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FINAL REPORT ON GEOLOGIC FEATURES AT THE SAN ONOFRE NUCLEAR GENERATING STATION, UNITS 2 AND 3

# GEOTECHNICAL GROUP

FINAL REPORT ON GEOLOGIC
FEATURES AT THE SAN ONOFRE
NUCLEAR GENERATING STATION,
UNITS 2 AND 3

By:

Fugro, Inc.

For:

Southern California Edison Company

August, 1976

fugro

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# I. INTRODUCTION

## General

This report presents the final observations and conclusion of an investigation for Southern California Edison Company (SCE) by Fugro, Inc., of significant geologic features revealed in the excavations for the SONGS Units 2 and 3. The scope of this investigation involved the identification, mapping and interpretation of all significant geologic features (structural features) which were exposed during grading operations. The recognition and analysis of these geologic features at SONGS has been part of the continued monitoring of grading by Fugro geologists.

The objectives of this investigation and final report are to summarize the characteristics of all geologic features (A, B, C and D) observed at SONGS, discuss their age and origin, and evaluate the significance of the features with respect to the San Onofre site.

This report contains: (1) descriptions of the scope and background of the investigation, (2) a synopsis of the types of discontinuities described in Fugro reports "Analysis of Geologic Features at the San Onofre Nuclear Generating Station," dated July 5, 1974, and "Analysis of C and D Type Features at the San Onofre Nuclear Generating Station," dated November 1, 1974, (3) details of the Unit 3 investigation, (4) a summary of observations made during the investigation, (5) a review of theoretical considerations

in connection with explanations of origin, as discussed in Fugro reports dated July 5, 1974, and November 1, 1974, and (6) the summary and conclusion regarding the geologic features observed. A description of the geology and structure of the site vicinity and a detailed description of the A, B, C, and D features are contained in the Fugro reports of July 5, 1974, and November 1, 1974. Detailed descriptions have not been repeated here.

History

The A and B features described in this report were first observed by Mr. Gene Hawkins, SCE geologist, on May 29, 1974, during grading of SONGS 2 and 3. SCE project management was notified immediately following the discovery, and from May 30 to June 2, 1974, detailed site inspections were conducted by SCE geologists (G. Hawkins, G. Hunt, P. West). On June 3, 1974, Fugro, Inc., was notified and three geologists (J. Smith, R. Strand, K. Wilson) made a field inspection the same day initiating the original investigation of the A and B type features by Fugro, Inc.

Subsequent to completing the investigation of the A and B type features (June 3 to July 3, 1974) grading operations were inspected on a daily basis (through September, 1974) by a Fugro geologist. Monitoring at the excavation for Units 2 and 3 continued on a periodic basis from October, 1974, to February, 1976.

As the grading continued, portions of the C and D features were first noted about August 20, 1974, in temporary cut-

slopes by Fugro geologists. Personnel of SCE were notified and a program was initiated to trace the features on existing cut surfaces to the maximum extent possible and to clear off additional areas. The newly recognized features were further revealed in the Units 2 and 3 excavations at later dates, and were noted during the continued detailed inspections of the deeper portions of the excavation. No additional features were observed during the remainder of excavation monitoring.

Description of Investigation

Fugro's inspection and investigation of the geologic features at SONGS continued during excavation activities and included:

- A review of geologic literature of the site, site vicinity, and region.
- Review of available oblique and vertical photographs of the site.
- Geologic mapping of the as-graded geology in the Units 1, 2 and 3 area, with special emphasis on locating structural features in the San Mateo Formation.
- Mapping of features in San Mateo Formation at two areas outside of site property.
- Scraping of covered surfaces with a skiploader and exhuming of sumps and construction pits using a backhoe.
- Excavation of 19 backhoe trenches.
- Drilling of 7 bucket auger borings to depths of 25 feet.
- Detailed photography and logging of all backhoe trenches and pertinent exposures.

- Petrographic studies of A, B, C and D features.
- Theoretical analysis regarding the origin of these features.
- Search for other A, B, C and D type features outside the Unit 2 and 3 area.

The completed field investigation and report preparation (3 reports), involved approximately 295 man-days from June, 1974, to February, 1976.

The geologic conditions reported were reviewed in the field with members of the AEC, ACRS, and USGS on the following occasions:

| Date | Agency | Attendees |
|---|---|---|
| 6/8 through 6/11/74 | AEC Staff | Mr. W. Gammill |
| | AEC Staff | Mr. T. Cardone |
| | AEC Staff | Mr. C. Stepp |
| | AEC Staff | Mr. P. O'Reilly |
| | USGS Staff | Mr. F. McKewan |
| 6/15/75 | AEC Staff | Mr. T. Cardone |
| | ACRS Consultant | Dr. J. Wilson |
| | ACRS Consultant | Dr. S. Philbrick |
| | ACRS Staff | Mr. G. Quittschreiber |

## II. SYNOPSIS OF THE SITE LITHOLOGY AND GEOLOGIC DISCONTINUITIES IN THE SAN MATEO FORMATION

For a more detailed description of the site geology, the reader is referred to the Fugro report of July 5, 1974 "Analysis of Geologic Features at the San Onofre Nuclear Generating Station" and Section 2.9, SONGS PSAR.

### San Mateo Formation

The San Mateo Formation (Pliocene?) underlies the SONGS Units 2 and 3 site, is widely distributed west of the Christianitos fault, and is well exposed along the coast. The formation consists predominantly of massive light brown to light gray, arkosic sandstone with scattered interbeds of rounded gravel, and layers of fine silty sandstone and siltstone. The sandstone is slightly cemented, but is dense and forms steep canyon walls and near-vertical cliffs along the coast. Locally, large fragments of siltstone and claystone, up to 10 feet or more in diameter, have been incorporated into the San Mateo sandstone by turbidity currents or submarine slumping during deposition.

### Terrace Deposits

At the SONGS 2 and 3 site, Pleistocene marine and non-marine terrace materials ($Qt_1$) have been deposited over wave cut benches in the San Mateo Formation. The $Qt_1$ terrace constitutes a broad, gently sloping coastal plain which is extensively developed along the San Onofre coast. The thickness of terrace deposits varies from 30 to 50 feet

along the coast. Although no fossils were found locally in this unit (at the site), mollusks have been recovered from these same marine terrace deposits about 4.5 miles south of the site (PSAR, Section 2.9.4). Thorium-protactinium age-dating of shell materials collected from a correlative terrace, 10 to 20 miles northwest of the San Onofre site, indicate that the $Qt_1$ terrace has a minimum age of 120,000 years (PSAR, Section 2.9.4, and Fugro report dated September 12, 1975 "Summary of Geomorphic and Age Data for the First Emergent Terrace ($Qt_1$) at SONGS").

Pleistocene terrace materials ($Qt_1$) that have been recognized in the site vicinity consist of a series of crudely stratified mixtures of brown to gray-brown sand, silt and clay with scattered lenses and layers of gravel, cobbles and some boulders. Recent field investigations (Fugro, September, 1975) have shown that these terrace deposits at the site excavation and areas northwest and southeast of the site, are composed of a series of alternating marine and continental (subaerial) sediments.

At the site, marine terrace deposits (Qm) occur as small, localized pockets overlying erosional irregularities in the San Mateo Formation.

Geologic Discontinuities in the San Mateo Formation

Five types of geologic discontinuities were observed in the San Mateo Formation in the excavation for SONGS Units 2 and 3:

- Joint-like features demonstrating a very minor amount of strike-slip shear displacement (no vertical component); Type A trends north and north-northeast, Type B trends about N50W (Drawing 1); both A and B features dip near vertical.
- Joint-like features striking approximately N50W (Feature D) and N60E (Feature C) dipping gently $15^{\circ}$ to $20^{\circ}$N and $5^{\circ}$ to $19^{\circ}$N, respectively (Drawing 1); Feature D demonstrates minor reverse shear movement; movement on Feature C cannot be demonstrated.
- Slump structures, graded bedding and other sedimentary structural features characteristic of the formation and lithification of saturated and unconsolidated sediments which were rapidly deposited.
- Claystone lenses and fragments set within the sandstone as inclusions.
- Color banding in the sandstone.

Of these five types of features, only the first two (i.e., A, B, C, D) are significant structural geologic features.

The A and B type features appear as thin, white resistant seams which form sinuous zones up to several inches wide. Amount and sense of displacement on these features is about 4 inches left lateral for Type A, and a similar amount of right lateral displacement for Type B. No vertical displacements have been observed.

Minimum age of both A and B features was established by overlying relationships of marine and non-marine terrace deposits. Both types of features do not displace the terrace-bedrock contact and, as a result, are older than the terrace deposit (at least 120,000 years old).

Feature C is a relatively short, local feature, extending for approximately 30 feet across the cut slope and about 30 feet across the graded pad (Drawing 1). It consists of a sinuous zone of thin (1/8 to 1/4 inch), white, resistant ribs that appear similar to the typical A and B features.

Attitudes on Feature C vary. The average strike is about N 60 E with dips ranging from 5 to 19 degrees northwest. Displacement has not been clearly demonstrated on this feature.

In contrast to Feature C, Feature D consists of an individual or series of individual hairline, planar fractures in the San Mateo Formation. Where Feature D intersects claystone layers within the San Mateo Formation, the feature is often a thin, planar surface which only becomes apparent after the claystone has desiccated. Attitudes on Feature D vary locally due to its gentle northeasterly dip. The average strike of Feature D over the graded area is approximately N50W.

An investigation of Trench No. 15 (Fugro, November, 1974) shows the D feature overlain by undisturbed terrace

materials, clearly indicating that Feature D is older than 120,000 years.

## III. SUMMARY OF OBSERVATIONS UNITS 2 AND 3 EXCAVATION

### Type A and B Features

Six Type A features were exposed in grading for Units 2 and 3 (Drawing 3, Fugro, July 5, 1974 and attached Drawing 1), however, only one Type A feature (Feature A6b, and its elements) extends across the full width of the graded area (Drawing No. 1). This longest branch (Branch A6b) trends south from the Unit 2 excavation where it splits into three elements, and continues toward the seawall (Drawing 1).

The A features appear as a single light gray or white, slightly resistant ridge in the San Mateo Formation, or, more often, a zone of individual ridges (elements). The zones vary in width (one to six inches, averaging about two to four inches) and display rope-like intertwining patterns of the individual elements, which give pinch-and-swell appearance on the graded surface.

Careful scraping, cleaning, trenching, and, in some cases, complete excavation of the claystone inclusions have repeatedly demonstrated a consistent amount and sense of movement along Feature A. Clay inclusions within the San Mateo Formation show left lateral offset (no vertical component was observed) along one or more of thin shear surfaces. Amounts of displacement range from 1/2 inch on a single surface, to four inches cumulative slip across the thin zone.

Type B features strike between N45W and N56W and show virtually the same physical characteristics as the Type A: their color, sinuous appearance, approximate width and near vertical dip are very similar to Type A.

Of the fourteen "B" features revealed in the excavation, all terminate (die out) to the southeast (Drawing No. 1). Feature B-14 is the longest B feature exposed. This feature may be equivalent to B-11a, which terminates in a southeast direction on the southeast side of the Unit 2 excavation, continuing southeast through the Unit 3 excavation as Feature B-14 (Drawing 3). The feature was not traceable beyond the Unit 3 excavation; it is believed to terminate slightly southeast of Unit 3 (Drawings 1 and 3).

Features $B_2$, $B_7$, and $B_9$ through $B_{13}$ (Drawing 1) have been traced to the western limit of the grading, and their existence beyond this point can only be inferred from analysis of available exposures farther west on the SONGS property. Detailed mapping of the cut slopes and other exposures on SONGS 1 shows that there are significantly fewer B features (i.e., three which lie on trend with B features mapped in the Unit 2 area; Fugro, July 5, 1974). This indicates that most of the B features mapped in the Unit 2 area must terminate slightly west of the graded area. However, direct correlation of particular B features between Unit 1 and Units 2 and 3 is not reliable because of the distance between exposures.

Several B features were observed intersecting claystone inclusions in the San Mateo Formation. Careful analysis of these inclusions in three dimensions, indicated that the "B" features show consistent right lateral strike-slip displacement (no vertical displacement observed) with lateral displacement ranging from 1/2 to two inches (amounts very similar to A features).

Where A and B features intersect, individual elements of each may be offset by elements of the other in equal amounts (3 to 4 inches) left-laterally (A feature) and right-laterally (B feature) (Drawing 11, Fugro, July 5, 1974).

Minimum age of these features has been established by overlying relationships of marine and non-marine terrace deposits. Feature A is clearly overlain by undisturbed marine terrace deposits at three locations in the Units 2 and 3 area (Drawing 1 and Fugro, July, 1974). At SONGS 1, both A and B features have been traced in existing cuts to points where they are also overlain by undisturbed terrace deposits (Fugro, July, 1974). Minimum age of the marine terrace deposits and the wavecut platform has been established at 120,000 years old, indicating the A and B features are older.

Feature C

Feature C is exposed in the San Mateo Formation at the toe of the cut slope east of Unit No. 3 (Drawing No. 1).

The feature extends for approximately 30 feet across the cut slope and about 30 feet across the graded pad, and consists of a sinuous zone of thin (1/8 to 1/4 inch), white, resistant ribs that appear very similar to the typical A and B features. Considering all the various branches, Feature C has an apparent maximum thickness of about 18 inches and thins to about 6 inches at the present toe of the slope (about elevation 29 feet). Across the graded pad Feature C trends N60E and dips 5 to 19 degrees northwest. It continues with uniform thickness (2 inches) for about 15 feet, then bifurcates and pinches out within the following 15 feet (Drawing No. 1).

Feature C is short and does not intersect any A, B, or D features, so their mutual structural relationships cannot be evaluated.

A complete search of all available exposures of San Mateo Formation, within and outside the site, has revealed no other C features (Fugro, November, 1974).

Feature D

Feature D is exposed in the San Mateo Formation from the excavation southeast of Unit 3 to the Unit 2 excavation (approximately 1,050 feet; Drawing 1, for details see Drawings 2 and 3). In contrast to Feature C, Feature D consists of individual hairline, planar fractures in the San Mateo Formation. Within the sandstone, the fractures have a distinct surface, but contain no evidence of gouge, cementation, crushing,

or extensional separation.

Where Feature D intersects claystone layers within the San Mateo Formation, the feature is often a thin, planar surface which only becomes apparent after the claystone has desiccated.

Feature D is continuously exposed in cut slopes and graded pads across the SONGS 2 and 3 site. Continuity is usually demonstrated by a single trace containing a number of discontinuous branches. In several instances (e.g., between Units 2 and 3), a single, long, continuous element will essentially pinch out and be superceded by a parallel element which usually overlaps its predecessor.

At the western limit of the grading, Feature D branches and pinches out within the San Mateo Formation on the north and west slopes of the Unit 2 excavation (Drawings 1 and 2).

Attitudes on Feature D range from N72E, 12NW at the northeast limit of the excavation, to N77W, 15-20NW, between Units 2 and 3, to N35W, 32NE, at Unit 2 (Drawing No. 1). The apparent irregularity of a few of the elements in plan view is amplified because of the low angle of dip. A broad bend in strike (from N60E to about N60W) occurs southeast of Unit 3 where Feature D intersects a series of interbedded clay layers (Drawing 1). Where Feature D intersects claystone layers, the planar surface commonly coincides with or parallels a bedding plane.

Examples of displacements have been noted where Feature D intersects color banding, clay inclusions, and Type A and B features (Fugro, November, 1974). In each instance, the apparent sence of displacement is reverse and the amounts range from 1/4 inch or less to about 2 3/4 inches.

The cross cutting structural relationships between Features A, B and D indicate that D was the last to form. This observation is further substantiated by the fact that Feature D displaces color banding in the sandstone, while A and B features seem to have affected the formation of color bands, rather than offsetting them. Feature D was traced in continuous exposures across the site southeast to where it is overlain by terrace deposits, which have been established in previous studies (SONGS 2 and 3, PSAR) to be at least 120,000 years old. Trench No. 15 (Fugro, November, 1974) shows the D feature overlain by undisturbed terrace materials (i.e., no disturbance of the terrace/bedrock contact), clearly indicating that Feature D is older than 120,000 years.

Two other examples of D type features were recognized in the deeper excavations at SONGS 2 and 3. These features are southwest of the Feature D described above. The first D type feature is exposed in a cut slope 160 feet south-southeast of the center of Unit 2 containment (Drawings 1 and 2). This feature has the same planar, hairline appearance as Feature D and shows minor offset (1/4 inch with a

right lateral sense of movement) of A features projecting across it. The attitude of the feature is N50E, 11NW, which is similar to the strike and dip of Feature D in the cut slope northeast of Unit 3. The feature is about 180 feet southwest of Feature D. Careful inspection and logging of the feature and the surrounding cut slopes indicate that the feature extends for 45 feet and is not continuous in adjacent cut slopes.

The second D type feature (not shown in Drawing 1) was observed in a temporary excavation across the intake structure (the deepest excavation at SONGS 2 and 3), about 450 feet southwest of Feature D. The feature was photographed, but not logged due to caving and unstable trench walls. This feature has the same general appearance as Feature D and has an attitude of N15E, 15NW. The full extent of this feature is not known because final grade of the intake structure was not deep enough to expose it and the feature was not observed on the surrounding slopes.

A search was conducted for other D features outside the Unit 2 and 3 excavation, however, no other examples were observed.

## IV. ORIGIN OF A, B AND D FEATURES

### Mechanics of Shear Features

Of the three sets of planar features observed, two, A and B, are nearly vertical, as shown in perspective in Figure A (Drawing 5), and one, Feature D, dips at an angle of about 20° to the northeast (Figure B, Drawing 5). All of the features are plainly shears, as described earlier, but there are some differences among them. Features A and B are more highly anastomosed and have a greater total displacement across them than shear D. In addition, grain crushing is more evident on A and B and has progressed to such an extent that, in brushing, these features appear in relief, whereas shear D exhibits a lesser resistance to abrasion than the adjacent material. The greater resistance in the shear zones of A and B is presumably related to the greater cohesion of fine-grained shear debris, since cementing materials appear to be absent in the sheared region.

The degree of grain crushing which occurs in the shearing of a granular material is related to the composition of the grains and also to the hydrostatic component of the stress at which shearing is carried out. If no shearing is present, siliceous grain breakdown becomes significant at hydrostatic stresses above about 150 kg/cm$^2$ (2100 psi); breakdown develops at much lower stresses, on the order of 20 to 30 kg/cm$^2$ (280 to 420 psi), when the material is sheared to yield. Shearing at hydrostatic stresses below

about 10 kg/cm$^2$ (140 psi) produces little or no grain breakdown (Vesic and Clough, 1968). Applying these considerations to the shear features observed at the site, it can be concluded that shears A and B developed at mean of hydrostatic stresses in the order of 20 to 30 kg/cm$^2$ or greater, whereas feature D was formed at mean stresses below about 10 kg/cm$^2$. Similar shear features accompanied by grain crushing are described in Engelder (1974).

The orientation of the A and B features is consistent with a major principal stress in a nearly horizontal direction bisecting the smaller angle between them, i.e., in a direction N20W, and a minor principal stress also in the horizontal plane at right angles to this. This requires the vertical gravitational stress to be the intermediate principal stress. The angle between A and B shear surfaces implies a friction angle of about 35$^\circ$ for the material when it yielded. For this friction angle the ratio between the major and minor principal stresses is about 4. The intermediate principal stress is approximately equal to the mean stress, so that from the above consideration of grain crushing along the A and B features, the vertical stress at the time of their formation must have been 20 to 30 kg/cm$^2$ or greater. Since this was the gravitational stress component, it indicates an overburden height above the present level of the shear features of the order of 300 feet, or greater, at the time of their formation.

For the A and B set to develop, it is not sufficient for the stress conditions to have been achieved only by an increase in the N20W major stress component. If this had occurred without a simultaneous decrease in the other horizontal component, then the vertical stress would have become the minor principal stress and the shearing process would have generated features closely similar to shear D (i.e., a thrust dipping at a fairly shallow angle northward). A mechanism of stress change involving a decrease in the horizontal component of stress at right angles to the compressive stress increase is therefore required. This would be developed by a lateral extension of the San Mateo block in the N70E/S70W direction. Such an extension could have occurred during the downdropping of the San Mateo caused by dip-slip displacements along the Cristianitos fault as suggested previously.

As mentioned above, a horizontal major principal compressive stress and a more-or-less vertical minor principal stress is necessary to explain the occurrence of the D feature. In addition, the D feature appears to have formed at lower mean stresses than those involved in the development of the A and B shears. Assuming essentially unchanged material properties, the major/minor principal stress ratio during shearing along the D plane would still be about 4. With a mean stress intermediate between these stresses, and the order of 10 $kg/cm^2$ or less, as required

by the absence of crushing in D, it can be deduced that the nearly vertical minor principal stress at the time of D-feature formation must have been in the order of 4 $kg/cm^2$. This corresponds to an overburden thickness on the order of 60 feet.

A hypothetical sequence of events is, therefore, that at some stage after the formation and probably at least partial consolidation of the San Mateo material, a north-south component of horizontal stress began to increase. These stress changes eventually resulted in the generation of the nearly vertical conjugate set of A and B features in the formation at a depth of at least 300 feet below the upper surface existing at that time (Drawing 5). The lateral extension permitting the reduction in the east-west component eventually stopped when the shearing displacement reached the level currently observed. Erosion of the upper surface proceeded, lowering the surface by about 200 feet, when the generally north-south compression continued, or was reactivated with some rotation towards a more northerly direction. The consequence at this time was the development of the D shear feature (Drawing 5). It would appear that this shear was generated when the upper level of the San Mateo was not much different from its present elevation, but before deposition of the overlying terrace gravels.

## V. SUMMARY AND CONCLUSION

The following summary has resulted from Fugro's investigation at San Onofre:

- In the excavation for Units 2 and 3, a number of planar shears have been revealed in the San Mateo Formation (sandstone) which forms the foundation rock for the site. These features can be categorized by orientation into four types: Type A striking nearly north, Type B striking approximately N50W, both dip near vertical, Type C (a local feature) striking approximately N60E, and Type D striking approximately N50W and dipping gently to the northeast.

- The A and B features are discontinuous conjugate, joint-like shears. Typically, they are a few inches wide, nearly vertical, linear or broadly curvi-linear in plan, and exhibit small strike-slip displacements ranging from 1/2 inch to 4 inches. There are no indications of any vertical slip or pull-apart due to tension. Type B features thin and eventually terminate in the eastern half of the graded area. The Type A features decrease in width or disappear in the southern part of the excavation.

- Where sets of Type A and B features intersect, individual elements of each offset elements of

the other. The sense of displacement at intersections or across clay inclusions is consistently left lateral for Type A features and right lateral for Type B.

- Both types of features are older than the wave-cut marine terrace which has beveled the San Mateo Formation. Marine and non-marine terrace deposits overlie and are unbroken by Type A and B features. The minimum age of the marine terrace surface and its deposits have been established from studies in the site vicinity to be at least 120,000 years old. Therefore, the A and B features are older than this minimum age.

- Feature C is relatively short, diffuse, and with the exception of its attitude, has similar physical characteristics to Types A and B features. There is only one Feature C exposed at the site and it has no indication of broad extent or evidence of recent displacements. Feature C terminates entirely within the San Mateo Formation and is probably contemporaneous with the formation of A and B features.

- Feature D pinches out to the northwest and is not continuous across the length of SONGS 2 and 3 site. Although Feature D displaces Types A and B features a minor amount, it does not displace the terrace/bedrock contact or the overlying terrace

deposits (at least 120,000 years old) and, as a result, can be demonstrated to be clearly older.

- Origin of the A, B, and C features is postulated to have resulted from north-south compressional stresses which were widespread in distribution. The formation of the D feature is consistent with the stress system required to produce the A and B features.

- No other structural features were observed in the excavation.

The investigation has concluded that the A, B, C, and D type features, exposed at the SONGS site, are not capable faults as defined in Appendix A to 10 CFR Part 100.

## VI. REFERENCES CITED

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Vesic, A. S., and Clough, G. W., 1968, Behavior of granular materials under high stresses: Proc. ASCE, v. 94, Jour. Soil Mech. and Found. Div., SM3, p. 661.

# APPENDIX A

# DETAILED INVESTIGATION UNIT 3 EXCAVATION

A detailed inspection of the SONGS Unit 3 cutslopes was conducted by Fugro, Inc. during excavation activities (June through Dec., 1975). Detailed logs and locations of the geologic features identified during this investigation are shown on Drawings 1, 3, and 4, and A1 through A5.

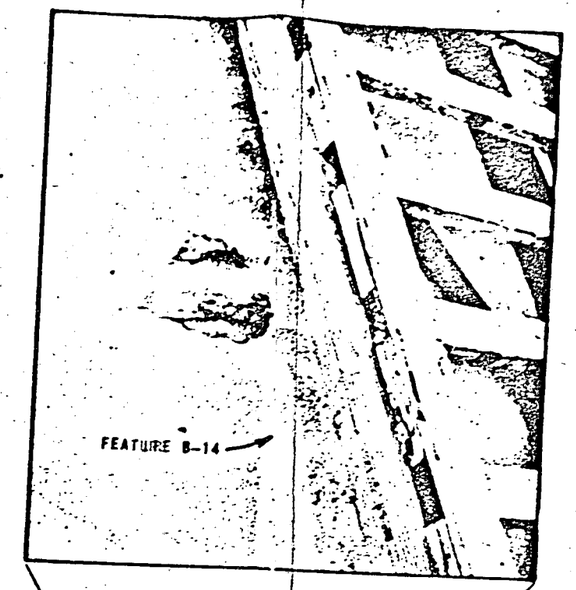
Only two features are present in the Unit 3 excavation. Feature D occurs at the northeast edge of the Unit 3 containment and Feature B-14 is present near the center of the containment.

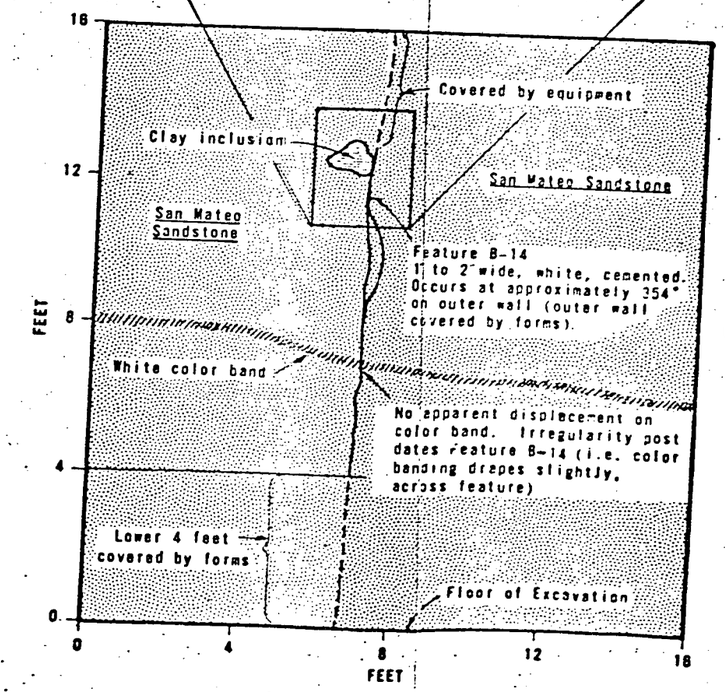
Feature D as indicated on Drawings 1, 2 and 3, is approximately located. The accuracy of location of Feature D through the Unit 3 containment excavation is within $\pm$ 5 feet laterally. This is due to the difficulty of continuously tracing the feature and restrictions posed by construction activities during the investigation. The feature was identified at four localities within the Unit 3 area and traced on this basis. Feature D strikes approximately N48W and dips $15^{\circ}$ to $20^{\circ}$ NE in this area. Short discontinuous branches of Feature D are not identified in the Unit 3 excavation. Displacements on Feature D within the area of Unit 3 were not observed.

Feature B-14 is present near the center of the Unit 3 containment. The feature was identified on all the intersecting

cutslopes and is continuous across the area of Unit 3. Feature B-14 strikes N47W and dips near vertical. Detailed examination (Drawings A1 through A5) shows the feature expressed as a resistant white ridge within the San Mateo sandstone, cemented by crushed quartz grains. The feature is generally expressed as a thin hairline crack within clay inclusions. One apparent exception to this is shown on Drawing A2 where the feature was not observed in the clay. This exception was probably due to the moist nature of the clay masking the presence of the feature; foundation forms were placed over this area before desiccation could occur. Displacements along Feature B-14 were not apparent on the clay inclusions, however, this is expected due to the lateral sense of movement on the B features, and the vertical plane of exposure inspected. Feature B-14 was traced only slightly beyond the southeast edge of the Unit 3 containment (Drawing 3) due to construction activities in that area. However, based on earlier investigations that did not identify any B features in the area to the southeast, it is apparent that the feature must terminate just beyond the Unit 3 area.

The detailed inspection of all the SONGS Unit 3 cutslopes shows that no other features are present in the area of the Unit 3 containment.

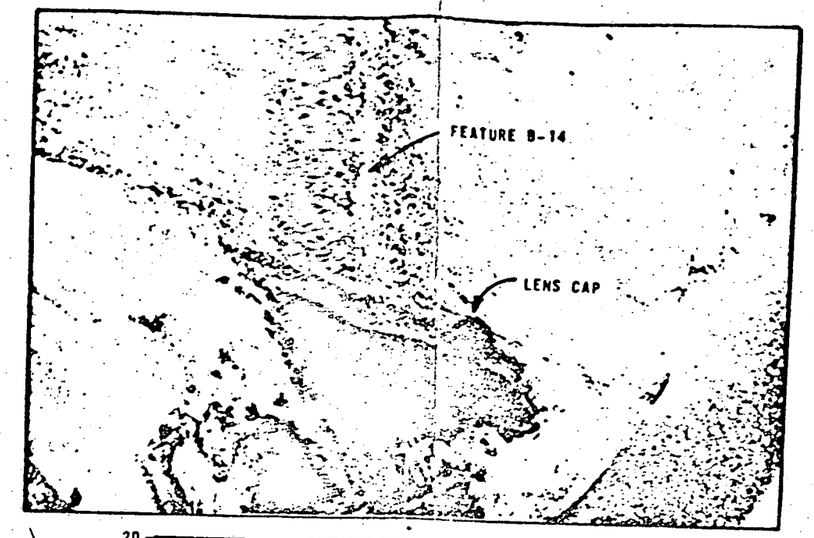


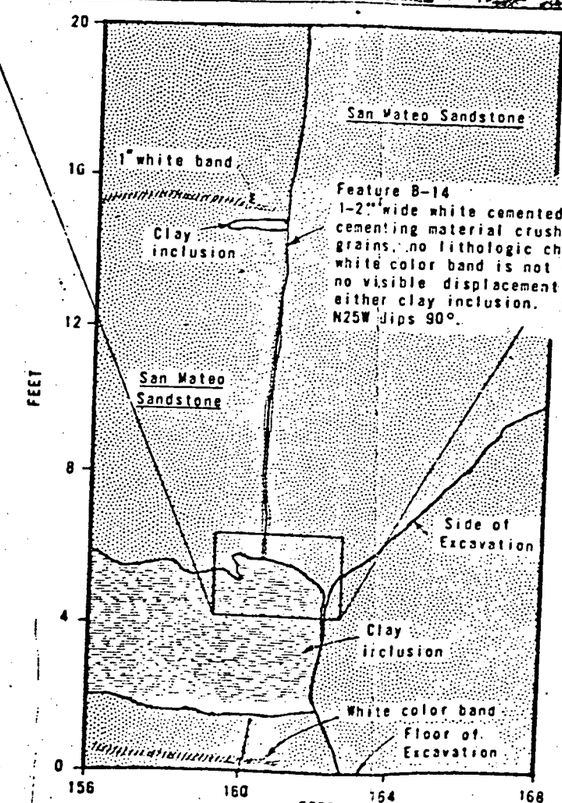




## LOG 1
## UNIT 3 EXCAVATION

NOTE: For location of detailed logs see Drawing No. 2

| | |
|---|---|
| DETAILED LOG 1 UNIT 3 EXCAVATION | Project No 74-069-03 |
| SAN ONOFRE NUCLEAR GENERATING STATION | Date 3-5-76 |
| UNITS 2 and 3 | COMPILED BY |
| SOUTHERN CALIFORNIA EDISON COMPANY | PREPARED BY |
| FUGRO, INC. Long Beach, California | CHECKED BY / APPROVED BY — DRAWING NO A-1 |

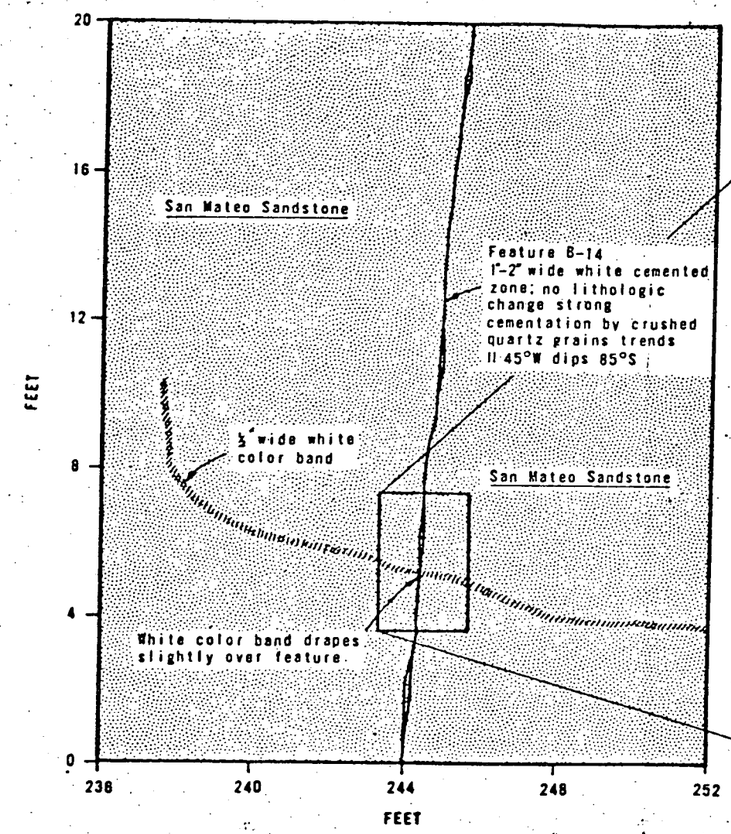


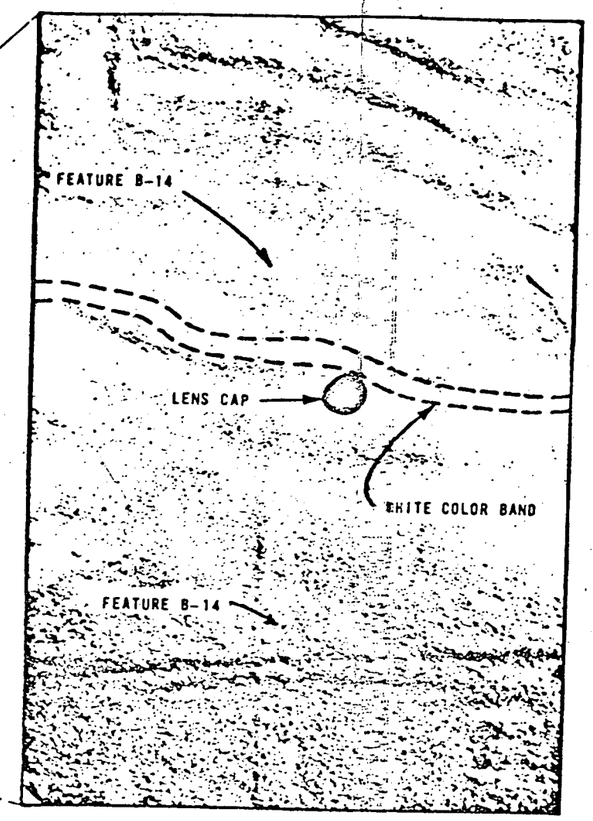




## LOG 2
## UNIT 3 EXCAVATION

NOTE: For location of detailed logs see Drawing No 2

| | |
|---|---|
| DETAILED LOG 2 UNIT 3 EXCAVATION | Project No 74-069-03 |
| SAN ONOFRE NUCLEAR GENERATING STATION | Date 3-5-76 |
| UNITS 2 and 3 | |
| SOUTHERN CALIFORNIA EDISON COMPANY | A-2 |
| FUGRO, INC. Long Beach California | |

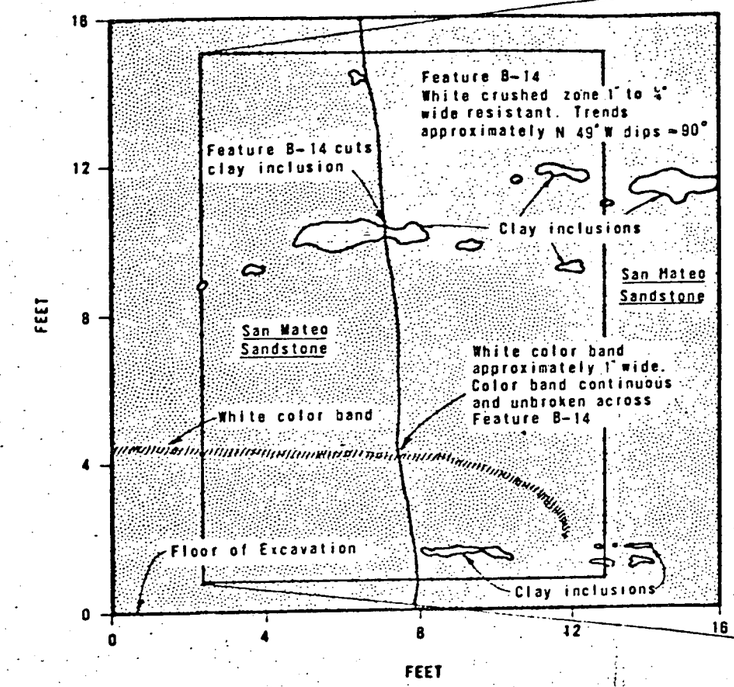


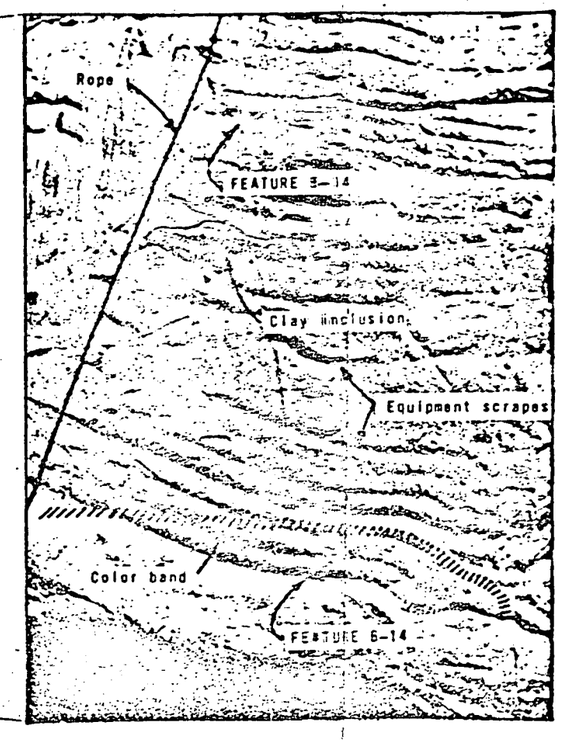




LOG 3 UNIT 3 EXCAVATION

NOTE: For location of detailed logs see Drawing No. 2

| | |
|---|---|
| DETAILED LOG 3 UNIT 3 EXCAVATION | Project No. 74-059-03 |
| SAN ONOFRE NUCLEAR GENERATING STATION | Date 3-5-76 |
| UNITS 2 and 3 | |
| SOUTHERN CALIFORNIA EDISON COMPANY | |
| FUGRO, INC. Long Beach California | A-3 |

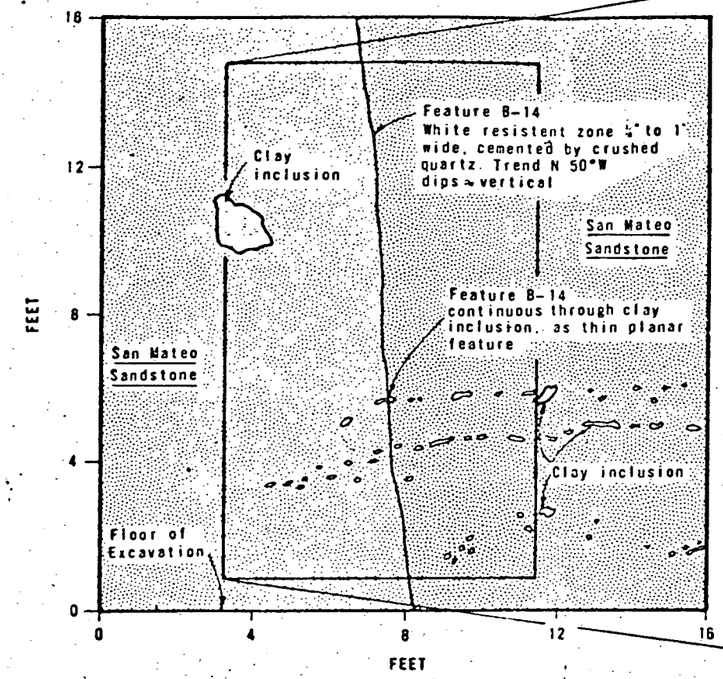


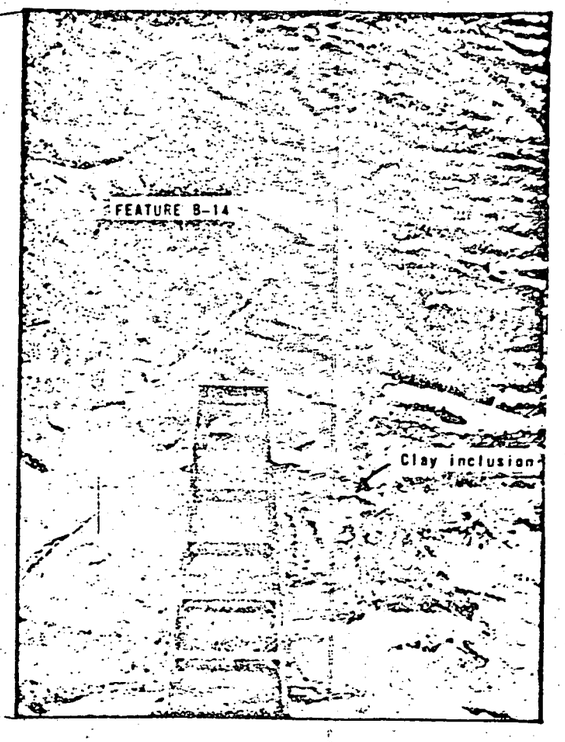




## LOG 4 UNIT 3 EXCAVATION

NOTE: For location of detailed logs see Drawing No. 2

| | |
|---|---|
| DETAILED LOG 4 UNIT 3 EXCAVATION | Project No 74-069-03 |
| SAN ONOFRE NUCLEAR GENERATING STATION | Date 3-5-76 |
| UNITS 2 and 3 | |
| SOUTHERN CALIFORNIA EDISON COMPANY | A-4 |
| UGRO, INC. Los Angeles California | |




LOG 5 UNIT 3 EXCAVATION

NOTE: For location of detailed logs see Drawing No. 2

| | |
|---|---|
| DETAILED LOG 5 UNIT 3 EXCAVATION | Project No. 74-069-03 |
| SAN ONOFRE NUCLEAR GENERATING STATION | Date 3-5-78 |
| UNITS 2 and 3 | |
| SOUTHERN CALIFORNIA EDISON COMPANY | Drawing No. A-5 |
| UGRO, INC. Long Beach California | |