THE STRUCTURE AND STRATIGRAPHY OF THE UPPER CRETACEOUS NEAR REDDING, CALIFORNIA

Thesis submitted in partial fulfillment for requirements of degree of Master of Science in Geology.

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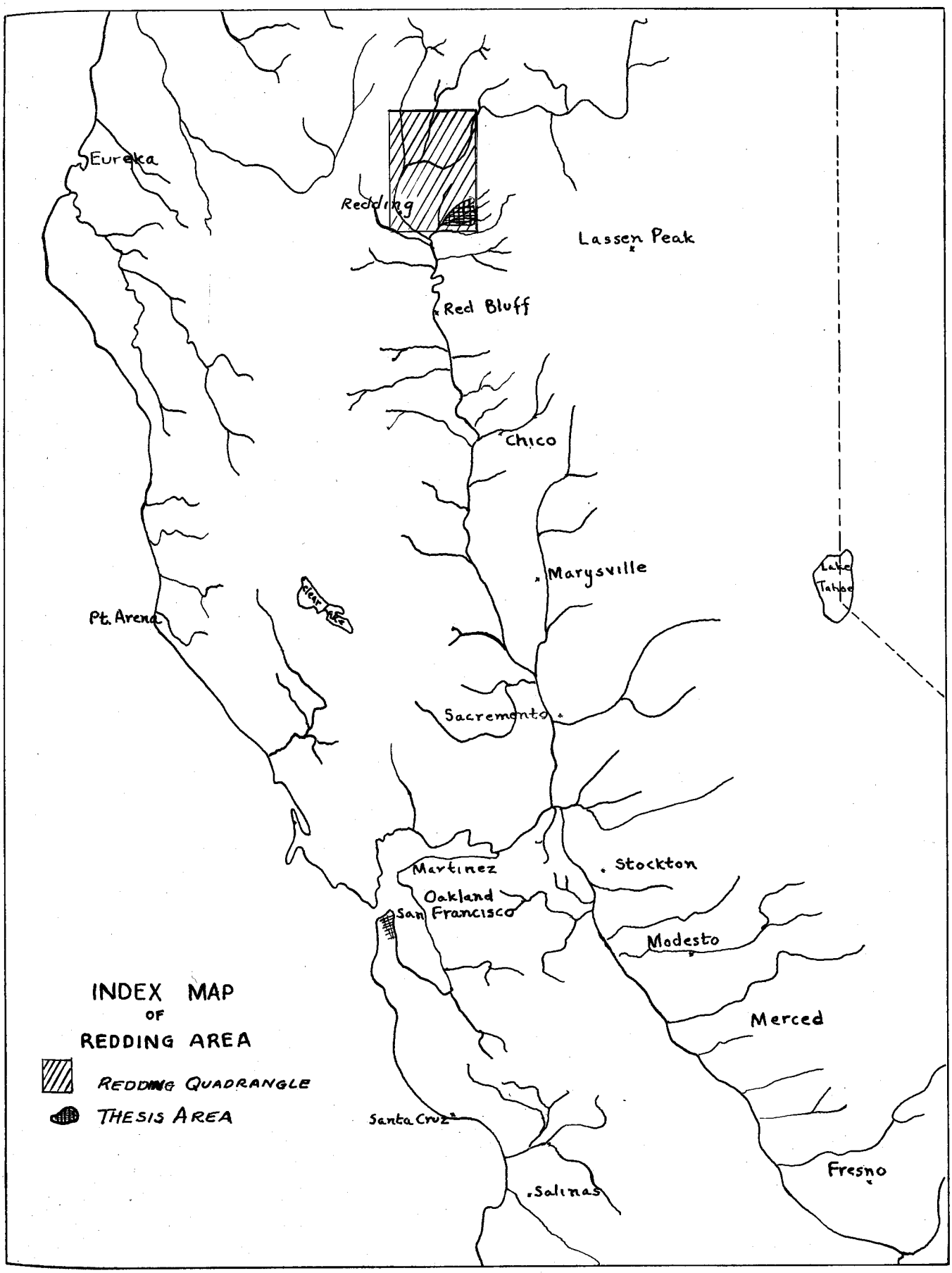
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Introduction

Thick sections of Cretaceous deposits are exposed almost continuously along the west side of the San Joaquin-Sacramento Valley of California, as well as at its northern end, and also sporadically along the east side. Aside from noting their occurrence and collecting fossils from a few scattered localities, early workers did little with these sections. Since later work in the valley has been almost exclusively confined to the Tertiary, the Cretaceous has remained comparatively unknown, as evidenced by the fact that until just recently the entire Upper Cretaceous series of California has been grouped together under the single formation name of Chico. However within the last few years it has become apparent that there exist a number of distinct faunal zones within the recognized limits of the Upper Cretaceous. Because of the thickness and scattered occurrences of these deposits, their division and correlation has come to be recognized as a very complex problem, and an immense amount of work must be done before a resonably complete and accurate section can be made.

Various sections of Upper Cretaceous are found in the Santa Ana Mountains, Jalama Creek region, along the east side of Mt. Diablo, Tehama Creek, Redding, Chico Creek, Tuscan Springs, Folsom, Deer and Antelope Creeks, and various other places along the east side of the Sacramento Valley. The

region near Redding has recently been the subject of investigation by Dr. W. P. Popenoe, who has already worked extensively with the Upper Cretaceous of the Santa Ana Mountains, and the present paper is a discussion of the structure and the stratigraphy of these beds, worked out in assisting Dr. Popenoe in his work at Redding. The field work was carried on during parts of July and August, 1936, and April and May, 1937.

At this time the writer wishes to acknowledge his deep appreciation of the generosity and kindness of Dr. W. P. Popenoe, without whose unflagging interest and aid this work would not have been possible.

Location. The Upper Cretaceous sediments under discussion here are located a few miles north and east of Redding, at the northern end of the Sacramento Valley. More particularly, these exposures lie along the valleys of Salt, Dry, and Swede Creeks, Oak Run, Clover, Basin Hollow, Old Cow, and South Cow Creeks, all located in the southeast quarter of the Redding Quadrangle. The present discussion will be concerned chiefly with the Clover Creek, Basin Hollow, Old Cow Creek, and South Cow Creek sections, with a resume of the work done on the sections along the other creeks (the work on which was done during the early part of the summer of 1936 by Dr. Popenoe and an assistant, Carl Ahlroth.)

Size. The areas exposed along these creeks are relatively narrow and quite long, and lie almost entirely within Townships

31 and 32 North, Range 2 West, and the western parts of the two adjacent Townships to the east. These areas vary in length from eight to ten or twelve miles, with the exception of the Basin Hollow Creek area, which is but two and a half miles long. The variation in width is considerable, both from stream valley to stream valley, and also along each valley itself, but the general average for each exposure probably is not much over a mile or perhaps a mile and a half. The total area, approximately, is between thirty and thirty-five square miles.

Topography. The relief of the area as a whole is quite low. The elevation of the beds at their lowest exposure along the creeks is between six and seven hundred feet above sea level; the highest is about thirteen hundred feet, or possibly even higher. Most of the Cretaceous exposures consist of rather low, rolling hills, with rounded divides between side gullies and tributaries. The inter-valley or inter-stream divides are broad and flat, formed by a capping of Tertiary lavas and gravels from the Mt. Lassen region. For the most part the valleys have been developed in soft shales resulting in rather gentle, broad, rolling topography, incised by sharp, shallow gullies. Occassionally, where formed in sandstone or conglomerate, the embankments may be very steep, and often rise precipitously fifty to a hundred feet or more. At such places the exposure is usually very narrow, with the flat-lying lavas all but overhanging the streams. In general, however, the

Cretaceous topography is quite gentle and unaccentuated.

Exposures. Exposures of the beds are neither very plentiful or particularly good. Most of the region is underlain by soft, easily-eroded shales, resulting in undercutting and slumping along gullies, thereby obscuring the attitude of the beds. The sandstones and conglomerates nearly always form persistent, easily traced outcrops wherever they occur, whether in the stream bed or along the hill slopes.

Maps. The maps used during work in this area were enlargements of the southeast quarter of the Redding Quadrangle, United States Geological Survey Atlas Folio no. 137, the geology of which was done by J. S. Diller and party, 1901-1904. The scale of the original is 1/125,000; of the enlargment 1/62,500. The contour interval is 100 feet.

Review of Literature

The region included in the Redding Quadrangle contains a great amount of varied and interesting geology, and although the literature concerning this district has been considerable, there has been very little of it that deals directly, or even in part, with the Upper Cretaceous sediments.

One of the earliest published works that contained any reference to these beds is an article by J. S. Diller in the U.S.G.S. Bulletin 33, 1886. In this paper he refers the sediments to the Chico group, and considers their occurrence in relation to others along the valley, and also in Oregon,

intimating the possibility of a maring connection of the two -- Sacramento Valley and Oregon Basin -- in Cretaceous time across the Mt. Lassen region, with a great island lying to the west.

Another report by Diller appeared in the Eighth Annual Report of the U.S.G.S., in 1886-87. In addition to some general structural and stratigraphical information, the report contained some fossil localities and their fossil lists.

The folio of the Redding Quadrangle, No. 138, also by Diller, came out in 1906, and was the next work to have anything of importance pertaining to the Cretaceous sections of the district. While it, of course, is far from being detailed in the section on the Cretaceous, this description remains today the most complete in published form.

Since the appearance of the Redding folio there has been little added to the literature on this problem, although there are occasional references to it in various articles. The latest work which has appeared with anything more than just an allusion to the sediments of the area was an article titled Geologic Formations of the Redding-Weaverville District, Northern California, by Norman E. A. Hinds, in the California Journal of Mineralogy and Geology, Volume 29, nos. 1 and 2, 1933. This article included a very brief summary of the stratigraphy, and gave a section of the formation measured along Dry Creek north of Frazier Corners.

The above are the more important references and cover nearly all the material that has appeared in print that has

any direct bearing on the present problem. While there have been other workers in the area, for example C.A. White. T.W. Stanton, F.M. Anderson, G.D. Hanna, etc., their results have either not appeared in print, or their work was included in some of the above references.

Stratigraphy

The Cretaceous sediments of this area consist of sandstones, shales, and conglomerates. The relation of these to each other and their occurrence in the area will be discussed after a description of their lithological characteristics. As there is no great degree of variation from one valley to the next, it will not be necessary to go into much detail for each section, and only a more general view for the region as a whole will be given.

A marked unconformity exists between the Cretaceous and the formations below it. In the Sand Flat region, the underlying rocks are metamorphosed sediments of Devonian and Carboniferous ages, while along the Dry Creek-Salt Creek section, the Upper Cretaceous rests on the Pit shales of Triassic time.[1] The unconformity, obviously, is very pronounced.

The underlying formation, or formations, in the areas discussed here are not known, for at no place is the base of

[1]Diller, J. S., U.S.G.S. Geologic Atlas, Redding Folio, No. 138, 1906.

the Cretaceous exposed. At the northeastern end of the Clover Creek section, the Cretaceous deposits lie in contact with the Triassic Bully Hill Rhyolite. This contact is believed to be a fault contact (for reasons to be given later.) The Bully Hill formation is a considerably altered and crumpled rhyolite flow, much decomposed at the surface, and often cut by dikes and sills. One such dike has formed at the northern end of the Clover Creek exposure the beautiful little Clover Creek Falls, where the stream plunges over the resistant quartz-hornblende-diorite dike in the ninety-foot drop.

Lithology. The conglomerate beds, of which there are several throughout the section, are usually composed of fairly well rounded pebbles of chert, slate, and a variety of volcanic and sedimentary rocks. The pebbles average small to medium in size, mostly under three inches in diameter, although some larger pebbles and boulders are present. The matrix is a fairly clean, fine-grained to arkosic sandstone in which the pebbles are tightly and firmly bound. The percentage of pebbles to matrix is very high. The maximum thickness of the conglomerate beds is probably not much over thirty or forty feet. Lensing is characteristic of these strata, and often layers which are fifteen or twenty feet thick may lense out almost completely within a few hundred yards. Fossils are often found in little pockets or lenses, from a foot to three or four feet long, and one or two feet each in the other dimensions. There are three or four of these conglomerate beds in the upper part

of the sections. They are the most resistant members of the whole section, and wherever they occur, form well defined outcrops. Sandstone beds are almost always associated with the conglomerates, both above and below.

The sandstone members of these sections form a very considerable part of the series. They are found all through the sections, in strata ranging from one or two feet up to a hundred feet or more in thickness. The lithological range is also very great, varying from a soft, fine-grained, platy, almost laminated, silty, olive-brown sandstone, to a very massive, hard, resistant sandstone, blue-grey on fresh fracture, and weathering brown. It usually occurs in resistant beds of from three to six or eight feet thick, with softer sandstone or shales above and below. It is often found in association with the conglomerates. The thick beds are occasionally so massive that it is hard to determine the bedding, particularly in the stream beds. In some regions where the more massive sandstone outcrops in the stream bed, fairly well formed potholes occur, with diameters up to three or four feet, and five or six feet in depth. Lensing, though present, is much less common than in the conglomerates. Fossils are found very abundantly in certain beds from an inch or two up to a foot or more in thickness. These fossiliferous beds are often very resistant, and generally are composed almost entirely of compacted shells. The occurrence of fossils in lenses is very common.

The shale is soft, fine-grained, grey, and always extremely fragmental. It is quite thinly bedded, frequently being laminated. The beds are very weak, and in many places are locally considerably deformed. Some banks show a curious tendency towards cross-bedding, but this is not developed to any great degree over the entire region. In many places beds made up almost exclusively of hard ironstone concretions are developed. These beds vary from an inch or two to almost a foot in thickness with corresponding variations in the size of the concretions. Very rarely these concretions contain ammonites.

In general, the shales are unfossiliferous. However, pelecypods, bacculites, gastropods, and ammonites are occasionally found, sometimes separately and sometimes together in pockets.

Many interesting sandstone dikes are developed in the shales, particularly in the west end of the Clover Creek exposure. Many of these dikes are a foot wide, and cut directly across the bedding of the shales, passing from one sandstone interbed to another.

The shale members of the sediments form the greater part of the sections. Although not appearing in outcrop as much as the sandstone, the shales nevertheless underlie the majority of the Cretaceous area. The region developed mainly on the shale has a gentle topography of rounded hills, which are fairly well sodded, and into which sharp, steep gullies are cut. The shale exposures are best seen in these gullies, or

at places along the banks of the stream.

Occurrence. The oldest Upper Cretaceous beds in the sections to be discussed are a series of dark grey to black, fragmental shales occurring at the western end of the Clover Creek section. These shales are perhaps correlative with the shale series occurring on the north side of Oak Run Valley and have been exposed here as the result of uplift on the west side of the Basin Hollow-Clover Creek fault.

Above this shale member a conglomerate-sandstone series is developed. This series consists of three or four lenticular conglomerate beds, fifteen to thirty feet thick, alternating with arkosic sandstone strata of varying thicknesses. The series is well shown in Clover Creek on the steep slope east of the stream, just opposite the Hunt Ranch. Although one or two of the conglomerate beds lens out, the series forms, in general, a nearly north-south band across the Clover Creek-Basin Hollow sections. This series also appears in Old Cow Creek, but there with what seems to be definitely greater stratigraphical interval between the conglomerate beds. This apparent difference may be occassioned to some degree by the fault which traverses the Old Cow Creek section, and which will be discussed later; or it may be due to the lensing of different conglomerate beds into the series. The series is continued to the south, where the lower part of it is exposed at the southwest extremity of the South Cow Creek section.

Conglomerates are also found in the South Cow Creek Section on the north side of the stream a half-mile northwest of Waggoner's ranch as shown by float blocks and boulders. The relation of these conglomerates to those described above is not definitely known.

The conglomerate-sandstone series discussed above evidently is the continuation of a similar series appearing in Oak Run. Other than these occurrences, the Upper Cretaceous here is devoid of conglomerates.

The sandstones occur in varying thicknesses throughout the entire section. Wherever the conglomerates are found, sandstones are also found. For the most part, however, they are found at northeastern ends of the exposures along the creeks (the lower parts of the section stratigraphically.)

In general it may be said that the shales lie intermediate between the conglomerates in the upper parts of the section and the sandstones below. But they are also found throughout the section in beds of varying thickness, and form a considerable part of the section.

Structure

General. The structure of the area as a whole is relatively simple and straight forward. In the Clover Creek-Basin Hollow Creek sections the sediments dip gently and evenly to the south and southwest throughout most of the exposure at an average inclination of between seven and ten degrees.

At various places in the section the beds are essentially horizontal, while occassionally dips to the southeast and others to the northwest are recorded. These latter attitudes are, of course, discordant and do not reflect the attitude of the section as a whole. Other and more local variations in strike and dip occur as a result of faulting, and will be discussed later.

The same general structural conditions are found in both Old Cow and South Cow Creek sections, with but slight variation. There is a tendency however for the dip of the beds to shift more and more towards the west the farther south in the sections. The average dip remains about the same (seven or eight degrees).

Faults. Relatively little faulting has occurred in this area, and the few faults that are present are comparatively minor in both areal extent and displacement.

Clover and Basin Hollow Creek. The northeastern end of the Clover Creek exposure is apparently bounded by a fault contact. Evidence for the fault is as follows: (1) the Cretaceous is topographically lower than the Triassic and Jurassic rocks north of it; (2) the Cretaceous strikes into the Bully Hill rhyolite (Triassic) and Jurassic dike rocks; (3) no basal conglomerate was found, and no lithologic change occurred in the Cretaceous as it neared the contact; (4) a reversal of dip from the normal south-southwesterly attitude of the Cretaceous occurs a short distance from the contact. From the drag indicated, it appears that the Cretaceous block

moved down and to the southeast in respect to the opposite block.

There is a small fault, called here the Basin Hollow fault, passing from the southeastern part of the Clover Creek section into the Basin Hollow section. It strikes roughly north-south as it crosses the Redding-Mt. Lassen road just east of the section line between Sections 4 and 5, T 31 N, R 2 W, and then swings southwest into the Basin Hollow region, where it is lost in the sandstones. The fault seems to be almost vertical, with the upthrown side to the west. The displacement is not great, probably measurable in the tens of feet. The fault does not appear in outcrop, but its presence is inferred from the discontinuity of the strong conglomerate and sandstone bed across a small gully to the bank on the west side, and from the disturbed condition of the shale banks on the west side, which have been raised into contact with the conglomerate. The fault could be traced for a total distance of about a mile.

Old Cow Creek. The strongest fault in the whole region occurs in the Old Cow Creek section. It runs somewhat obliquely across the Cretaceous exposures about S 65 W from just south of the high lava topped hill near the middle of the exposure, till it passes out of the section under the Red Bluff gravels in the middle of section 4, T 31 N, R 2 W. The fault was not observed in outcrop at any locality, and so its existence is inferrential. The evidence of faulting is as follows: (1) the discontinuity of a fairly thick, resistant

sandstone bed across the rather narrow valley just south of the high lava topped hill mentioned above; (2) the shales in the bed of the same valley dip to the north or into the nearly flat lying sandstone just opposite; this may be regarded as drag effect; (3) the sandstone bed as it nears and crosses the stream in this valley is strongly contorted and apparently dragged up vertically; (4) two other regions along the same general line of the strike of the fault to the southwest having similar relationships were located; (5) various gullies along the strike of the fault or close to it exposed shales and sandstones with unusually high dips. From these observational facts it seemed evident that a fault of intensity unusual in this region had occurred. The only other possible explanation for the above features would be a sharp, right angle fold. Such a flexure, however, could not be kept as a fold and still produce the amount of uplift which apparently is needed. It is a possibility, though, and as such should not be entirely overlooked.

Little is known of the character of the fault. It appears from the dragging of the beds to be nearly vertical, probably a high angle thrust, with uplift to the south. The amount of displacement could not be computed, but it is probably to be measured in the order of a few hundreds of feet. It was traced for about three miles across the section.

In connection with this fault, a small subsidiary or cross fault was noted on the north side of the main fault, just south of the highest part of the lava topped hill previously

referred to. It also is vertical, or nearly vertical, with uplift on the west side, the displacement being about fifteen feet. It apparently did not cross the main fault, for it could not be located on the south side of the valley.

South Cow Creek. Faulting in the Cretaceous of the South Cow Creek region apparently occurred only in the upper parts of the Pine Timber gulch. The faults here, of which there are only two or three, are high angle and of small displacement, neither one exceeding ten feet. The exposed Cretaceous at these points is very narrow, so little could be determined as to their extent. They trended roughly northwest-southeast.

Flexures. Flexures in this area fall into two general types: (a) those produced as drag effects of faults, and (b) small and relatively local flexures or warping due probably to the sudden increase of load when the Tertiary lavas were poured out over the area. Besides these two general types, there are a few very gentle and rather indistinct flexures that seem to be the results of warping over a larger region.

The first mentioned type of folds -- those that are produced as drag effects of faults -- are the most abundant in the area and show the greatest amount of distortion. All along the line of the Old Cow Creek fault the beds have been dragged up strongly on the north side of the fault, and down on the south side. In some places the competent sandstone

and conglomerate beds are nearly vertical. Similarly, flexures appear in connection with the faults in Pine Timber Gulch, and, to a lesser degree, along the Basin Hollow fault. In all cases, the shales, being the most incompetent series, are the most strongly affected.

Flexures which seem to have been formed from an increase in load are usually quite local in extent. Again the shales are affected the most, and it is not at all uncommon to find shale banks whose attitudes are discordant to the general structural trend. The sandstones and conglomerate members are affected in this way, and show only a slight flexing as a result. One of the best exposures of the flexing of these competent beds occurs along the south bank of Old Cow Creek in about the middle of the west half of Section 3, T 31 N, R 2 W.

Of the flexures resulting from general regional warping, only one was definite to be mapped. This one was an anticlinal structure having a north-south axis, exhibited by shales in the bed of Clover Creek, SW¼ of Section 32, T 32 N, R 2 W.

Summary. The structure of the beds along Clover Creek, Basin Hollow Creek, Old Cow Creek, and South Cow Creek consists in general of beds dipping gently to the southwest and west, at an average inclination of six or eight degrees. The dip changes slightly in direction from section to section, swinging from southwest in Clover Creek to west in South Cow Creek. Minor flexures are rather common throughout, and a few faults, most of them comparatively small, were encountered, causing

displacement and local changes of dip.

Resume of the Oak Run, Salt, Dry, and Swede Creek Sections

During June and the early part of July, 1936, W.P. Popenoe and an assistant, Carl Ahlroth, worked in the Redding district along Oak Run, Salt, Dry, and Swede Creeks. It was the original intention for the writer to visit personally this region in order to get a complete picture for the structure and stratigraphy of the region as a whole, but due to lack of time it was not possible to carry out this plan. The following brief summary of the structure and stratigraphy of this region, therefore, has been drawn entirely from information obtained by W.P. Popenoe and Carl Ahlroth during their work the earlier part of the summer.

The expression of the Upper Cretaceous along these creeks is quite similar to the areas already described to the southwest. In general, however, these more northerly areas are broader and much shorter in length of exposure than those along Clover, Old Cow, and South Cow Creeks. The two regions are approximately equal in area of exposed Upper Cretaceous sediments.

Stratigraphy. The only places in the whole Redding district where the base of the Upper Cretaceous is exposed are at a few scattered localities in the Dry and Salt Creek sections. Here the basal conglomerate is seen resting on the Pit shales

of Triassic in marked unconfirmity. This basal member is a dark brown to black, hard, well-cemented pebble conglomerate, with a hard, fine-grained matrix. The pebbles are angular to rounded, generally not over four or five inches in diameter, though becoming much coarser and larger near the contact. The majority of the pebbles appear to be cherts, although the assortment is quite heterogeneous, with many lavas and old sedimentaries well represented. The average thickness is about thirty or forty feet.

The basal conglomerate grades more or less quickly into the massive sandstone above. This sandstone member differs from the types found along the Clover, Old Cow, and South Cow Creek sections in that it typically shows cross-bedding to a marked degree, and, generally is decidedly less arkosic. At the bottom it is fairly course, but becomes clearer and finer-grained farther up. It is quite hard and resistant, weathers brown, but is grey on fresh fracture. The thickness is hard to estimate, but is probably of the order of five hundred feet. It occurs in a broad band across the upper half of the Dry, Salt, Creek exposures. Various parts of this bed carry fossils in great abundance.

The remainder of the exposures on these creeks is made up of shales of variable thickness. These shales are very similar to those of the regions described before and so a description here is not necessary. They are more fossiliferous than the others, however, particularly with respect to ammonites.

The stratigraphy in Oak Run is somewhat different. In general, the shales of the Salt, Dry, and Swede Creek regions carry over to Oak Run and are exposed in a wide band along the northwest half of the exposure. Stratigraphically above this, and on the east and south side of the stream, appear the sandstone and conglomerate beds so characteristic of the southern half of Clover Creek. The faunal assemblage in the sandstones and conglomerates is entirely different from that of Salt Creek, and is the one with which the fossils in the sandstones of Clover, Old Cow, and South Cow Creek are correlated. This zone is called the Oak Run fauna, while that of Dry, Salt, and Swede Creek is known as the Salt Creek fauna.

Structure. The attitude of the beds of the Salt, Dry, and Swede Creek sections are quite similar, having an average dip of between six and nine degrees nearly due south. In Oak Run the dips are mainly to the southeast, at about an equal inclination. Departures from these attitudes, particularly along the south and east side of Oak Run are due to local disturbances of small magnitude. The change of direction of dip from Swede Creek to Oak Run (from south to southeast) is probably the result of simple flexing, though of course the possibility of a fault beneath the lavas between the two exposures could not easily be proved or disproved.

Sand Flat. In the discussion above, no mention has been made of the so-called Sand Flat exposure of Upper Cretaceous, a few miles north of Redding, just east of Buckeye, on the

Redding-Alturas highway. Dr. Popenoe and Carl Ahlroth worked in this area for a time in June, 1936, but because of the scarcity of exposures, little could be definitely determined as to its relationship to the other exposures to the east and south. However, it seems to be more or less a continuation to the west of the basal members of the Salt And Dry Creek sections. The basal conglomerate is well exposed here. It is about forty feet thick, and rather similar lithologically to the basal conglomerate in Dry and Salt Creeks. The beds seem to be dipping gently, but evenly to the south. The faunal assemblage is apparently correlative with the Salt Creek fauna.

Bear Creek. The stream immediately south of South Cow Creek is Bear Creek. A fairly wide and very long exposure of Upper Cretaceous is found along the bed of this creek, mostly much farther to the east than the other localities. A few days at the end of the summer work of 1936 were spent by Dr. Popenoe and the writer in rapid reconnaissance of the lower part of the exposure. The work showed that the western part of the exposure (the highest stratigraphically) consists of massive sandstones of the same type found in other localities of this region, with an even and gentle dip (about 10) to the west. Several of the beds were quite fossiliferous, and the fauna resembles that of Oak Run. A large area farther east and north along Bear Creek -- a continuation of the exposure described here -- is yet unknown.

Other Localities. In addition to the areas so far discussed, two or three other smaller patches of Upper Cretaceous occur in the Redding district. One of these is just west of the town of Oak Run, and another, called Oak Flat, is located about a mile north of Oak Run. Still farther northeast is a somewhat larger area, near Round Mountain. None of these areas has been visited recently, but it is the intention of Dr. Popenoe to investigate these exposures in the near future.

Summary. In general the attitude of the beds of the whole Redding district suggests that this region was at the northeastern end of a geosynclinal trough in Cretaceous time. This is indicated by the fact that the dip of the beds, for the most part still initial dip, swings from due south in Salt, Dry, and Swede Creeks, to southwest along Clover, Old Cow, and South Cow Creek, and finally to due west in Bear Creek.

Review of the Paleontology

All of the fossils found along Clover, Basin Hollow, Old Cow, and South Cow Creek apparently belong to a single faunal zone, which is to be correlated with the Oak Run fauna. This Oak Run assmeblage is the second oldest faunal zone in the Redding area, the oldest being the Salt Creek fauna. Nearly all of the species of the Oak Run fauna have been described heretofore. A list of the more characteristic of

the described species from this fauna which were collected during the field work follows, together with a similar list of the Salt Creek Assemblage.

Oak Run Fauna

Meekia cf. M. navis Gabb
Glycyimeris veatchi (Gabb)
"Calva" varians (Gabb)
Cymbofora sp.cf.C.gabbiana(Anderson)
"Lutraria" truncata Gabb
Corbula sp.
Pteria pellucida? (Gabb)
Conchothyra cf.C. hamula (Gabb)
Plectocion curvirostus (Gabb)
Volutoderma averilli (Gabb)
Gyrodes expansus Gabb
Perissdax brevirostris (Gabb)
"Acteonina" californica Gabb
Oligoptycha obliqua (Gabb)

Salt Creek Fauna

Sandstones
Glycymeris pacificus (Anderson)
Meekia cf. M. sella Gabb
Pugnellus manubriatus Gabb
"Calva" sp.cf."C." varians(Gabb)
Gyrodes conradiana Gabb
Actaeanella oviformis Gabb
Trigonarca californica Packard

Shales
Cucullaea grairda (Gabb)
Tenea inflata (Gabb)
Glycymeris pacificus Anderson
Pinna calamitoides Shumard
Scaphites sp.
"Acteonina"sp.cf."A."californica

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ILLUSTRATIONS

Figure 1.

Characteristic conglomerate occurrence. Notice sandstone interbed (foreground, lower left corner). Exposure along west side of deep ravine north of Old Cow Creek, E ½ Sec. 4, T 31 N, R 2 W.

Figure 2.

Sandstone blocks in Clover Creek Section, showing the platy character which often develops in the sandstones. SW ¼ Sec 33, T 32 N, R 2 W.

Figure 1

Figure 2

Figure 3

Typical shale bank, illustrating the incompetence of the shale members. Clover Creek exposure, SW¼, Sec.33, T 32 W, R 2 W.

Figure 4

Sandstone dike developed in shale bank. Bed of Clover Creek, SE ¼, Sec 32, T 32 N, R 2 W.

Figure 3

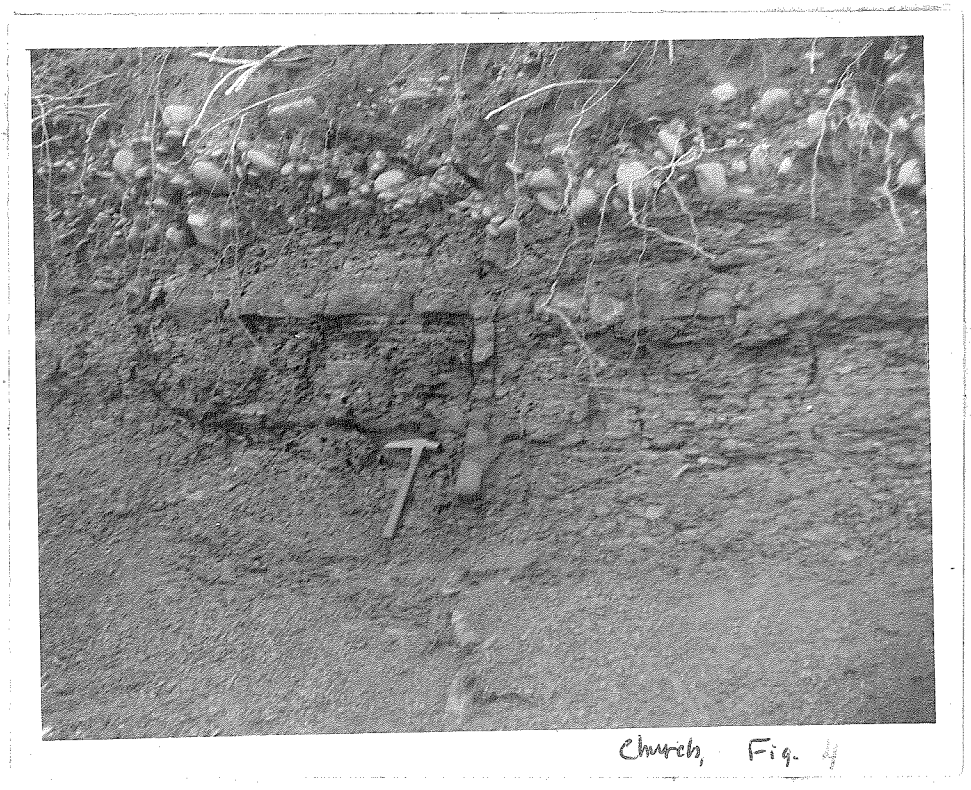

Figure 4

Figure 5

Outcrop of steeply dipping sandstone beds on the north side of the Old Cow Creek Fault. The high dip is the result of drag. NE ¼ Sec. 4, T 31W, R 2 W.

Figure 6.

Looking north along fault-gully of Basin Hollow Fault, just north of the Redding-Mt.Lassen road, SW¼ Sec.33, T 32 N, R 2 W. Flat-lying sandstone and conglomerate beds on east side of gully; shales on west side have a variety of attitudes.

Figure 5

Figure 6

Figure 7.

Type of fault typical in Pine Timber Gulch area. Displacement of sandstone bed about three feet.

Church, Fig. 7

Figure 7

STRUCTURE SECTIONS