

C+ report & research

B- defence

B-- grade

GEOLOGIC RECONNAISSANCE
of the
GOLD BLUFFS FORMATION
For the Purpose of
Determining its Origin

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ABSTRACT

In northern California, in the Klamath Mountain Region, between the Pacific Coast and Hoopa Valley, north of Eureka and south of Crescent City, there is a series of isolated conglomerate deposits. These conglomerates were deposited by an ancient Trinity River, during Plio-Pleistocene time, on the remnants of the Klamath-Bellspring Peneplain.

There are two principle occurrences of the conglomerate; one at Gold Bluffs in Redwood National Park (from which the formation takes its name), north of Orick, and the other on French Camp Ridge, just west of Hoopa Valley. These deposits can be correlated by a study of the compositions and distribution of their contained cobbles.

The plain on which these sediments were deposited has now been uplifted to a level approximately 3000 feet above sea level and has been ^{severely} heavily dissected.

INTRODUCTION

This study was undertaken as a senior thesis project for my Bachelor of Arts degree at Humboldt State College, Arcata, California.

The problem to be considered was presented to me by Dr. John C. Young. I was to try to determine if several patches of isolated conglomerates could be remnants of stream deposits from an ancient Trinity River. To prove this, I have attempted correlations of the conglomerate cobbles in several ways, based upon their composition. Jades were compared using x-ray powder diffraction techniques, granitics by thin section examination, and the entire cobble suite by pebble counts.

The deposits are located between Hoopa Valley on the east and the Pacific Coast to the west. Four locations were considered: French Camp Ridge, T38N, R10W; Johnson Road, T40N, R11W, SE $\frac{1}{4}$; Redwood Park, T40N, R11W, NW & SW $\frac{1}{4}$; and Gold Bluffs, T40, 41N, R1E (see figure 1).

Field work was done on weekends during the spring and fall of 1971-2, as the inland areas are inaccessible during the winter.

I was aided in my field work by Richard Kress, Ted Smith & Ron Gibbs. Dr. John Young supervised the project, accompanied me into the field, helped me to locate the various deposits and aided me in gaining access to them. Dennis Inman and Craig Gross helped me with thin sections and computer application of my x-ray work. I used the facilities at Humboldt State College to do x-ray, computer & thin section work, and the Geology Department's Toyota for transportation.

GEOGRAPHIC & GEOLOGIC SETTING

The Gold Bluffs Formation is present in the North Coast Ranges & Klamath Provinces of northern California. In this area, the Coast Range Mountains lie directly east of and parallel to the coast line, and rise to elevations near 4000 feet.

There is a north-south trending belt of South Fork Mountain Schist that underlies Hoopa Valley[?] and the northern end of French Camp Ridge. This belt is separated from the Franciscan Formation on the west by the Coast Range Thrust Fault. The Franciscan Formation forms another belt that is bounded on the west by other, much younger reverse faults of relatively small displacement, and the South Fork Mountain Schist outlier (Young, personal communication). This contact runs roughly north-northwest and seems to disappear under the Gold Bluffs Formation north of Orick. However, this series of small faults effects the Gold Bluffs as local deformation in the form of small *NE-dipping* reverse faults and some minor folding.

Most of this area is covered with climax redwood forest and open, grass-covered prairie. Logging operations in certain areas have increased accessibility to outcrops by creating new roads and clearing the land. These same operations, however, have created a high erosion rate, especially on the west flank of the Coast Ranges and engendered slides which annually wipe out many of the roads, making field work hazardous.

The usual rainy season goes from October to April, giving the coastal areas from ^{60 to 80} 30 to 40 inches of rain annually. Summers are moderate and foggy on the coast to very warm and dry inland. Vegetation

is lush and plentiful in most places, in one form or another.

Much of the coastal plain is used as grazing land, while the higher slopes are harvested for their timber. There is an established commercial salmon and crab fishing industry that works out of Trinidad and Eureka. During the summer, the area attracts tourists and boasts several state and national parks.

French Camp Ridge is accessible from either end of the following road network. One can go east on Highway 299 to Willow Creek and then north to Weitchpec on Highway 96. There is a bridge over the Klamath River there, and a dirt road winds for 6 miles up the east side of the ridge to the top. The ridge is barren of trees and supports only some ferns and ^{grass?} low bushes. The road runs along the ridge from north to south, turns west and becomes Bald Hills Road that eventually emerges on Highway 101 35 miles away, just north of Orick.

The deposit on Johnson Road is located 17 miles north of Bald Hills School. Johnson Road itself is washboard-dirt and is heavily traveled by Simpson Timber logging trucks. The deposit is isolated and difficult to reach due to road conditions and the relatively heavy traffic.

The Redwood Park localities are accessible either by foot or by car (only with permission of the U.S. Park Service). Logging roads criss-cross the area and make most of that which is east of Highway 101, north of Orick, fairly easy to get to with a 4-wheel drive vehicle.

The Gold Bluffs area is north of Orick, west of Highway 101.

The road to Fern Canyon goes west from Highway 101 and winds through logged-over areas and forest to the ocean, 4 miles away. The road is dirt and is not kept in very good repair. The southern parts of the beach are accessible only on foot, but one can drive along the beach as far as Fern Canyon to the north. The upper¹ portion of Gold Bluffs is covered with old and new logging roads and one can go almost anywhere with 4-wheel drive.

¹The "upper" portion of the Gold Bluffs referred to in this paper includes all that material between Highway 101 and a hypothetical line drawn along the 400 foot map contour. The "beach" portion later referred to is that area below the cliffs, facing the ocean. This area is a cross-section of the deposit, while the material collected from the upper portion is just on the surface.

FORMATION LITHOLOGY

In general, the Gold Bluffs Formation is a series of semi-consolidated conglomerates, sandstones, and some sandy shales. The *depositional* top is never seen, but the base is, and a minimum thickness of five hundred feet is not unreasonable, based on the formation's thickness at Gold Bluffs (Criswell, 1968). The conglomerate is composed of cobbles and fragments of many rock types, poorly cemented by sand and some clay. The particles range in size from a fraction of an inch across to boulders up to $1\frac{1}{2}$ feet in size. Most of the cobbles are from one to four inches in diameter. Compositions include milky quartz, chert, various granitics, other sediments and metamorphics.

11 The ~~granitics~~ *plutonic rocks* include mostly hornblende diorite, diorite and some gabbro (see appendix 2). The metamorphic material is mostly South Fork Mountain Schist², with occasional pieces of well-rounded hornblende-quartz gneiss. The chert cobbles are well-rounded, greyish-green to dark brown in color, and of varying sizes. The milky quartz cobbles are sometimes well-rounded, and often are of irregular shape, suggesting a vein or cavity filling. The sediments are greywacke and well-rounded masses of sometimes partially-metamorphosed small-pebble conglomerates, mostly from the Franciscan Formation. Unless the Gold Bluffs conglomerate directly overlies the parent rock, the source of most of these cobbles is nearly impossible to determine.

²South Fork Mountain Schist is a highly foliated, blue-green quartz-albite-muscovite-chlorite schist that gets its name from a mountain on which it occurs in southeast Humboldt County (Irwin, 1960).

The soil in the more weathered sections of conglomerate is stained bright red by oxidized iron in the sediment's matrix. At French Camp Ridge, this stain continues down into the soil on underlying layers for several hundred feet, giving the initial impression that the formation itself extends to that depth.

The pebbles and cobbles are often well-rounded and sometimes intensely weathered. Their composition varies from one location to another according to the underlying rock type. Weathering is more pronounced to the east, and lessens progressively to the west, due to the eastern locations' higher elevation and subsequent greater exposure to the elements. Pebble counts at French Camp Ridge and Gold Bluffs (see appendix I) show these trends. The deposit is continuous along French Camp Ridge for about three miles, but the cobbles change drastically from the north end to the south end. The north end of the conglomerate on the ridge overlies South Fork Mountain Schist and has almost as much angular metamorphic material as it has quartz (see appendix I). The south end overlies the Franciscan Formation and contains almost no metamorphics, but much quartz and Franciscan sediments. Since the South Fork Mountain Schist-Franciscan Formation contact runs northwest-southeast through the ridge about half way between these two points, it is assumed that the change in underlying rock type accounts for the abrupt change in cobble composition in the conglomerate.

In all locations, the Gold Bluffs Formation rests near-horizontally in unconformable contact with underlying rocks. Since the bedrock varies from sediments (Franciscan Formation) to metamor-

phics (South Fork Mountain Schist), the nature of the unconformity varies accordingly from angular to a nonconformity.

The age of the formation is uncertain. Based on freshwater pelecypods and riparian flora found in shale layers at Gold Bluffs, Criswell (1968) dated the formation as Plio-Pleistocene. Irwin (1960, pg. 43) dated the French Camp Ridge deposit as Cretaceous, but he cited no evidence for this date.

This author agrees with the Plio-Pleistocene date, as it corresponds nicely with the enplacement of the pre-existing Bellspring-Klamath Peneplain at an elevation which would accomodate the deposition of these sediments (Diller, 1902). This plain will be discussed later in this paper. ?

French Camp Ridge Site

French Camp Ridge is the largest inland deposit of the Gold Bluffs Formation. This deposit extends about three miles along the ridge, but is never more than 100 feet in width. The depth of sediments is difficult to determine because of the red soil stain previously mentioned and because the cobbles are widely scattered down the ridge sides in all directions. Nevertheless, observations around the ridge indicate that the formation is never more than 10 feet thick here.

The presence of fine-grained basal material at Gold Bluffs suggest that the deposits at French Camp Ridge and Johnson Road are not true conglomerates, but the remains of a sandy layer into which have settled the most resistant cobbles from the conglomerate that

once existed above it. There is also the possibility that the fine-grained layers only existed near the mouth of the river's flood plain where the water had less carrying-power, and not upstream in the presumably high^{er} energy area where French Camp Ridge is now.

The cobbles at this location are extremely weathered. The hardest specimens are chert and milky quartz, which are useless in correlation attempts, as they have many possible sources. The uncommon cobbles that are useful as "index" specimens are often so badly weathered as to be virtually unrecognizable. Granitics, nephrite and some metamorphics develop a discolored outer weathering rind. This rind often penetrates to the center of the cobble, obliterating the original structures and/or mineralogy.

Johnson Road Site

The Johnson Road site is a small (approximately 1/5 by 1/10 of a mile in size) remnant of the conglomerate, surrounded by the typical reddish soil. The cobbles at this location were extremely weathered (more so than at French Camp Ridge) and consisted mostly of quartz and clays (see JR samples in appendices II & III). Due to the small size of the deposit and the highly weathered nature of the cobbles, the material found at this site is not used to trace the ancient river's path. The site as a whole, however, has a significance which will be discussed later.

Redwood Park - Gold Bluffs Sites

At Redwood Park and Gold Bluffs, the conglomerate is well-preserved, much thicker and with a wider variety of rock types

included in the cobbles than at the inland sites. Since these sites are closer to the ocean and at a lower elevation, they have not been effected as much as the other locations by the post-peneplain uplift that has exposed French Camp Ridge and Johnson Road to more severe forces of erosion and weathering. Therefore, they probably reflect a truer picture of what the formation may have been at all sites prior to deformation of the underlying rocks. The cobbles on the surface do not reflect the underlying rock-type as much as they do at French Camp Ridge. This is probably due to the fact that the surface material at French Camp Ridge is only a few feet from the underlying bedrock and so is more likely to contain more of the bedrock as cobbles, while near the coast there are several hundred feet of conglomerate and sand above the bedrock.

The base of the formation is easily visible along the beach at Gold Bluffs, both $\frac{1}{4}$ mile south of the ranger station, and about a mile north of Fern Canyon. The sediments form a very gentle syncline, with beds never dipping more than 3 or 4 degrees. The base of the formation is a fine-grained sandy, often [?]shaly, sediment that grades upward into the conglomerate.

Along the beach, there are cross-bedding and pebble layers that are at varying levels in the formation and that usually do not extend for more than 10 or 20 feet laterally. These suggest a wide, shallow river entering the sea at this point, creating alternately sand dunes and pebble-filled channels (a delta area?), depending on weather and seasonal conditions.

Fossils are scarce and often fragmentary. The best locations

are in shale layers south of Fern Canyon. The fossils consist mostly of fragments of freshwater pelecypods and coastal plain flora similar to that which exists in the area today (Criswell, 1968).

There are sandy lenses in the conglomerate in the upper portion as far as $1\frac{1}{2}$ miles from the ocean that, in several locations, contain cross-bedding and pebble channels.

The conglomerate at Gold Bluffs and Redwood Park is weathered only within a few feet of the surface. The cobbles along the beach cliffs are fresh and in place. On the surface of the upper portion, the cobbles are mostly well-rounded chert and greywacke (see appendix I). The granitics and metamorphics here are weathered, some by the constant moisture in the air and some by the heat of at least two forest fires (west of Highway 101). Many cobbles are blackened and their outer surfaces have been somewhat altered by heat. The areas in which these cobbles are found (like the cut-over area on the west side of the ridge about a mile from the ocean) are littered with burned redwood stumps and logs.

Possible Bases For Correlation of
of French Camp Ridge with Redwood Park-Gold Bluffs

Granitics

Since most of the igneous material that has survived as conglomerate cobbles in the Gold Bluffs Formation is severely weathered, it was extremely difficult to analyze any of them accurately. Several samples were found, however, that were sturdy enough to make fair (although too thick) thin sections (see appendix II).

Most of the samples contained a high amount of quartz. Usually, most of the other minerals that were present have been altered to clays and micas that disguise their original nature. Pseudomorphs of micas and quartz after plagioclase are the only traces of what the original minerals might have been, except when their remnants are still present.

Although the samples cannot be definitely correlated from one location to another, there are several similarities that, combined, make correlation reasonable. Few of the original minerals remain in some samples, but the general crystal shapes and textures remain basically unchanged. Relic crystalline-granular textures and large, euhedral plagioclase suggests a granitic rock. Hornblende is still present in some samples in large amounts, although it is often partially altered to chlorite & mica. Plagioclase is often recognizable as having composition approximately An_{30} (Andesine-Oligoclase). These (two) facts, coupled with a crystalline granular texture, suggest that a hornblende diorite was ^{one of} the original rocks (samples RP7, RP14, GB68, GB69, FR3). There were many French Camp Ridge rocks

that resembled those identified in Redwood Park-Gold Bluffs as hornblende diorite, but they were so badly weathered that thin sections were out of the question and x-ray analysis would only have yielded the alteration minerals, which by far out-weigh the original minerals still present.

Conglomerate

On the south end of French Camp Ridge, the Franciscan Formation outcrops are a slightly metamorphosed, dense conglomerate with rounded quartz and chert pebbles in a dense quartz matrix. This conglomerate appears as cobbles in the Gold Bluffs Formation on French Camp Ridge and Gold Bluffs (see samples GB13, & FR201, appendix II). The Franciscan Formation at Gold Bluffs is mostly greywacke, so I propose that the conglomerate cobbles are foreign to that area and would have had to have been transported there, perhaps from the source at French Camp Ridge.

Jade

These are nephrite cobbles in the Gold Bluffs Formation in all locations except Johnson Road. The nephrite, however, occurs with a variety of accessory minerals.

None of the other conglomerate deposits in the Klamath region of comparable age (marine or non-marine) contain nearly as much nephrite as the Gold Bluffs, (Smith, 1972; Irwin, 1960).

The nephrite samples from French Camp Ridge are all larger than those found near the coast suggesting that they were not transported as far from their source. If this is true, it suggests an

inland source for the nephrite.

Though the nephrite occurs with different accessory minerals, it occurs with plagioclase in RP30, FR48, GB71 & GB73. This is not conclusive, but it is reason enough, coupled with the relative rarity of nephrite elsewhere in the region, to assume a common source for the jade at French Camp Ridge, Redwood Park and Gold Bluffs.

GEOLOGIC HISTORY

The development of the Klamath Mountains did not start until at least late Mesozoic time. The first major stage of uplift and erosion was the Klamath stage and lasted from the close of the Eocene to the end of the Miocene. This erosional surface has been thought to be, possibly, the peneplain on which the Gold Bluffs Formation was deposited (Young, personal communication; Criswell, 1968; Irwin, 1960). This is not possible, as the ages of the peneplain and the formation do not coincide and this surface was not continuous inland as far as the present Hoopa Valley (Diller, 1902).

The Miocene sediments that collected on this peneplain were mostly of marine origin. ^{reformer?} Remnants of these sediments are present in Del Norte Coast Redwood State Park east of Lake Earl near Crescent City. The Klamath Peneplain survived these deformations and was still recognizable, but at a higher level when they ceased.

When these disturbances stopped, a cycle of erosion began that eventually leveled the soft Miocene beds to almost sea level. The resultant plain, more extensive than the Klamath Peneplain, is called the Bellspring Peneplain.

There were many stages of uplift and erosion following the completion of the Bellspring Peneplain. These deformations raised the plain to 2500 feet, but then subsequently lowered it to within 500 feet of sea level. During this subsidence and at the lowest level, the Gold Bluffs Formation was deposited on the still-relatively continuous peneplain surface (Diller, 1902).

} evidence?
Diller, I presume

Did he use the term Gold Bluffs fm?

The ancestral Trinity River flowed over the remnants of the Klamath and Bellspring Peneplains in Plio-Pleistocene time. This ancestral river ^{flowed} ran at a moderate rate, as evidenced by the size of the cobbles it carried. Its flood plain was large, extending from the present Klamath River drainage in the north to an unknown point ^{probably} about 10 or 12 miles to the south. The actual width can only be speculated on, as no continuous remnant of the sediments remain.

By mid-Pleistocene, the peneplain had reached a level 500) source ? feet above sea level. Uplift of the Coast Ranges caused by thrust faulting began again, cutting off the river, which then ^{commenced to} ~~flowed~~) reference ? north, through what is now Hoopa Valley and out to sea in partnership with the pre-existing Klamath River. This uplift did not disturb the Klamath's path to the sea, so it continued to flow as it had.

At the present time, this last stage of uplift has brought the remains of the highly dissected peneplains to a level above most of the surrounding areas. The highest Gold Bluffs Formation remains are on French Camp Ridge at an elevation of 3000 feet.

CONCLUSION

The Gold Bluffs Formation is a ^{predom.} mostly non-marine sedimentary deposit that is composed mostly of semi-consolidated conglomerate.

It was deposited on the remnants of the extensive Klamath-Bellspring Peneplain in the Klamath region of northern California by the ancestral Trinity River. Mid-Pleistocene uplift in the Coast Ranges cut off the river and forced it north into the Klamath River. Since that time, the Gold Bluff Formation sediments have been uplifted and eroded and are now exposed only as isolated, intensely weathered patches of conglomerate at elevations anywhere from sea-level to 3000 feet.

Since these deposits are no longer continuous from east to west, they must be correlated to justify calling them all the Gold Bluffs Formation, a name which, until now, has been applied only to the deposit north of Orick, west of Highway 101 (Young, personal communication; Irwin, 1960). ^{Did Irwin use this name?}

Deposits at Gold Bluffs-Redwood Park and French Camp Ridge can be ^{tentatively} correlated using relative numbers and distribution of conglomerate cobbles, and analyses of granitics and jades present as cobbles.

The Johnson Road deposit was not correlated due to its heavily weathered nature, but it can be assumed that it was a part of the Gold Bluffs Formation, as it lies in a direct line (the old river's path) from Gold Bluffs to French Camp Ridge.

In this paper, I have presented probable correlations between the conglomerate compositions and the characteristics of

the conglomerate on French Camp Ridge with that at Gold Bluffs-Redwood Park. Criswell's paleo-study of Gold Bluffs (1968) and Diller's (1902) positions for the peneplains on which the formation was deposited correspond and indicate the same age: Plio-Pleistocene.

Based on my findings, I feel that there is considerable justification in naming all the conglomerate deposits herein discussed the Gold Bluffs Formation, of non-marine origin and Plio-Pleistocene age.

APPENDIX I PEBBLE COUNTS

Four pebble counts were taken, two at Gold Bluffs, and two on French Camp Ridge. The two at French Camp Ridge were from the north and south ends of the ridge. The counts taken from Gold Bluffs were one from the upper section, just off the Fern Canyon Road two miles from the beach, and one from a cliff on the beach, south of Fern Canyon.

The pebbles were collected by sifting *thru 1/2" screen* the loose conglomerate material from holes dug one yard square and of uniform depth (depth *1" or 1 yd?* depending upon soil conditions at the particular location).

The graphs from these pebble counts are based on percent volume of the samples (as determined by water displacement) and on percent number of particles each rock type represented for the whole sample in question.

All pebbles collected were greater than one half inch in size.

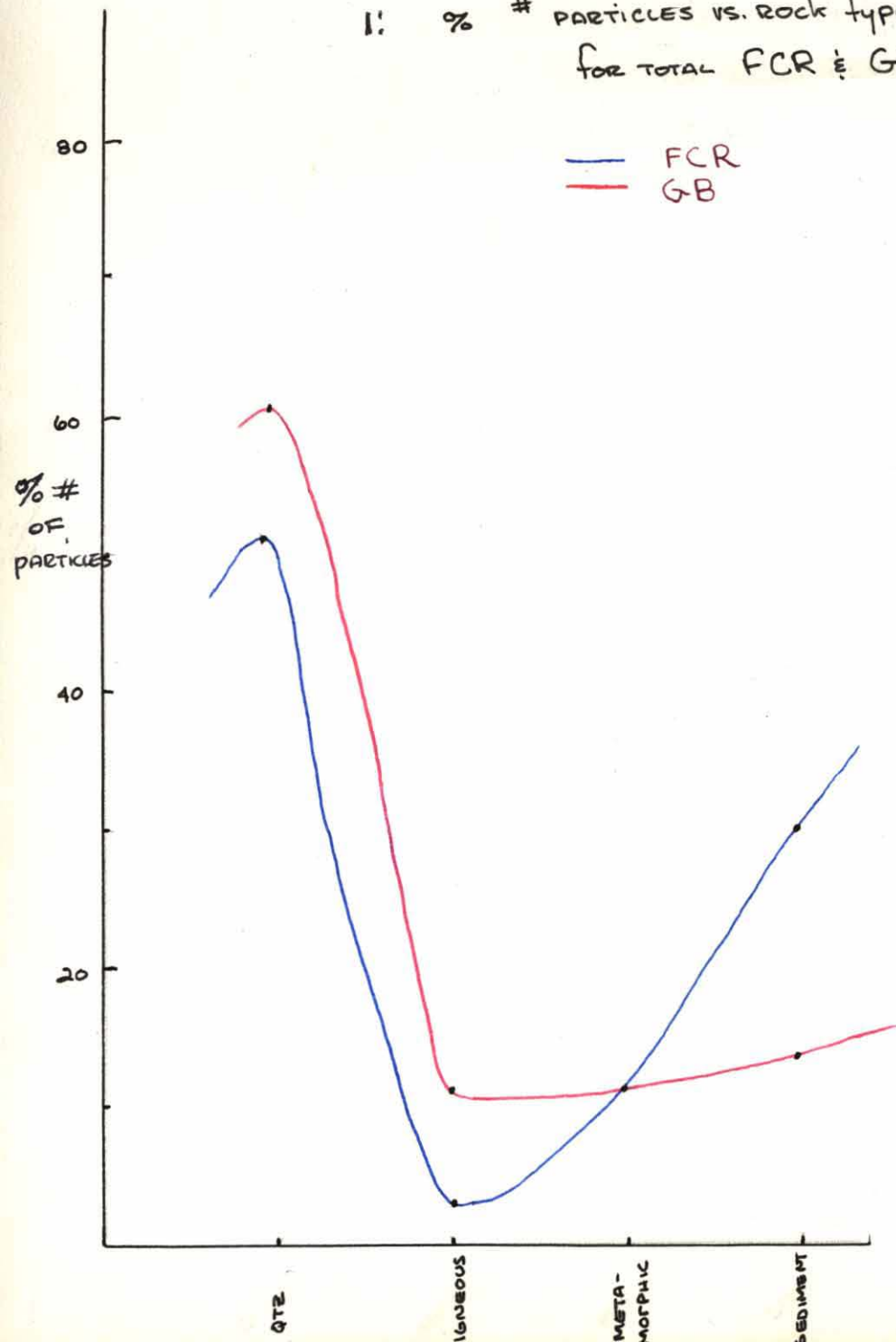
On the following diagrams the category "quartz" includes milky quartz and chert, since these are the two most resistant materials found and their compositions are the same. "Igneous" includes hornblende diorites, diorites and gabbro. The "metamorphics" are *meta* greywacke and gneiss. "Sediments" are greywacke and dense small-pebble conglomerate, both mostly from the Franciscan Formation. These four categories are arranged on the diagrams in order of their decreasing resistance (quartz on the left, then igneous, metamorphic, and sediments on the right).

to weather

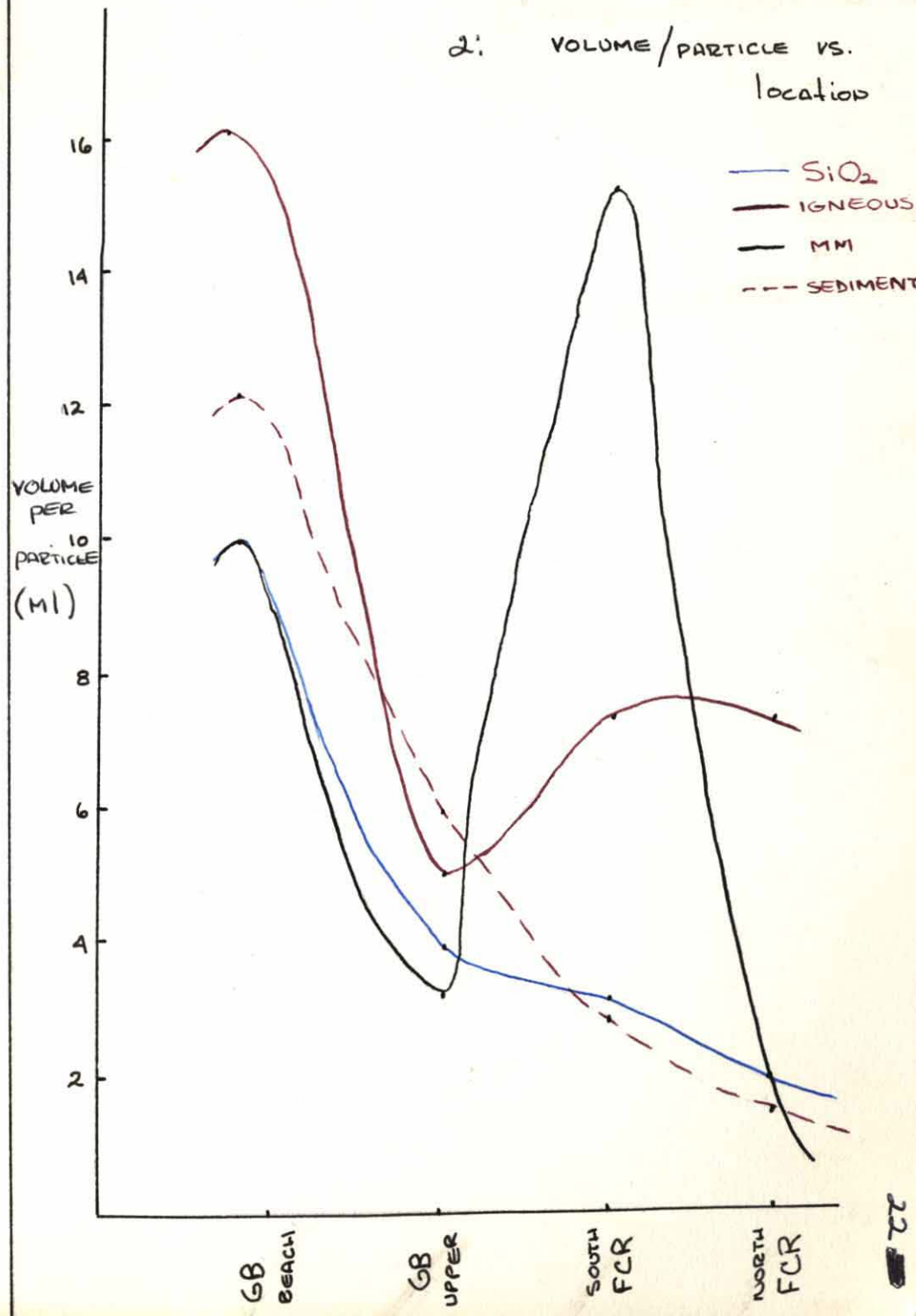
Diagram ¹~~one~~ shows how Gold Bluffs is a more realistic cross section of the original conglomerate cobbles, as it isn't overloaded with more resistant material, as is French Camp Ridge. Diagram ²~~two~~ shows how the more resistant cobbles are larger than the others, as would be expected. (the large peak for metamorphics at south FCR cannot be explained at this time).

Diagrams 3 & 4 clearly show how the underlying rock type effects the composition of the overlying cobbles at French Camp Ridge and somewhat at the other locations.

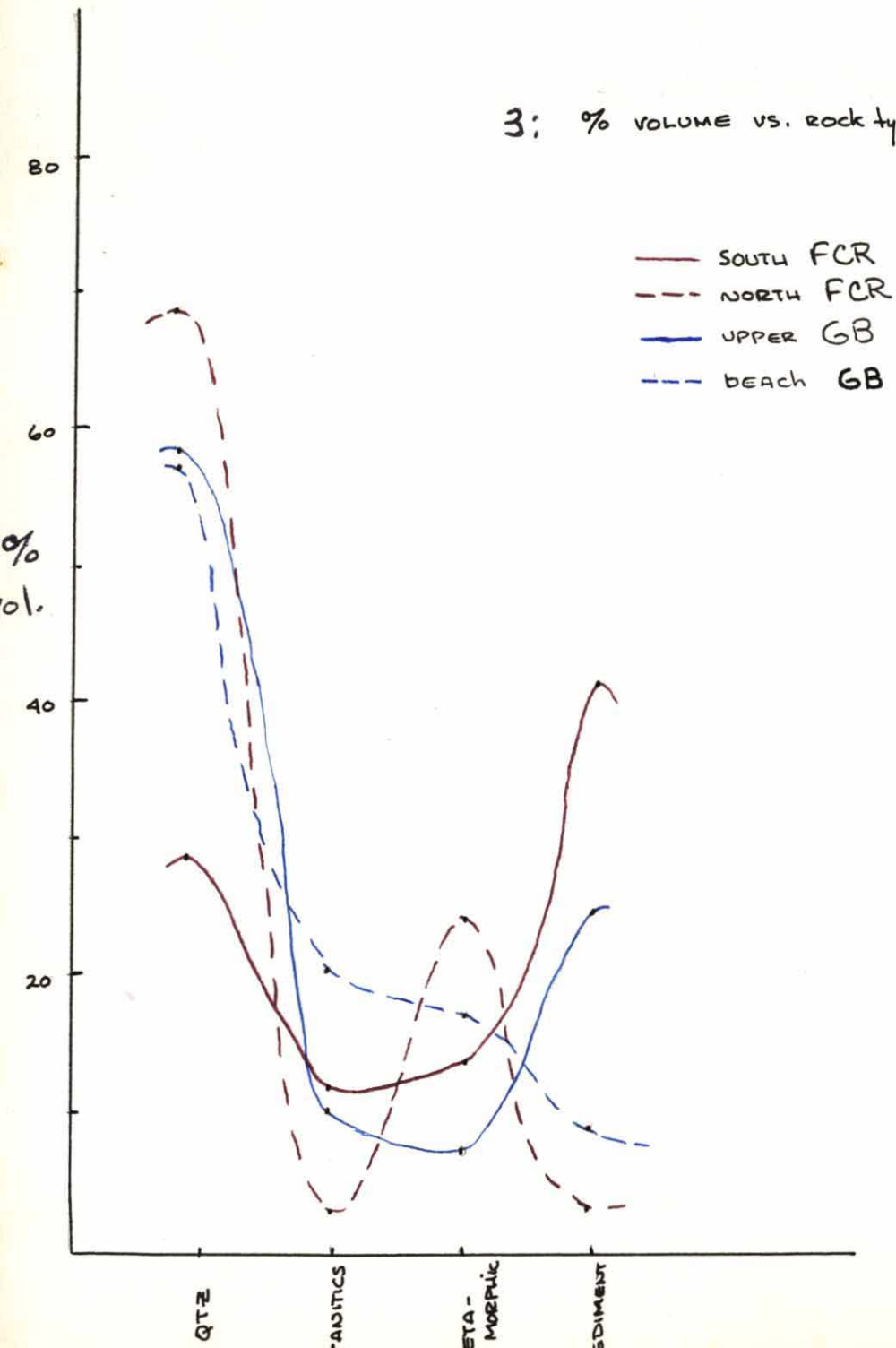
1: % # PARTICLES VS. ROCK TYPES
FOR TOTAL FCR & GB



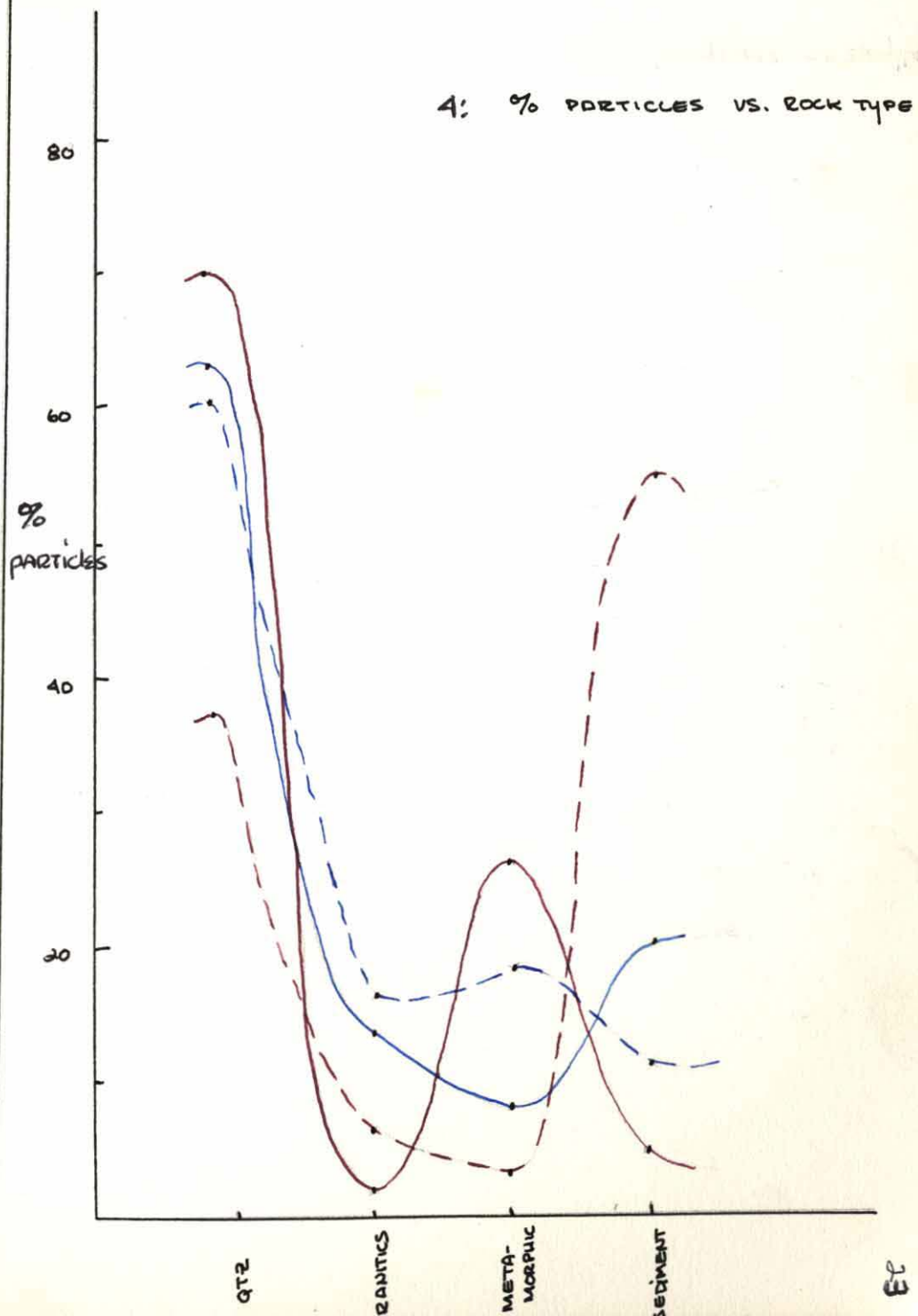
2: VOLUME / PARTICLE VS.
location



3: % VOLUME VS. ROCK TYPE



4: % PARTICLES VS. ROCK TYPE



APPENDIX II THIN SECTIONS

Note: Due to badly weathered condition of most of these rocks, these thin sections are thicker than is usually desirable. To take them down to the standard .03 inch thickness would mean destroying 9/10 of the rock material on the slide. Therefore, the minerals present were difficult to determine; quartz is highly birefringent and presents a peculiar optical figure, hornblende and plagioclase are sometimes almost opaque, etc.. These thin section descriptions are only partial, as I have stated no specific rock-type or origin for most of them. It is, however, stated when a rock might possibly have been granitic, as those are the ones used in the correlation.

GOLD BLUFFS

GB13 Hand specimen: well rounded, conglomerate with mostly angular quartz, which is very fractured, very hard but poorly consolidated (irregular groundmass), fragments mostly dark grey & black

T.S.: Quartz: 87%; angular, fractured grains up to 2 cm across, grey, green, buff, brown coloured, poorly cemented, edges slightly rounded, mostly chert, angular, microcrystalline

Limonite & magnetite: 5%; as stain (yellow discolouration of quartz) as opaque cement and as a few euhedral opaque grains

Muscovite: 3%; vein filling and occasional irregular flakes

unknown: one large dark crystalline grain, probably metamorphic (5%)

Rock: Conglomerate, probably from the Franciscan

*

GB27 Hand Specimen: dk brown, fine to medium grained, very dense rock, fragments semi-aligned, few fractures, discoloured yellow around edges, in and along fractures

T.S.: Quartz: 80%; angular chert particles from 1mm to 3cm, most stained brown, aligned with long directions semi-parallel

Muscovite: 5%; interstitial, irregular flakes of secondary origin

unknown: 15%; some grains might be of metamorphic or igneous origin, namely schist, diorite and others

Rock: partially metamorphosed conglomerate (probably Franciscan)

*

GB68 Hand specimen: very crumbly, pink with yellow weathering crust up to $\frac{1}{2}$ inch, semi-porous, buff angular, some euhedral crystals, in pink and yellow groundmass

T.S.: Quartz & clays: 90%; as intergrown groundmass

Hornblende (?): some brown patches with faint crystal outlines suggest possibly might have been hornblende

Plagioclase: relic grains, now quartz, but have plagioclase outline

Rock: possibly granitic

*

GB69 Hand specimen: light grey, crumbly rock with irregular buff inclusions with very small randomly scattered black laths

T.S.: Quartz: 82%; groundmass

Plagioclase: 10%; relic crystals, semihedral, An₃₀ - Andesine-Oligoclase, some are completely altered

Hornblende: 8%; brown relic grains, still lath shaped and pleochroic up to several mm long

Rock: granitic; possibly hornblende-rich volcanic

*

REDWOOD PARK

RP7 Hand specimen: yellow-brown, well-rounded dense rock; interior dark grey with angular white xls and laths; weathering rind is irregular up to 3/4 inch thick

T.S.: Plagioclase: 60%; andesine, groundmass intergrowth and large (3-7 mm) white, weathered, semi-hedral grains

Hornblende: 37%; green and green-brown phenocrysts

Magnetite: 3%; small black irregular grains in association with hornblende

Rock: Hornblende diorite (or at least basic granitic)

*

RP14 Hand specimen: large, well-rounded, dark grey rock; interior dark grey groundmass with white laths and angular xls plus irregular black xls with evident cleavage

T.S.: Hornblende: Green, intensely altered to mica and discoloured by limonite, mostly laths, some terminated, some penetration twins

Plagioclase: relic grains, some show twinning, (albite & penetration twins), composition An₅₅-Labradorite, discoloured, partially altered along edges to mica, distinct zones of alteration visible in some grains

Rock: hornblende diorite (or at least basic granitic)

*

RP19 Hand specimen: well-rounded, very weathered & crumbly, white & dark grey mottled rock, yellow stain along fractures; interior dark cleavable masses in white quartz (?) matrix

T.S.: (very thick slide)

Hornblende: 50%; brown laths & intergrowths, some iron-stained, some slightly pleochroic

Unknown: 50%; either quartz or plagioclase; thick grey, irregular nearly opaque masses between hb xls

Rock: if grey matter is plagioclase, possibly a hb diorite

*

RP40 Hand specimen: white & brown mottled, wellrounded, smooth interior dark green, irregular masses in light buff groundmass, some green masses altered to orange-brown material

T.S.: Hornblende: 50%; rounded masses of green hb, surrounded by thin weathering rings of chlorite (?) & magnetite, grains up to $2\frac{1}{2}$ cm across

Plagioclase: 40%; composition indeterminate, cloudy grey semi-hedral xls between hb grains

Muscovite: 10%; secondary flakes between other grains & as alteration of some of the hb

Rock: could have been igneous

*

FR3

FRENCH CAMP RIDGE

FR3 Hand specimen: light brown, fine grained, dense rock with occasional dark, rounded phenocrysts (5X groundmass size), exterior well rounded, interior darker colour with much pink grains suggesting orthoclase

T.S.: Plagioclase: 60%; from $\frac{1}{2}$ to 2 mm, angular & rounded grains, An₆₀, Labradorite, matrix intergrowths of nearly sub-microscopic xls

Quartz: 35%; angular grains, not interstitial

Magnetite: 5%; less than 1 mm in size, semihedral, random grains, some surrounding & in relic plagioclase & mm grains

Rock: granitic (?)

*

FR17 Hand specimen: pink, weathered to yellow outside, rounded rock with large angular phenocrysts (possibly qtz) in pink groundmass

T.S.: Quartz: 70%; large angular (1mm-12mm) submicrogranular particles, individual grains fractured & veined with muscovite, but not the matrix, suggesting sedimentary nature of rock

Matrix: 28%; bright red, iron-stained, probably mostly quartz

Muscovite: 2%; occasional irregular random particles

Rock: relic sediment

*

FR201 Hand specimen: highly fractured, dense conglomerate; particles large & well-rounded, aligned in some sections. Dark colored rock, fractures filled with lighter material

T.S.: Quartz: 80%; chert, large anhedral, angular fragments, greenish no figure visible, only original grains left

Limonite & magnetite: 15%; opaque masses in & surrounding relic metamorphic & sediment grains, stains many chert & other grains yellow and brown-red

Muscovite: 5%; secondary, in cracks, between grains, part of matrix, often growth from sides of a cavity

Rock: quartz conglomerate, probably from the Franciscan Formation

APPENDIX III X-RAY WORK

These are the results obtained from x-ray analyses of some of the conglomerate pebbles. The x-ray powder diffractometer used was a Siemens Crystalloflex IV belonging to the Geology Department, Humboldt State College.

Quartz is abbreviated with "Q" and tremolite or nephrite is underlined, as it was the most important mineral in this analysis.

French Camp Ridge

composition:

1	Q, Montmorillonite, fluormica
4	Q
17	Q, Montmorillonite
19	Q, serpentine, illite
32	Q
34	Q, (?)
40	Q, goethite
41	Q, illite
47	Q, <u>tremolite</u> , montmorillonite, ilmenite
48	Q, <u>tremolite</u> , oligoclase
70	Q, (?)
73	Q, chlorite

Gold Bluffs

3	<u>Tremolite</u> , ilmenite, serpentine
9	Q, chlorite, muscovite, montmorillonite, serp.
51	Q, andesine, serpentine, chlorite
66	Q
68	Q, muscovite, montmorillonite
69	Q, andesine, hedenburgite
71	Q, <u>tremolite</u> , andesine, marcasite
72	Q, <u>tremolite</u> , gibbsite
73	Chlorite, <u>tremolite</u> , andesine, hornblende

Johnson Road

1	Q, goethite
8	Q, goethite
23	Q
25	Q, montmorillonite

Redwood Park

8	Oligoclase, riebeckite
15	<u>Tremolite, (covellite)</u>
19	Q, andesite, chlorite, montmor., <u>tremolite</u>
30	<u>Tremolite, oligoclase, (Q)</u>
42	<u>Tremolite, oligoclase</u>
44	Q, antigorite
299	Montmorillonite

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