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ANALYSIS OF C AND D TYPE FEATURES AT THE SAN ONOFRE NUCLEAR GENERATING STATION

By:

Fugro, Inc.

Docket #50-361
Control #8001310141
Date 12-24-79 of Document:
REGULATORY DOCKET FILE
See Amdt 17 - FSAR

For:

Southern California Edison Company

November 1, 1974

FUGRO

LIST OF DRAWINGS

I. Introduction

General

This report presents the observations and conclusions of an investigation for Southern California Edison Company (SCE) by Fugro, Inc., of two newly noted geologic features, labeled C and D, revealed in the excavations for the SONGS Units 2 and 3. These features are physically distinct from the A and B features analyzed in our report dated July 5, 1974, and were only apparent in the deeper excavations, beyond the reach of the exploratory work for the earlier report. The recognition and analysis of these features is part of the continuing monitoring of final grading by Fugro geologists.

The objectives of this investigation and report are to analyze, in detail, the characteristics of the C and D features, determine their age, origin, and relationship to the A and B features, and evaluate the significance of these features with respect to the San Onofre site.

This report contains: (1) descriptions of the scope and background of the investigation, (2) a synposis of the types of discontinuities described in Fugro report "Analysis of Geologic Features at the San Onofre Nuclear Generating Station", dated July 5, 1974, (3) theoretical considerations in connection with explanations of origin, and (4) conclusions and recommendations regarding the C and D features. A synposis of the geology and structure of the site vicinity and a detailed description of the A and B features are contained

in the Fugro report of July 5, 1974, and have not been repeated here.

History

Portions of the C and D features described in this report were first noted in temporary cutslopes by Fugro geologists, about August 20, 1974. The new features were revealed in the Unit 2 excavation at a later date during detailed inspections of the deeper portions of the excavation. 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 further expose them by clearing off additional areas.

II. Synopsis of the Site Lithology and the Types of Geologic Discontinuities Reported in Fugro Report (July 5, 1974)

Lithology

San Mateo Formation: The San Mateo Formation of Pliocene or Mio-Pliocene age is widely distributed west of the Cristianitos Fault, is well exposed along the coast, and underlies the SONGS 2 and 3 site. 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 in diameter, have been incorporated into the San Mateo sandstone by turbidity currents or submarine slumping during deposition.

Terrace Deposits

Pleistocene terrace materials have been recognized in the site vicinity and 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 (Qt_1).

At SONGS 2 and 3 site, Pleistocene marine and non-marine terrace materials (Qt_1) have been deposited over the 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, mollusks have been recovered from 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, indicates that the Qt_1 terrace has a minimum age of 70,000 to 130,000 years (PSAR, Section 2.9.4).

At the site, marine terrace deposits (Qm) occur as small, localized pockets overlying erosional irregularities in the San Mateo Formation. The non-marine terrace deposits (Qtl_a through Qtl_c) are crudely stratified and range in composition from conglomerate to silty sand and silty clay.

Discontinuities

Four types of geologic discontinuities were originally observed in the San Mateo Formation in the initial excavations for SONGS 2 and 3:

- Joint-like features demonstrating a very minor amount of strike-slip shear movement; Type A trends north and north-northeast, Type B trends about N50W;
- Slump structures, graded bedding and other 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; and,

- Color banding in the sandstone.

Of the four types of geologic discontinuities, Type A and B features were of most interest. Both types of features appeared as thin, white resistant seams which formed sinuous zones up to several inches wide. Amount and sense of shear movement on these features were about 4 inches left lateral for Type A, and a similar amount of right lateral displacement for Type B.

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 (70,000 to 130,000 years old). Detailed discussions of these features and their relationships are presented in "Analysis of Geologic Features at the San Onofre Nuclear Generating Station" (July 5, 1974).

III. Description of Investigation

Fugro's investigation of the C and D features at SONGS included:

- Geologic mapping of the as-graded geology in the Unit 2 and 3 area, with special emphasis on locating structural features in the San Mateo Formation,
- Scraping of covered surfaces with a skiploader and exhuming of sumps and construction pits using a backhoe,
- Excavation of 5 backhoe trenches,
- Detailed photography and logging of all backhoe trenches and pertinent exposures,
- Petrographic studies of C and D features,
- Theoretical analysis regarding origin of feature D, and
- Search for other C and D type features outside the Unit 2 and 3 site.

The field investigation and this report preparation involved approximately 115 man-days during August, September, and October, 1974.

IV. Description of C and D Features

Feature C. Feature C is exposed in the San Mateo Formation at the toe of the cutslope northeast of Unit No. 3 (Drawing No. 2). The feature is relatively short, extending 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 generally appear very similar to the typical A and B features. Considering all the various branches, Feature C has an apparent maximum zonal 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 trenches N50E consistently with uniform thickness (2 inches) for about 15 feet, then bifurcates and pinches out within the following 15 feet (Drawing No. 11). On the permanent cut slope, the elements of the feature branch and pinch out within the San Mateo Formation (Drawing Nos. 9, 10, 11).

Attitudes on Feature C vary according to the particular elements of the zone; however, the average strike is about N50 to 60E, with dips ranging from 5 to 19 degrees northwest (Drawing No. 11). Bedding plane attitudes on the cut slope near Feature C strike about N75E and dip 12 degrees NW, indicating a gross similarity in general orientation with Feature C.

No clear examples of displacement have been recognized on Feature C; however, a questionable offset of a thin silty clay seam suggests about 2 1/2 inches of apparent right

lateral displacement. Because of its short length, Feature C does not intersect any A or B features, so their mutual structural relationships cannot be evaluated. Feature C occurs very close to Feature D (Drawing Nos. 10, 11), however, they do not intersect, and, as a result, their structural relationships also cannot be evaluated.

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

Feature D. Feature D is exposed in the San Mateo Formation from the excavation northwest of the present switchyard facility (Drawing Nos 9 and 3), to the Unit 2 excavation (approximately 1,050 feet distant). In contrast to Feature C, Feature D consists of an individual or series 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. The fractures are usually apparent after light brushing, because the planar surface erodes slightly more than the surrounding formation, leaving a thin line in the sandstone.

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. In a few claystone layers that are exposed in trenches, Feature D is associated with a soft zone (up to about 1 inch

thick), and the planar surface contains a thin layer (1/16 to 1/8 inch) of plastic clay (Drawing Nos. 16, 17, 18).

Feature D is continuously exposed in cutslopes and graded pads across the SONGS 2 and 3 site and has been plotted in detail on Drawing Nos. 2 and 3. Continuity is usually demonstrated by a single trace containing a number of discontinuous branches or secondary fractures. In several instances (e.g., between Units 2 and 3), a single, long continuous element will essentially pinch out and is superseded 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 (Drawing No. 3).

Attitudes on Feature D range from N72E, 12NW at the northeast limit of the excavation, to N77W, 15-20NE, between Units 2 and 3, to N35W, 32NE at Unit 2 (Drawing No. 2). The apparent irregularity of Feature D in plan view is amplified because of the low angle of dip. A broad bend in strike (from N60E to about N60W) occurs between Unit 3 and the north cutslope where Feature D intersects a series of interbedded clay layers. The clay layers strike N - W and dip 10 to 19 degrees NE. Due to the similar attitudes of the bedding and Feature D and the lower shear strength of the clay, the clay layers may have influenced the formation of the bend in Feature D.

The similarity of attitudes between Feature D and well-developed bedding planes in the deeper excavations is evident at a number of places across SONGS 2 and 3 (Drawing No. 2). Where comparisons can be made, there is usually a close agreement between the attitude of Feature D and the attitudes of interbeds or graded bedding in the sandstone. Where Feature D intersects extensive claystone layers, the planar surface commonly coincides with or parallels a bedding plane. In section, Feature D tends to be slightly steeper in the deep excavations and has a shallower dip near the ground surface. Dips in the bottom of Unit 2 excavation range from 18 to 32 degrees, while dips higher in the section near the terrace deposits are about 12 to 20 degrees.

Examples of displacements have been noted where Feature D intersects color banding, clay inclusions, and Type A and B features (Drawing Nos. 4, 5, 6, 12, 13). In each instance, the apparent sense of displacement is reverse, and the amounts range from 1/4 inch or less to about 2 3/4 inches. The best examples of Feature D intersecting color bands and clay inclusions occur on cutslope 2 (Drawing No. 12), where the displacements are consistently 2 1/2 to 2 3/4 inches with a reverse sense of movement. Within the Unit 2 excavation, displacements of color bands range from 0 to 3/4 inches, with reverse sense of movement (Drawing No. 8).

Where Feature D intersects B features, the sense of movement is always right lateral (in plan) with displacements of B

features observed up to 1 inch. The right lateral displacements in plan reflect a reverse sense of movement consistent with exposures of D features logged on cutslopes (Drawing No. 6). In section (Unit 2 excavation, Drawings 6, 7, and 8), displacements of the B feature by Feature D range from 3/8 to 3/4 inches, with a reverse sense of movement. In one instance, converging branches of Feature D form a wedge-shaped displacement across Feature B 13 and B 13a, and the sense of movement is still reverse (Drawing Nos. 7 and 8).

When Feature D intersects Type A features in section (i.e., on cutslopes), an occasional offset can be recognized (Drawing Nos. 4 and 5), but more often the plane of D extends through the A feature without any apparent offset. This apparent lack of displacement is probably due to the direction and sense of movement on D, which parallels the strike of A features, making any offset difficult to distinguish.

The 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 generally seem to have affected the shape and configuration of color bands without offsetting them. Since little is known of the absolute or relative age of color band formation, 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) at 70,000 to 130,000 years old. Trench No. 15 (Drawing No. 14) shows the D feature overlain by undisturbed terrace materials with no disturbance of the terrace/bedrock contact, clearly indicating that Feature D is older than 70,000 to 130,000 years.

Two other examples of D type features have been recognized in the deeper excavations at SONGS 2 and 3, and these features are stratigraphically below the Feature D described above. The first D type feature is exposed in a cutslope 160 feet south-southeast of the center of Unit 2 containment (Drawing No. 3). This feature has the same planar hairline appearance as Feature D and shows minor offsets (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. This D type feature is exposed in three dimension on a cutslope at elevation - 10 feet (Drawing No. 3). Stratigraphically, the feature is about 40 feet below Feature D. Careful inspection and logging of the feature and the surrounding cutslopes indicate that the feature extends for 45 feet and is not continuous in adjacent cutslopes. The similarity of appearance and attitude confirm this is a D type feature; however, the lack of continuity indicates that it is local.

The second D type feature was briefly observed in a temporary excavation across the intake structure (the deepest excavation

at SONGS 2 and 3). The feature was observed 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 is not known because final grade of the intake structure is not deep enough to expose it, and the feature has not been observed on the surrounding slopes.

A search was conducted for other D features outside the Unit 2 and 3 excavation and is discussed in Appendix B. Several D type features were observed in the Unit 1 excavation, but none were evident in the areas outside the site.

V. Origin of D Feature

Mechanics of Shear Features

Of the three sets of features observed, two --A and B-- lie essentially in the vertical plane as shown in perspective in Drawing 20A, and one, Feature D, dips at an angle of about 20^{o} to the northeast (Drawing 20B). 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 the 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. The hydrostatic component of the stress is defined as the mean of the normal stresses. 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, of 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 feature we observed at the site, it can be concluded that shears A and B developed at a 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. As discussed in the Fugro report (July 5, 1974), the angle between the A and B shear surfaces implies a friction angle of about 35^o 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 N20 W 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 block of San Mateo Formation in the N70E/S70W direction.

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 of 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.

Therefore, the sequence of events is that during 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. At the same time, an east-west component decreased. 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 20A). 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 20B). It is concluded 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.

VI. Conclusions and Recommendations

The following conclusions and recommendations have resulted from Fugro's investigation of the C and D features at San Onofre.

- There is only one Feature C exposed at the site. It is relatively short, diffuse, and with the exception of its attitude, has similar physical characteristics to types A and B features. Feature C terminates entirely within the San Mateo Formation and is probably contemporaneous with the formation of the 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 (70,000 to 130,000 years old) and, as a result, is demonstrably older. The formation of the D feature generally is consistent with the stress system required to produce the A and B features.

- It is recommended that the monitoring of major grading by a geologist be continued with emphasis on identifying any other features at SONGS 3.

VII. References Cited

Engelder, J.T., 1974, Cataclasis and the generation of fault gorge: Geol. Soc. America Bull., v. 85, p. 1515.

Fugro, Inc., 1974, Analysis of geologic features at the San Onofre nuclear generating station: 32p.

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

PETROGRAPHIC ANALYSIS OF C AND D FEATURES

1. Introduction

Petrographic analysis of composition, texture, cementation, and oriented fracturing of grains at or near C and D features and color bands was performed on thin sections of San Mateo Sandstone. Samples of C and D features are very fragile and require special sampling and handling methods in the field. Instead of diluted resin which easily penetrates the sandstone and was used to collect samples of A and B types features, undiluted casting resin mixed with hardener was directly brushed on the sandstone blocks (about 10 x 8 x 6 inches). After one to three days drying, the resin-coated block was carefully removed from its natural position without disturbing the C or D features. After removal, the remaining surfaces of the sample were immediately coated with resin. After drying, the block sample was transported to the thin section laboratory. Samples were further impregnated with clear epoxy resin diluted with styrene monomer. Thin sections were then cut in sequence across the C or D features or color bands. A total of 31 thin sections were analyzed; four from Feature A, four from Feature C, 15 from Feature D, three from color bands, and five from the San Mateo Formation.

2. Observation

General Characteristics of San Mateo Sandstone

The general petrographic nature of San Mateo sandstone does not differ greatly among thin sections, except for those samples taken from clay interbeds. The sandstone is arkose

and consists of subangular, unsorted clastic grains (about 80%), a matrix material, and voids (about 20%). The matrix is yellowish-brown, nearly isotropic material, probably oxidized clay minerals and hematite mixture. No calcite, chalcedonic, quartz, zeolite, or other authigenic and diagenetic minerals were found in the matrix. Clastic grains range in size from 0.1 mm to 4 mm in diameter, but most are from 0.3 mm to 1.5 mm. In mode, quartz grains constitute 50 to 60%, feldspar grains (mostly plagioclase) 15 to 20% and rock fragments (schist, quartzite, granite) and other minerals, mostly biotite, 5 to 10%. In some rocks, biotite minerals and clay minerals are abundant in the matrix. Many quartz and feldspar grains are fractured and fragmented. Such cracked and fragmented grains are not restricted to particular planar features, and are, therefore, considered to have resulted from sedimentary load pressure.

Feature C

The C type feature consists of a sinuous zone of thin (1/8 to 1/4 inch), white, resistant ribs that generally appear very similar to the typical A and B features. Under the microscope, the C feature is composed of essentially the same minerals as the country rock, but is typically finer-grained and richer in clayey cementing materials between sand grains. In the C feature zone, grains smaller than 0.5 mm in diameter constitute about 80% of the rock. The space between fragmented quartz and feldspar grains is filled with clay and micaceous minerals. Finely fragmented clastic grains in the C feature

suggest a cataclastic origin. Most quartz crystals exhibit undulatory extinction resulting from internal deformation. However, no preferred orientation or rotation of grains is observed.

Feature D

The D type feature consists of an individual or series of individual hairline planar fractures in the San Mateo Formation. Thin sections of D features indicate that some finely fragmented grains and clayey cementing materials occur, as in the C feature. However, characteristically, the D feature contains abundant elongate voids or empty fractures which apparently represent the friable fracture planes observed in the graded surfaces. The abundance of voids suggests that deformation probably did not take place repeatedly or was not intense enough to cause filling of the void spaces within the D feature.

Color Banding

Color banding is very common in the San Mateo Formation and occurs as undulatory layers, one inch to several feet wide, trending in random directions across the graded exposures. The banding is often white or orange-brown and contrasts with the gray or light gray-brown of the sandstone. The width of individual bands is usually consistent or gently tapering along the length. Microscopically, the brownish bands are characterized by yellow-brown materials (oxidized clay minerals, micas and hematite mixture) between sand grains, in fractures

within grains and in the edge of grains. In white color bands, brownish materials are lacking. The light bands appear to be the result of leaching or oxidation of the San Mateo Formation, possibly from percolating water and, as a result, do not constitute a structural feature within the rock.

3. Conclusion

The C and D type features are composed of finely fragmented sand grains resulting from granulation along the feature plane. The D feature contains empty fractures which suggest that granulation in the D was not intense enough to fill up the voids. However, no preferred orientation or rotation of grains is observed.

APPENDIX B

SEARCH FOR C AND D TYPE FEATURES OUTSIDE UNITS 2 AND 3 SITE EXCAVATION

Four areas outside of the SONGS Units 2 and 3 site were inspected for C and D type features in San Mateo sandstone. Areas investigated included the sea cliff exposures north of the site, sea cliff exposures south of the site to the Cristianitos Fault, the quarry area near Basilone Road, and the SONGS Unit 1 area. These areas are relatively well-exposed although surface smear and a short stratigraphic section (except for the quarry excavation) make identification difficult.

Criteria used for identification of C and D type features were:

C feature - a partially or completely cemented, low-angle or horizontal, white, slightly resistant, planar feature; single element or sinuous zone, and

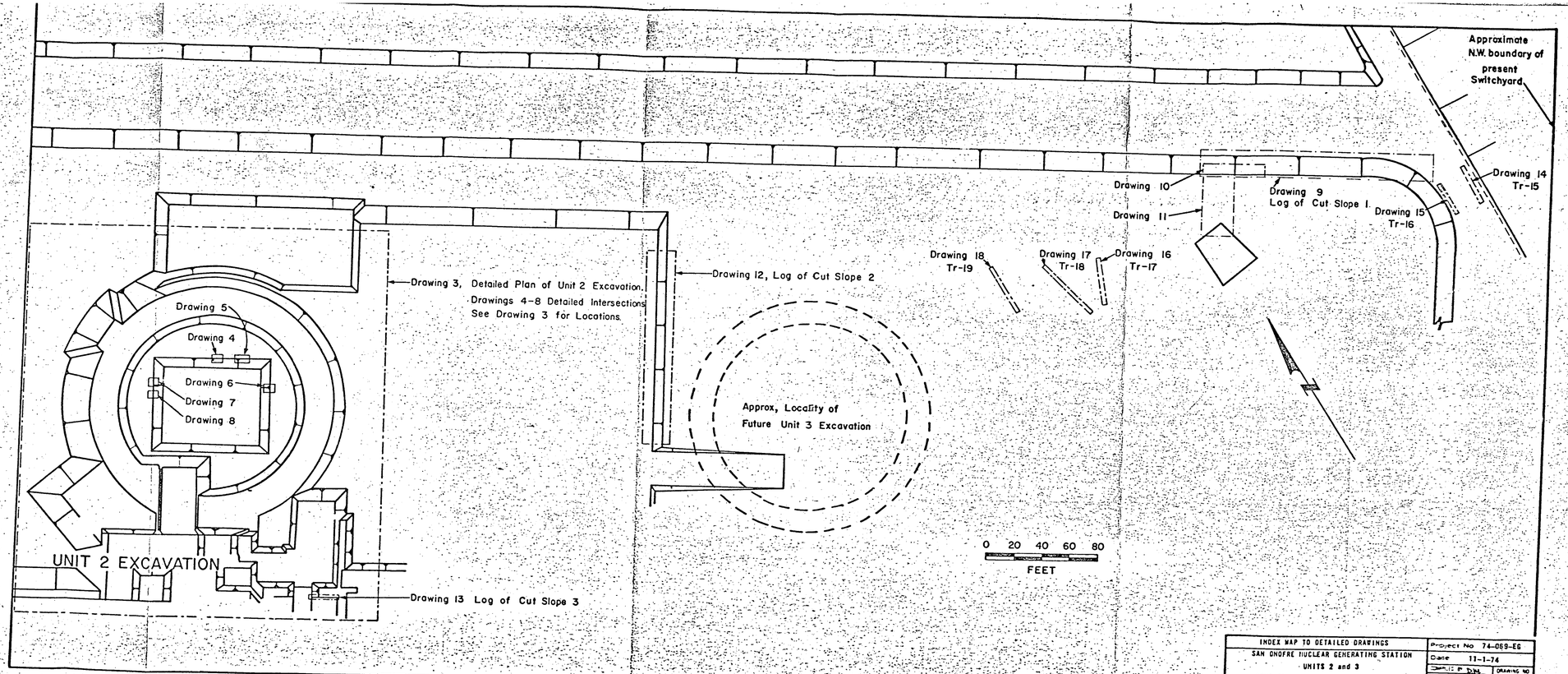
D feature - an uncemented, low-angle, planar, hairline fracture, which may offset A and B type features and color banding.

Two geologists carefully cleaned, brushed and examined exposures in these offsite areas. The results were that no C type features were found outside of the SONGS site. In the areas examined, vertical and/or high-angle A and B type features are abundant; however, due to their resistant nature, they are better preserved and more readily recognized.

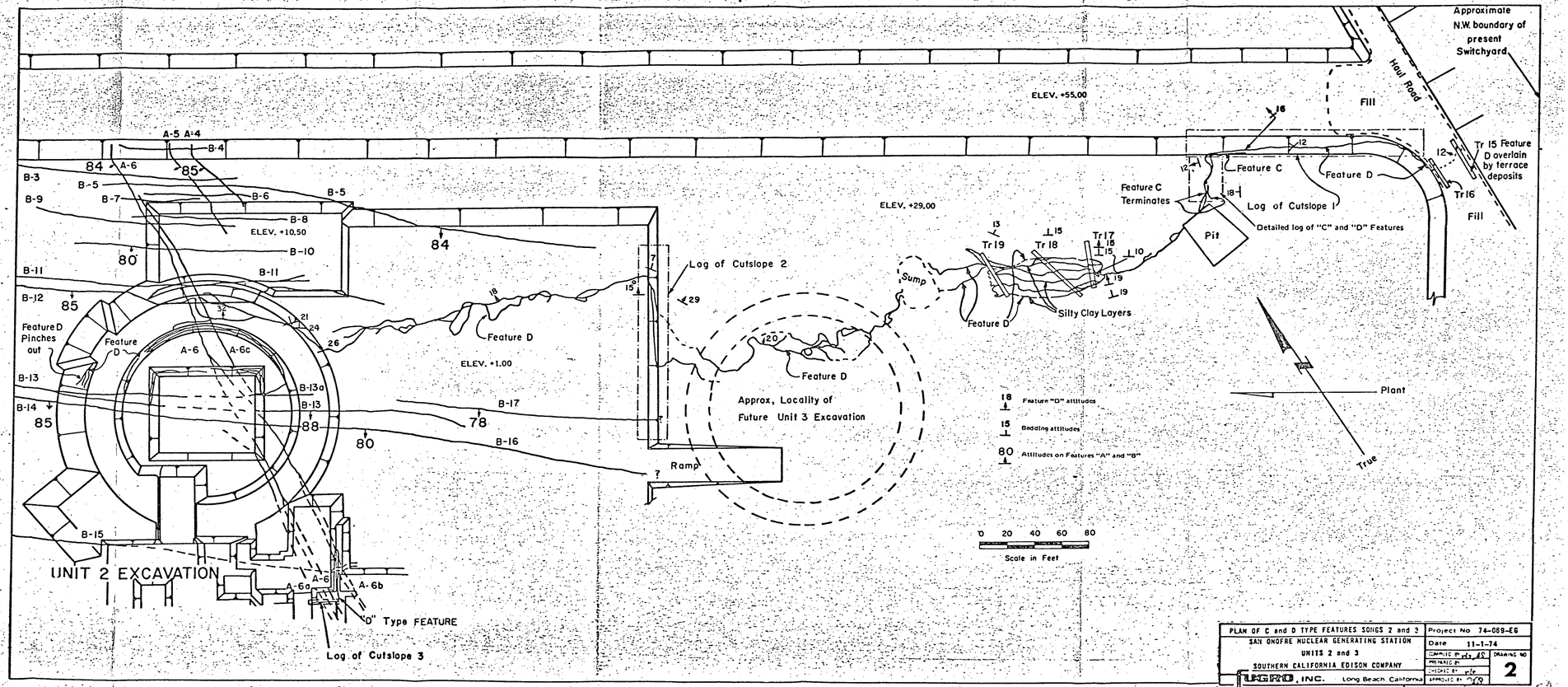
Along the sea cliff near the Cristianitos Fault, numerous high-angle shears criss-cross one another, but no C or D type features were observed.

In the SONGS Unit 1 area, several short D type features were found on the cut slope north-northeast of the existing reactor. One D type feature, about 10 feet long, striking N5W and dipping 12 SW, was noted immediately north of the guard station (Drawing 19). This feature was carefully cleaned and traced; however, it did not intersect any A or B features, and it did not extend to the terrace/bedrock contact. Three discontinuous D type features, each 10 to 20 feet long, occur 1 to 2 feet below the terrace-gravel/bedrock contact on the second level cutslope northeast of the existing reactor. These are nearly horizontal, do not intersect any other feature within the San Mateo Formation, and are not continuous to the terrace-gravel/San Mateo contact (Drawing 19).

The apparent absence of C and D features in natural and quarry exposures outside the site excavations is not unexpected since the features (especially the D) are very subtle and are only recognized in freshly graded surfaces that have dried considerably. Such conditions do not exist in the natural exposures examined.



INDEX MAP TO DETAILED DRAWINGS	Project No 74-089-EG
SAN ONOFRE NUCLEAR GENERATING STATION UNITS 2 and 3	Date 11-1-74
SOUTHERN CALIFORNIA EDISON COMPANY	Drawing No 1
UNGRO, INC. Long Beach California	



PLAN OF C and D TYPE FEATURES SONGS 2 and 3	Project No 74-069-E6
SAN ONOFRE NUCLEAR GENERATING STATION	Date 11-1-74
UNITS 2 and 3	COMPILED BY JKS / AG — DRAWING NO 2
SOUTHERN CALIFORNIA EDISON COMPANY	DRAWN BY
UCPRO, INC. Long Beach California	CHECKED BY JKS
	APPROVED BY

B-10

A-6 A-6c

B-11

B-12 S.O.11

ELEV. -10.50

26

S0 10

N 55 W
12 NE

14 15 6

B-13a

B-13

B-14

17 18

16 6

ELEV. -13.75

ELEV.+5 .75

ELEV.-10.25

ELEV. -15.58

A-6a A-6

ELEV. -10.25

ELEV. -9.25

A-6b

B-15

ELEV.-24.50

ELEV.-19.50

ELEV.-21.00

ELEV -10.0

ELEV.-17.75

ELEV.-9.25
S0 9

ELEV -13

LOG OF CUT SLOPE 3

EXPLANATION

FEATURES IN UNIT 2 EXCAVATION

A Feature

B Feature

D Feature

S0 9 Thin section sample locations

14 Detailed drawing of intersection

0 20 40 60

Scale in feet

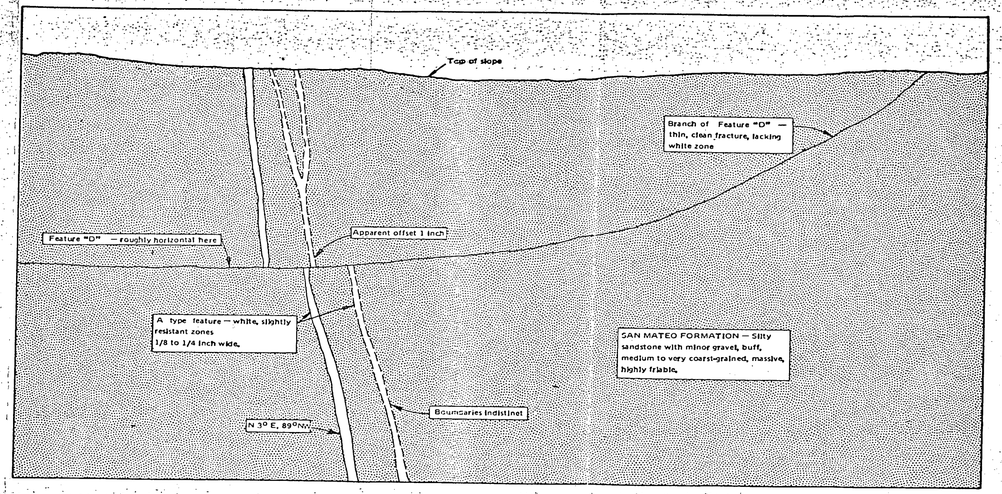
PLAN OF FEATURES IN UNIT 2 EXCAVATION
SAN ONOFRE NUCLEAR GENERATING STATION
UNITS 2 and 3
SOUTHERN CALIFORNIA EDISON COMPANY

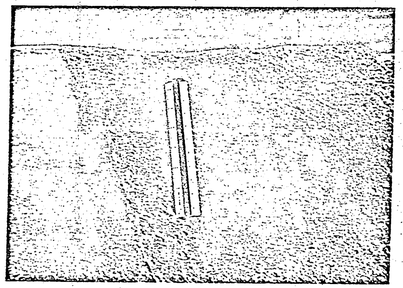
FUGRO, INC. Long Beach California

Project No 74-069-EG
Date 11-1-74
COMPILED BY SK, JS
PREPARED BY
CHECKED BY
APPROVED BY
DRAWING NO 3

INTERSECTION 14

N 57° W

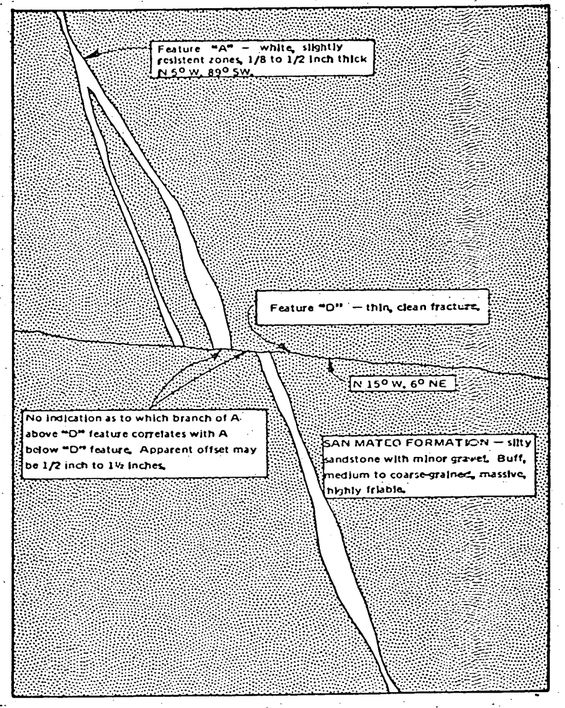




NORTHEAST CUTSLOPE OF REACTOR PIT, UNIT 2	Project No. 4y069-EG
SAN ONOFRE NUCLEAR GENERATING STATION UNITS 2 and 3	Date 2-13-1-76
SOUTHERN CALIFORNIA EDISON COMPANY	COMPILED BY SK / DRAWING NO 4
UGRD, INC. Long Beach, California	DRAWN BY / CHECKED BY MLS / APPROVED BY

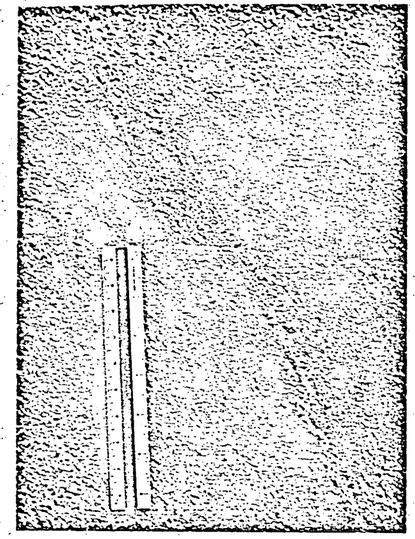
INTERSECTION 15

N 57° W



0 1 2 4

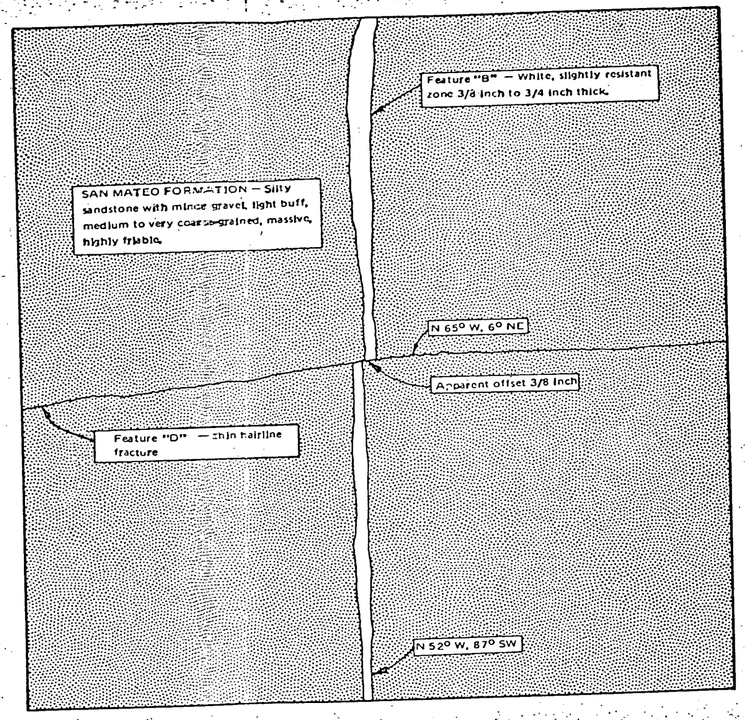
INCHES



NORTHEAST CUTSLOPE OF REACTOR PIT, UNIT 2	Project No.: 74-069-EG
SAN ONOFRE NUCLEAR GENERATING STATION UNITS 2 and 3	Date: 11-1-74
SOUTHERN CALIFORNIA EDISON COMPANY	COMPILED BY SK / PREPARED BY / CHECKED BY / APPROVED BY — DRAWING NO. 5
UGRO, INC. Long Beach, California	

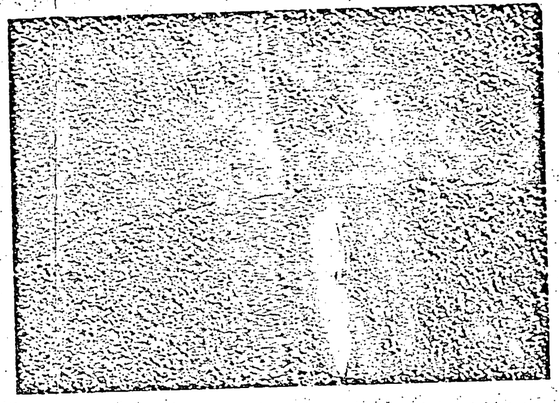
INTERSECTION 16

N 33° E



0 1 2 4

INCHES

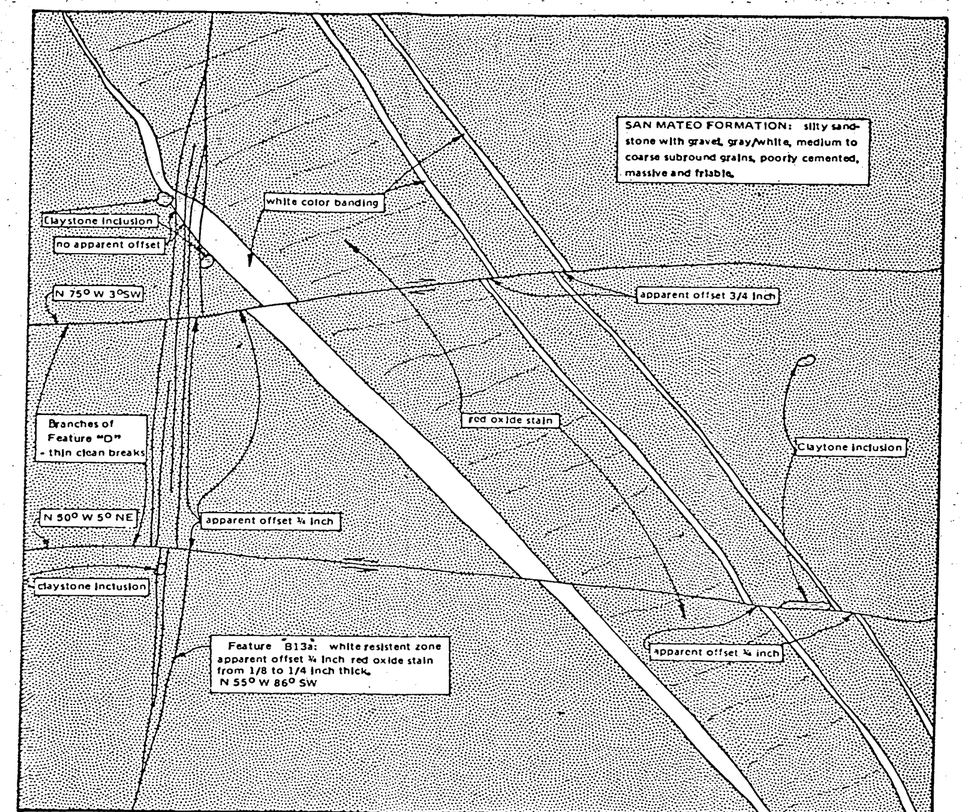


NORTHEAST CUTSLOPE OF REACTOR PIT, UNIT 2	Project No 74-369-EG
SAN ONOFRE NUCLEAR GENERATING STATION UNITS 2 and 3	Date 11-1-74
SOUTHERN CALIFORNIA EDISON COMPANY	DRAWING NO 6
UGRO, INC. Long Beach California	

24

INTERSECTION 17

N 33° W



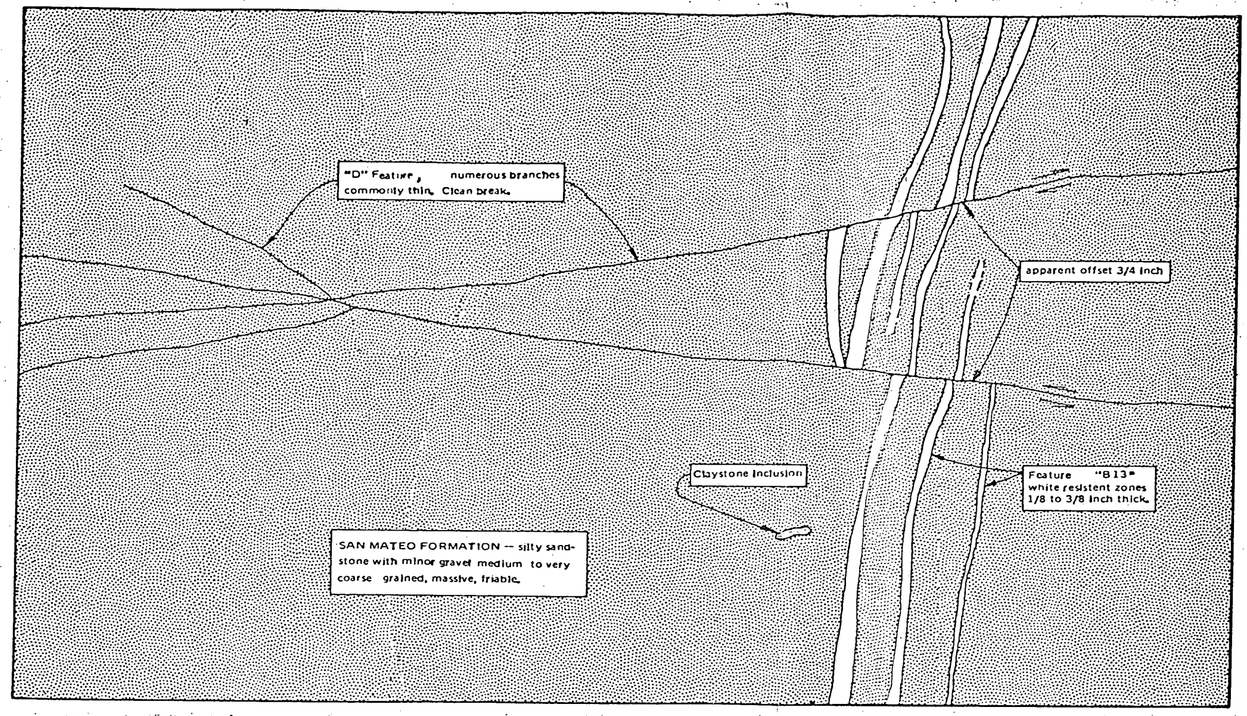
0 5 10

INCHES

NW c trlope in Unit 2 Reactor pit	Project No 74-069-FG
SAN ONOFRE NUCLEAR GENERATING STATION UNITS 2 and 3 SOUTHERN CALIFORNIA EDISON COMPANY	Date 11-1-74
	DRAWING NO 7
UNRO, INC. Long Beach California	

INTERSECTION 18

N 33° E



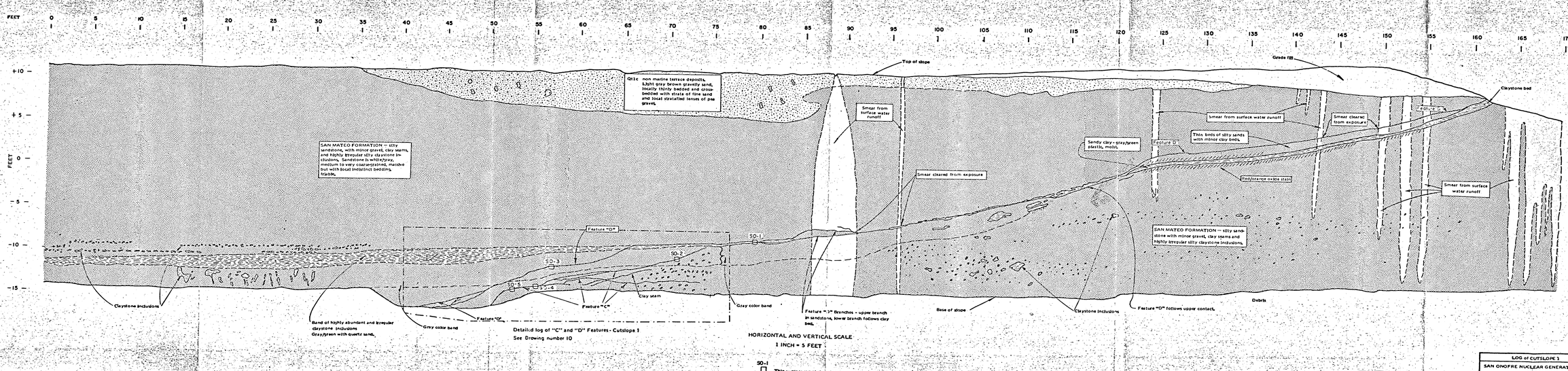
0 1 2 4

INCHES

NW CUTSLOPE, UNIT 2	Project No 74-069-EG
SAN ONOFRE NUCLEAR GENERATING STATION UNITS 2 and 3 SOUTHERN CALIFORNIA EDISON COMPANY	Date 11-1-74
	COMPILED BY SK
	PREPARED BY
	CHECKED BY RLS
UNITED, INC. Long Beach California	APPROVED BY
	DRAWING NO 8

CUTSLOPE 1

N 57° W



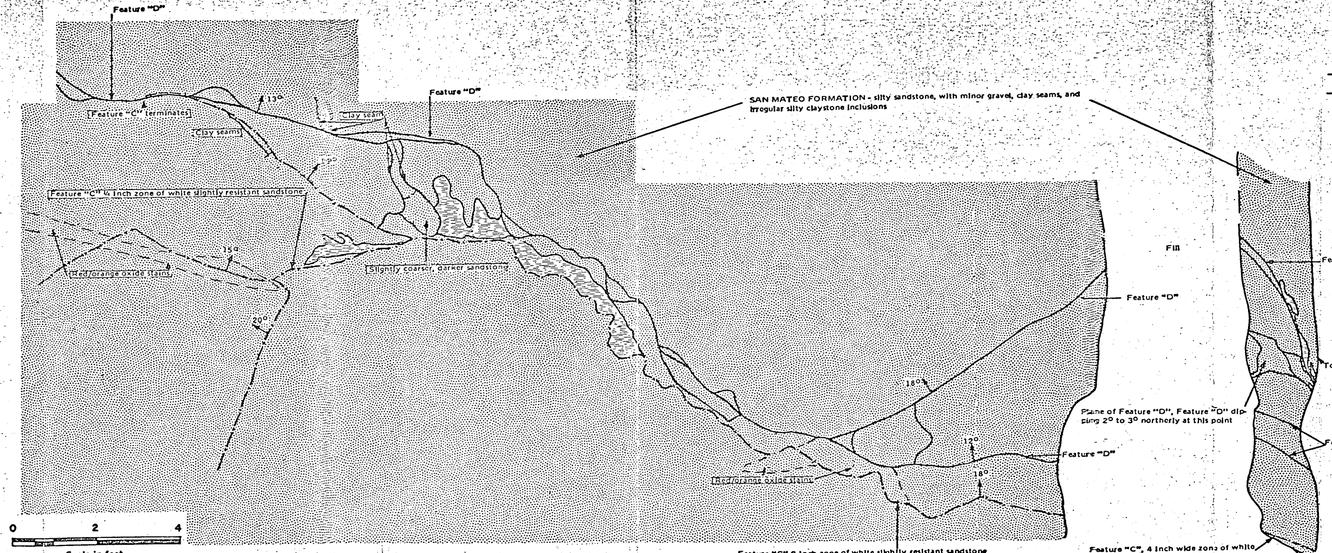
Detailed log of "C" and "D" Features - Cutslope 1
See Drawing number 10

HORIZONTAL AND VERTICAL SCALE
1 INCH = 5 FEET

50-1 ☐ Thin sections sample locations

LOG of CUTSLOPE 1	Project No 74-069-EG	
SAN ONOFRE NUCLEAR GENERATING STATION UNITS 2 and 3 SOUTHERN CALIFORNIA EDISON COMPANY	Date 11-1-74	
	DRAWN BY RK	DRAWING NO 9
	CHECKED BY AS	
UNITED, INC. Long Beach, California	APPROVED BY JS	

DETAIL LOG FEATURES "C and D"
TOE OF CUTSLOPE 1



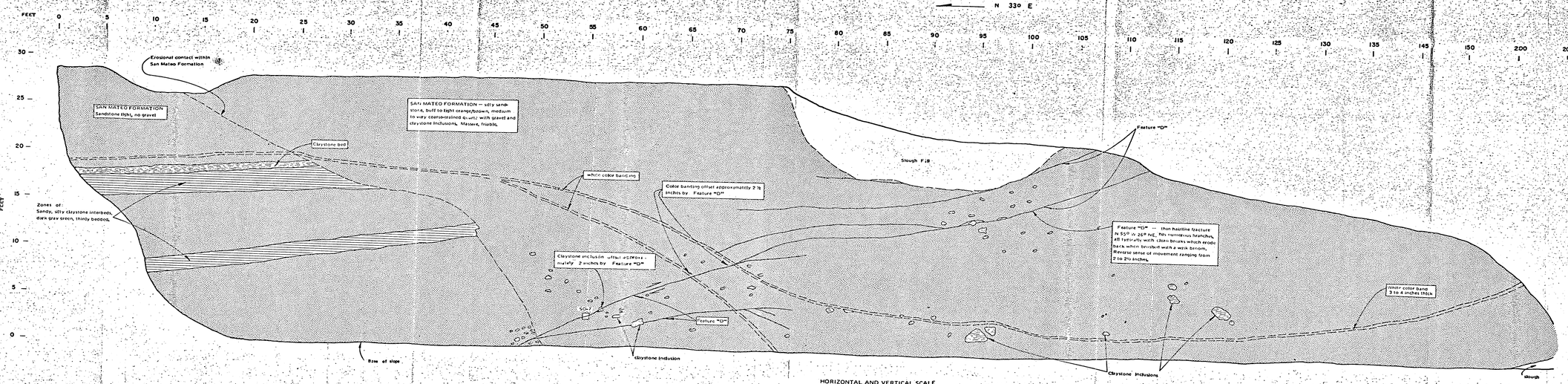
EXPLANATION

- Trace of Feature "C" - white slightly resistant branching seam
- Trace of Feature "D" - thin fracture, erodes where brushed
- Irregular inclusions of sandy or silty clay
- Dip of "C" and "D" features

Log of "C" and "D" Features - Excavation floor	Project No 74-069-EG
SAN ONOFRE NUCLEAR GENERATING STATION UNITS 2 and 3 SOUTHERN CALIFORNIA EDISON COMPANY	Date 11-1-74 DRAWN BY AS PLOTTED BY CHECKED BY APPROVED BY DRAWING NO 11
LEIGHTON, INC. Long Beach California	

CUTSLOPE 2

N 330° E



HORIZONTAL AND VERTICAL SCALE
1 INCH = 5 FEET

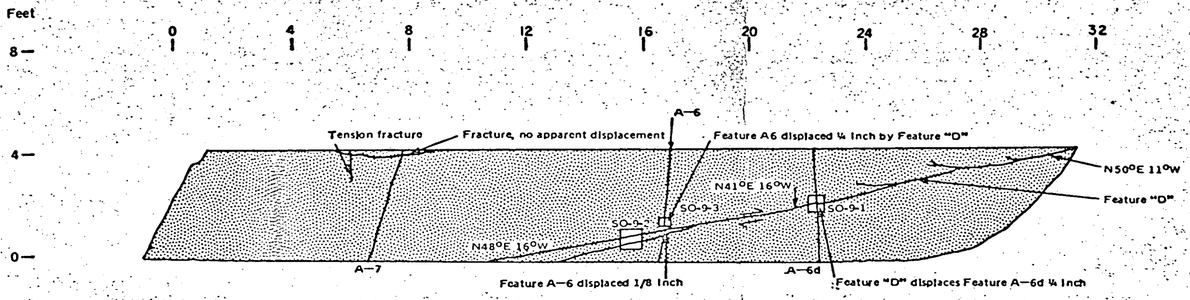
50-7 ☐ thin section sample

LOG of CUTSLOPE 2	Project No 74065-EG
SAN ONOFRE NUCLEAR GENERATING STATION UNITS 2 and 3	Date 11-1-74
SOUTHERN CALIFORNIA EDISON COMPANY	Drawing No 12
UGRO, INC. Long Beach, California	

1/0

CUTSLOPE 3

N57W



SAN MATEO FORMATION - silty sandstone, light gray brown, medium to very coarse grained, subround to subangular, quartz and feldspar grains with some volcanic fragments, poorly sorted, massive, friable.

Feature "A–6, A–6d and A–7", white, slightly resistant ridges 1/8 to 1/4 inch wide.

Feature "D" Low angle fracture erodes when brushed, displaces "A" Features.

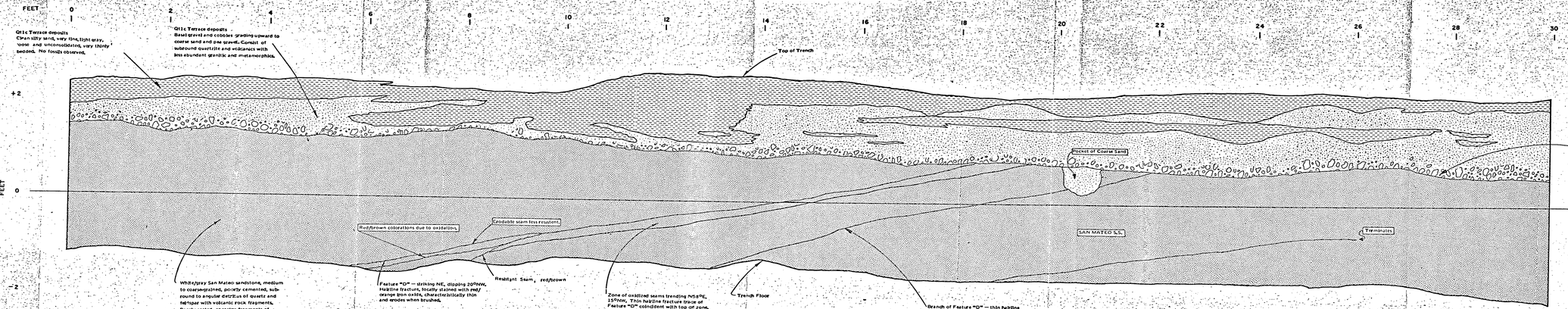
SO-9-1 Thin section sample location

1 INCH = 4 FEET
SCALE

LOG of CUTSLOPE 3	Project No 74-059-EG
SAN ONOFRE NUCLEAR GENERATING STATION UNITS 2 and 3 SOUTHERN CALIFORNIA EDISON COMPANY	Date 11-1-74 COMPILED BY QS PREPARED BY CHECKED BY NS APPROVED BY
UNITED, INC. Long Beach California	DRAWING NO 13

TRENCH 15

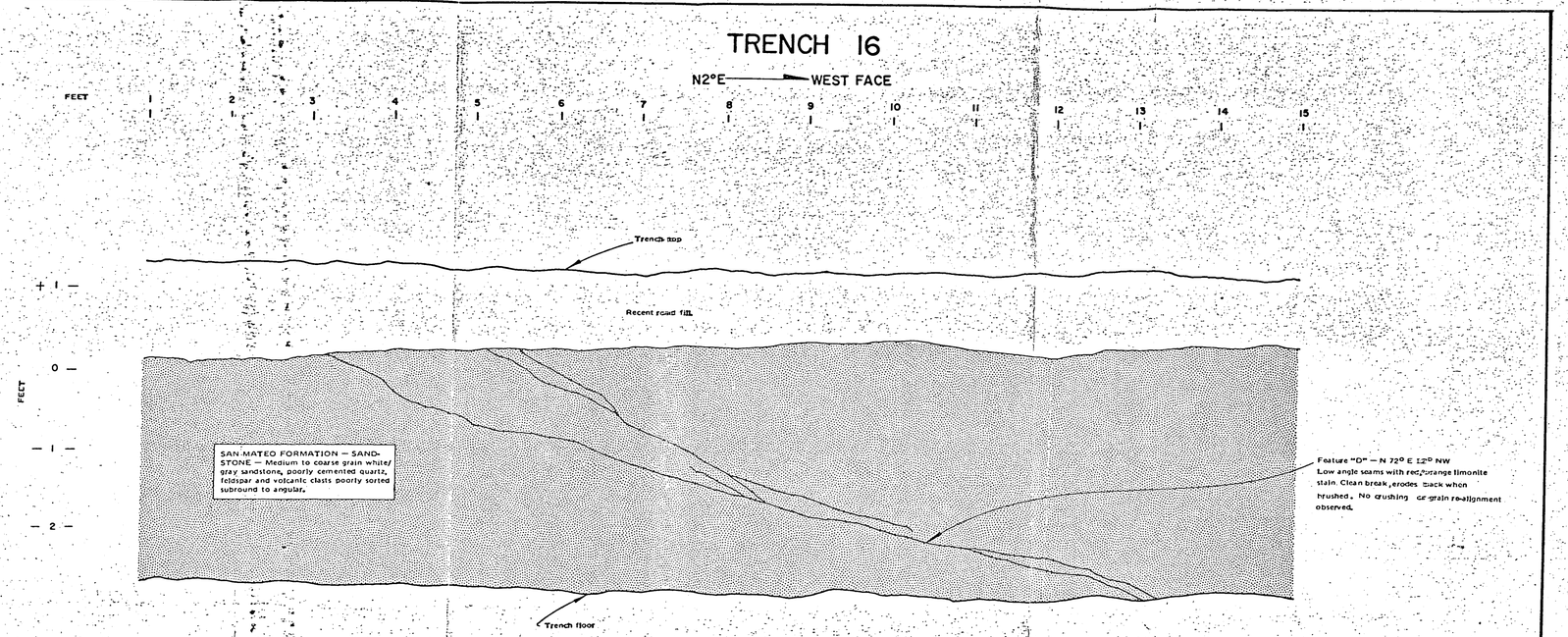
N 50 W EAST FACE



HORIZONTAL AND VERTICAL SCALE
1 INCH = 1 FOOT

TRENCH LOG 15	Project No.: 74-069-EG
SAN ONOFRE NUCLEAR GENERATING STATION Units 2 and 3 SOUTHERN CALIFORNIA EDISON COMPANY	Date: 11-1-74
	DRAWING NO. 14
UGRO, INC. Long Beach, California	

TRENCH 16

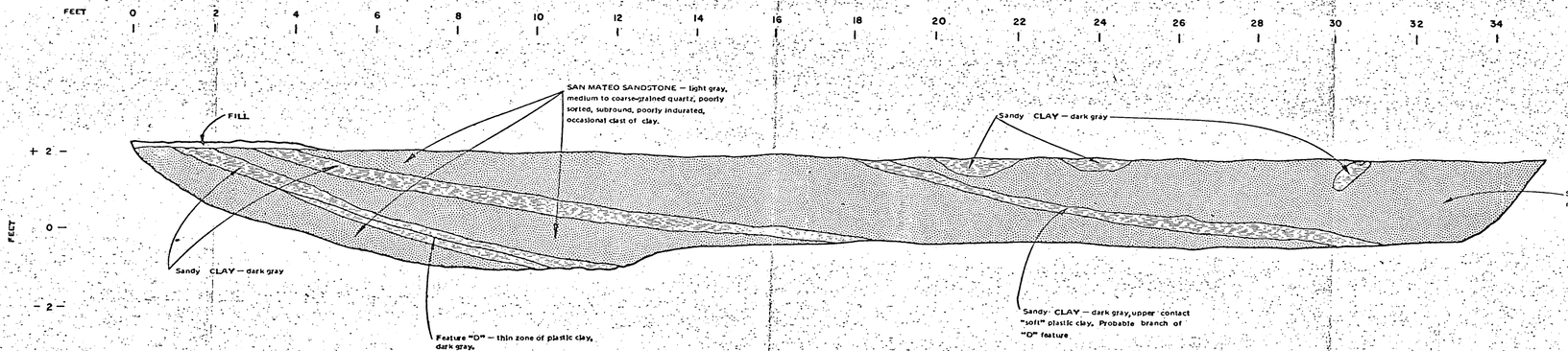


HORIZONTAL AND VERTICAL SCALE
1 INCH = 1 FOOT

TRENCH LOG 16	Project No 74-069-EG
SAN ONOFRE NUCLEAR GENERATING STATION UNITS 2 and 3	Date 11-1-74
SOUTHERN CALIFORNIA EDISON COMPANY	Drawn By DS
	Checked By
	Approved By
TERRO, INC. Long Beach California	Drawing No 15

TRENCH 17

N 25° E ——→ WEST FACE

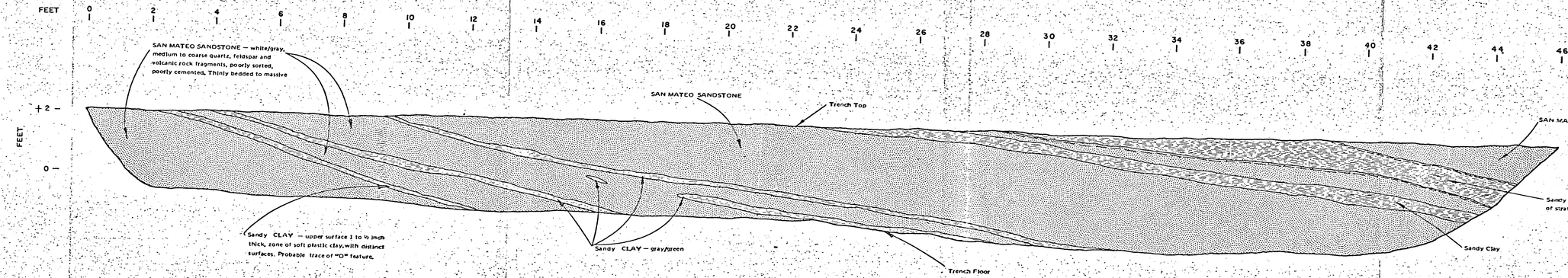


HORIZONTAL AND VERTICAL SCALE
1 INCH = 2 FEET

TRENCH LOG 17	Project No.: 74-069-EG
SAN ONOFRE NUCLEAR GENERATING STATION UNITS 2 and 3	Date: 11-7-74
SOUTHERN CALIFORNIA EDISON COMPANY	COMPILED BY DS
	PREPARED BY
	CHECKED BY
	APPROVED BY
UNRD, INC. Long Beach, California	Drawing No. 16

TRENCH 18

N 130 W ——— WEST FACE



HORIZONTAL AND VERTICAL SCALE
1 INCH = 2 FEET

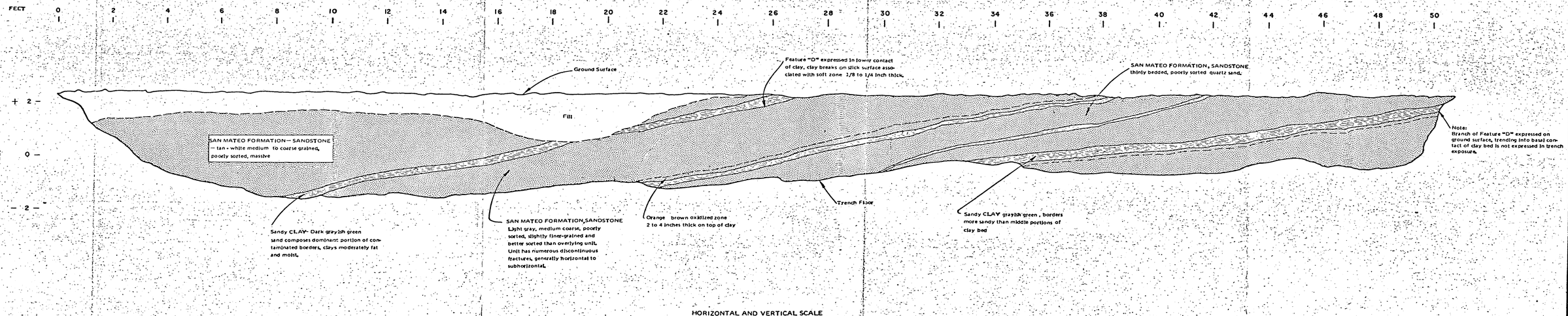
TRENCH LOG 18	Project No.: 74-069-EG
SAN ONOFRE NUCLEAR GENERATING STATION UNITS 2 and 3 SOUTHERN CALIFORNIA EDISON COMPANY	Date: 11-1-74
	DRAWN BY GS
	PREPARED BY
	CHECKED BY
	APPROVED BY
	DRAWING NO. 17

TERRA, INC. Long Beach, California

15

TRENCH 19

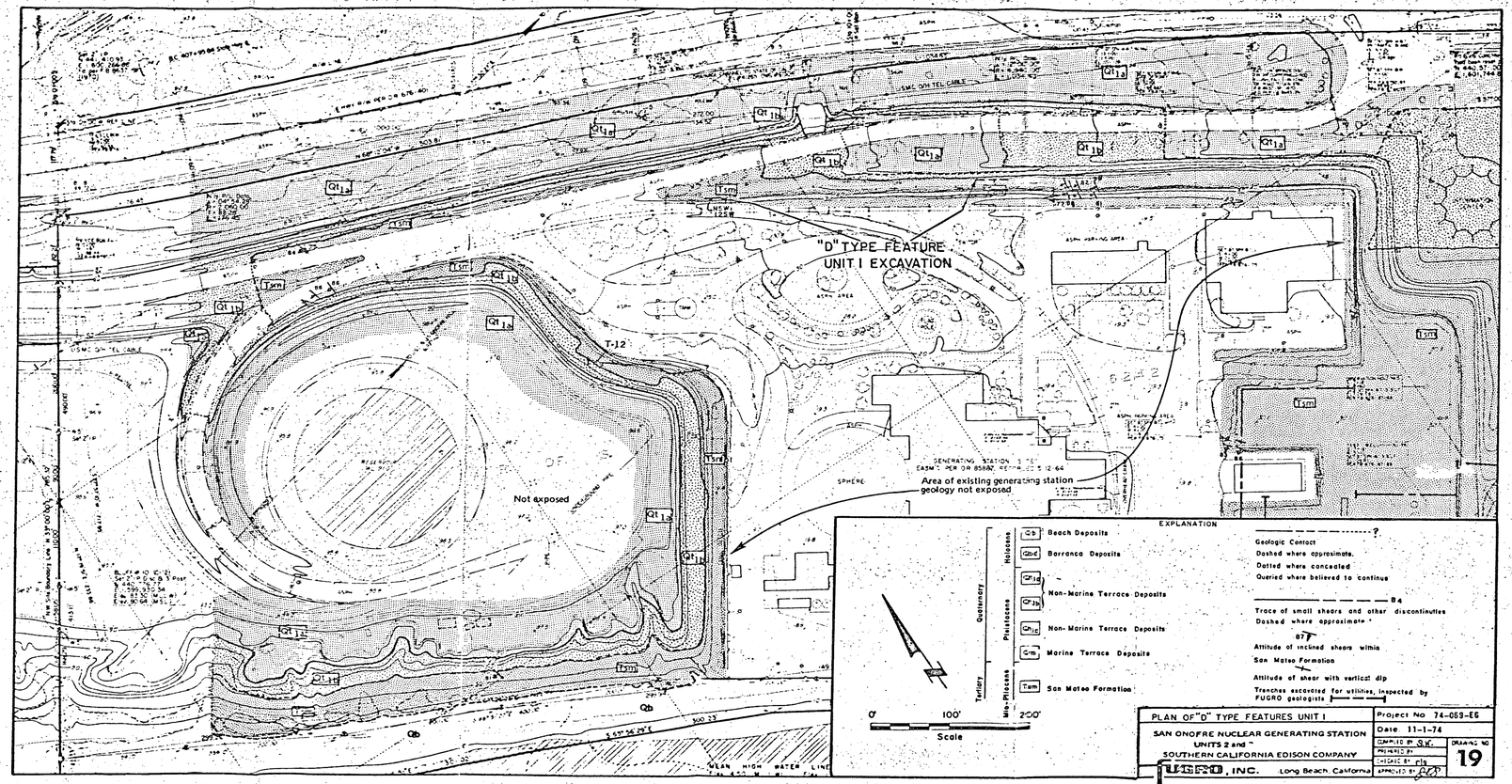
N 13° W EAST FACE

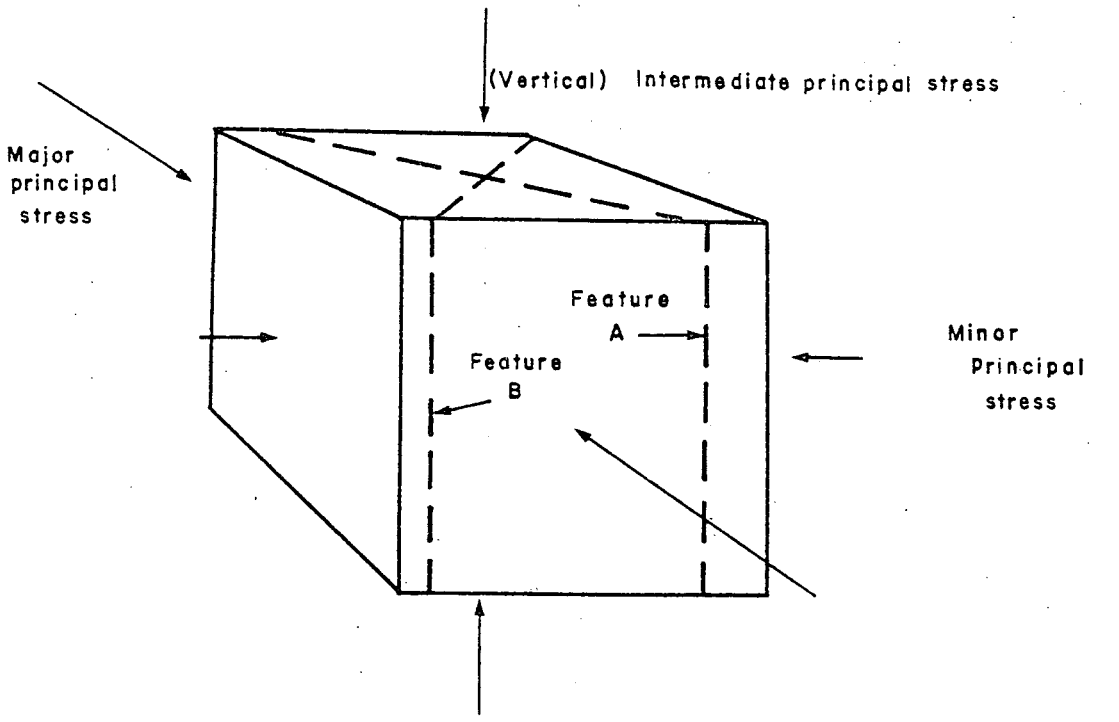


HORIZONTAL AND VERTICAL SCALE
1 INCH = 2 FEET

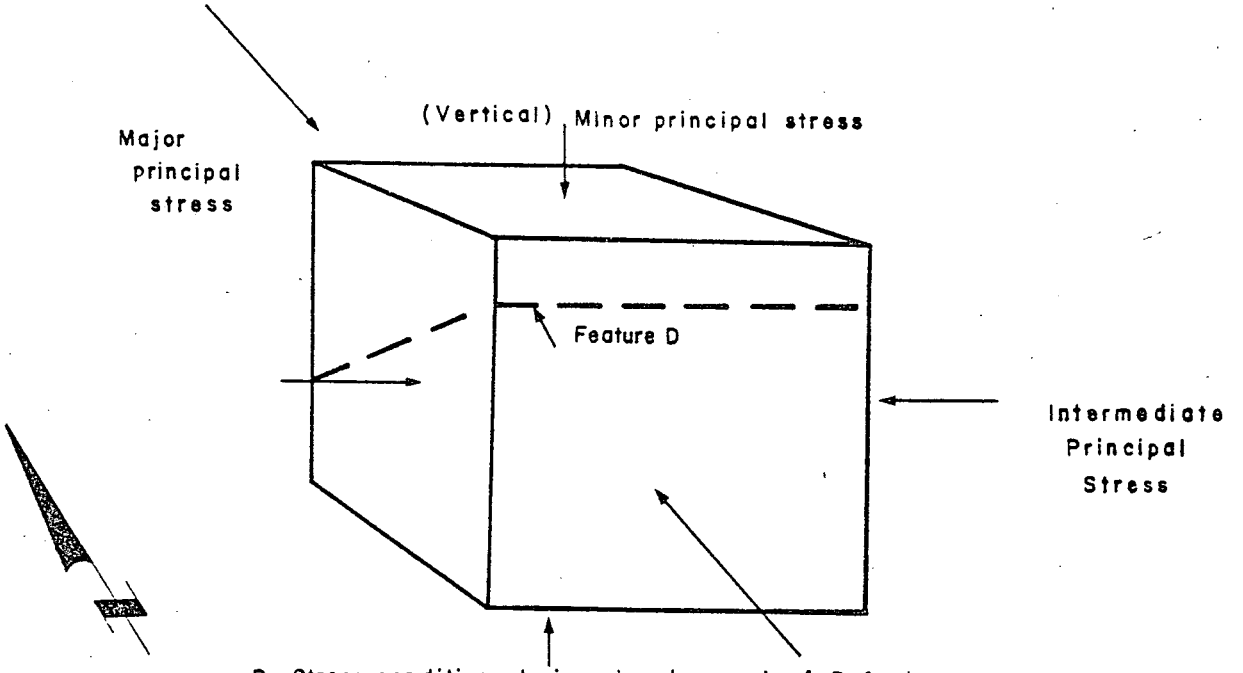
TRENCH LOG 19	Project No 74-069-EG
SAN ONOFRE NUCLEAR GENERATING STATION UNITS 2 and 3 SOUTHERN CALIFORNIA EDISON COMPANY	Date 11-1-74
	DRAWING NO 18
	DRAWN BY [illegible]
	CHECKED BY [illegible]
	APPROVED BY [illegible]

[illegible], INC. Long Beach, California


"D" TYPE FEATURE
UNIT I EXCAVATION
Not exposed
Area of existing generating station
geology not exposed
T-12
EXPLANATION
Qb Beach Deposits
Qbr-d Barranca Deposits
Qt 2a Non-Marine Terrace Deposits
Qt 2b
Qt 1c Non-Marine Terrace Deposits
Qm Marine Terrace Deposits
Tsm San Mateo Formation
Holocene
Pleistocene
Quaternary
Tertiary
Mio-Pliocene
Geologic Contact
Dashed where approximate.
Dotted where concealed
Queried where believed to continue
Trace of small shears and other discontinuities
Dashed where approximate
Attitude of inclined shears within
San Mateo Formation
Attitude of shear with vertical dip
Trenches excavated for utilities, inspected by
FUGRO geologists
0' 100' 200'
Scale
PLAN OF "D" TYPE FEATURES UNIT I
SAN ONOFRE NUCLEAR GENERATING STATION
UNITS 2 and 3
SOUTHERN CALIFORNIA EDISON COMPANY
FUGRO, INC. Long Beach, California
Project No 74-069-E6
Date 11-1-74
DRAWING NO
19



A. Stress conditions during development of A and B features.



B. Stress conditions during development of D feature.

REGIONAL STRESS CONDITIONS	Project No 74-069-EG
SAN ONOFRE NUCLEAR GENERATING STATION UNITS 2 and 3	Date 11-1-74
SOUTHERN CALIFORNIA EDISON COMPANY	COMPILED BY R.L.H. / PREPARED BY / CHECKED BY / APPROVED BY
TUDRO, INC. Long Beach, California	DRAWING NO 20