The eastern aiguille or main comb ridge[1] is composed of Preston Peak, Copper Peak, El Capitan, Lookout Mountain, and farther to the north Little Grayback. The western main comb ridge is composed of Prescott Peak, Bear Mountain, Twin Peaks, the Needle, Young's Peak, and Sanger Peak. Grats or lateral comb ridges are not so marked. A rather pronounced one extends east-west from Bear Mountain to Bear Basin Butte.

Bear Mountain deserves particular attention because of its striking form. When first observed by the writer from the side of El Capitan its similarity to a colossal arm chair or throne chair seemed striking. Refer to photo. This resemblance of a cirque to an armchair was noted by Gastaldi[2] in 1873. The back wall of the cirque, controlled by gigantic joint planes, has a drop of 1000 feet.

Characteristic of this area are the rock bound lakes, the grassy meadows, the abrupt, pine-clad valley walls, and the pyramidal rocky peaks rising above gaps having a typical hyperbolic profile. The area as a whole may be termed a fretted upland.

[1]Hobbs, Characteristics of Existing Glaciers, p. 19
[2]Gastaldi, B., Quart.Jour.Geol.Soc. 29:396-401 (1873)

STRATIGRAPHY

Generalized Advance Summery

The stratigraphic section of the Klamath Mountains is tremendously complicated and gives witness to a long and varied geologic history. Schists containing abundant hornblende and mica are the oldest units found. A number of formations consisting largely of slates and quartzites of Paleozoic age, some not definitely correlated, occur in highly deformed condition. The most extensively developed sedimentary formations are those developed in the Jurassic. Like all the other pre-Tertiary sedimentaries they are metamorphosed to a greater or less degree by regional deformation. The very absence of post-Jurassic systems of important thickness or extent gives eloquent testimony to the role played by subsequent degradation. True a few significant Miocene deposits occur in untransformed condition but they are thin and local in development. Quaternary deposits of various types, moraines, post-glacial meadow fill, fluviatile, and marine terrace sands and gravels complete the roster.

Igneous intrusive rocks preponderate in the crystalline mass of the western Siskiyous and indeed over the whole of the Klamath oldland. Excepting certain schists, none show pronounced metamorphism of the regional type. The basic varieties are, however, almost universally in some stage of geothermal transformation to serpentine. In the restricted area considered the oldest igneous rock, a hornblende diorite, was presumably intruded in the late Pennsylvanian orogeny. Various intermediate rocks and ultrabasic rocks were injected during the later Mesozoic. A coarse grained hornblende diorite is correlated with the Sierra Nevadan granodiorites of late Jurassic age. So many facies are represented in some groupds that distinction of type and relationships is rendered difficult. On the whole the section

studied yields rocks deposited at widely differing times under contrasting circumstances and igneous rocks varying from granite to peridotite, and from rhyolite to basalt. Many show serial variation in metamorphism either geothermal or regional. All are significant in the innumerable complicated events of orogeny and intrusion in the Klamath Mountains.

Colebrooke Schist

(Abrams Mica Schist[1])

It seems desirable to mention this formation even though undoubted occurrences were not located by the writer. The Abrams mica schist is a micaceous quartz schist presumably derived from argillaceous sandstone. According to Hershey[1] foliation is in general parallel to the lines of stratification.

Diller[2] observed outcrops of schist which he grouped under the title Mica Schist in many adjacent regions. He mentions a small area of schist 8 miles northeast of Crescent City and correlates them with more typical mica schists to the north exposed in South Fork Mountain. In the former isolated exposure, located on the Klamath oldland at the south end of Myrtle Creek Ridge, there occurs a fine grained quartz mica schist with interbeds of phyllite and slate.

The Colebrooke schist (Diller[3]) in Oregon is known to be pre-Cretaceous and is probably related with these California schists. In the former there is frequently sericite which gives the parting surfaces a silky appearance.[4] As in the California formation slates are interbedded. The

[1]Hershey, O.H., Am.Geol. 27:225 (1901)
[2]Diller, J.S., U.S.G.S. Bull. 546:14 (1914)
[3]Diller, J.S., U.S.G.S. Port Orford Folio. See also Butler, G.M. and Mitchell, G.J., MIN.Res.Ore. 2:2:36 (1916) and Statement by Diller in U.S.G.S. Bull. 360, p. 874 (1916)
[4]Butler and Mitchell, op. cit.

Dothan formation unconformably overlies the Colebrooke schist.

An area of phyllites and slates perhaps related to that on Myrtle Creek Ridge exists to the south along the eastern margin of the Mill Creek segment where it is faulted against the Bald Hills. Here the exposed rocks are characteristically altered to a depth of several inches. Near the surface the rock is a soft brown (from limonite) kaolin which still retains a semblance of the original foliation. This transformation has taken place under sub-aerial conditions on a portion of the Klamath surface. Whether or not these rocks should be correlated with the Abrams formation could not be verified, hence the disposition here made must be regarded as tentative.

While in the back-country the writer encountered a group of prospectors who had in their possession a piece of coarse quartz mica schist corresponding closely to Hershey's original description of the Abrams schist. In it were thin folia of gray and light brown muscovite separated by irregular layers of white quartz. They had just collected it near Bear Mountain but its source was not discovered by the writer.

The age and correlation of these schists will be discussed in connection with the Salmon formation which follows.

Salmon Hornblende Schist[1]

The Salmon formation is represented in the northern Preston Peak quadrangle by a small area between Bear Mountain, Twin Peaks, and Bear Basin. The Easternmost exposures in Clear Creek Valley and at the Nelson Prospect on the north side of Bear Mountain are isolated. They are possibly pendants in their respective surrounding intrusive. Planes of schistosity dip steeply and the strike varies from nearly east-west in Doe Creek Valley to north-south near Bear Basin. The thickness represented is about 2500'. Through-

[1]Hershey, O. H., Am. Geol. 27:225 ff. (1901)

out this section the homogeneity is remarkable and no interbeds were observed.

The color of the rock tends to be black from the presence of the hornblende. Elongate and flat crystals of hornblende predominate and are separated by thin layers of quartz and feldspar. The rock as a whole is fine grained. It is frequently cut by fine quartz stringers. For general appearance refer to figures 39 and 40, page 88.

Thin Section #121, Loc. 76

Salmon hornblende schist from Nelson Prospect on north slope of Bear Mountain.

Texture: Schistose - hornblende needles in longitudinal alignment.

Constituents: Brown hornblende, orthoclase, albite, quartz(undulating extinction).

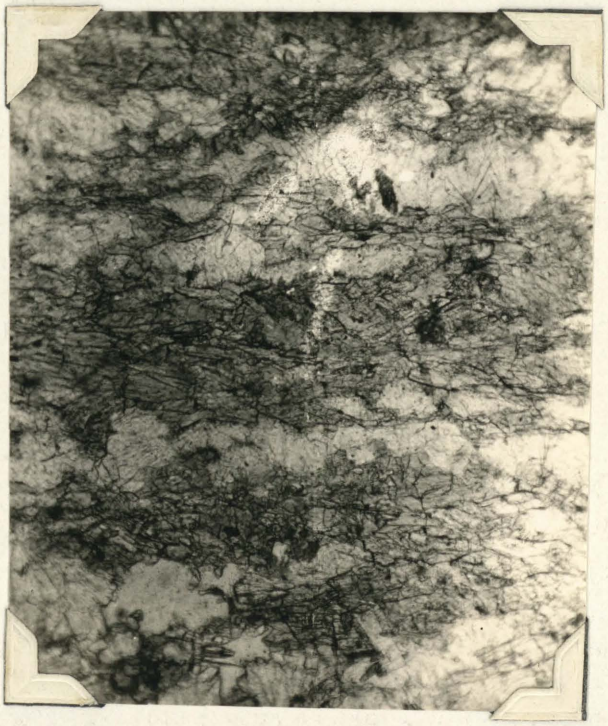

Figure 42 Photomicrograph of thin section #121, Salmon Schist, plane polarized light, x50. Showing bands of hornblende and felspathic material

Hershey suggested that the schists have resulted from alteration of an igneous mass. Hinds[1] found in the southeastern Klamath Mountains sedimentary interbeds but concludes that the series as a whole is a metamorphosed group of basic flows of the plateau type.

While observations of relationships have established neither the Abrams nor the Salmon schists in the time scale it is rather generally agreed that they are pre-Devonian. The fact that Silurian and Devonian sediments exist in northern California slightly altered renders improbable development of schists of Silurian age in the Klamath Mountains. This indicates a pre-Silurian age. Hershey considered them as much older than the Devono-Carboniferous and largely on lithologic grounds assigned them to the Algonkian (questionably in part to the Archean). Later in studying the Pelona schists near Randsburg in Kern County he suggested their correlation with the Abrams formation[2].

Hershey's[3] most significant generalization is important in securing a comprehension of the relations of these schist formations. To use his own words, "I propose to extend the name Pelona series over the Abrams and Salmon formations of the Klamath region. I believe this Pelona series has a definite time position in the geology of the Pacific Coast country comparable with the Belt series of sediments. It is the youngest important Archean series. Further, so far as my observation goes, it is the last sedimentary series preceding the Belt series."

The present writer cannot agree to this 800 mile correlation from southern to northern California on the basis of lithology and use of one name. Nevertheless, while Hershey's original bases of judgment of age,

[1]Hinds, N.E.A., Abst. 29th Ann.Meet. Cord.Sec.G.S.A.
[2]Hershey, O.H., Univ. Calif., Bull.Dept.Geol., 3:1:1 (1902)
[3]Hershey, O.H., Am.Jour.Sci. (4) 34:273 (1912)

namely degree of metamorphism and contortion, are not acceptable as conclusive criteria of correlation in view of many specific contradictions, it is believed by the writer that his generalizations offer a useful working hypothesis. Moreover, the balance of the evidence indicates a pre-Cambrian age for the Abrams and Salmon formations.

Bear Basin Formation

The Bear Basin Formation is composed largely of argillites, cherts, and fine conglomerates. It outcrops north and south of Bear Basin Butte and on Blue Ridge. The beds are steeply dipping to the east as a rule. Altho separated by intrusions of serpentine, there is a possibility that it may be connected stratigraphically with the Shelley formation. If the section were undisturbed it would lie higher than the Shelley slates. However, this relative position is probably due to elevation along the Orleans reverse fault. The formation is not known in contact with the Galice and is believed to be separated from it by the Wounded Knee-Broken Rib batholith of Preston diorite. On the west flank of Bear Basin Butte, cherts, shales, and fine conglomerates are injected along bedding planes by sills of Punchbowl diorite. On the east side the sediments are in contact with Salmon schists and to the south are intruded by a batholith of peridotite. Serpentine is locally present.

Grayback Formation

The Grayback formation is so named for its occurrence about Little Grayback in the northeastern corner of the Preston Peak quadrangle. In this vicinity it reaches its thickest development, probably over 5000 feet. The formation includes many different rock types, the most abundant being argillites. These argillites are resistant to weathering and form prom-

inent outcrops. Exposed surfaces are dull gray, this feature being responsible for the name of the type locality. Greenish cherts and jasper are relatively abundant. Especially notable are the igneous rocks associated. Interbedded flows of basalt are common. Some andesites are also present. Of particular interest from a chronologic point of view are limestone lenses which are distributed in a certain zone.

The Grayback formation outcrops over much of the northeastern corner of the quadrangle. It extends southward from the vicinity of Little Grayback tc the Kelly Lake region and eastward from Dunn Creek valley to Indian Creek valley. Isolated bodies are found on the ridge east of Copper Peak, on the ridge north of Lightning Gap, and on the ridge northeast of Young's Valley.

The sediments of the Grayback formation are the oldest known in the northern half of the quadrangle. Their relationships with neighboring rocks are always intrusive so far as known. They are intruded by the Preston hornblende diorite on the east slope of Little Grayback and by serpentine in numerous other places. The isolated patches are believed to be pendants in their surrounding igneous rocks.

The main mass of the formation has a strike of N 45° E and a south dip. Local variations are encountered but no folds or wrinkles were observed. The isolated patches have a NW strike and a north dip.

Description of the Rocks

Argillite

On fresh surfaces this is a black rock. Weathered surfaces are light gray. It is dense and very hard. The argillites are thin bedded, the bedding planes being separated on an average of one to two inches. Poorly developed cleavage planes are nearly parallel to the bedding planes. Of the more highly metamorphosed rocks some approach slates, others are phyllites. Hematite is sometimes present. On the whole the silica content is high. The dark color is possibly due to the carbon content. It appears probable that the argillites were, preceding dislocation metamorphism, carbonaceous sandy shales.

Chert

The cherts of the Grayback formation are characteristically thin bedded. The spacing of the bedding planes is usually about two inches.

Figure 43 Outcrop of green cherts having NE strike and south dip on the spur northeast of Little Grayback. Note lensing of beds

Their color varies from light gray to pink or pale green. Whether they

contain radiolaria or the siliceous skeletons of other organisms is not yet known. In some ways they resemble the Franciscan cherts.

Limestone

Three limestone lenses were found near what is apparently the base of the section. They lie on a northeast striking belt which is indicated on the areal map. The limestone is in part recrystallized. It carries many impurities. On the outcrop to the northeast of Little Grayback a peculiar design stands in relief. It appears siliceous and is probably the result of local accumulations of silica containing organisms. Hematite stains in the massive limestone are common.

Figure 44 Outcrop of limestone lens on spur northeast of Little Grayback. Note design appearing on surface

The lenses are rather small. The lens outcropping on the trail to Happy Camp south of Waldo is about 75 feet thick and as far as it can be traced 300 feet long.

It is difficult to explain the short extent of the lenses in consideration of their interbedding with the argillites. This mode of occurrence is by no means confined to the immediate area under discussion. Diller has described four belts of limestone lenses in Oregon of which the present occurrence corresponds to the second. In connection with these L. E. Reber has suggested that the lenses of each belt once formed a belt 150 feet thick which was sliced diagonally along planes from 500 to 2000 feet apart[1]. Some evidence of tectonic movement is afforded by a limestone breccia near the contact of the lens on the Happy Camp trail previously referred to. It is believed by the writer, however, that this brecciation was in adjustment to local dislocation conditions. No major fault planes were discovered. Faulting, moreover, would not explain occurrence on the line of strike. Metamorphism probably first found a continuous limestone bed. High hydrostatic pressure was developed by large superincumbent load which together with unequal pressure at different localities along the bed made possible rock flowage to points of lowest pressure. Bedding planes, fossils, and other traces of former state are almost obliterated.

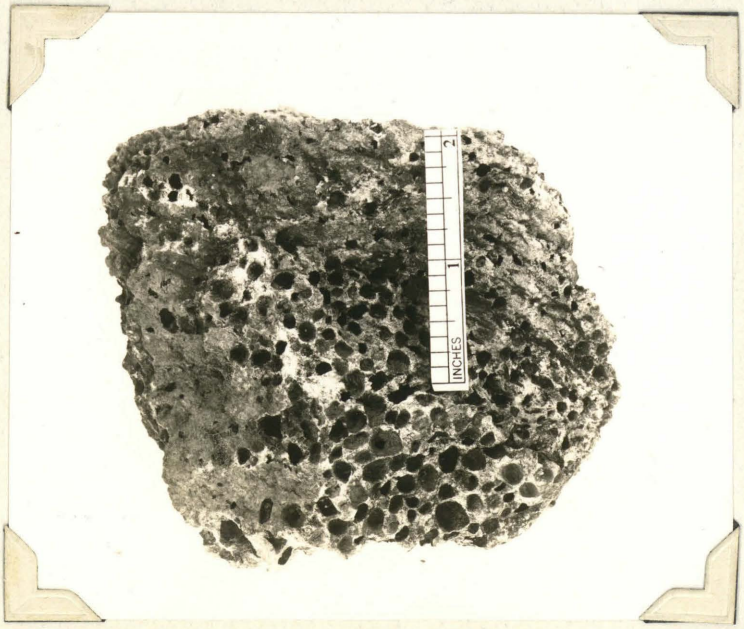

Figure 45 Photograph of vesicular lava interbedded with Devonian argillites. Rock has leached appearance and amygdules have probably been dissolved out. Found on west slope of Little Grayback

Lavas

In places along the ridge south of Little Grayback fragments of a very light vesicular andesite were found. The perseverence of undeformed open spaces in the lava during metamorphism of the shales to argillite is not conceivable. On the other hand there are no possible sources of recent lavas in the whole district. The andesitic lavas in this ridge are probably contemporaneous with the sedimentation. Former cavity fillings have been leached out.

About Poker Flat there are numerous occurrences of basalts, in many cases amygdaloidal. The long axes of these bodies strike northeast with the adjoining cherts and argillites. Volcanic agglomerates were also found in several places.

Thin Section #151, Loc. 90

Limestone from lens on trail to Happy Camp, five miles southeast of Waldo, Oregon.

Color: White
Texture: Fine grained, in part amorphous, in part recrystallized to calcite.
Constituents: Nearly pure calcium carbonate, calcite crystals in amorphous groundmass.
Minor: Quartz, magnetite, limonite

Age and Correlation

Diller[1] collected some poorly preserved fossils from the limestone lens occurring on the Happy Camp trail 10 miles southeast of Waldo and submitted them to Mr. E. M. Kindle. The corals were doubtfully determined as Favosites nitella and Cladopora robusta while one gastropod resembling Laxonema bella was observed. He considered the time represented as Devonian.

The middle Devonian Kennett of Shasta County is in some respects

[1]Diller, J.S., U.S.G.S. Bull. 380:50-51 (1909)

lithologically similar. In the Redding Quadrangle it is made up of black shales, cherts, and limestones. Interbedded volcanics are missing.

To the north of the California line Paleozoic sedimentary rocks occur which may be correlated with the Grayback formation. The limestones on Sucker Creek in which the Oregon Caves are situated are in line with the California occurrence.

Age and Correlation of Bear Basin Formation

This formation is isolated stratigraphically and has thus far yielded no fossils. It is believed to be distinct from the Shelley slates lying closest to it. In its lithology, presence of grayish streaked cherts, black argillites, and general induration, the formation resembles the Grayback formation of Devonian age. It appears appropriate, therefore, to provisionally correlate these groups.

Shelley Formation

The Shelley formation is a metamorphosed series of shales and sandstones. Conglomerates are rare and so far as is known cherts are absent. It outcrops in a long narrow north-south band along Shelley Creek Ridge, crossing upper Shelley Creek to the Patricks Creek Ridge, and terminating a little northwest of Monumental. It outcrops on the Redwood Highway along the Smith River between the south projecting spur east of the mouth of Patricks Creek and the Washington Ranch. It continues an indefinite distance to the south, east of Coon Mountain and Gordon Mountain. The slates are in general quite resistant to erosion. In this respect they are comparable to the adjacent igneous rocks.

The Shelley slates strike north and south and dip steeply east.

[1]Diller, J.S., U.S.G.S. Redding Folio No. 138

This would carry them under the Galice. However, the slates are bounded by igneous rocks. To the east on Monkey Creek and to the northeast by the Monkey pyroxene diorite, to the west by the High Dome dacite porphyry, both of which intrude it. In addition it is intruded by small masses of serpentine.

Figure 46 Shelly slates striking N S and dipping steeply east. Ridge east of Patricks Creek on Redwood Highway

The slates are very hard, black rocks and are occasionally cut by acidic dikes. Jointing is well developed. In Shelley Creek Ridge they are rather thick-bedded for shales, running up to over 6 inches. East of Gordon Mountain they are finely fissile, and thin-bedded. In the bed of Shelley Creek below Monumental they contain numerous limonite concretions. Locally the rock is cut by stringers of calcite.

Age and Correlation

The massive sandstone at the southeast corner of Baker Flat on Shelley Creek is sparsely fossiliferous. Many of the molds are deformed.

Diller[1] implies a faunal correlation with the Horsetown on the basis of Aucella from this locality. This is believed to be a mistake. Hershey[2] maps part of the formation with the Galice, part as Devonian. The writer has not accepted this correlation because of separation stratigraphically and because of great lithologic difference. The metamorphosed sediments of the Bear Basin area contain numerous cherts and other differ from the Shelly formation.

Galice Formation[3]

The Galice formation, typically developed at Galice on the Rogue River 18 miles below Grants Pass, is composed mainly of shales largely altered to argillites, thin-bedded, hard sandstones, and occasional fine conglomerates. This formation can be traced continuously into California from areas which Diller[4] considered Galice. The areal outcrop of the Galice extends from the upper end of the valley of the West Fork of the Illinois River in Oregon over the divide crossed by the Redwood Highway into the headwater region of the Middle Fork of the Smith River.

The formation seems everywhere to be thin-bedded. Certain areas are greatly metamorphosed by regional deformation. At Hazel View on the Highway divide, the bulk of the formation is slatey and highly contorted. Adjustment to deformation has taken place along some of the bedding planes with resultant brecciation and slickensides. Lenticular slabs are developed.

The argillites are usually of brownish tinge while the rarer sandstones may be bluish-gray. The soil cover of this formation is characteristically of an ochre shade and is thicker than that on adjacent igneous rocks.

[1]Diller, J.S., U.S.G.S. Bull. 196, p. 65 (1902)
[2]Hershey, O.H., Min. & Sci. Press, 102:468 (1908)
[3]Diller, J.S., Am. Jour. Sci. (4) 23:404-405 (1907)
[4]Diller, J:S., U.S.G.S. Bull. 546, map p. 46 (1914)

Thus it tends to stand out when viewed from a distance. The light colored slides on the cuts of the Redwood Highway switchback can be plainly seen from the trail on Young's Peak. This soil nourishes a thick brush cover of much more luxuriant nature and more vivid green than that nearby. This feature, likewise, tends to emphasize the areal distribution.

The Galice of the Preston Peak quadrangle is intimately associated with two igneous rocks, a rhyolite which occurs as sills and the dacite porphyry which intrudes slates near Horse Flat Forest Camp. Relationships with the pyroxene diorite were not observed but they are presumably intrusive.

Figure 47 Rhyolite porphyry dike in S dipping Galice Shales. Switchback Redwood Highway

The contact with serpentine on the east follows a fault. Serpentine was nowhere observed in the Galice.

One rhyolite sill was inspected on the Redwood Highway switchback, at an elevation of 2300 feet(?).

Several sills of about 18 inches thickness were observed intruding sharply bedded sandstones at the mouth of Sanger Creek.

Age and Correlation

The Galice and the Dothan are noted by Diller to be similar lithologically and his basis for distinction is their separation by igneous masses. Both formations dip to the northeast in the type areas and the Dothan lies to the west. He considers this position to be the result of overturning. Thus the indicated age of the Dothan is younger than the Galice. Imperfect fossils were obtained from the Galice on Cow Creek near the mouth of Rattlesnake Creek in the Riddle Quadrangle.[1] These were determined by T. W. Stanton as follows:

Aucella erringtoni
Ctenostreon ? sp.
Pecten ? (may be Lima)
Turbo ? sp.
Perisphinctes ? sp.

In the Grants Pass Quadrangle fossils were found in the Almeda Mine on the Rogue River. As near as can be determined they indicate late Jurassic age.

In the Preston Peak and Crescent City Quadrangles there are a number of reason for separating the Dothan and the Galice. In the first place, the formation assigned to the Dothan is separated from the Galice by intrusive serpentines and dacite porphyry and by the Shelley Creek slates. In the second place, they are quite unlike lithologically, the Dothan being largely sandstones, the Galice, shales and argillites. Thirdly, the Galice is more extensively metamorphosed than the Dothan. And lastly, the Galice is much more intricately deformed than the Dothan. Thus whatever doubt there may be concerning the separability of the two formations to the north, in California they are certainly distinct.

The Bragdon slate of the southeastern Klamath Mountains, a series of alternating thin-bedded black slates and thick-bedded blue quartzites, is compared with Hershey[2] to the Mariposa slates (late Jurassic) of the Sierra

[1] Diller, J.S., Am. Jour. Sci. (4) 23:404-405 (1907)
[2] Hershey, O.H. Am. Geol. 27:236 (1901)

Nevada. This assignment of the Bragdon was contested by Diller[1] who placed it at the base of the Carboniferous. Nevertheless, the Bragdon must be considered a possible correlative of the Galice. Diller[2] has suggested that the Galice is the correlative of the Mariposa slates of the Sierra Nevada.

Dothan Formation[3]

This formation was named by Diller from the Dothan Post Office on Cow Creek, southwestern Douglas County, Oregon. Here a broad belt of slates, thin-bedded hard sandstones, conglomerates, and cherts has a general northeast-southwest trend. Butler & Mitchell[4] traced this belt southwesterly to the California line. In the Crescent City Quadrangle rocks of this formation outcrop over a large area extending from the Oregon line south beyond the Klamath River and everywhere abut on the Pacific Ocean forming resistant sea cliffs. Toward the interior they are in contact principally with serpentine although they appear to overlie unconformably some older schists in two places.

The rocks are principally sandstones of two types, one a bluish rock on fresh fracture which weathers to a gray, the other a brown sandstone containing black shale pebbles. These sandstones are compact and well lithified so that fractures cut the clastic particles. Small areas are locally brecciated and show geothermal metamorphism. Bedding planes are in general sharp and the rocks as a whole are involved in broad folding. The chief constituent is quartz and the cement is silica.

Next in importance though much less extensive than the sandstones are the shales. They likewise appear to have suffered more pronounced trans-

[1]Diller, J.S. Am. Jour. Sci. 15:351 (1903)
[2]Diller, J.S. U.S.G.S. Riddle Folio No. 218, p. 3 (1924)
[3]Diller, J.S. Am. Jour. Sci. (4) 23:402 (1907)
[4]Butler & Mitchell, Min. Res. Ore. Vol. 2 No. 2

formation than the sandstones. They are slaty in appearance but bedding planes are distinctly preserved and parting takes place along them alone. They are usually black in color and extremely hard and brittle. They contain at Point St. George organic remains which though not determinable seem to be plant fragments.

Minor chert and jasper was observed on Rock Creek in isolated localities interbedded with sandstones. Within the formation are flows of basalt, one of which is exposed near the mouth of Gilbert Creek and another on Smith River below the Hiouchi (Redwood Highway) bridge. These basalts are unaltered though frequently veined with quartz.

Figure 48 Falls on Fall Creek near California-Oregon line where the resistance of the rhyolite has proved superior to that of the brecciated Dothan argillites

In southern Curry County, Oregon, rhyolite is found intruding the Dothan shales and sandstones. Patches occur near the mouth of the Chetco River and north of the town of Brookings. The rhyolite is particularly well developed near Mount Emily. On the ridge north of the Cleopatra

Prospect the rhyolite is interbedded with Dothan shales. The flow is about 100 feet thick and is responsible for the falls on Fall Creek. Where the California-Oregon line crosses the ridge several feet of rhyolitic ash overlie the flow.

Thin Section #8, Loc. 8

Dothan sandstone from sea cliff ½ mile west of Battery Point, Crescent City.

Color: Brown
Microtexture: Inequigranular, grains sub-angular to angular.
Constituents: Quartz, plagioclase, grains of hornblende-biotite schist, rhyolite, diorite, magnetite

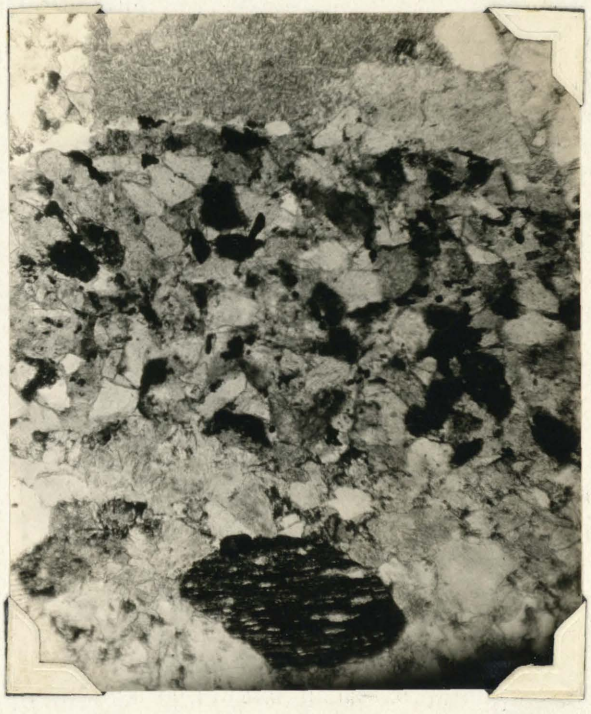

Figure 52 Photomicrograph of thin section of #8, Dothan sandstone, plane polarized light, x50. Diorite grain at top, band of angular quartz and feldspar, schist grain at bottom.

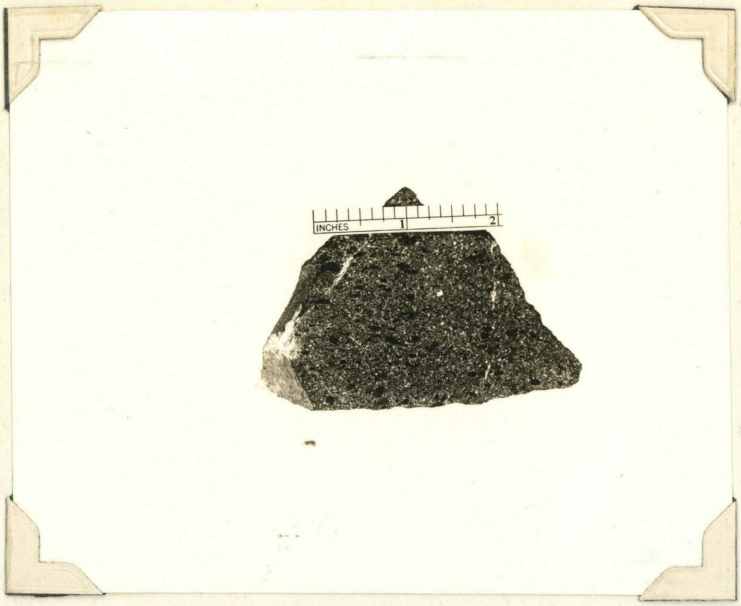

Figure 49 Photograph of Dothan sandstone from rocky cliff at point of debouchement of Smith River on the Crescent City Platform. Shows the black shale pebbles commonly occurring.

Figure 50 Showing flow structure in rhyolite flow interbedded with Dothan shales on ridge northwest of Cleopatra Mine

Figure 51 Photomicrograph of thin section #61, rhyolite from field locality 1o, Curry County, Oregon, crossed nicols, x50. Showing corroded quartz phenocryst

The assemblage of rocks above discussed has constituted one of the greatest problems in northern California and southern Oregon geology. The similarity of lithology to that of the Franciscan of middle California is obvious to the casual observer.

Louderback[1] after investigating the Mesozoic rocks of southwestern Oregon subdivided the lower Cretaceous Myrtle formation of Diller into two parts, the lower member of which exhibited striking similarity to the characteristic Franciscan, the upper or typical Myrtle which could be correlated with the Sahsta group. To the former he gave the name Dillard formation from a typical occurrence near the village of Dillard in the Roseburg quadrangle. This name is, however, in fact ultimately discarded in favor of extending the term "Franciscan." The belt of metamorphosed sediments extending up the northern coast of California is specifically considered by Louderback to be Franciscan. This assignment was accepted by Hershey[2] who also used Franciscan in referring to these rocks.

Diller nowhere refers specifically to the formation at this locality but Butler & Mitchell, as previously stated, traced it from the vicinity of the type locality of the Dothan to the California line.

There are a number of reason which incline the writer to use the local name. In this connection it seems well to present first resemblances to and second dissimilarities to the Franciscan in the Bay region.

1. Similarities

a. Induration and degree of metamorphism

While comparison of these features is useful it is by no means conclusive. Known Franciscan rocks are widely varied in these qualities.

[1]Louderback, G.D. Jour.Geol. 13:514-55 (1905)
[2]Hershey, O.H. Min. & Sci. Press 102:468 (1911)

b. Presence of cherts

In the area described they are rare and are not thin bedded or continuous.

c. Presence of basalts

In the Crescent City Quadrangle they are fresh and appear to be post-serpentinization.

d. Sandstone with numerous oriented black shale pebbles

This rock type is well characterized and in the area considered is extensively distributed.

e. Stratigraphic position

Approximate equivalence.

2. Dissimilarities

a. Absence of glaucophane schists

(So far as observed)

b. Absence of intruded and interbedded serpentine

In Del Norte County the contact with the serpentine is not frilled but is sharp and linear, in part a fault.

The above mentioned characteristics do not warrant such a close correlation with the type Franciscan as to justify the use of its name. Considerations of proximity and continuity prompt the use of the local name in accordance with United States Geological Survey practice.

Smith and Packard[1] assume the separate identity of Louderback's Dillard and the Dothan, hence of the supposed "Franciscan" along the California-Oregon Coast and the Dothan. They suggest that the Dillard is continuous with this "Franciscan". Diller's abstinence from the use of the word "Dillard" is taken to reflect an opinion that the "Dillard" and the Dothan are identical. Diller, moreover, refrains from using "Franciscan" although he correlates the Dothan with the Franciscan[2].

[1]Smith, W.D. & Packard, E. Jour. Geol. 27:90 (1919)
[2]Diller, J.S. Riddle Folio No. 218 U.S.G.S. (1924)

The Dothan has not yielded as satisfactory a fauna as the Galice. Fragmentary remains of Aucella erringtoni, a fossil occurring also in the Galice, have been found. Little idea of age relationships of these formations is gained from paleontology, excepting rough correspondence. As has been pointed out in connection with the Galice, lithologic and structural relationships are most important in assigning to the Dothan a position stratigraphically above the Galice.

Wimer Formation[1]

The Wimer formation is composed of a thin layer of marine sediments perched on the Klamath oldland about three miles east of the debouchement of the Smith River on the Crescent City Platform. The beds described by Diller lie on the ridges on each side of Myrtle Creek. They are given the name "Wymer" from the name of the old stage road which passes up Myrtle Creek Ridge on the way to Low Divide from Crescent City. The spelling "Wimer" is proper and is used by the U.S. Forest Service. This road has been abandoned for many decades. Concerning the formation at the type locality Diller[2] states: "These fine argillaceous sediments are composed largely of kaolinic material, with much angular quartz of disintegration and numerous minute siliceous organisms of radiolarian types. When heated it blackens and then becomes lighter like the bituminous shales of the Monterey series." The Wimer beds are very soft and easily eroded. The stage road which passed over them was shifted several times because the tracks were quickly eroded. These places are now ditches locally reaching over 5 feet in depth.

The Wimer beds are covered with manzanita and grass. Surface forms are gently rounded. A common attribute of the surface is the presence of

[1]Diller, J.S. U.S.G.S. Bull. 196, p. 32 (1902)
[2]Ibid

angular quartz pebbles. In addition to the occurrence at the type locality, an area of Wimer formation was found to the northeast of the Bald Hill. The beds are nearly flat-lying and rest unconformably on the older-pre-Tertiary rocks, serpentine, schists, and Dothan sandstones. At the Bald Hill occurrence the basement rock is a diorite. Bowlders of diorite are of common occurrence in the basal portion of the Wimer here. The contact may be traced around the nose of the hill and is found to be rather regular. This contact by its vertical variation indicates deposition on an erosion surface having a relief of a hundred feet or so. At the type locality on Myrtle Creek Ridge the patchy areal distribution of the sedimentary veneer gives evidence of deposition on a relatively level surface.

The deposits are as a rule fine grained but lithology varies locally. Two principal types are found at the type locality. One is a fine grained clay of grayish-white appearance. It is composed largely of kaolin, fine subangular quartz grains, with infrequent grains of a heavy mineral, probably magnetite. Streaks of limonite are evidently results of oxidation and hydration of the magnetite. In some places indurated bands of impure limonite occur. In this finest of the Wimer sediments are found leaf imprints and in places aggregations of the smaller molluscs. At Bald Hill the clay is a tawny brown. Occasional beads of bituminous material are found, a feature suggestive of conditions on some existing beaches.

On the Wimer Road to the north of the clays of the leaf imprint locality, the sediments are somewhat coarser and may be termed fine sandstone. The color is uniform brown from limonite. The subangular quartz grains form the major part of the rock. In this rock are local aggregations of shell molds, the shell material having in all cases been leached out. Coarser beds in the formation are rare and were observed only on Bald Hill.

Even here the largest fragment size is a gravel although pebbles are the chief constituents of the conglomerate beds.

The sediments are not distinctly bedded hence the attitude was difficult to ascertain. On a prominence in the northeast portion of the Bald Hill area, parallel indurated sheets of sandstone had a dip of 5° west and a strike of N 45° W. Another clue was given by the position of the fossils. It has been shown[1] that the stable position of lamellibranch tests on an agitated submarine floor is one in which the convex exterior is facing upward. Thus the plane of the periphery of the test will approximately represent the bedding plane. Excavations at the Bald Hill fossil locality indicated that at least 90% of the valves were close to horizontal.

The conditions of accumulation may be reconstructed with comparative ease. The beds were obviously laid down on a submerged surface of sub-aerial erosion, as may be determined from the areal distribution and relief. The back-country supplying the sediments must have been one of low relief in view of the large proportion of kaolin and fine quartz sand and the absence of coarse conglomerates. A littoral facies is indicated by mingled leaves and molluscs and by the bituminous pellets. However, quiet water conditions such as are found in estuaries and protected bodies must have prevailed. Broken shell fragments are exceedingly rare and signs of abrasion are infrequent. The fauna is definitely a life fauna, not a reworked fauna. The most delicate of shells are perfectly preserved. Bivalves more often than not are found in articulation.

The palaeontological materials are not pleasing to work with. The thin cover of porous sediments has been almost continually saturated with water. All calcareous matter has long since disappeared. However,

[1]Abel, O., Grundzuge die Biostratigraphie

but few shell molds collapsed with the removal. It is thus necessary to make casts with various substances, of which the following have been used, plaster of paris, sealing wax, lead, and gutta percha. The first proved most satisfactory for large forms, the last for the small forms and minute sculpture. A special technique of handling was developed. Despite the greatest care, however, the results are not in every case identifiable.

Figure 53 Photograph of Wimer sandstone from the Myrtle Creek Ridge fossil locality. Shows typical leaching out of calcareous constituents. Prominent pelecypod molds are produced by a new species related to Meretrix

The Wimer Flora

Diller submitted some of the leaf imprints to F. H. Knowlton[1] who reported: "The material submitted is a loose, friable, highly ferruginous sandstone, not well fitted for retaining plant remains. The plants consist of leaves and fruits but not a single example is preserved entire. From a somewhat hasty study of these fragments I am able to identify with reasonable satisfaction the following-names species: Magnolia lanceolata Lesq.,

[1]Diller, J.S., U.S.G.S. Bull. 196, p. 33 (1902)

Persea pseudo-carolinensis Lesq., Laurus salicifolia? Lesq., and Quercus sp.

From the evidence at hand it seems safe to say that the affinities of these beds are with the auriferous gravels or upper Miocene."

The Wimer Fauna

The writer was materially assisted in making some preliminary palaeontological determinations by Dr. H. R. Gale but the writer assumes all responsibility for the following discussion. It was possible to verify the presence of but three forms recorded by Dall[1] in 1901, these being Cerithiopsis, Macoma, and Balanus.

Myrtle Creek Ridge locality:

Faunal List

Meretrix, n. sp.

Mya, sp.

Solen sicarius? Gould

Cardium, sp.

Macoma balthica Linneus

Psephidia lordi (Baird)

Balanus, sp.

Calyptrea filosa Gabb (two forms probably varieties)

Tegula? , sp.

Epitonium, sp.

Odostomia?, sp.

Cerithiopsis, sp.

Priscofusus?, sp.

Truncatella stimpsoni Stearns

[1]Diller, J.S., U.S.G.S. Bull. 196, p. 34 (1902)

Bald Hill locality:

Pecten (AEquipecten) discus Conrad

Phacoides acutilineata Conrad

Solen sicarius? Gould

Cryptomya californica Conrad

Macoma nasuta Conrad

Tellina eugenia Dall

Polynices?, sp.

Fish remains

Worm burrows

Age: most of the above mentioned forms have a long range and hence do not aid materially in age determination. The fauna, in spite of the presence of some recent forms, may be said to have a Miocene aspect. Contributing to this opinion are Calyptrea filosa and Tellina eugenia. But the most definite basis is the undoubted presence of Pecten discus Conrad which ranges from middle through upper Miocene. According to H. R. Gale it is a good species for separating the Miocene and Pliocene. The evidence thus tends to substantiate the early opinion of Knowlton that the Wimer beds are upper Miocene.

Figure 54 Photograph of Wimer shale from Bald Hill fossil locality. Illustrates the occurrence of Pecten discus

Figure 55 Wimer shale from Bald Hill, showing common Macoma nasuta, Pecten discus, and Solen sicaria

Georgian Formation

The exposed section of this formation is very thin at Point St. George. On the northwest facing sea cliff here about 75 feet of sandstone and shale resting unconformably on Dothan sandstones have been cut by wave action. The contact dips to the northeast. The beds themselves dip 22° N and strike N 50° W. The terrace surface here is an uplifted and tilted abrasion platform bearing dune sands and kitchen middens. It stands about 30 feet above the tide at the southwest extremity (one knob rises 50 feet) and slopes northeasterly so that the sea cliff passes into a sandy beach. This cut surface bevels the Tertiary beds whose northerly extension is buried. Thus their total thickness may be considerably more than 75 feet. Fossiliferous shale fragments are commonly thrown up on the beach near the Talawa outlet and were evidently derived nearby, namely, from the sea bottom a short diatance out.

The beds immediately overlying the erosional contact are gray sandstones and are quite fossiliferous. Among other forms they contain Paphia, Cardium, Sicula, Zirphea, Litorina, and a few foraminifera. On the basis of a large collection from this locality Dall[1] correlated the horizon with beds at Cape Blanco, Oregon and the Empire formation at Coos Bay, Oregon. The fauna is markedly different from the Wimer fauna.

Southeast of Point St. George marine sediments outcrop at the two extremes of Pebbly Beach. At the end closest to the point a highly indurated fossiliferous clay shale outcrops and appears to rest on the eroded Dothan sandstones. The cliff section here is about 15 feet high. At low tide it is said that a lignite seam is exposed. An overwhelming majority of all the invertebrate found is a Macoma.

South of the middle portion of the beach a sandstone bearing the same fauna as those at the point appears. It dips 17° N and strikes N 47° W.

[1]Diller, J.S., U.S.G.S. Bull. 196:32 (1902)

Along the back of the beach from this place to the reappearance of the Dothan is a low bench of a blue gray sandstone containing innumerable fragments of carbonized wood. Overlying this bed is 10-15 feet of soft yellowish sand, the Battery formation.

Figure 56 Looking east along Pebbly Beach at high tide. Cliffs to the left, formed of fine Macoma-bearing shale. Beyond sandy beach the Georgian formation reappears. To the right stacks of Dothan. On the horizon snow-capped Bald Hills

The striking feature of the Georgian formation is its apparent thinness and lateral variation. Although no coarse material is present it is possible that relatively shallow water conditions prevailed on the platform dur- or immediately after deposition permitting marine currents to sweep portions away.

According to Howe[1] the Empire formation is lowest Pliocene. Whether or not this assignment will hold it is certainly possible that the Georgian formation is Pliocene. Dall[2] reports finding Pecten parmeleei and Terebratalia hemphilli known from the Pliocene of Santa Barbara in beds exposed be-

[1]Howe, H., Univ. Calif. Publ. Bull. Dept. Geol.
[2]Diller, J.S., U.S.G.S. Bull. 196:32-35 (1902)

neath the wharf at Crescent City at low tide. They may belong to the Georgian formation though Dall specifically separated them. The harbor locality is now inaccessible because of indrift of sand. Whether the beds are upper Miocene or Pliocene is not so significant to the present discussion as the clearness of distinction from the Wimer horizon, a distinction which Diller overlooked when he correlated them.

Figure 57 Looking west along Pebbly Beach at low tide. Note long low bench at back of beach to right. This bed contains myriads of fragments of carbonized wood. Following this bed to the point left of center the north dip of the top may be clearly seen under the capping of Battery sands.

Figure 58 Showing the occurrence of Macoma nasuta and Solen sicarius in Georgian shale from west end of Pebbly Beach

Klamath Oldland Gravels

The oldland gravels are stream deposits of the Klamath oldland cycle. No fossil animal remains are at present known from them. In view of the fact that they are extensively discussed in connection with oldland drainage their lithology and distribution will not be taken up here. The writer assumes that they are upper Pliocene or lower Pleistocene from physiographic deductions.

Battery Formation

Over much of the southern portion of the Crescent City platform is a capping of uncemented marine terrace sands. Along the southern ocean front the deposits reach 10 to 15 feet in thickness and lie nonconformably on Dothan sandstones in some places, on Georgian sandstones in other places. In road cuts on the Roosevelt Highway just northeast of Crescent City the thickness is over 20 feet. Here the massive sandstones are consolidated but not indurated. Much of the surface is covered with aeolian sand.

The type locality for the formation is Battery Point in Crescent City where a fossiliferous lens occurs. Immediately above the erosion surface on Dothan sandstone and cherts is a bed of gravels and cobbles of Dothan rocks in a blue mud matrix of over two feet in thickness. These are

Figure 59 Crescent City terrace locality at Battery Point. Dothan sandstones outcropping above the beach to the left. Lens of broken shells a few feet above top of stairway

followed by unfossilifersou yellow sands. About ten feet above the unconformity is a layer varying from 6 inches to 24 inches in thickness made up almost entirely of abraded shell fragments. The fragmentary condition is at-

tributed to violence of wave action when deposited. Occasionally complete tests are found. Among the forms found are Schizothaerus, Macoma, Cardium, Mya, Balanus, and a number of gastropods. They have a decidedly recent aspect and are possibly related to the upper San Pedro stage. On the basis of this fauna a Pleistocene age may be assigned to the Battery formation. Above the fossiliferous stratum lie three feet of yellowish sandstone. The beds are very close to the horizontal but appear to dip slightly northeastward.

Quaternary

Moraines

Morainal deposits are of minor importance. They are found in the regions experiencing the more profound glaciation. Some are found in the upper valley of the Illinois River. The best developed example lies along the east side of Clear Creek valley, Clear Creek having reworked the western margin. Near Poker Flat moraines are found in part flanking Mud Lake and Kelly Lake.

Meadow Fill

The glacial basins of the high Siskiyous have in some cases been filled with debris. The lower portions of such fill are the angular bowlders of disintegration. Toward the top the sediments are progressively finer, gravels, sands, and silts. In the silts and muds near the top is much humus and vegetal debris characteristic of the later bog stages of basin fill. The deposits as a whole may be classified as recent.

Quaternary

Stream Gravels

Stream gravels occur on terraces in the valleys of the present drainage system. In the channels themselves bars are not prominent save in the lower reaches of the Smith River below Hiouchi Bridge. The northern portion of the Crescent City platform is built of fluviatile materials. Thick sand and gravels rest on the Dothan sandstone southwest of the Hiouchi Bridge behind the line of escarpment at an elevation of 100 feet. In the discussion of physiography it was suggested that this is a delta deposit.

Dunes

The dune area of the Crescent City platform is large in its areal extent. The deposits have been discussed in connection with the physiographic development of the platform.

PETROLOGY OF THE IGNEOUS ROCKS

Preston Diorite

The Preston hornblende diorite is distinguished very clearly from the Punchbowl diorite occurring in the same general area by an uniformly finer texture, general veination, and by the presence of brown hornblende rather than gree. This is the most broadly scattered intrusive unit of acidic nature in the Siskiyou area investigated. It is the veritable core of the west flank of the Siskiyou Range and the pronounced north-south group of peaks extending north and east into Oregon and south and west into southern Del Norte County. Most of the relief of the interior area is due to the superior resistance to erosion of the Preston diorite in relation to that of the serpentine.

This formation received its name from the prominent peak, Preston Peak, which it forms. The surface outcrop of the batholith is bounded on the south by serpentine. However, it extends northerly through Copper Peak, El Capitan, Lookout Mountain and outcrops at Black Butte. It also forms Twin Peaks, the Needle, Young's Peak, Sanger Peak, Broken Rib and Wounded Knee Mountains.

The Preston diorite possesses a very uniform appearance. Its general color is gray. On a fresh surface the fineness of grain leads to a uniform intermediate between the white of the plagioclase and the black of the hornblende. On weathered surfaces the color is brownish to dark gray due to the alteration of the hornblende. It is characteristically closely fractured, the fissures being filled with white quartz. On Preston Peak itself the mass is thoroughly broken into blocks varying from several feet in diameter to over 100 feet. Open fissures have permitted weathering agents to cause widespread alteration. Locally there are areas of diorite contain-

Figure 60 Dike of Punchbowl diorite intruding Preston diorite in gap south of Young's Peak

ing numerous crystals of hornblende of needle form.

Thin Section #143, Loc. 86

Preston diorite from Preston Peak.
Texture: Porphyritic
Phenocrysts: Brown hornblende
Groundmass: Hornblende, orthoclase, sanidine, oligoclase
Minor: quartz, biotite
Accessory: magnetite
Alteration: kaolinite, sericite

Figure 61 Photomicrograph of thin section #143 Preston diorite, crossed nicols, x50. Showing phenocrysts of hornblende in groundmass of oligoclase and orthoclase

Thin Section #77, Loc. 52

Preston diorite from gap south of Young's Peak.

Color: Brown

Texture: Holocrystalline, fine grained

Constituents: Major: Hornblende, orthoclase (poikilitic with small sericite alterations)

Minor: Biotite, oligoclase, serpentine minerals in vein

Accessory: Magnetite

Figure 62 Photomicrograph of thin section #77, Preston diorite, plane polarized light, x 50. Showing hornblende

Figure 63 Same as figure 62, crossed nicols

Thin Section #78, Loc. 52

Contact of Punchbowl diorite and Preston diorite from gap south of Young's Peak.

Preston Diorite: Fine grained
Major: Hornblende, oligoclase, orthoclase
Minor: Quartz
Accessory: Hornblende contains clustered granules of magnetite

Thin Section #106, Loc. 66

Preston diorite from the south side of El Capitan.
Texture: Porphyritic, perpatic
Constituents: Phenocrysts, brown hornblende
Groundmass: Major: hornblende, orthoclase, oligoclase
Minor: quartz

Figure 64 Photomicrograph of thin section #106, plane polarized light, x 50. Showing phenocryst of hornblende and importance of hornblende in the matrix

Thin Section #117, Loc. 73

Preston diorite from top of Preston Peak.
Texture: Holocrystalline, fine grained, equigranular
Constituents: Major: Hornblende, orthoclase, biotite, oligoclase
Minor: Quartz

The Preston hornblende diorite is thus far the oldest recognized intrusive in the Preston Peak Quadrangle. It appears to invade the argillites of Devonian age. The upper age limit is not well marked. It is cut by the serpentine and by the Punchbowl diorite. The possible interval now recognized extends from Devonian to Jurassic. It seems probable that it is late Paleozoic, perhaps it was intruded during the late Pennsylvanian disturbance.

Hurdygurdy Peridotite

The Hurdygurdy peridotite is a dark green to black, coarsely crystalline rock. It is very nearly bimineralic and in its ultrabasicity has no extrusive equivalent, a feature emphasized by Bowen as indicating the origin of ultrabasic rocks by crustallization differentiation from the normal basaltic magma. Most of the basic and ultrabasic rocks of the Siskiyou Mountains have been subjected to varying degrees of serpentinization, hence it has been considered desirable to treat this intrusive as a unit. In this way the original nature of many serpentines may be emphasized for peridotite is quantitatively the most important source rock.

The name Hurdygurdy is given to the formation because it is exposed to the east of Hurdygurdy Butte. It is an important member of the group of rocks found in Blue Ridge and occurs in the drainage basin of the headwaters of the south fork of Smith River, which lies south of Bear Basin. The peridotite intrudes the Bear Basin formation of Devonian age and the Salmon hornblende schist but is itself intruded by the Punchbowl diorite. This relation is very clear from the large enclaves of peridotite in the Punchbowl formation at the type locality of the latter.

The rock weathers to a reddish soil which is especially abundant about Elk Camp on the trail from Blue Ridge to Island Lake. Its resistance to erosion is comparable with the adjacent igneous and metamorphic rocks.

The stream between Bear Mountain and Blue Ridge appears to follow the contact between the peridotite and the Punchbowl diorite.

Age: The age of the peridotite is not at present ascertainable with precision. Its relations with the other formations indicate that it is pre-uppermost Jurassic.

Macroscopic Description

The Hurdygurdy peridotite is coarse grained, the crystals averaging about 8 mm. in length. The dark green color is occasionally blotched with red limonite resulting from decomposition of magnetite and picotite. Enstatite is present in large proportions.

Microscopic Examination

Thin Section #66, Loc. 44

Peridotite from ridge south of Bear Basin Butte
Color: Green
Texture: Holocrystalline, coarse grained, equigranular
Constituents: Major: Olivine with alteration rims of bowlingite
enstatite, uralite, anorthite
Accessory: Magnetite, chromite
Alteration: Chlorite

Serpentine

The serpentine is almost omnipresent. It is found throughout the area in masses of large size. Under this heading are included inextricably mingled rocks showing great variation in composition which were classified in the field as: 1. serpentine proper, a lenticularly brecciated rock, sometimes coal black sometimes green, always slickensided, and with a homogeneous amorphous texture showing little or no trace of the original constituents; 2. meta-peridotite, a rock with residuals of enstatite and olivine, indications of original coarse grained texture, jointed not brecciated; 3. meta-gabbro, a rock notably more acidic, tending toward a fine grain; 4. greenstone, a resistant green rock tending to be aphanitic, frequently with flow structure but massive in nature rather than brecciated. The most persistent and abundant of these groups is the meta-peridotite. Here and there under

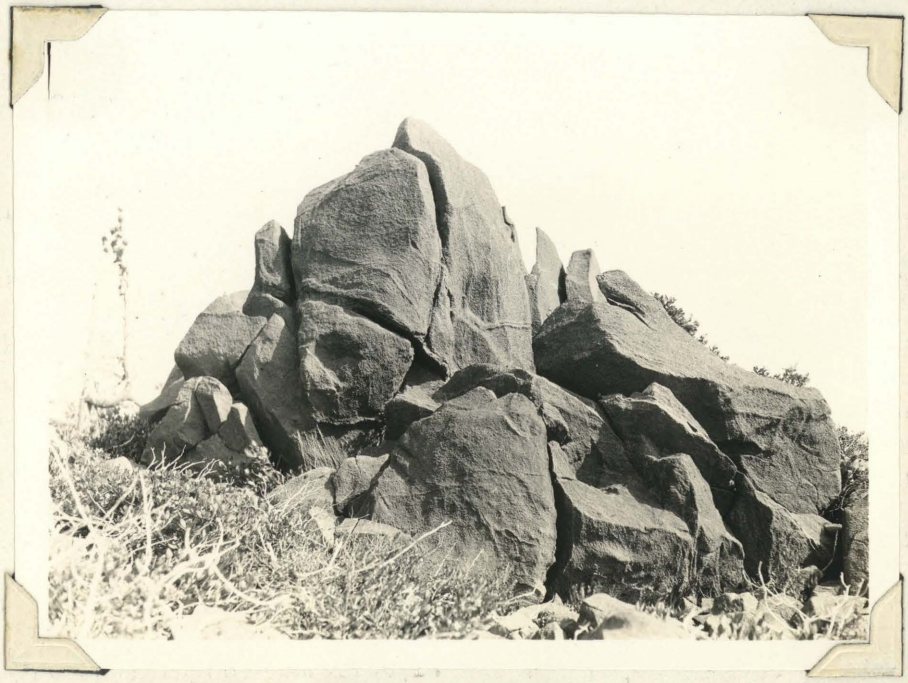

Figure 65 Resistant mass of meta-peridotite on Elk Camp Ridge. Silicified veins protrude while calcitic veins are characteristically leached out. Wind is predominant agent here.

particularly favorable conditions the serpentinization has been complete. From the very fact that so much latitude of composition exists it may be readily inferred that the rocks here discussed may not be uniform in age.

The characteristic dark green color which these rocks exhibit on fresh fracture is lost on weathered exposures. The color becomes in general a mottled gray on outcrops. This in some instances may vary from a black to a light, dusty gray. When soil has a chance to accumulate the color of the serpentine mass approaches a hematite red. The soil is as a rule thin

Figure 66 Detail of soil weathering in serpentine north end of Low Plateau. Pellets of hematite weather out in places and remain collected in nooks sheltered from the wind. They frequently show a high polish.

and poorly suited to plant life. Vegetation is characteristically scanty on serpentine slopes, a feature of extraordinary advantage in field mapping. This condition is to be attributed not so much to the chemical composition high in Mg and Fe but to the lack of porosity. Water is readily led away along fracture planes. Burned areas on serpentine are excessively slow in

reforestation.

As a rule serpentine is less resistant to erosion than the other rocks of the district. Higgins Copper has a peak of diorite while serpentine laps up on the slopes. It therefore owes its present relief to differential erosion. Subsequent streams have frequently worked headward in serpentine masses as in the cases of upper Hurdygurdy Creek, Jones Creek, Clear Creek, and the principal courses of the North and South Forks of the Smith River. Dikes of serpentine in the Preston diorite have led to the production of passes by differntial erosion, among them Cyclone Gap and Lightning Gap. Some ridges of the Siskiyou province such as the one followed by the trail between Waldo and Sanger Peak are largely serpentine but along their crests are masses of Preston diorite, presumably of the nature of inclusions or pendants.

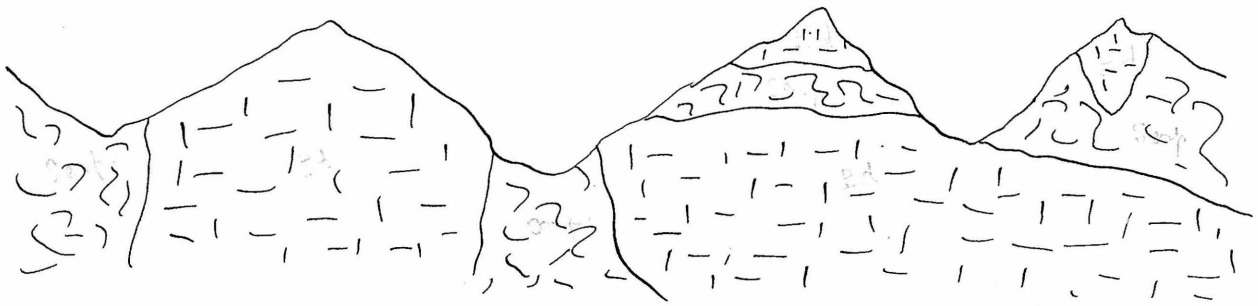

Figure 67 Illustrating the typographic and geologic relationships of serpentine to Preston diorite. Consideration of these features will be extremely useful in understanding areal distribution of these rocks.

Highly serpentinized areas are commonly subject to extensive sliding. Where the rock is lenticularly brecciated the lenses are coated with amorphous silica and slickensided. Fine products of disintegration plus

meteoric water provide ample lubrication, especially where the vegetal cover is sparse. The entrenchment of streams has naturally led to valley slopes too steep for repose. Artificial highway cuts have been subject to

Figure 68 Looking north across Smith River Valley 1½ miles above Gasquet at slide in serpentine. The brecciated nature of the serpentine makes it incapable of standing where undercut by stream action.

slides during the rainy season. The movement of a mass of serpentine down a slope is essentially different from that of a rigid block such as a lava capped slide block. In the latter case the dislocated mass tends to move as a unit down a concave plane leading to increasing back tilt of the surface and the beds with increasing descent. With serpentine the movement is distributed and resembles a slump. The mass assumes an arcuate curve and the material piles to the anterior in such a way that hollows are produced back of the mass. Where pronounced slides of this nature have occurred on

gentle slopes lakes have been impounded. Some lakes of this origin on the slopes of Little Rattlesnamke Mountain have been mapped as a reference to the Preston Peak Quadrangle will show. On both sides of Elk Camp Ridge which is composed practically entirely of serpentine, slides have taken place, occasionally of the degree necessary for the formation of backslopes.

Figure 69 Looking south down Patrick's Creek Valley from north end of Elk Camp Ridge. Characteristic serpentine slide and hummock topography is seen on Elk Camp Ridge to right. In the background the Ship Mountain phase of the Siskiyou scarp may be seen.

On the ~~west~~ east side hummocky slide topography is characteristic. Refer to figure 69. Where high relief exists as for example on some undercut slopes of the Smith River, slides are merely the descent of huge quantities of serpentine en masse.

The relations of serpentine to adjacent rocks are frequently complicated. The degree of brecciation along contacts might easily be mistaken as evidence for faulting. Measurable displacement has, however, not taken place in most cases. It is conceivable that during the process of serpentinization with attendant volume increase through hydration actual uplift of a

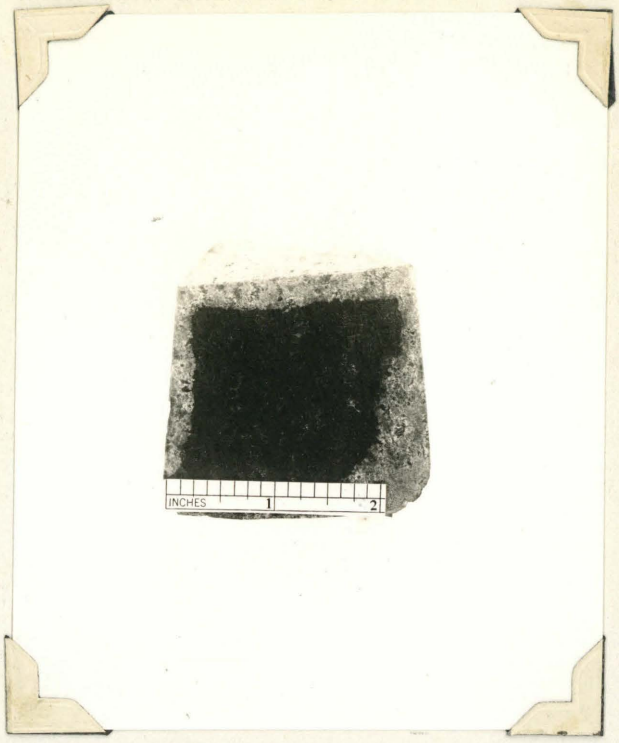

Figure 70 Fragment of joint block of metaperidotite from serpentine area east of Madrona Forest Camp on the Smith River. Shows leaching of accessible portions.

considerable mass might have occurred. Actual displacement as determined by known faults has taken place under conditions which preclude operation of differential erosion alone or simulated faulting. For example, faulting has taken place along Bald Hill and along the Siskiyou escarpment. Excepting such instances in which faulting may be verified, the contacts were considered intrusive (special instances of depositional contacts such as with the Wimer beds were noted).

Relationships: As has been mentioned the relationships to adjacent rocks is not always clear. The serpentine is undoubtedly intrusive into the older schists, the Grayback argillites and the Preston diorite. It is possible that these serpentines are older than those of the oldland province. Here it appears that the Dothan and the Galice have been intruded. The serpentine is definitely intruded by the Punchbowl diorite and the High Dome

dacite porphyry.

Age: The last mentioned serpentine is late Jurassic in age. It is probable that most serpentine is of this age. Those of the upland are post-upper Paleozoic. Hence they may be early or middle Mesozoic. The serpen-

Figure 71 Road cut in serpentine at Waldo, Oregon, showing relationship of thin soil to brecciated rock below. Dike of _____ seen in center.

tinization was pre-Punchbowl diorite and apparently belonged to the magmatic period of intrusion. Dikes of Punchbowl diorite on the north side of Bear Mountain appear to fill lenticular fissures. The greenstones are ascribed by Diller[1] to both Mesozoic and Paleozoic lavas and intrusives. They do not have a significant areal outcrop in the region and were not studied in detail by the writer. Here they may well be post-serpentine.

Lithology

The original rock: The studies of many workers have revealed the intrusive origin of serpentine. On the Pacific Coast the work of Palache, Kramm, Fairbanks, Turner, Lawson, Ransome, and Diller has repeatedly shown

[1]Diller, J.S., U.S.G.S. Bull. 546:20 (1914)

that peridotites and rocks of extremely basic nature have been the source. In the Klamath Mountains the preservation of peridotite, pyroxenite, and gabbro in locally unaltered condition together with associated meta-peridotite, meta-pyroxenite, and meta-gabbro gives clarity to the concept. The serpentine which is more abundant along fissures and contacts which offered easier access to hydrothermal agencies, is the general end point. Here again the point is not fixed for talc, magnesite, etc. represent further metamorphosis.

The Hurdygurdy peridotite seems a good example of this original rock. It is conceded, however, that this was not the exclusive source.

Serpentinization: The work of Benson[1] has shown that magmatic waters have been primarily responsible for serpentinization. He pointed out that serpentinization and carbonation have often been complete at the

Figure 72 Lens of acidic hypabyssal rock sheared during serpentinization. On stage road on north side Oregon Mountain 1 mile down Telephone Point.

[1]Benson, W.N., Am. Jour. Sci. (4) 46:692-731 esp. 710 (1918)

close of the orogenic epoch which the peridotite was erupted although there have sometimes been intruding differentiates of the primary magma in the interval. In the area studied the complementary acidic dikes in the serpentine are clearly of this nature. They have been affected by deformation and squeezing and are penetrated to a depth of several centimeters by serpentine minerals.

In the formation of serpentine the original olivine and bronzite of the peridotite is altered so that the chemical composition of the rock is different. The new composition, $3MgO2SiO_2 \cdot 2H_2O$, with FeO sometimes replacing MgO, implies that considerable water and silica are added while iron and magnesia are subtracted. The serpentine minerals developed have been carefully distinguished by Winchell[1] and include antigorite, penninite, clinochlorite and various chlorites. Chrysotilite and talc are also formed.

Talcitization: The formation of talc is not limited to the metamorphism of serpentine but is also produced in the contact zones of granites. Talc rocks are found in patches and dikes in the serpentine of this region.

Metaperidotite

This is a dark green to black rock with a typical palimpsest texture. Joint blocks are generally parallelopipeds. Residuals of olivine and bronzite indicate the original nature of this rock while large crystals of chlorite with platy crystals simulate mica. The fine grained matrix consists of matted bastite, chlorite, magnesite, chromite, and magnetite. The whole is frequently veined with chrysotilite.

[1]Winchell, A.N., Elements of Optical Mineralogy Part II, p. 373 (1927)

Thin Section #139, Loc. 83

Contact of serpentine and white rock of nodule from old trail on top of ridge east of Copper Peak.

Color: White
Texture: Pseudoporphyritic
Constituents: Sericite, bastite, kaolinite
Derivation: Contact gradational, nodule derived from aplite dikes intruded into serpentine source rock. Serpentinization led to alteration of constituents of leucocratic dike as well as the ultrabasic intrusive while volume changes in serpentine led to brecciation and dislocation of dike

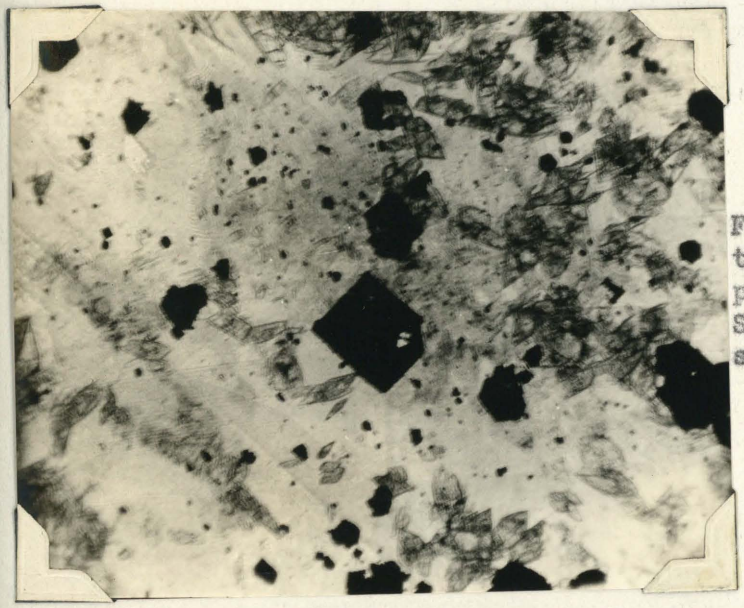

Figure 73 Photomicrograph of thin section #55, serpentine, plane polarized light, x50. Showing magnetite euhedral and subeuhedral, pyroxene residuals

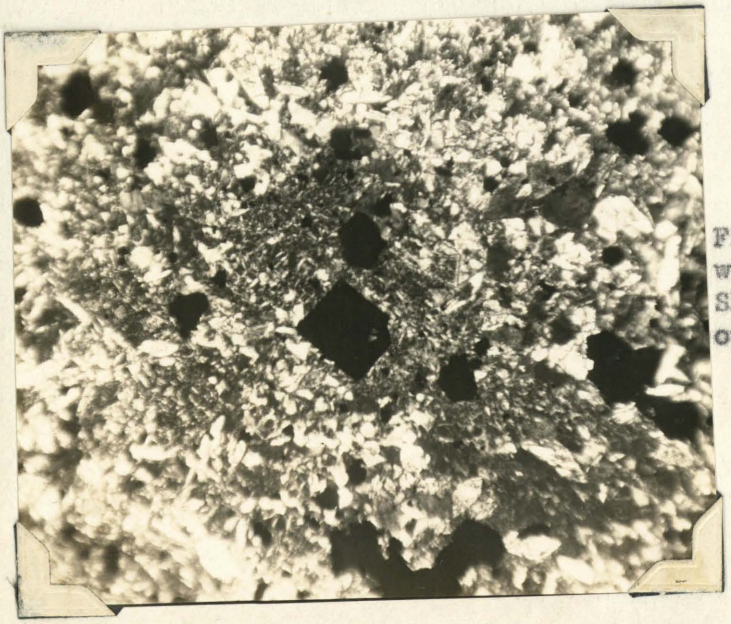

Figure 74 Same as figure 73 with crossed nicols. Showing matrix of bastite and other serpentine minerals

Figure 75 Detail of weathering of metaperidotite on Wimer Road near Rough and Ready Creek, Oregon. Siliceous veins stand in relief while calcite veins show negative relief. Chlorite crystals protrude as small lumps.

Serpentine

The lenticularly brecciated and slickensided serpentine is entirely aphanitic. The processes of hydration and conversion have removed all traces of original texture from a hand specimen. The resulting rock is composed wholly of the secondary minerals. The color varies from light green to black. Under the microscope fibers of antigorite may be seen to be matted with an amorphous ground mass. It has been observed that areas of mesh structure derived from olivine while banded fibers are formed from enstatite and diallage and lie parallel to the original cleavage.[1]

[1]Palache, C., Univ. Calif. Publ., Bull. Dept. Geol. 1:161-180

Figure 76 Exfoliation characteristic of serpentine. Gap on South Fork Trail south of Copper Camp. Lenticular brecciation makes scale-like slices of serpentine common where any area of completely serpentinized rocks occurs.

PETROLOGY

Punchbowl Diorite

The Punchbowl diorite, so-named from its extensive occurrence about the Devil's Punchbowl on Bear Mountain, is apparently a member of the Mesozoic group of intrusives. In the field it was called "Young Diorite" since it was the youngest intrusive observed. Relation to the likewise young Pyroxene Diorite could not be determined for they were nowhere in contact. The Punchbowl diorite shows extreme variation in mineral proportions though not in mineral composition. Major constituents are hornblende and plagioclase feldspar. As the former predominates

it assumes a dark gabbroic aspect, as it approaches the latter it appears syenitic. The median of composition may be represented by a diorite, albeit a basic type. Although the hornblende of the quartz diorite is generally of the green variety[1] while that of the melanocratic diorites is brown, the particular hornblende diorite in question contains green hornblende.

In Oregon to the north, between Jacksonville, Central Point, and Sams Valley there is a large area of tonalite, a rock containing sodic plagioclase, quartz, hornblende, and biotite. As described by A. N. Winchell[2] this tonalite contains accessory titanite and magnetite. The plagioclase found was andesine. Typical diorite is noted as occurring at the margins of the Siskiyou batholith where it comes in contact with shales. In importance, however, the tonalite is the correlative of the Punchbowl diorite. The former is regarded by Winchell as significant in relation to the origin of the ore deposits and the latter is regarded as significant by the writer in California. Moreover, the differences in composition and quartz content may not be so pronounced as indicated.

The range toward gabbro is most developed where considerable assimilation of peridotite, hornblende schist, and slate has taken place. Thus, at the type locality on Bear Mountain there are more or less corroded peridotite and schist inclusions. Schlieren of rock very high in plagioclase sometimes are in contact with the peridotite and show eutaxitic structure. See the accompanying photograph. Comparison of these xenoliths with the peridotite to the west between Bear Mountain and Blue Ridge indicates the former to be derived from the magma as the latter.

[1]Harker, Petrology for Students, p. 70 (1923)
[2]Winchell, A. N., Petrology & Min. Res. of Jackson & Josephine Cos. Min. Res. Ore. 1:5:46 (1914)

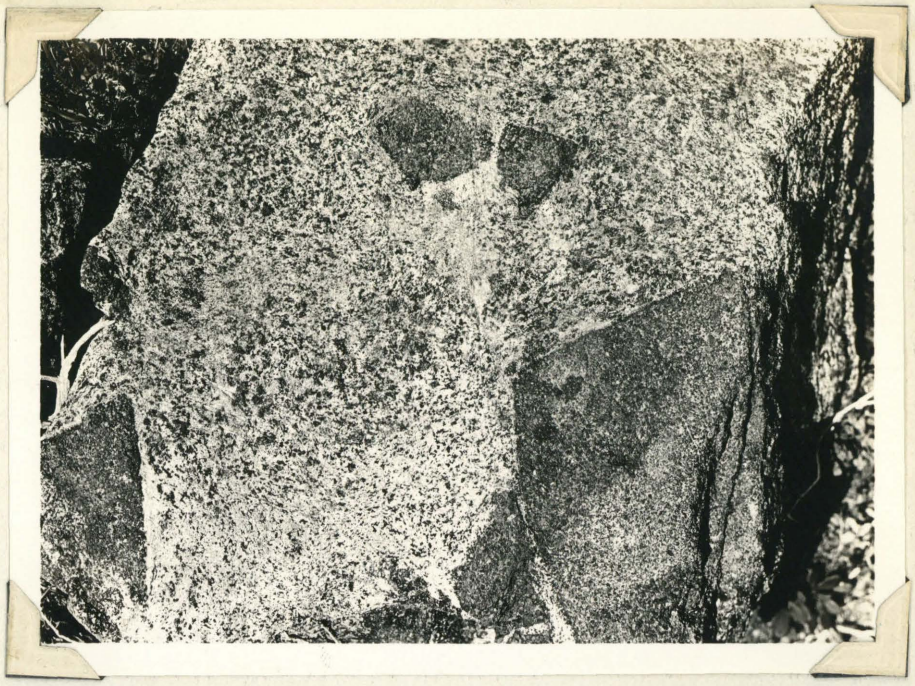

Figure 77 Xenoliths of peridotite in the Punchbowl diorite at the Devil's Punchbowl. Note angularity of joint planes on inclusions.

Figure 78 Lamprophyric dikes in the Punchbowl diorite of the Devil's Punchbowl with inclusions.

The diorite in this vicinity is evidently a contact facies. The massive rock itself frequently is shown to have been in a state of plastic flow when solidified, by parallel orientation of hornblende crystals. This phenomenon as well as the prevalent lamprophyric dikes are illustrated in figure 79. These dikes, composed like the country rock of hornblende and plagioclase (however, with the former greatly predominating) contain many

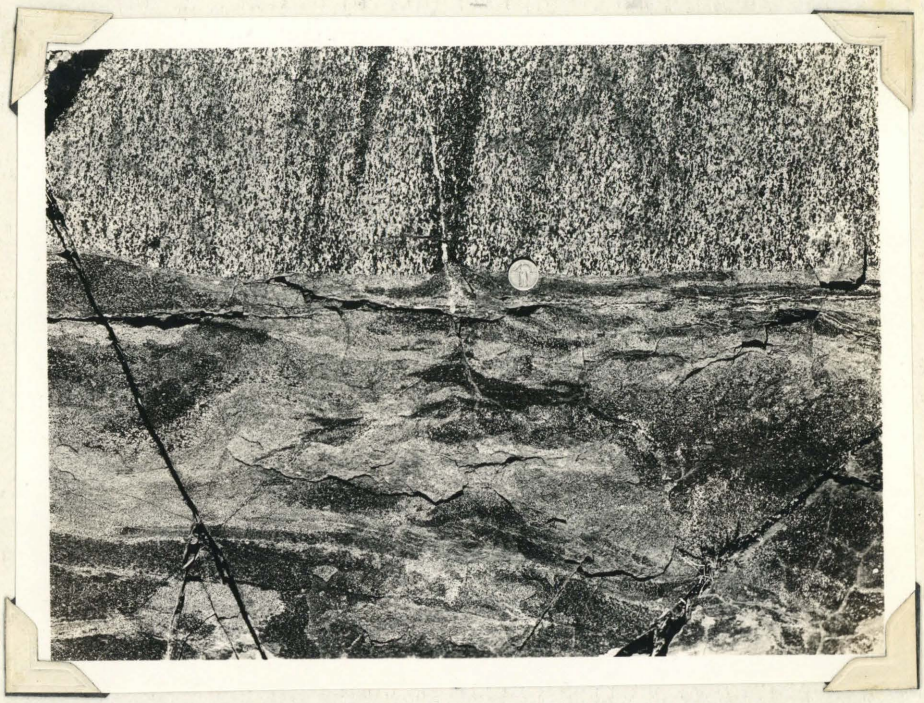

Figure 79 Contact of Punchbowl diorite and lamprophyric dike at the Devil's Punchbowl on Bear Mt. Dike shows cutaxitic structure. The flow structure of the country rock at right angles to the dike strikes east-west. The surface has been glacially polished.

corroded fragments of the country rock. Flow structure and small schlieren are extensively developed. In some instances they are diabasic.

The tendency toward differentiation of this dioritic body into ultrabasic segregations is striking, particularly when the relative homogeneity of composition and texture of the Preston hornblende-diorite is considered. In the great bowlders of the talus slope to the west of the second lake of the Punchbowl many of these autoliths are exposed in cross section. They

are composed almost entirely of hornblende corresponding exactly with that of the Punchbowl diorite. The segregation illustrated contains a local admixture of feldspar and shows effect of some dissolution, the hornblende tail presumably resulting from movement during a heated and somewhat incoherent stage.

Figure 80 Cognate inclusion or segregation of green hornblende in Punchbowl diorite at the Devil's Punchbowl.

In two other localities these self developed bodies are found. To the west of Cyclone Gap and between El Capitan and Copper Peak there is a tongue which is rendered quite heterogeneous by the presence of great numbers of hornblende aggregations. A part of this mass on the west side of Clear Creek invades fissures in the Preston diorite, bearing fragments of it as inclusions. Elsewhere along the contact it shows hornblende-rich aggregations.

The northernmost outcrops of this Punchbowl diorite are in dike-like masses near Twin Valley and northeast of Lookout Mountain.

The Bear Mountain batholith, as the main mass of the Punchbowl diorite may be appropriately designated, extends southward beyond Island Lake, Cameron Peak, and Prescott Mountain out of the area mapped. On the north rim of Prescott Lake which is perched on the northwest side of Prescott Mountain is an interesting pegmatite dike some four or five feet wide. The surrounding rock is gabbroic in character and quite dark in color. Adjacent to its walls the dike is largely plagioclase with small books of biotite. In places the dike contains small patches of fine hornblende crystal aggregations. They appear to have been introduced in a late stage of the dike-formation.

Another interesting occurrence in the Punchbowl diorite is the broad granitic dike passing through Cameron Peak, the prominence north of Prescott Mountain. This dike is about 30 feet in breadth and nearly vertical. It is the only occurrence of its nature noted and is the only intrusive rock of the area to contain abundant quartz. It contains in addition to orthoclase and quartz considerably biotite.

Age relationships of the Punchbowl diorite are not definite in relation to rocks in the west although the probability exists that it is closely related to if not the same as the gabbro-hornblendite rocks of the Big Boy Ridge district west of Oregon Mountain and the diorite dikes invading serpentine of the Low Plateau region. In the high Siskiyou district as has been mentioned, dikes invade the Preston diorite. They are also found in the serpentine near the contact on Bear Mountain. The more acidic dikes containing occasional needles of hornblende of the Whiskey Lake region and elsewhere are possibly differentiates. The Punchbowl diorite includes fragments of Salmon hornblende-schists and peridotite, thus establishing its subsequence to these. Excepting the lamprophyric complementary dikes,no younger intrusives can at present be established as such in the area.

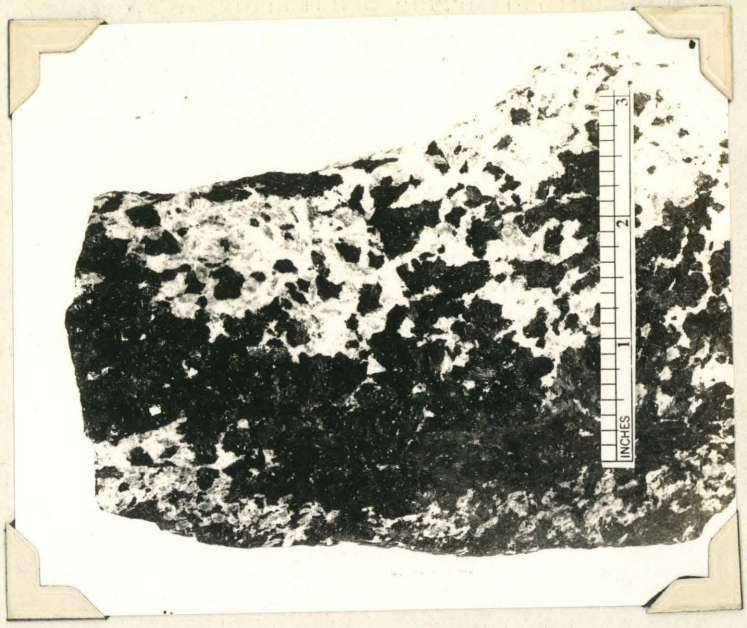

Figure 81 Punchbowl hornblende diorite from Devil's Punchbowl showing clustering of hornblende crystals.

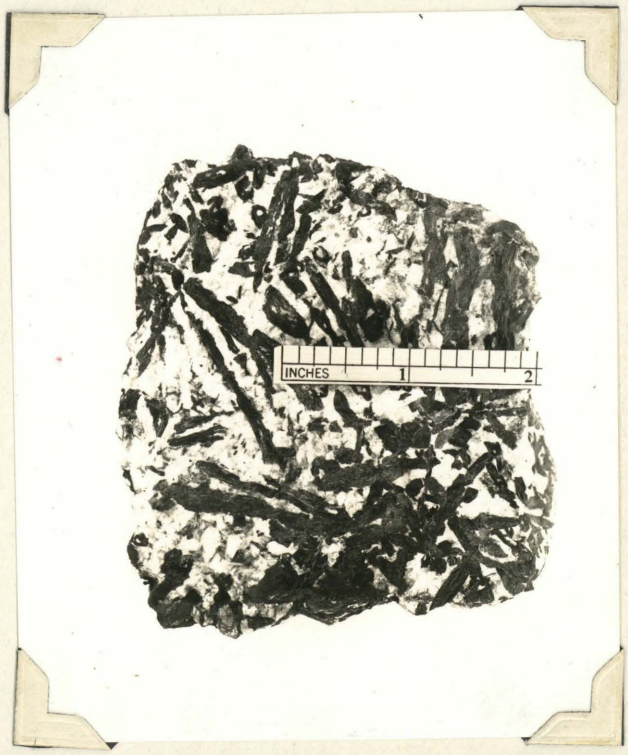

Figure 82 Facies of Punchbowl hornblende diorite from drainage basin of Rattlesnake Creek, northwest of Preston Peak. Phenocrysts of hornblende.

This group of rocks appears to be definitely the chronological and petrologic correlative of the Sierra Nevadan "granodiorites". Like them the group shows extreme though gradational variations in composition. An important difference is to be noted in the minor to insignificant role played by quartz in the Siskiyou batholith of the Preston Peak region. Excepting the quarts, the compositions are comparable. As is the case in the Sierras the members of the group invade serpentine. From consideration of general features of occurrence it would appear that the Punchbowl diorite and associated intrusives are to be correlated with the Sierra Nevadan "granodiorite" intrusives which are of upper Jurassic age. The rocks of the tonalite, diorite, gabbro series of southwestern Oregon were placed in the Jurassic by A. N. Winchell, probably on similar grounds.

Detailed Descriptions

Thin Section #148, Loc. 89

North rim of Prescott Lake

Color dark from preponderance of hornblende. Holocrystalline, medium grained, equigranular fabric.

Mineral Composition: Hornblende, andesine, muscovite. Minor: magnetite. Secondary: chlorite, kaolinite.

Relationships: Microtexture; seriate porphyroid, larger crystals hornblende and andesine, groundmass principally andesine. Magnetite is important constituent, is replaced by hornblende, and is usually rimmed with darker hornblende. Some hornblende crystals acicular. Andesine with characteristic albite twinning and occasional Carlsbad twinning. Alteration border of kaolinite.

Figure 83 Photomicrograph of thin section #148, Punchbowl diorite, crossed nicols, x50. Showing orthoclase, plagioclase, and hornblende.

Thin Section #149, Loc. 89

North rim of Prescott Lake

Pegmatite dike, white from plagioclase feldspar with dark fine hornblende aggregates. Pegmatitic texture.

Mineral Composition: Andesine, quartz, green hornblende. Minor: magnetite, apatite.

Relationships: Quartz frequently shows undulatory extinction, is earlier than feldspar. Hornblende has penetrated some fissures in quartz and feldspar.

Figure 84 Photomicrograph of thin section #149, dike in Punchbowl diorite, crossed nicols, x50.

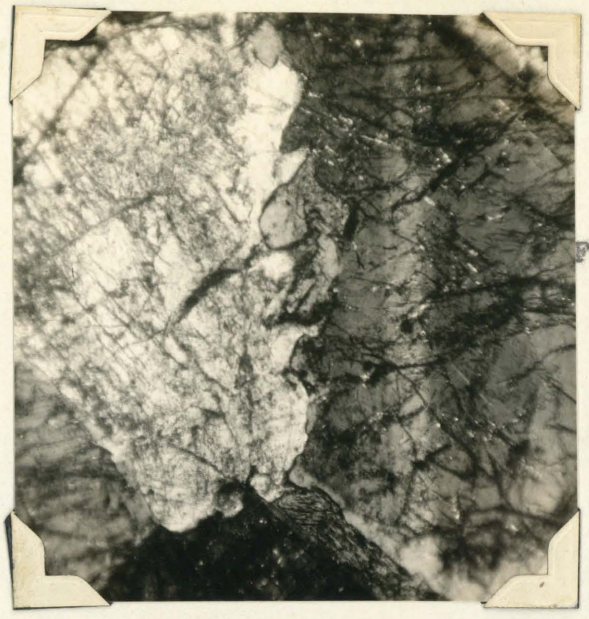

Figure 85 Photomicrograph of thin section #131, Punchbowl diorite, crossed nicols, x50. Showing interlocking of orthoclase crystals, small hornblende crystals at lower intersection.

Thin Section #147, Loc. 88

Granite dike on Cameron Peak, first peak north of Prescott Mountain and southwest of Island Lake.

Color: Brownish white
Texture: Holocrystalline, medium grained, equigranular
Constituents: Major: quartz, hornblende, biotite, microcline, orthoclase
Accessory: magnetite
Relationships: Microtexture; seriate intersertal, large crystals orthoclase and plagioclase, smaller crystals hornblende and quartz.

Figure 86 Photomicrograph of thin section #147, granite, crossed nicols, x50. At the bottom orthoclase, above, quartz and hornblende.

Thin Section #127, Loc. 77

Contact of hornblende schist and Punchbowl diorite from ridge north of the Devil's Punchbowl.

Texture: Diorite: Holocrystalline, equigranular
Schist: Flow cleavage, parallel alignment

Constituents: Diorite: Andesine, orthoclase, hornblende. Accessory: pyrite
Schist: Hornblende, plagioclase, quartz. Accessory: magnetite

Relationships: Sharp contact, some brecciation of diorite near contact.

Note on the Big Boy Hornblende Diorite

A hornblende diorite similar lithologically to the Punchbowl diorite occurs about the Big Boy Mine on the old Wimer road near Diamond Creek. The main diorite mass itself is extensively propylitized and contains cinnabar crystals along the joint planes. Large masses of hornblendite are found in adjacence and are cut by pegmatite dikes. It is believed that these hornblendite masses are segregation products of the diorite magma.

The serpentines and other rocks of the oldland area are sometimes cut by diorite dikes. These dikes belong to a later magmatic period than the stocks for inclusions of the latter exist in the former. The pneumatolytic activity associated with the intrusion of the dikes may have been responsible for the alteration of the main diorite mass itself.

Figure 87 Illustrating the relationship of the Big Boy hornblende diorite and hornblendite to the later diorite dikes. A segregation within an inclusion on Diamond Creek.

This occurrence probably represents one of the Sierra Nevadan intrusives and may be classed as part of the Punchbowl formation.

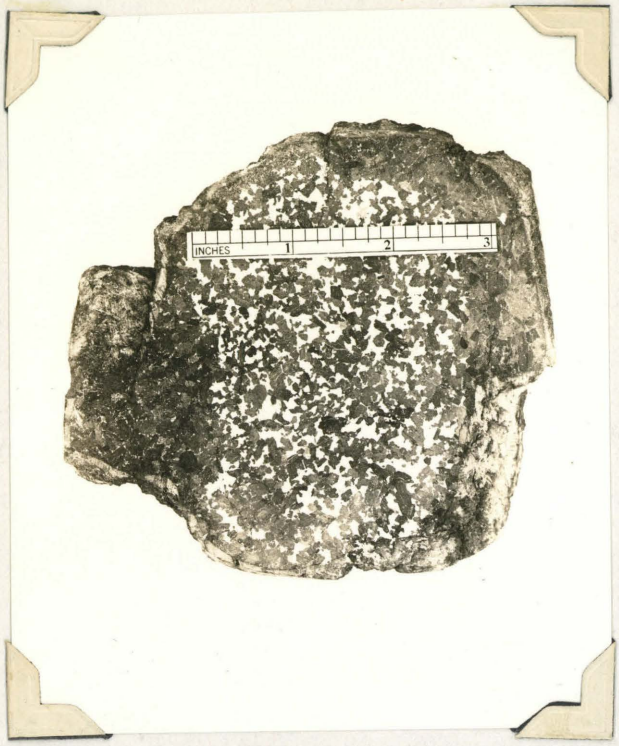

Figure 88 Inclusion of hornblende diorite in hornblendite. Big Boy Cinnabar Prospect

Figure 89 Inclusion of serpentine in hornblendite. Big Boy Cinnabar Prospect

Figure 90 Hornblendite cut by aplitic dikes. Big Boy Cinnabar Prospect

Madrone Pyroxene Diorite

The Madrone pyroxene diorite is a well defined petrologic unit. It is widely distributed in the Klamath oldland province but none is exposed in the Siskiyou upland. The rock is inclined to be greenish on fresh surfaces from the pyroxene content. This mineral forms approximately one half the rock, plagioclase feldspar the other half. Pyrite is sometimes present as an accessory, a feature reminiscent of the Punchbowl diorite. Where exposed below Madrone Camp south of Gordon Mountain the diorite is olivine-bearing. A large mass of the rock occurs in Monkey Creek Ridge and swings around Monumental to Oregon Mountain. Another body underlies the Wimer beds east of the Bald Hills. A mass of unknown extent outcrops on French Hill. In both these last mentioned places the rock is deeply weathered. Everywhere observed the relationships are intrusive save east of the Bald Hills. Here the diorite is faulted against serpentine and overlain unconformably by Wimer beds. Along the Smith River at various places dikes of pyroxene diorite intrude serpentine. The Madrone diorite intrudes various basic and ultrabasic rocks in the upper

Figure 91 Contact facies of Madrone pyroxene diorite and meta-gabbro on upper Monkey Creek

reaches of Monkey Creek.

The Punchbowl diorite and the Madrone diorite appear to be closely related. Like the Punchbowl formation the Madrone is believed to be Sierra Nevadan. The Punchbowl hornblende is not derived by alteration from the Madrone pyroxene. The two diorites are petrologically distinct.

Thin Section #20, Loc. 16

Madrone pyroxene diorite from road cut on Smith River one mile east of mouth of Myrtle Creek.

Texture: Holocrystalline, medium grained, equigranular.
Constituents: Uralite, orthoclase, microcline, muscovite, labradorite, augite.
Alteration: Sericite, chlorite.

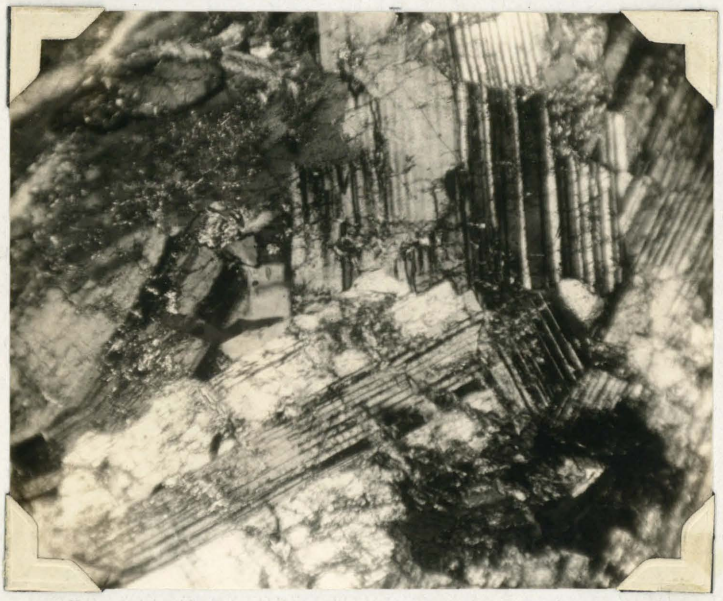

Figure 92 Madrone diorite thin section #20, crossed nicols, x50. Showing principally labradorite crystals.

High Dome Dacite Porphyry

The High Dome dacite porphyry is one of the most important formations of the area. Its widespread distribution under the Klamath Oldland province exceeded all anticipation in view of its nature and its extent in adjacent regions. In spite of its aphanitic texture it is not an extrusive as might be ordinarily be supposed. It is rather a hypabyssal intrusive as will be demonstrated in connection with contact relationships.

This rock is exposed in a long north-south mass including High Dome and a portion of Patrick's Creek Ridge. A body of unknown extent outcrops along the Smith River at the Horse Flat Forest Camp. As is the case with other bodies its major axis is probably north-south. A large area is exposed on French Hill and in the country to the south and east. This belt may or may not continuous with an apophysis in the Cresecent City Quadrangle extending north across the Smith River in the vicinity of Hardscrabble Creek. The latter outcrops for a mile and a half along Smith River and extends northerly beyond Signal Peak. One of the most interesting occurrences, the one first observed by the writer, is an intrusive in Dothan shales near Hiouchi Bridge. This mass seems to be a laccolith. The roof of shales, exposed in a highway cut, shows effects of contact metamorphism.

The dacite porphyry is extremely resistant and tends to form topographic prominences, though it like the other formations is beveled by the Klamath surface. High Dome which it forms is a good illustration of this quality. The soilc cover is as a rule relatively thin although under locally favorable circumstances it may be thick and support a luxuriant flora.

The High Dome dacite porphyry is quite homogeneous and possesses characteristics which make it readily recognizable. The color is a dark green and while more striking on fresh surfaces is maintained to some de-

gree on weathered exposures. The crystals of component minerals are much to small to be seen by the unaided eye and indeed in some cases are submicroscopic. Under low power of the microscope flow structure is noted in the case of the material of the laccolity. Joints are widely spaced in general, although in instances such as the talus slopes of High Dome, disintegration has extensively comminuted the originally huge blocks. The other process of weathering, namely, decomposition, is of less importance in the erosion of the dacite porphyry.

One of the most noteworthy features of the dacite porphyry is the frequent occurrence of pyrite and sulfides. This is not a local phenomenon which may be attributed to adjacent mineralizing intrusions. The dacite is the youngest igneous formation observed. Moreover, the occurrences are widely separated by various intervening formations. The north abutment of the Hiouchi Bridge is anchored in this resistant rock and bowlders resulting from the blasting show scattered clumps of untarnished pyrite. Occasionally it is concentrated nodules the size of a walnut. On the whole the peppering of glistening metallic yellow specks gives a striking effect. The crystals themselves are euhedral.

In outcrop of dacite porphyry on French Hill the pyrite is almost omnipresent though not always abundant. The dacite is the bedrock of the French Hill placer mine. To the southwest of the gravel workings an exploratory shaft is being sunk in the Klamath surface depression which carries the drainage of French Hill into Craigs Creek. Here a certain amount of scattered chalcopyrite is present. Where readily attacked by percolating ground water this has been reduced to metallic copper. In the north-east of the cabins on French Hill Mine a short open cut disclosed dacite of the same striking mineral facies. The sulfides are by

no means as common as at the previously mentioned locality although some masses as large as a hazelnut were observed. A third distinct case is afforded by the Scoville Copper Prospect on the west side of Patricks Creek Ridge facing High Dome. Here extensive concentrations occur.

The extensive occurrence of these sulfides in the High Dome dacite porphyry represent a phenomenon difficult of explanation. If an external source is assumed it must conjecturally lie beneath the area and be nowhere exposed, since the dacite appears to be the youngest intrusive. The exclusive assocaition of the sulfides with the dacite indicates a causal relationship for it is inconceivable that hypothetical mineralizing solutions should everywhere search out this hard and relatively little jointed rock. Many instances of primary pyrite have been observed. The Punchbowl diorite in the adjacent Siskiyous contains occasional grains. But nowhere to the writer's knowledge is primary pyrite of such large proportion. Such pyrite, moreover, frequently shows corrosion of corners, replacement, etc. which are not to be seen in the present instance. Consideration of the implications of the above-mentioned observations leads one to the conclusion that the sulfides of the dacite porphyry were deposited shortly after intrusion, solidification, and fracturing, by mineralizers rising from the dacite magmatic source. This conclusion has far-reaching significance in relation to the copper sulfide deposits of the region.

Thin Section #13, Loc. 12

High Dome Dacite porphyry from road cut at Hiouchi Bridge on Smith River.

Color: Light green
Texture: Seriate porphyritic, dopatic
Constituents: Plagioclase (not determined), hornblende, quartz, orthoclase
Accessory: Pyrite
Relationships: Grouping of crystalline material and aphanitic substances in flow arrangement

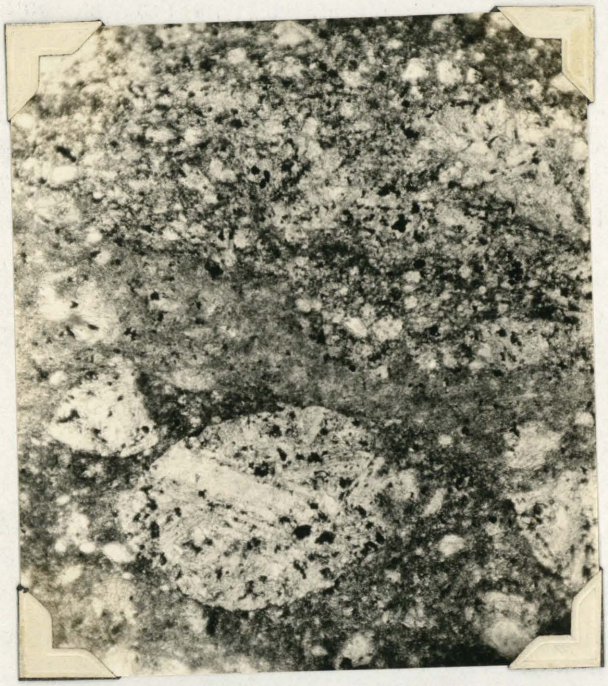

Figure 94 Photomicrograph of thin section #13, dacite porphyry, crossed nicols, x50.

Figure 93 Photomicrograph of thin section #43, tremolite vein in dacite, crossed nicols, x50. Showing tremolite needles penetrating orthoclase.

Age and Correlation

The High Dome dacite porphyry intrudes many of the rocks of the Klamath Oldland province. Use of the word "intrudes" requires explanation in view of the fact that aphanitic textures are commonly associated with extrusive rocks. While intrusion cannot at all localities be established as the manner of coming (i.e. extrusion cannot everywhere be ruled out), certain localities are definite in their evidence. On the old Shelley Creek road about 3½ miles south of Monumental, the Shelley Creek slates are cut by a sill of dacite porphyry. Near the contact the slate is metamorphosed. To the west of this sill and band of slates is the characteristic High Dome formation. On Baker Creek several broader sills are exposed by the stream cut and prospecting tunnels in mineralized areas clarify these relationships. To the east of Horse Flat Forest Camp dacite intrudes the Monkey Creek pyroxene diorite to the north. It cuts the serpentine on Smith River west of Hardscrabble Creek and as has been mentioned before occurs as a laccolithic intrusion in the Dothan ("Franciscan"). Thus it may readily be seen that the dacite porphyry is post late Jurassic although its upper limit is not so easily discerned.

In the Galice-Kerby-Waldo region Diller[1] notes the occasional presence of dikes and small knob-like areas of dacite porphyry. It cuts serpentine and Galice slates. According to Diller the porphyritic structure here is due to plagioclase, quartz, and hornblende occurring in sharply defined phenocrysts. This structure was not noted in the California area. Diller observed, however, that the rock is frequently non-porphyritic and without pyroxene, amphibole, and biotite. This would conform to

[1]Diller, J.S., U.S.G.S. Bull. 546, p. 21 (1914)

the case of the sill on Shelley Creek, mentioned previously. Another feature of similarity of the Oregon rocks being considered is the presence of a dike of dacite porphyry impregnated with pyrite on Josephine Creek.

In his study of the Roseburg Quadrangle[1] Diller noted dikes of dacite porphyry cutting the Cretaceous Myrtle formation. The same relations were noted by Butler & Mitchell[2] in Curry County. Thus it appears that the dacite porphyry is post-lower Cretaceous. It is pre-Miocene as may be judged from its beveling by the Miocene erosion surface. It was possibly intruded during the Paleocene orogeny.

[1]Diller, J.S. Roseburg Folio No. 49
[2]Butler, G.M. & Mitchell, G.J. Min. Res. Ore. Vol. 2 No. 2

Structure

Summary

The dominant structural axes of this portion of the Klamath Mountains strike somewhat west of north. In detail batholithic intrusions have similar orientation. In the large they follow an east-west cross-axis. Rocks of the region are in most cases much metamorphosed and have extremely complicated relationships to each other testifying to a long and eventful geologic life. Intrusive rocks have by their injection destroyed the evidence of relationships of the sedimentary-metamorphic group.

Folding is on the whole of minor importance. Although some formations such as the Galice are contorted in most cases a rather constant attitude prevails.

Faulting is prominent both on a large and small scale. Movement of small displacement has occurred along many of the contacts particularly in adjacence to serpentine. Three large faults have been located. That to the east is responsible for the Siskiyou front facing the Klamath oldland. It pursues a general northerly trend and dips east usually about 60°. From its southward extension it was named by Hershey the Orelans fault.

While quantitative data on displacement are not available (rocks to the east are igneous) it must by conservative estimate have been at least 4000-5000 feet. Considering the depth of denudation of the high country it quite possibly amounted to twice this figure. If the bench at 4200 feet on the Haystack near Sanger Peak is a portion of the Klamath oldland the post-Pliocene throw would be about 1000 feet.

A second line of faulting has displaced Rattlesnake Mountain and Little Rattlesnake Mountain with respect to each other as may be seen from their offset summits. The fault strikes northwesterly along the west face of the Bald Hills and may continue to join the Crescent City fault. On the

fault the Mill Creek segment has been tilted to the northeast.

The Crescent City fault is one inferred to be present immediately offshore south of Cresecnt City which s rikes behind the platform to the vicinity of Smith River where it arcs to the west and passes into the Pacific. It is believed that there has been displacement of over 1000 feet on the fault south of Crescent City since the Pliocene.

Joint planes while not in perfect accordance throughout the area are in general oblique to the major directions. The region appears to have suffered tangential compression particularly along an east-west axis.

As has been deomonstrated the Siskiyou Range in particular and the Klamath group in general have been a positive element in the earth's crust during much of geologic time and especially since the Jurassic. In all the long uplift, dissection, and intrusion, the region has been a massif receiving crustal assaults from all quarters with resulting fracturing, faulting, and metamorphism of the rocks.

STRUCTURE

Introduction

It is necessary to understand the structural design of a region if we hope to decipher its geologic history. The larger concept of the structural design rests in the last analysis upon the correlation of the minutae. Here in the rugged, timber-covered, northwestern Klamath Mountains knowledge of the detail is increasingly difficult to acquire. In detail the structure is frequently hopelessly complex and confusing. Rocks of almost every variety exist under almost all conceivable conditions. The phenomena of metamorphism may be detected almost universally. The igneous rocks themselves involve a myriad of details on internal constitution and external relationship. Relationships of sedimentary series separated by intrusive masses are scarcely discernable yet all contacts of major importance involve at least one igneous rock.

Internal Structures

Igneous Structures

It will be remembered from the section on stratigraphy that the intermediate intrusives, namely, the Preston and Punchbowl hornblende diorites, show little metamorphism. Contacts are sharp and clear as in the case of those of the granitic rocks of the Sierra Nevada[1]. Only the later dacite gives evidence of significant contact action and even in this case the contact aureoles rarely exceed 10-15 feet. Mischegesteine are notably lacking save in the Punchbowl formation. At the Devil's Punchbowl the many phenomena of intrusion are reflected in the internal structure of the rock. Flow structure, schlieren, autoliths, and xenoliths are all clearly exemplified. Since these structural feaures are discussed at length in connection with the petrology they need not be elaborated here.

[1]Pabst, A., Univ.Calif.Publ.Bull.Dept.Geol. 17:329 (1928)

Structure

Regional Metamorphism

If contact metamorphism is not widely observed its deficiency is amply supplied by the general distribution of its distant relative, regional metamorphism. This type of rock alteration is variously known as dynamo-metamorphism, obstruction metamorphism, dislocation metamorphism, etc. Grubenmann-Niggli prefer use of the latter term in view of the regional character of all types of metamorphism. Dynamo-metamorphism is rejected because of the insignificance of movement in many instances.

Regional metamorphism has affected all the older sedimentary rocks in a scale roughly diminshing in intensity with the youth of the formation. The Abrams mica schist represents a metamorphosed series of sediments. The later Salmon hornblende schist is a metamorphosed series of basic lavas. The phyllites of the Bald Hills region are among the older metamorphics. All these groups persevere as jostled and deformed remnants of a once extensive terrane, mere palimpsests of an impressive geologic section. The Salmon schists of the Bear Basin region were, subsequent to metamorphism and development of flow cleavage, broadly folded.

The Bear Basin sediments and the correlated Grayback formation have been subjected to large crustal forces. The flow cleavage developed has, however, not been of the ultimate type characteristic of perfect adjustment. Schists and true slates are lacking. The shales have been in part recrystallized with formation of argillites. The cherts being highly siliceous are not subject to such pronounced changes. As might be expected the carbonate rocks, namely, the limestones, are most susceptible to metamorphism. In the Grayback limestones recrystallization to marble is locally complete but this alteration is not general.

The Shelley shales and sandstones have been metamorphosed to argillites and slates. Certain bands of slates have been finely brecciated. The Galice beds have been rather generally altered to brown argillites although a few of the sandstones remain little changed. The Galice is the most highly deformed formation in the area. It is finely wrinkled and folded. Because of scantiness of exposures a detailed examination of structures was not attempted. As a whole the formation seems to be dipping east and striking north-south. The later member of the Mesozoic sedimentary series, the Dothan, in contrast to the Galice is not as a whole so highly metamorphosed. Most Dothan sediments may still be classed as shales and sandstones. Instead of being finely folded as the Galice, the Dothan beds are bent into broad folds. Although difference in orogenic stress may be in part responsible, the greater competency of the massive Dothan sandstones is certainly important to the differences in internal structure. The Dothan rocks in general strike northwest.

All of the sediments mentioned above have been subjected to varying degrees of regional metamorphism. Modern researches have shown that such metamorphism in the Alps proceeded at relatively low temperatures frequently below 200° C. and but rarely approaching 500° C. The rock changes are facilitated by dislocation processes, high hydrostatic pressure, and the presence of volatile mineralizers. The latter may be derived from concomitant intrusions of magma at a considerable distance. These conditions are readily fulfilled in mountain making. Before uplift considerable thicknesses of rock may contribute to the load developing high uniform compression and bringing lower rocks into higher temperature zones. When the factor of non-uniform pressure is introduced by earth movements, conditions are favorable for mineral transformation and recrystallization. Intrusions which

occur in the later stages of mountain building, presumably as the result of release of pressure on superheated rocks, provide volatiles for regional action as well as metamorphosing adjacent rocks by contact action.

The western Siskiyou region is now so deeply denuded that it is impossible to ascertain former beds. At the same time portions of the mountain roots are exposed. From the long record of metamorphism, however, it may be clearly recognized that considerable thicknesses of Paleozoic and possibly early Mesozoic sediments once existed (perhaps not simultaneously) over the region. It is also to be noted that diastrophic forces have a number of times developed mountains, each period of such activity influencing the metamorphic character of the rocks in an additive way.

Hydrothermal Metamorphism

Hydrothermal metamorphism is a very loose term covering any kind of rock change resulting from action of hot waters. The changes may occur at any depth and are associated sometimes with contact metamorphism, sometimes with regional metamorphism. In the present instance we are principally concerned with the alteration of the ultrabasic rocks to serpentine. The process of serpentinization which has been discussed in connection with the petrology of the serpentines is selective and usually maintains contacts at nearly their original sharpness. Throughout the area the serpentines (which are undoubtedly secondary rocks) are found preserving their former relationships as dikes, stocks, etc. Schistosity is not produced but rather a lenticular brecciation as an extreme manifestation of the expansion caused by hydration.

Serpentinization may procede by a process which J. Konigsberger has called "telepneumatolytic" action. Hot water and gases from somewhat distant intrusions may seek out the susceptible rocks along fissures. The rock

alteration may then proceed almost immediately after solidification or long after depending upon structural control and conditions favoring chemical reaction. Talc dikes and talcized areas are developed as a further manifestation of this telepneumatolytic action.

Another case of hydrothermal metamorphism is to be observed at the Big Boy mine on the old Wimer Road on Diamond Creek. Here a large diorite area has been finely jointed, impregnated with cinnabar along the joint planes, and later thoroughly decomposed by hydrothermal action. Limonite and sericite have formed from the biotite while kaolin has formed from the feldspars.

Jointing

The development and position of joint planes varies with the type of rock. One characteristic which may be noted almost universally is the absence of a north-south strike. The principal plane of jointing of the igneous rocks strike N 80° E and dips 40°-20° N. The secondary plane may strike N 60° W and dip S 60°. The tertiary plane may strike N 50° E and dip S 60°. While absolute values differ, the above-given figures appear to represent a mean. From the study of the strain ellipsoid we know that shearing tends to take place along planes directed 45° to the direction of application of pressure. The generalized joint diagram for the western Siskiyou area would indicate a predominating stress from east to west. This belief is strengthened by the north-south alignment of formations and by the northward trending structures.

Jointing is undoubtedly important in the structural control of certain topographic features. The north face of the pyramidal horn, Preston

Peak, is a gigantic joint plane striking N 80° E and dipping north 40°. The back wall of the cirque containing the Devil's Punchbowl is controlled by great planes in the Punchbowl diorite. These features may be observed by referring to figures . Jointing has also served to determine the position of dikes and veins by giving channels to various magmatic and pneumatolytic solutions.

Broader Features of the Western Siskiyou Structure

In examining the areal map of this region one of the first impressions which may be gained is the remarkable north-south alignment of the principal formations. True in the complexly interlocked intrusives of the upland this orientation is harder to discern. Even in the case of the widely distributed Preston diorite, however, one may note a north-south alignment of outcrops. This is apparently related to the antecedent north-south structure which was in turn developed in response to east-west compression. While in detail the batholiths and stocks of the igneous complex of the western Siskiyous are avoid in the exposed section the general trend of the bodies in the range as a whole is east-west. Hence in view of the theory of permissive intrusion accompanying orogenic deformation, the mountain mass owes its form to north-south compression developing the east-west zone of weakness. Such compression with elevation of crustal rocks presumably through release of pressure permits superheated silicate solids of underlying "peripheral magmatic reservoirs" to melt. The magma rises in the zone of release till it reaches an equilibrium with hydrostatic pressure.

The writer does not agree with previously published accounts[1] of origin of the various components of the Klamath group by folding. Folding and deformation have taken place in the distant past and may have developed

[1]Anderson, F. M., Jour. Geol. 10:144-49

folded mountains whose roots may be dimly recognized, but the present northwestern group, at least, is the result of uplift and dissection. The uplift has been both of the nature of regional upwarping and local faulting. As has been emphasized, the absence of post-Jurassic sediments indicates the positive or upward moving nature of the district while the deformation of the Mesozoic strata flanking the mountains suggests that the positive Klamath metamorphic complex has behaved as a crystalline massif or foreland.

Within the limited area studied the patches of metamorphic and sedimentary rocks scattered in a variety of intrusives have difficultly decipherable structural relations. The early Paleozoic is represented by a distinct hiatus but the Devonian Grayback formation with its prevailing northeast strike indicates that direction of compression was ther more from the northwest than from the west as in later geological time. The sedimentary formations found to the west of the Siskiyou upland are largely Mesozoic belts with beveled outcrops. They are separated by Mesozoic intrusives. In the case of the Shelley formation no other limb has been located, it is simply a homoclinal structure. It would thus appear that the region was the seat of intense orogenic activity in the later Mesozoic, possibly Sierra Nevadan time. At this time the sedimentary series were folded, metamorphosed and intruded. Uplift and truncation led to present areal distribution exemplified on the Klamath oldland.

The Orleans Fault

Faulting is responsible for the present position of many of the formations. Diller[1] in discussing the structure in southwestern Oregon has pointed out a general southeast dip of formations with the youngest Mesozoic to the northwest apparently underlying the Paleozoic and older rocks. "This apparent reversal of the natural order is due either to folding and overturn-

[1]Diller, J. S., U.S.G.S. Bull. 546:22 (1914)

ing of the strata or to faulting, by which the older rocks are made actually or apparently to overlie the younger. Both folding and faulting very probably have contributed to the complex structure of the region, but the part played by each is not as yet understood and will require detailed investigation." Diller likewise notes that the fault bounds the Devonian sediments and the Galice. This fault was indicated as the Orleans fault on a reconnaissance map of part of Del Norte County published by Hershey[2]. Diller's section shown in figure illustrates his concept of the sequence.

In the Crescent City quadrangle the Dothan appears to have a general eastward dipping position. (See structure section). It is, however, separated from the Galice by many intervening intrusives and possibly by faults. It appears to be in normal position. The writer is not inclined to accpet at present overturning of the complete section suggested by Diller. The Paleozoic rocks if projected westward would overlie the Galice Jurassic but this position is believed to be due to uplift on the Orleans fault, not to overturning.

The Orleans fault is a well marked structural feature as may be seen from the influence it has on the areal distribution of formations. Its topographic expression has been discussed in relation to physiography. It was indicated that the fault separates the Siskiyou upland from the Klamath oldland. It may be traced along the west front of the higher peaks, Sanger Peak, Wounded Knee Mountain, Bear Basin Butte, and Ship Mountain. A ramification of the system is believed to pass to the east of Ship Mountain also. At Bear Basin Butte the Bear Basin beds (correlated questionably

[1]Diller, J.S., U.S.G.S. Bull. 546:22 (1914)
[2]Hershey, O.H., Min. & Sci. Press 102:468 (1911)

with Devonian Grayback formation) are raised above serpentines and the slates of the Shelley formation. To the west of the Haystack near Sanger Peak the fault separates serpentine on the east from the Galice argillites on the west. West of the ridge north of Sanger Peak a fault of this system separates greenstone on the east from slates on the west. These slates are, juding from distribution north of the Oregon line and out of the area studied, presumably Galice. The slates here have the characteristic strike of N 30° E and dip 65° S. The fault plane strikes north-south and the hade is 36° E. It is thus a steeply dipping reverse fault. There is no well defined zone of gouge but the slates are brecciated near the contact. Because of the paucity of sedimentary rocks to the east of the fault in California it is difficult to state with precision the displacement. If the terrace developed at 4200 feet on the west side of the Haystak is a remnant of the Klamath erosion surface which reaches 3000 feet and more nearby, the post-Pliocene throw is over 1000 feet. The height of the peaks of the upland, reaching 7310 feet in Preston Peak, suggests that the throw during the Tertiary may be many times 1000 feet. A throw of 10,000 feet is by no means improbable.

Bald Hills Fault

A definite fault lies to the west of the Bald Hills striking in a northwesterly direction. The Red Mountain fault mapped by Hershey[1] would apparently project west of the line of this fault although its northward continuation has not been identified. The Bald Hills fault is apparently of the scissors variety. The flat top of Rattlesnake Mountain in the

southwestern part of the Preston Peak quadrangle is an erosion surface which has been elevated about 400 feet above the corresponding surface to the east on the top of Little Rattlesnake Mountain. To the west of the Bald Hills is a flat lying area with a deeply weathered surface which is about 400 feet below the erosion surface on top of the Bald Hills. As has been explained in connection with physiography the Mill Creek segment, lying between this fault and the coastal Crescent City fault on the west, has been tilted to the northeast producing certain complications in drainage. The increasing throw of this block to the south is manifested by the higher sea cliff. Knobs are found on the ridges just west of the fault line and are supposedly the results of rapid weathering of the brecciated zone.

A fault which may be connected with this system was found on Rock Creek about two miles above its mouth. The zone of clay gouge is one foot in thickness. The plane strikes N 72° E and dips 69° S. On the east side of the Bald Hills the surface which the Wimer beds rests on has been dropped about 100 feet. This fault is, however, of minor importance. The main Bald Hills fault may continue northwestward to join the Crescent City fault and may thus exercise a structural control on the lower course of the Smith River. This inference could not be verified.

The Crescent City Fault

This term specifically refers to the fault primarily responsible for the escarpment east of Crescent City. To the south of the Crescent City platform it lies off the coast. The presence of a fault could not be verified by observation of the actual plane and no data on its exact position and attitude could be obtained. It is inferred from physiographic evidence, the north-south alignment of the escarpment (refer to figure), and the differing histories of the platform and the oldland. As has been mentioned the scarp itself has been modified by marine erosion and later sub-aerial erosion. The Crescent City fault itself gives no evidence of post-marine planation movement.

While the fault planes of the Crescent City and Bald Hill faults were not observed, the writer has represented them in the structure section to be reverse. Several considerations favor this view. In the first place the faults are all approximately parallel and appear to have been simultaneously active. Tension and compression at the same time are mutually exclusive. The Orleans fault is known to be reverse so the others are probably similar. In the second place the Klamath region is known to have been subject to general circumferential compression which has folded the overlapping Mesozoic and Tertiary strata. This condition is favorable to occurrence of compressional faults.

To the north of the platform the plane presumably curves strongly and passes out to sea. The acuteness of angle made by topographic slopes near the village of Smith River is probably not to be attributed to faulting but to later modification by Rowdy Creek which debouches on the platform at this place. Displacement appears to have been entirely vertical, varying from place to place but reaching a maximum of 1400 feet several miles south of Crescent City. Here the upthrown east block, the Mill Creek segment of

the Klamath oldland, is fronting directly on the lower western block covered by the Pacific Ocean. Many of the basin range faults are inclined to be arcuate and the maximum curvature possible is not known. The writer believes that in the present case involving vertical movement the acuteness of the inferred bend near the debouchement of Rowdy Creek offers no insurmountable objection to the existence of a fault.

It might be mentioned in passing that the northward continuation of the San Andreas rift may lie some 15 miles or so offshore. One supposed ramification of this rift strikes into the Pacific near Bear Ridge at the mouth of the Eel River. During the San Francisco earthquake of 1906 the Bald Hills of Humbolt County just south of the Klamath River received some severe shocks. Earthquakes from time to time have affected the Klamath region but signs of recent movement have not been recorded in the mountains themselves. On November 22, 1873 heavy shocks threw half the chimneys down in Crescent City and rang the fire bell. The shock was also felt at Happy Camp. This and other shocks felt in the region may have proceeded from an offshore rift.

Resume' of Geologic History

During the Proterozoic the Klamath region was a basin of deposition, accumulating the series of sediments which were later to become the Abrams and Colebrooke schists. According to Hershey the sedimentation was continuous, there being deposited at the base an argillaceous sandstone with some strata of quartz sand, followed by carbonaceous and siliceous shales, calcareous sediments, and uniform deposition of shales. The deposition was followed by uplift of the region and volcanic activity on a large scale was accompanied by accumulation of a considerable thickness of basic lava flows and somesedimentary interbeds, the whole of which was to become the Salmon schist. Probably near the close of the Proterozoic and possibly during the Grand Canyon-Killarney Revolution these series were folded, metamorphosed to mica and hornblende schists, and elevated. Mountains may have been developed which persevered through the lower Paleozoic.

A hiatus succeeds the deformation of the Abrams and Salmon deposits which may only be interpreted as indicating a high stand of the land. Cambrian deposits have never been recognized in the mountain area or in adjacent regions. With the Silurian came a depression and some sediments were accumulated in areas adjacent to the mountains which at that time probably had low relief. In the Devonian the Klamath region again became a basin of deposition varying periodically in depth with occasional emergence. A thick series of shales, cherts, and limestones were laid down. Volcanic activity is attested to by the basalt flows, some of which are vesicular. In places they show signs of mineralization. To the northeast of the Preston Peak quadrangle Carboniferous shales and limestones were deposited continuously. Sediments of this age were widely deposited over the Klamath region. Toward the end of the Paleozoic with the coming of the Appalachian Revolution uplift and deformation occurred with slight concomitant regional metamorphism.

In the Preston Peak quadrangle it is believed that intrusions of hornblende diorite may have taken place at this time.

A long hiatus follows in the early Mesozoic, the Triassic and lower Jurassic. During this time interval the Klamath region was standinghigh and shed sediments to adjacent seas in north central California and central Oregon. Late in the Jurassic peripheral basins were submerged and received sediments. The Galice shales were deposited at this time in considerable thicknesses especially in the Rogue River region. Ultrabasic rocks were intruded as batholiths and dikes. Later, Dothan (Dillard or Franciscan) sandstones, shales, and cherts were deposited about the western margins. Other Jurassic sediments were deposited in the northern California geosyncline and in the central Oregon geosyncline. Considerable igneous activity took place in Dothan time as evidenced by interbedded basalt flows, rhyolitic stocks, flows, and tuffs. Following Dothan time and during the Sierra Nevadan revolution the region was again uplifted and deformed. Extensive intrusions of diorite and granodiorite took place with accompany- important mineralization. The ultrabasics were to varying degree serpentinized by hydrothermal metamorphism. General and rather intense regional metamorphism accompanied the orogeny developing the argillites of the region.

The subsequent history of the northwestern Klamath region has been one of denudation for marine sedimentation later occurred only marginally. During the early Cretaceous sediments were shed to the Knoxville seas and later to the Horsetown (lower Myrtle of Oregon) seas which surrounded the region. This continued through the Chico while a brief subsidence led to the deposition of Cretaceous outlyers on the flanks of the Klamath region. Some of these lie a few miles north of the border in Curry County, Oregon. During the late Cretaceous or possibly during the Laramide Revolution intrusions of dacite porphyry took place with attendant mineralization.

The early Tertiary found the region being uplifted and denuded. Faulting of reverse nature took place along north-south and northwest striking planes. An early Tertiary peneplain may have been formed which may possibly be recognized in the general accordance of rdiges in the interior at 5000 feet. The intrusive masses resisted erosion and became monadnocks. Whether or not an early Tertiary peneplain was developed over the whole of the Klamath area, it appears from the present study that a pepeplain (hereinbefore termed the Siskiyou peneplain) flanked the interior region by the upper Miocene. At this time subsidence of the marginal areas occurred and thin deposits of marine sands were accumulated in places. Warping occurred and near the northern limit of the Coast Ranges and the lower and middle Pliocene Wildcat beds were deposited. Differential erosion occurred in the Pliocene. A new erosion surface reaching by late Pliocene an old age stage, the Klamath oldland, was formed. This surface cut the Pliocene beds. Regional uplift occurred and inaugurated the Quaternary dissection still going on. The more recent history of the local Crescent City platform has been related elsewhere in this paper.

THE MINERAL RESOURCES OF DEL NORTE COUNTY, CALIFORNIA

John H. Maxson

Index Maps to Locations of Mineral Resources

Gold deposits	indicated	by	brown ink
Copper "	"	"	green "
Chromite "	"	"	black "
Cinnabar "	"	"	red "
Manganese "	"	"	blue "

Crescent City Quadrangle

1. Ora Anna Mine
2. Oro Pino Prospect
3. Alta Mine
4. Zoar Copper Prospect
5. Tyson Rowdy Creek Mine
6. Zoar Chrome Prospect

Northwest Quarter Preston Peak Quadrangle

7. French Hill Mine
8. Haines Flat Mine
9. Hard Luck Prospect
10. Summit Claim
11. Monumental Mine
12. Higgins Prospect
13. Anderson Prospect
14. Britten Prospect
15. Scoville Prospect
16. Cleopatra Mine
17. Tyson Chrome
18. Gordon Mt.Group
19. High Plateau #8
20. Sunny Brook Prosp.
21. Big Boy Prospect
22. Black Beauty Prospect

Northeast Quarter Preston Peak Quadrangle

23. Preston Peak Prospect
24. Bear Mt. Claims
25. Chicago Camp
26. The Chromite Prospect
27. Doe Creek Prospect
28. White Feather Prospect

Figure 95 Index to mineral deposits of Crescent City Quadrangle

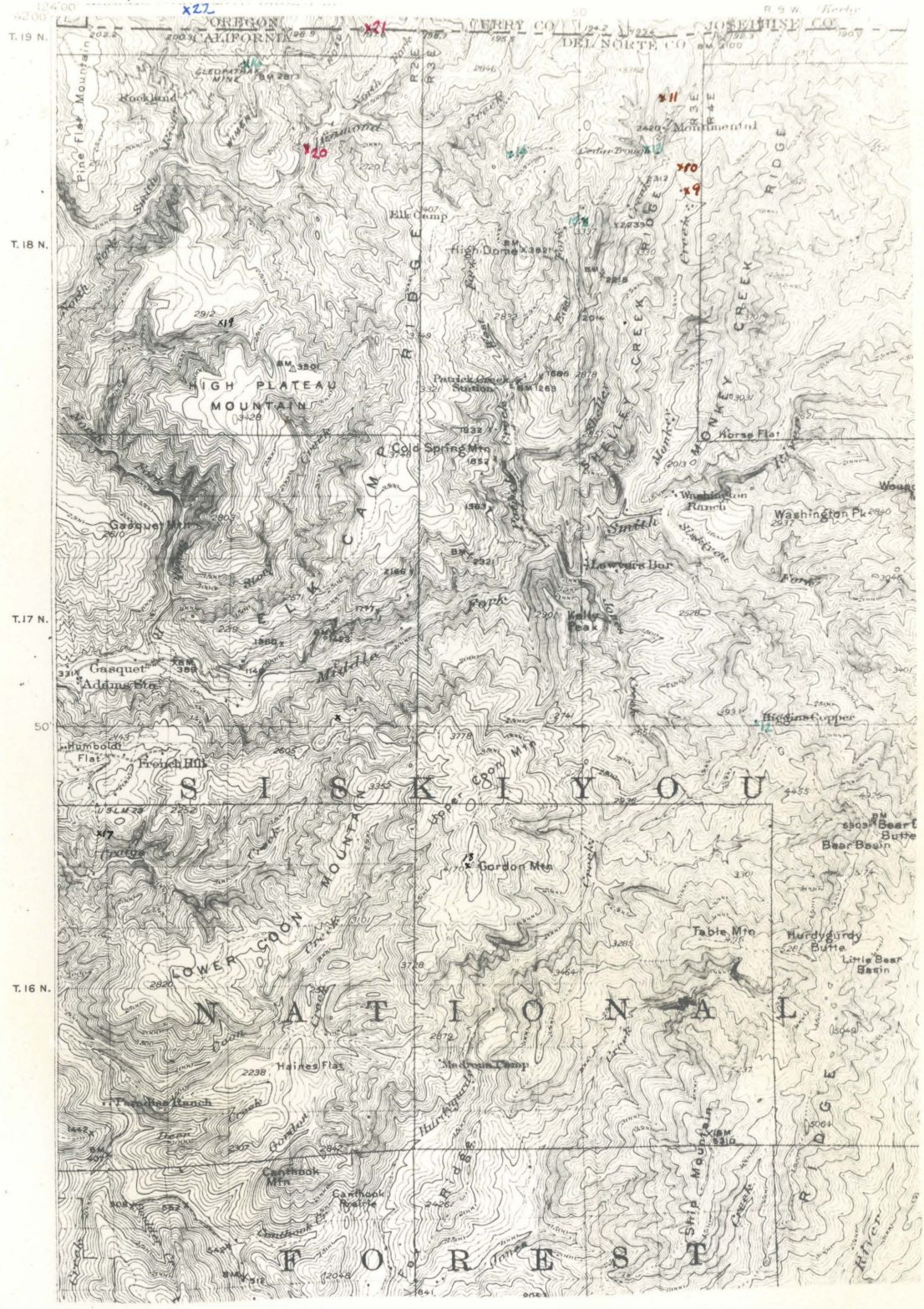

Figure 96 Index to mineral deposits of northwest quarter of Preston Peak Quadrangle

PRESTON PEAK QUADRANGLE
R. 8 W.
R. 5 E.
R. 6 E.
T. 19 N.
T. 18 N.
T. 17 N.
T. 16 N.
BOUNDARY LINE
Little Grayback
Poker Flat
Haystack
Sanger Pk
Lookout Mtn
Twin Valley
Washington Pk
Wounded Knee Mtn
Broken Rib Mtn
El Capitan
Copper Pk
Twin Peaks
Rattlesnake Meadow
Preston Pk
Doe Flat
Bear Basin Butte
Bear Basin
Bear Mtn
Hurdygurdy Butte
Little Bear Basin
Island Lake
Little Bear
(Kerby)
(Seiad)

Mineral Resources

Advance Summary

The mineral resources of the northwestern Klamath Mountains are of various kinds. In the Preston Peak and Crescent City Quadrangles, although many deposits are known, there are at present no producing mines. The deposits are not as a rule of high grade nor are they large. These facts, added to the inaccessibility of this region and high cost of transportation, are responsible for the failure to exploit them.

From time to time mining activity has been stimulated by high prices for metals and a number of deposits have been exploited for short periods. The first such occasion was in 1863 when copper ore was discovered at Low Divide and some shipments were made via Crescent City and the ocean. Sporadic prospecting and development work continued for some time later. In 1918 the great demand for metals for war use led to the maximum expansion of mining activity. The mineral most actively sought was chromite because chromium was needed for hardening steel. Del Norte County was the largest producer of chromite in the northwest. Some 7,903 tons was shipped and 4,345 additional tons was mined but not shipped.

Chromite which is widely scattered in the serpentine and metaperidotite of Del Norte County is one of the most important of the mineral resources. Copper sulfides are locally concentrated in such quantity as to have encouraged extensive prospecting. Gold has yielded the largest total revenue. The great period of production from placers has now passed and insignificant amounts of gold are now produced. The placer gold has come from stream gravels of the present cycle, terrace gravels, Klamath oldland gravels, and beach sands. Amounts derived from the latter source are negligible. Some gold quartz lodes occur but they have been on

the whole disappointing.

Although unimportant in the past some cinnabar deposits are being actively investigated and give promise of future development. Such development will be stimulated not only by current high market value of quicksilver but also by the fact that it can be dsitilled on the spot thus eliminating excessive transportation charges.

The occurrence of a number of other minerals may be noted including platinum, osmiridium and awaruite in the placer sands, manganese minerals, talc, Maoric jade, limestone, etc. Brick clay is found near Crescent City. In recent years the value of the rock quarried for use in the breakwater at the Crescent City harbor has far exceeded that of the mineral production.

Gold

History

The very earliest history of the Klamath country is intimately connected with the search for gold. The region was first penetrated in 1849 by gold seekers. Settlements were started along the Trinity and Klamath Rivers and the placers yielded a large amount of gold. About this time some sailors deserted their ship near Paragon Bay (now Crescent Bay) and made their way overland to the Illinois River valley. Here they started placer workings which came to be known as Sailor Diggins, later Waldo. Waldo became the seat of Josephine County, Oregon, and was a flourishing mining town.

Groups of prospectors were scouring the Siskiyou Mountains in the 50's. Crescent City was built in 1853 and became the center of activities in the northwestern Klamath Mountains. Chronicles of these days record the hardships encountered and the troubles with the Indians. Soldiers who had fought the Rogue Indian War in 1855 helped to build the McGrew Road from Crescent City to Sailor Diggins. Throughout the last half of the nineteenth century efforts were made to exploit auriferous gravels of Del Norte County

with only moderate success. Sporadic attempts are still being made.

Stream Placers

Present Cycle

None of the gravel deposits of the present cycle is being worked steadily. Practically all of the bars of present streams have, however, been prospected or worked in the past. The Smith River was worked in the early days but very little was obtained from the north and middle forks. The south fork was rich in places, particularly near the mouth of the creeks. Productive properties were located on Myrtle Creek, Craig's Creek, Patrick's Creek, Siskiyou Fork of the Smith River, and Monkey Creek. Most of these properties were worked by one or two small giants during the winter months. The gravel benches of the Monkey Creek Mine were formerly ground-sluiced by water taken from Monkey Creek 1½ miles above.

Throughout the drainage system there are accumulations of black sand. The heavy oxides of iron and chromium were abundantly furnished by the large areas of basic rocks. In addition to gold some of the sand contains platinum. At Antone Kauss' mine on Craig's Creek pieces of coarse platinum worth up to $25 have been found. Diamonds have also been found in the black sands of the Smith River.

Terrace Gravels

Work was started in 1878 on Big Flat by the Big Flat Mining Co. or the "Boston Company." The property had a large gold production but is now exhausted.

Auriferous Gravels of the Oldland Cycle

French Hill Mine

The French Hill Mine is one of the oldest placer properties in the county. Work was started by the Siskiyou Mining Co. in 1860. Water was obtained from the headwaters of Craig's Creek through a large ditch called the Siskiyou Ditch. Insufficient water supply proved to be a heavy handicap. For a long period before acquisition by the present owners the property was owned by Jack Darnell. It is at present owned by the French Hill Mining and Milling Co.

A newly constructed ditch to Craig's Creek is expected to provide ample water during the winter for operating two or three giants. The gravels lie in a shallow valley on the French Hill remnant of the Klamath oldland. The deposit is about 1½ miles long, 300 feet wide and 30 feet in thickness. The pebbles and bowlders in the gravels are largely of serpentine and diorite and range from 4 inches to 2 feet in diameter. The average is about 10 inches.

The black sand is richest along the dacite bedrock and is irregularly distributed in a way characteristic of stream deposits. The gold is coarse and is associated with platinum. During former operations platinum formed 5% of the total value of the output.

Haines Flat Mine

Work was carried on at Haines Flat in 1877, but, according to reports, mining was never profitable. A large flume and ditch carried water from Gordon Creek to the flat. The Klamath oldland remnant has the gravels preserved in a shallow, southward-sloping valley. The deposits are extensive and reach in places 35 feet in thickness. On the whole they are much finer than those at French Hill. A large cabin was built in the workings with accommodations for a large staff. It is now disintegrating. Several

years ago attempts were made to ground sluice some of the gravels with unsatisfactory results. No information could be gained regarding the character of the gold.

Other Oldland Placers

A number of other gravel accumulations of the Klamath oldland remain on certain remnants. A large area of gravel is said to exist on Rattlesnake Mountain but the occurrence was not visited. Interesting deposits occur in Josephine County, Oregon, just north of the state boundary of California and south of Waldo. The Osgood or High Gravel Mine has been operated rather regularly over a long period and has produced large amounts of gold. The gravels resemble those at French Hill and rest on a weathered and eroded greenstone basement. They were considered Cretaceous shoreline deposits by J. S. Diller but they appear to the writer to be correlated with the other late Pliocene oldland accumulations.

Beach Placers

The beach sands of the Crescent City platform like those of Curry County in Oregon to the north contain large amounts of black sand and considerable values in gold and platinum. A concern known as the Oro Del Norte Co. erected a plant two miles south of Crescent City in 1913 and attempted an electromagnetic concentration. The plant was built near the beach and was supplied by a suction pipe and conveyor. The sand was passed to a revolving screen, water was added and the sand and water passed over several plates, the first being large aluminum plates with riffles, the second being small aluminum plates with riffles, and the third a metal plate of unknown composition. An alternating current was passed through the plates and the black sands were supposed to be repelled leaving the

gold and platinum. The enterprise failed and no traces of the plant are left.

Small quantities of gold and platinum have been obtained with rockers on Pebble Beach. When the Crescent City breakwater was being constructed it is reported that black sand accumulations in fissures along the bedrock carried fine gold in fair amounts.

Gold Lodes

Hard Luck Mine

The Hard Luck Mine consists of six claims on upper Monkey Creek. Two tunnels were driven on the leached outcrop of a quartz vein. The vein carries arsenopyrite and some gold.

Summit Claim

The Summit Claim on the divide between Shelley Creek and Monkey Creek east of Baker Flat (formerly site of Shelley Creek Station). Staked by E. A. McPherson and F. A. Sanford.

Monumental Consolidated Quartz Mine

The Monumental Mine was developed by Col. Draper. It consists of eight claims northwest of the old settlement of Monumental on Shelley Creek. They were patented in 1916 and the present owner is the Gunn and Davis Estates. E. A. McPherson of Grants Pass is the local agent. The mine was worked until 1905 and maintained until 1910 after which water was allowed to fill the workings. Plans are under way to pump the mine dry and resurvey it.

The veins are associated with the east-west striking contacts of Shelley slate and dacite porphyry. This contact dips 70° south. A hoist was built over the hanging wall and the shaft passes into the igneous foot wall at a depth of 70 feet. There are a number of levels with drifts at 40 feet, 100 feet, and 120 feet. The ore was stoped out along the drifts,

hoisted, transferred to mule carts and hauled one-half mile down the hill to the mill which is located on the old Gasquet stage road. A large camp was located here.

The ore is soft and leached near the surface but passes into a hard arsenopyrite ore with depth. The gold in the quartz vein is associated with specular iron, arsenopyrite, and some copper minerals. The ore is said to average $40 per ton with the high grade ore varying from $100-120 per ton.

Ora Anna Mine

The Ora Anna Mine is one of the older mines of Del Norte County. It consists of one patented and three unpatented claims on the east side of Bald Hill at an elevation of 1400 feet. There are two parallel veins between a slate hanging wall and a diorite wall. The veins average 6 feet in width, striking east-west and dipping 45° north. They are reached by a tunnel 300 feet long. The ore consists of free gold, arsenopyrite, and other sulfides. The property has been idle since 1897.

Oro Pino Prospect

The Oro Pino Prospect is owned by T. S. Stevens. An inclined shaft has been sunk 75 feet on a quartz vein in decomposed pyroxene diorite. The vein strikes north 46° east and dips north 53°. The gold is fine and flaky. It occurs in pockets in the vein, associated with are pyrite, manganite, and limonite.

Copper

History

Copper was discovered in the Low Divide District in 1853. Mines were developed in 1860 and shipments of ore were made to Swanson and Germany. This ore brought $41 to $102 per ton. Between 1860 and 1863 some 2000 tons

were shipped from the Alta and Union Mines. After 1870 the district deteriorated. During the heyday of mining activity a typical mining camp of several hundred inhabitants existed at Altaville. This site is now known only as Low Divide and there are scarcely any vestiges of the former village. Frank Zoar, an old-time miner, is the only inhabitant.

In the later 19th century there was considerable activity in prospecting numerous other deposits in Del Norte and Siskiyou counties.

General Nature and Occurrence of the Copper Deposits

The most characteristic mineral of the copper ores of northwesternmost California is chalcopyrite. Pyrite and pyrrhotite are also present. Supergene sulfides are of minor importance as are the oxidized copper minerals. The zones of oxidation and enrichment are relatively shallow. Long continued erosion has been in part responsible. Heavy annual rainfall keeps the water table close to the surface. The ore deposits are frequently in serpentine or near the contact of serpentine and diorite. In the Preston Peak Quadrangle the diorite concerned is usually the Preston hornblende diorite. The latter is older than the serpentine. The veins themselves antedate serpentinization for they are extensively brecciated and fragments of ore are commonly coated with serpentine. The major deposits are related to the Punchbowl diorite and its correlatives among the Sierra Nevadan intrusives. In Del Norte County the (late Cretaceous) High Dome dacite porphyry is responsible for some small deposits.

The pyrite-chalcopyrite deposits of Shasta County, California, which have been large producers are found in the Devono-Carboniferous-Metamorphic series and are related to an alaskite porphyry and quartz diorite. The latter is presumably the equivalent of the granodiorite of the Sierra Nevada.

To the northwest in Siskiyou County, California, and Josephine County, Oregon, are a number of deposits which may be grouped in three north-south belts. The easternmost one contains the Blue Ledge Mine near the middle fork of the Applegate River in California and several prospects on Squaw Creek in Oregon. The ore occurs in a vein averaging five feet in width increasing to 40 feet in places. The country rock is a micaceous schist. The chalcopyrite-pyrite ore is said to average 6% copper and $5 in gold per ton. 250,000 tons are reported to be blocked out.

The second belt is represented in the Grey Eagle Mine near Indian Creek, five miles north of Happy Camp, Calif. According to the "Mines Handbook" of 1926 the mine is located on a flat dipping lode varying from 10 to 80 feet in width. The underground development is extensive. Reserves of 1,045,000 tons of ore averaging 3.23% copper and 40¢ in gold are reported.

The third belt is of immediate interest to this discussion and reaches from Preston Peak north into Oregon. The deposits in California will be described in detail. Those in Oregon near Takilma, which have been active producers, have been described by G.F.Kay[1]. During the summer of 1930 a detailed examination of them was made by P.J.Shenon of the United States Geological Survey, in connection with a general survey of mineral resources in southwestern Oregon. The results of this study have not been published yet.

The Queen of Bronze Mine at Takilma is located on scattered ore bodies in serpentine and along contacts with diorite. The ores of the nearby Cowboy Mine are similar in the general mode of occurrence. In the Queen of Bronze Mine the largest body mine contained about 10,000 tons. The oxidized zone is less than 90 feet deep. The primary ore contains

[1]Diller & Kay, U.S.G.S. Bull. 380:76 (1909)

chalcopyrite, pyrite, pyrrhotite, quartz, and calcite. The ore averages 8½% copper with $3 in gold and 17¢ in silver to the ton. The ore is transported to Tacoma for smelting. Drop in the price of copper led to closing in 1930. The reported total production is about $1,500,000.

Description of Deposits

Preston Peak Mine

The Preston Peak Mine consists of five patented claims on the north slope of Copper Peak and adjacent to Preston Peak. It is reported to be owned by W.T.Thompson and Edgar L. Wallace of Los Angeles. The deposit was one of the pioneer discoveries in the region. It was opened up and considerable underground work was done in 1899 by the Preston Peak Mining Co. Since 1900, the mine has been idle, cabins built in Indian Creek Valley have fallen in ruins, and the shafts have filled with water.

Mr. K. J. Khoeery of Takilma who had visited the workings gave information regarding the development. The main tunnel was driven southerly in the diorite some 405 feet. At 250 feet this crosscut an 8 ft. vein of chalcopyrite ore averaging 16% copper and $2 in gold per ton. Here a winze was sunk 40 feet and at this depth the mineralized zone was 40 feet in width. A 30 ft. drift driven to the west of this ore body disclosed another vein 12 feet thick containing the oxidized copper minerals.

The mine is reported to contain a large quantity of ore and conditions appear favorable for persistence of the ore in depth. Exploitation of this promising deposit will probably not take place in the immediate future because of its isolation. It can be reached only by trail and is in the center of a rugged area.

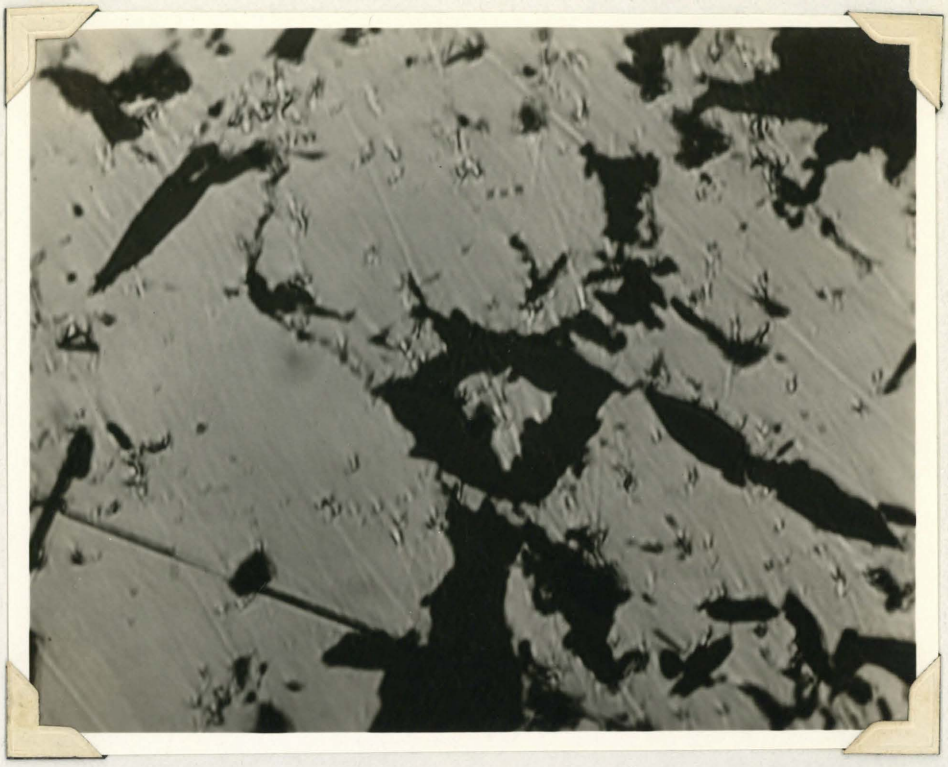

Figure 98 Photomicrograph of "ore" from the Preston Peak Mine showing residual of chalcopyrite in chalcocite. Groundmass chalcopyrite. x500

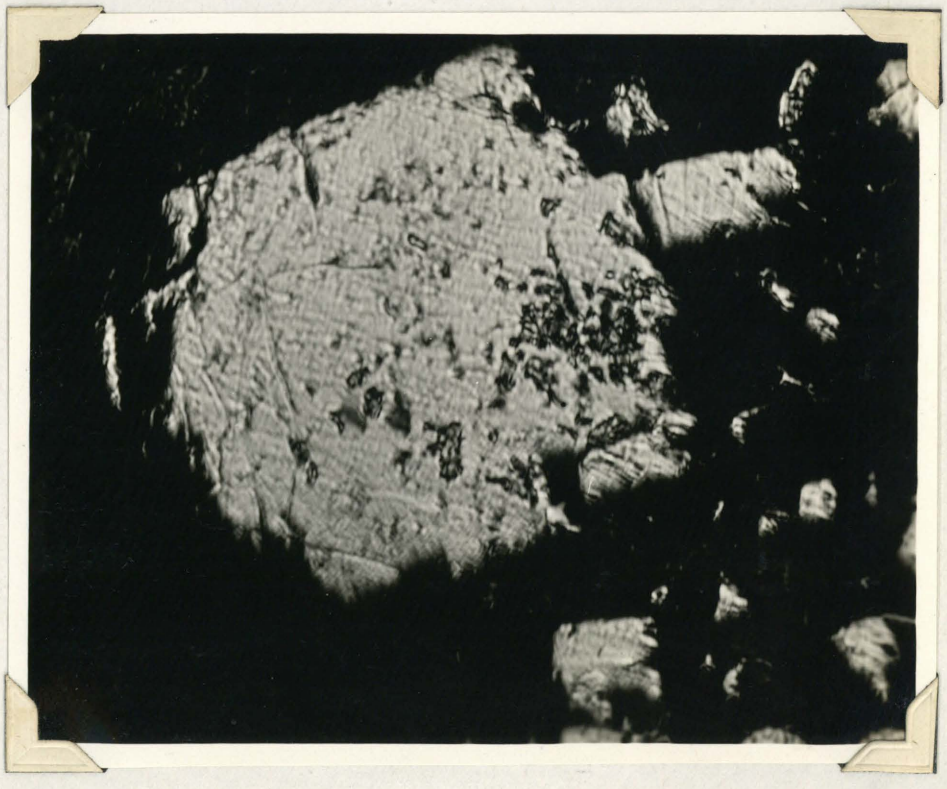

Figure 99 Photomicrograph of pyrite crystal in dacite porphyry from Hiouchi Bridge. x150

Bear Mountain Prospects

Several copper prospects are located on Bear Mountain near the Devil's Punchbowl. They were located by Fred Nelson, now deceased, who lived at Trout Camp. Nelson's Prospect on the north slope of Bear Mountain is located at the contact of serpentine and Salmon hornblende schist. A tunnel 20 feet long driven south into the ridge has disclosed no trace of ore. The serpentine is rather generally out by stringers and veins of asbestos, as shown in the accompanying figure, but these appear to have no economic importance. The back of the tunnel discloses some lenticular dikes of altered aplite related to the Punchbowl formation.

Chicago Camp

The Chicago Camp (also known as the Del Norte Camp) is located near Wiskey Lake about ¼ mile east of Sanger Peak. Some 178 claims were staked by a Chicago association of claim-holders. An extensive program of development was carried on in 1917 and 1918. Five miles of road were built south of Waldo, Oregon, the whole route of about 10 miles was surveyed, and the stumps were blasted along the route for two miles north of the camp. The proposed grade of the road would not have exceeded 5%. Cabins, laboratories, and power equipment were installed on the site of the deposits. In conjunction with the claim holders association a large sanatarium was begun at Waldo. At the end of the war with drop in prive of copper and shortage in funds the exploration ceased. A year later all interests were relinquished by the Chicago group. Most of the claims including the office building are now held by K. J. Khoeery. Waldo itself is deserted and largely in ruins.

The copper deposits of the district do not make an impressive surface showing. Several tunnels have been driven on veins in various parts of the property and some low grade chalcocite-pyrite ore has been removed. It is reported that a magnetic survey and diamond drilling revealed a very large

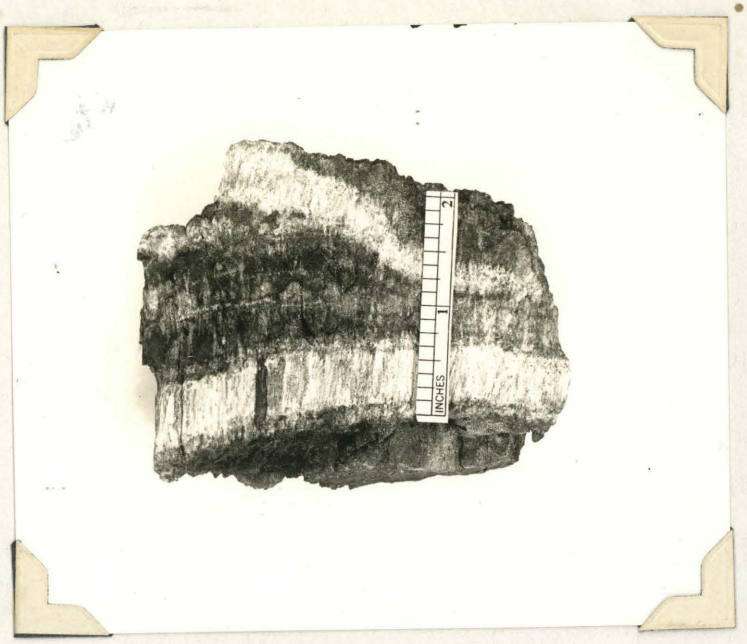

Figure 100 Asbestos veins in serpentine from the Nelson Prospect on Bear Mountain

Figure 101 Chalcopyrite bearing quartz vein from Scoville Prospect on Patricks Creek

ore body at a depth of 300 feet. As in the other deposits of the region serpentine and diorite are the country rock.

Higgins Copper Group

The group consists of five claims on the east slope of Higgins Mountain. They are on the Siskiyou Fork of the Smith River five miles south of its mouth. A few open cuts have been made on the oxidized outcrops of veins in serpentine.

Anderson Prospect

This is located one-half mile east of Baker Flat (site of old Shelley Creek Stage Station) and one mile northwest of Anderson's Ranch on Shelley Creek. The veins contain some Chalcopyrite and pyrite and occur along the contact of the High Dome dacite porphyry and the Shelley slates. Four short tunnels have been driven.

Britten Prospect

The Britten Prospect is about a mile and a half north of High Dome on upper Diamond Creek. The ore bearing veins are in schist and are associated with some diorite. A shaft 60 feet deep and a drift of 35 feet disclosed a 9 foot vein.

Scoville Prospect

This prospect is located on the east side of Patricks Creek about a mile and a half northeast of the old Patricks Creek station. Two tunnels have been driven east into the ridge on veins in the High Dome dacite porphyry. The ore consists of chalcopyrite in quartz.

French Hill Prospect

An open cut a short distance west of the French Hill Placer Mine has

disclosed a deposit of pyrite and chalcopyrite in the High Dome dacite porphyry. Pyrite crystals are commonly found in outcrops of this formation as at Hiouchi Bridge. It is believed to be genetically related to the last four occurrences described.

The Cleopatra Mine

This copper deposit is located north of Diamond Creek and just south of the Oregon line in Sections 3 and 4, R 2 E, T 18 N. It is one of the older mines of the region having been opened by an English company in the 60's. Ore was then packed by mule to the old McGrew Road. After its abandonment it passed through a succession of hands. More money was invested without return. The seven claims are now held by Paul Dressle of Grants Pass.

Several veins, that run from one to two feet wide, have been followed in by several hundred feet of underground workings. The veins are in serpentine and are apparently associated with dikes and stocks of Madrone diorite. The ore observed was of low grade pyritic character. No considerable ore body is believed to be present.

The Low Divide District

Alta Mine

The Alta Mine was one of the earliest developed in Del Norte County. It has been abandoned for many years. A dump is the only marker of the site where formerly between 1860 and 1870 was located a stream hoist, air compressor, mine buildings, shafts, etc. In these days there was an incline 455 feet deep with four levels and over 1000 feet of drifts. There was also an adit drift reaching the incline from the gulch. A second vein was opened by a winze below this drift. The Union Mine, located on the northward extension of the Alta vein, has very extensive underground workings. The ore carried from 10 to 18% of copper.

The mines are in serpentine on a vein which runs north and south along the ridge east of Copper Creek. It dips east 40 to 60 degrees. The principal minerals of the ore are pyrite, chalcopyrite, bornite, and pyrrhotite. Locally there is some supergene enrichment and chalcocite is present.

Zoar Prospect

To the northwest of his cabin at Low Divide Frank Zoar has several claims. These lie near the head of Copper Creek on the ridge to the east. Several prospecting tunnels have been driven through the vein. The ore is soft and shows supergene alteration. Chalcopyrite seems to make up the mass of the ore with some sooty chalcocite. Samples are reported to run 18% copper.

Chromite

History of Chromite Mining

Chromite was found in the country back of Crescent City before the Civil War. It was brought to the Attention of the Tysons in Baltimore who had been mining chromite in Maryland since about 1838. They acquired property on French Hill and at Low Divide. From 1869-1873, about 1500 tons of ore were shipped annually from Crescent City aroumd the Horn to Baltimore. When imported chromite from Greece and Asia Minor reached the United States the mines were shut down. There was no further activity until after the World War had begun. Imports from New Caledonia, the principal producer, were practically cut off. After the entrance of the United States into the war the government encouraged the exploitation of native deposits. Large amounts of chromite were mined and shipped. Then the prices broke because of importation of several shiploads of ore from New Caledonia. Chrome mining was demoralized. When the end of the war came a large amount of chromite remained in depots where it may be found today. Operators were partially recompensed for their loss by the government. Since 1918 there has been no activity. Prospects for future activity are not good in view of smallness of deposits, lack of adequate transportation, and cheap sources of supply from Rhodesia and New Caledonia.

Occurrence of the Ore

The chromite deposits investigated by the writer are all in serpentine or metaperidotite. None were observed in unaltered rocks although such occurrences have been noted.[1] The association with ultrabasic rocks, however, appears to be universal. Serpentine is widely distributed in the Preston Peak and Crescent City Quadrangles and wherever it is present chromite is likely to be found. Chromite prospects are scattered over the broad belt of serpentine of the Klamath oldland and in the serpentine stocks of the Siskiyou upland.

The ore bodies themselves are generally more or less tabular in form. They are in reality flat lenses. Although cases of gradational contacts with the country rock are known, the lenses studied in Preston Peak and Crescent City Quadrangles have sharply defined boundaries. The bounding surfaces are frequently slickensided.

Figure 102 Glaciated outcrop of chromite lens in valley of Doe Creek. Note sharpness of contact with the lighter serpentine.

[1]Vogt, zeit. f. prakt. Geol. Jahrgang 1894:384-393

Nature of the Ore

Minerals

The principal ore mineral is chromite whose formula is $FeO \cdot Cr_2O_3$, representing 68% chromic oxide and 32% ferrous oxide. The iron may be replaced by magnesium and the chromium by aluminum and ferric iron. In this way a gradation may be observed from spinel, $MgO \cdot Al_2O_3$, through picotite, $(MgFe)O \cdot (AlCr)_2O_3$ to the chromite. Chromite is coal black in a hand specimen. In thin section it is reddish brown. The streak is brown and hardness is 5.5.

Picotite, the chrome spinel, varies in color from yellowish brown to greenish brown. It has not been identified in Del Norte County ores by the writer. The chrome garnet, uvarovite ($3CaO \cdot (AlCr)_2O_3 \cdot 3SiO_2$), occurs sparsely along the joint planes of the chromite. The green euhedral crystals of uvarovite are usually very small, rarely exceeding a millimeter in diameter. Another silicate, the chrome clorite known as kammerite or kotschubeite ($4H_2O \cdot 5MgO \cdot (AlCr)_2O_3 \cdot 3SiO_2$), is occasionally found in cavities and along joints. It is a pink mineral of micaceous habit.

Structure

The chromite ores are structurally divisible into four types, (1) even-granular ores, (2) disseminated ores, (3) nodular ores, (4) banded ores.

Even-granular structure. This is the common structure of the chrome ore. The chromite crystals are relatively uniform in size. They rarely exceed two millimeters in diameter in the coarsest ore and in the finer types the chromite individuals may be less than 5 mm. in diameter. In the most profitable bodies the ore consists largely of closely packed hypidiomorphic chromite grains with minor interstitial olivene, pyroxene, or serpentine minerals. In the coarser and lower grade ores the mineral grains are frequent-

Figure 103 Banded chromite and serpentine from Tyson High Divide Mine. Note displacement of the bands.

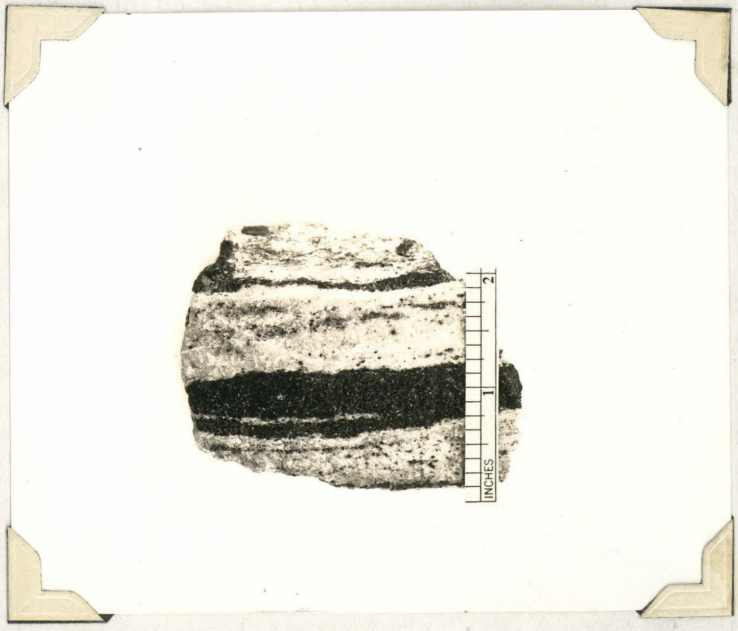

Figure 104 Banded ore from The Chromite Prospect, Copper Peak, showing relation of chromite individuals to groundmass. Believed by the writer to be a primary structure.

ly loosened making the material very friable.

Disseminated structure. In this type of ore the chromite grains are euhedral and are scattered in a matrix of serpentine. Portions of the Tyson deposit on French Hill were composed of octrehedra or near-octrahedra of chromite in light green serpentine, each forming about 50% of the total. The chromite was evidently the first-formed mineral.

Nodular structure. This structure has been noted by Diller in ore from Brush Creek, a tributary to Briggs Creek, Josephine County, Oregon. The nodules according to Diller range from one-tenth to three-fourths of an inch in diameter and may be either spherical or ellipsoidal in form. The lentils are usually parallel in orientation. The nodules of chromite are surrounded by the altered primary silicates (olivine and pyroxene). Veins of serpentine cut the nodules indicating their prior formation. The nodules in ore from the Placer Chrome Mine of Eldorado County California are cut by veins of serpentine derived from tremolite which was in turn derived from pyroxene.

Banded structure. Chromite commonly occurs in more or less parallel layers which may vary from 5 or 6 cm. in thickness down to about a millimeter. At first sight the black bands of chromite appear to stand our sharply from the lighter colored alternate layers. It is seen, however, that the bands are not persistent in many cases. The intervening material may be the original olivene and pyroxene or various minerals derived from them. Serpentine minerals, antigorite, penninite, clinochlorite, and chrysotilite, are most common. Magnesite is sometimes present. On close investigation it is seen that the contact is not sharp. Chromite crystals along the margin are interlocked with the serpentine minerals. While chromite is concentrated in the bands secondary minerals are found in interstices and in the bands of secondary minerals themselves occur scattered chromite crystals. These

scattered individuals usually show alignment.

Widely differing views are held as to the origin of this banding. Vogt[1] illustrates a number of banded chromite ores from Norway and ascribes their formation to the magmatic period. The basis for regarding bands as a flow phenomenon rests in the precedence of chromite in crystallization and its separation before the congealing of the magma. The transecting bands which he mentions are more difficult of explanation and, of course, were found later. Grout[2] through his studies of the Duluth Gabbro rejects many previous ideas of banding of igneous rocks, namely, 1. partial assimilation of inclusions, 2. lit par lit or fluidal gneiss, 3. deformation during solidification, 4. deformation just after solidification, 5. streaked differentiation, with reference to rhythmic cooling or intrusive action, 6. successive intrusions, 7. heterogeneous intrusions. After noting parallelism of banding to boundaries and contacts he ascribes banding to convection during crystallization.

Diller[3] in connection with the banded ores of the Hamburg region, Siskiyou County, California, noted parallelism with adjacent gneissic structures and believed the conditions operating to produce the latter also produced the former. Recently Rogers[4] has attempted to explain the structure as a replacement phenomenon during a late magmatic stage.

A careful investigation by Fisher[5] has shown that chromite is not only developed as a primary mineral but also as a secondary mineral during the hydrothermal period. However, in the case of the ores studied chromite was not found as a pseudomorph after any of the silicates. Other criteria of replacement could not be established. The typically banded ores of Del

[1]Vogt, J.H.L., Zeitschr. prakt. Geol. 381-399 (1894)
[2]Grout
[3]Diller, J.S., U.S.G.S. Bull. 725A, p. 18 (1921)
[4]Rogers, A.F., 30th Ann. Meeting G.S.A. Cordilleran Section
[5]Fisher, L.W., Econ. Geol. 24:691 (1929)

Norte County, appear to be a manifestation of flow structure. Cross veining noted in some deposits, particularly the Zoar prospect at Low Divide seems to be associated with the period of serpentinization. It is suggested that hydrothermal solutions of this period did not dissolve the chromite itself but carried with them distinct crystals which were left in the fissures. The serpentine of the fissure veins shows no remnants of primary silicate structure found in fissure walls and is believed to have been introduced. While there appears to be some crustification of the serpentine itself the chromite grains are irregularly distributed.

Origin of the Chromite

Chromite is generally recognized as a product of magmatic segregation. In this respect it is related to magnetite which also occurs in segregations. Vogt has established the igneous origin of chromite deposits in Norway. Diller regarded the deposits of the Klamath Mountains as products of magmatic segregation or the crystallization differentiation of Bowen. All the great chromite deposits of the world are found in serpentine. Those of Asia Minor, New Caledonia, and southern Rhodesia are in this rock. Those of Maryland, North Carolina, California and Oregon are similar though smaller. Occasional association of peridotite pyroxemite or dunite indicate the original chemical and mineral composition of the magma from which the chromite was derived.

Of late doubt has been cast on the igneous origin of chromite. Sampson[1] has suggested the possibility of the serpentinization and introduction of chromite being coincident because of association with hydrothermal minerals. As has been mentioned in connection with banding the writer recognizes movement of chromite and filling of fissures during the hydrothermal stage. He regards the amounts so transported and deposited as negligible in comparison with the primary ore. The early crystallization of the chromite of the

[1]Sampson, E., Econ. Geol. 24:632 (1929)

Figure 105 Photomicrograph of thin section #103, banded chromite, crossed nicols, x50. A chromite band in matrix of serpentine minerals.

Figure 106 Photomicrograph of thin section #104, chromite-serpentine contact, plane polarized light, x50. Shwoing brecciation of chromite crystals.

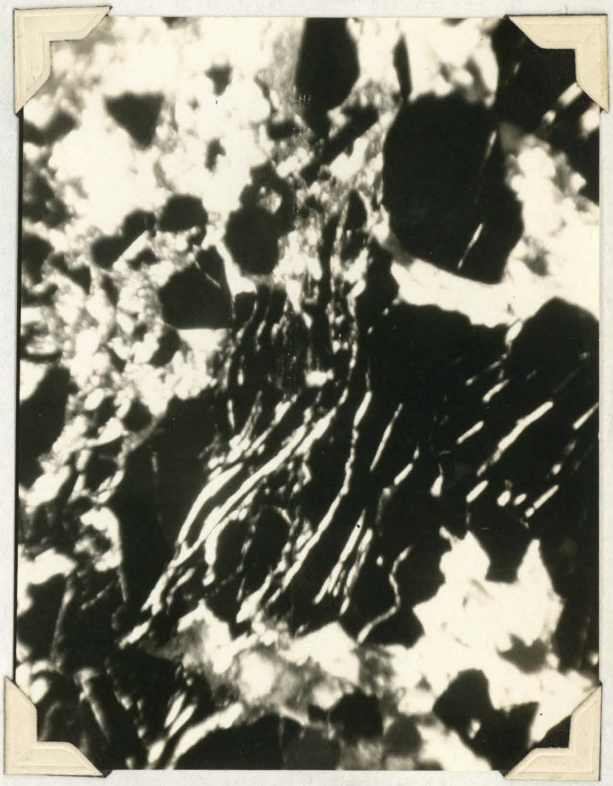

Figure 107 Same as figure 106 with crossed nicols. Showing matrix of serpentine minerals.

Klamath deposits has been shown by Diller. In the Castle Crag Mine near Dunsmuir, California, the chromite in places is in direct contact with pyroxenite, dunite, and saxonite. The marginal portions of the chromite were poikolitic with minute serpentine inclusions, the serpentine having been derived from the primary silicates. Thin sections of ores from the Chromite Prospect on Copper Peak north of Preston Peak show penetration of the chromite along fractures by antigorite. Parallel with the contact with the serpentine the chromite crystals are cut by fine, multiple, parallel fractures. The pre-existent chromite lens was thus fractured along its margins by movements during serpentinization resulting from hydration and expansion.

A clear and convincing account of the origin of chromite has been given by Fisher.[1] His conclusions are that there are three periods of chromite deposition which may be stated as follows:

1. Early magmatic chromite, crystallization of chromite well advanced before crystallization of silicates but some overlap.
2. Late magmatic chromite, chromite replaces, surrounds, embays, and cuts cleavable minerals. This exists in largest quantity.
3. Chromite of hydrothermal period, early associated minerals, anthophyllite, actinolite, tremolite, later minerals, chlorite, talc, kammerite, penninite, magnesite.

Studies of Del Norte County chromite deposits give substantially concordant evidence. It is to be emphasized, however, that chromite of the early magmatic period is very important in developing the lenticular accumulations through crystal settling. The Del Norte County chromite deposits are believed to have formed before the congealing of the ultrabasic magma.

[1]Fisher, L.W., Econ. Geol. 24:691 (1929)

Description of Deposits

The Chromite Prospect

This prospect is located on the northeast slope of Copper Peak about ½ mile west of Cyclone Gap. It has been held by A. C. Hoofer and George Elder. Some chromite has been mined but none has been shipped.

The deposit is a north-south directed lens in serpentine country rock. The lens is about 40 feet thick and unknown length and depth. It is probably at least 100 feet long while a test shaft shows it to be over 20 feet in depth. In addition to the test shaft there are two tunnels about 20 feet long.

Most of the ore is massive of the even-granular structure although some banded ore exists near the contact. The chromite is frequently veined with chrysotilite and in places is coated with serpentine. Brecciation is general.

Doe Creek Prospect

This is a northwest-southeast striking lens in serpentine located on Doe Creek at an elevation of 3400 feet. No exploration or development has been done. The prospect is held by Homer White and Jim Hogue. The lens is about 10 feet thick, 50 feet long, and of unknown depth. It is shown in figure .

White Feather Prospect

This prospect is located on the ridge east of Young's Peak. It is a lens in metaperidotite which on the surface appears small. No development save a small open cut has been done. The chromite appears to be high grade. The prospect has been held by A. C. Hoofer and George Elder.

The White Feather and the two previously described prospects are unfavorably situated with respect to transportation. Ore would have to be

carried by pack train for about 12 miles. This feature will undoubtedly prevent development for many years.

The Gordon Mountain Group

The group of chromite deposits on and about Gordon Mountain were operated by the California Chrome Company during the War. Much preliminary labor was required to render them accessible. The road was extended from French Hill some six or seven miles to Gordon Mountain. Since the abandonment of the deposits, the U. S. Forest Service has extended this road south to Big Flat.

The group consists of five deposits, the Zinc Saddle, No. 7, No. 8, Rowen, and the Madrone. To the wouthwest of the highest point on Gordon Mountain a short distance is a chromite lens in serpentine. Most of the body appears to be buried and comparatively little worked by open cut. The shaft is filled with water to within 30 feet of the surface.

Another chromite lens in serpentine occurs on the slope north of the gap between French Hill and Coon Mountain. This lens strikes northwest-southeast and varies in breadth from 10 feet on upper slope to 20 feet lower down. The ore was high grade but relatively small in amount, much of the body having been eroded away. Some of the ore contained admixture of serpentine.

The French Hill Mine

This mine was one of the first located on Del Norte chromite. It is owned by the Tyson Mining Company of Baltimore, Maryland. The mine is located on the southern margin of French Hill at an elevation of 1700 feet.

The ore lens strikes northwest-southeast and plunges south beneath the hill slope. It lies in the serpentine at the contact with micaceous schist on the east. This schist strikes north and south and dips about 30

Figure 108 Workings on chromite lens on Low Plateau looking northwesterly along strike. Body bounded sharply by joint planes.

Figure 109 Lens in place between north dipping joint planes. Low grade friable ore along basal portion to left. High grade ore along narrow zone near top wall.

degrees E. The serpentine is extraordinarily brecciated and contains scattered small pieces of chromite. Much of the ore is of even granular structure but near the northwest part of the deposits a low-grade disseminated ore appears. This ore consists of euhedral chromite individuals in a matrix of serpentine.

The ore was mined from a glory hole about 50 feet in diameter and removed through two tunnels which cut the ore body about 50 feet below the surface. The ore was transferred to trucks. The loading bins with about 15 tons of ore in them, have slid into the road.

High Plateau Chrome #8

This deposit was one of the largest producers in 1918 when it was owned by E. J. Hawkins of Crescent City and operated under lease by Adams and Maltby. It lies on the north slope of Low Plateau at an elevation of 2700 feet in the north half of Section 28, T 18 N, R 2 E. A narrow gauge road from 5 to 6 feet wide was built up Diamond Creek to connect with the Wimer Road. In 1918 the ore was transferred from the bunkers to narrow gauge Ford trucks which carried it to bunkers at the junction with the Wimer Road. Here it was passed into standard trucks and transported to Waters Creek station on the railroad southwest of Grants Pass. The deposit is now claimed by A. P. Jepson.

The ore body is arcuate striking in general northwest and southeast. In places the lens is shallow. While many tons have been removed a large quantity remains. The contact with serpentine is not sharp and small nodules of chromite are found in the adjacent country rock. Toward the northwest end a cross section of the body may be seen. The north 1½ feet is of high grade ore probably running over 52% chromic oxide. About 20 feet of low grade ore is exposed to the south. The chromite in this ore is coarsely

crystalline with a matrix of decomposed serpentine minerals. This ore is very friable. Chrome garnet and chrome mica are common.

Low Divide Group

The Rowdy Creek Mine

This mine is owned by the Tyson Mining Company and consists of one claim located on Rowdy Creek (Copper Creek) and three claims on High Divide Mountain about 2 miles southwest of Low Divide itself. High Divide Mountain is flat-topped, an oldland remnant, lying at 2200 feet elevation.

The ore bodies are lenses in serpentine and dunite. The main body was worked through a shaft now filled with water to within 40 feet of the surface. A hoist and dump were used to feed ore to the bunker whence it was passed to trucks. The ore was transferred at Crescent City to ships. The lenses strike northwesterly. Those to the northwest of the main ore body were mined by open cuts.

Most of the ore is of even-granular structure but some is banded chromite and serpentine.

Zoar's Chrome

This lies 100 feet southwest of the cabin at Low Divide and is owned by Frank Zoar. The ore occurs in a vein 8-10 inches wide and as nodules in serpentine. About 40 tons of 52 % ore were removed during the war.

Figure 110 Chromite hoist and bunkers over ore lens, Tyson Chrome, High Divide.

Quicksilver

History

Cinnabar was discovered on Diamond Creek in the NW ¼ of Sec. 11, T 18 N, R 2 E, in the early 50's. At that time placer miners from as far as Kerby, Oregon, a distance of 35 miles, went to Diamond Creek to obtain mercury for amalgamation processes. The property was first located by an English Company in the 60's. It was claimed by anmy others thereafter. In 1916 it was claimed by John Taggart and associates of Smith River. They built a retort in 1917 with three units and underdraft. Three inch pipe condensers ran into water. The retort had a capacity of 500 pounds of ore and was operated for six hours. One flask of quicksilver was recovered in 1917 when operations ceased. It was found that most of the quicksilver was being lost.

Figure 111 Original workings of the Sunny Brook Cinnabar Prospect, now largely covered with terrace debris from cave-in. The lode strikes northeasterly in the direction of John Taggart.

The Sunny Brook Cinnabar Prospect

This property is now held by Lee Brown of Los Angeles who has the two center claims and by John Taggart of Smith River who has two claims to the south and one to the north. In 1930 some development work was being done. The main shaft, which caved in 1917, was being reopened.

The ore mineral is cinnabar, HgS, which occurs in stringers in quartz veins with serpentine country rock and in fissures in the serpentine itself. There are two parallel lodes striking due north and south. These are much fissured. They are near broad dikes of hornblende diorite (outcropping 100 feet to the northwest) which may have served as the source of the ore since they are also associated with the Big Boy cinnabar deposits.

The workings and retort are on an extensive terrace on the northwest side of Diamond Creek. Over the lodge is an overburden of a few feet

of creek boulders. A cut has been made 100 feet north of the retort which is 40 feet long in a north-south direction and 5 to 6 feet in width. A crosscut below the creek level is being driven to connect with the old tunnel. In this working bunches of native quicksilver were found along the strike.

The ore appears to be of good grade running from one to two percent mercury. The average run is reported to be 10 pounds of mercury to the ton.

Big Boy Cinnabar Group

The Big Boy cinnabar deposits lie on the north fork of Diamond Creek at an elevation of 2150 feet. They are four miles northeast of the Sunny Brook Group. Two claims in Curry County, Oregon, are owned by R. E. Strayner and J. J. Hoogstraat. Three claims in California are owned by O. H. Hagberg, H. W. Lipple, and George Davis. The group is operated under a partnership arrangement.

The cinnabar is scattered along fine joint fissures in a huge mass of propylitized diorite. In this rock the feldspars have completely altered to kaolinite, and to sevicite, and the amphiboles to limonite, etc. The altered diorite is exposed over the top of the ridge west of the ridge with the camp, (Refer to map) and on the west is in contact with or continuous with the dikes passing near the Sunny Brook Prospect. On the north is a tongue of serpentine while to the east less altered rocks occur including a fresh hornblendite or gabbro containing inclusions of serpentine.

The alteration of the diorite is not believed to be the result of meteoric waters connected with the Klamath oldland stage although remnants of this surface are found nearby. Rather the cinnabar was introduced and the rock was altered simultaneously by pneumatolytic action in a late magmatic stage. This view is significant in implying alteration and mineralization to an inknown, presumably great depth.

Figure 112 Sam Hoogestraat on cut of decomposed hornblende diorite at the Big Boy Mine. Rock thoroughly propylitized. Cinnabar along fissures and joint planes.

Figure 113 Concentrating sluices at the Big Boy Mine. Much cinnabar escaped with the waste from outlet of upper sluice.

Thus the deposit is very large. A report by W. A. Hutton estimates that the body contains 25,000,000 cubic yards carrying 3 to 5 pounds of cinnabar to the ton. The difficulties encountered are principally connected with the concentration of this low-grade ore.

The original locator, John Griffin, has put in a ditch along the top of the ridge and ground sluiced what was originally a small slide. The water was run through a 10 inch sluice box with Hungarian block riffles. The concentrates were retorted in two 4 inch pipes.

The present equipment installed by J. I. L. Dredging Company of Spokane who leased the property is essentially a refinement of the above. A 3 inch giant was operated in the slide and the material run through a series of sluices making a gravity separation. It was hoped that in this way the heavier cinnabar crystals could be concentrated. The process was extremely inefficient, however, and the property is at present idle pending installation of more efficient equipment.

Manganese

Black Beauty Prospect

This prospect is located on the east side of the north fork of Smith River at an elevation of 1400 feet. It lies in southeastern Curry County, Oregon, about one mile north of the state boundary. It was located in 1918 by John Taggart, James Keaton and Reves Costello and restaked in 1924. Its present ownership is in doubt.

The deposit appears to be a replacement body along a brecciated zone in Dothan cherts and jasper. The surface outcrop on the slope of the hill is 65 to 70 feet in width and runs 150 feet or more in a direction N 35° W. The ore minerals are pyrolusite and manganite. The oxidized zone extending to the depth of exploration (15 feet) has considerable wad. The gangue consists of suspended chert fragments and porous silica.

The ore is reported to be of high grade, name 72% manganese but so far as may be seen from the exploration such high grade ore occurs only in small masses. With depth, however, the chances for high grade ore appear good.

The development is small and consists of a cut and tunnel extending 30 feet to the east from the face of the hill. The ore disappears at the back. One short cross cut extends to the north of the open cut. Observations indicate that the body dips about 60° southwest. A cabin has been built south of the workings.

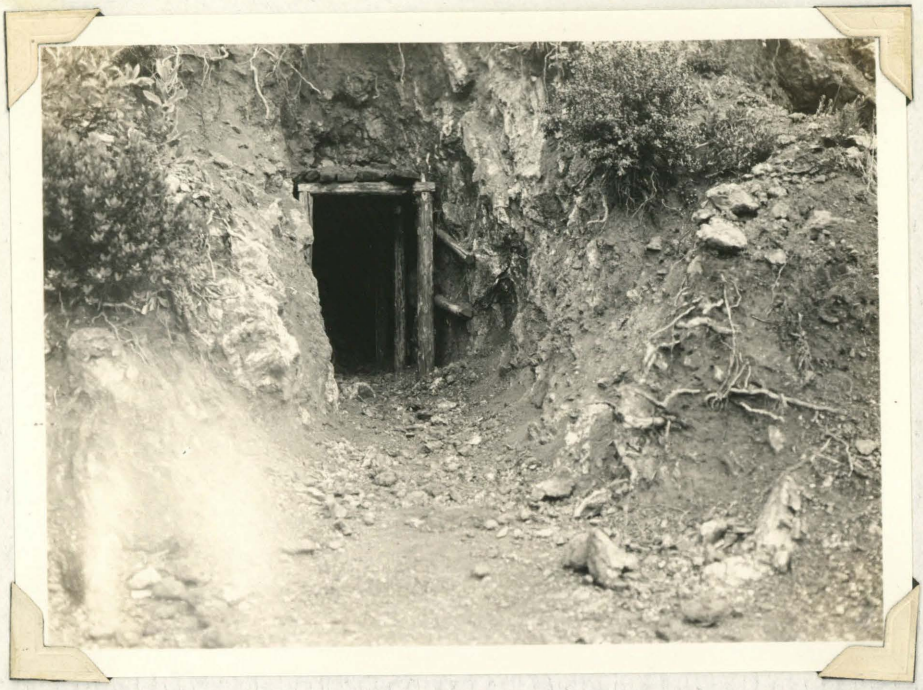

Figure 114 Black Beauty Manganese Prospect near Sourdough. High grade ore near center of steeply plunging shoot seen above support beams. Lower grade ore with chert in open cut.

Figure 115 High grade pyrolusite manganese "ore" showing traces of the chert structure.