Appendix C:
Geologic Reports and Studies

Appendix C: Geologic Reports and Studies

No.	Date	Document
1.	June 18, 1939	Tolman, C.F., "Report on Tonnage and Composition of Limestone Available in Proposed Quarries A and B, Permanente Corporation, and Superficial Residuary Clay on the Property of the Permanente Corporation, Santa Clara County, California," Stanford University
2.	November, 1946	Pantin, Jose Henrique, "Insoluble Residues of the Calera Limestone in Santa Clara County, California," Stanford University
3.	May 28, 1982	Mathieson, Elizabeth, "Geology of the Permanente Property, Kaiser Cement Corporation, Permanente, California"
4.	February 9, 2007	Drilling / Geologic Map

C. F. TOLMAN
STANFORD UNIVERSITY
CALIFORNIA

June 18, 1939

The Permanente Corporation
1522 Latham Square Building
Oakland, California

Gentlemen:

At your request I submit the results of our sampling of a portion of the Permanente limestone, situated on the southern slope of Bald Peak and on the northern slope of Permanente canyon. The area sampled lies above the 1500 foot level, and also above the mass of Franciscan sandstone and volcanics which separates the great limestone body into two portions. The area sampled covers the Southeast Quarter of Section 18, Township 7 South, Range 2 West and does not include large and easily available bodies of high grade limestone north and east of this area nor the large mass of limestone below the 1500 level on the northern slope of Permanente canyon, nor the mass of limestone south of Permanente Creek. These three additional areas contain large tonnages of high grade "dark" limestone.

The area sampled and the areal extent of the entire body of Permanente limestone is shown on the Location Map accompanying this report.

The present preliminary report is accompanied by the following photographs, maps and tabulations:

I. Panorama (In Envelope).

Panorama of the south slope of Bald Peak showing the limestone body from Permanente Creek to the top of Bald Peak and the included beds of Franciscan sandstone and volcanics (andesite), trenches dug for sampling, the old lower and upper quarries, and the location of proposed quarries A and B.

II. Maps and Geologic Sections.

(1). Location map showing extent of Permanente limestone and clay areas sampled. (In roll).

(2) Geologic map of the area above the 1500 foot contour embracing proposed new quarries A and B. (In roll).

(3) Sample map of the area of proposed new quarries A and B. (In roll).

(4) Geologic cross sections showing geology and chemical composition of areas embraced in proposed quarries A and B. The estimates of tonnage and calculations of average value are based on these cross sections. (In envelope).

(5) Map of Clay Area A. (In roll).

(6) Map of Clay Area B. (In roll).

(7) Map of Clay Area C. (In roll).

(8) Map of Clay Area D. (In roll).

III. Tabulations.

(1) Tabulations of chemical analyses of limestone to

date.

(A) Jack hammer samples.

(B) Diamond drill samples.

(C) Hand samples.

(2) Tabulations of analyses of surface clay to date.

(3) Tabulations of analyses of andesite and associated sandstone formation.

(A) Upper andesite.

(B) Franciscan sandstone and shale along west limestone contact.

(C) Interbedded Franciscan sandstone and shale.

(4)A) Analyses of bay clays north of the Bayshore Highway (Poland Hand Samples of Clays).

(B) Logs of wells in area east of Bayshore Highway.

(5) Tabulations showing tonnage and composition of the Permanente limestone available within the proposed quarry sites A and B. (Text, pp. 17 and 18).

(6) Tabulations showing tonnage of clay available on the properties of the Permanente Corporation. (Text, p. 20).

Respectfully submitted,

Tolman, C. F.

REPORT ON TONNAGE AND COMPOSITION OF LIMESTONE AVAILABLE IN PROPOSED QUARRIES A AND B, PERMANENTE CORPORATION, AND SUPERFICIAL RESIDUARY CLAY ON THE PROPERTY OF THE PERMANENTE CORPORATION SANTA CLARA COUNTY, CALIFORNIA

PART I, (TEXT)

C. F. Tolman

Stanford University

June 18, 1939

REPORT ON TONNAGE AND COMPOSITION OF LIMESTONE AVAILABLE IN PROPOSED QUARRIES A AND B, PERMANENTE CORPORATION, AND SUPERFICIAL RESIDUARY CLAY ON THE PROPERTY OF THE PERMANENTE CORPORATION SANTA CLARA COUNTY, CALIFORNIA

Part I, (Text)

SUMMARY OF REPORT

The Permanente limestone available above the lowest level of the two proposed quarries consists of three limestone formations: (1) lower "white" cherty limestone, (2) "dark" high grade limestone, (3) upper "white" cherty limestone.

The average composition and tonnage available of these three types of limestone above the 1500 foot level (in the proposed quarries) are as follows:

		Tons	Composition
Upper light limestone	=	1,341,600	72.04% $CaCO_3$
Dark limestone	=	15,320,000	86.21% $CaCO_3$
Lower light limestone	=	13,430,000	69.07% $CaCO_3$

Interstratified between the lower "white" limestone and the high grade "dark" limestone is a bed of clayey Franciscan sandstone about 30 feet thick. The tonnage of this material is 2,444,000 tons. The chemical composition is given in Tabulation No. 3 C. This material can either be wasted or utilized to mix with the clay-bearing portion of the cement mix.

The limestone formations mentioned above rest on a thick block of Franciscan sandstone and volcanics (andesite). This formation limits the base of the upper quarry and by its thickness greatly reduces the available tonnage of limestone underlying the sandstone and extending down to the bottom of the canyon of Permanente Creek.

Most of the available limestone above the 1500 foot level can be extracted from the two proposed quarries. If it is desired to utilize all of the limestone above the Franciscan base a subsidiary quarry can be run in from the 1400 foot level to extract the material below the 1500 foot level.

The geologic cross sections have been used to calculate tonnage and average composition of the three limestone formations. They should also be used in laying out the proposed quarries.

Finally, only a portion of the available tonnage of high grade "dark" limestone on the Permanente property will be extracted from the proposed quarries. The extent of the entire Permanente limestone body is shown on the Location Map attached to this report.

Clay.

3,697,100 tons gross and 2,137,550 ~~2,835,500~~ tons after coarse is deducted of residuary clay capping most of the property of the Permanente Corporation has been sampled and analyzed, and the analyses are attached herewith.

Unlimited deposits of bay clays are available in the swamp lands of the San Francisco Bay eight miles from the property of the Corporation and clays of similar character occur under a thin layer of overburden between the bay and Bayshore Highway.

PERMANENTE FORAMINIFERAL LIMESTONE

The limestone body herein described is the largest known deposit of foraminiferal limestone of Franciscan Age. Exposures of this type of limestone were mapped by A. C. Lawson in the San Mateo and Tamalpais quadrangles[1], by J. C. Branner in the Santa Cruz quadrangle (including the Permanente deposit)[2], and the continuation of this zone was mapped by John van Steen Tolman south of Guadalupe Creek and on Calero Creek south of Calero damsite in the New Almaden quadrangle.[3] Limestone occurs as lenticular masses in this zone nearly one hundred miles long.

By far the largest and most important of these deposits is the Permanente limestone mass. Detailed drilling and sampling has shown that the Permanente limestone is divided into three distinct units: (1) the lower "white" limestone, also designated in the field as cherty white limestone, averaging 200 feet in thickness as shown in the geologic cross sections; (2) the central formation of "dark" limestone, averaging 200 feet in thickness, also called blue limestone on account of the color of weathered surfaces, colored by hydrocarbon residues; it contains

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[1] U.S. Geol. Surv. Geologic Atlas, San Francisco Folio, No. 193, p. 22, 1914.

[2] U.S. Geol. Surv. Geologic Atlas, Santa Cruz Folio, No. 163, 1909.

[3] Geological Report on the Calero, Almaden, and Guadalupe Damsites, Plate VIII, 1934.

only a small amount of chert; (3) the upper horizon of "white" limestone with much interbedded chert, similar in character and composition to the lower horizon of "white" limestone.

The base of this series is a wedge-shaped mass of Franciscan volcanics and sandstone, the uppermost contact of which lies in the vicinity of the 1500 foot level and will form the bottom of the proposed quarry B. Below the Franciscan inclusion the limestone series is repeated by thrust faulting, and a large additional tonnage of available limestone not included in this report occurs below the 1500 foot contour down to Permanente Creek and also on the mountain slopes south of the creek. The investigation of the details of this faulting and of the structure of the entire mass of limestone has not as yet been completed and will be discussed in the final report and depicted in the final cross sections. The accompanying cross sections show the structure in so far as it affects the proposed quarries A and B.

An interesting feature discovered by detailed sampling is the uniformly high grade of the "dark" limestone and the uniformly lower grade of the two "white" limestone members carrying interbedded chert. This relation is constant and geologic structure was determined by lithology (color of formation), chemical composition, and by the attitude of the beds shown by dips and strikes. It seems probable that conditions which developed the small amount of hydrocarbons in the enclosed basin in which the "dark" foraminiferal limestone was laid down were unfavorable for the deposition of abundant chert, while in the absence of hydrocarbons the micro-organisms secreting silica and the foraminifera secreting calcium carbonate were both active.

The separation of the deposit into one high grade (in calcium carbonate) and two lower grade members is of economic importance. As shown on the geologic cross sections the "dark" limestone and the "white" limestone can be quarried separately, and any mixture desirable can be sent to the cement mill.

If the "white" limestone is used in large amounts the chert must be separated from the limestone. This can be accomplished in part by rejecting the larger chert beds in quarrying and nearly complete elimination of chert can be accomplished by flotation. Mixing of high grade "dark" limestone with the lower grade "white" limestone might make it possible to manufacture cement for many years without recourse to flotation, and, in any case, probably only the "white" limestone, and possibly only a portion of the "white" limestone, will be treated by flotation.

As the important geologic features are depicted on the maps and cross sections, these are described briefly in the following paragraphs with emphasis laid on the features of practical importance in regard to quarrying and mixing for cement. Further technical geologic description will be reserved for the final report.

DESCRIPTION OF PANORAMA OF SOUTHERN SLOPE OF BALD PEAK TO PERMANENTE CREEK (TAKEN JUNE 13, 1939).

This panorama shows Trenches No. II, III, IV, and V and diamond drills at Holes No. 9 at right, 8 at center, and 6 at left. The wedge of Franciscan sandstone and volcanics is shown in the center ground and widens greatly to the right, that is, towards the east, cutting out both the upper and lower limestone bodies east of the two old quarries. Hence, the continuation of the limestone beyond the proposed quarries lies to the northeast of the present Upper Quarry. This relation is shown on the Location Map.

The photograph was taken on the high ridge south of Permanente Creek, and hence the limestone south of the creek is not shown on the photograph.

DESCRIPTION OF GEOLOGIC MAP.

The geologic map of the proposed quarries A and B of the Permanente Corporation shows the areal extent of the geologic formations enumerated in the introductory paragraph. On it are plotted the numerous strikes and dips registering the attitude of the beds that were measured during this examination. As much of the area is covered with brush and soil, trenching was necessary to expose the limestone formations.

The outcrop areas of the "dark" limestone with high calcium carbonate content and low in chert are shown in blue. There are two areas of this formation shown on the map, a minor strip parallel to the main fault zone (also described as the "boundary fault") which cuts and terminates the Permanente limestone on the northwest, and the main outcrop, approximately one half the area mapped, bounded on the northwest by the "breccia fault".

This body of high grade limestone makes the deposit commercially valuable, and without it the two "white" cherty members would probably not be of commercial value.

The "dark" limestone surrounds the outcrop area of upper "white" cherty limestone, and this in turn encloses the upper Franciscan andesite. This pattern of older beds surrounding younger members is a graphic representation of the main structure of the limestone body above the 1500 foot level; namely, a syncline or trough plunging towards the east (see cross sections).

The "upper andesite", colored in green at the right center of the area mapped, widens rapidly towards the east of the quarry area and joins the main body of Franciscan andesite and sandstone shown on the map. This thickening of the volcanic members shown at the bottom of the map cuts out the limestone to the east of the area mapped.

The lower cherty limestone, colored in pink, lies south of the "dark" limestone and above the main included mass of Franciscan andesite and sandstone. It is brought up again northwest of the main body of "dark" limestone by the "breccia fault". The narrow band of "dark" limestone mentioned previously borders the lower cherty limestone on the northwest and is completely cut off by a great "boundary" fault zone, the hanging wall of which is shown on the map.

STRUCTURAL CROSS SECTIONS.

The geologic structure is shown on vertical cross sections which are usually constructed from formational boundaries and strike and dip observations plotted on the geologic maps. In addition to these data we have used the following information:

(1) Core samples obtained from ten diamond drill holes which show the character of rock and attitude of beds in each hole.

(2) The logs of nine diamond drill holes put down by the Santa Clara Holding Company and chemical analyses of this material.

(3) The logs of three churn drill holes bored by the California Portland Cement Company and chemical analyses of sludge samples.

(4) Jack hammer samples. These holes were from 12 to 20 feet deep and were spaced at 50 foot intervals. The dry cuttings were collected, and character of each sample shows type of limestone. These samples were analyzed.

In plotting all the above data it was discovered that the sedimentary sequence - namely, (1) the lower "white" cherty limestone, (2) the intermediate "dark" non-cherty limestone, and (3) the upper "white" cherty limestone - was well established. Color, chemical analysis and occurrence all gave an identical sequence of formations. The maps and cross sections showing chemical composition are identical with the maps and cross sections on which geologic formations are plotted.

This result was both surprising and satisfactory as it was feared, before the detailed studies were carried on, that the chert might be distributed erratically throughout the limestone sequence and that large bodies of homogenous high grade material might not exist.

The definite formational boundaries between these three types of limestone also assisted in determining the structure of the deposit, and, therefore, the accompanying geologic cross sections are far more accurate than could have been made from geologic observations at ground surface alone, no matter how detailed such observations might be.

Structural Cross Section through Trench No. II.

This section shows the geologic conditions near the eastern margin of the proposed quarries and also the position of the upper andesite exposed where the trench intersects the road to the Permanente Clubhouse. Diamond Drill Hole No. 7 was put down in the center of this volcanic material. The analyses of this "upper andesite" are tabulated. It appears that it can be incorporated in the clay of the cement mix if the clay is low in magnesia and silica.

The bulk of the material shown in this section is high grade "dark" limestone which averages a little over 200 feet in thickness. A band of Franciscan sandstone which contains a little andesite in Drill Hole No. 1 averages about 40 feet thick in the section, thinning towards the north. The analyses of this interbedded layer of sandstone is shown in Tabulation No. 3.

If this material can be used as a portion of the clay constituent of the cement mix, it will not be necessary to waste it in quarrying.

Only a small thickness of the upper "white" limestone is shown in this section.

The lower "white" limestone has been penetrated to a depth of 230 feet in Hole No. 5 and 223 feet in Drill Hole No. 6 which did not reach to the underlying Franciscan sandstone. The position of the main block of andesite and sandstone will be indicated more accurately after Drill Holes No. 8, 9 and 10 reach this material. It is hoped, therefore, that these holes will be continued until the underlying Franciscan material is encountered.

The upper andesite shown in Drill Hole No. 7 lies in the faulted syncline. This syncline is the main structural feature of the limestone body and was mentioned in the description of the geologic map. At the south end of the section the limestone is folded, and the anticline is dragged into the overturned position by the thrust fault at the contact with the main Franciscan block.

Cross Section through Trench No. III.

This cross section shows the lower cherty member 150 to 200 feet thick, the interbedded Franciscan layer 15 to 50 feet thick, and the maximum thickness of the "dark" non-cherty member varying from 220 feet to nearly 300 feet in this cross section.

The bulk of the material south of Drill Hole No. 2 encountered in this portion of the quarry will be the high grade "dark" limestone.

The main syncline shown in the cross section has flattened into a gentle structure. The overturn along the thrust fault is pronounced. The main fault which cuts off the limestone body lies just north of the section, and the parallel "breccia fault" is shown on the north end of the section.

Cross Section through Trench No. IV.

In cross section No. 4 the main boundary fault is shown at the north and the parallel "breccia fault" some 300 feet to the south. The high grade "dark" limestone is from 180 to 200 feet in this section and is separated from the underlying "white" limestone by the bed of Franciscan sandstone (shown in all the cross sections) 15 to

30 feet thick. The average thickness of the lower limestone as determined from the log of Drill Hole No. 5 is about 200 feet.

In this section the high grade limestone forms a belt of nearly 200 feet in thickness, approximately parallel to the ground surface, extending from the cliffs just above the main Franciscan contact to a point 290 feet south of the property line.

The main synclinal structure has flattened out into two gentle undulations approximately parallel with the ground surface.

This section is extended across Permanente canyon to the base of the limestone south of Permanente Creek. The structure of the limestone members is indicated by plotting the contacts between the lower "white" limestone, the "dark" limestone, and the upper "white" limestone. The structure of the lower body will be portrayed in detail in the final report.

Cross Section through Trench No. V.

This interesting cross section shows the "boundary fault" at the north end of the section and the "breccia fault", also shown in the cross section through Trench No. IV. It also shows a local compression of the main syncline and the universal overturning of strata at the Franciscan sandstone contact at the base of the proposed quarry. The interstratified layer of Franciscan sandstone shown in all the cross sections feathers out at the south end of the section. The "dark" high grade limestone in this section of the quarry will not average over 50 feet in thickness and will comprise the near-surface material.

To quarry the large body of lower "white" limestone it will be necessary either to utilize or to waste the interbedded Franciscan sandstone layer.

The limestone is entirely cut off about 100 feet south of the property line by the "boundary fault", and from this point for a distance of 190 feet southerly the "dark" limestone constitutes a thin surface cap. Under this cap and extending to the "breccia fault" 360 feet south of the "boundary fault", a thickness of about 200 feet of the underlying "white" cherty limestone only is available for quarrying.

Cross Section through Drill Holes W-1 and DD 2, 5 and 6.

This cross section is approximately at right angles to the cross sections previously described and may be considered a longitudinal cross section roughly parallel to the northerly quarry faces.

This cross section brings out the continuity of the included stratum of Franciscan sandstone which separates the "dark" limestone from the underlying "white" cherty limestone. It shows the cutting out of the "dark" limestone at the west end of the section by the "breccia fault".

The Practical Value of the Cross Sections.

The north-south cross sections are used to determine tonnage and average value of the quarry above the 1500 foot level. All the material above that level can be worked out by two quarries, one at about the 1500 foot level, and the second at the 1700 foot level.

These cross sections can serve as a guide if it is desired to mine exclusively the high grade "dark" limestone for a number of years and for the laying out of the quarry to get any desired percentage mixture of the "dark" and the "white" limestone.

The interbedded layer of Franciscan sandstone will either be wasted or used in the clay mix. This tonnage, therefore, can be added to the available clay supply. In any case, it must be deducted from the limestone tonnage.

Due to request for prompt transmission of this report, these sections were not reduced to the same scale as the geologic map.

SAMPLING

Three sampling methods were used in the exploration of the limestone body at Permanente; namely, diamond drilling, jack hammer drilling and moiled hand channels across exposed outcrops. It was first thought that the hand channel sampling would be important. However, two main obstacles were encountered in hand sampling: (1) the scarcity of exposures that could be fairly sampled and (2) differential weathering of limestone which caused the chert to protrude on the rock surfaces. The latter caused silica to be added to the sample unless extreme care was maintained.

The jackhammer sampling was developed to supplement the hand channel samples. Holes were drilled at fifty foot intervals along each of the five trenches that were cut down to bedrock. The holes varied in depth according to the type of rock drilled. Twenty foot holes were drilled where the rock was homogenous and did not cave badly, and the average hole was between twelve and sixteen feet deep.

Each hole was divided into four foot sample intervals, and during drilling all cuttings were blown from the hole by means of a blowpipe and drillings for each four feet constituted a sample. The cuttings were collected by means of a powder box fitted with the necessary holes and gaskets so that the drillings would be blown into the box container. All drilling was done without water, and the cuttings were easily lifted by the blowpipe from these comparatively shallow depths.

The diamond drill sampling is primarily dependent upon continuous sludge return. The broken and laminated character of the rock rarely allows more than 25% core recovery. Continuous sludge return was obtained by cementing the hole whenever the water was lost during drilling, and further, by cementing at the end of each shift. All of the cuttings during the drilling of each five foot run were collected and washed in a large tub, dried, quartered and preserved as a sample.

All of the core that was recovered was placed in individual core boxes and after examination was split into two equal parts. One part was crushed, pulverized and analyzed, while the other was permanently filed in a core box.

Where appreciable core was recovered the core and sludge analyses were combined according to the percent of core recovered.

TONNAGE ESTIMATES

Method of Calculation.

The tonnage of the limestone was calculated as follows:

Planimeter measurements were made of each formation. Each cross sectional area was multiplied by one half the distance between adjacent trenches for section 3 and 4. The tonnage represented by Trench II was determined by multiplying the areas by a width of 386 feet. The tonnage represented by Trench V was determined by multiplying the planimeter area by 236 feet, and the triangular shaped additional area to the west was determined by multiplying one half the planimeter area of Trench V by 300 feet.

Tonnage of Formations.

1700 - 1900 Quarry:

Upper light limestone = 577,000 tons
Dark limestone = 8,433,000 tons
Lower light limestone = 6,665,000 tons
Total limestone = 15,675,000 tons
Upper Andesite = 131,000 tons
Franciscan sandstone & andesite = 873,000 tons

1500 - 1700 Quarry:

Upper light limestone = 764,600 tons
Dark limestone = 6,887,000 tons
Lower light limestone = 6,765,000 tons
Total limestone = 14,416,600 tons
Franciscan sandstone & andesite = 1,571,000 tons

Total Both Quarries:

Upper light limestone = 1,341,600 tons
Dark limestone = 15,320,000 tons
Lower light limestone = 13,430,000 tons
Total limestone = 30,091,600 tons
Upper andesite = 131,000 tons
Franciscan sandstone & andesite = 2,444,000 tons

CALCULATION OF CHEMICAL ANALYSES

The average grade of the limestone was derived by weighting the analyses according to the thickness of the beds penetrated by diamond drill holes and intersected by jack hammer samples.

The analyses of diamond drill holes were averaged for 25 foot intervals except where marked variations were noted. These results were plotted on the cross sections.

The following composition was derived for all limestone above the 1500 foot level:

Upper light limestone = 72.04% $CaCO_3$

Dark limestone = 86.21% $CaCO_3$

Lower light limestone = 69.07% $CaCO_3$

CLAY DEPOSITS

As stated in various communications addressed to this Corporation, various types of clay are available, and the available tonnage of two types is practically unlimited.

These available clay deposits are as follows:

(1) The residuary clay mantle that overlies the bedrock capping most of the property of the Permanente Corporation. Five areas, namely, Areas A, B, C, D and E, have been bored, sampled, and tonnage estimates made. A portion of this large tonnage is of special value for initial operations on account of more favorable chemical composition as shown on the tabulated analyses and because certain of the stripped areas will not be conspicuousely visible when viewed from the valley.

A part of Area B is superficially altered Santa Clara formation, the bedrock of which is clay cemented wash conglomerate. If samples of this area are satisfactory, it is probable that deep cuts can be made in the Santa Clara formation and large additional tonnage can be provided in the immediate vicinity of the plant.

An unlimited tonnage of clay of constant value can be obtained by dredging cheap marshland of the San Francisco Bay or by mining in pits a similar clay which is covered by a shallow overburden and extends approximately up to the Bayshore Highway.

The data available in regard to these deposits is limited to a preliminary report made to the Permanente Corporation by Mr. J. F. Poland. He states:

"<u>Area 1.</u> The marshlands and sloughs on the southwest side of San Francisco Bay will furnish an inexhaustible supply of blue clay. Eight samples of this clay have been collected and turned in to your Permanente laboratory for analysis. This area has the advantages of cheap land and no overburden. It is eight miles from your property, however.

"<u>Area 2.</u> The Bayshore Highway area will supply clay of essentially the same quality as that obtainable from the the marshlands. ....Land values will be higher than in Area 1, but the source of supply will be six to seven miles from your plant. Test boring of any property is recommended before purchase. A power or hand auger outfit will furnish the cleanest samples.

"Development operations in this area would probably require the removal of 6 to 10 feet of superficial soil. This region is not planted to fruit trees and should be lower priced than the land in Area 3, particularly east of the Bayshore Highway. The Sunnyvale Air Base occupies much of the central part of this area, but there is an extensive region available east of the Air Base property."

A copy of the logs of wells situated within Area 2 between the Bayshore Highway and the bay appears in Tabulation 4 B, and the analyses of the samples of the slough material taken by Mr. Poland appears in Tabulation 4 A.

A study of the tonnage estimates and chemical analyses indicates that there are large and sufficient deposits of various types of clay available, and the engineers in charge of the plant can select the type of deposit most satisfactory under the particular conditions that exist at Permanente.

CLAY TONNAGES

The clay tonnage was determined by multiplying the average depth of the clay samples times the horizontal area in square feet.

	Gross Tonnage	% Coarse Waste	Net Tonnage	
Area A =	1,050,000	48.3	553,350	542,850
Area B =	1,755,000	39.5	1,061,000	
Area C =	757,400	39.6	457,400	
Area D =	134,700	43.3	76,300 ~~783,750~~	
TOTAL =	3,697,100		~~2,855,500~~ 2,148,050	2,137,550

1 A

JACKHAMMER SAMPLES

ASSAY LOG
JACKHAMMER SAMPLES
[redacted] NO. HOLE
[redacted] LOCATION [redacted]
DESCRIPTION
[redacted]

WEIGHT OF CORE	ASSAY OF CORE			MgCO3	WEIGHT OF SLUDGE	ASSAY OF SLUDGE				CALCULATED ASSAY			
	CaCO3	SiO2	R2O3			CaCO3	SiO2	R2O3	MgCo3	CaCO3	SiO2	R2O3	MgCO3
1A	92.6	2.2	1.2										
1B	95.0	1.4	0.9										
2A	98.0	0.9	0.3										
2B	89.0	10.6	0.6										
2C	91.8	5.7	0.7										
3A	96.3	1.8	0.2										
3B	97.0	1.2	1.1										
3C	86.9	11.6	1.0	0.4									
4A	95.2	4.0	0.8										
4B	94.2	2.3	1.0										
4C	96.0	2.2	0.8										
5A	92.9	2.6	2.0										
6A	88.6	9.0	1.1										
6B	78.9	21.0	1.5										
6C	77.2	21.1	1.0	0.6									
7A	80.8	18.5	0.7										
7B	85.3	12.7	0.9	0.9									
7C	78.5	10.2	1.9										
8A	20.0	62.6	55.3	4.5									
8B)													
8C (	NOT RUN												
8D)													
9A	90.0	6.4	1.7										
9B	93.3	3.4	1.3										
9C	95.7	3.3	---										
10A	84.0	13.6	4.2										
10B	91.7	6.4	1.0										
10C	96.2	2.2	0.7										
11A	95.2	3.0	1.7										
11B	87.4	10.2	0.8										
11C	93.5	1.5	0.5										

ASSAY LOG
JACKHAMMER SAMPLES

Page 3

NO. HOLE
LOCATION
DESCRIPTION

ole ber	WEIGHT OF CORE	ASSAY OF CORE CaCO3	SiO2	R2O3	MgCO3	WEIGHT OF SLUDGE	ASSAY OF SLUDGE CaCO3	SiO2	R2O3	MgCO3	CALCULATED ASSAY CaCO3	SiO2	R2O3	MgCO3
II	23A	86.7	11.9	0.8										
	23B	96.7	2.9	---										
	23C	86.6	11.2	1.6										
	24A	87.0	10.6	1.4										
	24B	81.2	16.1	1.9										
	24C	74.9	22.5	1.6										
	25A	77.1	20.0	1.2										
	25B	77.1	20.6	0.2										
	25C	52.9	31.0	10.7										
	26A	80.0	18.4	1.4										
	26B	83.7	14.0	2.5										
	26C	91.0	8.6	---										
		CaO			MgO									
	27A	1.9	65.0	28.8	0.5									
	27B)													
	27C (													
	27D)	Not Run												
	27E)													
	28A	65.5	31.9	2.4										
	28B	64.3	26.7	2.1										
	28C	86.2	12.0	1.6										
		CaO			MgO									
	29A	2.7	85.3	12.6	0.8									
	29B	55.4	42.0	2.1	---									
	29C	74.1	24.0	1.8										
	30A	84.5	14.3	1.1										
	30B	93.4	5.0	0.9										
	30C	91.0	6.4	1.1	1.1									
	31A	92.5	5.5	1.1										
	31B	95.8	1.7	0.5	0.6									
	31C	96.4	2.9	0.6	0.4									
	32A	93.3	4.1	---	0.9									
	32B	95.6	2.4	---										
	32C	97.5	1.1	---										

ASSAY LOG
JACKHAMMER SAMPLES

NO. HOLE
LOCATION
DESCRIPTION

WEIGHT OF CORE	ASSAY OF CORE $CaCO_3$	SiO_2	R_2O_3	$MgCO_3$	WEIGHT OF SLUDGE	ASSAY OF SLUDGE $CaCO_3$	SiO_2	R_2O_3	$MgCO_3$	CALCULATED ASSAY $CaCO_3$	SiO_2	R_2O_3	$MgCO_3$
33A	89.5	10.2	0.3										
33B	92.2	6.6	0.8										
33C	80.2	18.3	1.1										
34A	91.1	5.0	1.8										
34B	94.8	4.2	0.7										
34C	95.6	4.6	0.6										
35A	99.2	0.4	0.4										
35B	98.1	1.7	0.3										
35C	80.7	16.9	0.5										
36A	70.9	25.0	1.6										
36B	83.5	14.6	2.1										
36C	97.4	2.3	0.3										
37A	89.2	7.8	1.4										
37B	81.7	15.2	0.7										
37C	96.2	2.7	0.5										
37D	95.0	3.2	0.7										
38A	81.1	14.0	0.8										
38B	81.3	16.5	1.1										
38C	92.7	4.6	0.6										
39A	91.8	6.0	1.1										
39B	96.7	1.1	0.3										
39C	98.5	1.9	---										
40A	88.5	9.0	1.1										
40B	86.2	12.7	0.7										
40C	79.0	19.2	1.4										
40D	95.0	3.5	0.9										
40E	90.1	6.0	1.0										

ASSAY LOG
JACKHAMMER SAMPLES

NO. HOLE
LOCATION
DESCRIPTION

MPLE MBER	WEIGHT OF CORE	ASSAY OF CORE CaCO3	SiO2	R2O3	MgCO3	WEIGHT OF SLUDGE	CaCO3	SiO2	R2O3	MgCO3	CaCO3	SiO2	R2O3	MgCO3
JH	41A	78.7	17.7	1.8										
	41B	86.6	12.1	1.0										
	41C	94.9	2.7	0.8										
	42A	80.0	9.2	2.4										
	42B	89.0	7.2	1.7										
	42C	80.5	18.2	1.3										
	43A	93.7	6.5	0.6										
	43B	83.2	15.2	0.8										
	43C	91.9	6.7	0.6										
	43D	72.7	26.0	0.6										
	43E	89.5	10.8	0.9										
	44A	Soil Not Cut												
	44B	75.3	24.7	0.1	0.7									
	44C	79.9	18.4	1.0										
	45A	83.6	15.4	0.7										
	45B	68.5	28.5	0.8										
	45C	88.3	11.3	0.4										
	46A	63.3	35.0	0.9										
	46B	61.3	37.6	0.6										
	46C	54.0	45.1	1.0										
	46D	83.0	15.8	2.0										
	46E	91.1	7.9	0.8										
	47A	94.8	3.4	1.1										
	47B	94.8	3.5	1.1										
	47C	83.9	14.7	0.9										
	47D	82.4	15.4	1.5										
	47E	91.8	6.9	1.1										
	48A	27.5	61.9	4.8										
		CaO			MgO									
	48B	0.1	65.4	12.5	0.8									
	48C	tr.	89.0	9.6	MgO 0.8									
	48D	CaO 0.2	79.0	18.6	MgO 1.3									
	48E	CaO 0.5	83.9	14.1	MgO 0.8									

ASSAY OF LOG
JACKHAMMER SAMPLES

NO. HOLE
LOCATION
DESCRIPTION

LE ER	WEIGHT OF CORE	ASSAY OF CORE				WEIGHT OF SLUDGE	ASSAY OF SLUDGE				CALCULATED ASSAY			
		CaCO3	S1O2	R2O3	MgCO3		CaCO3	S1O2	R2O3	MgCO3	CaCO3	S1O2	R2O3	MgCO3
57A		90.8	3.2	0.7										
57B		91.9	6.4	0.5										
57C		92.0	7.1	0.6		[illegible]								
58A		93.0	5.2	1.1										
58B		86.9	11.7	1.1										
58C		92.2	4.3	0.7										
59A		74.3	18.6	5.2										
		CaO			MgO									
59B		55.8	8.2	6.0	1.7									
59C		92.6	5.4	0.6										
59D		75.0	21.8	1.3										
59E		84.5	14.7	0.6										
		CaO			MgO									
60A		53.6	36.8	7.7	1.3									
60B		68.2	29.9	1.4										
60C		76.1	22.4	1.2										
61A		24.6	68.3	5.1										
61B		51.3	46.2	2.5										
61C		83.0	16.3	0.6										
61D		82.6	15.1	1.3										
61E		86.3	9.8	1.5										
62A		57.0	40.2	2.1										
62B		83.8	14.7	1.2										
63A		75.3	23.1	2.0										
		CaO			MgO									
63B		32.2	49.3	11.7	5.9									
63C		34.5	57.5	4.7										
63D		51.9	45.7											
63E		49.2	49.3	1.7										
		CaO			MgO									
63-64A		14.0	53.8	26.3	6.7									
63-64B		47.7	45.2	6.4										
63-64C		49.2	41.4	5.7										
		CaO			MgO									
63-64D		15.3	62.1	7.1	1.1									
63-64E		34.0	56.8	5.9										

ASSAY OF LOG
JACKHAMMER SAMPLES

NO. HOLE
LOCATION
DESCRIPTION

MPLE UMBER	WEIGHT OF CORE	ASSAY OF CORE $CaCO_3$	SiO_2	R_2O_3	$MgCO_3$	WEIGHT OF SLUDGE	ASSAY OF SLUDGE $CaCO_3$	SiO_2	R_2O_3	$MgCO_3$	CALCULATED ASSAY $CaCO_3$	SiO_2	R_2O_3	$MgCO_3$
JH	64A	CaO 1.5	94.1	3.4	MgO —									
	64B	CaO 0.7	77.5	18.1	MgO 3.5									
	64C	CaO 3.9	60.2	29.7	MgO 6.3	(Andesite)								
	64D	CaO 2.9	65.3	22.0	MgO 6.5	"								
	64E	CaO 1.2	94.3	3.0	MgO 1.2									
	65A	CaO 5.3	55.8	25.8	MgO 11.0	"								
	65B	CaO 7.2	51.2	26.4	MgO 12.2	"								
	65C	CaO 10.6	48.0	24.9	MgO 11.6	"								
	65D	CaO 17.0	46.8	25.1	MgO 9.3	"								
	65E	CaO 23.9	42.5	24.5	MgO 8.8	"								
	66A	87.9	10.1	0.8										
	66B	75.3	23.6	1.2										
	66C	70.2	28.3	1.1										
	66D	68.1	29.3	1.8										
	66E	51.6	45.5	2.2										
	67A	CaO 23.3	56.4	13.5	MgO 1.0									
	67B	82.4	14.5	1.3	0.7									
	67C	68.1	29.7	1.4										
	68A	38.8	56.4	5.8										
	68B	46.5	51.2	2.4										
	68C	56.7	40.5	2.2										
	69A	Soil Not Cut												
	69B	84.3	13.3	1.2	1.6									
	69C	86.8	12.0	1.0										
	69D	90.0	8.8	1.0										
	69E	91.8	6.8	0.6										
	70A	94.5	3.1	0.9										
	70B	96.1	2.2	0.8										
	70C	98.6	1.2	0.5										

ASSAY OF LOG
JACKHAMMER SAMPLES

[illegible]

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DESCRIPTION

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HOLE NUMBER	WEIGHT OF CORE	ASSAY OF CORE CaCO3	SiO2	R2O3	MgCO3	WEIGHT OF SLUDGE	ASSAY OF SLUDGE CaCO3	SiO2	R2O3	MgCO3	CALCULATED ASSAY CaCO3	SiO2	R2O3	MgCO3
JH	71A	93.6	5.0	0.7										
	71B	94.6	1.3	---	2.9									
	71C	96.5	1.5	---	1.2									
	71D	91.8	6.6	1.1										
	71E	89.7	9.0	0.7										
	72A	61.0	36.4	2.0										
	72B	90.9	8.1	1.0										
	72C	76.0	21.0	1.8										
	72D	78.1	20.2	1.1										
	73A	85.0	13.6	1.4										
	73B	84.1	14.6	1.2										
	73C	86.6	11.1	1.2										
	73D	95.5	2.8	0.8										
	73E	86.8	11.2	1.4										
	74A	65.0	28.0	3.4	3.7									
	74B	75.0	22.9	1.6										
	74C	71.0	26.2	1.5										
	74D	80.2	10.2	1.2										
	74E	87.6	10.7	1.1										
	75A	78.5	17.7	1.7										
	75B	73.0	25.1	1.0										
	75C	67.5	30.7	1.1										
	75D	61.9	35.6	1.6	0.8									
	76A	72.8	25.4	1.0										
	76B	78.8	18.9	1.3										
	76C	73.8	23.6	1.5										
	77A	84.4	15.0	0.6	0.8									
	77B	77.8	20.3	1.1										
	77C	74.3	25.4	1.1										
		CaO			MgO									
	77D	38.8	51.5	8.4	0.9									

ASSAY OF LOG
JACKHAMMER SAMPLES

NO. HOLES
LOCATION
DESCRIPTION

LE MBER	WEIGHT OF CORE	ASSAY OF CORE				WEIGHT OF SLUDGE	ASSAY OF SLUDGE				CALCULATED ASSAY			
		CaCO3	SiO2	R2O3	MgCO3		CaCO3	SiO2	R2O3	MgCO3	CaCO3	SiO2	R2O3	MgCO3
JH	78A	36.9	59.2	3.6										
	78B	84.0	14.8	1.3										
	78C	79.5	18.3	1.2										
	78D	71.1	27.4	1.4	1.0									
	78E	68.7	28.4	1.3										
	79A	94.9	3.4	1.2	1.4									
	79B	76.3	21.4	1.4	1.2									
	79C	78.6	20.6	1.1	1.0									
	79D	48.2	35.2	9.0	2.6									
	80A	95.1	4.0	0.4	1.0									
	80B	86.1	12.1	1.1	0.9									
	80C	89.5	9.3	0.5	0.9									
		CaO			MgO									
	81A	15.7	48.1	29.7	6.7									
	81B	47.3	35.9	9.5	2.2									
	81C	84.5	12.6	1.1	1.2									
	82A	81.0	16.2	1.4	1.6									
	82B	Caved - No Sample												
	83A	97.7	1.5	0.6	0.3									
	83B	78.1	20.4	0.9										
	83C	95.0	3.4	0.6										
	83D	89.7	8.5	0.8										
	83E	89.8	8.3	1.5										
	84A	78.1	19.6	1.8										
	84B	92.5	5.6	0.6										
	84C	94.8	2.6	0.7										
	85A	91.0	5.5	1.2										
	85B	94.8	2.9	0.5										
	85C	90.1	8.4	0.6										

ASSAY LOG
JACKHAMMER SAMPLES

NO. HOLE
LOCATION
DESCRIPTION

LE ER	WEIGHT OF CORE	ASSAY OF CORE $CaCO_3$	SiO_2	R_2O_3	$MgCO_3$	WEIGHT OF SLUDGE	ASSAY OF SLUDGE $CaCO_3$	SiO_2	R_2O_3	$MgCO_3$	CALCULATED ASSAY $CaCO_3$	SiO_2	R_2O_3	$MgCO_3$
	12A	95.6	2.8	0.9										
	12B	97.0	1.5	0.1										
	12C	88.0	9.9	1.4										
	13A	OVERBURDEN												
	13B	59.2	40.5	1.4										
	13C	38.7	57.5	2.6										
	14A	74.8	23.4	---										
	14B	72.2	26.1	1.0										
	14C	54.2	44.4	0.8										
	15B	93.5	5.6	1.8										
	15C	82.8	15.3	0.6										
	16A	65.9	31.1	1.6										
	16B	93.4	5.1	---										
	16C	91.0	8.9	0.5										
	17B	91.8	5.9	---										
	17C	90.5	7.2	1.4										
	18A	79.4	15.4	2.0										
	18B	95.0	4.1	---										
	18C	95.5	3.2	---										
	19A	65.2	32.5	2.5	0.4									
	19B	88.0	10.6	0.6	0.8									
	19C	84.6	15.7	0.8										
	20A	83.7	15.6	1.8										
	20B	86.5	11.3	1.3										
	20C	83.6	15.1	0.9										
	21A	90.3	7.8	1.6										
	21B	71.6	25.8	1.8										
	21C	87.9	11.1	0.8										
	22A	86.5	11.7	0.6										
	22B	97.9	0.6	0.6										
	22C	78.0	21.2	1.1										
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]									
	[illegible]	[illegible]	[illegible]	---	[illegible]									
	[illegible]	[illegible]	[illegible]	---										
	[illegible]	[illegible]	[illegible]	---										

ASSAY LOG
JACKHAMMER SAMPLES

NO. HOLE
LOCATION
DESCRIPTION

Sample Number	WEIGHT OF CORE	ASSAY OF CORE CaCO3	SiO2	R2O3	MgCO3	WEIGHT OF SLUDGE	ASSAY OF SLUDGE CaCO3	SiO2	R2O3	MgCO3	CALCULATED ASSAY CaCO3	SiO2	R2O3	MgCO3
JH	23A	86.7	11.9	0.3										
	23B	96.7	2.9	---										
	23C	86.6	11.2	1.6										
	24A	87.0	10.6	1.4										
	24B	81.2	16.1	1.9										
	24C	74.9	22.5	1.6										
	25A	77.1	20.0	1.2										
	25B	77.1	20.6	0.2										
	25C	52.9	31.0	10.7										
	26A	80.0	18.4	1.4										
	26B	83.7	14.0	2.3										
	26C	91.0	2.6	---										
		CaO			MgO									
	27A	1.9	65.0	26.8	0.3									
	27B)													
	27C (													
	27D)	Not Run												
	27E)													
	28A	65.5	31.9	2.4										
	28B	64.3	28.7	7.1										
	28C	86.2	12.0	1.6										
		CaO			MgO									
	29A	2.7	83.3	12.6	0.8									
	29B	55.4	42.0	2.1	---									
	29C	74.1	24.0	1.8										
	30A	84.5	14.3	1.1										
	30B	93.4	5.0	0.9										
	30C	91.0	6.4	1.1	1.1									
	31A	92.5	6.3	1.1										
	31B	95.8	1.7	0.5	0.6									
	31C	96.4	2.9	0.5	0.4									
	32A	95.3	4.1	---	0.9									
	32B	95.6	2.4	---										
	32C	97.5	1.1	---										

ASSAY LOG
JACKHAMMER SAMPLES

NO. HOLE
LOCATION
DESCRIPTION

SAMPLE NUMBER	WEIGHT OF CORE	ASSAY OF CORE				WEIGHT OF SLUDGE	ASSAY OF SLUDGE				CALCULATED ASSAY			
		CaCO3	SiO2	R2O3	MgCO3		CaCO3	SiO2	R2O3	MgCO3	CaCO3	SiO2	R2O3	MgCO3
11	33A	88.5	10.2	0.8										
	33B	92.2	6.6	0.6										
	33C	86.2	13.5	1.1										
	34A	91.1	6.0	1.8										
	34B	94.6	4.2	0.7										
	34C	95.6	4.6	0.6										
	35A	99.2	0.4	0.4										
	35B	95.1	1.7	0.3										
	35C	80.7	16.9	0.5										
	36A	70.9	26.0	1.6										
	36B	83.5	14.6	2.1										
	36C	97.4	2.5	0.8										
	37A	89.2	7.8	1.4										
	37B	81.7	15.2	0.7										
	37C	96.2	2.7	0.6										
	37D	95.0	3.2	0.7										
	38A	81.1	14.0	0.5										
	38B	81.5	16.5	1.1										
	38C	92.7	4.6	0.6										
	39A	91.8	6.0	1.1										
	39B	96.7	1.1	0.8										
	39C	99.5	1.9	---										
	40A	88.5	9.0	1.1										
	40B	86.2	12.7	0.7										
	40C	79.0	18.2	1.4										
	40D	95.0	3.5	0.9										
	40E	90.1	6.0	1.0										

ASSAY LOG
JACKHAMMER SAMPLES

NO. HOLE
LOCATION
DESCRIPTION

MPLE MBER	WEIGHT OF CORE	ASSAY OF CORE CaCO3	S102	R203	MgCO3	WEIGHT OF SLUDGE	CaCO3	S102	R203	MgCO3	CaCO3	S102	R203	MgCO3
JH	41A	78.7	17.7	1.8										
	41B	86.6	12.1	1.0										
	41C	94.9	2.7	0.8										
	42A	80.0	9.2	2.4										
	42B	89.0	7.2	1.7										
	42C	80.5	18.2	1.3										
	43A	93.7	6.5	0.6										
	43B	83.2	15.2	0.6										
	43C	91.9	6.7	0.6										
	43D	72.7	26.0	0.6										
	43E	89.5	10.8	0.9										
	44A	Soil Not Cut												
	44B	75.3	24.7	0.1	0.7									
	44C	79.9	18.4	1.0										
	45A	85.5	13.4	0.7										
	45B	68.3	28.3	0.3										
	45C	83.8	11.8	0.4										
	46A	65.8	35.0	0.9										
	46B	61.3	37.6	0.6										
	46C	54.0	45.1	1.0										
	46D	83.0	15.8	2.0										
	46E	91.1	7.6	0.8										
	47A	94.8	3.4	1.1										
	47B	94.8	3.6	1.1										
	47C	83.9	14.7	0.9										
	47D	82.4	16.4	1.3										
	47E	91.6	6.9	1.1										
	48A	27.5	61.9	4.8										
		CaO			MgO									
	48B	0.1	85.4	12.5	0.8									
	48C	tr.	89.0	9.5	MgO 0.8									
	48D	CaO 0.2	79.9	18.6	MgO 1.3									
	48E	CaO			MgO									
		0.5	83.9	14.1	0.8									

ASSAY LOG
JACKHAMMER SAMPLES

NO. HOLE
LOCATION
DESCRIPTION

PLE BER	WEIGHT OF CORE	ASSAY OF CORE CaCO3	SIO2	R2O3	MgCO3	WEIGHT OF SLUDGE	ASSAY OF SLUDGE CaCO3	SIO2	R2O3	MgCO3	CALCULATED ASSAY CaCO3	SIO2	R2O3	MgCO3
					MgO									
[illegible]	49A	Tr.	89.8	8.7	0.8									
		CaO			MgO									
	49B	2.8	85.8	10.7	0.6									
		CaO			MgO									
	49C	2.0	73.8	22.8	1.4									
		CaO			MgO									
	50A	0.8	88.2	9.4	0.7									
	50B	Tr.	83.5	14.8	MgO 1.0									
	50C	77.3	20.3	2.5	0.7									
		CaO			MgO									
	51A	1.1	82.6	14.7	0.9									
		CaO			MgO									
	51B	0.8	86.9	9.6	0.8									
	51C	CaO			MgO									
		3.0	80.5	15.6	0.9									
		CaO			MgO									
	51D	45.8	44.5	5.4	---									
	51E	58.3	39.1	2.1										
		CaO			MgO									
	52A	3.5	75.4	19.3	1.1									
	52B	92.5	4.2	0.8										
	52C	91.0	7.5	1.2										
	52D	79.8	17.2	1.0										
	52E	80.3	18.2	1.3										
	53A	92.6	3.6	2.2										
	53B	92.5	3.7	1.0										
	53C	90.0	6.8	---										
	54A	89.8	7.9	1.0										
	54B	95.6	2.5	---	0.6									
	54C	87.5	9.0	1.9										
	54D	94.8	4.4	1.0										
	54E	86.7	10.5	0.8										
	55A	91.0	6.8	3.3										
	55B	96.7	1.5	0.8										
	55C	90.9	7.4	1.2	0.7									
	56A	94.8	2.7	1.0										
	56B	95.8	1.2	1.4										
	56C	95.2	1.4	1.2										
	56D	95.4	2.7	0.6	0.9									
	56E	95.5	2.8	1.0										

ASSAY OF LOG
JACKHAMMER SAMPLES

NO. HOLE
LOCATION
DESCRIPTION

AMPLE UMBER	WEIGHT OF CORE	ASSAY OF CORE CaCO3	S102	R203	MgCO3	WEIGHT OF SLUDGE	ASSAY OF SLUDGE CaCO3	S102	R203	MgCO3	CALCULATED ASSAY CaCO3	S102	R203	MgCO3
JH	57A	90.8	3.2	0.7										
	57B	91.9	6.4	0.8										
	57C	92.0	7.1	0.9										
	58A	93.9	3.2	1.1										
	58B	86.9	11.7	1.1										
	58C	93.2	4.3	0.7										
	59A	74.9	18.6	5.2										
		CaO			MgO									
	59B	85.5	8.2	6.0	1.7									
	59C	92.6	5.4	0.6										
	59D	75.0	21.8	1.3										
	59E	84.5	14.7	0.6										
		CaO			MgO									
	60A	53.6	36.8	7.7	1.3									
	60B	68.2	29.0	1.4										
	60C	76.1	22.4-	1.2										
	61A	24.6	68.2	5.1										
	61B	51.3	46.2	2.5										
	61C	83.0	16.3	0.5										
	61D	82.6	15.1	1.3										
	61E	86.8	9.8	1.5										
	62A	57.0	40.2	2.1										
	62B	83.8	14.7	1.2										
	63A	75.3	23.1	2.0										
		CaO			MgO									
	63B	32.2	49.8	11.7	3.9									
	63C	34.3	57.5	4.7										
	63D	51.9	45.7											
	63E	49.2	49.3	1.7										
		CaO			MgO									
	63-64A	14.0	52.8	26.3	6.7									
	63-64B	47.7	43.2	5.4										
	63-64C	49.2	41.4	5.7										
		CaO			MgO									
	63-64D	15.5	62.1	7.1	1.1									
	63-64E	34.0	56.8	5.9										

ASSAY OF LOG
JACKHAMMER SAMPLES

NO. HOLE
LOCATION
DESCRIPTION

MPLE MBER	WEIGHT OF CORE	ASSAY OF CORE $CaCO_3$	$S1O_2$	R_2O_3	$MgCO_3$	WEIGHT OF SLUDGE	ASSAY OF SLUDGE $CaCO_3$	$S1O_2$	R_2O_3	$MgCO_3$	CALCULATED ASSAY $CaCO_3$	$S1O_2$	R_2O_3	$MgCO_3$
JH	64A	CaO 1.6	94.1	3.4	MgO ——									
	64B	CaO 0.7	77.5	18.1	MgO 3.5									
	64C	CaO 3.9	60.2	29.7	MgO 6.3	(Andesite)								
	64D	CaO 2.9	66.8	22.0	MgO 6.5	"								
	64E	CaO 1.2	94.3	3.0	MgO 1.2									
	65A	CaO 3.9	53.8	25.8	MgO 11.9	"								
	65B	CaO 7.2	51.2	25.4	MgO 12.2	"								
	65C	CaO 10.6	48.0	24.9	MgO 11.6	"								
	65D	CaO 17.0	46.6	25.1	MgO 9.6	"								
	65E	CaO 25.8	42.6	24.5	MgO 8.6	"								
	66A	87.9	10.1	0.8										
	66B	75.3	23.6	1.2										
	66C	70.2	28.3	1.1										
	66D	68.1	29.6	1.6										
	66E	51.5	45.5	2.2										
	67A	CaO 25.8	56.4	15.5	MgO 1.0									
	67B	82.4	14.6	1.3	0.7									
	67C	68.1	29.7	1.4										
	68A	36.6	58.4	3.8										
	68B	45.5	51.2	2.4										
	68C	56.7	40.5	2.2										
	69A	Soil Not Cut												
	69B	84.3	13.3	1.2	1.6									
	69C	86.8	12.0	1.0										
	69D	90.0	8.8	1.0										
	69E	91.5	6.8	0.8										
	70A	94.5	3.1	0.9										
	70B	96.1	2.2	0.8										
	70C	98.6	1.2	0.5										

ASSAY OF LOG
JACKHAMMER SAMPLES

NO. HOLES
LOCATION
DESCRIPTION

E R	WEIGHT OF CORE	ASSAY OF CORE CaCO3	S102	R203	MgCO3	WEIGHT OF SLUDGE	ASSAY OF SLUDGE CaCO3	S102	R203	MgCO3	CALCULATED ASSAY CaCO3	S102	R203	MgCO3
	71A	93.6	5.0	0.7										
	71B	94.6	1.8	---	2.9									
	71C	94.5	1.3	---	1.2									
	71D	91.8	6.6	1.1										
	71E	89.7	9.0	0.7										
	72A	61.0	36.4	2.0										
	72B	90.9	8.1	1.0										
	72C	76.0	21.0	1.8										
	72D	78.1	20.2	1.1										
	73A	85.0	13.6	1.4										
	73B	84.1	14.6	1.2										
	73C	86.6	11.1	1.2										
	73D	95.3	2.8	0.8										
	73E	86.8	11.2	1.4										
	74A	68.0	28.0	2.4	0.7									
	74B	75.0	22.9	1.8										
	74C	71.0	26.2	1.5										
	74D	88.2	10.2	1.2										
	74E	87.6	10.7	1.1										
	75A	78.5	17.7	1.7										
	75B	73.0	23.1	1.0										
	75C	67.5	30.7	1.1										
	75D	61.9	35.6	1.6	0.6									
	76A	72.8	25.4	1.0										
	76B	78.8	18.9	1.3										
	76C	73.8	23.6	1.5										
	77A	84.4	15.0	0.8	0.8									
	77B	77.8	20.3	1.1										
	77C	74.3	23.4	1.1										
		CaO			MgO									
	77D	38.8	51.5	8.4	0.9									

ASSAY OF LOG
JACKHAMMER SAMPLES

NO. HOLES
LOCATION
DESCRIPTION

PAGE 10

PLE BER	WEIGHT OF CORE	ASSAY OF CORE				WEIGHT OF SLUDGE	ASSAY OF SLUDGE				CALCULATED ASSAY			
		$CaCO_3$	SiO_2	R_2O_3	$MgCO_3$		$CaCO_3$	SiO_2	R_2O_3	$MgCO_3$	$CaCO_3$	SiO_2	R_2O_3	$MgCO_3$
JH	78A	36.9	59.2	3.6										
	78B	84.0	14.5	1.3										
	78C	79.5	18.8	1.2										
	78D	71.1	27.4	1.4	1.0									
	78E	68.7	28.4	1.3										
	79A	94.9	3.4	1.2	1.4									
	79B	76.3	21.4	1.4	1.2									
	79C	78.6	20.6	1.1	1.0									
	79D	48.2	38.2	9.0	2.6									
	80A	95.1	4.0	0.4	1.0									
	80B	86.1	12.1	1.1	0.9									
	80C	88.5	9.6	0.5	0.9									
		CaO			MgO									
	81A	15.7	48.1	29.7	6.7									
	81B	47.3	35.8	9.5	2.2									
	81C	84.5	12.6	1.5	1.2									
	82A	81.0	16.2	1.4	1.6									
	82B	Caved - No Sample												
	83A	97.7	1.5	0.6	0.9									
	83B	78.1	20.4	0.9										
	83C	95.0	3.4	0.6										
	83D	89.7	8.5	0.8										
	83E	89.6	8.2	1.3										
	84A	76.1	19.6	1.8										
	84B	92.3	3.6	0.5										
	84C	94.6	2.6	0.7										
	85A	91.0	8.6	1.2										
	85B	94.3	2.9	0.5										
	85C	90.1	8.4	0.8										

ASSAY OF LOG
JACKHAMMER SAMPLES

NO HOLES
LOCATION
DESCRIPTION

MPLE MBER	WEIGHT OF CORE	ASSAY OF CORE CaCO3	S102	R2O3	MgCO3	WEIGHT OF SLUDGE	ASSAY OF SLUDGE CaCO3	S102	R2O3	MgCO3	CALCULATED ASSAY CaCO3	S102	R2O3	MgCO3
JH	86A	95.6	3.1	1.3										
	86B	93.4	2.9	0.8										
	86C	95.2	2.8	0.8	1.1									
	86D	96.2	2.3	0.5										
	86E	93.1	2.2	1.4	1.4									
	87A	63.2	34.7	1.8										
	87B	83.1	15.7	1.4										
	87C	94.6	4.4	0.5										
	88A	93.0	4.4	1.4										
	88B	87.5	11.8	0.6										
	88C	92.4	5.4	0.8										
	89A	93.0	3.2	0.7										
	89B	87.2	11.2	1.0										
	89C	90.4	8.4	0.9										
	89D	84.5	13.9	0.9										
	89E													
	90A	94.5	2.1	0.7										
	90B	88.1	10.1	0.7	1.0									
	90C	93.5	5.3	0.8										
	91A	81.2	17.2	0.9										
	91B	97.0	1.7	0.4										
	91C	96.6	2.1	0.4										
	92A	96.0	2.5	0.5										
	92B	97.5	1.7	0.5	1.1									
	92C	96.0	3.9	0.7	1.0									
	92D	84.8	15.0	0.9										
	92E	65.8	29.4	1.0	1.2									
		CaO			MgO									
	93A	3.5	92.1	2.3	1.0									
	93B	24.5	72.8	2.3										
	93C	64.6	33.8	1.0										

ASSAY OF LOG
JACKHAMMER SAMPLES

NO. HOLES
LOCATION
DESCRIPTION

MPLE MBER	WEIGHT OF CORE	ASSAY OF CORE CaCO3	S102	R203	MgCO3	WEIGHT OF SLUDGE	ASSAY OF SLUDGE CaCO3	S102	R203	MgCO3	CALCULATED ASSAY CaCO3	S102	R2O3	MgCO3
H	94A	64.5	33.1	1.8										
	94B	62.0	36.2	1.5										
	94C	62.9	35.5	1.2										
	95A	83.6	13.4	1.0	1.0									
	95B	79.2	18.4	1.1	1.0									
	95C	65.6	32.4	1.6	1.0									
	95D	62.5	35.9	1.5	1.0									
	95E	64.5	33.7	1.5										
	96A	71.2	28.2	0.9										
	96B	81.1	17.5	0.8										
	96C	85.9	11.8	0.8	1.2									
	97A	28.7	1.8	0.5										
	97B	58.7	38.4	1.2	1.0									
	97C	47.0	50.4	1.3	1.0									
	98A	42.5	54.4	2.1										
	98B	69.5	26.5	2.2										
	98C	67.6	29.9	1.5	0.8									
	98D	78.7	19.5	1.1										
	98E	87.7	10.7	1.0	1.0									
	99A	95.1	2.9	0.6										
	99B	96.2	1.3	0.5										
	99C	96.8	2.0	0.7										
	99D	96.3	3.6	0.5	1.0									
	99E	94.4	3.5	0.5										
	100A	94.7	2.9	0.5	-1.0									
	100B	94.7	3.7	0.5	-1.0									
	100C	95.6	3.0	0.5	-1.0									
	100D	96.3	3.0	0.3	-1.0									
	100E	96.2	3.5	0.5	-1.0									

ASSAY OF LOG
JACKHAMMER SAMPLES

NO. HOLE
LOCATION
DESCRIPTION

MPLE MBER	WEIGHT OF CORE	ASSAY OF CORE CaCO3	S102	R2O3	MgCO3	WEIGHT OF SLUDGE	ASSAY OF SLUDGE CaCO3	S102	R2O3	MgCO3	CALCULATED ASSAY CaCO3	S102	R2O3	MgCO3
JH	101A	95.3	2.8	0.5										
	101B	93.1	4.8	1.2										
	101C	96.7	1.9	0.4										
	101D	96.6	2.0	0.4										
	101E	96.5	2.9	0.6										
	102A	92.1	4.3	0.6										
	102B	97.5	1.5	0.5										
	102C	96.8	2.0	0.4										
	102D	93.8	5.4	0.6										
	103A	92.5	4.6	1.2	-1.0									
	103B	95.4	3.0	0.7										
	103C	88.0	11.2	1.2										
	103D	62.8	34.3	1.6	-1.0									
	103E	84.0	15.6	0.7										
	104A	65.8	30.6	1.6										
	104B	74.0	22.8	1.1										
	104C	68.9	29.1	1.2										
	104D	67.9	28.7	1.9										
		CaO			MgO									
	105A	15.8	58.9	19.7	3.1									
		CaO			MgO									
	105B	6.8	51.4	29.8	7.5									
		CaO			MgO									
	105C	15.0	50.3	26.5	7.6									
		CaO			MgO									
	105D	11.0	55.2	23.4	8.0									
		CaO			MgO									
	105E	8.7	60/6	22.6	5.4									

ASSAY OF LOG
JACKHAMMER SAMPLES

NO. HOLE
LOCATION
DESCRIPTION

PLE BER	WEIGHT OF CORE	ASSAY OF CORE				WEIGHT OF SLUDGE	ASSAY OF SLUDGE				CALCULATED ASSAY			
		CaCO3	S102	R2O3	MgCO3		CaCO3	S102	R2O3	MgCO3	CaCO3	S102	R2O3	MgCO3
K	106A	84.4	12.7	1.6										
	106B	84.0	13.0	1.3										
	106C	65.6	20.9	7.6										
	106D	CaO			MgO									
		16.1	44.3	35.2	4.4									
		CaO			MgO									
	106E	6.0	50.3	35.0	5.7									
	107A	63.4	33.6	1.2	1.0									
	107B	57.7	40.4	1.3	-1.0									
	107C	63.3	35.6	1.1										
	108A	57.3	40.9	1.2										
	108B	68.9	28.5	1.6	-1.0									
	108C	67.8	29.8	1.4	-1.0									
	109A	79.5	15.8	1.7										
	109B	81.0	16.5	1.0										
	109C	77.1	20.7	0.9										
	109D	93.2	4.7	0.9	-1.0									
	109E	68.0	29.8	1.3										
	110A	73.2	24.6	1.2	-1.0									
	110B	76.5	21.6	1.1	-1.0									
	110C	84.5	13.6	0.8										
	111A	71.6	24.5	1.4										
	111B	66.9	31.0	0.9										
	111C	72.0	25.6	1.0										
	112A	88.9	7.5	1.2										
	112B	89.3	7.0	1.2										
	112C	81.5	13.3	1.5										
	112D	73.5	30.9	1.0	1.1									
	112E	69.7	28.2	1.0										
	113A	90.1	8.2	0.8										
	113B	93.2	5.8	0.4										
	113C	75.7	21.4	1.0	0.5									

ASSAY LOG
JACKHAMMER SAMPLES

NO. HO4E
LOCATION
DESCRIPTION

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MPLE UMBER	WEIGHT OF CORE	ASSAY OF CORE CaCO3	S102	R2O3	MgCO3	WEIGHT OF SLUDGE	ASSAY OF SLUDGE CaCO3	S102	R2O3	MgCO3	CALCULATED ASSAY CaCO3	S102	R2O3	MgCO3
JH 114A		92.5	5.0	1.3										
114B		94.0	4.0	0.3										
114C		97.8	3.4	0.8										
115A		93.2	3.5	1.4										
115B		88.3	8.7	0.9	-1.0									
115C		89.8	6.9	0.7										
115D		87.0	8.6	0.9										
115E		92.0	7.0	0.7										
116A		82.3	15.8	0.9										
116B		92.2	5.0	1.3										
116C		96.7	1.2	0.4										
117A		95.8	1.5	1.6										
117B		95.8	3.3	0.6										
117C		95.4	3.3	0.8										
118A		91.3	6.4	0.7										
118B		82.5	15.1	0.6										
118C		88.4	9.0	0.9										
118D		95.9	2.1	0.7										
118E		89.6	17.5	0.8										
119A		96.0	2.1	0.4										
119B		97.2	1.1	0.5										
119C		90.0	7.8	0.5										
120A		84.3	14.3	0.8										
120B		92.3	4.7	0.7										
120C		90.9	6.3	0.6										
121A		95.6	2.7	1.2										
121B		96.5	1.4	0.4										
121C		96.4	1.5	0.6										
121D		97.2	1.2	0.6										
121E		97.2	1.7	0.7										

ASSAY LOG
JACKHAMMER SAMPLES

NO. HOLE
LOCATION
DESCRIPTION

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MPLE MBER	WEIGHT OF CORE	ASSAY OF CORE				WEIGHT OF SLUDGE	ASSAY OF SLUDGE				CALCULATED ASSAY			
		CaCO3	S102	R203	MgCO3		CaCO3	S102	R203	MgCO3	CaCO3	S102	R203	MgCO3
JH	122A	89.7	7.0	0.3										
	122B	88.4	9.3	0.6										
	122C	93.2	5.9	0.9										
		CaO			MgO									
	123A	60.9	29.9	7.2	0.9									
	123B	84.8	8.8	1.6										
	123C	93.5	2.6	0.1										
	124A	87.1	11.6	1.0										
	124B	71.4	24.6	1.0										
	124C	77.5	22.3	0.8										
	124D	53.3	45.8	1.5										
	124E	47.1	40.7	1.2										
	125A	68.3	29.2	1.0										
	125B	64.3	33.9	0.8										
	125C	54.4	42.8	0.9										
	126A	85.2	19.0	0.9										
	126B	83.3	15.2	0.8										
	126C	86.4	12.0	0.6										
	126D	65.9	32.0	1.0										
	126E	64.2	33.4	1.5										
	127A	37.7	58.2	1.8										
	127B	59.1	39.0	3.6										
	127C	41.7	56.7	1.4										
	127D	55.8	43.2	1.6										
	127E	55.7	42.7	1.2										
	128A	82.5	14.5	1.4										
	128B	88.7	10.2	1.0										
	128C	92.2	6.9	0.9										
	128D	92.4	6.5	0.9										
	128E	97.0	2.9	0.6										

ASSAY LOG
JACKHAMMER SAMPLES

NO. HOLE
LOCATION
DESCRIPTION

PAGE 17

LE BER	WEIGHT OF CORE	ASSAY OF CORE				WEIGHT OF SLUDGE	ASSAY OF SLUDGE				CALCULATED ASSAY			
		CaCO3	S102	R2O3	MgCO3		CaCO3	S102	R2O3	MgCO3	CaCO3	S102	R2O3	MgCO3
H	129A	90.4	5.6	1.5										
	129B	91.5	6.6	0.7										
	129C	89.5	11.0	0.8										
	129D	95.5	4.2	0.4										
	129E	91.8	7.4	0.7										
	130A	92.2	6.5	0.8										
	130B	74.0	21.6	1.4										
	130C	75.0	21.9	1.1										
	130D	83.3	15.5	0.8										
	130E	87.6	11.3	0.9										
	131A	78.5	20.6	---										

Drilled 16' - No cuttings returned after 5 feet.

ASSAY LOG
JACKHAMMER SAMPLES

NO. HOLE
LOCATION
DESCRIPTION Trench 5

PAGE 18

SAMPLE NUMBER	WEIGHT OF CORE	ASSAY OF CORE				WEIGHT of SLUDGE	ASSAY OF SLUDGE				CALCULATED ASSAY			
		CaCO3	S102	R2O3	MgCO3		CaCO3	S102	R2O3	MgCO3	CaCO3	S102	R2O3	MgCO3
JH	132A	CaO 5.8	54.1	28.0	MgO 6.7									
	132B	CaO 3.8	53.5	30.7	MgO 8.9									
	132C	CaO 2.8	52.0	31.2	MgO 8.3									
	133A	CaO 31.4	46.1	17.4	MgO 3.1									
	133B	CaO 16.2	48.2	15.3	MgO 2.6									
	133C	CaO 5.2	56.7	30.7	MgO 5.0									
	134A	CaO 13.2	44.7	27.9	MgO 4.7									
	134B	CaO 10.0	48.2	33.9	MgO 6.3									
	134C	CaO 12.3	47.3	32.2	MgO 4.9									
	134D	CaO 9.5	48.2	32.5	MgO 5.8									
	134E	CaO 4.3	51.8	32.4	MgO 6.5									
	135A	97.0	2.6	0.4										
	135B	97.0	1.6	0.6										
	135C	94.5	4.4	0.6										
	135D	88.7	10.9	0.6										
	135E	87.7	10.7	0.7										
	136A	81.7	16.4	1.2										
	136B	91.5	5.5	0.8										
	136C	91.5	7.5	0.5										
	136D	91.7	6.7	0.7										
	136E	94.8	3.0	0.5										
	137A	72.9	25.2	1.2										
	137B	48.8	49.0	1.0										
	137C	89.0	9.8	0.8										
	137D	92.2	4.8	0.6										
	137E	94.0	3.8	0.6										

ASSAY LOG
JACKHAMMER SAMPLES

NO. HOLE
LOCATION
DESCRIPTION

PAGE 19

	WEIGHT OF	ASSAY OF CORE				WEIGHT OF	ASSAY OF SLUDGE				CALCULATED ASSAY			
HLE BER	CORE	CaCO3	S102	R203	MgCO3	SLUDGE	CaCO3	S102	R203	MgCO3	CaCO3	S102	R203	MgCO3
	138A	35.3	61.8	1.0										
	138B	59.4	38.5	0.9										
	138C	76.3	20.4	0.4										
	139A	67.7	31.4	---										
	139B	87.3	8.5	0.4										
	139C	74.5	24.3	0.8										
	140A	73.3	25.1	1.3										
	140B	56.7	43.1	0.6										
	140C	58.0	40.2	1.0										
	140D	77.1	22.6	0.4										
	140E	63.6	35.1	1.1										
	141A	74.2	22.3	0.5										
	141B	60.8	37.6	0.8										
	141C	76.0	22.7	0.6										
	141D	80.5	17.8	0.7										
	141E	81.4	15.4	0.8										
	142A	72.5	24.7	1.2										
	142B	89.8	8.6	0.6										
	142C	90.7	7.6	0.7										
	143A	92.4	7.1	0.9										
	143B	95.7	2.9	0.8										
	143C	79.8	18.9	1.1										
	143D	90.3	8.7	0.7										
	143E	91.5	5.2	0.3										
	144A	88.4	10.1	0.3										
	144B	87.7	9.1	2.2										
	144C	78.9	19.9	1.2										
	145A	92.2	5.8	0.2										
	145B	88.7	10.0	0.4										
	145C	95.5	3.1	0.4										

ASSAY LOG
JACKHAMMER SAMPLES

NO. HOLE
LOCATION
DESCRIPTION

FIE BER	WEIGHT OF CORE	ASSAY OF CORE				WEIGHT OF SLUDGE	ASSAY OF SLUDGE				CALCUIATED ASSAY			
		CaCO3	S102	R2O3	MgCO3		CaCO3	S102	R2O3	MgCO3	CaCO3	S102	R2O3	MgCO3
	146A	94.8	3.8	0.8										
	146B	98.0	1.2	0.6										
	146C	75.1	23.5	0.6										
	146D	93.5	4.8	0.6										
	146E	94.4	4.7	0.5										
	147A	82.1	14.2	0.4										
	147B	95.8	3.1	0.5										
	147C	97.1	1.7	0.6										
	148A	95.7	3.0	0.7										
	148B	95.2	2.7	0.6										
	148C	96.5	2.4	0.6										
	149A	88.4	8.1	1.4										
	149B	94.8	2.5	0.5										
	149C	84.2	15.0	0.4										
	149D	96.2	2.5	0.8										
	149E	94.0	2.3	1.0										
	150A	92.9	3.9	0.5										
	150B	95.2	2.9	0.8										
	150C	95.8	2.0	1.0										
	151A	96.1	2.2	0.5										
	151B	95.7	4.1	0.6										
	151C	86.7	11.6	——										
	152A	95.4	2.3	1.4										
	152B	96.0	2.8	0.5										
	152C	94.2	2.2	1.0										
	152D	96.0	1.8	0.6										
	152E	89.8	7.1	0.7										
	153A	95.2	3.8	1.1										
	153B	97.1	0.8	0.4										
	153C	97.4	0.4	0.6										
	153D	96.7	0.5	0.2										
	153E	96.3	0.9	0.2										

ASSAY LOG
JACKHAMMER SAMPLES

NO. HOLE
LOCATION
DESCRIPTION

PLE BER	WEIGHT OF CORE	ASSAY OF CORE				WEIGHT OF SLUDGE	ASSAY OF SLUDGE				CALCULATED ASSAY			
		CaCO3	S102	R203	MgCO3		CaCO3	S102	R203	MgCO3	CaCO3	S102	R203	MgCO3
	154A	94.1	2.6	0.2										
	154B	90.2	7.6	0.3										
	154C	95.0	2.8	0.3										
	154D	96.4	2.2	0.2										
	154E	88.8	10.2	0.4										
	155A	63.8	34.2	1.3										
	155B	69.8	29.9	1.4										
	155C	92.9	6.2	0.4										
	155D	89.0	10.0	0.6										
	155E	95.1	3.8	0.4										
	156A	78.7	19.5	0.8										
	156B	76.4	21.4	1.0										
	156C	83.9	15.1	0.6										
	156D	84.2	14.7	0.8										
	156E	80.4	18.5	0.8										
	157A	71.5	27.8	0.6										
	157B	73.3	25.3	0.8										
	157C	76.5	22.7	0.8										
	157D	73.6	24.6	1.1										
	157E	74.0	26.1	0.5	4.0									
	158A	20.3	61.0	19.1										
	158B													
	158C	45.3	42.0	7.6	6.5									
	158D	31.2	52.5	9.4	6.6									
	158E	7.6	61.6	23.1	3.5									
	159A	87.2	9.8	0.3										
	159B	80.5	15.4	2.0										
	159C	72.5	24.1	0.7										
	159D	84.6	12.2	0.8										
	159E	78.5	19.9	0.9										

ASSAY LOG
JACKHAMMER SAMPLES
NO. HOLE
LOCATION
DESCRIPTION

	WEIGHT					WEIGHT								
MPLE	OF	ASSAY OF CORE				OF	ASSAY OF SLUDGE				CALCULATED ASSAY			
MBER	CORE	CaCO3	S102	R203	MgCO3	SLUDGE	CaCO3	S102	R203	MgCO3	CaCO3	S102	R203	MgCO3
JH	160A	81.8	17.4	0.7										
	160B	86.3	12.9	0.4										
	160C	85.5	12.0	0.3										
	160D	82.3	15.4	0.2										
	160E	86.0	12.4	0.4										
	161A	CaO			MgO									
		2.6	88.8	6.7	0.7									
		CaO			MgO									
	161B	5.5	88.5	5.0	1.0									
	161C	38.7	58.5	1.3										
	161D	31.1	66.7	0.8										
	162A	1.1	92.5	5.1	0.8									
	162B	0.8	90.8	7.2	0.6									
	162C													
	162D	81.5	17.5	0.8	3.3									
	162E	93.0	7.0	0.6										
		CaO			MgO									
	163A	28.3	63.0	6.8	0.7									
		CaO			MgO									
	163B	57.5	36.7	2.9	0.7									
	163C	76.2	22.8	0.5										
	164A	84.1	13.8	1.1										
	164B	84.7	13.1	0.3										
	164C	74.6	24.2	0.8										
	164D	74.8	21.5	2.0										
	164E	57.7	40.2	1.3										
	165A	55.0	42.7	1.3										
	165B	34.5	63.4	1.1										
	165C	53.4	44.5	1.2										
	166A	53.1	45.8	1.3										
	166B	57.3	38.7	1.2										
	167A	61.3	36.8	1.4										
	167B	61.7	36.9	0.6										
	167C	70.4	28.0	0.8										
	167D	75.3	24.0	0.6										
	167E	76.5	20.8	1.4										

ASSAY LOG
JACKHAMMER SAMPLES

NO. HOLE
LOCATION PAGE 23
DESCRIPTION

SAMPLE	WEIGHT OF		ASSAY OF CORE			WEIGHT OF		ASSAY OF SLUDGE			CALCULATED ASSAY			
NUMBER	CORE	CaCO3	S102	R203	MgCO3	SLUDGE	CaCO3	S102	R203	MgCO3	CaCO3	S102	R203	MgCO3
JH	168A	65.2	32.7	1.2										
	168B	45.0	52.5	1.6	2.7									
	168C	42.8	55.3	1.6										
	169A	64.4	35.4	1.6										
	169B	57.7	41.5	1.1										
	169C	66.8	31.7	1.0										
	170A	67.6	29.9	1.2										
	170B	80.6	17.8	1.0										
	170C	77.3	20.2	1.1										
	170D	81.8	16.9	1.0										
	170E	85.1	13.6	1.0										
	171A	82.5	16.8	1.2										
	171B	93.0	6.5	0.8	2.8									
	171C	96.1	1.8	0.1										
	172A	94.8	2.0	0.4										
	172B	97.5	1.2	0.4										
	172C	96.5	1.9	0.7										
	173A	96.7	1.9	0.4	1.5									
	173B	96.2	2.8	0.6										
	173C	95.0	4.8	0.5										
	173D	95.8	3.1	0.4										
	173E	95.0	2.3	0.6										
	174A	94.5	2.3	0.8										
	174B	95.0	2.7	0.6										
	174C	97.0	2.3	0.7										
	175A	90.6	5.6	1.8										
	175B	98.4	1.2	0.4										
	175C	97.0	1.8	0.5										

ASSAY LOG
JACKHAMMER SAMPLES

NO. HOLE
LOCATION
DESCRIPTION

PLE BER	WEIGHT OF CORE	ASSAY OF CORE				WEIGHT OF SLUDGE	ASSAY OF SLUDGE				CALCULATED ASSAY			
		CaCO3	SiO2	R2O3	MgCO3		CaCO3	SiO2	R2O3	MgCO3	CaCO3	SiO2	R2O3	MgCO3
	176A	83.4	14.5	0.8										
	176B	80.5	19.4	0.8										
	176C	89.2	8.9	0.8										
	176D	85.5	13.3	0.6										
	176E	88.7	10.3	0.7										
	177A	84.4	14.5	0.9										
	177B	95.0	4.2	0.4										
	177C	96.5	2.5	0.4										
	178A	95.2	3.5	0.7	1.9									
	178B	92.9	5.6	1.0										
	178C	80.0	19.2	0.8										
	179A	82.2	14.7	1.4										
	179B	79.0	18.8	1.6	2.7									
	179C	75.6	21.2	1.9										
	179D	55.7	43.5	1.2										
	179E	60.1	33.0	3.5										
	180A	70.8	22.1	4.3										
	180B	58.3	28.0	10.4	1.9									
	180C	83.2	15.3	0.9										
	181A	81.8	16.3	1.0										
	181B	75.6	22.2	1.3										
	181C	52.6	45.2	0.7										
	182A	80.6	18.9	0.7										
	182B	82.2	15.3	0.6										
	182C	77.2	20.9	0.8										
	182D	89.5	8.8	0.7										
	182E	96.6	2.4	0.7										

ASSAY LOG
JACKHAMMER SAMPLES

NO. HOLE
LOCATION Page 25
DESCRIPTION

	WEIGHT	ASSAY OF CORE				WEIGHT	ASSAY OF SLUDGE				CALCULATED ASSAY			
PLE BER	OF CORE	$CaCO_3$	SiO_2	R_2O_3	$MgCO_3$	OF SLUDGE	$CaCO_3$	SiO_2	R_2O_3	$MgCO_3$	$CaCO_3$	SiO_2	R_2O_3	$MgCO_3$
JH	183A	76.8	21.7	1.1										
	183B	71.2	27.1	0.9										
	183C	54.8	43.6	1.4										
	184A	70.3	28.0	0.8										
	184B	86.0	11.8	1.2										
	184C	95.8	3.0	0.8										

1 B

DIAMOND DRILL SAMPLES

ASSAY LOG

NO. HOLE Diamond Drill Hole #1

LOCATION

DESCRIPTION

Sample Number	Weight of Core	ASSAY OF CORE				Weight of Sludge	ASSAY OF SLUDGE				CALCULATED ASSAY			
		$CaCO_3$	SiO_2	R_2O_3	$MgCO_3$		$CaCO_3$	SiO_2	R_2O_3	$MgCO_3$	$CaCO_3$	SiO2	R2O3	MgC
0-5		94.1	4.2	0.7		)					94.1	4.2	0.7	
5-10						)								
10-15		95.7	3.0	0.4		)					95.7	3.0	0.4	
		89.5	8.6	1.0		)								
15-20		72.7	24.3	2.4		A)	74.7	17.6	0.9		81.1	16.4	1.7	
20-25		89.7	8.3	1.0		B)	76.8	15.7	0.8		89.7	8.3	1.0	
25-30		88.0	10.2	1.0		)	Grab Samples--not considered in				88.0	10.2	1.0	
30-35		97.0	1.4	0.4	-1.0	)	corrected assay				97.0	1.4	0.4	
35-40		81.4	16.3	1.9	#1.0		93.6	4.4	1.5	0.5	92.8	4.6	1.5	
40-45		80.0	17.6	1.8	-1.0		86.2	12.0	0.9	0.4	86.0	12.0	0.9	
45-50		41.7	55.0	2.5			92.3	6.8	1.0	0.9	88.9	9.2	1.0	
50-55		87.6	10.3	1.6	-1.0		91.2	6.9	1.0		90.9	7.0	1.0	
55-60		33.2	63.0	3.6	-0.5		79.0	22.7	1.2		77.6	23.8	1.0	
60-65		67.8	30.5	3.3	#1.0		80.3	16.8	1.4		79.6	17.6	1.4	
65-67		26.7	67.2	4.4	#1.0		77.8	15.8	1.4		73.8	16.7	1.5	
67-74		44.0	52.3	3.6	-1.0		80.5	16.0	1.9		79.5	16.7	1.9	
[illegible]		61.0	35.8	1.5	-1.0		80.5	16.8	1.6		78.9	17.0	1.6	
81-84		80.2	16.8	2.3	-1.0		70.9	26.8	1.7		71.0	26.7	1.7	
84-89		39.4	57.9	1.8			70.8	26.0	2.0		68.2	28.56	2.0	
89-95		70.7	25.4	3.1	-0.5		79.5	17.2	2.0		78.4	19.5	2.1	
95-101		66.1	20.3	2.9	-0.5		71.0	25.8	2.4		70.1	24.8	2.48	
101-103		60.5	38.6	1.8			83.9	12.7	1.7		80.2	16.4	1.7	
103-108		74.3	23.0	3.6			No Sludge Return				74.5	23.0	3.6	
108-113		55.1	41.3	2.1			below this point				55.1	41.3	2.1	
113-116		61.5	34.0	2.9							61.5	34.0	2.9	
116-121		35.6	62.8	1.3							35.6	62.8	1.3	
121-126		32.8	62.6	4.0							32.8	62.6	4.0	
126-128		76.2	21.5	1.6							76.2	21.5	1.6	
128-129		56.8	41.5	2.1							55.8	41.5	2.1	
129-132		45.9	49.3	3.9							45.9	45.3	3.9	
132-137		45.0	35.7	12.9	7.1						45.0	35.7	12.9	7.
137-137½		66.1	28.8	2.1							66.1	28.8	2.1	
137½-142		87.0	10.5	1.2							87.0	10.5	1.2	

ASSAY LOG

NO. HOLE Diamond Drill Hole #2

LOCATION

DESCRIPTION

Sample Number	Weight of Core	ASSAY OF CORE				Weight of Sludge	ASSAY OF SLUDGE				CALCULATED ASSAY			
		$CaCO_3$	SiO_2	R_2O_3	$MgCO_3$		$CaCO_3$	SiO_2	R_2O_3	$MgCO_3$	$CaCO_3$	SiO_2	R_2O_3	$MgCO_3$
0-5		93.5	5.2	0.5			87.8	10.6	1.2		90.9			
5-10		94.8	3.7	0.6			85.0	12.3	2.0		90.6			
10-15		91.8	6.4	0.8			93.8	3.5	1.0		93.0			
15-20		97.3	2.3	0.8			No Sludge				97.3			
20-25		95.8	2.4	0.8			No	"			95.8			
25-30		94.8	3.6	0.5			92.5	2.6	4.5	1.1	93.4			
30-35		97.0	1.4	0.4	-1%		96.2	1.5	1.4		96.3			
35-40		85.7	12.5	1.0			87.8	9.8	-		87.1			
40-45		92.7	6.4	0.7			91.0	5.5	1.0		91.1			
45-50		93.8	4.7	0.6			88.1	10.1	0.8		89.2			
50-55		96.8	1.6	0.4			89.8	7.4	1.9		90.0			
55-60		97.6	1.2	0.8			95.4	2.0	3.0		95.5			
60-65		91.7	5.9	0.7			95.6	2.9	1.4		95.2			
65-68		96.9	1.6	0.7			92.9	5.2	1.7		93.8			
68-73		94.7	3.0	0.6			No	Sludge			94.7			
73-74		95.8	2.4	0.6			No	"			95.8			
74-78		95.2	2.6	0.6			No	"			95.2			
78-80		95.6	2.3	0.6			(93.5	2.6	6.0	1.1	94.1			
80-85		96.0	1.9	0.3			(							
85-90		No	Core				92.2	5.1	2.5		92.2			
90-94½		98.3	0.5	0.5			95.9	3.2	1.4		96.3			
94½		92.3	5.9	0.7			95.5	2.9	1.1	0.7	95.4			
100-107		94.4	0.8	1.7			87.5	10.4	2.9	0.8	87.8			
107-112		96.8	1.3	0.4			86.2	11.5	2.7		86.6			
112-117		96.7	1.5	0.2			85.4	11.9	3.6	0.9	85.8			
117-122		97.7	0.7	0.3			93.8	5.5	2.4		93.9			
122-127		96.7	1.3	0.8			92.3	7.0	1.9		92.4			
127-132		81.6	17.4	1.0			95.2	3.7	2.9	1.2	94.0			
132-137		93.5	6.9	0.6			91.4	3.6	6.5	2.1	91.4			
137-142		96.5	2.3	0.5			88.4	8.9	1.4		88.8			

ASSAY LOG

NO. HOLE Diamond Drill Hole #2

LOCATION

DESCRIPTION

Sample Number	Weight of Core	ASSAY OF CORE				Weight of Sludge	ASSAY OF SLUDGE				CALCULATED ASSAY			
		$CaCO_3$	SIO_2	R_2O_3	$MgCO_3$		$CaCO_3$	SIO_2	R_2O_3	$MgCO_3$	$CaCO_3$	SIO_2	R2O3	$MgCO_3$
142-147		76.4	21.5	1.0			81.8	16.2	1.4		81.3			
147-152		76.6	21.5	1.1			91.2	3.5	0.6	1.4	90.6			
152-157		82.6	15.9	0.7			91.5	5.0	0.1		91.1			
157-162		97.1	1.6	0.4			87.8	9.6	1.4		89.1			
162-167		94.5	3.3	0.3			88.9	7.8	1.6		89.3			
167-172		30.0	66.5	2.3			82.8	12.2	2.8		80.6			
172-178		71.2	25.4	2.0			87.6	7.8	1.9		87.3			
178-182		68.3	27.8	2.0			68.0	28.4	3.2		68.0			
182-186		72.3	24.4	1.9			68.5	27.8	0.9		68.7			
186-191		61.3	36.2	2.0			80.0	14.7	1.1		78.0			
191-191½		26.9	70.0	1.9			No	Sludge			26.9			
191½-200		51.5	45.7	2.6			72.2	14.5	10.9	1.8	71.6			
200-206		46.6	50.3	2.0			80.5	14.7	4.1		78.2			
206-207½		32.0	65.2	2.0			No	Sludge			32.0			
207½-208		87.2	4.7	0.8							87.2			
208-208^{9}		75.2	20.7	1.5							75.2			
[illegible]-211		94.1	2.4	0.9							94.1			
211-213		73.3	21.5	1.1							73.3			
213-218		67.8	29.4	1.3							67.8			
218-222		69.4	2[illegible].0	1.4			(93.0	4.1	2.5		88.7			
222-226							(							
226-228		58.2	37.7	1.6			79.4	14.5	4.9		78.9			
228-233		59.2	36.8	1.8			87.2	10.4	2.2		84.6			
233-238		37.4	59.6	1.3			80.0	17.1	2.0		76.1			
238-243		48.1	47.6	2.7			No	Sludge			48.1			
243-244		63.5	35.2	1.8			77.9	19.1	1.9	± 1	72.1			
244-249		42.9	53.3	2.3			72.3	22.5	3.2	± 1	65.2			
249-254		24.2	71.3	2.4			63.7	35.7	1.9	± 1	62.1			
254-259		54.0	41.3	3.5			59.8	38.2	1.7	± 0.5	59.4			
259-264		53.3	44.3	1.5			67.2	27.5	5.4	2.0	65.6			
264-271		No	Core				69.1	28.2	1.6	± 1	69.1			
271-278							55.5	37.0	3.9	2.4	55.5			

ASSAY LOG

NO. HOLE Diamond Drill Hole #3

LOCATION

DESCRIPTION

Sample Number	Weight of Core	ASSAY OF CORE				Weight of Sludge	ASSAY OF SLUDGE				CALCULATED ASSAY			
		$CaCO_3$	SiO_2	R_2O_3	$MgCO_3$		$CaCO_3$	SiO_2	R_2O_3	$MgCO_3$	$CaCO_3$	S_1O_2	R_2O_3	$MgCO_3$
0-5		93.9	5.2	0.5							93.9			
5-10		98.8	0.6	0.3			87.7	10.0	2.5	0.4	88.6			
10-15		98.0	1.2	0.2			86.8	10.1	1.5		87.2			
15-20		88.5	9.8	0.5			94.3	3.7	0.6		94.2			
20-24		No	Core				95.4	3.4	0.8		95.4			
24-29		"	"				95.5	3.5	0.8		95.5			
29-34		91.1	8.0	0.5			90.8	4.3	3.7		90.9			
34-39		89.8	9.0	0.6			87.8	8.3	2.2		88.0			
39-44		97.3	1.4	0.2			85.8	5.6	8.9		86.2			
44-49		89.0	9.2	0.4			88.0	8.5	2.9		88.0			
49-50		91.1	3.8	1.6	3.2		88.0	7.5	4.6	3.2	88.9			
50-55		69.2	12.4	1.7	14.9		80.6	12.5	8.6		76.0			
55-58½		55.8	29.9	8.9			No	Sludge			55.8			
58-60^7		26.4	56.1	9.6	1.2		"	"			26.4			
60^7-63		28.3	53.2	9.8			"	"			28.3			
[illegible] 70		80.7	16.8	1.4			83.0	11.5	6.9		82.4			
[illegible]75		97.5	1.8	0.6			66.0	22.6	15.0	2.4	71.6			
75-80		94.3	5.1	0.5			No	Sludge			94.3			
80-84		96.6	2.8	0.4			71.0	18.0	10.4	1.3	76.1			
84-89		75.6	22.9	0.8			90.4	9.4	1.8	1.7	87.4			
89-91		97.6	1.8	0.5			83.9	13.9	1.5	-0.5	87.1			
91-96		82.2	17.2	0.7			72.6	24.0	3.0	1.6	74.1			
96-99		95.0	4.4	0.4			89.2	7.2	2.5	1.8	92.3			
99-101½		84.7	14.6	0.5			80.1	16.6	1.9	1.9	80.8			
100½-103½		94.2	5.1	0.5			No	Sludge			94.2			
103½-107		61.9	33.7	3.1			"	"			61.9			
107-112		91.3	7.3	1.1			"	"			91.3			
112-118		74.0	25.0	1.0			67.3	30.9	1.3	0.5	68.6			
118-126		76.2	22.9	1.0			70.3	27.7	0.9	0.5	70.6			
126-130		No	Core				88.8	8.7	2.1		88.8			
130-134		40.1	58.4	1.0			75.4	22.9	1.2	-1.0	73.6			

ASSAY LOG

NO. HOLE Diamond Drill Hole #3

LOCATION

DESCRIPTION

Sample Number	Weight of Core	ASSAY OF CORE				Weight of Sludge	ASSAY OF SLUDGE				CALCULATED ASSAY			
		$CaCO_3$	SiO_2	R_2O_3	$MgCO_3$		$CaCO_3$	SiO_2	R_2O_3	$MgCO_3$	$CaCO_3$	SiO_2	R_2O_3	$MgCO_3$
134-139		74.6	24.2	0.8			76.6	20.8	2.5	-1.0	76.6			
139-144		No	Core				No	Sludge			--			
144-149		86.0	12.2	0.5			74.2	24.3	2.8	1.6	77.5			
149-154		47.5	50.8	1.0			68.2	34.7	2.9	1.2	67.8			
154-157		55.6	43.0	9.6			62.0	30.3	5.5	2.0	61.4			
157-162		52.4	45.9	1.3			27.0	68.1	2.8	-1%	28.0			
162-168		55.9	42.5	1.8			26.9	70.4	2.6	1.2	29.2			
168-174		73.7	25.6	0.8			No	Sludge			73.7			

ASSAY LOG

NO. HOLE Diamond Drill Hole #4

LOCATION

DESCRIPTION

Sample Number	Weight of Core	$CaCO_3$	S_1O_2	R_2O_3	$MgCO_3$	Weight of Sludge	ASSAY OF SLUDGE				CALCULATED ASSAY			
							$CaCO_3$	S_1O_2	R_2O_3	$MgCO_3$	$CaCO_3$	S_1O_2	R_2O_3	$MgCO_3$
0-5		96.3	2.1	0.7			96.5	1.8	1.1	0.8	96.6			
5-10		94.8	3.9	0.4			88.4	8.9	1.2		88.8			
10-14		97.0	0.8	0.6			94.0	3.9	0.9		94.1			
14-18		96.3	1.3	0.9			95.2	1.6	1.5		95.4			
18-23		96.6	1.6	0.6			99.0	1.9	1.5		98.7			
23-26		95.2	2.0	0.8			89.9	2.7	1.5		90.9			
26-29		95.8	2.0	0.7			91.2	3.5	5.2	1.7	92.3			
29-34		92.7	5.8	0.8			93.2	4.0	4.2		92.9			
34-36		96.8	1.9	0.4			95.9	1.9	1.1		96.0			
36-40		95.6	2.3	0.2			96.5	1.4	2.0		96.4			
40-44		97.2	1.1	0.4			97.2	1.4	0.8		97.2			
44-49		97.3	1.4	0.5			97.3	1.0	0.9		97.3			
49-54		96.8	1.2	0.2			97.3	1.1	0.7		97.2			
54-59		98.8	1.4	0.4			No	Sludge			98.8			
59-62		96.5	1.5	1.3			85.3	12.8	2.6		85.8			
62-67		96.5	2.8	0.4			95.2	3.3	0.7		95.5			
67-72		98.2	1.5	0.4			94.3	3.3	1.0		94.5			
[illegible]6		97.3	1.8	0.4			No	Sludge			95.2			
[illegible]-79		96.4	2.6	0.4			94.8	2.7	0.9		95.2			
79-84		95.7	2.8	0.5			95.2	2.3	1.9		95.2			
84-87		95.8	2.5	1.0			94.8	3.0	1.0		94.8			
87-92		96.5	2.4	0.7			95.3	2.2	1.5		95.4			
92-97		96.2	1.8	0.5			95.5	2.5	1.7		95.6			
97-102		96.3	1.6	0.4			96.3	2.0	1.3		96.3			
102 -104		97.8	1.1	0.2			94.2	2.3	1.7		94.6			
104-109		97.8	1.6	0.3			89.5	5.6	2.0	3.0	90.0			
109-114		96.5	3.6	0.4			90.6	5.7	2.4		90.7			
114-119		91.6	7.2	0.6			87.8	7.2	3.1	1.8	88.0			
119-125		84.4	14.4	0.8			89.3	7.1	2.8	2.5	89.2			
125-130		80.4	17.8	1.0			No	Sludge			80.4			
130-134		90.5	9.0	0.6			90.0	7.1	2.1	1.5	90.0			

ASSAY LOG

NO. HOLE   Diamond Drill Hole #4

LOCATION

DESCRIPTION

ample umber	Weight of Core	$CaCO_3$	S_1O_2	R_2O_3	$MgCO_3$	Weight of Sludge	ASSAY OF SLUDGE				CALCULATED ASSAY			
							$CaCO_3$	S_1O_2	R_2O_3	$MgCO_3$	$CaCO_3$	S_1O_2	R_2O_3	$MgCO_3$
134-139		91.1	7.8	0.5	-1%		89.8	6.9	2.1	1.5	89.9			
139-144		95.2	3.2	0.4	"		83.2	10.5	3.4	2.0	84.2			
144-149		97.2	1.2	0.3	"		85.3	10.3	3.2	2.0	86.9			
149-154		97.5	1.4	0.4	"		84.2	10.4	3.5	2.9	87.6			
-158		92.7	5.6	0.4	"		85.9	11.5	0.6		86.3			
158-162		98.0	1.0	0.3	"		86.7	10.2	0.6		87.5			
162-166		97.4	0.8	0.2	"		86.9	9.7	0.7		87.7			
166-171		No	Core				72.8	24.6	2.4		72.8			
171-176		"	"				78.5	18.4	0.5		78.5			
176-181		98.2	0.8	0.2	-1%		83.2	14.6	1.1		83.6			
181-183		No	Core				84.3	13.7	1.6		84.3			

ASSAY LOG

NO. HOLE Diamond Drill Hole No. 5

LOCATION

DESCRIPTION

ample umber	Weight of Core	$CaCO_3$	SiO_2	R_2O_3	$MgCO_3$	Weight of Sludge	ASSAY OF SLUDGE $CaCO_3$	SiO_2	R_2O_3	$MgCO_3$	CALCULATED ASSAY $CaCO_3$	SiO_2	R2O3	MgCO3
-7	)						93.2	5.9	0.9	1.1	93.3			
-15	)	97.5	1.0	0.2			93.5	4.0	0.5	1.4	93.5			
6-20	)						90.5	3.3	5.2	-1.0	90.5			
0-25		93.2	4.8	0.2			92.3	5.7	0.8	-1.0	92.8			
5-30		No	Core				91.3	8.5	5.2	-1.0	91.3			
0-32							91.8	7.1	1.3	-1.0	91.8			
2-37		89.0	9.2	0.4			90.6	6.4	1.8		90.5			
7-42		No	Core				89.2	8.8	1.0		89.2			
2-47		97.2	0.7	0.2			93.5	4.2	1.3		93.6			
7-52		97.3	0.4	0.1			91.7	5.9	1.5		91.9			
2-57		No	Core				93.5	2.5	0.3		93.5			
7-62		96.5	1.0	0.2			81.8	9.5	7.8	1.6	82.1			
2-67		90.6	6.2	0.4			82.3	14.6	2.5		82.7			
7-71		95.8	3.8	0.6			85.7	12.0	2.0		86.0			
1-77		90.1	6.5	0.4			92.7	5.1	1.8		92.4			
7-82		96.0	1.9	0.3			89.5	7.5	2.4		89.6			
9		81.3	15.7	1.1			85.5	11.9	1.9		85.0			
-94		74.2	22.2	1.2			68.6	31.4	1.6		67.6			
-99		88.5	7.5	0.9			74.2	23.1	2.8		75.9			
-104		89.3	7.3	0.8			79.3	18.7	1.7		80.1			
104-109		86.8	9.8	0.7			76.7	17.8	2.8		77.9			
109-114		66.2	20.9	1.0			85.5	11.6	2.4		84.7			
114-119		90.5	6.1	0.6			70.2	25.4	1.3		71.0			
119-124		72.9	23.6	1.0			76.1	21.5	0.9		75.8			
124-129		59.2	37.6	2.0			None				59.2			
129-134		84.7	12.7	1.1			72.3	22.7	1.4	0.7	73.0			
134-139		58.2	38.9	1.3			74.3	19.4	1.6	1.8	73.9			
139-144		75.7	23.4	1.5			69.7	25.5	1.1	0.9	70.7			
144-150		28.3	67.7	1.4			None				28.3			
150-155		66.8	30.1	1.0			64.3	30.7	4.3		64.3			

ASSAY LOG

NO. HOLE Diamond Drill Hole #5

LOCATION

DESCRIPTION

Sample	Weight	ASSAY OF CORE				Weight	ASSAY OF SLUDGE				CALCULATED ASSAY			
Number	of Core	CaCO$_3$	S102	R203	MgCO3	of Sludge	CaCO3	S102	R203	MgCO3	CaCO3	S102	R203	MgCO3
155-157		No	Core				28.0	55.5	9.8	4.8	28.0			
157-161		"	"				26.8	54.1	11.4	5.2	26.8			
161-164		"	"				CaO 13.1	62.3	16.2	MgO 2.9	13.1			
164-169		"	"				62.6	28.5	3.0	4.0	62.6			
169-174		88.1	9.3	0.8			60.9	29.1	4.0	4.6	64.1			
174-179		91.3	6.8	0.7			78.9	18.1	1.7	1.9	79.3			
179-182		76.3	21.9	0.8			75.3	16.2	2.4	2.6	75.4			
182-188		89.9	8.1	0.9			96.7	2.1	0.6		96.4			
188-193		85.0	13.2	0.6			93.3	4.7	1.2		92.2			
193-198		97.0	3.3	0.5			91.3	6.8	0.9		92.4			
198-204		88.7	10.4	0.4			90.3	8.5	1.4		90.7			
204-209		93.8	4.6	0.4			84.0	14.8	0.7		84.6			
209-214		91.0	7.6	0.4			83.4	15.1	0.8		83.7			
214-219		73.2	25.3	0.6			77.4	20.8	0.9		76.6			
219-224		73.1	26.8	0.6			76.0	22.3	0.8		75.7			
224-229		75.3	23.0	0.7			66.1	27.3	3.9	2.0	66.2			
[illegible]234		No	Core				77.3	18.9	2.1	1.7	77.3			
234-239		80.0	19.3	0.7			67.7	29.6	2.1		68.4			
239-244		36.2	62.8	0.8			71.9	25.1	2.4	2.0	70.5			
244-249		No	Core				65.7	28.3	2.1		65.7			
249-254		74.8	24.2	0.8			71.0	27.5	1.5	1.2	71.1			
254-259		No	Core				62.7	33.5	3.6		62.7			
259-262		"	"				60.3	34.9	2.5	1.1	60.3			
262-267			"				62.2	33.3	2.5	1.5	62.2			
267-272			"				62.2	34.1	1.7	1.4	62.2			
272-279		46.7	50.2	1.0			67.4	28.2	2.0	1.4	66.2			
279-288		44.4	52.0	0.7			60.3	34.0	3.4	-1.5	59.1			
288-294		56.2	40.7	0.8			61.7	34.0	2.9	-1.5	61.5			
294-299		43.4	54.3	0.8			48.6	44.0	4.1	-1.5	48.1			
299-302		No	Core				51.9	45.8	2.6	1.4	51.9			

ASSAY LOG

NO. HOLE
LOCATION
DESCRIPTION

SAMPLE NUMBER	WEIGHT OF CORE	ASSAY OF CORE CaCO3	S102	R2O3	MgCO3	WEIGHT OF SLUDGE	ASSAY OF SLUDGE CaCO3	S102	R2O3	MgCO3	CALCULATED ASSAY CaCO3	S102	R2O3	MgC
303-309		71.3	26.3	0.8			59.3	35.0	4.0	2.4	59.5			
309-314		85.6	12.7	0.5			57.2	40.1	1.4		61.1			
314-318		78.4	21.0	0.6			57.2	39.2	1.6		60.8			
18 -323		63.3	34.5	0.5			54.4	40.4	4.0		54.6			
323-328		62.5	36.5	0.7			55.8	41.0	2.2		54.0*			
328-333		61.8	37.1	0.6				None			61.8			
333-338		69.8	29.1	0.4			74.6	18.0	12.0		74.4			
338-343			No Core				73.8	18.1	12.5		73.8			
343-349		80.5	18.6	0.6			69.0	25.4	5.6		71.5*			
349-356		65.1	32.4	0.8			48.3	47.0	2.9	1.7	49.0			
356-357		29.2	68.2	0.8			47.7	45.4	4.4		46.6			
357-362		65.8	31.7	0.6			68.3	25.9	3.4		68.2			
362-368			None				47.6	38.3	8.4		47.6			
368-374		87.2	11.3	0.5			79.9	15.3	2.7	1.8	81.2*			
374-380		62.7	35.3	0.7			62.3	31.2	3.8	2.0	62.3			
380-385		51.3	46.0	1.0			53.6	40.3	3.8	2.0	53.4			
[illegible]-388		87.6	11.4	1.0			47.3	44.2	5.0	2.2	48.6			
388-392			None				34.3	59.2	4.2		34.3			
392-396			"				32.5	60.9	4.4	2.1	32.5			
396-400		69.6	29.5	0.7			57.6	39.0	1.6	1.2	59.7*			
400-404		46.6	53.0	0.7			57.6	39.1	1.3	1.1	57.1			
404-409	1/4	57.8	40.4	1.2			55.2	39.2	3.3	1.9	55.4			
409-414			None				56.6	38.8	4.2	1.8	56.6			

ASSAY LOG

NO. HOLE
LOCATION
DESCRIPTION

SAMPLE NUMBER	WEIGHT OF CORE	ASSAY OF CORE CaCO3	S102	R2O3	MgCO3	WEIGHT OF SLUDGE	ASSAY OF SLUDGE CaCO3	S102	R2O3	MgCO3	CALCULATED ASSAY CaCO3	S102	R2O3	MgCO3
0- 5							94.9	3.4	0.3					
5-10							95.1	4.0	0.6					
10-15							94.2	1.8	1.2					
15-20							92.2	6.6	0.6					
20-26							92.6	5.8	0.6					
26-32							89.5	7.7	1.8					
32-37							89.4	7.4	3.9					
37-42							90.5	6.4	2.8					
42-47							89.5	7.0	3.0					

#6A

ASSAY LOG

NO. HOLE
LOCATION
DESCRIPTION

SAMPLE NUMBER	WEIGHT OF CORE	ASSAY OF CORE				WEIGHT OF SLUDGE	ASSAY OF SLUDGE				CALCULATE[illegible] ASSAY			
		$CaCO_3$	SiO_2	R_2O_3	$MgCO_3$		$CaCO_3$	SiO_2	R_2O_3	$MgCO_3$	$CaCO_3$	SiO_2	R_2O_3	MgC
0- 5							91.5	6.2	1.5					
5-10							91.5	6.5	1.1					
10-15							93.0	4.8	1.0					
15-20							93.6	4.5	0.7					
20-22							92.8	5.6	1.3					
22-27							90.3	6.4	2.1	1.1 *				
27-29							90.0	7.6	1.4					
29-35							81.9	8.2	1.3	0.9				
35-40							82.8	7.5	1.6	0.8				
40-45							83.5	13.6	4.1	9.8 *				
45-48														
48-53							38.8	50.9	8.1	2.5				
53-58							64.5	27.0	8.5	2.0 *				
58-60							37.1	51.8	10.3	2.9				
60-65							25.4	49.5	13.9	11.6				
65-70							22.2	52.3	15.4	10.5				
							CaO			MgO				
[illegible]-4							12.4	50.1	26.5	8.8				
74-78-1/2							20.6	48.3						
78½-80½								—						
80½-83								48.3						
83-88							CaO	47.2						
88-93								—						
93-99								46.4						
99-104								49.0						
104-110							8.2	50.8	29.8	11.9				
110-116							10.6	49.8			*			
116-118								—						
118-123							64.6	32.5	1.8					
123-128								—						
128-133								—						
133-138								—						
138-143														

ASSAY LOG

NO. HOLE
LOCATION
DESCRIPTION

SAMPLE NUMBER	WEIGHT OF CORE	ASSAY OF CORE CaCO3	S102	R203	MgCO3	WEIGHT OF SLUDGE	ASSAY OF SLUDGE CaCO3	S102	R203	MgCO3	CALCULATED ASSAY CaCO3	S102	R203	MgC
143-148							63.7	33.6	1.3					
148-153							66.2	31.6	1.2					
153-158							64.8	32.6	1.2					
158-163							65.2	32.8	1.0					
163-168							71.2	24.5	3.6 *					
168-173							53.8	39.9	5.0					
173-178							57.5	38.8	2.6					
178-183							41.2	56.9	1.4					
183-188							24.3	70.8	2.7					
188-193							36.6	62.0	2.6					
193-196							25.3	72.1	3.0					
196-201							39.8	51.8	4.3					
201-206							47.5	48.2	0.3					
206-212							52.8	44.4	1.6 *					
212-217							82.5	13.4	3.8					
217-222							65.9	32.0	1.8					
222-229							83.0	12.8	3.2					
[illegible]-234							74.9	20.0	3.9					
234-239							78.0	17.6	4.0 *	1.4				
239-241							No Sludge							
241-246							42.3	57.2	2.6	1.2				
246-251							22.0	71.8	5.9					
251-256							37.2	56.6	4.9	1.0				
256-259							29.6	65.8	4.7	1.0				
259-264							82.7	11.4	5.2					
264-269							44.8	50.8	2.3					
269-274							58.5	37.4	3.5	1.3				
274-278							45.9	39.5	5.5					
278-283							62.2	34.9	2.6					
283-288							61.3	35.2	2.6	1.2				
288-292							59.8	36.0	2.9					

ASSAY LOG

NO. HOLE Diamond Drill Hole #6A

LOCATION

DESCRIPTION

Sample Number	Weight of Core	ASSAY OF CORE CaCO3	SiO2	R2O3	MgCO3	Weight of Sludge	ASSAY OF SLUDGE CaCO3	SiO2	R2O3	MgCO3	CALCULATED ASSAY CaCO3	SiO2	R2O3	MgCO
292-297							46.3	43.1	6.8					
297-303							48.3	42.6	6.4					
303-308							44.5	40.3	5.9					
308-313							67.2	28.4	3.0					
313-317							67.5	27.5	3.5					
317-324							93.0	3.9	2.3					
324-329							63.2	30.0	4.9					
329-334							63.3	30.0	5.5					
334-340							62.5	30.1	5.0					

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ASSAY LOG

NO. HOLE
LOCATION
DESCRIPTION

SAMPLE NUMBER	WEIGHT OF CORE	ASSAY OF CORE CaCO3	S102	R203	MgCO3	WEIGHT OF SLUDGE	ASSAY OF SLUDGE CaCO3	S102	R203	MgCO3	CALCULATED ASSAY CaCO3	S102	R203	MgCO
0- 5		No Core					37.9	60.2	1.8					
5- 9		36.5	61.7	0.8			26.4	72.0	1.1					
9-12		No Core					20.4	77.8	1.2					
12-14		37.7	59.3	0.9			22.8	76.3	1.3					
14-17		15.5	82.8	1.0										
16-18		24.9	72.0	1.2			29.3	68.8	1.2					
-20		40.3	57.3	0.9			49.7	47.8	1.2					
20-27		55.2	42.5	1.0			46.7	48.7	1.7					
27-30		56.2	41.3	0.8										
30-32		60.2	38.2	0.4			70.3	27.5	1.2					
32-35		46.0	50.8	0.5			57.6	36.9	3.6 *					
33-34		66.0	32.0	0.6			No Sludge							
36-37 37-42		59.7	40.1	0.7			80.9 86.4	16.5 11.1	2.4 1.4					
42-47		No Core					85.9	13.9	1.0					
47-52			"				81.5	16.1	1.1					
52-55			"				75.7	21.9	1.1					
[illegible]			"				86.3	9.4	2.6					
60-73			"				No Sludge							
73-74			"				71.8	24.2	4.6 *	1.9				
74-77		22.4	75.8	0.5			No Sludge							
77-82		No Core					47.5	51.6	1.1					
82-86			"				34.6	64.4	1.0					
86-91			"				39.4	59.5	1.1					
91-96			"				37.6	60.9	1.2					
96-101			"				40.0	59.3	1.0 *					
101-106			"				91.5	6.9	1.1					
106-111			"				59.4	39.9	1.2					
111-116		86.5	13.6	0.5			68.7	28.4	1.9					
116-121		95.4	4.4	0.3			73.3	24.7	1.0					
21-126		91.0	8.8	0.4			58.3	39.9	1.3					
126-131		96.2	3.9	0.1			66.4	30.7	1.1 *					

ASSAY LOG

NO. Hole Diamond Drill

LOCATION

DESCRIPTION 7A

Sample Number	Weight of Core	$CaCO_3$	SiO_2	R_2O_3	$MgCO_3$	Weight of Sludge	ASSAY OF SLUDGE				CALCULATED ASSAY			
							$CaCO_3$	SiO_2	R_2O_3	$MgCO_3$	$CaCO_3$	SiO_2	R_2O_3	$MgCO_3$
131-136)	1	96.3	3.0	0.1			96.5	2.8	0.6					
136-141)	18						95.2	3.4	0.5					
141-146		97.2	1.7	0.2			95.4	3.6	0.4					
146-151		No Core					94.5	2.0	0.4					
151-156		------					95.3	4.2	0.5					
156-161		------					91.8	4.5	--					
161-166		------					92.9	4.4	1.9					
166-171		------					92.8	4.5	1.2					
171-176		------					90.0	7.8	0.9					
176-181		96.7	1.8	0.2			94.5	3.6	2.4					
181-186		No Core					92.8	4.2	2.3					
186-191		------					92.1	5.0	1.2					
191-196		------					No Sludge							
196-201		------					96.3	2.8	0.6					
201-206		------		[illegible]			92.8	6.8	0.8					
206-211		------					92.0	7.2	0.8					
211-216		------					90.4	8.3	0.8					
216-221		94.2	3.2	0.5			87.0	9.2	3.8					
221-226		No Core					81.0	14.8	3.5					
226-231		83.7	14.2	0.4			No Sludge							
231-236		95.1	3.8	0.6			86.2	9.8	3.4					
236-241		No Core					90.6	5.7	3.4					
241-244		No Core					88.6	7.4	2.6					
244-249		96.0	1.6	0.4										
249-254		No Core												
254-259														

ASSAY LOG

NO. HOLE Diamond Drill Hole No.3

LOCATION

DESCRIPTION

Sample Number	Weight of Core	ASSAY OF CORE				Weight of Sludge	ASSAY OF SLUDGE				CALCULATED ASSAY			
		CaCO3	SiO2	R2O3	MgCO3		CACO3	SiO2	R2O3	MgCO3	CaCO3	SiO2	R2O3	MgC3
0-7							No Sludge							
7-12							63.8	34.1	1.0					
12-17							75.9	22.1	0.6					
17-23							No Sludge							
23-25							No Sludge							
25-30							97.7	1.8	0.5					
30-36							91.5	6.2	3.1					
36-42							97.0	2.3	1.8					
42-47							No Sludge							
47-52							94.0	2.7	2.2					
52-58							96.3	2.6	1.0					
58-63							90.8	7.7	1.8					
63-68							93.6	4.8	0.5					
68-71							95.0	3.2	0.8					
71-76							88.3	9.5	1.2					
76-81							83.6	14.4	1.0					
81-86							83.9	13.6	1.2					
86-92							82.7	11.4	3.2					
92-98														
98-103							96.6	1.8	0.8					
103-105														
105-108														
108-113														

ASSAY LOG

NO. HOLE Diamond Drill Hole No. 9

LOCATION

DESCRIPTION

Sample Number	Weight of Core	ASSAY OF CORE				Weight of Sludge	ASSAY OF SLUDGE				CALCULATED ASSAY			
		CaCO3	S102	R203	MgCO3		CaCO3	S102	R203	MgCO3	CaCO3	S102	R203	MgO
0-5		97.0	1.2	0.4			59.7	26.1	6.5					
5-10		95.6	2.9	0.2			80.7	11.0	5.2					
10-15)		96.9	1.4	0.2			96.0	2.0	2.0					
15-19)							97.5	1.7	0.5					
19-23		97.0	1.4	0.1			97.5	1.6	1.1					
23-28		96.4	1.7	0.3			86.5	8.8	4.6					
28-32		98.2	1.3	0.3			95.2	2.0	3.0					
32-37							97.5	1.6	1.0					
37-42							96.5	2.2	2.6					
42-47							No Sludge							
47-53							87.0	10.1	2.2					
53-58							66.3	29.2	1.2					
58-63							92.5	8.8	2.9					
63-65							93.3	3.8	1.5					
65-70							95.5	1.9	1.9					
[illegible]74							94.3	2.0	3.0					
74-79							95.7	2.1	0.7					
79-84							97.2	2.0	0.7					
84-89							92.8	4.5	0.9					
89-94							93.4	4.4	1.0					
94-100														
100-103														
103-108														
108-113														
113-119							85.0	13.2	1.2					
119-123														
123-128							85.8	12.8	1.4					
128-131														
131-139							34.0	63.5	2.6					

[redacted]

<u>1 C</u>

HAND SAMPLES

ASSAY LOG
H. S. SAMPLES (MOILED HAND SAMPLES)

NO. HOLE
LOCATION
DESCRIPTION

SAMPLE NUMBER	WEIGHT OF CORE	ASSAY OF CORE				WEIGHT OF SLUDGE	ASSAY OF SLUDGE				CALCULATED ASSAY			
		CaCO3	S102	R203	MgCO3		CaCO3	S102	R203	MgCO3	CaCO3	S102	R203	MgCO3
HS	1	70.8	27.2	1.1		White	Limestone							
	2	41.4	55.4	2.0		"	"							
	3	70.4	27.6	0.9		"	"							
	4	78.2	19.6	1.9		"	"							
	5	90.8	7.6	0.9		Blue	"							
	6	96.3	2.5	1.4		"	"							
	7	93.2	6 .3	1.7		"	"							
	8	93.5	2.7	0.2		"	"							
	9	92.7	3.2	0.1		"	"							
	10	90.6	7.1	2.0		"	"							
	11	92.7	5.3	low		"	"							
	12	87.5	10.3	1.3		"	"							
	13	92.8	5.5	0.2		"	"							
	14	92.6	3.8	0.2		"	"							
	15	90.3	4.5	0.3		"	"							
	16	72.4	26.8	0.2		"	"							
	17	63.3	35.0	0.8		White	"							
	18	71.7	24.2	0.6		"	"							
	19	59.7	38.9	0.8		"	"							
	20	66.2	30.5	1.4		"	"							
	21	68.3	28.3	1.3		"	"							
	22	76.6	22.6	0.8		"	"							
	23	87.7	12.2	0.9		"	"							
	24	89.5	9.2	1.1		Blue	"							
	25	97.0	1.8	---		"	"							
	26	97.0	2.1	0.6		"	"							
	27	75.5	21.4	1.4		"	"							
	28	77.4	19.9	1.5		White	"							

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TABULATIONS OF ANALYSES OF THE SURFACE CLAYS TO DATE

TRANSCRIPT OF ANALYSIS OF CLAY BORE HOLED
Permanente Project
Area A.

Sample No.			Basis	SiO	Al O	Fe O	CaO	MgO	Undet.	% Coarse Waste
BH	1	0-5'	Ignited	66.0	14.1	7.7	1.0	4.3	6.9	59.
	1	5'-6'6"	"	62.6	19.5	5.7	0.9	4.0	7.5	58.
	2	0-3'3"	"	50.5	17.2	15.7	3.4	4.6	8.6	74.
	4	0-5'	"	60.9	18.3	8.2	1.4	9.0	2.2	49.
	6	0-5'	"	70.3	19.0	3.9	1.2	2.2	3.4	45.
	6	5'-8'6"	"	57.4	23.4	8.5	2.3	3.7	4.7	70.
	7	0-5'	"	54.6	30.7	10.0	0.8	3.7	0.2	79.
	7	5'-10'	"	57.5	19.4	9.1	0.6	4.3	9.1	65.
	9	0-3'1"	"	60.0	21.7	8.0	0.9	4.8	4.6	67.
	11	0-2'	"	69.6	14.4	11.4	0.7	1.9	2.0	91.
	12	0-5'	"	56.9	25.8	8.6	0.8	3.9	4.0	52.
	12	5'-7'2"	"	58.2	23.0	7.4	0.4	3.9	7.1	54.
	19	0-5'	"	58.5	25.1	6.9	0.9	3.4	5.1	74.
	19	5'-10'	"	57.2	26.2	8.6	0.8	3.4	4.8	68.
	21	0-16"	"	61.8	23.4	6.9	1.9	2.8	3.2	44.
	31	0-3'	"	68.5	20.1	4.7	0.7	2.2	3.8	47.
	36	0-3'	"	69.0	19.5	4.3	1.0	2.3	3.9	42.
	38	0-2'6"	"	69.2	19.7	4.6	0.9	2.1	4.5	61.
	40	0-5'6"	"	69.7	18.2	4.7	0.9	2.2	4.3	50.
	41	0-4'6"	"	68.0	19.2	4.7	1.0	2.3	4.8	58.
	43	0-5'	"	68.8	19.5	4.1	0.8	1.9	4.9	35.
	43	5'-10'	"	66.7	19.8	5.0	0.8	2.1	5.6	38.
	43	10'-11'2"	"	66.2	20.1	5.4	0.9	2.3	5.1	41.
	51	0-5'	"	59.0	24.8	7.4	0.7	3.4	4.7	65.
	51	5'-6'9"	"	57.7	14.6	14.0	0.4	6.7	6.8	58.
	61	0-4'	"	65.3	19.4	7.7	1.4	2.6	3.6	26.
	68	0-4'6"	"	67.9	19.9	4.5	0.9	2.5	4.3	54.
	70	0-2'8"	"	69.2	18.5	4.5	0.9	2.2	4.7	48.
	77	0-5'	"	58.4	25.1	8.3	0.6	3.4	4.2	82.
	81	0-4'	"	71.4	17.3	4.0	1.1	1.6	4.6	43.
	83	0-5'7"	"	72.5	18.3	3.8	0.6	1.5	3.3	31.
	83	5'-10'	"	72.3	17.9	3.7	0.6	1.7	3.3	23.
	98	0-5'	"	68.2	18.7	4.2	1.9	2.0	5.0	33.
	98	5'-6'4"	"	66.6	20.4	5.1	1.0	2.3	4.6	73.
	106	0-5'5"	"	68.5	18.3	5.8	1.2	2.4	3.8	45.
	111	0-5'2"	"	67.1	21.3	3.5	1.4	2.4	4.3	29.
	114	0-5'5"	"	62.7	20.9	8.6	1.5	3.5	2.8	22.
	116	0-4'	"	56.2	20.4	13.7	3.4	48.	1.5	47.
	121	0-5'	"	69.2	18.3	5.3	1.6	2.3	3.3	44.
	121	5'-10'	"	52.6	19.5	16.8	4.2	5.2	1.7	50.
	121	10'-14'	"	52.4	19.1	16.1	5.1	5.4	1.9	42.
	122	0-5'	"	59.4	19.7	11.2	2.4	5.0	2.5	19.
	122	5'-6'8"	"	65.3	17.5	9.7	1.6	4.5	1.4	37.
	124	0-5'	"	66.3	20.1	5.3	0.7	2.4	5.2	20.
	128	0-5'	"	66.0	18.7	7.3	1.6	5.8	0.6	52.
	137	0-5'	"	54.4	16.2	3.4	0.9	1.5	3.6	53.
	137	5'-11'	"	66.0	19.9	6.5	1.0	2.8	3.8	34.
	143	0-3'9"	"	69.9	18.6	4.6	0.9	1.9	3.9	56.
	147	0-1'8"	"	66.4	21.4	4.6	0.7	2.4	4.5	49.
	150	0-5'6"	"	68.7	10.2	5.3	1.3	2.3	3.2	38.
	150	5'6"6'9"	"	89.5	18.4	3.0	0.9	2.1	4.1	34.
	152	0-3'6"	"	68.4	19.7	4.8	0.8	1.9	4.4	30.

Sample No.		Basis	SiO	Al O	Fe O	CaO	MgO	Undet.	%Coarse Waste
BH	162 0-4'2"	Ignited	68.4	18.8	4.8	0.7	3.4	3.9	43.
	169 0-4'	"	68.2	19.5	4.6	0.8	2.5	4.4	45.

ANALYSIS OF CLAY SAMPLES

AREA NO. B

Sample No.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Undetermined	Percentage of Coarse Material (Rejected)
BH 173A	54.3	17.4	14.2	3.4	7.9	2.8	46
173B	53.8	17.2	14.8	2.9	7.3	4.0	41
174	57.4	17.9	10.6	3.1	7.7	3.3	38
175	62.3	16.3	10.6	1.3	4.1	5.4	42
176	58.1	16.5	13.4	2.2	6.5	3.3	36
177	57.3	15.8	9.9	3.0	10.7	3.3	44
178A	67.3	17.2	6.8	0.9	2.6	5.2	57
178B	62.6	20.4	8.2	0.9	3.1	4.8	53
179A	70.4	17.1	4.8	1.2	2.2	4.3	34
179B	72.9	14.9	4.7	1.1	1.3	5.1	36
179C	70.6	15.4	6.4	0.8	2.0	4.8	37
180	74.6	14.8	3.9	0.7	2.1	3.9	24
181	70.5	16.9	4.7	0.7	2.4	4.8	39
182	68.8	19.2	4.8	0.8	2.3	4.1	32
183A	68.7	17.6	5.0	1.8	3.2	3.7	39
183B	69.3	20.6	1.8	1.3	4.0	3.0	26

ANALYSIS OF CLAY SAMPLES

AREA NO. B

Sample No.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Undetermined	Percentage of Coarse Material (Rejected)
BH 225 72.[illegible]	68.7	18.9	2.6	1.1	2.3	6.4	41
226	69.7	18.4	3.5	1.0	1.8	5.6	35
227	66.5	19.6	5.0	1.6	2.4	4.9	40
228	64.2	21.1	4.7	1.4	2.8	5.8	29
229	69.7	16.1	5.0	2.6	2.0	5.6	46
230	68.8	18.9	3.6	1.4	2.1	4.2	40
231	72.7	16.8	3.9	0.2	2.1	4.3	38
232	71.7	16.2	5.2	1.1	2.0	3.8	19
233	59.0	18.7	13.7	0.7	6.1	3.8	41
234 58.0	53.5	21.6	13.7	1.9	5.6	3.7	50
235	47.7	18.5	14.1	7.8	8.6	3.3	47
236	53.9	19.2	13.3	3.2	7.6	2.7	42
237	56.4	17.4	15.5	2.1	6.2	2.4	43
238	54.4	19.6	12.4	2.6	7.6	3.4	30
239	58.0	19.0	11.1	2.1	5.8	4.0	40
240	54.2	17.2	12.5	5.3	8.1	2.5	32
241	58.2	19.4	11.7	2.2	6.0	2.5	21
242	58.9	18.2	11.2	2.8	5.1	3.8	34
243	58.4	18.0	12.0	1.9	6.1	3.6	32
244	57.1	15.6	9.8	4.3	6.6	6.4	32
245	58.2	17.8	13.4	2.3	6.4	1.9	21
246	52.4	20.7	12.6	2.5	7.7	4.1	41

Sample No.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Undetermined	Percentage of Coarse Material (Rejected)
BH 247	53.2	19.1	12.5	3.6	7.3	4.3	36
248	58.5	18.0	11.9	1.7	5.2	4.7	36
249	57.4	20.6	12.9	1.7	*	7.4	28
250	67.1	19.5	4.9	0.9	*	7.6	35
251	71.5	15.7	4.7	1.3	*	6.8	37
252		No clay - all rock					
253	69.6	17.1	6.1	0.4	2.5	4.3	31
254	69.8	15.7	5.6	1.1	*	7.8	33
255	73.2	13.2	4.6	1.0	*	8.0	
256							
257	68.2	19.5	4.1	0.8	2.0	5.4	30
258	70.3	17.4	3.6	1.4	2.3	5.0	54
259		No clay - all rock					
260	63.2	17.8	10.0	2.1	3.6	3.3	45
261	56.4	19.0	12.0	2.4	6.9	3.3	41
262	62.2	16.5	9.1	2.5	7.4	2.3	36
263	60.5	17.2	9.2	4.7	4.9	3.5	27
264	47.6	13.2	10.5	12.8	14.7	1.2	26
265	52.7	20.4	14.3	3.9	7.7	1.0	40
266	51.8	19.0	14.7	4.6	7.5	2.4	42
267	70.2	17.9	4.2	0.8	2.0	4.9	46
268	68.2	18.1	7.9	0.2	2.7	2.9	43
269 63.4	60.1	18.9	13.1	2.7	4.5	0.7	35

(*) Range 2 - 6%

ANALYSIS OF CLAY SAMPLES
AREA NO. B

Sample No.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Undetermined	Percentage of Coarse Material (Rejected)
BH 270	54.8	17.7	15.2	4.5	7.6	0.2	48
271	51.8	19.3	14.1	3.9	8.9	2.0	38
272	68.5	18.0	5.4	1.3	2.7	3.1	31
273	54.1	18.9	12.7	4.2	6.3	3.8	43
274	49.6	18.1	15.2	4.9	9.4	2.8	60
275	52.4	18.9	16.7	4.0	1.9	6.1	35
276	69.7	17.6	3.4	1.7	2.1	5.5	31
277	69.7	17.9	4.6	0.8	2.2	4.8	35
278	70.3	15.4	4.1	1.4	2.2	6.6	45
279 73.8	72.4	16.3	5.3	0.9	1.9	3.2	24
280	51.1	17.5	12.7	4.3	10.0	4.4	53
281	53.0	17.1	15.5	4.8	8.2	1.4	57
282	56.2	18.1	12.6	4.6	7.2	0.3	25
283	45.7	15.2	14.7	8.8	15.7	-	36
284							
285	61.3	17.2	10.9	3.0	5.3	2.3	35
286	72.3	14.1	3.8	1.3	1.6	6.9	29
287							
288	71.9	16.3	3.5	1.4	1.8	5.1	40
288B	71.4	17.6	3.6	1.1	2.1	4.2	32
289							
290	55.2	16.6	14.0	4.7	7.5	2.0	59

ANALYSIS OF CLAY SAMPLES
AREA NO. B

Sample No.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Undetermined	Percentage of Coarse Material (Rejected)
BH 291							
292	57.2	17.2	11.5	3.2	6.8	4.1	22
293	51.3	18.1	14.7	6.4	6.8	2.7	45
294	50.1	17.8	13.6	4.8	10.2	3.5	64
295	55.0	18.9	13.1	2.4	5.6	5.0	47
296A	74.1	14.7	4.0	0.7	1.5	5.0	29
296B	64.3	17.2	9.1	1.9	4.1	4.4	26
297	51.7	17.8	12.8	3.7	11.0	3.0	55
298	54.4	16.5	13.0	4.8	8.4	2.9	49
299	54.6	17.7	12.5	3.1	7.3	4.8	34

ANALYSIS OF CLAY SAMPLES
AREA NO. B
-5-

Sample No.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Undetermined	Percentage of Coarse Material (Rejected)
BH 326	70.1	17.7	4.5	0.9	2.3	4.5	55
327	70.1	18.5	4.9	0.5	2.3	3.7	36
328	66.3	20.2	5.0	0.9	2.9	4.7	46
329 78.[illegible]	68.8	18.2	4.9	1.5	2.3	4.3	55
330	68.8	20.4	1.5	1.1	2.3	6.9	63
331	69.0	17.9	4.6	1.3	2.4	4.8	47
332	71.5	17.8	1.9	1.3	1.7	5.8	62
333	70.3	16.8	4.0	1.5	2.0	5.4	57
334							
335	69.5	17.1	3.0	1.3	2.2	6.9	49
336	71.2	17.1	3.3	1.1	1.8	5.5	51
337	72.6	16.7	3.5	1.7	1.5	4.0	31
338	73.2	16.8	3.4	0.3	1.5	4.8	26
339	73.5	15.0	4.8	1.1	1.5	4.1	28
340 76.6	73.4	17.0	3.2	1.1	1.6	3.7	50
341	69.2	17.7	4.3	1.0	2.4	5.4	37
342							
343							
344							
345							
346							
347							

ANALYSIS OF CLAY SAMPLES

AREA NO. C

Sample No.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Undetermined	Percentage of Coarse Material (Rejected)
BH 193	53.2	19.0	14.0	3.2	8.8	1.8	45
194	60.6	20.3	9.6	1.9	5.0	2.6	37
195	47.7	19.9	15.0	9.9	3.3	4.2	42
196	54.7	18.1	14.1	2.6	9.1	1.4	40
197	56.8	19.0	13.2	4.1	6.2	0.7	38
198	58.1	15.1	15.2	1.4	9.3	0.9	45
199	53.7	17.1	15.8	4.1	8.2	1.1	38
200	62.3	16.7	11.0	1.5	5.3	3.2	39
201	63.6	17.1	9.8	1.0	5.4	3.1	48
202	64.5	19.0	11.4	1.2	2.8	1.1	32
203	61.7	15.0	14.6	1.8	3.9	4.0	38
204	69.5	14.2	10.6	1.6	2.2	1.9	35
205	69.3	18.6	8.6	0.8	1.5	1.2	46
	59.6		12.5				

ANALYSIS OF CLAY SAMPLES

AREA NO. C

Sample No.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Undetermined	Percentage of Coarse Material (Rejected)
BH 300	61.0	19.8	9.3	1.3	4.7	4.9	40
301	71.0	17.1	5.1	0.4	2.1	4.3	38
302	69.9	16.2	6.1	2.4	1.8	3.6	33
303	63.5	19.1	7.5	1.2	1.9	6.8	45
304	70.5	17.8	5.6	0.5	2.2	2.4	24
305	52.4	19.8	16.6	4.7	3.7	2.8	61
306	55.3	20.5	12.8	1.7	6.8	2.9	20
307	65.4	17.8	10.7	1.7	2.6	2.8	22
308	70.9	14.1	10.0	0.3	1.9	2.8	48
309							
310	59.3	18.2	13.8	2.2	4.8	1.7	45
311	51.7	22.3	16.9	3.3	4.2	1.6	40
312	50.8	21.0	15.2	7.4	4.7	0.9	38
313	48.7	21.8	18.3	4.4	4.9	1.9	60
314	71.8	16.8	8.7	0.7	1.1	0.9	64
315	69.2	17.7	10.1	0.8	1.3	0.9	43
316	58.0	20.6	14.0	0.3	5.1	2.0	25
317	60.5	18.7	11.9	0.4	3.5	5.0	31

ANALYSIS OF CLAY SAMPLES
AREA NO. C
-2-

Sample No.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Undetermined	Percentage of Coarse Material (Rejected)
BH 350	71.2	16.7	4.8	1.3	1.5	4.5	37
351	72.4	16.4	5.0	0.9	1.7	3.6	25
354							
355	71.2	16.2	4.7	1.4	2.2	4.3	46

ANALYSIS OF CLAY SAMPLES

AREA NO. D

Sample No.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Undetermined	Percentage of Coarse Material (Rejected)
BH 184 57	52.5	19.7	13.7	3.4	8.1	2.6	60
185 56	52.1	16.5	17.5	2.7	10.2	1.0	44
186 79	71.7	13.9	8.0	1.3	2.9	2.2	63
187A	59.9	18.6	12.0	1.2	4.7	3.6	32
187B 63.5	61.9	17.7	10.4	1.2	5.8	3.0	48
187C	58.0	15.9	10.3	5.1	8.9	1.8	33
188	60.1	19.6	9.4	0.4	6.3	4.2	54
189A	70.0	15.5	9.1	0.9	2.3	2.2	39
189B	68.4	16.9	9.2	0.2	2.3	3.0	31
190	56.4	23.8	12.0	4.9	2.3	0.6	35
191 68	59.4	22.1	10.9	3.9	2.8	0.9	30
192	58.8	19.4	11.5	2.2	6.8	2.1	51
	60.7		11.16				

TABULATION 3.

Analyses of Andesite and Associated Sandstone Formation.

(A) Upper Andesite.

(B) Franciscan sandstone and Shale along West Limestone Contact.

(C) Interbedded Franciscan Sandstone and Shale.

TABULATION 3.

Analyses of Andesite and Associated Sandstone Formation.

(A) Upper Andesite.

(B) Franciscan sandstone and Shale along West Limestone Contact.

(C) Interbedded Franciscan Sandstone and Shale.

UPPER ANDESITE

(Jackhammer Samples)

	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO
JH 27	55.0	28.8		1.9	9.5
JH 65A	53.8	14.2	11.6	3.9	11.9
JH 65B	51.2	14.0	11.4	7.2	12.2
JH 65C	48.0	14.1	10.8	10.6	11.6
JH 65D	45.6	14.2	10.9	17.0	9.6
JH 65E	42.6	14.2	10.3	23.8	8.6

Franciscan Sandstone and Shales along West Limestone Contact

(Jackhammer Samples)

	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO
JH 132A	54.1	16.7	11.3	5.8	5.7
JH 132B	53.8	17.9	12.8	3.8	6.9
JH 132C	52.0	17.3	13.7	2.8	8.5
JH 133A	43.1	10.0	7.0	31.4	3.1
JH 133B	46.2	11.1	9.0	16.2	2.6
JH 133C	56.7	17.3	12.4	6.8	5.0
JH 134A	44.7	14.5	13.4	15.2	4.7
JH 134B	53.2	15.8	14.1	10.0	6.3
JH 134C	47.3	15.9	13.9	12.8	4.9
JH 134D	48.2	17.3	14.7	6.5	5.8
JH 134E	51.0	17.6	14.8	4.5	6.5

Interbedded Franciscan Sandstone and Andesite

	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO
Diamond Drill No. 6					
60-65	48.5	15.2	10.2	16.8	7.6
70-74	50.1	16.7	9.8	12.4	8.8
74 -78	48.3	15.2	9.6	13.3	8.5
80-85	48.3	15.3	9.8	12.4	8.5
85-89	47.2	19.8	12.6	8.8	10.6
95-99	46.4	17.7	10.9	6.9	9.8
99-104	49.0	18.7	11.7	8.9	10.3
110-116	49.8	18.8	11.6	6.7	11.9
Diamond Drill No. 5					
161-164	62.5	12.2	6.0	13.1	2.9
Churn Drill Hole W-1					
169-182	59.8	7.7	4.6	21.7	2.2
182-196	49.0	10.8	4.4	14.7	1.8
Churn Drill Hole W-3					
263-272	55.2	3.0	2.8	30.5	0.8

	SiO_2	R_2O_3	$CaCO_3$	$MgCO_3$
Diamond Drill Hole No. 2				
264-271	28.2	1.8	69.1	1.0
271-278	37.0	3.9	55.5	2.4
Diamond Drill Hole No. 3				
50-55	12.4	1.7	69.2	14.9
58-60	56.1	9.6	26.4	1.2

4 A

ANALYSES OF BAY CLAYS —— POLAND HAND SAMPLES

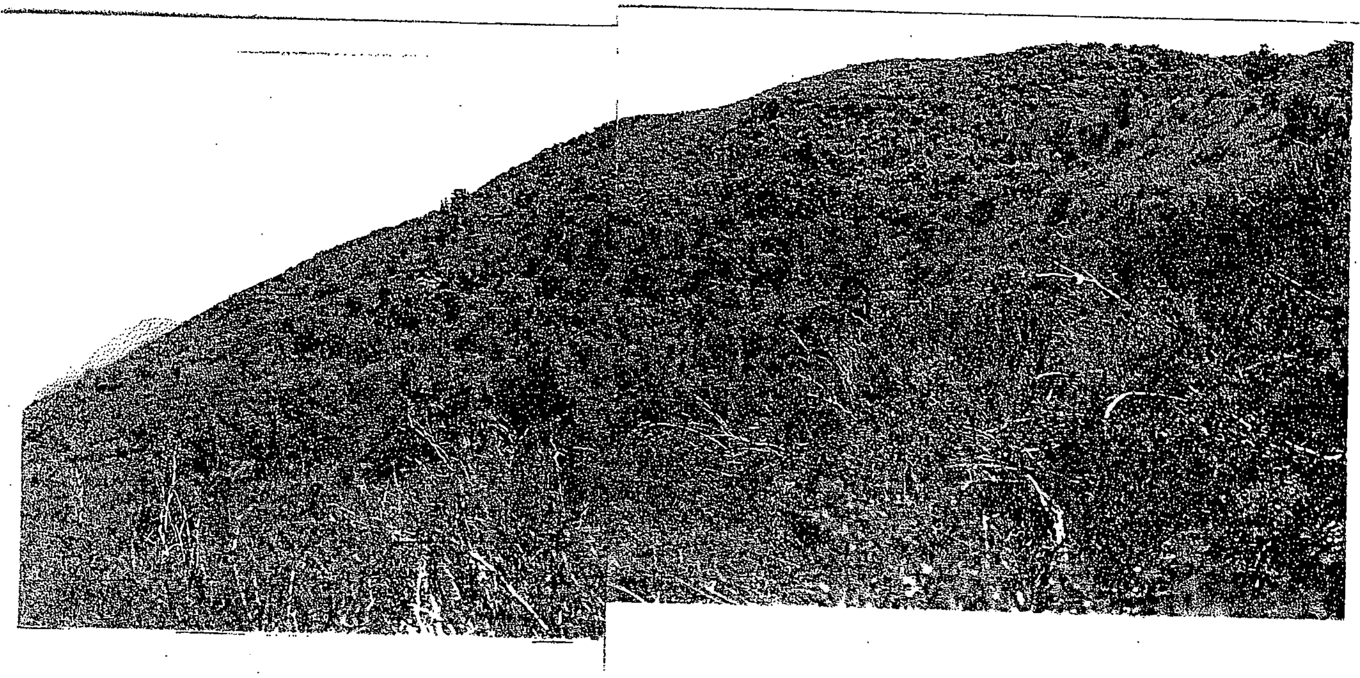
TRANSCRIPT OF POLLAND HAND SAMPLES OF CLAYS
Permanente Project

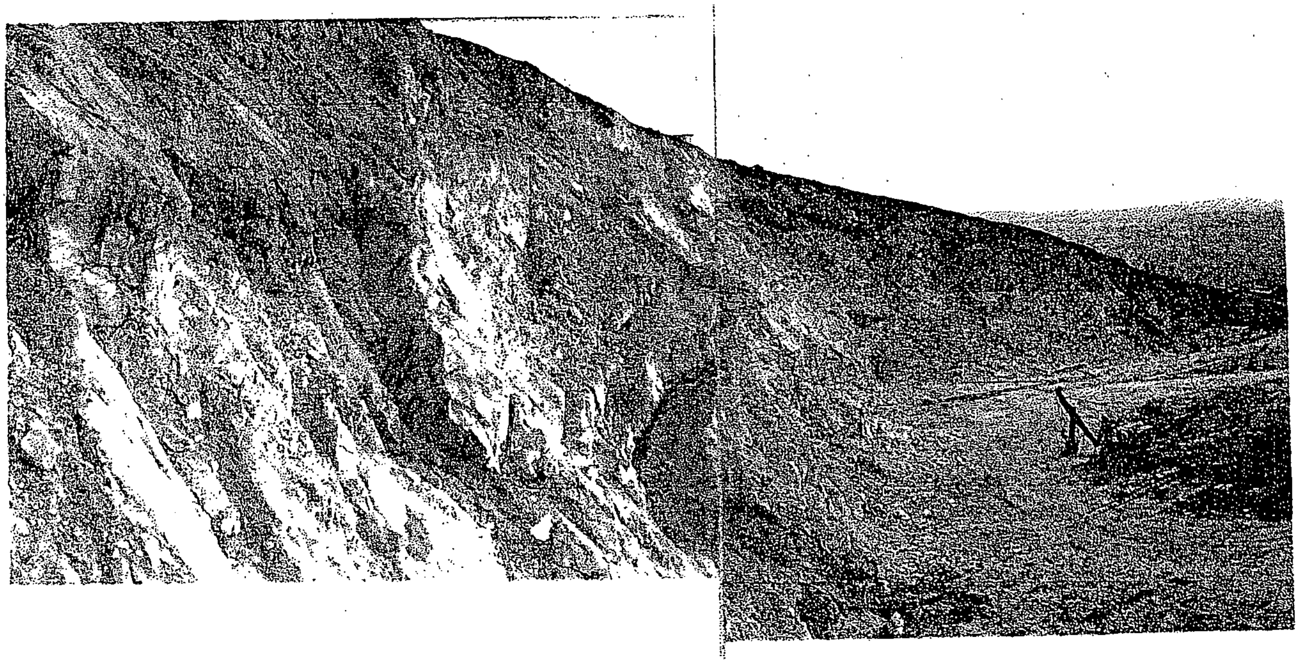
	SiO2	Al2O3	Fe_2O_3	CaO	MgO	Undet.	%Coarse Waste
P 1	61.0	20.4	7.7	2.2	4.6	4.1	
P 2	62.5	19.4	7.9	2.2	3.9	4.1	
P 3	62.3	18.8	8.3	1.4	4.3	4.9	
P 4	61.2	20.6	8.6	1.1	3.9	4.6	
P 5	62.5	19.4	8.4	1.3	3.9	4.5	
P 6	63.1	19.7	8.3	0.3	4.5	4.1	
P 7	56.4	15.5	6.6	8.3	8.5	4.7	
P 8	59.6	20.4	9.3	1.4	4.4	4.9	
P 10	58.8	17.5	12.5	4.6	4.9	1.7	
P 17	66.1	16.0	8.1	2.7	3.4	3.7	
P 18	58.7	16.2	14.9	3.3	4.7	2.2	

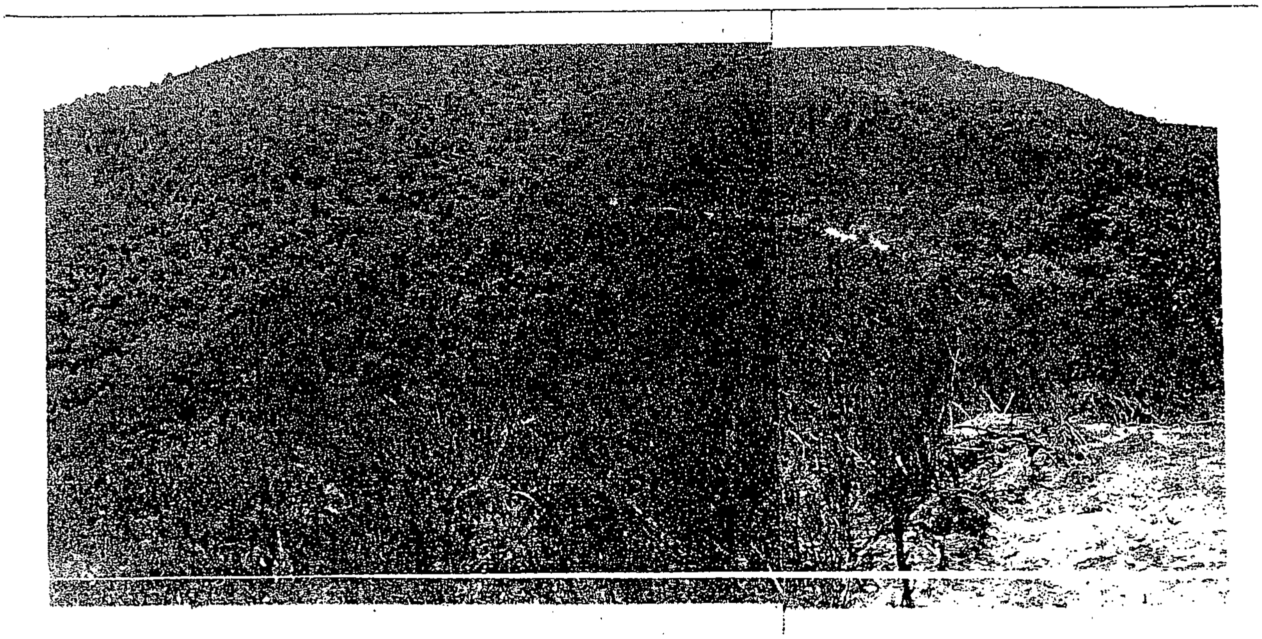
4 B

LOGS OF WELLS EAST OF THE BAYSHORE HIGHWAY

WELL NO.	Owner	Log	
1	Lowe & Lowe,	6 - 15	soil
	Monte Vista	15 - 305	yellow clay
2	Vidovich & Caviglia,	0 - 3	soil
	Collins Ave.,	3 - 35	clay
	Sunnyvale	35 - 55	gravel
		55 - 110	sand & gravel
3	A. G. Rose,	0 - 20	clay & gravel
	Grant Rd. and	20 - 85	soft clay
	Portland Ave.	85 - 90	red clay
		90 - 95	gravel
		95 - 140	soft red clay
4	Lewis Co.,	22 - 55	blue clay
	Ranch 8,	55 - 59	fine gravel
	Agnew Rd. near	59 - 100	blue clay
	Bayshore Highway		
5	Machado Well,	0 - 11	soil
	Mtn. View,	11 - 13	sand & gravel
	Alviso Rd.	13 - 177	blue clay
6	Tompkins,	0 - 9	adobe
	Bayshore Highway	9 13	yellow clay
	& Jagels Rd.	13 - 18	yellow sand
		18 - 49	blue clay
		49 - 55	fine gravel
		55 - 67	yellow clay
		67 - 172	blue clay
7	H. Mitarai,	0 - 5	soil
	Freitas Dairy	5 - 60	yellow clay
	Ranch	60 - 111	sandy blue clay
8	Y. Oku,	0 - 20	soil
	Mtn. View &	20 - 30	yellow clay & gravel
	Alviso Rd.	30 - 60	yellow clay
		60 - 115	yellow clay & gravel
9	U. S. Air Base -	0 - 8	top soil
	(old well)	8 - 24	blue clay
		24 - 29	gravel
		29 - 87	blue clay
		87 - 112	yellow clay
10	Poncini,	0 - 10	top soil
	Mtn. View - across	10 - 13	sand
	Bayshore Highway	13 - 65	yellow clay & gravel
	from Air Base	65 - 85	gravel & clay
		85 - 167	blue clay







SAMPLE MAP
OF
PROPOSED QUARRIES A AND B
PERMANENTE CORPORATION
SANTA CLARA COUNTY, CALIFORNIA

Showing location of Jackhammer holes,
Diamond Drill holes, Churn Drill Holes,
and Outcrop Samples above 1500 foot
level and $CaCO_3$ content of each sample.

Quarry A from 1700 contour to 1930 contour
Quarry B from 1500 contour to 1700 contour

LEGEND

Scale 1 inch = 100 feet

0 100 200 300

Contour Interval 0 feet
Datum Mean Sea Level

Roads = ...

Jackhammer Holes .... ○
Hole numbers in vertical letters below symbol
Percentage $CaCO_3$ in slant letters at right of symbol

Diamond Drill Holes
Drilled by Permanente Corporation .... ●
Drilled by Santa Clara Holding Co. .... ◉

Churn Drill Holes
Drilled by California Portland Cement Co. ◎

Outcrop Samples
Taken by Permanente Corporation ..... •

June 14, 1939

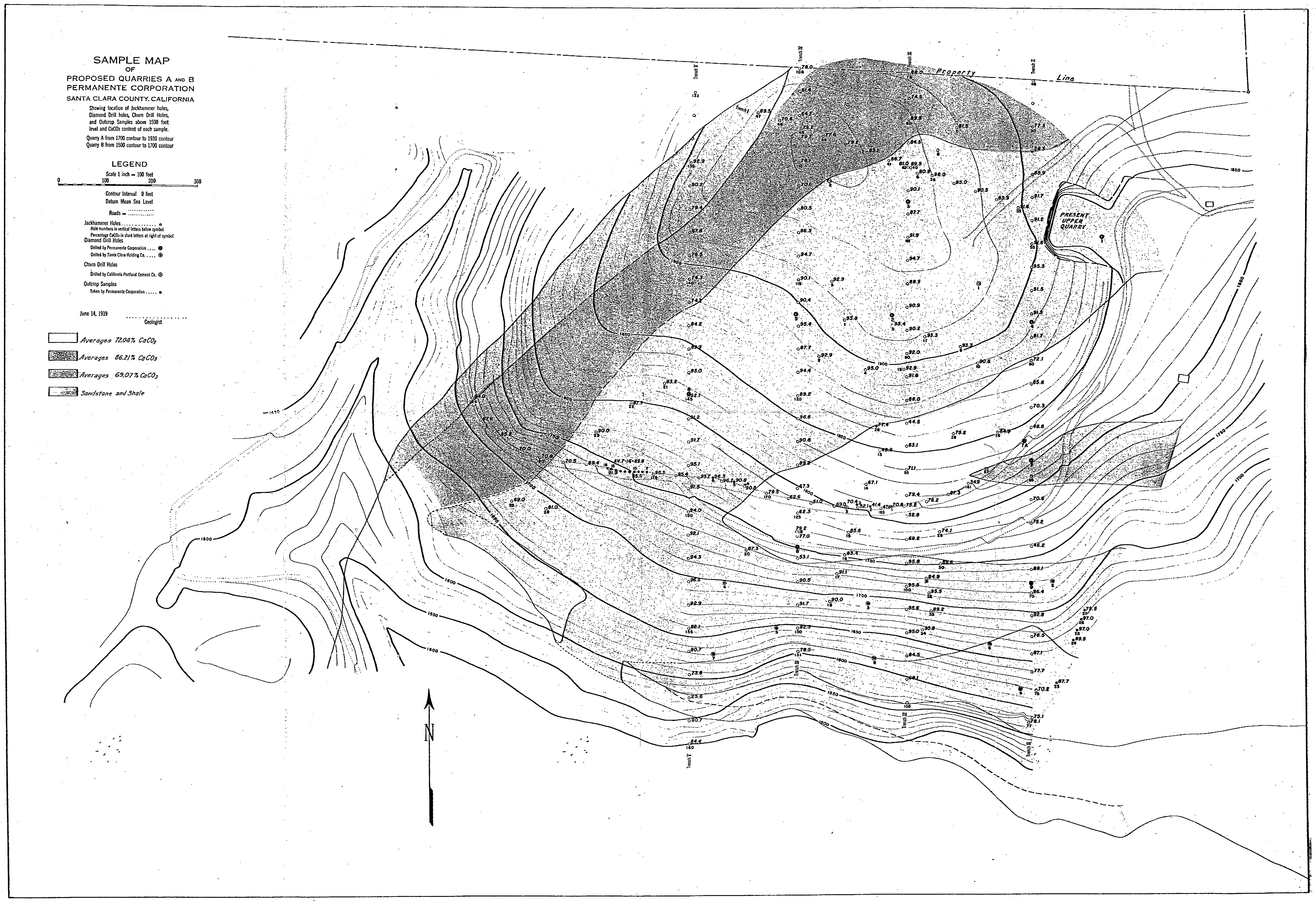
....
Geologist

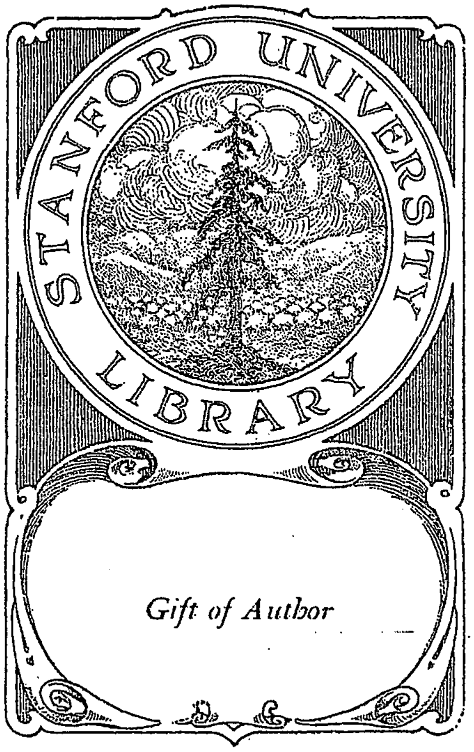
☐ *Averages 72.04% $CaCO_3$*

▨ *Averages 86.21% $CaCO_3$*

▨ *Averages 69.07% $CaCO_3$*

▨ *Sandstone and Shale*





INSOLUBLE RESIDUES OF THE CALERA LIMESTONE IN SANTA CLARA COUNTY, CALIFORNIA

A Thesis

submitted to the Department of Geology and the Committee
on Graduate Study of the Leland Stanford Junior University
in partial fulfillment of the requirements for the degree
of Master of Arts

by

Jose Henrique Fantin
November 1946

Konrad B. Krauskopf
Approved for the Department

A. I. Levorsen
Approved for the Department

Approved for the Committee on
Graduate Study

INSOLUBLE RESIDUES OF THE CALERA LIMESTONE IN SANTA CLARA COUNTY, CALIFORNIA

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ABSTRACT

This paper is the result of a study of the insoluble residues of the Calera limestone in the western portion of the Santa Clara County, California.

The limestone is subdivided into two lithologic units which were further subdivided by means of insoluble residues into two subdivisions each. Each subdivision contains characteristic residues which made possible a correlation of limestone exposures in four different areas.

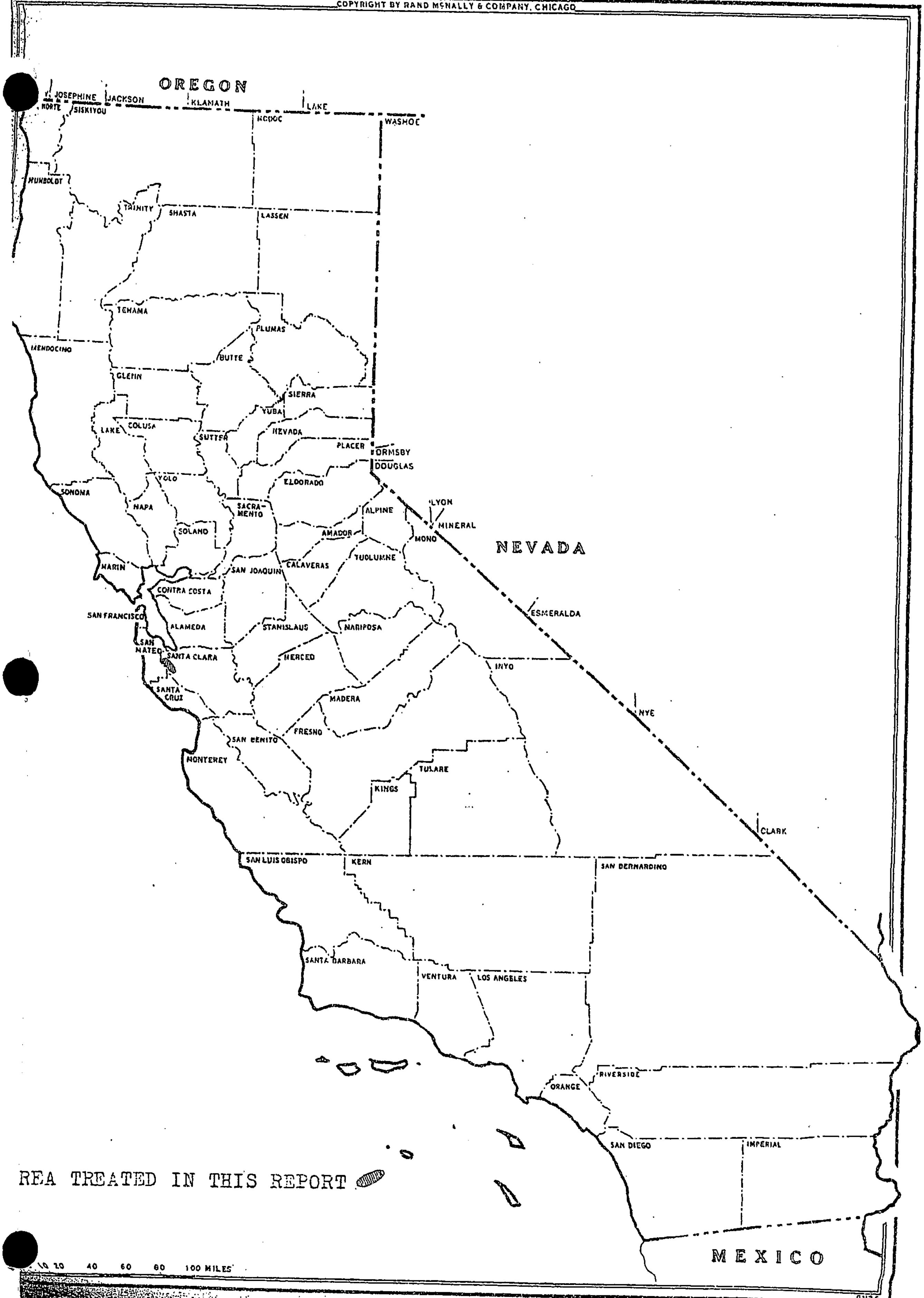
In connection with this study, the history of the development of the insoluble residue method in the United States also is discussed. The Calera limestone is regarded as a formation of Upper Cretaceous age, later than and distinct from the so-called Franciscan group.

Plate No. 1

RAND McNALLY

LOOSE LEAF OUTLINE MAP

CALIFORNIA



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This Map is also available in size 17 x 22

CHAPTER I

INTRODUCTORY STATEMENT

During the spring of 1946 the writer collected a number of samples from a section through the Calera limestone on the property of the Permanente Cement Co.

A study of insoluble residues from these samples showed that the section could be divided into zones. The results were encouraging enough to justify a more extensive investigation in order to see whether or not the insoluble residue method could be applied as an aid in correlating outcrops of this limestone. Consequently, during the summer of 1946, several sections were sampled between Permanente and Calero, in the western part of Santa Clara County, California. The description and correlation of the residues obtained and a general discussion of the Calera limestone at the localities visited by the writer during the investigation constitute the bases for this paper.

Acknowledgments

The writer is deeply grateful to Professor K. Krauskopf for his assistance and advice given during the course of this investigation. Mr. Kenneth Grimm, consulting geologist of the Permanente Cement Co., granted permission for field work at the properties of the company and gave valuable geological information and maps of part of the area.

The writer expresses his gratitude to Dr. E. H. Bailey of the United States Geological Survey, who kindly loaned topographic equipment and furnished information about the location of several limestone deposits in the Los Gatos area.

Mr. C. J. Church aided in the identification of foraminifera. The assistance of Mr. L. J. Miranda with the plane table made possible the survey of Guadalupe Section No. 1. The writer is indebted to Mr. S. A. Duran for his cooperation in the identification of certain minerals by X-ray spectrography.

Finally, the writer wishes to express his gratitude to all the members of the Stanford Geological Department for their kindness and courtesy extended to him during his stay at the Leland Stanford Junior University.

Field Work

The field work was done in the spring and summer of 1946.

Nine sections of the Calera limestone were sampled and many other outcrops were visited by the writer.

In order to find the relation of the limestones to adjacent formations, geologic reconnaissance maps were made of small areas, using as base maps enlargements (1:10,000) from the Palo Alto and Los Gatos quadrangle sheets. Most of the sections were measured with a seven-foot steel tape. When outcrops were disturbed or partially covered, so that sections could not be followed bed by bed, a plane table and telescopic alidade were used for locating the samples.

A total of 160 limestone samples, in most cases collected at intervals of five feet stratigraphically, were obtained from the different sections measured.

Location of the Sections

Outcrops of the Calera Limestone visited by the writer are confined to the western part of Santa Clara County. The limestone forms a series of isolated deposits which crop out in a belt up to 4 miles wide and 25 miles long trending southeasterly from Permanente to Calero. This limestone belt extends farther south and is probably a continuation of similar deposits to the north between Crystal Springs Lake and San Pedro Point.

The following list gives the approximate location of the sections sampled by the writer. (See Plate No. 2.)

Permanente Sect. No. 1.	S.W.¼ Sect. 17, T.7.S. R.2.W. M.D.M. B & M.
" " No. 2.	S.E.¼ Sect. 18, T.7.S. R.2.W. M.D.M. B & M.
" " No. 3.	N.W.¼ Sect. 17, T.7.S. R.2.W. M.D.M. B & M.
Los Gatos No. 1.	N.E. corn. S.W.¼ Sect. 20, T.8.S. R.1.W. M.D.M. B & M.
" " No. 2	S.W.¼ Sect. 21, T.8.S. R.1.W. M.D.M. B & M.
" " No. 3	S.W.¼ Sect. 24, T.8.S. R.I.W. M.D.M. B & M.
Guadalupe No. 1,	3/4 miles south of Guadalupe Dam.
Guadalupe No. 2,	3/4 miles south of Guadalupe Dam.
Calero No. 1,	1 mile due East from the Calero Dam.

CHAPTER II

INSOLUBLE RESIDUES

Definition

The term "insoluble residues" is used to designate the residues left when a limestone or dolomite is dissolved in hydrochloric acid.

Historical Summary on Insoluble Residues

Probably the first paper in geologic literature on the study of insoluble residues was written in 1888 by E. Wethered.[1]

Wethered studied the carboniferous limestones at Clifton (England) and separated different beds by their insoluble residue content. The following paragraph is quoted from his paper:

> "I am not aware that anyone has examined the residues obtained from the limestone after boiling portions in strong acid."

In the United States, Earl A. Trager[2] in 1920 pointed out the difficulties of subsurface correlation when no prominent features are found in a rather thick formation. He recommended the study of insoluble residues by a method sufficiently rapid to be practical for the oil operator. It consisted of a determination of the lime, shale and sand

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1. E. Wethered, <u>Insoluble Residues Obtained from the Carboniferous-Limestone Series at Clifton.</u> Quar. Jour. Geol. Soc. London Vol. 44, (1888) P. 186
2. E. A. Trager, <u>Examination of Well Cuttings</u>, Economic Geology, Vol. 15, (1920) P. 174

content of limestone drill cuttings.

The amount of lime is the difference in weight between the sample used and the residues obtained from it. The amount of shale and sand is determined when the residue is placed in a graduated tube of a centrifuge which is rotating at a speed of about 700 R.P.M. By the action of the centrifuge both the sand and shale are separated from each other by a sharply defined line.

In 1926, J. E. Lamar[3] described the general character of the limestone of the Chester Series and pointed out the method used by the Illinois Geological Survey in sub-surface correlation which consisted in:

1. Finding the amount of residue left by the dissolved carbonate rock.
2. Determining the size of the particles composing the residue.
3. A study of heavy minerals and microfossils present.

By 1936, about 82,000 samples of insoluble residues, chiefly from Cambro-Ordovician rocks of Missouri and adjacent areas, had been studied at the Missouri Geological Survey by the method devised by Wethered in 1888 and revived in 1928 by McQueen.[4]

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[3] J. E. Lamar, Sedimentary Analysis of the Limestones of the Chester Series. Econ. Geol. Vol. 21. (1926) pp. 578-585.

[4] H. S. McQueen, Insoluble Residues as a Guide in Stratigraphic Studies, Biennial Report of the State Geologist, (1931) Appendix I, pp. 102-131.

The results of investigations made by McQueen were only published after seven years of observation. His study is considered the classical work in this subject and his methods have been followed by many subsequent investigators.

The insoluble residue method has been applied in Missouri chiefly in connection with the problem of finding water-bearing zones in certain dolomites and limestones. The great experience acquired in that study by McQueen[5] led him to state the following opinion:

> "......The method has now been developed from the state of the experimental to the realm of large-scale, everyday routine."

In 1931, Ockerman[6] studied the residues of the Hunton and Viola limestones of Kansas and pointed out that the character of the residues persist wherever they are found in that region.

In the years from 1931 to 1935, a number of workers applied the method in Kentucky, Michigan, Colorado, Wisconsin and Pennsylvania, with subsurface correlation as the main purpose of the studies. The techniques used and the materials described are all similar. However, St. Clair[7]

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[5] H. S. McQueen, *Economic Application of the Insoluble Residue Method*, Technical Publication No. 724, Class 1, Mining Geology No. 61, (1936).

[6] J. W. Ockerman, *Insoluble Residues of the Hunton and Viola Limestones of Kansas*, Journal Sed. Petrology, May 1931, Vol. 1, p. 46.

[7] Donald St. Clair, *The Use of Acetic Acid to Obtain Insoluble Residues*. Jour. Sed. Petrology Vol. 5, No. 5, (1935) pp. 146-149.

in studying the Upper Silurian limestones in New York found the use of acetic acid more satisfactory than hydrochloric acid. According to him, the former preserves a more complete mineral suite than the latter, providing a clean residue free from colloidal material, floculated clay, or organic coating.

In 1936, Patton[8], studying the insoluble residues of the Pennsylvania limestones of Texas, found fragments of natural glasses. He pointed out that "the isotropic nature of the material is of a conspicuous nature and that manifestly it does not have value in geologic correlation in that region."

In 1937, a new modification of the study of insoluble residues was applied by Taylor[9] to the study of rock salt in the Gulf Coast. He studied the water-insoluble residues of rock salt from 20 localities in Louisiana and suggests that the method might afford clues as to the age of the salt. Comparisons of the water-insoluble residues with those from the Silurian and Permian deposits of North America showed conspicuous differences.

In 1939, Born[10] used the insoluble residue method

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[8] L. T. Patton, *Natural Glasses of the Insoluble Residues of the Pennsylvanian Limestones of Texas*, Science N. S., Vol. 83, No. 2143, (1936) pp. 83-84.

[9] R. E. Taylor, *Water-insoluble Residues in Rock Salt of Louisiana Salt Plugs*. Amer. Assoc. Petrol. Geol. Bull. Vol. 21, No. 10, (1937) pp. 1268-1310.

[10] K. E. Born, Geology and Petroleum Resources of Clay Co. Tenn., Tennessee Dept. Conserv. Div. Geol. Bull. 47, XII (1940) p. 188.

in correlating the Cambro-Ordovician limestone and dolomite of Clay Co., Tennessee.

In 1940, Moore[11] studied the insoluble residues of the Morrow Group of Pennsylvanian age. His correlation is based chiefly on the character of the quartz grains found in the residues. The following paragraph is quoted from his paper:

> "These were the only grains that provided a clue to changing environments of deposition, and consequently would mark horizon boundaries."

In 1942, by studying the insoluble residues of the Ellenburger formation in West Texas, Cole[12] divided it into five zones in a section approximately 1335 feet thick. His study is of particular interest insofar as insoluble residues are concerned, because his correlation is based chiefly on the characteristics of chert. Chert zones located accurately the stratigraphic position of any section in the Cambro-Ordovician dolomite.

At the present time, an interesting investigation is being carried on by Crowley and Hendricks[13] in north-central

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[11] Moore C. A. Morrow gr. of Adair Co., Oklahoma. Am. Assoc. Petroleum geologists Bul., Vol. 24. No. 3 (1940) pp. 409-434.

[12] Taylor Cole, *Subsurface study of Ellenburger formation in West Texas.* Amer. Asso. of Petr. geologists. Bull. Vol. 26 No. 8, (1942) pp. 1398-1409.

[13] A. J. Crowley and L. Hendricks, *Lower Ordovician and Upper Cambrian Subsurface Subdivisions in North Central Texas.* Amer. Asso. of Petroleum geologists, Bull. Vol. 29, (1945) pp. 413-425.

Texas, for they expect to subdivide the Ellenburger formation into units, to identify the units that are oil bearing, and to determine the physical properties that make a rock an oil or a gas reservoir. The first part of the investigation is already accomplished. The Ellenburger formation was separated into six units and two of these were subdivided again into two subunits.

CHAPTER III

THE CALERA LIMESTONE: HISTORICAL REVIEW

The term Calera Limestone is used tentatively in this paper to designate certain limestone strata which commonly occur with rocks of the Franciscan Group in the counties of San Mateo and Santa Clara, Calif. The first statement found by the writer regarding these strata was made by Lawson[14] in 1894. He used the term "foraminiferal limestone" of the Franciscan series and mentioned two localties in the San Francisco Peninsula region where the strata have lithological variation. These are: the Calera Valley and two and a half miles due east of San Pedro Point. The age of the Franciscan series at that time was rather uncertain. Lawson's[15] statement on the subject is as follows:

> "It is of Mesozoic Age, but enough is not yet known of its fossil fauna to permit more precise determination."

In 1895, Ashley[16] included the limestone near Point San Pedro in what he called the Methamorphic in his studies on the Neocene of California. The area covered by the Santa Cruz Mountains - part of the Coast Range - was studied.

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14. A. C. Lawson, Sketch of Geology of the San Francisco Peninsula. U.S.G.S. 15th Ann. Report 1893-1894, pp. 419-420.
15. Op. cit., p. 407.
16. G. H. Ashley, Studies in the Neocene of California, Journal of Geology, Vol. III, No. 4, (1895) pp. 435 - 436.

Regarding the formation concerned in this paper, the following statement is found:

> "Under the term, methamorphic, may be included the beds of limestones occurring through the mountains, the granite forming the core of the range, the methamorphic sandstone, the thin-bedded chert, and the serpentine."

Then he added:

> "The limestone whose age is unknown, occurs in two beds, extending southward from near Point San Pedro."

In the columnar section of the Santa Cruz Mountains made by Ashley, the name Gavilan is given to the limestone; the presence of foraminifera is emphasized, and it is considered as Pre-Cretaceous in age. In addition to this, the Franciscan sandstone is considered in part Cretaceous (?) and the presence of plant remains, Inoceramus and Aucella is pointed out. The limestone beds included in the methamorphic of Ashley were erroneously correlated by him with the Gavilan Limestone of Becker[17] which crops out about 60 miles south of San Francisco.

Becker's "Gavilan Limestone" in fact is a coarsely crystalline marble found as inclusions in the old pre-Jurassic granitic rocks of the Coast Range.

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17. C. F. Becker, U.S. G. S. Mon. 13, (1888) pp. 128, 181.

The name Calera Limestone is mentioned for the first time in an abstract of a paper read by Lawson[18] at a meeting of the Geological Society of America in 1902. From his abstract, the following paragraph is quoted:

> "Other features of the paper are the subdivisions of the Franciscan Group. There are seven stratigraphic subdivisions by the recognition of a persistent horizon of "foraminiferal limestone" and two important horizons of radiolarian chert."

In his columnar section, the Calera limestone is 60 feet thick and appears to be underlain and overlain by Volcanics.

In 1909, Branner, Newsom and Arnold[19] mentioned the occurrence of limestone in their description of the Santa Cruz Quadrangle.

The following statement is quoted:

> "Small quantities of limestone are found in the Franciscan. The principal area is on the slope of the Black Mountains. Its relation to the adjacent rocks is not definitely known, but it is believed to be interbedded with them."

In 1914, Lawson[20] formally described the type locality

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18. A. C. Lawson, *A Geological Section of the Middle Coast Range of California,* (Abstract), Science New. Ser. Vol. 15, (1902), pp. 415-416.

19. Branner, Newsom and Arnold, *Description of the Santa Cruz* Quadrangle. U.S.G.S., Folio No. 163 (1909).

20. A. C. Lawson. San Francisco Folio (1914)

of the limestone in the San Francisco Folio and considered it as a member of the Cahil sandstone.

The following paragraph is quoted from this report:

> "The Calera limestone member is so named from Calera Valley, in the San Mateo Quadrangles, where it is well exposed on the sea cliff at the lower end of the valley."

According to Lawson, the Cahil sandstone (Jurassic)(?) occurs at the lower part of the Franciscan Group and the Calera limestone is restricted to the middle part of the lower half of the Cahil sandstone.

In 1933, Hokel[21] considered that the limestones of Santa Clara County are Franciscan in age, but emphasized that the term Calera member cannot safely be extended too far. Informally, he refers to the limestones as Franciscan (Jurassic) (?).

In 1943, Taliaferro pointed out that limestones are common within the Franciscan and that in many places they contain foraminifera. The great bulk of limestone found by him occurs in the upper part of the Franciscan in contrast with those found by Lawson which are considered to be about 500 feet above the lowermost part of the Group.

Taliaferro concluded that the "Franciscan and Knoxville together are Titonian in age, Late Upper Jurassic."

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[21] C. E. Hokel, Limestone Deposits of the San Francisco Region, Cal. Jour. Min. and Geology. Vol. 29, No. 1, 2, (1933) p. 354.

The Calera member is considered in this paper as a well-defined lithogenetic unit of formational rank whose relation to rocks of Franciscan lithological character is merely structural. The age and the structural relations of the Calera formation will be discussed in a later chapter.

CHAPTER IV

REVIEW OF INDUSTRIAL LIMESTONE PRODUCTION IN CALIFORNIA

Exploitation of limestone deposits in California began during the early days of the Spanish settlements on the Pacific Coast. Some of the limestone deposits or areas close to them still keep the names used by the Spaniards to designate a place where limestone is burned to obtain lime or a lime-maker such as Calera and Calero respectively.

Figures on the production of industrial limestone started to be published regularly in 1894. Since that time, there have been several periods of intensive output of industrial limestone. From a year after the San Francisco earthquake, up to the beginning of the first World War, production was maintained at an average rate of 400,000 tons per year, the output reaching a maximum of 680,000 tons in 1910. From 1915 to 1926, the output was relatively small, average yearly production being only 190,000 tons. The maximum production recorded in the history of California was reached in 1927. During the depression, production was only slightly higher than immediately after the first World War. In 1935 production started to rise again and in the first three years of the second World War, the output was maintained at an average of 530,000 tons per year. See Plate 3.

At the present time the most important use of limestone is in the manufacture of cement. After Pennsylvania, California ranks second in the United States in cement production. Up to date, there are thirteen mills in the state, and one of them, operated by the Permanente Cement Company is the largest single plant in the world. The manufacture of cement started in California in 1900. (See Plates 4 and 5). Production in 1942 reached the maximum in both value and output in the history of California. 23,306,518 barrels representing a value of $35,808,841 were produced in that year. After oil and natural gas, cement is the third source of income in the mineral production of California.

CHAPTER V

TERMINOLOGY AND METHODS

As a result of the increasing number of papers on the subject, during the past ten years, new specific terms and synonyms have been added to the literature. The following are the most important:

Calcicast:[22] This term is used to describe casts or impressions of calcite crystals in any insoluble residue such as chert, glauconite, pyrite, etc.

Dolocast:[23] Like the preceding but applied to casts or impressions of dolomite.

The terms *"oocastic"*,[24] *"oolicastic"*[25] or *"oomoldic"*[26] chert have been used by some authors to designate the cavity left by an oolite in a siliceous matrix. They are synonyms.

Skeletal[27] is used by Cole to designate closely spaced

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22. H. A. Ireland, *Use of Insoluble Residues for Correlation in Oklahoma*, Amer. Assoc. Petrol. Geologist Bull. Vol. 20, No. 8, (1936) p. 1094.

23. H. S. McQueen, *Insoluble Residues as a Guide in Stratigraphic Studies*, Biennial Report of the State Geologist, Missouri (1931), Appendix I, p. 108.

24. Taylor Cole, *Subsurface Study of Ellenburger Formation in West Texas*, Amer. Assoc. Petrol. Geologist Bull. Vol. 26, No. 8, (1942) p. 1401.

25. Leo Hendricks, *Subsurface Divisions of the Ellenburger in North Central Texas* Univ. Texas Bur. Econ. Geol. Bull. 3945, (1940) p. 961.

26. A. J. Crowley and Leo Hendricks, *Lower Ordovician and Upper Cambrian Subsurface Subdivisions in North-Central Texas.*, Amer. Assoc. Petrol. Geologist. Bull. Vol. 29, No. 4, (1945) p. 417.

27. Taylor, Cole, op. cit.

rhombohedral cavities in a siliceous matrix.

Method of Procedure

During the field work, every limestone sample was megascopically described. In doing so, particular attention was given to the color, odor, texture, stratification, presence of lenses and nodules of chert, amount of pyrite and micro-organisms.

Laboratory Technique

In the preparation of the residue 12 grams of each original sample were weighed out, the individual fragments measuring about 0.5 cm. in diameter. Then the material was placed in a 100 ml. beaker and covered with 50 ml. of a 1:1 solution of hydrochloric acid. The reaction was carried out at room temperature, more acid being added until effervescence ceased. Complete digestion of the calcium carbonate was obtained with an average of 80 cc. of the solution per sample. The material left was washed with distilled water and decanted until all the colloidal material and clay particles were eliminated.

The residue obtained by this process was allowed to dry and weighed in a sensitive balance. Subsequently, it was bottled in a cork-stoppered glass vial. The same process was repeated for each sample collected. See Plate 6.

Graphic Representation of Results

The following characters of each sampled section were represented in a single plate:

1. Thickness of the section, location of the samples and their lithologic character.

2. Predominant color of the residues.

3. Percentage of insoluble material in original sample. This is represented on a logarithmic scale along the horizontal axis of the graph. This mode of representation is convenient when the percentage recovered is very small. The points plotted in the diagram are joined by broken lines, whose intersection represents the exact location of the sample with respect to the columnar section. The broken line was found convenient for correlation purposes.

4. The percentage of individual components in the residue is represented by symbols in a rectangle 5 inches wide and with a length proportional to the length of the section measured. The horizontal scale represents the percentage composition of the residue and the vertical scale the thickness of the units distinguished by their residues.

In plotting the residues two kinds of constituents were considered, essential constituents and accessories. The essential constituents are those which characterize a zone or unit, and on which correlations were chiefly based. The accessories are those whose percentages are small and which may or may not be characteristic. Where the percentage of a residue considered as accessory becomes large, it is considered as essential in that part of the section. Such a change is exceptional. The symbols used to express the accessory residues are enclosed in a rectangle whose horizontal dimension represents the percentage. The vertical one does not necessarily represent its vertical range in the section. (See Plate 16). When two, three, or more consecutive samples show a fairly constant percentage of an accessory residue it may indicate a recognizable horizon in a particular zone of a given section but without further work to establish the persistence of accessories, it is unsafe to use them in correlation.

In the correlation chart (Plate No. 20) the kinds of accessory residues are shown in each section regardless of their percentages. Also, it was found convenient to reduce the logarithmic representation of the total insoluble residue of each section to 1/5 of the original horizontal scale and to represent it at the left of the corresponding columnar section.

Method of Examination

In most cases a binocular microscope was used for the examination of the residue. When doubt existed regarding the composition of the residue, the material was immersed in clove oil and studied under a petrographic microscope.

The percentages of the components were obtained by counting the different grains spread over a three by five inch black centimetered pan. This operation was repeated as much as twenty times in different parts of the pan.

CHAPTER VI

GENERAL CHARACTER AND AMOUNT OF RESIDUES

The residues may be divided into allogenic and authigenic residues. Allogenic residues are those derived from older rocks and deposited with the calcareous mud that subsequently formed the limestone. Authigenic residues are those that were formed contemporaneously with or after the deposition of the limestone.

Allogenic Residues

Carbonaceous Silt

This residue consists of silt with abundant carbonaceous material, black or dark brown in color, with skeletal structures or with a finely porous texture, at times with calcicasts on the surfaces of the fragments. See Plate 7.

Gray Silt

This residue is characterized by aggregates of dark to light grey silt, frequently with a honeycomb or finely porous texture. The aggregate usually disintegrates to a fine powder when it is touched with a dissecting needle. See Plate 8.

Very Fine Grained Sand

This residue consists of very fine quartz grains. The quartz grains usually are colorless, sub-angular or rounded, with an average diameter of 0.04 mm. and a range in diameter from 0.016 to 0.07 mm. Frequently these grains are bound together to form small, soft lumps of sugary appearance which are easily broken by the pressure of a dissecting needle. For convenience, these quartz grains will be described as sand, although many of them have the size of coarse silt rather than sand. See Plates 9 and 10.

Clay

Soft pellets and flakes with a waxy luster usually are found in the residue. The clay flakes occur in the limestone forming very thin seams or filling cavities in stylolite-like structures. See Plate 11.

Chert

White or honey colored detrital chert in grains of about 0.5 mm. in diameter, with a conchoidal fracture and smooth vitreous surface, is of sporadic occurrence in the residues. The percentage of chert is so small that it is not considered in the graphic representation of the residues.

Authigenic Residues

Glauconite

Glauconite is found in small amounts in some of the sections near the town of Los Gatos. It occurs as pellets up to 2 mm. in diameter with calcicoats. The calcicoats probably formed during or after the last stage in the formation of glauconite. According to Galliher[28] during the process of formation of glauconite after biotite, the latter mineral begins to swell and becomes porous or

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[28] E. W. Galliher, Geology of Glauconite, Amer. Assoc. of Petrol. Geologists. Bull. Vol. 19, No. 11 (1935), p. 1588.

spongy. During this process the calcareous mud may penetrate in the pores and cracks and later on develop crystals of calcite or dolomite in a ground mass of glauconite. See Plate 12.

Micro-rhombohedral Quartz

A puzzling constituent of some residues is quartz in distinctive micro-rhombohedral crystals which resemble distorted cubes. See Plate 13.

The crystals are colorless with a frosted appearance. Under the petrographic microscope they appear to have numerous colorless inclusions which often are concentrated near the periphery of a crystal.

The crystals with a definite rhombohedral shape have symmetrical extinction. The interfacial angles of these crystals are 84 and 96 degrees respectively. The birefringence is low. The interference figures obtained always appeared very diffused and eccentric. The average index of refraction was found to be 1.553.

Although the optical properties of the mineral checked with those of quartz, the rhombohedral habit is peculiar for quartz. To make certain of the identification, an X-ray diffraction photograph was taken (Debye-Scherrer method). Lines on the photograph coincided with the lines of quartz, which clearly establishes the mineral's identity.

The origin of the rhombohedral quartz cannot be fully settled without further petrographic work. The lack of abrasion and the presence of zones of bubbles around the borders of the grains suggest an authigenic origin. Secondary quartz has been frequently reported in sedimentary rocks, but commonly in the form of double-ended hexagonal prisms, with or without detrital grains as nuclei. So far as the writer knows, this is the first time that grains of rhombohedral shape have been found. The unusual shape suggests that the grains may be pseudomorphs of another mineral. The measured rhombohedral angles are closest to the angles of chabazite, but chabazite is rarely found in limestones and there is no other evidence of its presence in the Calera limestone. Most probably the grains are replacements of calcite rhombohedroms; the high angles may indicate an unusual crystal form of calcite, or the measurements may be in error because of the small size of the grains.

Barite

Barite crystals with tabular habit, colorless and transparent, are often found in the residues. This mineral is frequently found associated with black carbonaceous silt. Aggregates of barite suggest that the mineral occurs as a cementing or cavity-filling material. Its high index of refraction, and the parallel and symmetrical extinction in rectangular and rhombic fragments, respectively, are distinctive features of the mineral. See Plate 14.

Chert

Authigenic chert, white or light gray with smooth and vitreous surfaces, exhibiting calcicasts and casts of foraminifera, is frequently associated with colorless very fine-grained quartz sand, the sand being attached and cemented to the chert fragments. See Plate 10.

Replaced Fossils

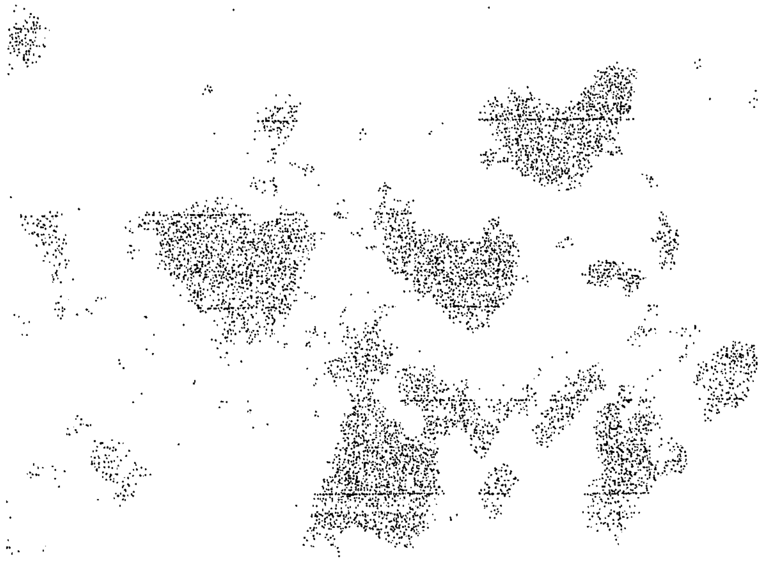
Some beds of the Calera limestone contain abundant micro-fossils, but residues from even the most fossiliferous beds contain only a few foraminifera (*Nodosaria* and *Globigerina*) in which calcite is replaced by limonite.

Lignite Fragments

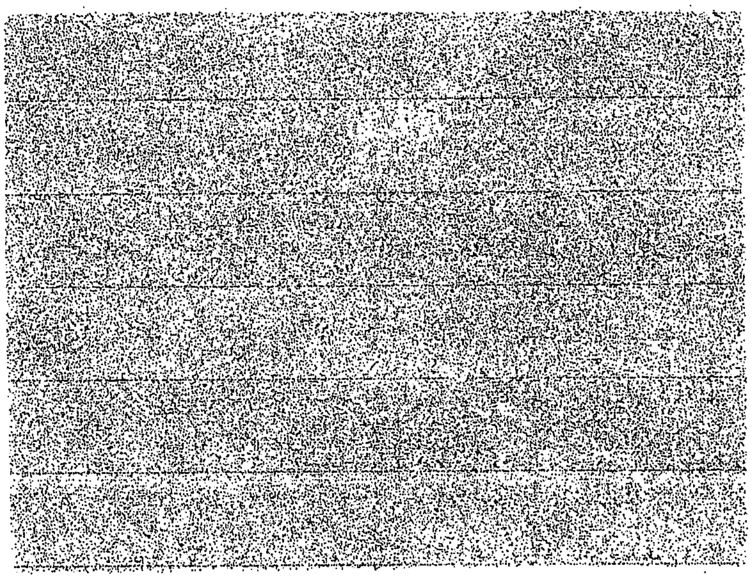
Black, brittle lignite fragments with a resinous luster and conchoidal fracture are sometimes found in the residues. At present they do not have any value for correlation purposes.

Pyrite and Its Alteration Products

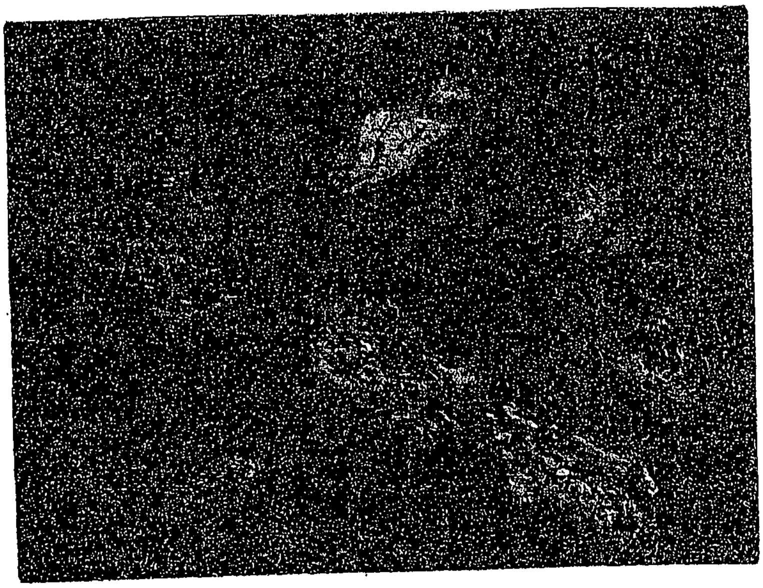
No pyrite crystals with their typical brass-yellow color were found in any of the residues. However, pseudomorphic limonite after pyrite in single cubes, pyritohedrons or in complicated mixed forms constitutes the most common accessory residue in the Calera formation. See Plate 12.

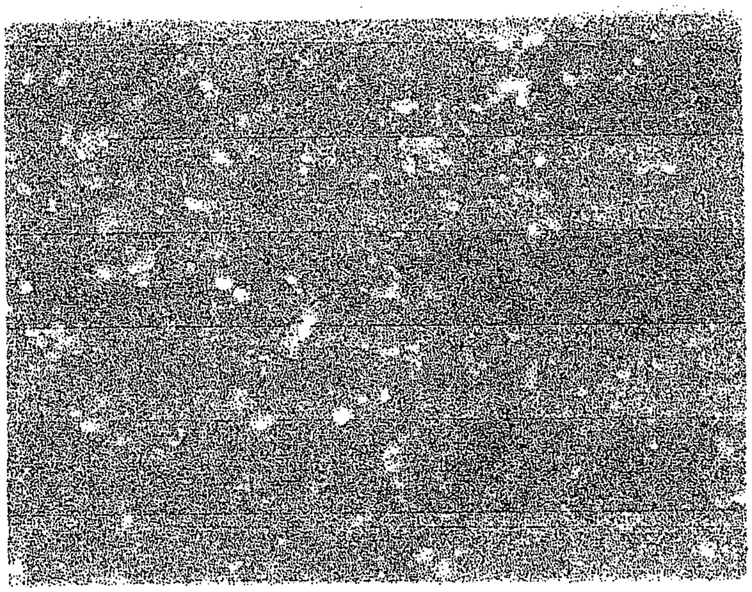


Insoluble residue from Permanente Section No. 1. The residue consists of black carbonaceous silt aggregates typical of Subdivision A of the Dark Gray member.
- X 9 -

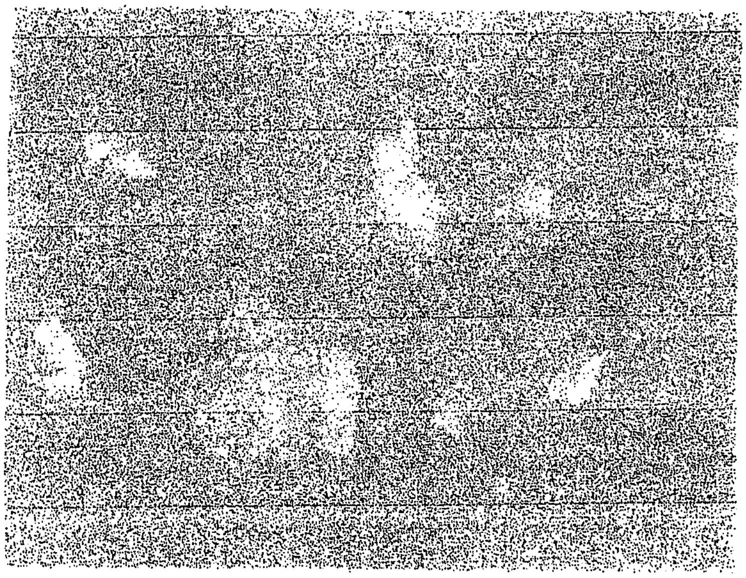


Insoluble residues from Permanente Section No. 1. The residue consists of soft, light gray silt aggregates with a honeycomb structure produced by solution of criptocrystalline limestone. Typical of Subdivision C of the Foraminiferal lst.
- X 9 -

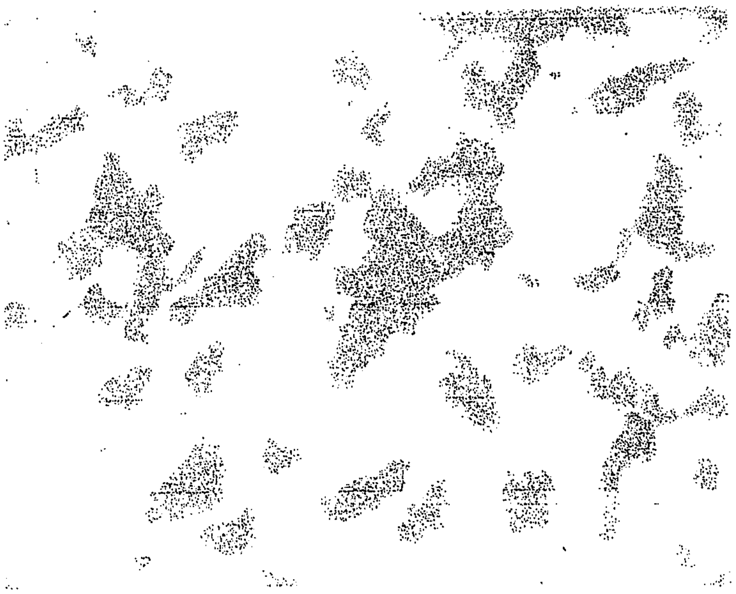




Insoluble residues from Permanente Section No. 2. The residue consists of very fine quartz sand, typical of Subdivision D of the Foraminiferal lst.
- X 35 -

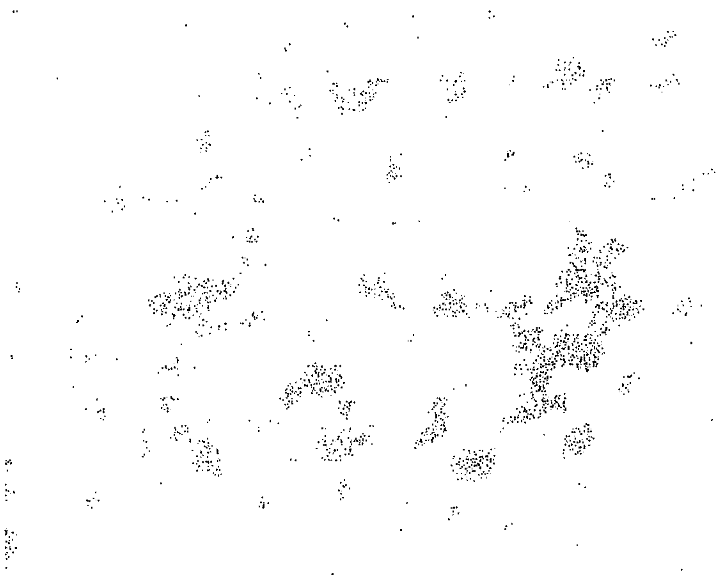


Insoluble residue from Permanente Section No. 3. The residue consists of aggregates of very fine quartz sand and fragments of calcicastic chert with a waxy luster. A single pellet may consist in part of chert and in part of sand-aggregate.
Typical of Subdivision D of the Foraminiferal lst. - X 6 -

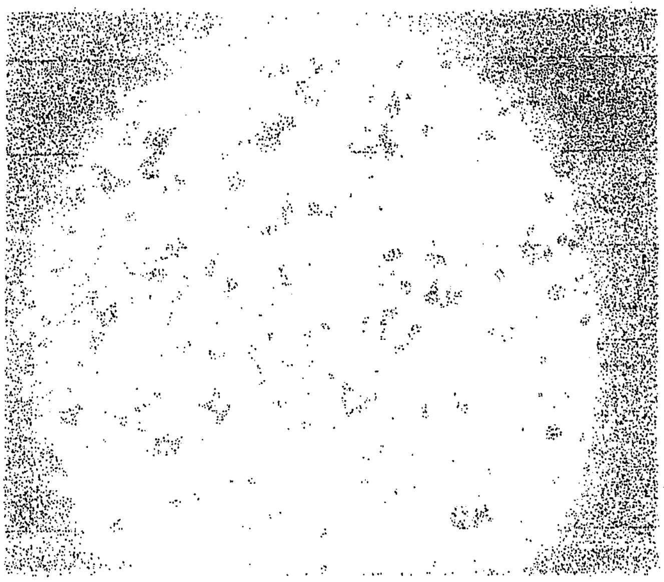


Insoluble residues from Guadalupe Section No. 1. The residue consists of black carbonaceous clay pellets with a waxy luster. Typical of Subdivision A of the Dark Gray member. - X 9 -

Plate No. 12



Altered pyrite crystals and pellets of calcicastic glauconite separated from silty residue of limestone from Los Gatos Section No. 3. From Subdivision C of the foraminiferal limestone. - X 9 -



Insoluble residues from the Dark Gray Member in Calera Section No. 1. The residue consists of black carbonaceous material and tiny rhombohedral crystals of quartz. - X 37 -

Insoluble Residues from Permanente Section No. 2. The residue consists of very fine grained quartz sand and larger crystal fragments of colorless barite. From Subdivision B of the Dark Gray member.
- X 9 -

CHAPTER VII

THE CALERA LIMESTONE IN THE PERMANENTE AREA

Introduction

The Permanente area is a property of the Permanente ment Co. and is located in Sections 17 and 18, T 7 S. 2 W, Mt. Diablo Base and Meridian. The area may be vided into two parts, the Upper Quarry in the northern rt of the property and the Lower Quarry in Permanente nyon. The difference in elevation between the quarries about 600 feet.

In this area three sections were measured. Two of them, ection No. 1 and Section No. 2, were sampled in the Lower ry and the third, Section No. 3 in the Upper Quarry. e Plate 15. A total of 70 limestone samples were collected ring the field work.

Stratigraphy

eneral

The limestone is surrounded by rocks typical of the ranciscan group - sandstone, shale, red chert, porphyritic ndesite, tuff and agglomerate.

Some of the igneous rocks are clearly extrusive and ome clearly intrusive, but the relations between the two are ot certain. The age relation of the igneous rocks among hemselves and to the limestone, are likewise not clear; t least a part of the igneous material is contemporaneous h or later than the limestone.

In the eastern portion of the Permanente property younger beds are exposed in a road cut between the cement plant and the upper quarry. They consist of light brown to buff, massive, medium-grained, poorly consolidated sandstone. These beds as mapped by Branner belong to the Santa Clara formation of Upper Pliocene age.

Two members of the Calera limestone are easily distinguisable in the field, a dark gray limestone and a lighter foraminiferal limestone. The latter is stratigraphically higher. These members probably do not represent the complete thickness of the formation.

Dark Gray Member

Megascopic Description

This unit is characterized by a dark gray or bluish-gray limestone which in fresh fracture usually has a petroleum-like odor. The texture of the rock is finely crystalline in the lower part, somewhat coarser in the upper part. The fine-textured limestone commonly shows a platy separation parallel to bedding. Lenses of chert in this unit are scarce or absent. The thickness of the unit in the Lower Quarry is 65 feet, but the actual thickness may be greater since the rock was found in fault contact with a body of andesite. The scarcity of chert in this unit makes it the best material in this area for the manufacture of cement. The average calcium carbonate content of the rock is 95%.

Insoluble Residues

The dark gray limestone at Permanente has been divided into two subdivisions, called here Subdivisions A and B, on the basis of insoluble residues. See Plates 16 and 17.

Subdivision A

This subdivision makes up the lower part of the dark gray unit. Characteristically the residues are almost entirely composed of black carbonaceous silt aggregates with porous texture, often exhibiting calcicasts, their shapes determined by smooth, shiny surfaces as if they were originally bounded by large calcite crystals or masses of limestone. These skeletal aggregates may be as large as [illegible] mm. in diameter. Usually disseminated in them are rhombohedral quartz crystals with a frosted appearance. The diameter of the quartz grains does not exceed 0.070 mm.

In Section No. 2, there were found two horizons where rhombohedral quartz and detrital quartz in the form of very fine grained sand were very prominent.

The total amount of residue in Subdivision A ranges between 2 and 5% of the original rock. The maximum observed thickness of this subdivision at Permanente is 40 feet.

Subdivision B

Subdivision B, overlying Subdivision A, is characterized y essential residues consisting largely of gray and brownish gray very fine grained sand. The sand may occur as aggregates with calcicasts, porous texture or minute rounded holes that were interpreted as cavities left by foraminifera after digestion in hydrochloric acid. Clay pellets, barite and alteration products of pyrite occur as the accessory residue. None of the accessory minerals or clay pellets were persistent enough to determine a horizon in the subdivision.

The average percentage of residue in relation to the weight of sample is 6 per cent. The thickness of this subdivision averages 20 feet and ranges up to 40 feet.

Foraminiferal Limestone

Megascopic Description

This unit is characterized in the field by its light gray color, dense texture, a conchoidal fracture which developes sharp wedges, and the presence of foraminifera. Chert lenses are very abundant in this unit, especially in its lower part where alternating lenses of chert and siliceous limestone occur at several horizons. See Plates 16, 17 and 18. The limestone is usually well bedded, but is massive locally.

In the Upper Quarry about 10 feet above the contact with the dark gray limestone is a thin bed, ranging in thickness from a few inches up to two feet, of brecciated cherts fragments in a sandy clay matrix. This bed is visible in parts of the Lower Quarry in approximately the same stratigraphic position, but it is concealed by soil and vegetation at the sites of the measured sections No. 1 and 2. Geologists working with the Permanente Company call this peculiar bed the "Sand Line" and regard it as a bedding plane fault.

The thickness of the Foraminiferal limestone is uncertain, since its upper contact is always either definitely a fault contact or else too obscure to be deciphered. In the Upper Quarry the thickness exposed from the floor of the quarry up to a body of andesite is about 62 ft. In the eastern part of the Lower Quarry the limestone reaches a maximum of 92 feet and in the western part it is 62 feet thick. At both sides the limestone is in fault contact with a crushed and slickensided brown weathered rock which looks like andesite or a related volcanic rock.

Insoluble Residues

The Foraminiferal limestone has been divided on the basis of insoluble residues into two distinctive subdivisions, called here in Subdivisions C and D. See Plates 16, 17 and 18.

Subdivision C

In this subdivision the essential residue consists of gray porous silt aggregates like chalk. Accessory residues are black shiny and brittle pellets of lignite, brown waxy clay flakes, barite, and limonite as an alteration of pyrite or marcasite. The percentages of the individual accessory residues are so small that in many cases their presence was noted but not recorded on the graph. The total amount of insoluble residue averages 15% of the original sample, although locally where chert lenses and nodules are abundant the amount of residue is as high as 31%. The thickness of Subdivision C ranges between 26 and 33 feet.

Subdivision D

The essential residues of this subdivision are very characteristic. They consist of individual micro-grains of quartz sand or aggregates of such grains which are easily disintegrated with the dissecting needle. The individual quartz grains are colorless, sub-angular to rounded, and some have a frosted surface produced by the presence of secondary silica. The average diameter of the grains is about 0.04 mm. Chert, clay pellets and flakes, altered pyrite, and barite constitute the accessory residues.

The chert always exhibits calcicasts and foraminiferal casts; the color is white or light gray; the surface is usually vitreous, occasionally finely granular. The clay flakes are characteristic of the lower part of the subdivision and their presence is related to the occurrence of very thin sinuous clay seams in the limestone.

The amount of residue in respect to the weight of sample averages 6%. The maximum measured thickness of this subdivision, as exposed in Permanente Section No. 1 is 66 feet; the actual thickness is unknown.

Structural Geology

This area, like many others where Franciscan rocks are resent, is characterized by a high degree of disturbance.

The Calera limestone at Permanente apparently is re- tricted to a wedge-like area bounded by two main faults that ntersect in the westernmost part of the property. The orthern fault trends northeast-southwest, the southern fault orthwest-southeast. See Plate 15.

Within this wedge-like area two main structural units an be distinguished, one in the northern part and one in he southern part. For convenience these structures will be alled the Northern Anticline and the Southern Anticline.

The axis of the Northern Anticline trends southeast- d. On the north flank the average dip of the beds is at low angle to the north; on the south flank they become ertical or overturned to the north.

The Southern Anticline likewise trends southeastward, ut the beds on the north flank dip about 60 degrees to the orth. The south flank is overturned and only part of it s exposed in Permanente Canyon, where the structure is omplicated by a longitudinal fault.

Separating the Northern Anticline from the Southern nticline there is a body of andesite and related volcanic ocks bound by two northward-dipping faults approximately arallel to the limestone bedding. The relation of the andesite to the limestone could be explained either (1) by folding and downfaulting of andesite originally above the limestone, or (2) by intrusion of an andesite dike along a fault in the limestone, followed by faulting along the dike walls. See Plate 19.

Numerous minor faults, both longitudinal and transverse, local folds, and other complications are present. The general structure of the limestone suggests that it has been folded and faulted down into the Franciscan rocks, probably as a result of a north-south compressive force.

Correlation

In the preceding discussion it was stated that the insoluble residues of the Calera formation at Permanente are characteristic and that their conspicuous appearance and persistency enable the writer to divide the limestone into four subdivisions. These four subdivisions of the two members - the Dark Grey and the Foraminiferal - were recognized in all the sections, except that in Section No. 3 where Subdivision A is not present because the lower part of the section is not exposed in that locality.

The correlation is chiefly based on the character of the essential constituents which are the same for the corresponding subdivisions present in each section. The essential constituents by themselves give enough data [illegible]

tions measured unfortunately are not completely exposed, therefore the thickness of Subdivision A of the Dark Gray and Subdivision D of the Foraminiferal limestone are not known. Subdivision B and C, however, were accurately measured and their boundaries determined in two of the sections. In Section No. 3 the lower part of B is not exposed.

In Subdivision A the characteristic residue is black carbonaceous silt which is readily determined by its dark gray to black color and by its texture. The percentage of residue of the samples collected from this part of the section remains fairly constant.

Residues in Subdivision B consist in all the sections of light gray very fine grained quartz sand aggregates as the essential constituent, and pyrite and barite restricted to certain horizons as accessory residues. These horizons cannot be definitely correlated from one section to another.

Subdivision B varies in thickness from about 21 feet in Section No. 1 up to 39 feet in Section No. 2. In Section No. 3 the lower part is not exposed but the thickness measured was 28 feet. The pattern of the percentages of residues plotted in the logarithmic scale is less uniform than that of Subdivision A. Near the contact between Subdivision A and B in Sections 1 and 2 the percentage of residues decreases notably, and this fact can be used as another evidence which might help in correlation.

Residues from Subdivision C of the Foraminiferal limestone are characterized by light gray silt aggregates.

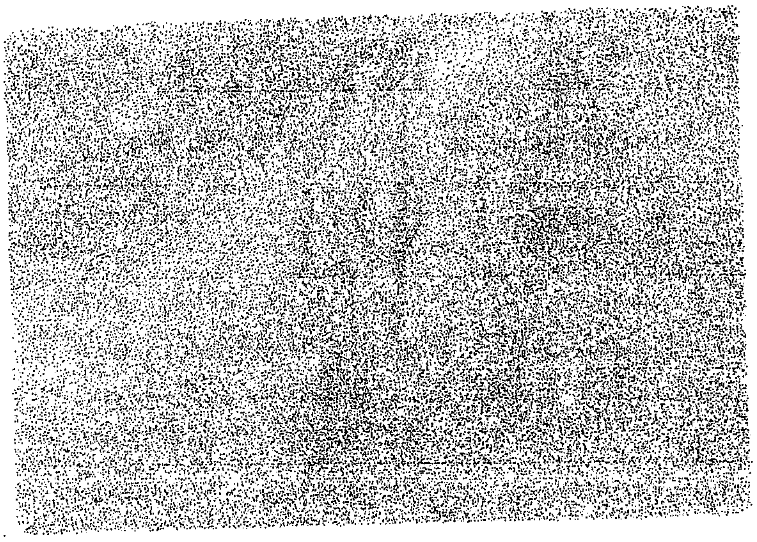
The thickness of this subdivision is very uniform, about 25 feet in Sections 1 and 3 and 31 feet in Section No. 2. The accessory residues are of no value in correlation. Altered pyrite and barite for instance are present in certain horizons in Section No. 3 but they do not occur in the other two sections. The pattern given by the percentage of residues is rather suggestive, horizons of abundant insoluble residues occur in Section No. 1 and No. 2 at approximately the same stratigraphic level, in Section No. 3 however the peak is not very prominent.

Subdivision D unfortunately is not completely exposed in any of the sections. Its residues, composed of conspicuous white, very fine grained quartz sand as essential constituent and restricted pyrite and clay flakes as accessories are very distinctive. The pattern of the percentage of residues although incomplete indicates that the lower part of the subdivision is characterized by a horizon of low percentage approximately at the same level in the three sections. Another horizon of low percentage of residue is found about 25 feet above the contact with the underlaying Subdivision C. This level is not found in Section No. 2, perhaps because the section is incomplete. See Plate 20.

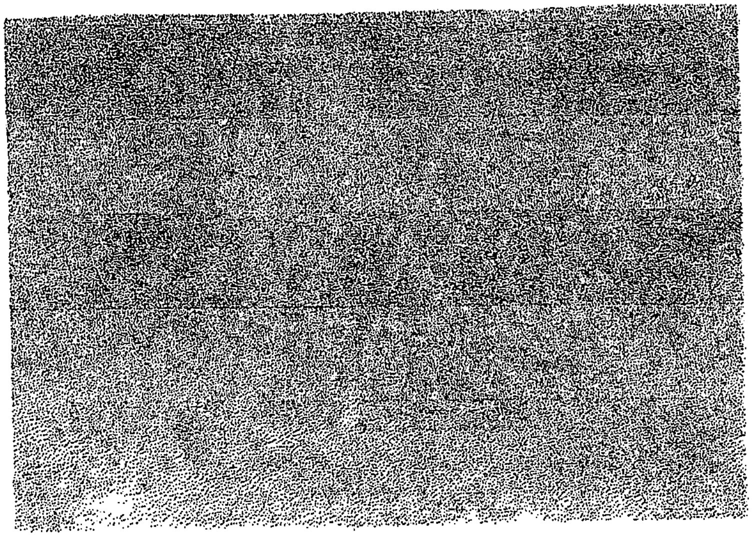
In summary, three sections of the limestone at Permanente have been successfully correlated by means of insoluble residues. Section 1 and 2 were chosen to test the persistency of heavy minerals zones along the strike of beds which can be followed from one section to the other. Section 3 is in a different but nearby structure. Correspondence of insoluble residues zones in the three sections establishes the validity of this method of correlation over short distances. In general, the correlation depends on (1) the megascopic characteristics of the Dark Gray and Foraminiferal limestones and (2) the distinctive essential residues obtained from the four subdivisions. Accessory residues proved to have little value in correlation. Percentages of residues show suggestive resemblances between the sections, but are not very dependable in correlation.

Upper quarry at Permanente showing successive working levels. Andesite in left background, Foraminiferal limestone in right foreground.

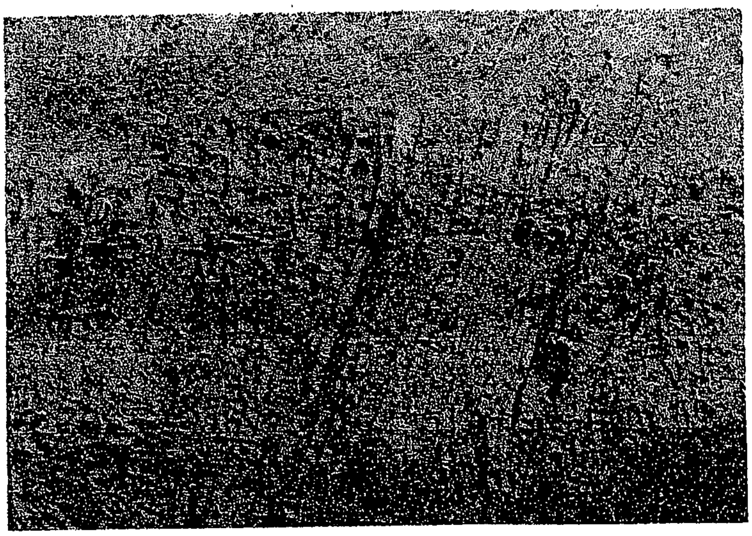
Plate No. 22



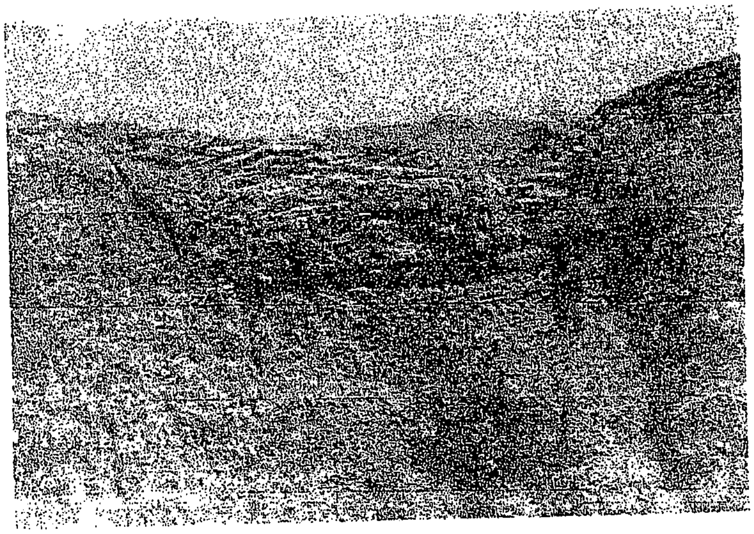
Overturned beds of the Dark Gray member dipping to the north in the Lower Quarry of the Permanente property. Vertical dimension about eight feet.



Typical exposure of well bedded red chert along road between the cement plant and the upper quarry at Permanente.



Irregular andesite sheet about one foot thick along a fault plane in limestone. Locality Permanente, Upper Quarry.



CHAPTER VIII

THE CALERA LIMESTONE SOUTH OF PERMANENTE

Los Gatos Area

Five different limestone exposures near the town of Los Gatos were examined by the writer and three of them were sampled at intervals of five feet stratigraphically.

Los Gatos Section No. 1

This section is located about a half mile south of Los Gatos on the property of H. E. Hallawell. Only 40 feet of limestone are exposed. From bottom to top the exposure consists of dark gray to black, massive, dense limestone (5 feet), a layer of interbedded limestone and chert (7 feet), and massive, light gray, dense limestone with microfossils and scattered black chert nodules (28 feet). The limestone is overlain by massive, brown weathered sandstone and underlain by brown weathered shale and basalt.

Insoluble residues from this section consist of black carbonaceous silt and black waxy clay pellets in the lower five feet, and aggregates of tiny colorless quartz grains in the remainder. Just above the zone of black silt and clay the residues contain glauconite pellets with calcicasts and crystals of altered pyrite. See Plate 25.

Insoluble residues from these limestones are fairly similar to those in Subdivision D of the Foraminiferal limestone and Subdivision A of the Dark Gray limestone at Permanente.

Los Gatos Section No. 2

This section was measured in an old quarry located northeast of St. Joseph Hill on SW¼ Section 27 - T8S, R1W, M.D.M. At this locality again limestones resembling the dark gray and the Foraminiferal limestone members are exposed, but it was impossible to find the relation between the two types because rubble from quarrying operations has covered the contact.

The beds crop out on a hillside on the 1200 ft. contour level, with a general southwest strike and a dip to the southeast. Similar exposures, with the same general trend, were seen on the north side of St. Joseph Hill. Of the Dark Gray limestone only a 20-foot stratigraphic thickness is exposed. These beds are underlain by badly weathered brownish shale with no traces of stratification. The insoluble residue of the samples collected consists of black carbonaceous silt resembling the residues in Subdivision A of the Dark Gray limestone at Permanente.

Residues in the Foraminiferal Limestone at this locality are like those in Subdivision C at Permanente. They consist of light gray silt aggregates, some with finely disseminated altered pyrite. The Foraminiferal limestone is overlain by brown to buff badly weathered shale and sandstone.

Los Gatos Section No. 3

This section is located in an old quarry on SW¼, Sec. 23 T8S, R1W, MDM. The exposure is a massive, gray dense limestone body about 50 feet thick dipping 35 degrees to the southwest. The lower part of this limestone contains abundant foraminifera. Altered pyrite crystals up to 2 mm. in diameter are conspicuous in the middle part of the section. Occasionally glauconite pellets are found. Chert nodules are common throughout the section, becoming very prominent in the upper part.

In lithological character these beds are similar to the Foraminiferal limestone member. Insoluble residues resembling the suites from both Subdivisions C and D at Permanente are present. Residues from the lower beds (C) are characterized by gray silt aggregates as essential residue and pyrite and glauconite as accessories. The average total percentage of residue is about 5% and the thickness 38 feet.

Residues from the upper beds (D) consist of very fine grained quartz sand and quartz aggregate. Altered pyrite is *fairly abundant forming about 16% of the residue. The* thickness of the subdivision is approximately 15 feet. See Plate 26.

This deposit, which was sampled during the early days of the investigation, is considered as not being representative due to the poor exposure. Later the writer found a better and thicker exposure in a road cut between Guadalupe and Los Gatos on the NW corner of SW¼ of Sec. 24 T8S, R1W, MDM, but due to the lack of time detailed work was not done.

At this locality the writer found two layers of light brown calcareous andesitic tuff with conspicuous chlorite pellets and lentils of green shale. These two strata, which are interbedded with light gray dense limestone, contain well preserved foraminifera, chiefly Globotruncana. Because of the presence of chlorite and other basic minerals the rocks weather rather easily and in places where the weathering process has been most active a good assemblage of foraminifera may be obtained. As far as the writer knows this is the first time that relatively soft beds bearing foraminifera have been reported from the Calera limestone.

Guadalupe Area

Introduction

On the hills southwest of the Guadalupe Reservoir, limestone beds crop out at intervals for a distance of about two miles, approximately along the 750 foot contour level. One of these deposits, perhaps the largest one, is located about 3/4 mile south of the Guadalupe Dam where it forms nearly vertical scarps more than 80 feet high. Because of the heavy vegetation this deposit is not easy to see except from the hills at the northeast side of the Guadalupe Reservoir. Part of this deposit was sampled and measured with plane table and telescopic alidade.

The outcrop was not accurately located by extending the map to a reference point, but it is in or near the southeastern corner of Sect. 32 of T.8.S., R. 1. E., M.D. B. and M. See Plate 2.

Geology

The massive character of the limestone and its structural complications made the stratigraphy rather difficult to interpret.

Two sections were measured in this area, of which one, Guadalupe Section No. 1, may be considered representative. In this area, both the Dark Gray and the Foraminiferal limestone are exposed. The structure can best be interpreted as a plunging anticline faulted near its axis and with its eastern limb overturned. See Plate 27.

The core of this structure is occupied by the Dark Gray limestone and the flanks by incomplete sections of the Foraminiferal limestone. The west flank of the anticline is directly below a large exposure of greenstone, and the bedding dips between 10 and 25 degrees to the northwest. The relation of the foraminiferal limestone in the east flank of the structure with other rocks was not seen because of the heavy soil. The east flank of the anticline dips about 65 degrees to the southwest. The difference in elevation between the top of the eastern flank and the top of the western flank is about 75 feet.

Stratigraphy

Dark Gray Limestone

The Dark Gray limestone is poorly exposed. In lithological character it is identical with the Dark Gray limestone of Permanente: a dark limestone, crystalline, with petroleum odor in fresh fractures. The residues of this member are similar to those of Subdivision A at Permanente. The average amount of residue is 5% and the stratigraphic thickness exposed is only 12 feet. The top of this subdivision is marked by a horizon with residues consisting of waxy clay pellets and flakes and authigenic rhombohedral quartz. See Plate 28.

Foraminiferal Limestone

The Foraminiferal Limestone also has the same character as its equivalent at Permanente, although microfossils are not very abundant. Residues corresponding to Subdivision C consist mostly of gray silt aggregates; the thickness of this subdivision is about 27 feet, and the average percentage of residues is 5%. Residues in the part corresponding to Subdivision D consist of very fine grained clean quartz sand. The lower part, as at Permanente, Section No. 3, is characterized by a horizon with clay flakes. The percentage of residue is 6% and the thickness exposed is only 33 feet. On the west flank of the anticline a layer of interbedded limestone and chert lenses about thirteen feet thick is exposed. From the lower part of this layer up to the contact of the limestone with the greenstone, the Foraminiferal zone has an exposed thickness of 55 feet. See cross-section on Plate 27.

Calero Area

The Calero Reservoir area is located in what is known as the lands of San Jose in the northwest portion of T 9 S, R 2 E, M.D. B. and M. See Plate 2.

In this area the most common rocks are sandstone and shale of Franciscan type. Along the northern margin of the reservoir is a series of small hills forming an arc convex to the north. In these hills interbedded sandstone and shale are present. In the bottom of the reservoir scattered outcrops of massive, medium grained, greenish-gray, and brown sandstones were seen during the summer where the reservoir reached its lowest water level. On the southern bank of the reservoir there is a conspicuous small hill where strata of Calera limestone are exposed in a section about 80 feet thick. This section was measured, and samples were collected from its scarp every five feet. The limestone body dips about 45 degrees to the south. The heavy mantle of soil concealed the contacts of the limestone with other formations, but presumably the deposits occur between bodies of sandstone and shale, which were the only rocks seen relatively close to the limestone.

Just south of the small hill is a ridge 200 feet high, with a heterogeneous group of rocks cropping out on its slopes. From the bottom of the reservoir to the top of the hill the following rocks are exposed. Brown and red shales of the Franciscan group type are in fault contact with massive limestone beds of the Calera formation. The limestone is overlain by brown and red cherts, which also are in contact with serpentine and silica carbonate rocks. The serpentine occupies the core of the hill which is surrounded on its south flank by outcrops of brownish gray massive well indurated sandstone.

A fairly large deposit of the Calera limestone occurs about 1 mile south of the reservoir. This deposit was quarried in past years. The rocks surrounding the limestone-bearing area are brown weathered sandstone and shale of the Franciscan group type. In addition to these, red chert beds and serpentine were seen on top of the hills north and northwest of the deposit. See Plate 29.

Stratigraphy

The Calera formation is represented at this locality by approximately 80 feet of massive, gray, dense limestone with scattered black chert nodules which become more

Subdivision B, since it is underlain by limestone resembling Subdivision A and overlain by limestone resembling Subdivision C. At Permanente Subdivision B is characterized by residues of detrital quartz sand, while here the residues are chiefly authigenic rhombohedral quartz, although a little detrital quartz is present with the rhombohedral quartz, the two types of residues are quite different. This may mean that beds corresponding to Subdivision B are missing here at Calero, and that the zone of rhombohedral quartz is a horizon of Subdivision A (like the much thinner horizons of rhombohedral quartz in Section No. 2 at Permanente). Or it may mean that the residues in Subdivision B change their character southward. See Plate 31.

Possibly it is significant that residues of rhombohedral quartz are found associated with parts of the Dark Gray limestone containing carbonaceous silt residues.

Correlation

General.

The lithology of the limestone in the Los Gatos, Calero and Guadalupe areas is very similar to that at Permanente.

Except at Calero the limestone is divided into a dark gray limestone below and a lighter gray, foraminiferal limestone above. These major units can be further subdivided on the basis of insoluble residues into four subdivisions which are similar to the subdivisions at

Permanente. Even at Calero, where the division into dark and light limestone is not megascopically observable, the subdivisions based on insoluble residues can be easily recognized.

As in the short-range correlation at Permanente, the essential constituents of the residues provide the most reliable basis for long-range correlation. The similarity between residues from different sections is not as close over long distances as it is among the three Permanente sections, but the resemblances are close enough and the stratigraphic sequence is sufficiently similar so that a correlation of the isolated limestone exposures seems possible.

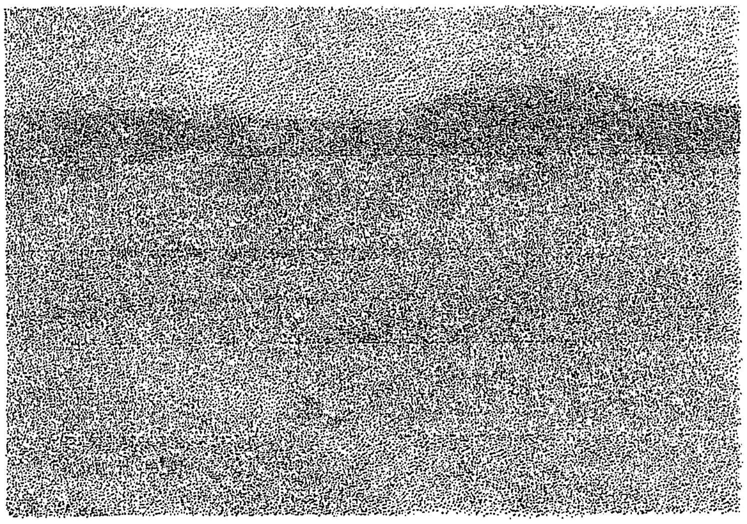
Subdivision A. Limestones with black carbonaceous silt as the essential residue are found at the base of the sections at Los Gatos (No. 2), Guadalupe (No. 1) and Calero. The residues are similar in most details to the residues of Subdivision A at Permanente. Horizons with residues rich in rhombohedral quartz are conspicuous, as in Permanente Section No. 2. The total percentage of residue is also very uniform with depth, as in the section at Permanente.

Subdivision B. The presence of this subdivision is doubtful in the sections south of Permanente. In Los Gatos Section No. 1 a light foraminiferal limestone with insoluble residues consisting chiefly of aggregates of quartz grains, similar to Subdivision D at Permanente, immediately overlies Subdivision A. At Guadalupe and at Calero the beds overlying Subdivision A have residues consisting chiefly of rhombohedral quartz and only minor amounts of detrital quartz, quite different from the dominantly detrital quartz in Subdivision B at Permanente.

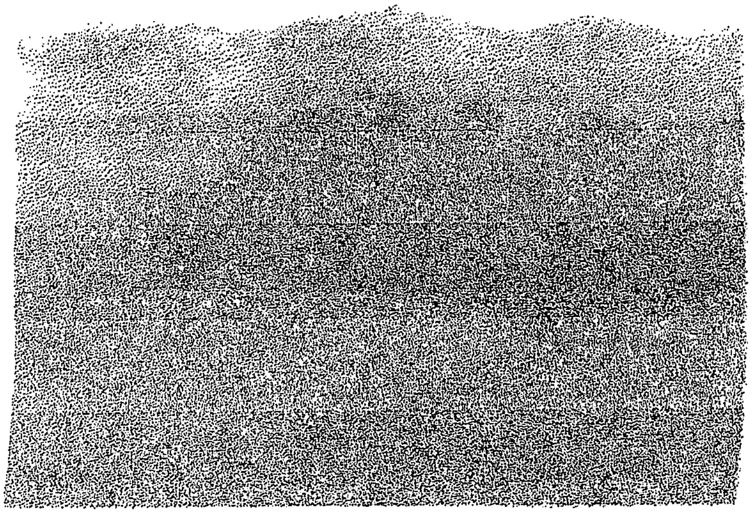
Subdivision C. Light gray limestones with residues consisting chiefly of gray porous silt aggregates with minor amount of altered pyrite overlie the beds with rhombohedral quartz at Guadalupe and at Calero. Similar limestones occur at the base of Los Gatos Section No. 3 and as an isolated outcrop in Los Gatos Section No. 2. In all details these limestones and their residues resemble Subdivision C at Permanente.

Subdivision D. Foraminiferal limestones with residues consisting of fine quartz sand and minor pyrite, closely resembling Subdivision D at Permanente, form the upper parts of Guadalupe Section No. 1 and Los Gatos Sections No. 1 and 3. It may be significant that a horizon with abnormally low total percentage of residues occurs about 25 feet above the base of this subdivision both in Guadalupe Section No. 1 and Los Gatos Section No. 3, corresponding with a similar horizon at the same stratigraphic level in Permanente Sections No. 1 and 2.

Ruins of a lime kiln near an old quarry in the Calero reservoir. Both kiln and quarry are under water during the rainy season.



Partial view of the Calero reservoir.
Photograph taken from an old quarry on
the southern bank of the reservoir.



Exposure of the Calera formation at the top of a conspicuous hill on the southern bank of the Calero Reservoir.

CHAPTER IX

AGE AND STRUCTURAL RELATION OF THE CALERA FORMATION

As explained in an earlier chapter, the Calera limestone is generally regarded as a member of the Franciscan group because of its association with Franciscan rocks in the field and because of its apparently lenticular character. The writer feels that the present study and other recent studies provide good evidence for treating the limestone as a formation independent of the Franciscan group and of Cretaceous rather than Jurassic age. The following paragraphs are a brief summary of this evidence.

At the many limestone exposures visited by the writer in Santa Clara and San Mateo Counties, the limestone is indeed associated with Franciscan types - shale, sandstone, volcanic rocks, and red chert. But nowhere was a normal contact with any of these rocks found; most exposed contacts, either at the top or at the base of the limestone, are clearly fault contacts, although a few are so complex that their interpretation is doubtful.

Taliaferro (28) states, without giving detailed evidence, that the limestone is commonly interbedded with sandstone and shale, locally with red chert and basalt. Lawson (29) also, in his work on the San Francisco Region, concluded that the limestone is interbedded with sandstone.

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28. N. L. Taliaferro. Franciscan Knoxville Problem. Amer. Assoc. Petrol. Geol. Vol. 27 (1943) p. 144.
29. A. C. Lawson. San Francisco Folio. U.S.G.S. (1914) p. 5.

He does not discuss the matter in detail, but simply states, "In the Cahil formation there is a conspicuous foraminiferal limestone which separates the sandstone below and above it into distinct divisions."

Because Franciscan contacts are usually so poorly exposed, and because limestone contacts wherever visible are so commonly faulted, it seems to the writer that the limestones mentioned by Taliaferro and Lawson may well be faulted against sandstone and shale rather than interbedded with them. Indeed, a glance at Lawson's map (Plate 35) of the Crystal Springs - San Pedro area shows that much of the limestone here in its type locality is patently not interbedded with sandstone, but is in contact with intrusive rock.

The lenticular nature of the Calera limestone may be interpreted either as an original structure due to deposition in reefs or isolated basins, or as a secondary structure produced by intense deformation of a once more continuous bed. The fact that zones in the limestone can be correlated over considerable distance by means of insoluble residues is good evidence for the second hypothesis. At least the correlation means that the limestone in different areas must have laid down simultaneously, under similar environmental conditions, if not as

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Paleontological evidence indicates that the Calera formation is not of the same age as the Franciscan group (Upper Jurassic). In 1942, Thalmann (30) studied thin sections of the limestone at Permanente and found the following genera which are typical index fossils for the Upper Cretaceous:

Globotruncana sp. aff. G. appenninica Renz

Globotruncana linneiana (d'Orbigny).

In 1943 the same author (31) studied limestone samples collected by Taliaferro two miles north of Mendocino Co., California, and found the following genera:

Globotruncana renzi Thalmann
Globigerina cretacea d'Orbigny
Gumbelina sp.
Bolivina sp.
Astacolus ? sp.

According to Thalmann: "The Globotruncana species clearly indicate at least a Turonian age for the so-called Franciscan limestone at Laytonville, California."

Near Los Gatos on SW½ of Sec. 24, T.8S., RII.W., M.D., B. and M., the writer found a calcareous andesitic tuff interbedded with the limestone which contains an assemblage

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30. H. E. Thalmann. Globotruncana in the Franciscan limestone, Santa Clara Co., California. Geol. Soc. of America Bull. Vol. 54, No. 12 (1942) p. 1827 (abstract)

of well preserved foraminifera. The assemblage collected proved to contain different genera of Globotruncanas. Mr. C. C. Church who had the opportunity to study them made the following statement:(32)

> "I have looked at your slide of foraminifera, and they appear to me to be Upper Cretaceous. Most of them are Globotruncana of two or more species."

The accumulated evidence clearly indicates an Upper Cretaceous age for the Calera limestone.

In summary, the absence of definite evidence for interbedding of the limestone with Franciscan rock, the indication from insoluble residues that the limestone was once a more continuous bed, and the paleontological proof of its Cretaceous age, all suggest strongly that the limestone was deposited originally as a thick bed *or as a number of contemporaneous reefs on top of the* older Franciscan rocks. Subsequent orogenic movement distorted and fragmented the limestone and erosion has removed all but isolated remnants which were downfolded or downfaulted into Francisca rocks.

If the limestone is Upper Cretaceous, some of the igneous rocks which intruded it and some of the extrusive rocks which overlie it must be of Cretaceous or later age, instead of Franciscan as generally supposed.

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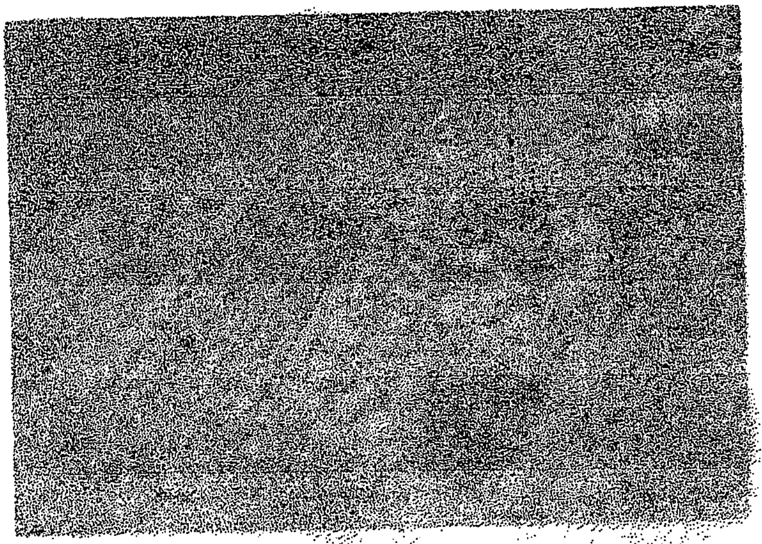
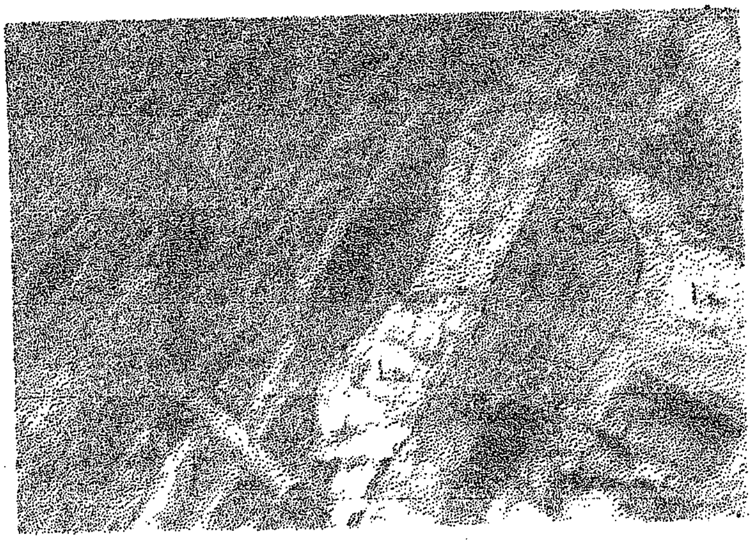
32. C. C. Church, in a personal letter.



Locality: S.W.¼ of Sect. 24 T8S, R1W, M.D., B. & M. Andesitic calcareous tuff containing foraminifera, (chiefly *Globotruncana*) interbedded with light gray, dense well bedded foraminiferal limestone.



Detail of contact shown in preceding photograph. Ad=Andesitic calcareous tuff containing foraminifera. Ls=light gray foraminiferal limestone. Ch=chert.


Ls.
Ls

CHAPTER X

SUMMARY AND RECOMMENDATIONS

Summary of Conclusions

(1) The insoluble residues of the Calera limestone are of distinctive and persistent character, and their lithological variations may be used as an aid for correlation purposes.

(2) The Calera limestone is considered as a formation. Two members - the Dark Gray and the Foraminiferal limestone - are recognised in the western portion of Santa Clara County, California.

(3) Based on a study of insoluble residues, each of the two members is subdivided into two subdivisions.

(4) The age of the Calera formation is considered as Upper Cretaceous because of the presence of different species of Globotruncana first found by Thalmann at Permanente and Calera and during the course of the investigation by the writer in a locality near Los Gatos.

(5) The Calera formation is considered as an independent unit separate from the so-called Franciscan group.

Recommendations

The writer recommends the application of insoluble residue studies to the Calera formation in places where the discrimination of overturned strata or other structural complications are important for calculating the reserves of high grade limestone deposits suitable for economic purposes.

It has been seen that except in certain cases the lithological character of the formation is so uniform that it does not permit determination of the position of a poor exposure in the stratigraphic column. The insoluble residues, however, are an additional aid in determining stratigraphic position. Besides the application of this method for stratigraphic purposes it is also of economic value in finding which part of the section has the highest purity and therefore is the most suitable for the manufacture of cement or lime.

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GEOLOGY OF THE
PERMANENTE PROPERTY,
KAISER CEMENT CORPORATION,
PERMANENTE, CALIFORNIA

Elizabeth L. Mathieson
Associate Geologist
Mineral Resources Department
Kaiser Cement Corporation
May 28, 1982

CONTENTS:

ABSTRACT:

Reconnaissance geologic mapping of Kaiser Cement Corporation's Permanente property in 1981 delineated the approximate distribution of rock units outside of the present quarry area. Surface exposures of limestone bodies totaling approximately 46 million tons were mapped outside the quarry. The most promising sources of limestone not currently being mined are immediately north and south of the present quarry. The former area may contain 3 million tons, and the latter, on the south bank of Permanente Creek, may contain 16 million tons. Mining north of the quarry, however, is restricted by a ridgeline protection easement. The remaining tonnage is on the ridge south of the rock plant loading area and in the southwest corner of the property. An additional 700,000 tons of limestone is estimated to underlie the Midpeninsula Regional Open Space District property northeast of the quarry.

27 M.T.

All proposed structures and waste dumps should be sited with reference to the distribution of limestone bodies shown on the Geologic Map (Plate 2). Placement of a waste dump or sanitary landfill in Bryan Canyon is not expected to restrict access to any large bodies of limestone. The proposed waste rock conveyor, however, could limit access to as much as 14 million tons of limestone on the slope above the rock plant loading area. Several major ancient landslide deposits and smaller active landslides on the south wall of Permanente Canyon may present slope stability problems for construction projects. The proposed westward extension of the west dump would not limit access to any mapped limestone, but more mapping is recommended on the southwest rim of the canyon west of the present dump.

Further detailed mapping is recommended immediately north and south of the quarry to correlate the limestone in those areas with that in the quarry. Additional reconnaissance mapping in the unmapped areas of the Permanente property would complete the Geologic Map.

INTRODUCTION:

Kaiser Cement Corporation's Permanente property (Fig. 1) was mapped in the summer of 1981 for the purpose of compiling a reconnaissance geologic map. The present quarry area was not included as it is subject to a separate investigation. Approximately two-thirds of the 3500-acre property was mapped in order (1) to determine whether or not proposed construction projects or projected dump areas would restrict future access to any large bodies of limestone, (2) to delineate all other significant limestone bodies on the property, and (3) to map rock types and geologic structure using all outcrops and road cuts on the property.

A geologic map compiled in 1945 by Permanente Cement Company's Chief Geologist K. E. Grimm was the most recent in-house geologic map available for any part of the Permanente property, other than the quarry itself. Grimm's map covers the southwest corner of the property, most of Area 1 of this report. The Permanente property is included in recent reconnaissance geologic maps produced by several government geologists (Dibblee, 1966; Rogers and Armstrong, 1973; Sorg and McLaughlin, 1975).

Elevations on the property range from 400 feet in Stevens Creek Canyon in the southeast corner to 2600 feet on Monte Bello Ridge in the southwest corner. Slopes are steep except on several old, massive landslides and on top of Monte Bello Ridge. Vegetation is dense on most of the property and consists primarily of (1) bay laurel trees with sparse underbrush in valley bottoms, and (2) sparse oak trees with dense brush on ridges and slopes. Recent landslide deposits and areas that formerly were cleared for grazing support extremely dense poison oak.

The 1981 mapping project was supervised by Senior Quarry Engineer Carlito Bayan and conducted by Associate Geologist Elizabeth Mathieson; Quarry Engineer Mark E. Beers; two summer field assistants, Steven Miller and Johnathan Tal; and Engineering Aide Mike Crowley. Approximately 40 working days were spent on the project, about 1000 man-hours in the field and 280 man-hours in the office.

The topographic base map, scale 1"=400', was prepared photogrammetrically by Harl Pugh & Associates of South San Francisco from aerial photographs taken April 7, 1979. Field locations were marked on the map and on black and white aerial photograph stereo pairs taken February 10, 1981, (approximate scale 1:20,000) and on black and white prints of color aerial photographs taken April 30, 1981, (1:16,900 and 1:23,000) by T. M. Graphics of South San Francisco. Color transparencies of the latter set were examined in the office. We mapped road cuts, stream cuts, tree-filled valley bottoms, accessible ridges, and individual outcrops located from air photos in less accesible areas.

Locations of outcrops on air photos and on the topographic map were determined in the field primarily by inspection and occasionally by pace and compass methods. Dense vegetation and inaccuracies discovered on the topographic map during the project precluded the use of compass resection. Hand specimen samples were collected from all rock types, and larger chip samples, approximately 3 pounds each, were collected from each limestone outcrop. Where bedding orientation could be determined, limestone outcrops were sampled perpendicular to the bedding. The chip samples were assayed by x-ray fluorescence at the Permanente plant laboratory.

We attempted to include representative proportions of each rock layer in the assay samples. Nevertheless, conflicting duplicate assay results from one outcrop of limestone with interbedded chert (#<u>40</u>)* suggest that the assay results should be used only as a rough estimate of the grade of rock in a particular area.

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*Location numbers underlined in text are enclosed by rectangles on Plate 1. Those not underlined are circled on the plate.

The accompanying Data Base Map (Plate 1) shows the locations of all outcrops and float mapped in the field. Data from those locations were used to draw contacts between rock units on the Geologic Map (Plate 2). Because of the isolated nature of the outcrops and the fact that very few contacts are exposed, most contacts are located approximately and are mapped as "Franciscan contacts of uncertain type." They may be fault contacts, intrusive contacts, or depositional contacts. The boundaries of shear zones may be sharp fault contacts or gradational contacts between intact rock and increasingly sheared rock. Attitudes of contacts are unknown.

Dased lines on the Data Base Map represent field traverses and indicate the degree of coverage of the area.

Five Geologic Cross Sections (Plate 3) were constructed from the Geologic Map. They illustrate interpretive downward projections of the surface geology.

REGIONAL GEOLOGY:

The Permanente property is within the Coast Ranges physiographic province. The Franciscan assemblage, a Jurassic-Cretaceous eugeosynclinal complex, constitues the larger of two basement complexes in the province (Page, 1966) and underlies most of the Permanente property (Fig. 2). The limestone mined at Permanente is part of this assemblage.

The primary geologic structures in the province trend northwest-southeast. One major structure is the active San Andreas fault, which lies approximately three miles southwest of the Permanente plant. The internal structure of the Franciscan assemblage is complex:

> "Although the Franciscan is pervasively deformed by folds and faults, the structures within it cannot generally be ascertained because of its persistent heterogeneity and lack of key beds. Most folds trend northwest, but arcuate map patterns around plunging folds are rarely obtained, probably because of widespread faulting along, and parallel to, the axial parts of the folds. The major faults, which have a similar trend, are shear zones that in places are as much as a mile wide. These contain large blocks of more resistant Franciscan rocks in a sheared matrix..."
>
> (Bailey, Irwin, and Jones, 1964, p.8).

The basement Franciscan rocks are overlain by younger rocks that include the Miocene Monterey formation, primarily a marine shale, and the Plio-Pleistocene Santa Clara formation gravel and sand (Rogers and Armstrong, 1973).

ROCK UNITS:

The two rock formations that underlie most of the Permanente property are the Franciscan assemblage of Jurassic-Cretaceous age and the Santa Clara formation of Plio-Pleistocene age (Sorg & McLaughlin, 1975). The northeastern corner of the property includes small areas of Monterey formation(?) of Miocene age (Rogers & Armstrong, 1973).

The limestone mined at Permanente is part of the Calera limestone member of the Franciscan assemblage (Wachs & Hein, 1975). Much of the limestone is interbedded with black chert. Other Franciscan units mapped on the property are, in order of relative abundance, (1) volcanics, including flows, pyroclastics, and greenstone (altered volcanics); (2) sandstone, primarily graywacke; and (3) chert, both red and black.

The eastern portion of the Permanente property, which is characterized by lower topographic relief and elevation, is underlain by moderately- to poorly-consolidated sand and gravel of the Santa Clara formation. Prominent outcrops in one small area of the northeastern corner of the property appear to belong to the Miocene Monterey formation.

The following is a key to the rock unit symbols used on the geologic map:

Qaf - Artificial fill. Waste rock and dust dumps.

QTsc - Santa Clara formation. Yellow-brown sandy gravel, gravelly sand, and sand interbeds, poorly sorted. Most is poorly consolidated. Belongs to Stevens Creek member of formation (Rogers & Armstrong, 1973).

Tm - Monterey formation(?). Thin-bedded dark gray limestone, red and grayish-green mudstone, and pinkish-white limestone interbedded with red chert.

Franciscan Assemblage

KJv - Volcanics. Includes dark green vesicular basaltic rocks with calcite amygdules, dark green aphanitic rocks, dark green porphyritic-aphanitic rocks with rounded black mafic phenocrysts or rounded white to light blue quartz(?) phenocrysts, pyroclastic(?) dark green and purple aphanitic clasts in a white calcite matrix, purplish-brown porphyritic-aphanitic rocks with olive green phenocrysts, and dark green medium to coarsely crystalline greenstone(?) with abundant olivine crystals and prominent plagioclase cleavage faces. Most of the volcanics weather to dark reddish-brown and produce a red, clayey, expansive soil.

KJs - Sandstone. Predominantly dark gray graywacke, fine grained, with rounded quartz grains and abundant lithic fragments. Some is medium brown. Some is moderately foliated. Interbedded with black shale in many places. Weathers to medium brown and produces a light brown sandy soil. At #68, one sandstone outcrop contains some serpentine.

KJch - Chert (not interbedded with limestone). Thin-bedded red chert crops out in a fault block bounded by sandstone along the main road between the quarry and the plant. Much of it has black, dendritic manganese "flowers." Includes minor interbeds of black, green, and yellow chert. Massive black chert is exposed poorly on the ridge north of the microwave relay station southeast of Black Mountain and north of Monte Bello Road. Some is brecciated and recemented. We were unable to determine the structural relationship between the chert and the surrounding sandstone and volcanics.

KJls - Limestone. Light to dark gray, micritic to medium crystalline. Light gray limestone usually is micritic and often contains tiny darker gray specks that may be foraminiferal remains. Dark gray limestone usually is fine to medium crystalline and often has a bituminous odor. Much of the light gray limestone contains thin (1-4") interbeds of black chert which reduces the calcium carbonate content of the rock. Limestone, in general, forms more prominent outcrops than the other rocks in the area. No attempt was made to correlate limestone units in outer areas with those in Permanente Quarry.

sz - Shear Zone. Isolated blocks of Franciscan volcanics, sandstone, limestone, and chert in a sheared matrix. This unit is typical Franciscan "melange."

MAP AREAS:

AREA 1

Area 1 was mapped primarily by E. Mathieson and J. Tal.

Structure

Outcrops in the Black Mountain area, as in most of the Permanente property, are rare. Bedding attitudes have no systematic pattern. The large-scale structure appears to consist of wide northwest-trending bands of Franciscan volcanics separated by wide shear zones. The shear zones contain large, resistant blocks of limestone that form ridge-top outcrops. There are few outcrops of other rock types.

Limestone

The southwest corner of the property contains many prominent but scattered limestone outcrops. Some occur as large ridge-top or hillside exposures, but many are small and isolated.

K. E. Grimm, whowas the chief geologist for Permanente Cement Company in the early 1940's, conducted an exploration program in the Black Mountain area. His reports (Grimm, 1943, 1945) were based on extensive surface mapping, trenching, and drilling. Grimm concluded that the outcrops are "local isolated remnants of an earlier larger mass." Our field work confirmed that the outcrops are isolated, but they probably are small fault blocks within a shear zone rather than erosional remnants of a large ridge-top body of limestone. The blocks of limestone probably are separated by a less-resistant matrix of sheared volcanics, sandstone, limestone, and chert. Such "melange" zones are characteristic of the Franciscan assemblage.

Grimm (1945) recognized limestones of two different ages in the Black Mountain area. He used microfossils to correlate the younger limestone with the "upper light" (low grade) limestone at the Permanente quarries. We were unable to distinguish limestone of different ages. Most of the Black Mountain limestone assayed as high grade, and approximately one-fourth has a bituminous odor like that of the black high grade rock in the quarry. In Area 1, one-third of the bituminous rock is dark gray, two-thirds is medium gray, and one-tenth is light gray. Of the total limestone mapped in the Black Mountain area, most is medium gray, micritic to fine grained, and highly fractured.

We mapped more limestone outcrops than shown on Grimm's map, but most of the previously unmapped outcrops are very small. The dimensions of outcrops shown on Grimm's map disagree with dimensions cited in his text. Although the precise locations of his drill holes are unknown, his drill hole assays (Appendix) and our geologic map can be used to make a rough estimate of limestone tonnage available in the area.

The three 1945 drill holes that penetrated limestone give an average of 155 feet for the minimum depth of limestone at the hole locations. The drill hole results suggest that the boundaries of the limestone bodies are near vertical; most holes drilled near the edges of the limestone exposures within the limestone did not pass out of the limestone. Those drilled just outside the limestone exposures did not penetrate limestone. If one assumes that 150 feet of limestone underlies each of the four largest areas of limestone in Area 1, the total tonnage of limestone in the four areas is approximately 15 million tons. Because the geologic structure of the area could not be determined from surface mapping, we are unable to infer the presence of additional concealed limestone bodies. Three of the seven drill holes were outside the areas of limestone exposure, and none of the three intersected limestone at depth (average depth 143 feet). Nevertheless, additional large blocks of limestone may lie beneath the surface in the mapped shear zones.

AREA 1 (Cont'd)

Other Rock Types

The shear zones in Area 1 contain, in addition to limestone, small blocks of Franciscan volcanics, sandstone, and chert. Volcanics mapped in the shear zones are exposed exclusively in road cuts and stream cuts. A small road-cut exposure adjacent to the limestone at #132 consists of highly weathered dark green vesicular volcanics. At #145, a small outcrop consists of dark purplish-brown, porphyritic-aphanitic rock with olive-green phenocrysts. At #161, limestone is in fault contact with dark green pyroclastics or brecciated volcanics with a calcite matrix. The volcanics at #162 are extremely sheared and consist of dark green and dark purple pyroclastics and vesicular rocks. Calcite amygdules fill some of the vesicles. The sheared outcrop nearby, at #163, is a light yellowish-brown volcanic rock.

Sandstone crops out in both shear zones in Area 1. Adjacent to Monte Bello Road near the western Kaiser property line (#142, #164, #211, #213), the sandstone is medium borwn to dark gray and fine grained. Near the point where Monte Bello Road crosses the southern Kaiser property line, dark gray to dark brown sandstone (#119, #221, #222) is associated with chert. Dark gray chert at #118 and #222 is brecciated and recemented with silica. Black chert with phosphate (?) nodules occurs at #120, and both red and black chert occur at #149.

Two distinct northwest-trending bands of volcanics bound the shear zones in Area 1. The northwestern half of the southern band (#129, #130) includes dark green vesicular basalt(?) with calcite amygdules. At #135, vesicles are filled with pink and green quartz(?). The southeastern half of the southern band consists of dark green aphanitic to finely crystalline volcanics (#215, #220) and dark green porphyritic-aphanitic volcanics with rounded black phenocrysts (#217, #218, #219).

AREA 1 (Cont'd)

The wide northern band of volcanics continues both northward and eastward into Area 2. In Area 1, the band includes dark green greenstone, fine to medium grained, with abundant olivine crystals (#175, #177, #178). Outcrops at #177 and #178 are extremely sheared. Other outcrops (adjacent to #177, #179, #180, #181, #182) consist of dark green to dark gray aphanitic to porphyritic-aphanitic volcanics and pyroclastics. Phenocrysts are black and rounded. Outcrops at #32 and #180 are very sheared.

There are no exposures of the Santa Clara or Monterey formations in Area 1.

AREA 2

Area 2 was mapped primarily by M. Beers and S. Miller. Most of the bedding attitude information in the limestone exposures immediately south of Permanente C was transferred from K. E. Grimm's 1943 "Geologic Map of the Permanente Quarries, Santa Clara County, California," 1"=200'. The north-central portion of the area i occupied by the west dump.

Structure

Outcrops in Area 2 are rare except on the northern ends of two limeston ridges immediately south of Permanente Creek and southwest of the present quar The major structures of Area 1 extend into Area 2, but fewer large exposures of limestone were mapped in the shear zones of Area 2.

The wide northern band of volcanics is interrupted in its eastern half by a large body of limestone south of Permanente Creek and a large body of sandstone on the north side of the ridge south of the creek. The nature and orientation of the contacts between these units are unknown. The east-central portion of the area is cut by a major northwest-trending, east-dipping fault that truncates the limestone body south of Permanente Creek.

Limestone

Most of the limestone mapped in Area 2 is exposed as prominent outcrops on steep slopes immediately across Permanente Creek from the western end of the quarry. These outcrops form the northern ends of two north-trending ridges. The base of the eastern ridge was quarried in the 1940's. Limestone on both ridges is light to dark gray, but light gray predominates on the eastern ridge. The presence of chert was noted in limestone near the top of the eastern ridge. Four assays of samples from the western ridge averaged 95% $CaCO_3$. Six from the eastern ridge averaged 84% $CaCO_3$.

AREA 2 (Cont'd)

Two diamond drill holes (DDH 802 and DDH 803) were drilled in the large body of limestone on the south bank of Permanente Creek in 1981. Both were drilled at a 45° angle into the hill, one to 300' depth and one to 400'. Except for minor intrusives near the surface, the holes penetrated only limestone. A conservative estimate of limestone tonnage in this body, above the creek bottom, is 7 million tons. The drilling results imply that at least an equivalent tonnage lies below the creek bottom. Therefore, the steep south bank of Permanente Creek contains at least 14 million tons of limestone within a short distance of the present quarry.

Another large body of limestone, on the north bank of Permanente Creek where the creek makes a wide bend to the south and bends back to the north, was quarried in the 1950's. Most of the useful rock is believed to have been removed in this area.

Three smaller limestone bodies and several small, isolated outcrops were mapped in Area 2. A linear series of apparently connected outcrops (#42, #43, #47) uphill from the main limestone body south of Permanente Creek covers an area of approximately 70,000 ft^2 and is surrounded by sandstone. This limestone is light to dark gray, has a bituminous odor, and assayed as high grade. A smaller (50,000 ft^2) linear series of outcrops father west (#84, #85, #86) is medium to dark gray limestone and assayed as medium to high grade. There is red chert in one of these outcrops. A ridge-nose body of limestone near the western edge of Area 2 (#78) covers an area of approximately 150,000 ft^2. The rock is light to dark gray, contains some black chert, and assayed as medium grade on the average.

Other Rock Types

The most continuous rock unit in Area 2 is a wide northwest-trending band of volcanics that includes all of the northern portion of the area and extends to the southeastern corner. The northern east-west trending ridge is underlain primarily by pyroclastic volcanics (#8, #15), some of which are extremely sheared (#4, #5, #199). The southern half of the volcanic band consists primarily of aphanitic and porphyritic-aphanitic volcanics with black, light blue, white, or light green phenocrysts with rounded edges. The southeastern limit of this volcanic band extends into Area 3B.

The large body of sandstone immediately south of the limestone exposures on the south bank of Permanente Creek contains siltstone as well as gray sandstone. Outcrops #48 and #49 are sheared. A second body of sandstone underlies the mined-out limestone body on the north bank of Permanente Creek at the big bend in the creek. A third body of sandstone is exposed east of the fault that truncates the eastern edge of the south-bank limestone body. The three outcrops (#38, #44, #45) are medium to dark gray graywacke.

The southwestern corner of Area 2 is underlain by the eastward extension of a shear zone mapped in Area 1. It includes two small limestone bodies, described above, several smaller isolated limestone outcrops, and several outcrops of sandstone and volcanics.

No rocks of the Santa Clara or Monterey formations were mapped in Area 2.

AREA 3A

This area is the north-facing slope below (north of) the 1500' skyline ridge of the Permanente Quarry. It was mapped by E. Mathieson and J. Tal.

Structure

The extreme upper (southern) portion of the north-facing slope that makes up Area 3A is underlain by limestone that probably is continuous with the limestone exposed in the north faces of the quarry. The lower slope is underlain by volcanics. The east-trending limestone/volcanics contact is of unknown orientation and type.

The center of Area 3A is underlain by an ancient major landslide mass. The mass probably is a rotational slump block that slid during wetter climatic conditions several thousand years ago. It covers an area approximately 700 feet wide and 1400 feet long, and it may be 50-100 feet thick.

Limestone

Limestone forms the only outcrops above 1400' elevation on the slope. Most of the limestone is thin-bedded and contains minor amounts of chert. Ten samples averaged 86.1% $CaCO_3$. We could make no generalizations about the structure along the ridge, but the exposures suggest that the limestone on the north-facing slope is continuous with that exposed in the north wall of the quarry. If so, the northeastern skyline ridge of the quarry probably contains 2 million tons of limestone between the 1400- and 1500-foot elevations. Mining in this area is restricted by a ridgeline protection easement.

Limestone also crops out over an area 600 feet long and 500 feet wide on the surface of an ancient major landslide mass (Location 3A-1). The mass probably is a rotational slump block. Its original position was farther up the slope to the south, and the limestone in it may originally have been continuous with the limestone mined from the upper quarry in the 1940's and 1950's. The thickness of limestone in the block in unknown. A 50-foot thick body of limestone would contain approximately 1 million tons, the mining of which is restricted by the same ridgeline protection easement. The outcrops in the slump block are low and are surrounded by dense limestone rubble. Most of the outcrops are recemented limestone breccias, and many of the clasts are bituminous. Seven samples averaged 90.0% $CaCO_3$.

Other Rock Types

The volcanics in Area 3A are primarily pyroclastics (#191, #193 - #198). Some (#192, #200, #201) are dark green or blue-green porphyritic-aphanitic rocks with rounded blue or black phenocrysts. Greenstone is exposed at #223. No rocks of the Santa Clara or Monterey formations were mapped in Area 3A.

AREA 3B

Area 3B was mapped primarily by E. Mathieson and J. Tal. Portions of this area would be affected by a recently proposed waste rock disposal system. The system would include a conveyor line in Permanente Creek Canyon and a waste dump in Bryan Canyon, the valley southeast of the plant garage. The western fourth of the conveyor alignment coincides roughly with the location that in 1971 was proposed for a waste dump in Permanente Creek Canyon.

Structure

The primary structural feature in Area 3B is a northwest-trending fault zone that is considered to be an extension of the Berrocal fault zone (Sorg and McLaughlin, 1975). One main strand of the fault extends from south of Area 3B northwestward into Permanente quarry. Its location is marked by topographic anomalies on the main southeast-trending ridge south of Permanente Creek and by a 500-foot-wide shear zone in Permanente Creek Canyon.

The second main strand of the fault zone extends from south of Area 3B northward along the road from the Voss quarry to the plant garage. It separates Franciscan rocks on the west from Santa Clara sand and gravel on the east. The location of its northern extension is uncertain. Rogers and Armstrong (1973, Plate 1) mapped it northward through the plant area. Sorg and McLaughlin (1975) mapped it northwestward to the west of the plant, along the central segment of the contact between the Franciscan assemblage and the Santa Clara formation. We did not resolve the discrepancy.

Major contacts in Area 3B trend northwest. There are no wide shear zones like those in Areas 1 and 2. More coherent blocks of individual rock types are exposed.

AREA 3B (Cont'd)

Three large, ancient landslides have been mapped in Area 3B. Like the large slide mass in Area 3A, these are deep bedrock slides that probably moved during a wetter climatic period. Nevertheless, they might be reactivated by extensive grading. The slide mass at Location 3B-1 appears to be a slump block. Its toe may be supported laterally by the fill under the rock plant loading area. The proposed alignment of the waste rock conveyor crosses the top of this landslide deposit.

The proposed conveyor alignment crosses the lower portions of two massive, ancient landslide deposits (3B-2 and 3B-3) on the south wall of Permanente Creek Canyon in addition to the smaller slide mass at 3B-1. These are complex slide masses that include smaller, more recently active landslides along Permanente Creek (e.g. 3B-4). Much of the proposed conveyor alignment traverses the large, ancient slide masses slightly uphill of the oversteepened slopes along Permanente Creek that are most susceptible to slope failure. These potential slope stability problems would affect design and construction of the conveyor line.

Limestone

The only significant limestone mapped in Area 3B is exposed in an area at least 700 feet long and 560 feet wide at the east end of the short ridge above the rock plant loading area (Location 3B-5). Bedding orientations and the outcrop pattern suggest that the limestone body is truncated by a fault on the southwest, and limestone exposed at the upper switchback on the road at the east end of the ridge (#80) is pervasively sheared. The average depth of the limestone probably exceeds 100 feet. This ridge is estimated to contain approximately 8 million tons of limestone.

AREA 3B (Cont'd)

A small (10,000 ft^2) exposure of limestone in two road cuts west of the road to the Voss quarry (Location 3B-6) does not appear to be continuous with the limestone at 3B-5, but a long, narrow area free of outcrops lies between the two exposures. That area might be underlain by limestone, and the limestone body exposed at 3B-6 may be more extensive at depth.

No outcrops were mapped on the slide mass just south of the rock plant loading area (Location 3B-1). The soil on the flat top of the slump block contains intermixed fragments of limestone, sandstone, and volcanics. Limestone fragments predominate and are most abundant at the east end of the knob. Much of the slump block may consist of limestone that originally was continuous with the limestone on the ridge to the south, at 3B-5. The total volume of all rock in the slump block is about 1.5 million cubic yards. If limestone makes up half the volume of the slump block, the block contains approximately 1.5 million tons of limestone.

Construction of the proposed waste rock conveyor would restrict mining access to limestone in the slump block at 3B-1. It might limit access to the limestone at 3B-5. It should be noted that the northern extent of the limestone at 3B-5 is unknown; it may extend downslope to the proposed conveyor alignment. The maximum total tonnage of limestone at both 3B-5 and 3B-1 is unlikely to exceed 14 million tons.

The presence of thick travertine deposits in the creek bed between #62 and #64 indicated that limestone is present in the ridge above, but none was mapped.

AREA 3B (Cont'd)

Other Rock Types

The best exposures in Area 3B are in Permanente Creek Canyon. The westernmost sandstone body is limited on the east by the main western strand of the Berrocal fault zone. It consists of dark gray graywacke with some shale (#15, #39). Graywacke blocks predominate in the 500-foot-wide shear zone to the east. There are occasional blocks of volcanics, and some are covered with travertine.

A wide northwest-trending band of sandstone underlies most of the northeast and east-central portions of Area 3B. The sandstone on the north wall of Permanente Creek Canyon upstream from the road rock surge pile consists primarily of fine-grained dark gray graywacke with some dark gray siltstone. The sandstone downstream from the surge pile (#46-53) is fine-grained, foliated light green graywacke.

Most sandstone outcrops south of the slide mass at 3B-2 are dark gray graywacke. Sheared graywacke at #58, however, is foliated and light green like that in the main canyon. The green color may be produced by chlorite that formed during incipient metamorphism during shearing. The sandstone at #158, adjacent to the eastern branch of the Berrocal fault, is extremely sheared and weathered. The south end of the same road cut contains sheared fault blocks of volcanics and sandstone.

A fault block of thin-bedded red chert is exposed at the northeastern edge of Area 3B and extends into Area 4. It contains some interbeds of black chert and has abundant manganese stains.

AREA 3B (Cont'd)

An 800-foot wide band of volcanics is exposed east of the main western strand of the Berrocal fault in Permanente Creek Canyon. Most are dark green and aphanitic, but some individual outcrops (#22, #34) contain dark green aphanitic rocks and dark green or purplish-brown porphyritic-aphanitic rocks with rounded black or blue-green phenocrysts. The volcanics at #35 are varied and include some graphite veins which suggest that the rock has undergone partial metamorphism. The eastern edge of the band of volcanics, adjacent to the sandstone contact, consists of greenstone. The rock is dark green, is fine to medium crystalline, and contains abundant olivine and prominent plagioclase crystals.

In the southern half of Area 3B, volcanics occur along the main southwest-trending ridge on both sides of the western branch of the Berrocal fault. They consist primarily of pyroclastics, but most of the outcrops at the northern end of the Voss property consist of interbedded(?) dark green aphanitic and pyroclastic rocks. Outcrops at #64 and #262 are purplish-gray porphyritic-aphanitic rocks. Two outcrops, #65 and #94, contain both greenstone and pyroclastics.

The entire area proposed for a waste dump in Bryan Canyon is underlain by sand and gravel of the Santa Clara formation. Because the north-northwest-trending fault that forms the western boundary of the Santa Clara formation in this area dips steeply to the east (Sorg and McLaughlin, 1975), some limestone may underlie the west side of the waste dump area at depth. The tonnage is not expected to be significant.

AREA 4

Area 4 was mapped by M. Beers, S. Miller, E. Mathieson, and J. Tal. It includes land owned by Kaiser Cement Corporation, Kaiser Aluminum & Chemical Corporation, and the Midpeninsula Regional Open Space District.

Structure

The eastern edge of Area 4 includes a contact between the Franciscan assemblage on the west and the Monterey formation(?) on the east. We located outcrops of Monterey formation(?) limestone and mudstone but did not map the contact. Rogers and Armstrong (1973) mapped the contact as a northwest-trending fault of unspecified type. Sorg and McLaughlin (1975) mapped it as a northwest-trending west-dipping reverse fault. Not shown on Plate 2 are irregularly distributed areas underlain by Santa Clara sand and gravel near the eastern edge of Area 4.

The north-northwest-trending fault near the center of Area 4 coincides approximately with the northern extension of the Berrocal fault mapped by Sorg and McLaughlin (1975). We located it on the basis of (1) a zone of extremely sheared rock in a road cut east of #<u>60</u> and (2) a break in slope that coincides with a sandstone/volcanic contact on the ridge between #<u>206</u> and #<u>207</u>.

Limestone

There are few limestone outcrops in Area 4. Franciscan limestone crops out over an area of approximately 100,000 ft² on the end of a ridge just inside the Midpeninsula Regional Open Space District property, at the western edge of Area 4. The end of the ridge may contain 700,000 tons of limestone. The limestone body appears to be the eastern extension of the rock in the ridge that forms the northern wall of the quarry. Samples assayed as high grade limestone.

AREA 4 (Cont'd)

A single large outcrop of dark gray limestone was mapped in the valley northwest of the large water tank on the ridge north of the plant. One assay was 95.3% $CaCO_3$; a second was 42.0% $CaCO_3$.

Limestone of the Monterey formation(?) is exposed on a steep creek bank at the eastern edge of Area 4. One outcrop (#209) consists of dark gray, thin-bedded micritic limestone with no odor. It assayed 75.4% $CaCO_3$. An adjacent outcrop contains red and grayish-green laminated mudstone, and a cave in black sandstone in the same outcrop contains large crystals of white calcite. A large cliff-forming outcrop (#210) consists of pinkish-white, micritic limestone interbedded with red chert. The sample assayed 57.6% $CaCO_3$. This limestone is not considered to be of sufficient quantity or quality for cement manufacture.

Other Rock Types

Sandstone underlies most of the southern half of Area 4. Most is dark gray and fine grained and contains abundant quartz. One outcrop (#22) contains red chert. At #205, fine-grained medium gray sandstone is interbedded with dark brown laminated shale.

Dark gray vesicular basalt(?) is exposed at #207 and extends several hundred feet downslope to the east. The rock contains calcite amygdules and forms odd-looking low, blocky, irregularly-angular outcrops with 1/8"-thick white weathering rinds.

CONCLUSIONS:

1. Any construction projects proposed for Permanente Creek Canyon should be placed to permit future access to the large body of limestone upstream from the 1150-foot elevation on the creek. Much of the southern wall of the canyon downstream from the limestone body consists of ancient landslide deposits that might be reactivated if extensive grading work is conducted. The southern banks of the creek are oversteepened and unstable in many places.

2. The eastern portion of the waste rock conveyor proposed for Bryan Canyon would limit access to limestone in the slump block at 3B-1 and might limit access to the limestone at 3B-5. The maximum estimated total limestone tonnage in these areas is 14 million tons.

3. Placement of a waste rock dump or sanitary landfill in Bryan Canyon is not expected to restrict access to any large bodies of limestone.

4. The proposed westward extension of the west dump into the adjacent southeast-trending canyon should not limit access to any limestone. Nevertheless, we did not map the northeast ends of two ridges that extend into the canyon from the southwest, and the geologic structure is poorly understood.

5. The most promising sources of limestone not currently being mined are immediately north and south of the quarry (Table 1). The first consists of (a) the northeastern skyline ridge of the quarry, where an estimated 2 million tons of limestone exist between the 1400- and 1500-foot elevations, and (b) an ancient landslide mass that may contain 1 million tons of limestone. Mining in both areas is restricted by a ridgeline protection easement. The second potential source is a large body of limestone exposed on the steep northern ends of two ridges immediately across Permanente Creek from the present quarry. Field mapping results and drill hole data indicate that this body contains approximately 7 million tons of limestone above the creek level and at least 7 million tons below creek level.

6. The Black Mountain area in the southwest corner of the property contains approximately 15 million total tons of limestone above the 150-foot depth in the four largest bodies of limestone. Additional unmapped limestone bodies may exist beneath the surface in that area and in the sourthern third of Area 2 to the east.

RECOMMENDATIONS FOR FURTHER WORK:

1. Correlate limestone units in the north wall of the quarry with those exposed on the north-facing slope of the skyline ridge.
2. Correlate limestone units in the south wall of the quarry with those exposed in Permanente Canyon.
3. Drill one deep angle hole perpendicular to the dip on the next ridge west from Holes 802 and 803, south of Permanente Creek.
4. If more mapping is to be done in the southwestern portion of the property, a bulldozer will facilitate access through the dense brush. The limits of limestone bodies will be more easily defined if trenches can be dug.
5. Map the unmapped south-central portion of the property.
6. Map the northeast ends of the two ridges that extend into the canyon that has been proposed for a westward extension of the west dump.

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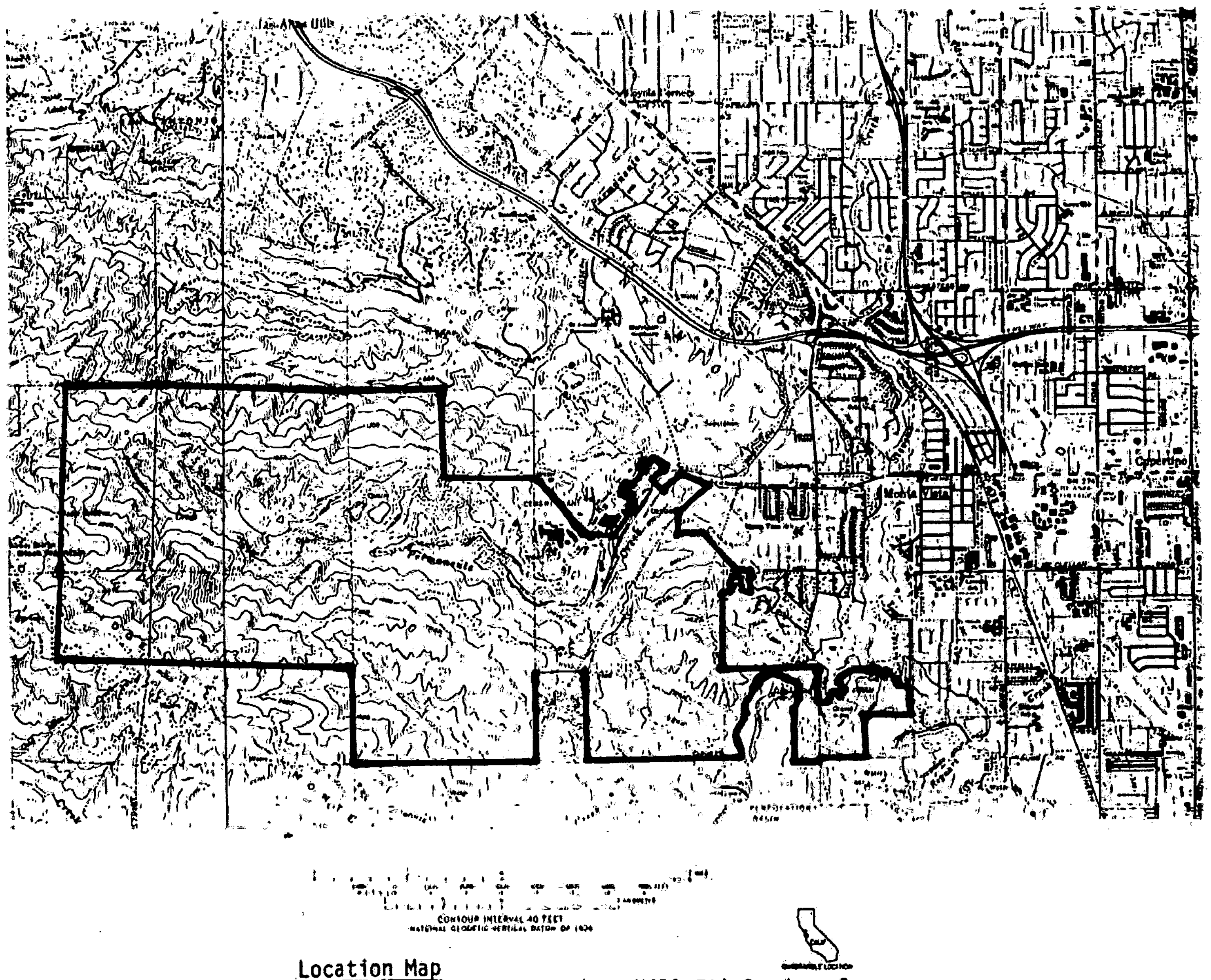
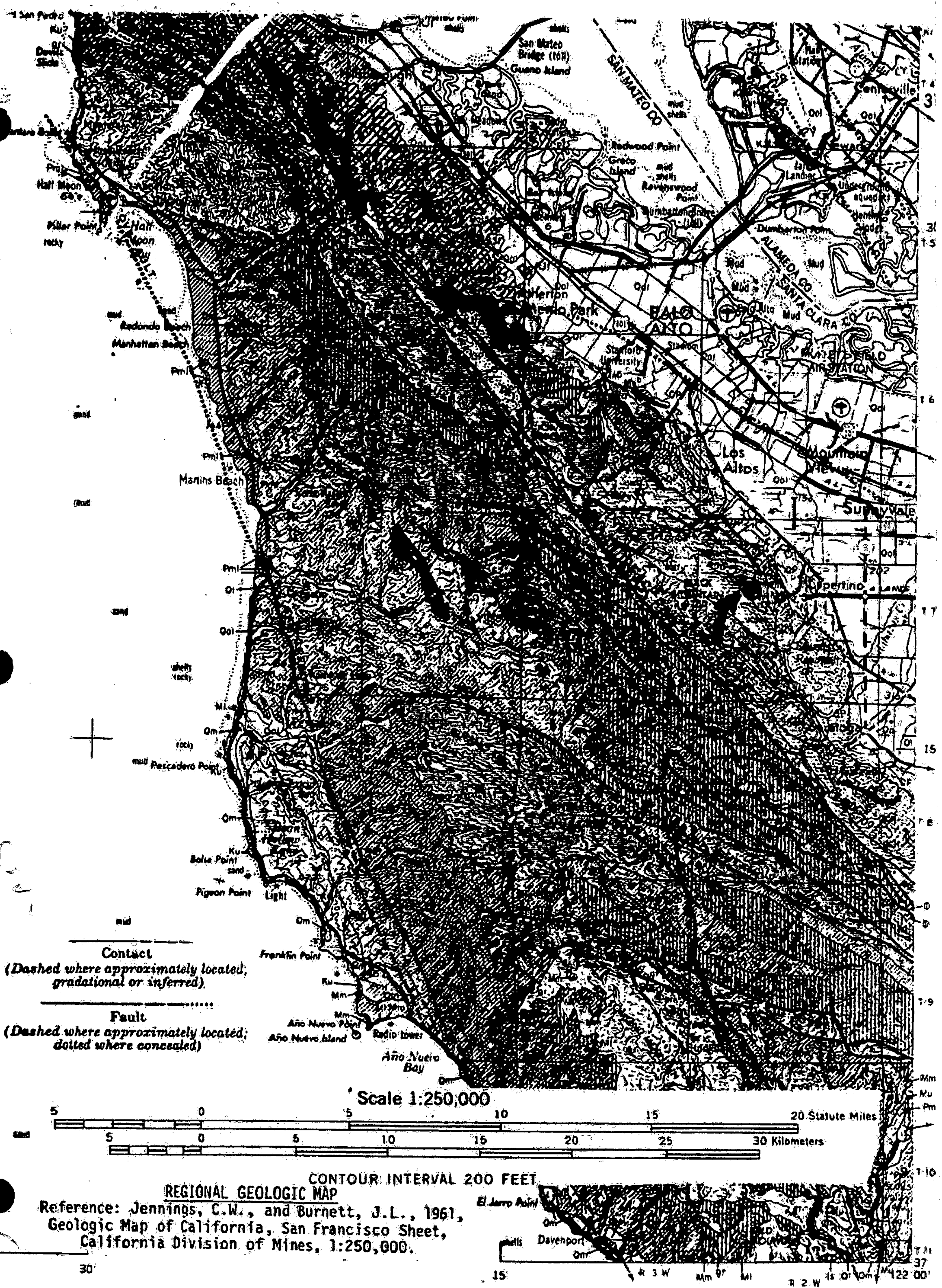


<u>Location Map</u>
Base: Cupertino and Mindego Hill 7½' Quadrangles,
U. S. Geological Survey, 1961, photorevised 1980
(reduced approximately 50%).

FIGURE 1



REGIONAL GEOLOGIC MAP

Reference: Jennings, C.W., and Burnett, J.L., 1961,
Geologic Map of California, San Francisco Sheet,
California Division of Mines, 1:250,000.

FIGURE 2

(continued on next page)

EXPLANATION

Era	System	Series	Symbol	SEDIMENTARY AND METASEDIMENTARY ROCKS		Symbol	IGNEOUS AND META-IGNEOUS ROCKS
CENOZOIC	QUATERNARY	Recent		Dune sand			
			Qal	Alluvium			
			Qsc	Stream channel deposits	GREAT VALLEY	Qrv	Recent volcanic: Qrv^r —rhyolite; Qrv^a —andesite; Qrv^b —basalt; Qrv^p —pyroclastic rocks
			Qf	Fan deposits	GREAT VALLEY		
			Qb	Basin deposits	GREAT VALLEY		
				Salt deposits			
				Quaternary lake deposits			
				Glacial deposits			
		Pleistocene	Qt	Quaternary nonmarine terrace deposits			
				Pleistocene marine and marine terrace deposits		Qpv	Pleistocene volcanic: Qpv^r —rhyolite; Qpv^a —andesite; Qpv^b —basalt; Qpv^p —pyroclastic rocks
			Qc	Pleistocene nonmarine			
	TERTIARY	Pliocene	QP	Plio-Pleistocene nonmarine		✳	Quaternary and/or Pliocene cinder cones
			Pc	Undivided Pliocene nonmarine			
				Upper Pliocene nonmarine			
				Upper Pliocene marine		Pv	Pliocene volcanic: Pv^r —rhyolite; Pv^a —andesite; Pv^b —basalt; Pv^p —pyroclastic rocks
			Pmlc	Middle and/or lower Pliocene nonmarine			
				Middle and/or lower Pliocene marine			
		Miocene		Undivided Miocene nonmarine			
				Upper Miocene nonmarine			
				Upper Miocene marine			Miocene volcanic: Mv^r —rhyolite; Mv^a —andesite; Mv^b —basalt; Mv^p —pyroclastic rocks
				Middle Miocene nonmarine			
				Middle Miocene marine			
				Lower Miocene marine			
		Oligocene	Φc	Oligocene nonmarine			Oligocene volcanic: Φv^r —rhyolite; Φv^a —andesite; Φv^b —basalt; Φv^p —pyroclastic rocks
				Oligocene marine			
		Eocene	Ec	Eocene nonmarine		Ev	Eocene volcanic: Ev^r —rhyolite; Ev^a —andesite; Ev^b —basalt; Ev^p —pyroclastic rocks
				Eocene marine			
		Paleocene		Paleocene nonmarine			
				Paleocene marine			

FIGURE 3a

(continued)

Era	Period		Unit		Unit
	Undivided	▨	Cenozoic nonmarine	▨	Cenozoic volcanic: QTv^r—rhyolite; QTv^a- andesite; QTv^b—basalt; QTv^p—pyroclastic rocks
		▨	Tertiary nonmarine		
		▤	Tertiary lake deposits	▤	Tertiary intrusive (hypabyssal) rocks: Ti^r–rhyolite; Ti^a–andesite; Ti^b—basalt
		■	Tertiary marine	■	Tertiary volcanic: Tv^r—rhyolite; Tv^a—andesite; Tv^b—basalt; Tv^p—pyroclastic rocks
MESOZOIC	CRETACEOUS	K	Undivided Cretaceous marine		
		▤	Upper Cretaceous marine	▤	Franciscan volcanic and metavolcanic rocks
		▨	Lower Cretaceous marine	▨	Franciscan formation
	JURASSIC	▨	Knoxville formation	▨	Mesozoic granitic rocks
		▤	Upper Jurassic marine	▨	Mesozoic basic intrusive rocks
		▨	Middle and/or Lower Jurassic marine	■	Mesozoic ultrabasic intrusive rocks
	TRIASSIC	▤	Triassic marine	▨	Jura-Trias metavolcanic rocks
	UNDIVIDED	▥	Pre-Cretaceous metamorphic rocks (ls = limestone or dolomite)	▨	Pre-Cretaceous metavolcanic rocks
		ms	Pre-Cretaceous metasedimentary rocks	gm	Pre-Cenozoic granitic and metamorphic rocks
PALEOZOIC		P ls	Paleozoic marine (ls = limestone or dolomite	▤	Paleozoic metavolcanic rocks
	PERMIAN	▨	Permian marine	▨	Permian metavolcanic rocks
	CARBONIFEROUS	C	Undivided Carboniferous marine	▨	Carboniferous metavolcanic rocks
		▤	Pennsylvanian marine		
		▥	Mississippian marine		
	DEVONIAN	■	Devonian marine	■	Devonian metavolcanic rocks
	SILURIAN	■	Silurian marine	▨	Undivided pre-Devonian and Devonian metavolcanic rocks
	ORDOVICIAN	■	Ordovician marine		
	CAMBRIAN	■	Cambrian marine		
		▨	Cambrian – Precambrian marine		
PRECAMBRIAN		▥	Undivided Precambrian metamorphic rocks $p\mathrm{C}g$ = gneiss, $p\mathrm{C}s$ = schist	■	Undivided Precambrian granitic rocks
		▨	Later Precambrian sedimentary and metamorphic rocks		
		■	Earlier Precambrian metamorphic rocks		

HEAVY BORDER ON BOXES INDICATES UNITS THAT APPEAR ON THIS SHEET

FIGURE 3b

TABLE 1

SUMMARY OF ESTIMATED LIMESTONE TONNAGES

Location of Limestone	Page	Tonnage
Black Mountain area	9 - 10	15 million
South bank of Permanente Creek	13 - 14	14 million
Skyline ridge of quarry	16	2 million
Landslide north of quarry	16 - 17	1 million
Slide mass and ridge above rock plant loading area	19 - 20	14 million
Midpeninsula Regional Open Space District Property	23	700,000
Total		46,700,000 tons

APPENDIX A
FIELD SAMPLE ASSAYS

PERMANENTE FIELD SAMPLE ASSAYS

Summer 1981

Sample	*Mapping Station	Raw $CaCO_3$	Ignited					SiO_2/R_2O_3	Potential	
			SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO		C_3S	C_3A
EM30052	8	91.2								
EM30053	11	82.4	14.68	2.31	3.64	77.60	1.50	2.47	177.0	5.76
EM30055	22	85.5								
EM30056	37	90.2								
EM30057	69	82.6	22.50	0.950	1.93	74.58	0.593	7.81	118.0	3.51
EM30058	70	55.2								
EM30059	71	69.6	39.11	0.898	1.03	58.94	0.502	20.28	65.55	1.21
EM30060	74	79.0	27.81	0.79	1.02	67.86	0.56	15.35	56.9	1.40
EM30061	75	92.6								
EM30062	76	91.3								
EM30063	77	91.0								
EM30064	78	70.0	39.74	1.09	1.38	56.80	0.617	16.09	-81.65	1.80
EM30065	79	68.0	39.18	1.07	0.993	54.78	0.437	19.01	-82.93	0.826
EM30066	80	72.8	35.18	1.12	2.71	61.77	0.58	9.19	-35.7	5.30
EM30067	81	65.2	38.77	0.94	1.11	52.68	0.56	18.91	-89.0	1.40
EM30068	90	76.0	32.71	0.768	1.14	64.97	0.539	17.17	7.19	1.71
EM30069	91	94.8								
EM30070	92	80.8	26.65	0.767	0.829	69.78	0.556	16.70	74.89	0.90
EM30071	93	95.4								
EM30072	106	80.6	25.94	1.42	1.50	71.11	0.745	8.89	80.27	+1.57
EM30073	116	56.0								
EM30074	122	92.1								
EM30075	123	94.4								
EM30076	124	91.1								
EM30077	125	92.0								
EM30078	126	70.1	35.88	0.866	1.25	63.00	0.483	16.94	-25.89	1.85
EM30079	127	92.0								
EM30080	128	78.8	28.32	0.706	0.883	69.82	0.477	17.83	62.08	1.15
EM30081	131	92.9								
EM30082	132	92.1								
EM30083	133	94.9								
EM30084	134	94.0								
EM30085	136	78.9								
EM30086	137	92.7								
EM30087	138	92.9								
EM30088	139	93.7								
EM30089	140	89.1								
EM30090	141	88.7								
EM30091	144	87.1								
EM30092	144	89.8								
EM30093	144	57.3								
EM30094	146	90.8								
EM30095	146	89.2								
EM30096	147	66.5	35.62	0.968	1.18	54.32	0.398	16.56	-59.25	+1.50
EM30097	148	32.3								
EM30100	143	50.7								

*EM station numbers are enclosed in rectangles on Plate 1. MEB station numbers are equivalent to SM numbers and are circled on Plate 1.

PERMANENTE FIELD SAMPLE ASSAYS

Summer 1981

Sample	*Mapping Station	Raw $CaCO_3$	Ignited						Potential	
			SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	SiO_2/R_2O_3	C_3S	C_3A
EM30101	149	95.8								
EM30102	165	85.4								
EM30103	166	68.5	40.07	1.01	1.49	56.63	0.378	16.00	-85.46	2.25
EM30104	167	76.2	31.35	0.756	0.842	67.97	0.0142	19.62	31.73	+0.953
EM30105	168	90.6								
EM30106	169	76.3	32.47	0.593	0.898	66.40	0.0961	21.77	16.68	+1.37
EM30107	170	89.1								
EM30108	170	93.4								
EM30109	171	95.2								
EM30110	172	83.2	24.88	0.747	1.67	73.93	1.37	10.45	99.59	-3.17
EM30111	174	75.9	34.85	0.807	0.775	64.16	0.423	22.03	-10.07	+0.687
EM30112	190	88.7								
EM30113	209	75.4	21.99	4.78	1.48	69.58	0.917	3.51	99.37	-4.17
EM30114	210	57.6								
EM30115	212	91.5								
EM30116	216	82.5	24.80	0.73	1.29	71.97	0.54	12.25	94.80	2.20
EM30117	225	94.0								
EM30118	225	94.1								
EM30119	225	95.0								
EM30120	226	96.5								
EM30121	226	97.0								
EM30122	227	94.0								
EM30123	227	80.0	26.71	0.916	1.29	71.55	0.599	12.12	78.31	1.86
EM30124	227	80.8	25.18	0.648	1.11	73.29	0.576	14.29	98.54	1.86
EM30125	228	95.0								
EM30126	229	74.4	35.03	0.853	0.86	64.18	0.494	20.45	-11.92	+8.37
EM30127	230	81.0	25.65	0.506	0.615	72.79	0.574	22.87	96.54	+0.774
EM30128	231	94.8								
EM30129	231	75.8	32.98	0.677	0.66	65.55	0.549	24.69	10.82	+0.603
EM30130	232	92.2								
EM30131	232	92.6								
EM30132	233	96.4								
EM30133	234	95.6								
EM30134	235	77.2	30.66	1.10	1.13	68.02	0.551	13.70	34.74	+1.13
EM30135	236	82.2	24.32	0.668	0.624	72.78	1.19	18.54	106	-0.49
EM30136	237	75.7	31.78	0.674	0.655	65.87	1.09	23.92	21.28	+0.594
EM30137	238	84.4	20.47	0.630	0.875	76.30	1.32	13.60	148	-1.25
EM30138	239	82.6	25.35	0.686	0.984	73.40	0.715	15.18	98.53	1.45
EM30139	240	80.1	25.12	0.549	0.555	70.46	1.43	22.74	91.45	+0.542
EM30140	241	93.4								
EM30141	260	96.2								

PERMANENTE FIELD SAMPLE ASSAYS

Summer 1981

Sample	*Mapping Station	Raw $CaCO_3$	Ignited					SiO_2/	Potential	
			SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	R_2O_3	C_3S	C_3A
MEB01		64.4								
MEB02		92.4								
MEB03		91.1								
MEB04		53.2								
MEB05		91.7								
MEB06		95.9								
MEB07		95.1								
MEB08		93.5								
MEB13		62.3								
MEB13a	13	90.6								
MEB14		95.2								
MEB15		97.9								
MEB16		97.4								
MEB17	17	98.2								
MEB19		96.5								
MEB20	24	95.3								
MEB21	24	42.0								
MEB22	25	83.0	2.36	0.387	1.07	95.65	0.801	1.62	31.80	-2.10
MEB23	26	93.4								
MEB24	26	77.9	28.02	0.712	1.07	19.04	0.457	15.74	59.92	+0.163
MEB25	27	93.7								
MEB26	30	95.5								
MEB27	31	26.0								
MEB28	33	88.0								
MEB29		89.3								
MEB30	40	96.1								
MEB31	40	76.7	31.99	0.901	1.17	67.47	0.349	15.46	22.44	+1.57
MEB32	42	94.7								
MEB33	43	91.1								
MEB34	44	70.5	40.46	0.832	0.896	59.35	0.525	23.42	-73.09	0.966
MEB35	44	87.6								
MEB36	45	94.2								
MEB37	47	90.4								
MEB38	54	85.1								
MEB39	78	96.2								
MEB40	78	91.0								
MEB41		66.5	33.54	1.48	1.18	53.16	0.597	12.61	48.50	0.603
MEB42		71.0	36.36	1.16	0.864	60.12	0.648	17.93	-39.06	0.321
MEB43		82.6	23.00	1.05	0.925	72.68	0.627	11.62	11.3	0.669
MEB44		94.7								
MEB45		96.7								
MEB46		92.0								
MEB51		95.3								
MEB52		74.8	33.52	0.821	1.01	64.65	0.412	18.30	0.481	1.29
MEB53		80.7	27.09	0.816	1.09	71.65	0.50	14.22	77.30	1.50

PERMANENTE FIELD SAMPLE ASSAYS

Summer 1981

Sample	*Mapping Station	Raw $CaCO_3$	Ignited					SiO_2/R_2O_3	Potential	
			SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO		C_3S	C_3A
MB154	79	93.8								
MB155	80	70.2	33.74	1.15	1.10	58.80	0.660	14.96	-26.06	0.96
MB156	81	86.4								
MB157		85.1								
MB158	84	76.4	32.07	0.835	0.645	66.54	0.795	21.66	21.64	0.29
MB159	84	83.0	25.33	0.646	0.585	73.96	0.684	20.57	1.04	0.45
MB160	85	86.2								
MB161	86	94.2								

APPENDIX B
ROTARY DRILL HOLE ASSAYS

PERMANENTE CEMENT COMPANY
INTER-OFFICE MEMORANDUM

DATE August 27, 1945

O J. W. Sharp

FROM O. E. Jack

SUBJECT Test Hole Analysis

COPIES TO -
D. A. Rhoades
L.G. Hall
W.J. Knuth
K.E. Grimm
E.L. McMaster

EFERRING TO

Attached hereto is a report of the carbonate values on Test Holes No. 52-45, 53-45, 54-45 and 55-45, from the top of Black Mountain.

Samples were taken and carbonate determinations made for every five feet of depth.

OEJ/ab

45-50	90.4
50-55	83.2
55-60	82.3
60-65	68.3
65-70	34.6
70-75	34.8
75-80	35.0
80-85	32.0
85-90	32.8
90-95	38.0
95-100	26.0
100-105	47.5
105-110	36.8
110-115	27.8
115-120	18.8
120-125	27.6
125-130	31.7
130-135	30.4
135-140	24.4
140-145	25.4
145-150	23.9
150-155	15.1
155-160	17.0
160-165	29.4
165-170	27.3
170-175	20.0
175-180	21.8
180-185	16.0
185-190	14.7
190-195	14.4
195-200	12.4
200-205	15.0

50-55	12.7
55-60	7.6
60-65	14.6
65-70	17.8
70-75	13.0
75-80	12.8
80-85	23.2
85-90	17.4

TEST HOLE NO. 54-42

0-5	80.0
5-10	85.2
10-15	84.2
15-20	90.0
20-25	79.4
25-30	9.8
30-35	17.4
35-40	39.7
40-45	25.8
45-50	39.7
50-55	21.0
55-60	30.0
60-65	38.4
65-70	46.0
70-75	71.1
75-80	----
80-85	39.4
85-90	36.2
90-95	77.2
95-100	69.6
100-105	80.7
105-110	76.4
110-115	72.1
115-120	72.7
120-125	78.6
125-130	66.8
130-135	----
135-140	74.5
145-150	43.8
150-155	35.4
155-160	34.3

PERMANENTE CEMENT COMPANY
INTER-OFFICE MEMORANDUM

DATE August 31, 1945

TO J. W. Sharp

FROM O. E. Jack

SUBJECT Test Hole Analysis

COPIES TO
D. A. Rhoades
L.G. Hall
W. J. Knuth
K. E. Grimm
E. L. McMaster

EFERRING TO

Attached hereto is a report of the carbonate values on Test Holes No. 56-45, and 57-45, from the top of Black Mountain.

Samples were taken and carbonate determinations made for every five feet of depth.

OEJ/ab

	8/27/45	8/29/45
No. Ft.	TEST HOLE #56-45	TEST HOLE #57-45
0-5	88.4	7.0
5-10	85.0	8.5
10-15	79.6	8.4
15-20	82.8	7.6
20-25	81.2	9.3
25-30	62.2	51.0
30-35	82.0	55.4
35-40	78.8	60.2
40-45	79.6	50.0
45-50	79.8	48.4
50-55	93.8	33.0
55-60	92.3	32.8
60-65	89.8	32.2
65-70	81.7	42.6
70-75	84.2	61.0
75-80	87.0	58.0
80-85	81.8	50.0
85-90	74.6	31.8
90-95	80.1	43.8
95-100	75.2	50.0
100-105	62.0	47.8
105-110	66.5	30.8
110-115	60.4	34.6
115-120	48.0	30.0
120-125	31.8	27.0
125-130	49.7	27.2
130-135	66.0	23.0
135-140	53.8	
140-145	67.6	
145-150	78.0	
150-155	79.2	
155-160	72.3	
160-165	71.2	
165-170	70.3	
170-175	65.2	
175-180	61.6	
180-185	60.8	
185-190	64.0	
190-195	53.8	
195-200	61.0	
200-205	64.0	
205-210	66.0	
210-215	63.0	
215-220	64.0	
220-225	77.4	
225-230	55.6	
230-235	69.0	
235-240	57.6	
240-245	65.1	
245-250	61.8	
250-255	58.3	
255-260	64.0	
260-265	64.4	
265-270	67.0	

8/27/45

No. Ft.	TEST HOLE #56-45 (continued)
270-275	74.9
275-280	60.8
280-285	78.3
285-290	70.6
290-295	76.2
295-300	75.2
300-305	70.4
305-310	69.6
310-315	67.0
315-320	72.4
320-325	76.2
325-330	69.6
330-335	66.2
335-340	75.8
340-345	67.4
345-350	

APPENDIX C
DIAMOND DRILL HOLE LOGS

1 of 6

DRILL HOLE LOG

Hole No.: 802

Location: 1870 N, 6218 W

Elevation: 1278

Remarks: Drilled at 45° angle into hill (S 46 W).

Driller:

Date: 1981

Logged by: M.E. Beers

ANALYSES:

	Depth	LITHOLOGIC NOTES Description		Raw CaCO3	SiO2	Fe2O3	Al2O3	CaO	MgO	S/R LOI	C3S	
Bx 1	1-10	Grey to dark grey ls, fractured, veinlets of calcite		92.2								90%
Bx 2	10-16	Black ls (HG) some dark grey ls interbedded, fractured.	14									98%
Bx 3	16-22	Black ls (HG), fractured some veinlets of calcite		91.6								95%
Bx 4	22-48	Black ls (HG), highly fractured, abundant veinlets of calcite.	28 42	81.2 85.8	26.62	.91	1.19	74.4	.57	12.69	77.6	38%
Bx 5	48-55	Black ls (HG) interbedded with some grey ls, highly fractured & goused.	56									95%
Bx 6	58-62	Black ls (HG), highly fractured, abundant veinlets of calcite.		75.4	25.73	.78	1.12	64.8	.55	13.52	59.8	65%
Bx 7	67-71	Black ls (HG), highly fractured veinlets of calcite.	70									98%
Bx 8	71-77	Black ls (HG), Highly fractured veinlets of calcite.										

5 10 15 20 25 30 35 40 45 50 55 60 65 70 75

2 of 6

DRILL HOLE LOG

Hole No.: 802
Location:
Elevation:
Remarks:

Driller:
Date:
Logged by:

ANALYSES:

LITHOLOGIC NOTES

	Depth		Description		Raw $CaCO_3$	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	LOI	C_3S	
Bx 8		75 + +	Contact at 77'	77	49.6								
→	77-80	V V 80	Clayey cataclastic fault gouge										95%
Bx 9	80-85	V	Greenish-grey volcanics,										
		V 85	highly fractured, weathered in	84									
→		V	fractures.										95%
Bx 10	85-94	V V 90	Greenish-grey volcanics,										
		V V	highly fractured, weathered										
→		V 95	in fractures										98%
	94-103	V V	Greenish-grey volcanics,										
Bx 11		V V	fractured.										95%
		100 V V											
→	103-108	V 105	Greenish-grey volcanics, fractured,										
		V	fault contact at 108'.										
Bx 12	108-115	+ + 110	Black ls (HC) fractured,										
		+ +	abundant veins of calcite.	112									95%
		+ +											
→	115-117	115 + +	Black ls (HG) fractured, abundant										
Bx		+ 120	veins of calcite.		79.6	25.83	.965	1.51	67.26	.522	7.85	19.92	
13	117-122	+	Fault gouge, cataclastic rock.										
	122-126	+ 125	Black ls (HC) fractured, veins										
→		+ +	of calcite.	124									95%
Bx 14	126-133	+ 130	Black ls (HG) highly fractured,										98%
		+	some veinlets of calcite.										
→		+ + 135			65.4	28.96	3.14	6.13	52.15	1.86	2.85	11.72	
Bx 15	133-145	+ +	Black ls (HG) highly fractured										90%
		+ 140	and faulted, veinlets of calcite.	140									
		+											
		+ +											
→		145			87.2								
Bx 16	145-159	+	Black ls (HG) highly fractured										60%
		+	and faulted, veins of calcite.										

150

3 of 6

DRILL HOLE LOG

Hole No.: 802

Location:

Elevation:

Remarks:

Driller:

Date:

Logged by:

ANALYSES:

	Depth		LITHOLOGIC NOTES Description		Raw $CaCO_3$	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	LOI	C_3S	
		150											
Bx 16				159									
		155											
		160											
	159-172		Grey ls interbedded with		708	38.6	1.27	1.66	59.74	.708	13.19	63.11	
Bx 17		165	Black ls, highly fractured,										
			weathered in fractures.										70%
				168									
		170											
	172-181	175	Grey to Black ls (HC?),										
Bx 18			highly fractured, some		72.2	36.02	1.04	1.02	62.64	.98	17.47	27.12	
		180	veins of calcite.										90%
				182									
Bx 19	181-190	185	Grey to Black ls, highly										
			fractured, abundant veins										
			of calcite.		75.4	27.69	1.56	237	6361	2.55	7.05	30.4	98%
	190-196	190	Grey ls, fractured, abundant										
Bx 20		195	veins of calcite.										98%
	196-199		fault gouge, cataclastic rock.	196									
	199-212	200	White ls highly fractured,										
Bx 21		205	and faulted,		37.4								65%
		210		210									
Bx 22	212-220	215	White ls, highly fractured										
			and faulted, veins of		94.6								98%
			calcite										
Bx 23	220-225	220	White ls, highly fractured										
			and faulted, minor amounts	224									
		225											

4 of 6

DRILL HOLE LOG

Hole No. : 802

Location :

Elevation :

Driller:

Date :

Logged by :

Remarks :

ANALYSES:

Depth			LITHOLOGIC NOTES Description		Raw CaCO$_3$	SiO$_2$	Fe$_2$O$_3$	Al$_2$O$_3$	CaO	MgO	LOI	C35	
Bx		225	of grey ls interbedded.										95%
23					92.2								
→		230											
Bx	229-238		White ls with minor amounts										
24		235	of grey ls interbedded, highly										98%
			fractured and faulted.	238									
→													
Bx	238-251	240	White to grey ls, highly										75%
25		245	fractured and faulted.		81.2								
		250											
→				252									
	251-257	255	White ls with some grey ls,										
			interbedded highly fractured and										
→		260	faulted (Clay seam or fault gouge		85.2								95%
			252 - 253.5)										
		265		266									
Bx	259-27[illegible]		White to grey ls, highly										45%
27		270	fractured, clay seams.		69.8	36.39	.998	1.24	57.14	1.14	16.4	42.79	
		275											
→		280		280									
Bx	[illegible]		White ls, with some grey ls,										98%
28		285	highly fractured & faulted.		73.2	34.39	.837	.810	61.85	.615	21.20	20.29	
→													
Bx													
29	[illegible]	290	White ls interbedded w/ grey ls,										98%
			highly fractured and faulted.										98%
→ Bx	294-301	295	Grey ls, highly fractured	294									
30													
		300											

5 of 6

DRILL HOLE LOG

Hole No. : 802
Location :
Elevation :
Remarks :

Driller:
Date :
Logged by :

ANALYSES:

Sample	Depth	LITHOLOGIC NOTES Description		Raw CaCO3	SiO2	Fe2O3	Al2O3	CaO	MgO	LOI	C3S	
	300			50.5								
By 31 [illegible]	305	Grey ls, highly fractured, some veinlets of calcite in fractures	306									98%
By 32 [illegible]-317	310	Grey ls, highly fractured, some weathering and calcite in fracturing		68.2	41.28	.746	.610	53.78	.441	30.45	102	95%
By 33 319-325	315 320	Grey ls, highly fractured & faulted	322									95%
By 34 325-334	325 330	Grey ls interbedded with minor amounts of dark grey ls, highly fractured, veinlets of calcite.		60.9	27.28	.674	.75	70.28	.543	1916	72.8	95%
By 35 334-340	335	White ls interbedded w/grey ls. highly fractured.	336	42.6								98%
By 36 [illegible]	340 345	Grey to dark grey ls, highly fractured, minor areas of calcite veins	350									70%
By 37 [illegible]	350 355	Grey ls, highly fractured, weathered in fractures.		68.0	40.15	.976	.799	57.35	.544	22.61	78.47	65%
	360 365		364									98%
By 38 [illegible]-374	370 375	Grey ls, highly fractured.		74.4	3385	.804	.825	62.92	.506	2079	7.79	

6 of 6

DRILL HOLE LOG

Hole No.: 802

Location :

Elevation :

Remarks :

Driller:

Date :

Logged by :

ANALYSES:

	Depth		LITHOLOGIC NOTES Description		Raw $CaCO_3$	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	LOI		
Bp	375-382	375	Grey ls, highly fractured.										
39		380	some dark grey ls in	378									
→			lower section of core.										98%
Bp	382-395	385	Grey ls to Black ls,		63.8								
40			highly fractured, veinlets										
		390	of calcite.	392									90%
→ Bp	395-400	395	Black ls, fractured, small										
41 →		400	veinlets of calcite	400									98%

1 of 4.

DRILL HOLE LOG

Hole No.: 803

Location: 1458 N , 6361 W

Elevation: 1252

Remarks: Drilled at 45° angle into hill (S 46 W).

Driller:

Date: 1981

Logged by: M.E. Beers

ANALYSES:

LITHOLOGIC NOTES

	Depth	Description		Raw $CaCO_3$	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	LOI		
Bx 1	1-15.	Minor dark grey ls interbedded with volcanic, highly weathered, moderate fractures, minor veinlets of calcite										60%
Bx 2	15-22	Greyish-green volcanic, highly weathered, moderately fractured, minor interbedding of ls, ≈ 1 foot in thickness										98%
Bx 3	22-30	Greenish-grey diabase, highly weathered and fractured										98%
Bx 4	30-39	Greenish-grey diabase, highly weathered, fractured										98%
Bx 5	39-47	Greyish diabase, very highly weathered, fractured	42									98%
Bx 6	47-52	Dark grey to mottled ls, highly weathered and fractured		79.2	25.38	1.01	1.55	71.81	.678	9.94		
Bx 7	52-60	Dark grey to mottled ls, highly fractured, veinlets of calcite	56									98%
Bx 8	60-70	Dark grey ls, very highly fractured, veinlets of calcite (MC-HC?)		85.1								85%
Bx 9	70-76	Dark to light grey ls, very highly fractured, veinlets of calcite. (MC-RR)	70	90.2								98%

2 of 4

DRILL HOLE LOG

Hole No.: 803

Driller:

Location :

Date :

Elevation : 1252

Logged by :

Remarks :

ANALYSES:

	Depth	75	LITHOLOGIC NOTES Description		Raw $CaCO_3$	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	LOI		
Bx	76-83		Grey to Black ls, highly										
10		80	fractured, abundant veinlets										
			of calcite. (HC-MC)										98%
Bx	83-91	85	Dark grey mottled ls, highly	89									
11			fractured, abundant veinlets										
			of calcite (HC)										95%
		90			90.7								
Bx	91-99	95	Grey to dark grey mottled ls,										
12			highly fractured, abundant										
			veinlets of calcite (HC)	98									98%
Bx	99-108	100	Dark grey mottled ls, highly										
13		105	fractured, weathered in some										
			fractures, abundant calcite (HC)		90.0	28.31	.957	.758	72.25	.644	16.49		98%
Bx	108-116	110	light to dark grey ls, highly										
14			fractured, weathered in	112									
		115	some fractures (MC)										98%
Bx 15	116-125	120	Grey to dark grey ls, fractured,		77.8	32.48	1.00	.72	67.21	.647	18.88		
			some weathering, (MC)										95%
		125		126									
	125-134		Grey ls, fractured, some										
Bx			veinlets of calcite (MC)										95%
16		130			74.6	31.99	1.77	2.68	63.31	.957	4.44		
Bx	134-143	135	Grey ls, minor fracturing,										
17		140	minor weathering in	140									
			some fractures, (MC)										98%
Bx	143-152	145	light grey to grey ls, fractured,										
18			minor weathering. (MC-RQ)		88.3								98%
		150											

3 of 4

DRILL HOLE LOG

Hole No. : 803
Location :
Elevation : 1252
Remarks :

Driller:
Date :
Logged by :

ANALYSES:

	Depth	150	LITHOLOGIC NOTES Description		Raw CaCO3	SiO2	Fe2O3	Al2O3	CaO	MgO	LOI		
→													
Br 19	152-161	155	light grey to white ls, fractured	154									
			some weathering in										
		160	fractures (RR)										90%
→					87.8								
	161-174	165	light grey to white ls, very										
B			highly fractured, minor										
20		170	weathering. (RR)	168									80%
→					90.4								
Br 21	174-183	175	light grey to white ls, highly										
		180	fractured, weathered in										
			some fractures. (RR)	182									95%
→													
Br 22	183-192	185	light grey to white ls, highly										
		190	fractured, weathered in		87.6								
			some fractures. (RR)										90%
Br 23	192-199	195	light grey to white ls, highly	196									
			fractured, weathered in										
→		200	some fractures (RR)										95%
Br 24	199-208		light grey to white ls, highly										
		205	fractured, weathered in		94.2								
			some fractures. (RR)										95%
Br 25	208-216	210	light grey ls, highly fractured	210									
			weathered in fractures.										
		215	Two small inclusions of diabase		(RR)								98%
Br 24	216-224		Grey to dark grey ls, highly		83.4	19.72	1.11	2.3	76.13	.802	3.41		
		220	fractured, weathered in										
			some fractures. - (RR)										98%
→		225		224									

DRILL HOLE LOG

Hole No. : 803

Location :

Elevation : 1252

Remarks :

Driller:

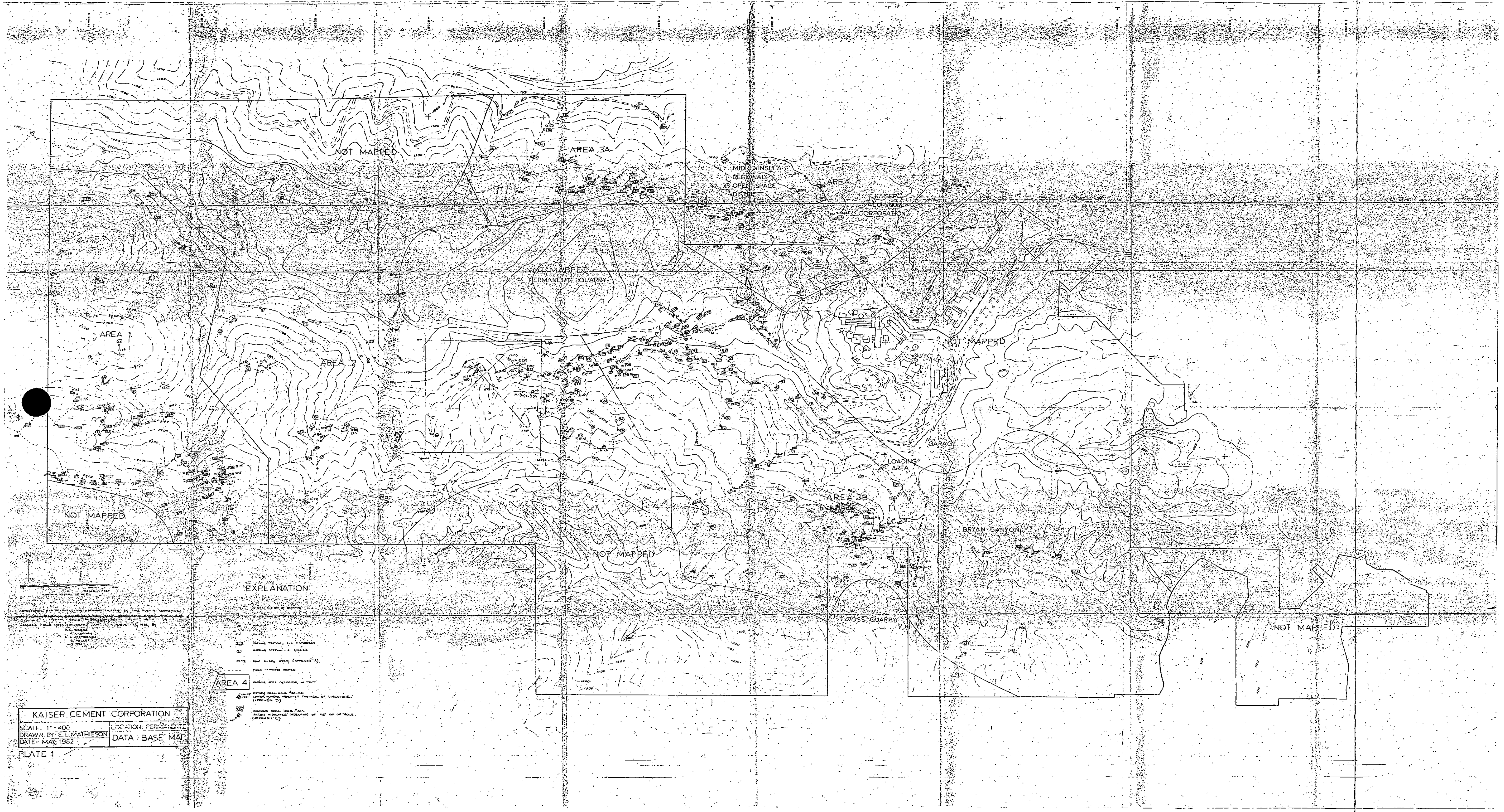
Date :

Logged by :

ANALYSES:

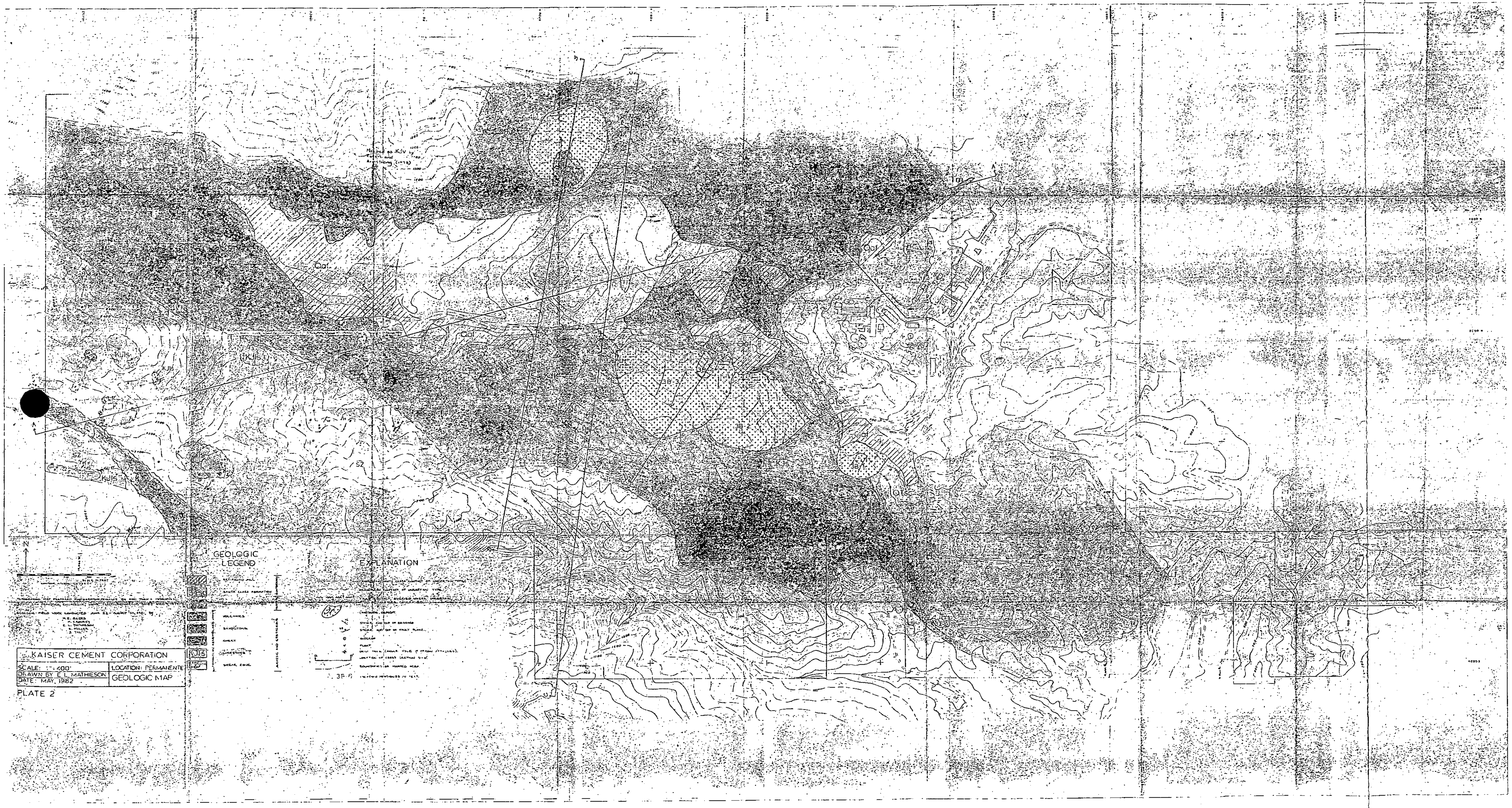
	Depth		LITHOLOGIC NOTES Description		Raw $CaCO_3$	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	LOI		
	224-234	225	Grey ls interbedded with										
By 27		230	some black ls, highly		72.8	37.5	.95	.87	6657	.55	20.62		
			fractured, minor weathering.		(MG-	RR)							95%
→													
By	234-243	235	Grey ls, very highly										
28		240	fractured, minor	235									
			weathering. (MG-RR)										95%
→					63.8								
By 29	243-252	245	lightgrey to grey ls, very										
		250	highly fractured, minor										
→			weathering. (MG-RR)	252									85%
By	252-258	255	light grey ls, highly										
30			fractured some weathering (RR)										98%
→		260			78.8	29.9	.75	.75	68.62	1.05	19.85		
By	258-267		Grey to white ls, highly										
31		265	fractured, some weathering. (RR)										90%
				266									
→													
	267-277	270	Light Grey to grey ls,										
By 32			highly fractured, minor		68.0	40.77	.95	.61	5337	1.51	26.03		
		275	weathering. (RR)										90%
→													
By 33	277-286	280	Grey to dark grey ls,	280									
			fractured, minor weathering.										95%
			(MG-RR)										
→		285			57.2								
By 34	286-295	290	Grey to dark grey ls, highly										
			fractured, minor weathering (MG)										98%
→				294									
By 35	295-300	295	Grey to dark grey ls, fractured										
→		300	minor weathering. (MG)		54.0								98%

Bottom of Boring



KAISER CEMENT CORPORATION
SCALE: 1" = 400'
DRAWN BY: E. L. MATHIESON
DATE: MAY, 1982
LOCATION: PERMANENTE
DATA: BASE MAP

PLATE 1

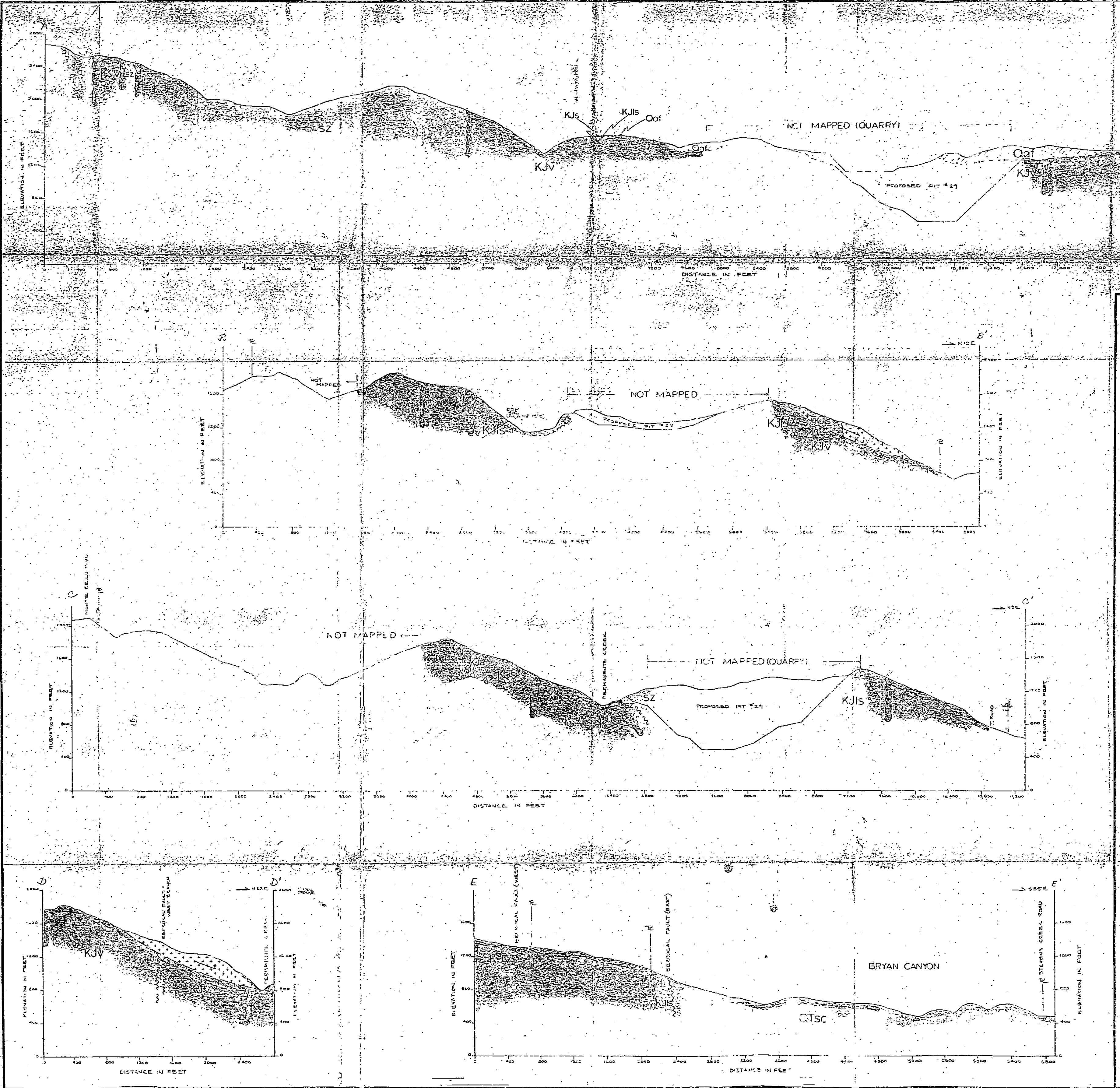


KAISER CEMENT CORPORATION

SCALE: 1" = 400'
DRAWN BY E.L. MATHIESON
DATE: MAY, 1982

LOCATION: PERMANENTE
GEOLOGIC MAP

PLATE 2



GEOLOGIC LEGEND

- Qaf ARTIFICIAL FILL
- QTsc SANTA CLARA FORMATION
- Tm MONTEREY FORMATION
- KJv VOLCANICS
- KJs SANDSTONE
- KJls LIMESTONE
- SZ SHEAR ZONE

FRANCISCAN ASSEMBLAGE

TERTIARY AND CRETACEOUS | TERTIARY | QUATERNARY

EXPLANATION

FRANCISCAN CONTACT OF UNCERTAIN TYPE

FAULT CONTACT, QUERIED WHERE UNCERTAIN

LANDSLIDE DEPOSIT

CDH 802 ANGLE DRILL HOLE

APPARENT DIP OF BEDS

PROPERTY LINE

HORIZONTAL & VERTICAL SCALE IN FEET

SEE PLATE 2 FOR LOCATIONS OF SECTIONS

KAISER CEMENT CORPORATION	
SCALE: 1" = 400	LOCATION: PERMANENTE
DRAWN BY E. L. MATHIESON	CROSS SECTIONS
DATE: MAY, 1962	A-A' THROUGH E-E'

PLATE 3

DESIGNED
DRAWN: GD
CHECKED
DATE
REGION: WEST
LOCATION
DWG FILE
SCALE
HORIZONTAL 1"=400'
VERTICAL N/A

HANSON AGGREGATES, INC.
WEST REGION
PERMANENTE QUARRY
SANTA CLARA COUNTY, CA

PRINT DATE: 2-8-07
FLIGHT DATE: 2005

Hanson

Hanson Aggregates, Inc.