# Memorandum

To: MR. JERRY PEARCE
Chief, Geotechnical Branch C
Geotechnical Design South

Date: March 14, 2002

File: 08-SBd-58-KP35.1-50.0
EA 08-043510

Attention: Mr. Jeremy Lancaster

From: **DEPARTMENT OF TRANSPORTATION**
**DIVISION OF ENGINEERING SERVICES**
**GEOTECHNICAL SERVICES - MS #5**

Subject: Seismic Refraction Survey for Rippability Evaluation, State Route 58.

**Introduction**

This report documents results of a seismic survey undertaken for a proposed realignment and widening of State Route 58 at Hinkley, San Bernadino County. The purpose of the survey was to determine the rippability of the materials within the proposed new alignment. Proposed cuts within the area of interest are expected to be up to 16 meters. Precambrian gneiss/marble dominate the geology of the site and were observed in outcrop throughout.

**Data Acquisition and Processing**

Seismic refraction data were recorded along two continuos profiles using an EG&G Smartseis 24 channel seismograph with 14 MHz geophones. Each profile was 120 meters in length and had 5-meter geophone spacings.

Explosives were used as the seismic source for the survey. The seismic source was detonated in a shallow borehole. During data acquisition, the profile geometry (shot and geophone locations) was recorded and stored in seismograph memory. Refraction data from each shot were also stored in the seismograph's memory. Five shots were recorded for each profile. Both profile geometry and refraction data were backed-up to paper and floppy disk upon completion of the survey. The attached map shows the general location and orientation of the profiles. All elevations presented in this report are relative to a temporary benchmark (TBM) set in the field and given an arbitrary elevation of 30.48 meters (100.0 feet). The TBM is an existing lath marking centerline stationing labeled CL 383+00 for Profile 1. Profile 2 elevations were referenced off of a different lath labeled RW 383+00. Actual field elevations can be determined if surveyed elevations of our referenced benchmark are provided.

Interpretation of the survey results used the Generalized Reciprocal Method of refraction interpretation (GRM; Palmer, 1980). The method can accommodate variation in refractor velocity and depth along the seismic line, is relatively insensitive to refractor dip (up to 20 degrees), and can accommodate hidden layer conditions (where supporting borehole data exist).

Viewseis computer program was used to analyze and interpret the refraction data. This is a commercially developed program that uses the GRM method for interpretation and presentation

of refraction data. This method calculates refractor depths for each geophone location, using overlapping refraction arrival times from both forward and reverse shots. Accuracy of the GRM method relies on data from both forward and reverse shots, and on the selection of an optimum XY value. XY is defined as the distance of separation, measured at the surface, where forward and reverse seismic waves originate from the same point on the refractor.

Where incomplete refractor coverage exists, the refractor can be modeled using the standard intercept-time method of interpretation (ITM), but with comparatively reduced accuracy.

In addition to the intercept-time method of interpretation, two methods of GRM interpretation can be used: the approximate velocity (AP) and the average velocity (AV) method. The approximate velocity method is relatively insensitive to selection of the optimum XY. However, this method requires that every refractor above the target be defined. The average velocity method is very sensitive to optimum XY selection and is, therefore, normally used only where supporting borehole information exists. However, the average velocity method does not require that every refractor above the target be known. The type of line drawn for the refractor represents the method used for interpretation. ITM interpretations are shown as a solid line, GRM interpretations are drawn as a series of arcs—the envelope formed by the locus of interconnecting points at the base of these arcs represents the "best fit" model for the refractor.

The refraction data were transferred from the seismograph to the Viewseis program via floppy disks. Utilizing the Viewseis program, initial P-wave arrivals were picked for the seismic line and refractor layers assigned. GRM analyses were then performed. Resulting travel-time curves, velocity models, and depth sections are presented in Figures 1-2 of this report. Layer velocities, thicknesses, and rippabilities are summarized in Table 1. Average velocities and thicknesses are approximate and were estimated from velocity models and depth sections.

Profiles in this report are presented in terms of velocity units. A velocity unit is a three-dimensional unit, which due to its elastic properties and density, propagates seismic waves at a characteristic velocity or within a characteristic velocity range. Velocities denoted in this report and in the seismic refraction sections are expressed in meters per second. At least one velocity is present within a geological rock unit. In addition, each zone of weathering, or fracturing within that geological unit can constitute its own velocity unit. Conversely, when two rock units such as water saturated gravel and moderately weathered rock propagate seismic waves at the same velocity and are adjacent to each other, both units would be part of the same velocity unit. Lastly, discontinuous velocities might result from variation in the degree of alteration in the form of physical and chemical weathering and should be considered in the interpretation of the data.

**Results and Conclusions**

Ambient noise was minimal. Data quality is therefore good to excellent. While all three Viewseis methods (ITM, AV, and AP) were used to better understand the refractors, the optimum models for these lines utilized the AP method and are presented in this report accordingly. Results are summarized in Table 1.

Figure 1 shows compiled travel time curve, velocity model, and a depth section for Profile 1. Three velocity zones were detected. Zone 1 is easily ripped (ER), with an average velocity of 462 meters per second (m/s). Its average thickness is 1.8 meters. This zone is interpreted to be loose surficial deposits and slope wash. Zone 2 has an average velocity of 1785 m/sec., indicating moderately difficult ripping (DR/LB). It varies in thickness from 14.5 meters on the east to 16.4 meters at station 115 meters, and thickens to 20.1 meters at station 55 meters. This zone is interpreted as intensely weathered, highly fractured quartz diorite. LOTB identified rock at this depth as quartz diorite. LOTB indicates the fractures within the upper 7 meters were open, while at depth the fractures were healed. RQD also increased where healed fractures existed. Although the seismic velocity indicates difficult ripping/light blasting, it appears in outcrop to be more competent than the seismic velocity indicates. Therefore, it is likely that blasting will be more economic than ripping for that zone. Zone 3 has a seismic velocity of 2941 m/sec. and would require blasting if encountered. Its thickness is unknown as it extends beyond the depth of investigation. Zone 3 rock type is the same as zone 2 according to LOTB, but the fractures are healed with calcite, hematite, or epidote, providing for a higher seismic velocity. Zone 3 is deeper than the deepest proposed cut of 16 meters from ground level.

Figure 2 shows the compiled travel-time curve, velocity model, and depth section for Profile 2. Three velocity zones were detected. Zone 1 is easily ripped (ER), with an average velocity of 462 m/sec. Its thickness is 2.0 meters on the west to 1.7 at the east, with an average thickness of 1.9 meters. Zone 1 is interpreted to be colluvium and slope wash. Zone 2 has an average seismic velocity of 1627m/sec. (DR/LB). The average thickness for zone 2 is 14.0 meters. Zone 2 is interpreted as intensely weathered, highly fractured quartz diorite. Again, blasting is indicated for this zone. The third zone has a seismic velocity of 3046 m/sec.; indicating blasting will be needed if encountered, but it appears to be deeper than the deepest proposed cut (16 meters). Its thickness is unknown as it extends beyond the depth of this investigation. LOTB data identifies this zone as fractured, quartz diorite exhibiting healed fractures.

| Line Number | Layer | Average Thickness (m) | Range of Thickness (m) | Average Velocity (m/s) | Inferred Material | Rippability[1] |
|---|---|---|---|---|---|---|
| 1 | 1 | 1.85 | 1.8-1.9 | 462 | Colluvium | ER |
| 1 | 2 | 17.3 | 14.5-20.1 | 1785 | Weathered, fractured, qtz. Diorite | DR/LB |
| 1 | 3 | N/A | N/A | 2941 | Quartz diorite | BL |
| 2 | 1 | 1.9 | 1.7-2.0 | 462 | Colluvium | ER |
| 2 | 2 | 14 | 10.9-15.6 | 1627 | Weathered, fractured, qtz. Diorite | DR/LB |
| 2 | 3 | N/A | N/A | 3046 | Quartz diorite | BL |

[1] ER= Easily Ripped, MD= Moderately Difficult, DL/LB= Difficult Ripping/Light Blasting, BL= Blasting required. NA=Not Applicable.

Table 1. Results from interpretation of seismic refraction data.

**Rippability**

Ripping ability is based on unpublished Caltrans data for a Caterpillar D9G series bulldozer with a single-tooth ripper. These values are as follows:

| Velocity (m/s) | Rippability |
|---|---|
| <1050 | Easily Ripped |
| 1050-1500 | Moderately Difficult |
| 1500-2000 | Difficult Ripping/Light Blasting |
| >2000 | Blasting Required |

Different excavation equipment may experience different results. Penetrating efficacy of the ripping tooth is often more important in predicting ripping success than seismic velocity. If fracture or bed orientation does not allow tooth penetration, the soil or rock may not be rippable without blasting or other means of mechanical fracturing, despite having a low seismic velocity. Undetected blocks or lenses of high-velocity material may also be present within rippable zones, requiring blasting for excavation.

Thank you for the opportunity to work on this project. If you have any questions or need additional assistance, please call me at (916) 227-1307.

**References**

Palmer, D., 1980, The generalized reciprocal method of seismic refraction interpretation, Society of Exploration Geophysicists, Tulsa, Oklahoma, 104 p.

Report by:

Dennison Leeds
Engineering Geologist
Geophysics and Geology Branch

Reviewed by:

William Owen, CEG 1735
Chief, Geophysics and Geology Branch

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W. P. OWEN
No. 1735
Exp. 3/02
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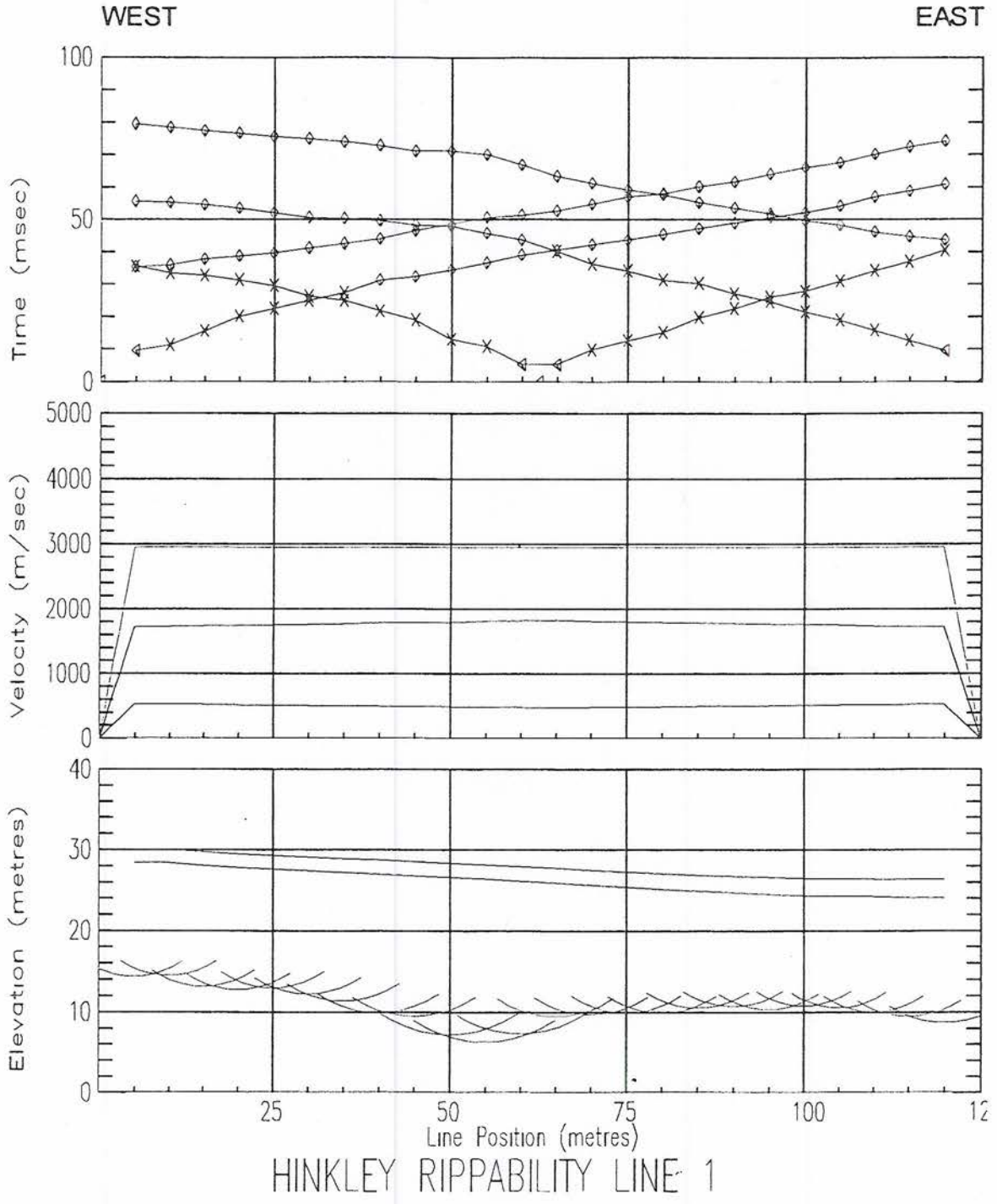
STATE OF CALIFORNIA

Attachment
c: Project File

dl/WO/highway58SR Report.doc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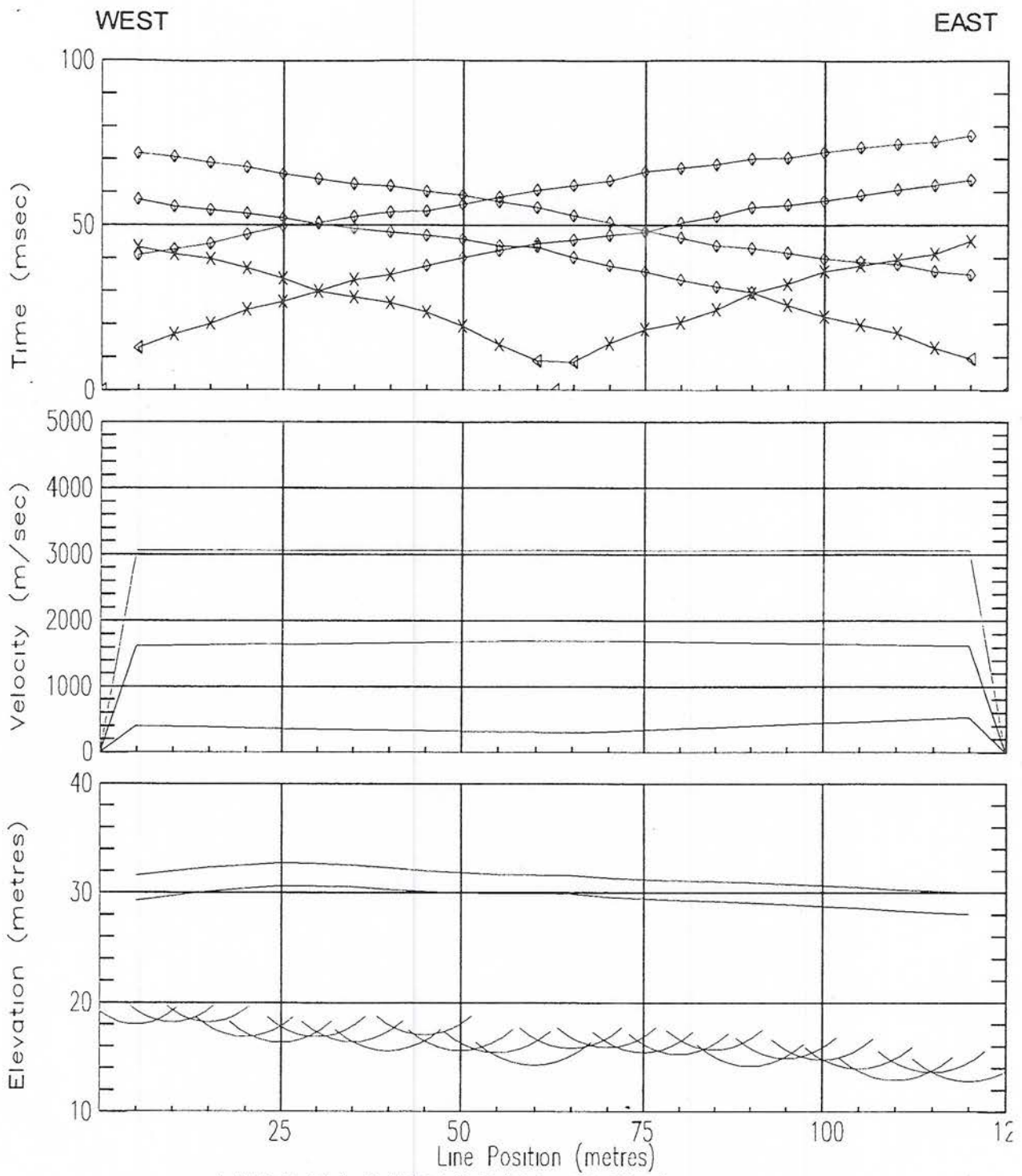
Time (msec)
100
50
0
Velocity (m/sec)
5000
4000
3000
2000
1000
0
Elevation (metres)
40
30
20
10
0
25
50
75
100
Line Position (metres)
HINKLEY RIPPABILITY LINE 1

Figure 1.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EAST
Time (msec)
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Velocity (m/sec)
5000
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3000
2000
1000
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Elevation (metres)
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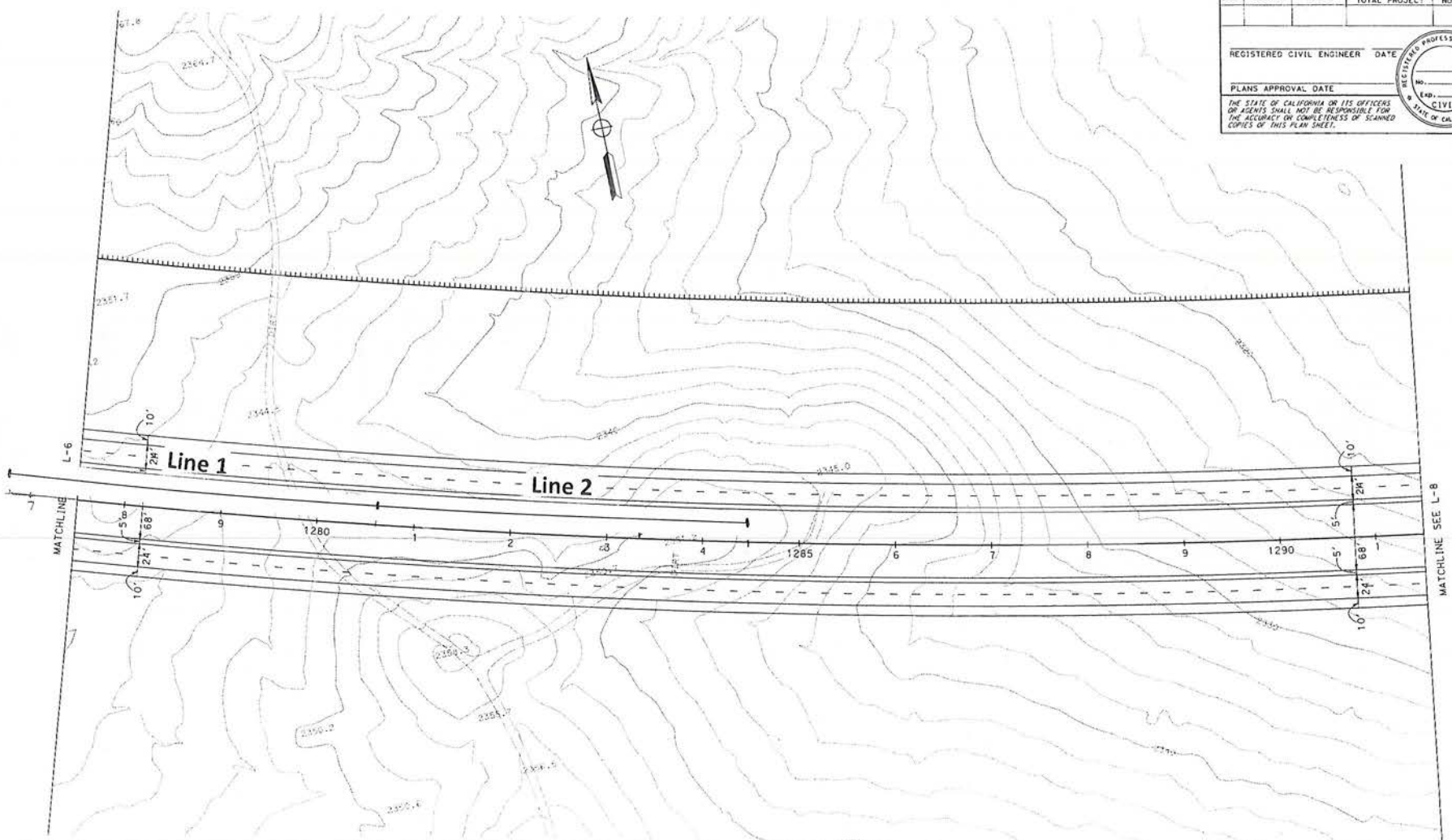
75
100
Line Position (metres)
HINKLEY RIPPABILITY LINE 2

Figure 2.




| Dist | COUNTY | ROUTE | POST MILES TOTAL PROJECT | SHEET No. | TOTAL SHEETS |
|---|---|---|---|---|---|
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REGISTERED CIVIL ENGINEER DATE

PLANS APPROVAL DATE

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| REVISED BY | DATE REVISED |
|---|---|
| | |

CALCULATED-DESIGNED BY

CHECKED BY

FUNCTIONAL SUPERVISOR

STATE OF CALIFORNIA - DEPARTMENT OF TRANSPORTATION

Caltrans

CALTRANS
Division of Engineering Services
Geotechnical Design-South 2

EA: 08-043510

Date: April 2013

**Geophysical Profile Location Map**

SR 58 Realignment @ Hinkley
08-SBd-58-PM 22.2/31.1

Figure No. 1

**LAYOUT**

SCALE: 1"=50'

L-7

LAST REVISED: DATE PLOTTED => 17-OCT-2012
00-00-00 TIME PLOTTED => 11:04

BORDER LAST REVISED 7/2/2010 | USERNAME => a112557 DGN FILE => b043510e00l7.dgn | RELATIVE BORDER SCALE IS IN INCHES 0 1 2 3 | UNIT 0000 | PROJECT NUMBER & PHASE 00000000001

State of California

Business, Transportation and Housing Agency

# Memorandum

To: MR. JERRY PEARCE
Chief, Geotechnical Branch C
Geotechnical Design South

Date: May 23, 2002

File: 08-SBd-58-KP35.1-50.0
EA 08-043510

Attention: Mr. Jeremy Lancaster

From: **DEPARTMENT OF TRANSPORTATION**
**DIVISION OF ENGINEERING SERVICES**
**GEOTECHNICAL SERVICES - MS #5**

Subject: Earthwork Factors, State Route 58.

**Introduction**

This memo is an addendum to the report dated March 14, 2002 regarding the results of a seismic survey undertaken for a proposed realignment and widening of State Route 58 at Hinkley, San Bernadino County. The purpose of this addendum is to furnish earthwork factor information as requested. Earthwork factor data is included in Table 1 below.

| Line Number | Layer | Average Thickness (m) | Earthwork Factor | Average Velocity (m/s) | Inferred Material | Rippability [1] |
|---|---|---|---|---|---|---|
| 1 | 1 | 1.85 | N/A | 462 | Colluvium | ER |
| 1 | 2 | 17.3 | 1.31 | 1785 | Weathered, fractured, qtz. Diorite | DR/LB |
| 1 | 3 | N/A | 1.43 | 2941 | Quartz diorite | BL |
| 2 | 1 | 1.9 | N/A | 462 | Colluvium | ER |
| 2 | 2 | 14 | 1.30 | 1627 | Weathered, fractured, qtz. Diorite | DR/LB |
| 2 | 3 | N/A | 1.49 | 3046 | Quartz diorite | BL |

[1] ER= Easily Ripped, MD= Moderately Difficult, DL/LB= Difficult Ripping/Light Blasting, BL= Blasting required. NA=Not Applicable.

Table 1. Results from interpretation of seismic refraction data.

**Earthwork Factors**

The earthwork factor for a highway grading project is the ratio of embankment to excavation volume. A factor of 1.0 indicates no volumetric change from excavation to emplacement. This is an empirical correlation between the seismic velocity of rock and their earthwork factors. Earthwork factors were derived from the velocity data and are summarized in table 1. Earthwork factors are based on published Caltrans studies (Stephens, 1978) and are extrapolated if necessary.

Thank you for the opportunity to work on this project. If you have any questions or need additional assistance, please call me at (916) 227-1307.

**References**

Palmer, D., 1980, The generalized reciprocal method of seismic refraction interpretation, Society of Exploration Geophysicists, Tulsa, Oklahoma, 104 p.

Stephens, E., 1978, Calculating earthwork factors using seismic velocities, California Department of Transportation, Report No. FHWA-CA-TL-78-23.

Report by:

Dennison Leeds
Engineering Geologist
Geophysics and Geology Branch

Reviewed by:

William Owen, CEG 1735
Chief, Geophysics and Geology Branch

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STATE OF CALIFORNIA

Attachment
c: Project File

dl/WO/highway58SR Report 1a.doc

# Route 58 Realignment--Hinkley
# 08-SBd-58-KP 37.8/39.2
# Borings 03-B13 & 03-B9

## Borehole Geophysical Measurements

**RTE 58 near Hinkley, San Bernardino County, California**

**EA: 08-043510**

A Report for Submittal to

Mr. Shawn Wei
Chief, Geotechnical Design – South 2, Branch C

Date: 12/1/03


Report By

David Hughes
Engineering Geologist
Geotechnical Support Branch

Reviewed By

William Owen, CEG 1735
Senior Engineering Geologist
Geotechnical Support Branch


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STATE OF CALIFORNIA

State of California

Business, Transportation and Housing Agency

File: 08-SBd-58-KP 37.8/39.2

RTE 58 Realignment--Hinkley
San Bernardino County, CA
EA: 08-043510

## INTRODUCTION

This report is a compilation of borehole geophysical measurements acquired at Route 58 Realignment—Hinkley, in San Bernardino County, California. This work was performed in August and September 2003 at the request of Faheem Syed. This report includes mechanical caliper and acoustic televiewer measurements. Engineering geologic interpretations for the measurements are also provided.

## DATA PRESENTATION

Information for each borehole is given on a cover sheet that describes the borehole information and data quality on Table 1, with an engineering geologic interpretation discussion. The geophysical logs are included in this report. Please refer to Appendix 1 for more in-depth descriptions of the logging equipment and quality designators.

Data files are available for review at your convenience. If you have any questions or comments, please contact David Hughes at (916) 227-4473, or William Owen at (916) 227-0227.

Attachments
cc: F Syed
W Owen – Project File

WO:dh

**Route 58 Realignment—Hinkley**
**08-SBd-58-KP 37.8/39.2**
**Boring 03-B13**

Drilling was conducted by Caltrans Drilling Services, and a lithologic log based on core samples was prepared by a Caltrans Geologist. The boring was completed and reamed to 13 cm diameter in August, 2003. The depth of the boring was reported as 19.1 meters (m) below ground surface (bgs). Mechanical caliper and Acoustic Televiewer measurements were acquired in this boring.

**Table 1. Summary of Borehole Conditions**

| | |
|---|---|
| Boring Number: | 03-B13 |
| Location: | Please refer to LOTB plan view. |
| Reference Elevation: | Ground level (GL) Not Provided, (Depth = 0.0). |
| Drill Bit Diameter: | Reamed to 13 cm |
| Total Depth (TD): | (Drilled) 19.1 m |
| Casing: | Conductor casing, surface to approximately 1.1 m bgs |
| Start Logging: | 8/28/03, ~1100 hrs |
| End: | 8/28/03, ~1700 hrs |
| Notes: | Loose rock encountered in boring at approximately 5.3 m bgs. Loose rock also encountered in bottom of boring. |

## ENGINEERING GEOLOGIC INTERPRETATION

### Field Notes

Preliminary study prior to field operations shows this area is within the 0.5-0.6g peak acceleration contour of the Lockhart Fault. Field observations and geologic (core) logging note the earth materials at the site consist of limestone (marble) and gneiss. During drilling and geologic logging, two faults were crossed, as suggested by clay gouge zones, slickensides, and interlayering of geologically different materials (marble-gneiss-marble). Much of the core was fractured, with two high angle fracture sets and a third low angle fracture set. Fractures varied from tight and healed fractures to apparent open, loose fractures. During placement of the Acoustic Televiewer tool, apparent loose rock was encountered at approximately 5.3 m bgs. Apparent loose rock was also encountered at approximately 14.7 m bgs.

### Geophysical Logs

### Caliper Log

Washouts were encountered at approximately 2 to 4 m, 9 m, and 14.5 m bgs. Two of these intervals appeared to produce loose rock that obstructed the borehole during geophysical logging, as noted above. Intermittent borehole rugosity was noted throughout the measured section.

**Acoustic Televiewer**

Multiple Acoustic Televiewer (AT) logs were collected in the field using various gain and borehole diameter settings. The most detailed AT log was collected from 1.96 m to 16.47 m bgs, and is included in this report. Planar features (fractures), appearing as sinusoidal waves, were manually picked using various contrast settings and vertical resolutions. These picks are shown on the log plot, along with a table of calculated feature strike and dip. These features were also plotted on stereonet plots. Log plots, tables and stereonet plots are included in this report.

**Discussion**

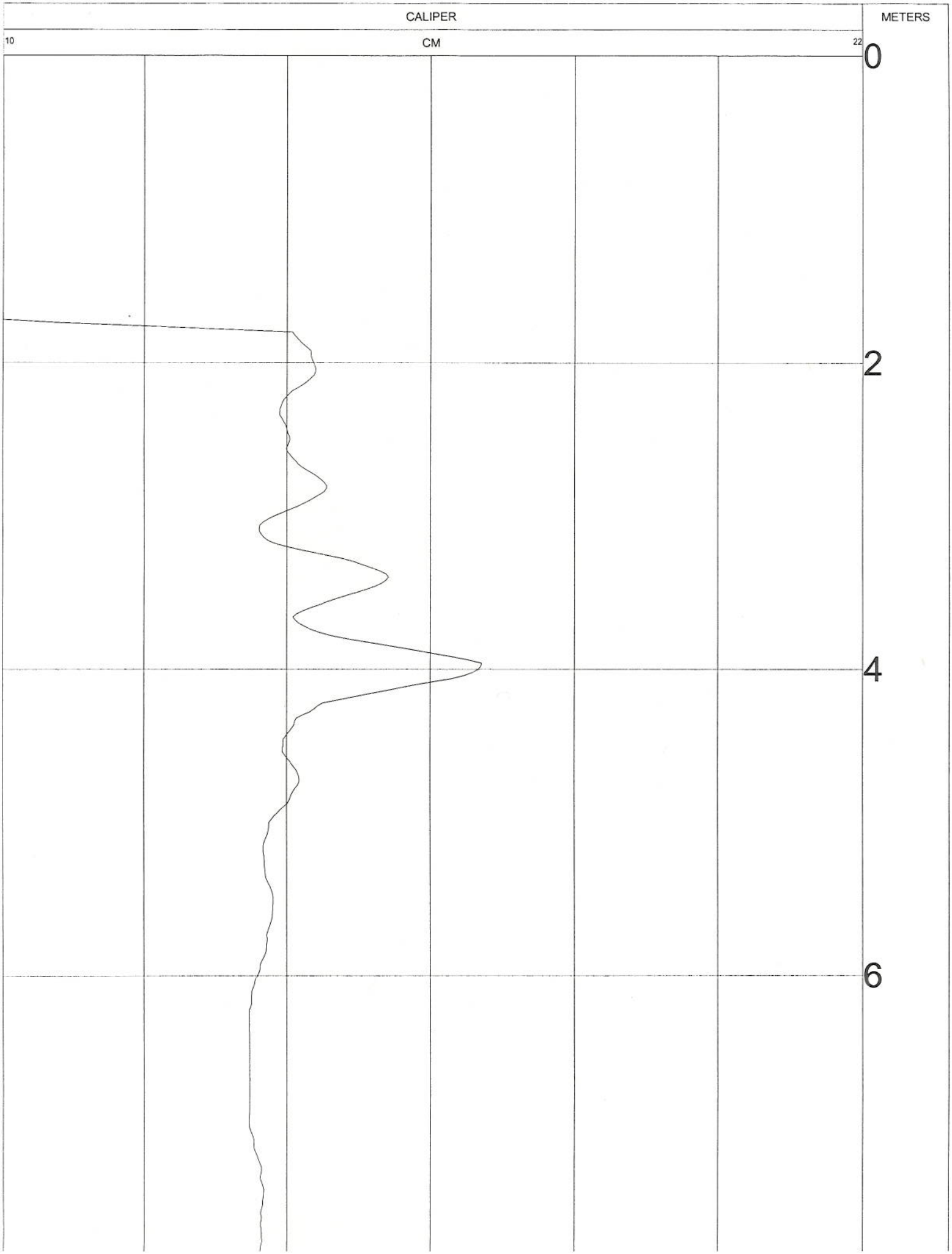
Based on stereoplots of structural conditions likely to give rise to failures (Hoek and Bray, 1977), the stereonet plot of this boring suggests potential wedge failure on two intersecting discontinuities. Possible direction of sliding would be to the northwest. Based on the fractured condition of the core noted during geologic logging, loose (fractured) rock, separating larger, more competent blocks, would be encountered during excavation. This would contribute to slope instability, independent of wedge failure. The presence of the two faults (noted above) would also contribute to slope instability.

# Century GEOPHYSICAL CORP.

## Hinkley 58 Realign 03-B13

| | | | | | |
|---|---|---|---|---|---|
| COMPANY | : Caltrans | | | OTHER SERVICES: | |
| WELL | : Hinkley 58 Realig | | | Acousti | |
| LOCATION/FIELD | : 03-B13 | | | | |
| COUNTY | : SbD | | | | |
| STATE | : CA | | | | |
| SECTION | : | TOWNSHIP | : | RANGE | : |
| DATE | : 08/28/03 | PERMANENT DATUM | : | | |
| DEPTH DRILLER | : 19.1 m. | | | KB | : N/A |
| LOG BOTTOM | : 19.24 | LOG MEASURED FROM: | GL | DF | : N/A |
| LOG TOP | : 1.67 | DRL MEASURED FROM: | GL | GL | : |
| CASING DIAMETER | : 15. | LOGGING UNIT | : 7311 | | |
| CASING TYPE | : Steel | FIELD OFFICE | : Land Hole | | |
| CASING THICKNESS: | | RECORDED BY | : Hughes, Ma | | |
| BIT SIZE | : 13 | BOREHOLE FLUID | : 0 | FILE | : ORIGINAL |
| MAGNETIC DECL. | : 13.5 | RM | : 0 | TYPE | : 9065A |
| MATRIX DENSITY | : 2.71 | RM TEMPERATURE | : 0 | | |
| NEUTRON MATRIX | : Dolomite | MATRIX DELTA T | : 140 | | |
| | | | | THRESH: | 20000 |

08-043510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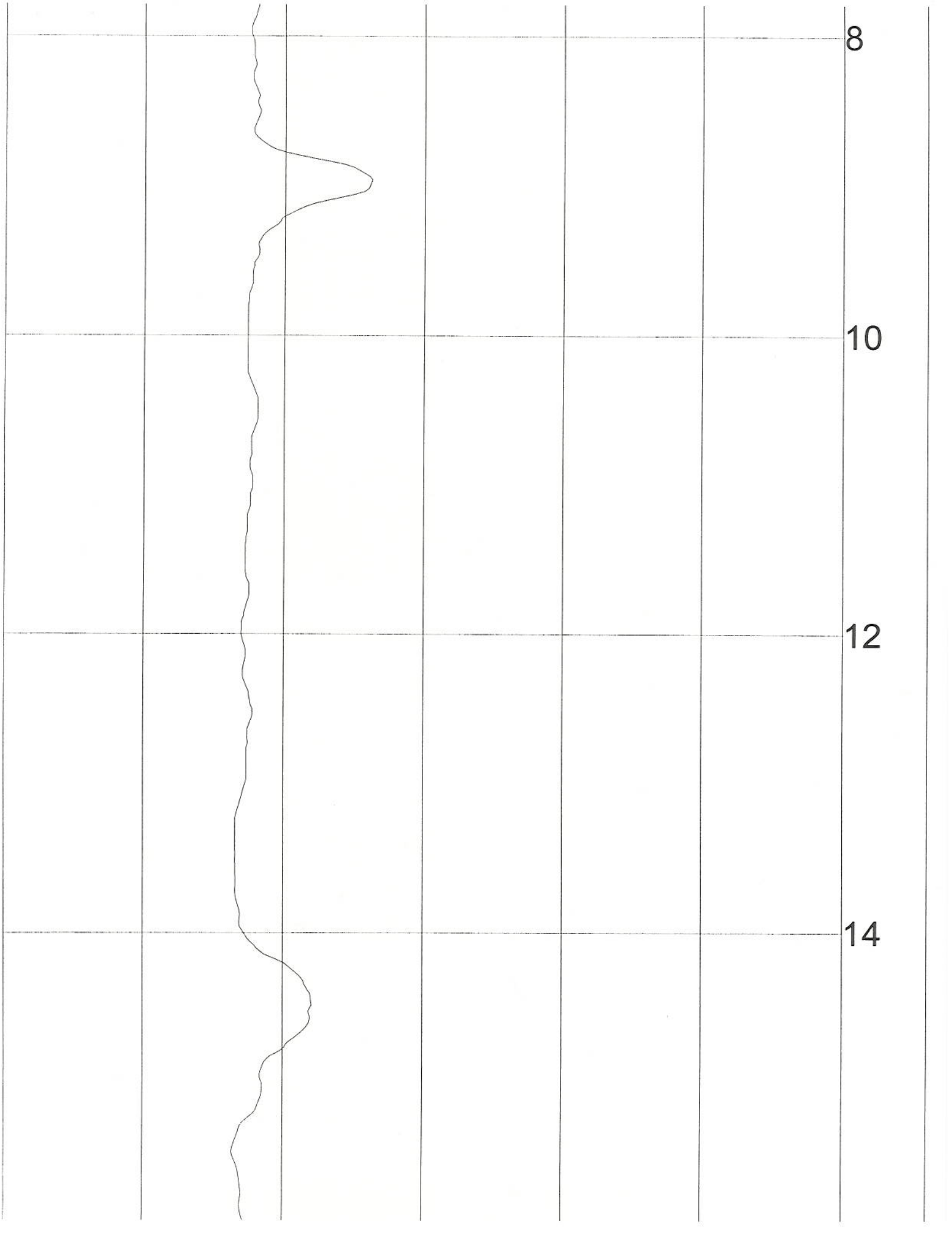
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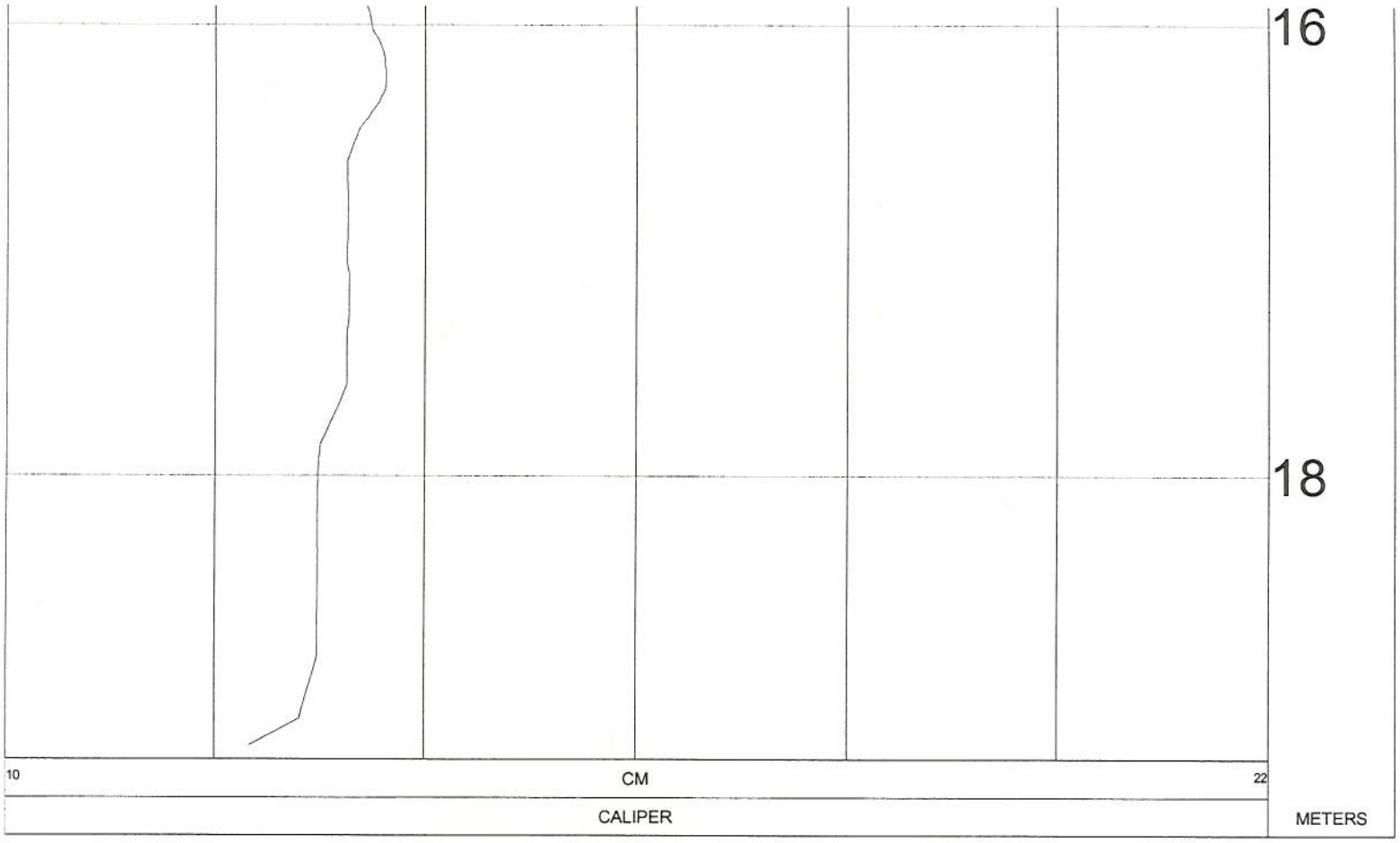
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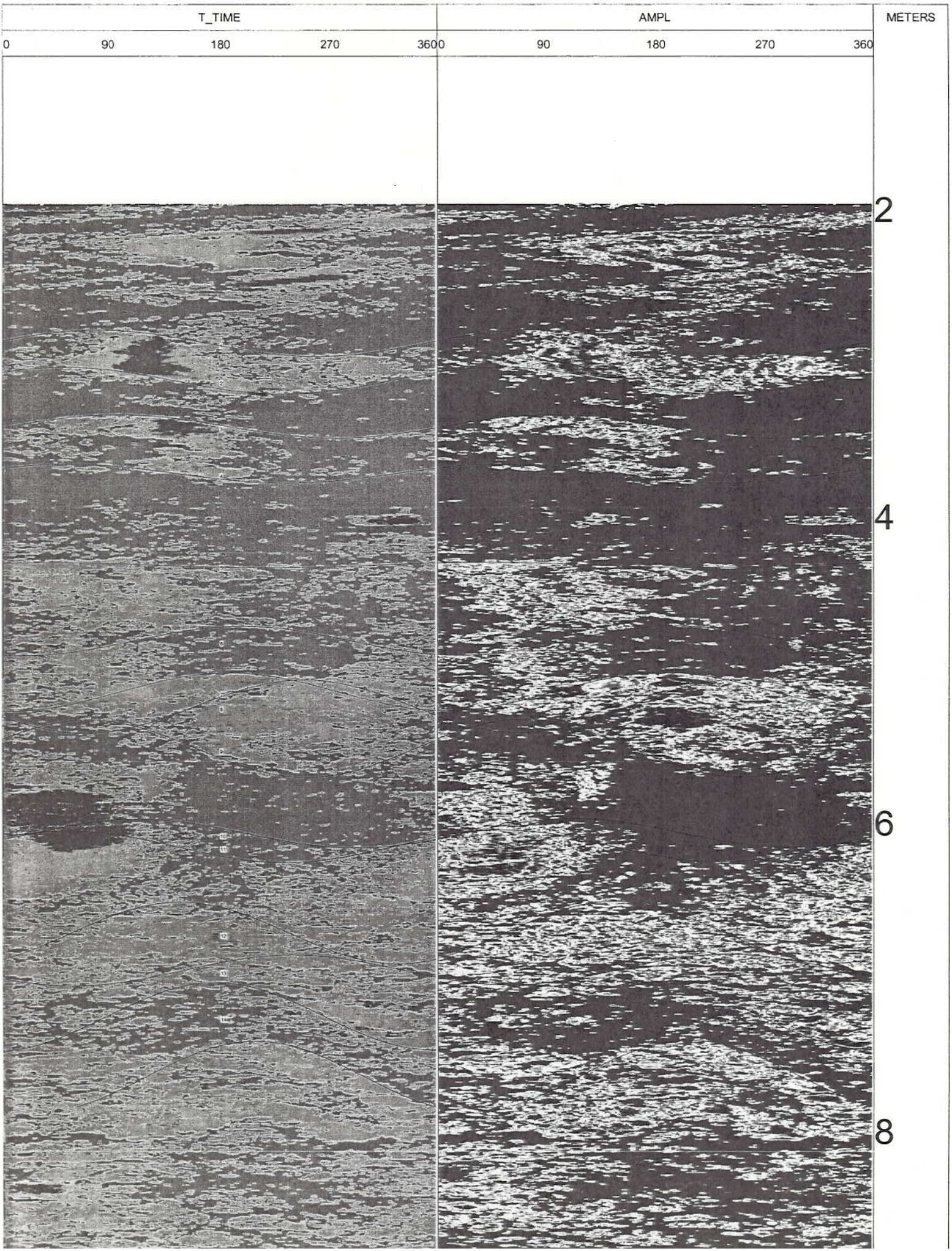
# Century GEOPHYSICAL CORP.

## 58 Realign 03-B13

| | | | | | |
|---|---|---|---|---|---|
| COMPANY | : Caltrans | | | OTHER SERVICES: | |
| WELL | : 58 Realign 03-B13 | | | Caliper | |
| LOCATION/FIELD | : 08-SbD-58 | | | | |
| COUNTY | : SbD | | | | |
| STATE | : CA | | | | |
| SECTION | : | TOWNSHIP | : | RANGE | : |
| DATE | : 08/28/03 | PERMANENT DATUM | : | | |
| DEPTH DRILLER | : 19.1 m. | | | KB | : N/A |
| LOG BOTTOM | : 16.47 | LOG MEASURED FROM: | GL | DF | : N/A |
| LOG TOP | : 1.96 | DRL MEASURED FROM: | GL | GL | : |
| CASING DIAMETER | : 13 | LOGGING UNIT | : 7311 | | |
| CASING TYPE | : Steel | FIELD OFFICE | : Land Hole | | |
| CASING THICKNESS: | | RECORDED BY | : Hughes | | |
| BIT SIZE | : 13 cm. | BOREHOLE FLUID | : 0 | FILE | : PROCESSED |
| MAGNETIC DECL. | : 13.5 | RM | : 0 | TYPE | : 9800A |
| MATRIX DENSITY | : 2.71 | RM TEMPERATURE | : 0 | | |
| NEUTRON MATRIX | : Dolomite | MATRIX DELTA T | : 140 | | |
| | | | | THRESH: | 20000 |

EA: 08-04351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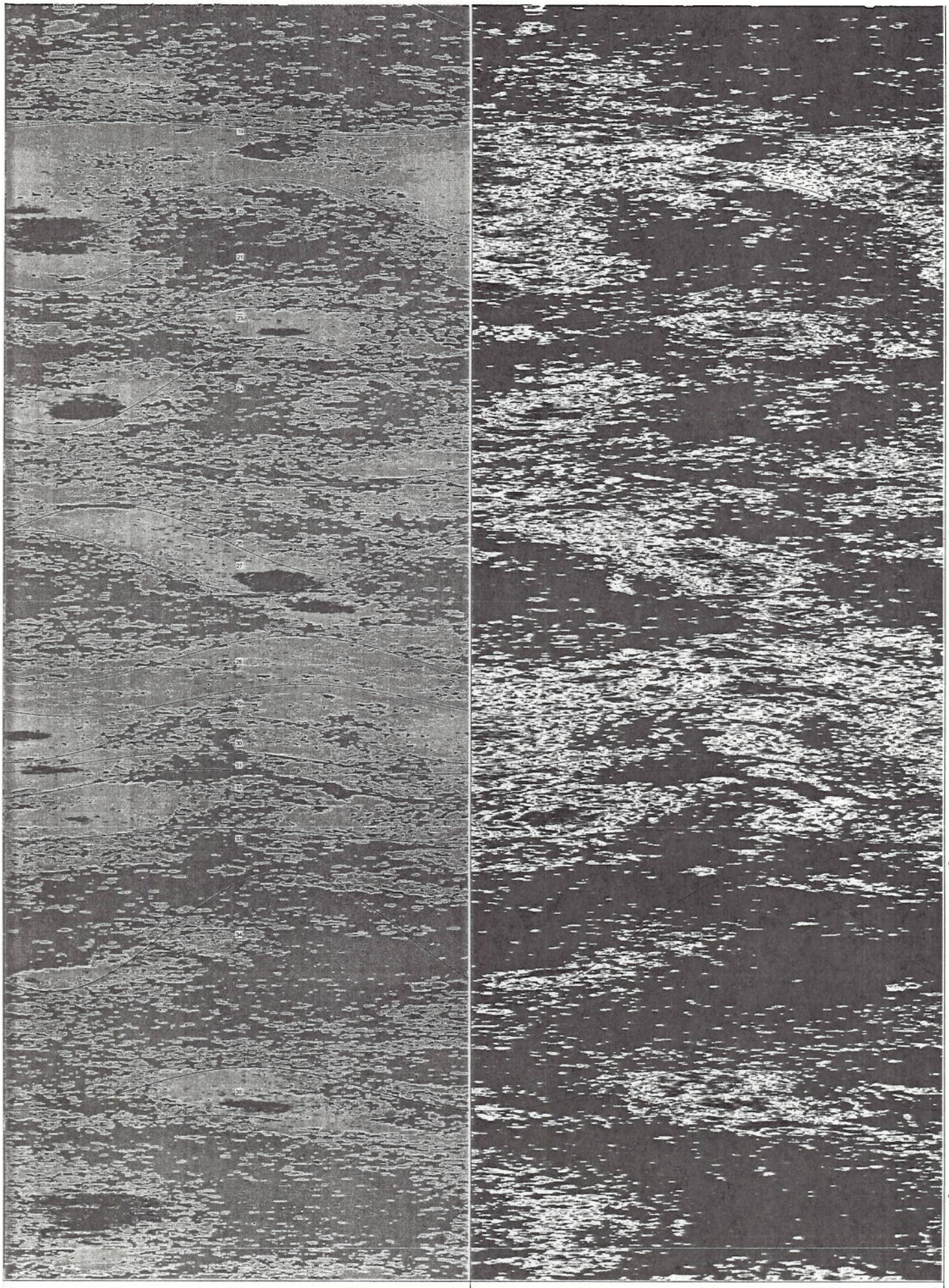
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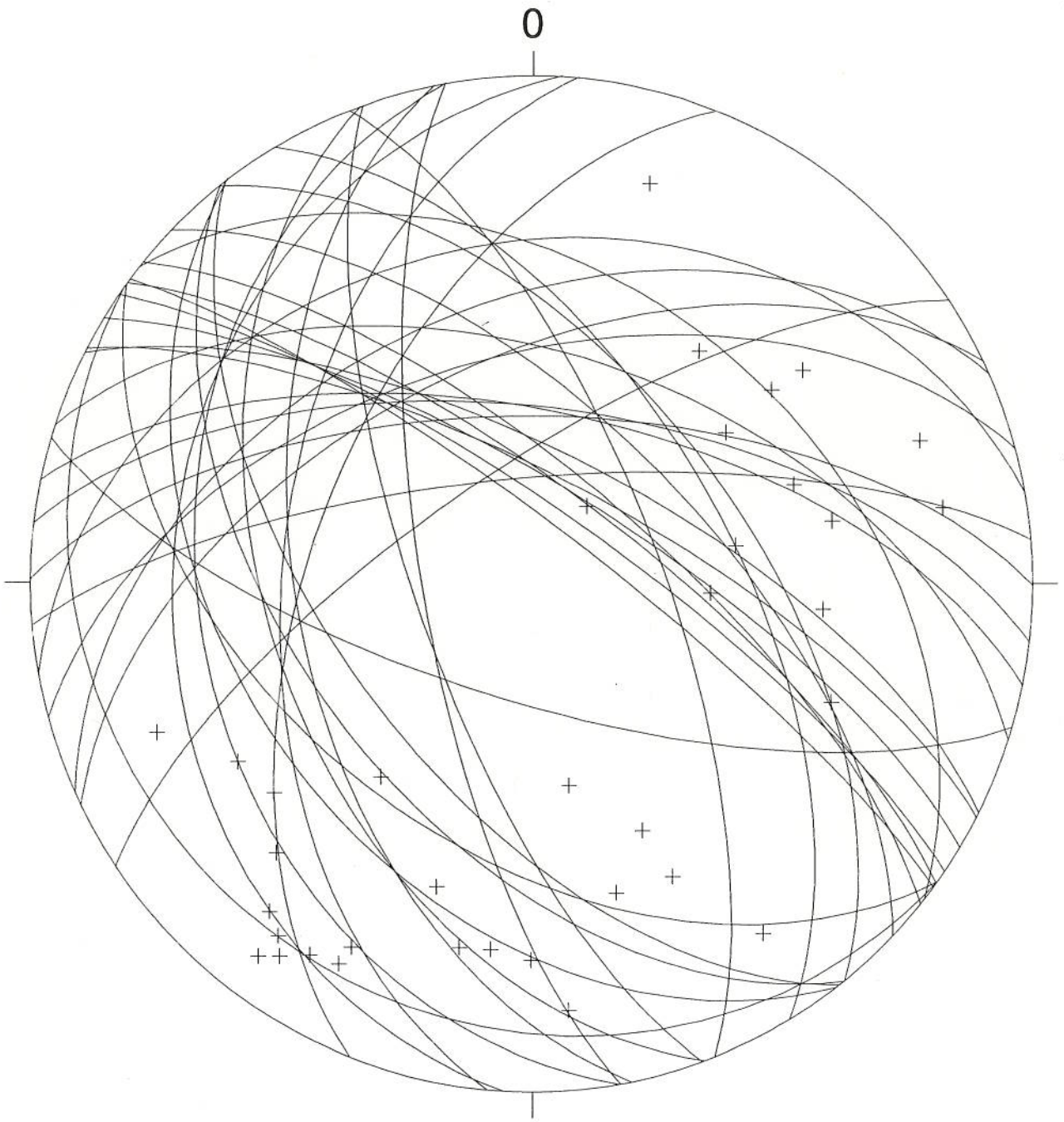
COMPANY : Caltrans
WELL : 58 Realign 03-B13

| FRACTURE NUMBER | DIP * ( DEG ) | AZIMUTH * ( DEG ) | TO ( M ) | FROM ( M ) | APERTURE ( CM ) | BORE ( CM ) | CATEGORY |
|---|---|---|---|---|---|---|---|
| 1 | 51.11 | 258.45 | 2.78 | 2.95 | 0.00 | 13.63 | Fracture |
| 2 | 51.02 | 231.49 | 3.02 | 3.19 | 0.00 | 13.80 | Fracture |
| 3 | 48.62 | 275.15 | 3.33 | 3.48 | 0.00 | 13.00 | Fracture |
| 4 | 40.06 | 232.60 | 3.65 | 3.78 | 0.00 | 13.91 | Fracture |
| 5 | 14.93 | 215.66 | 4.30 | 4.33 | 0.00 | 13.00 | Fracture |
| 6 | 52.76 | 17.95 | 4.71 | 4.90 | 0.00 | 13.88 | Fracture |
| 7 | 61.76 | 6.72 | 5.01 | 5.26 | 0.00 | 13.00 | Fracture |
| 8 | 69.39 | 68.52 | 5.06 | 5.40 | 0.00 | 13.00 | Fracture |
| 9 | 71.00 | 250.05 | 5.32 | 5.69 | 0.00 | 12.53 | Fracture |
| 10 | 53.89 | 291.46 | 5.97 | 6.16 | 0.00 | 13.52 | Fracture |
| 11 | 57.58 | 232.21 | 6.04 | 6.25 | 0.00 | 13.00 | Fracture |
| 12 | 71.76 | 326.18 | 6.51 | 6.91 | 0.00 | 13.00 | Fracture |
| 13 | 57.99 | 58.97 | 6.85 | 7.05 | 0.00 | 13.00 | Fracture |
| 14 | 73.33 | 355.12 | 7.03 | 7.47 | 0.00 | 13.00 | Fracture |
| 15 | 73.19 | 27.37 | 7.41 | 7.87 | 0.00 | 13.85 | Fracture |
| 16 | 33.76 | 259.87 | 7.97 | 8.06 | 0.00 | 13.00 | Fracture |
| 17 | 46.88 | 215.96 | 8.63 | 8.77 | 0.00 | 13.00 | Fracture |
| 18 | 74.79 | 36.18 | 8.50 | 8.98 | 0.00 | 13.00 | Fracture |
| 19 | 29.06 | 273.39 | 9.50 | 9.58 | 0.00 | 14.11 | Fracture |
| 20 | 69.19 | 26.79 | 9.84 | 10.21 | 0.00 | 13.74 | Fracture |
| 21 | 74.47 | 31.29 | 10.07 | 10.53 | 0.00 | 13.00 | Fracture |
| 22 | 72.06 | 39.13 | 10.47 | 10.83 | 0.00 | 12.17 | Fracture |
| 23 | 40.38 | 38.41 | 10.61 | 10.72 | 0.00 | 13.00 | Fracture |
| 24 | 78.05 | 34.54 | 10.80 | 11.38 | 0.00 | 13.00 | Fracture |
| 25 | 46.29 | 249.79 | 11.54 | 11.68 | 0.00 | 13.00 | Fracture |
| 26 | 72.06 | 259.83 | 11.81 | 12.24 | 0.00 | 13.00 | Fracture |
| 27 | 70.73 | 196.52 | 11.97 | 12.35 | 0.00 | 13.00 | Fracture |
| 28 | 62.94 | 43.93 | 12.60 | 12.88 | 0.00 | 13.96 | Fracture |
| 29 | 55.83 | 51.27 | 12.89 | 13.08 | 0.00 | 13.00 | Fracture |
| 30 | 63.34 | 0.32 | 13.09 | 13.37 | 0.00 | 13.00 | Fracture |
| 31 | 44.47 | 335.67 | 13.29 | 13.43 | 0.00 | 13.00 | Fracture |
| 32 | 53.99 | 334.09 | 13.40 | 13.59 | 0.00 | 13.00 | Fracture |
| 33 | 33.42 | 349.82 | 13.76 | 13.85 | 0.00 | 13.00 | Fracture |
| 34 | 80.67 | 36.71 | 14.03 | 14.74 | 0.00 | 13.00 | Fracture |
| 35 | 62.44 | 11.59 | 15.20 | 15.46 | 0.00 | 13.61 | Fracture |
| 36 | 53.09 | 344.60 | 15.49 | 15.67 | 0.00 | 13.63 | Fracture |

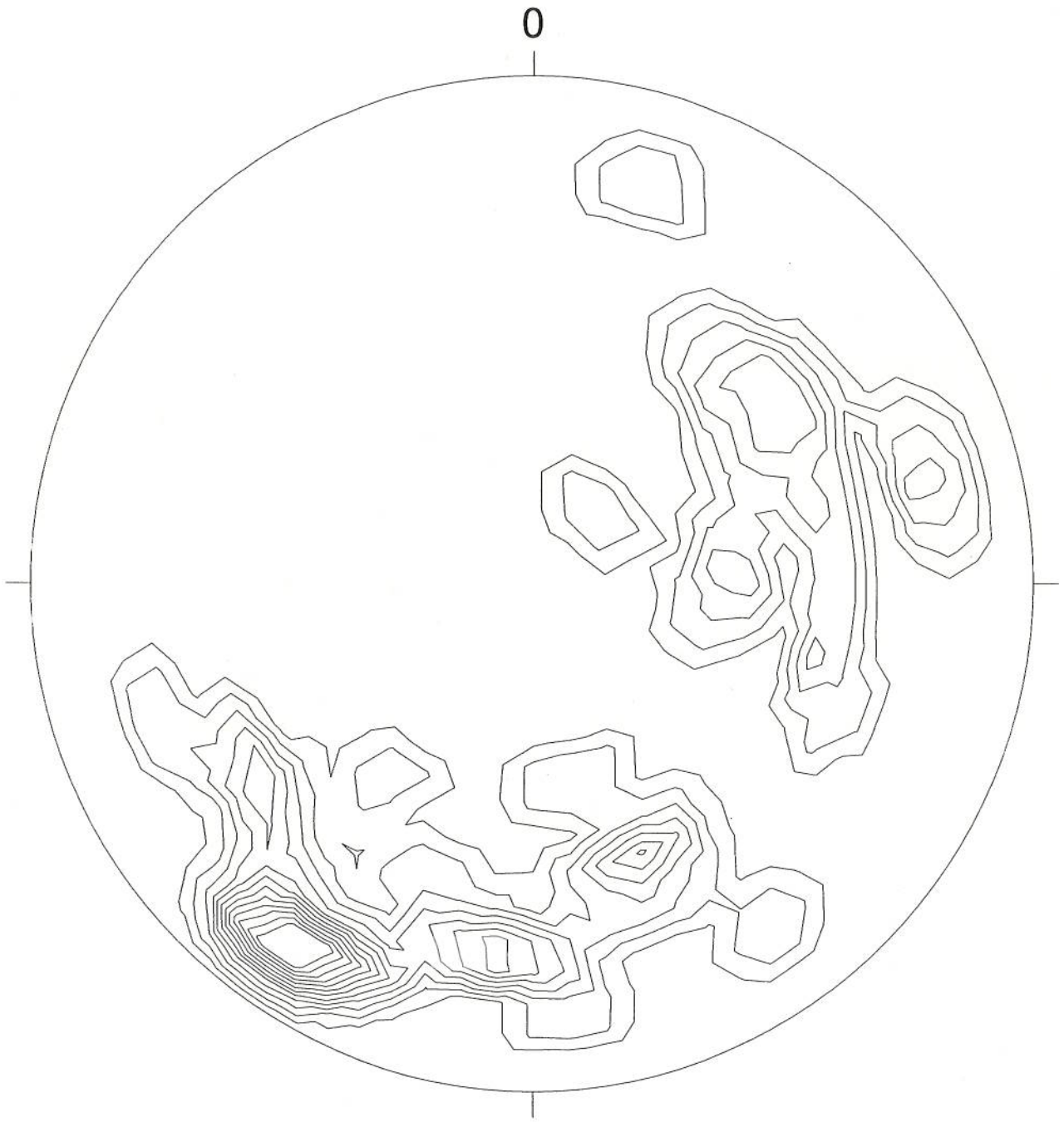
* NOTE: THESE MEASUREMENTS ARE DIP & DIP DIRECTION OF THE PLANE




HIGHWAY 58 REALIGN
@ HINKLEY
BORING 03-B13

+ n=36 (P)
Num total: 36

Equal area projection, lower hemisphere




HIGHWAY 58 REALIGN
@ HINKLEY
BORING 03-B13

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min. dens.=0.00
Contours at:
0.00,1.00,2.00,3.00,
4.00,5.00,6.00,7.00,
8.00,9.00,10.00,11.00,
12.00,
(Multiples of random distribution)

Equal area projection, lower hemisphere

**Route 58 Realignment—Hinkley**
**08-SBd-58-KP 37.8/39.2**
**Boring 03-B9**

Drilling was conducted by Caltrans Drilling Services, and a lithologic log based on core samples was prepared by a Caltrans Geologist. The boring was completed and reamed to 13 cm diameter in September, 2003. The depth of the boring was reported as 14.6 meters (m) below ground surface (bgs). Mechanical caliper and Acoustic Televiewer measurements were acquired in this boring.

**Table 1. Summary of Borehole Conditions**

| | |
|---|---|
| Boring Number: | 03-B9 |
| Location: | Please refer to LOTB plan view. |
| Reference Elevation: | Ground level (GL) Not Provided, (Depth = 0.0). |
| Drill Bit Diameter: | Reamed to 13 cm |
| Total Depth (TD): | (Drilled) 14.6 m |
| Casing: | Conductor casing, surface to approximately 1.1 m bgs |
| Start Logging: | 9/3/03, ~1130 hrs |
| End Logging: | 9/3/03, ~1630 hrs |
| Notes: | Loose rock encountered in boring at approximately 6 m bgs. |

## ENGINEERING GEOLOGIC INTERPRETATION

### Field Notes

Preliminary study prior to field operations shows this area is within the 0.5-0.6g peak acceleration contour of the Lockhart Fault. During conversation with the Caltrans driller, borehole conditions were noted as "similar to B13". Fractured gneiss was logged during drilling: marble and faulting were not encountered. During placement of the Caliper tool, apparent loose rock that blocked the boring was encountered at approximately 6 m bgs. The driller reamed the boring, and logging continued.

### Geophysical Logs

### Caliper Log

Washouts were encountered at approximately 3.25 m, and 6 m bgs. The washout at 6 m appeared to produce loose rock that obstructed the borehole during geophysical logging, as noted above. A rugose borewall is noted from commencement of logging at 1.78 m to approximately 7 m bgs. Intermittent rugosity was noted to the bottom of the measured section at 14.40 m bgs.

**Acoustic Televiewer**

Multiple Acoustic Televiewer (AT) logs were collected in the field using various gain and borehole diameter settings. The most detailed AT log was collected from 1.81 m to 14.34 m bgs, and is included in this report. Planar features (fractures), appearing as sinusoidal waves, were manually picked using various contrast settings and vertical resolutions. These picks are shown on the log plot, along with a table of calculated feature strike and dip. These features were also plotted on stereonet plots. Log plots, tables and stereonet plots are included in this report.

**Discussion**

Based on stereoplots of structural conditions likely to give rise to failures (Hoek and Bray, 1977), the stereonet plot of this boring suggests potential wedge failure on two or more intersecting discontinuities. Possible directions of sliding might be to the northwest, southeast or northeast. Based on comparison with Boring 03-B13, sliding to the northwest is suggested. Based on the fractured condition of the borehole noted during geophysical logging, loose (fractured) rock, separating larger, more competent blocks, would probably be encountered during excavation. This would contribute to slope instability, independent of wedge failure.

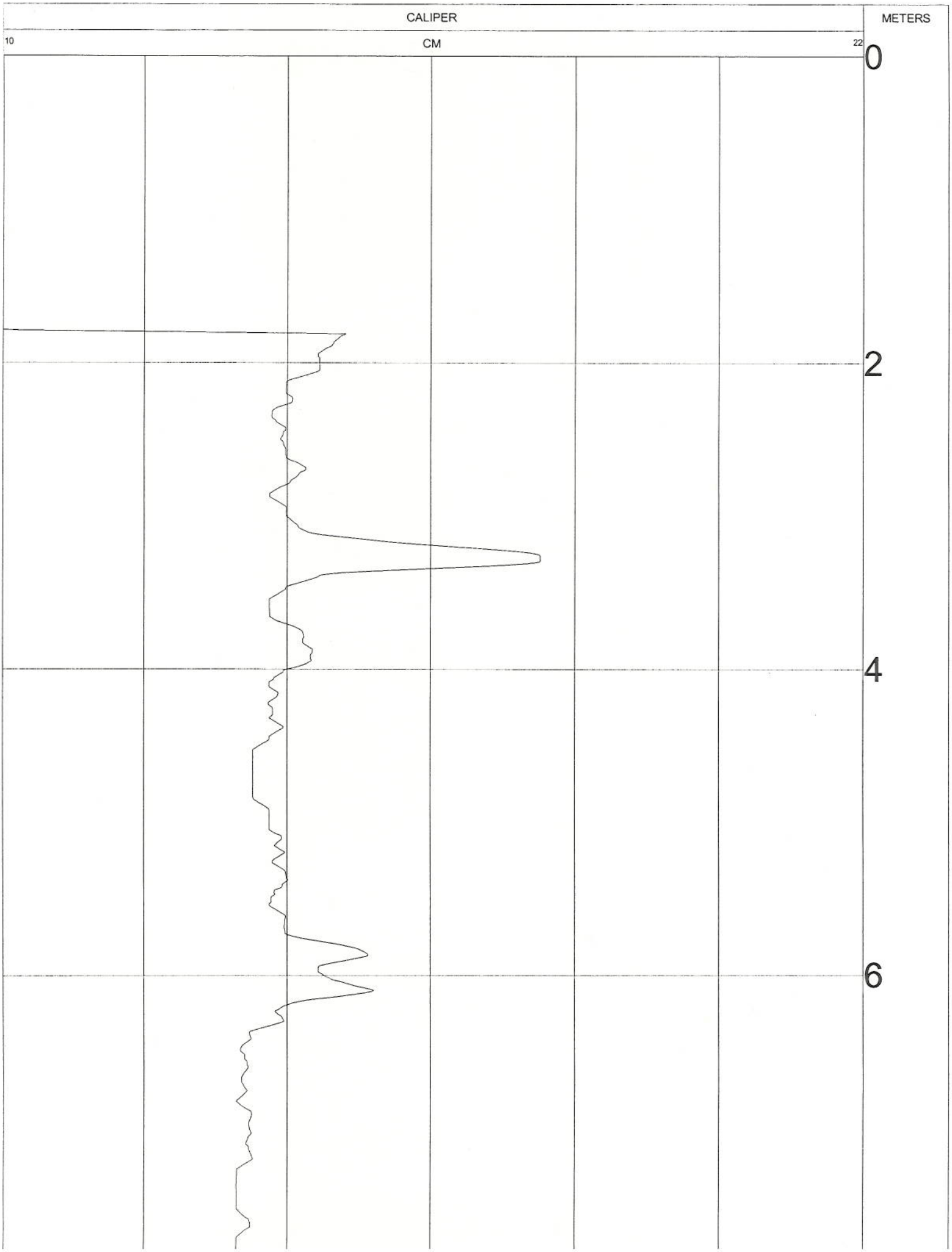

Century GEOPHYSICAL CORP.

# RTE 58 Realignment 03-B9

| | | | | | |
|---|---|---|---|---|---|
| COMPANY | : Caltrans | | | | |
| WELL | : RTE 58 Realignment 03-B9 | | | | |
| LOCATION/FIELD | : | | | | |
| COUNTY | : SbD | | | | |
| STATE | : CA | | | | |
| SECTION | : | TOWNSHIP | : | RANGE | : |
| DATE | : 09/03/03 | PERMANENT DATUM | : | | |
| DEPTH DRILLER | : 14.6 m. | | | KB | : N/A |
| LOG BOTTOM | : 14.40 | LOG MEASURED FROM: | GL | DF | : N/A |
| LOG TOP | : 1.78 | DRL MEASURED FROM: | GL | GL | : |
| CASING DIAMETER | : N/A | LOGGING UNIT | : 7311 | | |
| CASING TYPE | : N/A | FIELD OFFICE | : Land Hole | | |
| CASING THICKNESS: | | RECORDED BY | : HughesTurn | | |
| BIT SIZE | : 13 | BOREHOLE FLUID | : 0 | FILE | : ORIGINAL |
| MAGNETIC DECL. | : 13.5 | RM | : 0 | TYPE | : 9065A |
| MATRIX DENSITY | : 2.71 | RM TEMPERATURE | : 0 | | |
| NEUTRON MATRIX | : Dolomite | MATRIX DELTA T | : 140 | | |
| | | | | THRESH: | 20000 |

OTHER SERVICES:
Caliper
AcousTe

EA: 08-04351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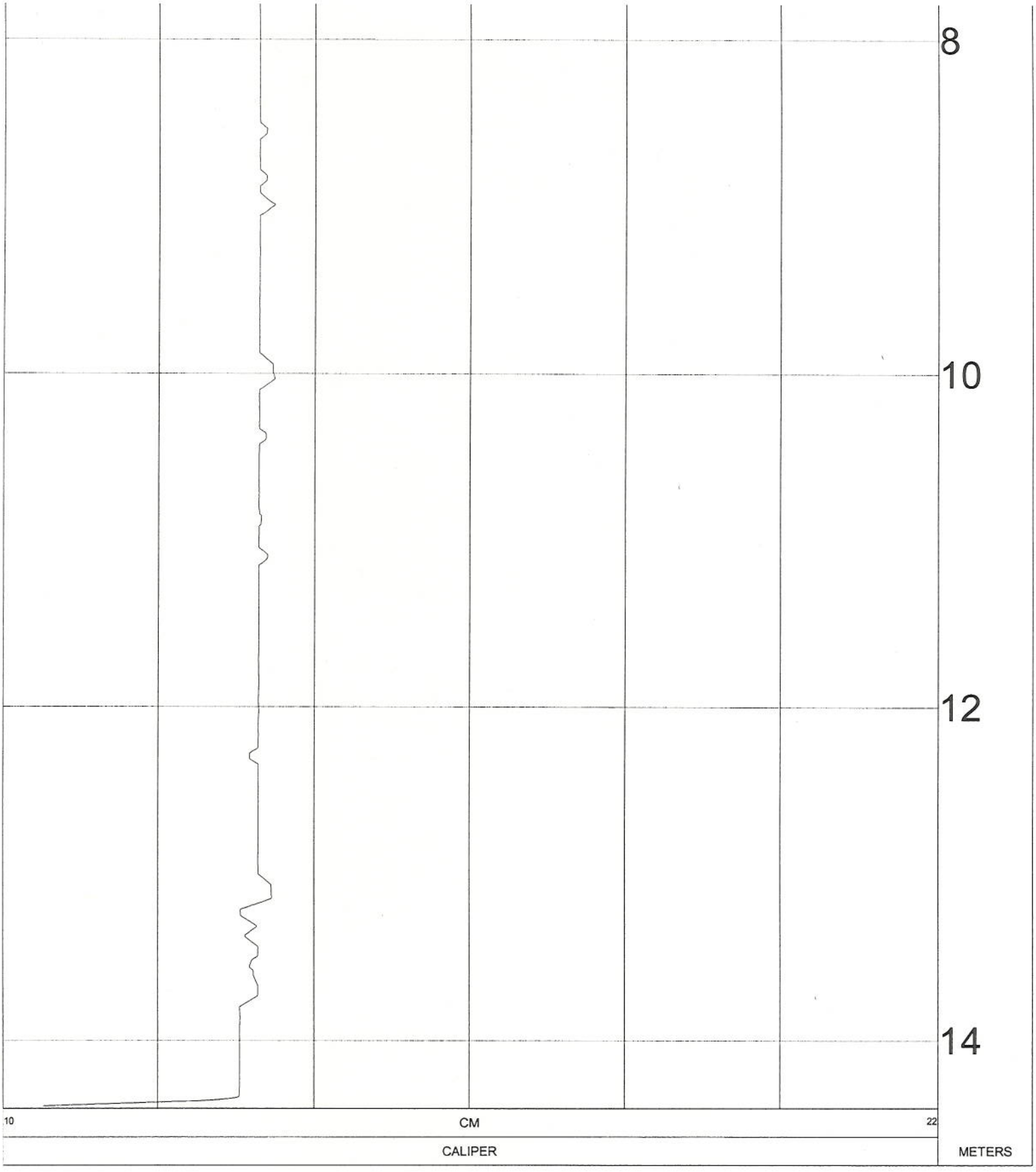
METERS
10
CM
22
0
2
4
6


8
10
12
14
10
CM
22
CALIPER
METERS

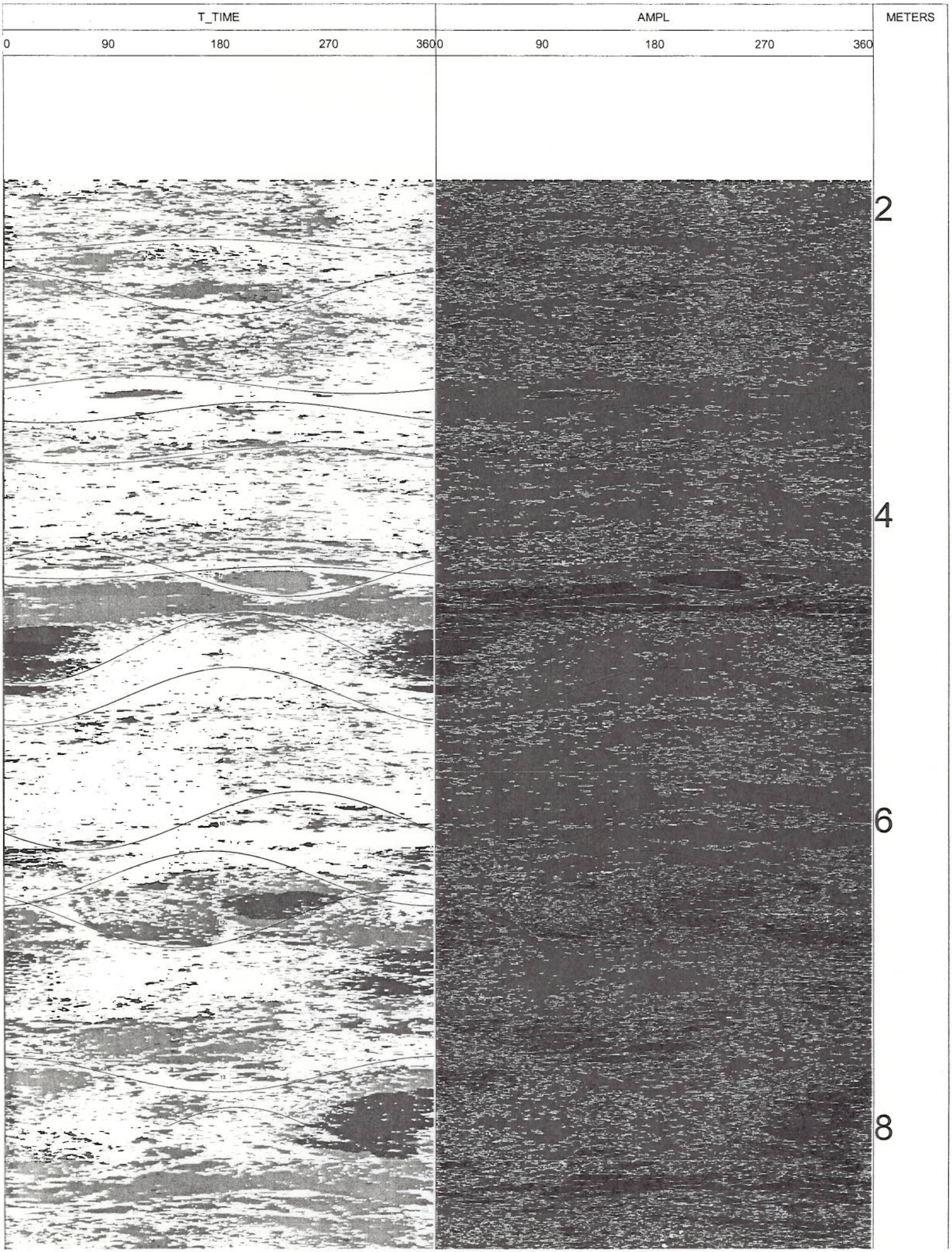

Century GEOPHYSICAL CORP.

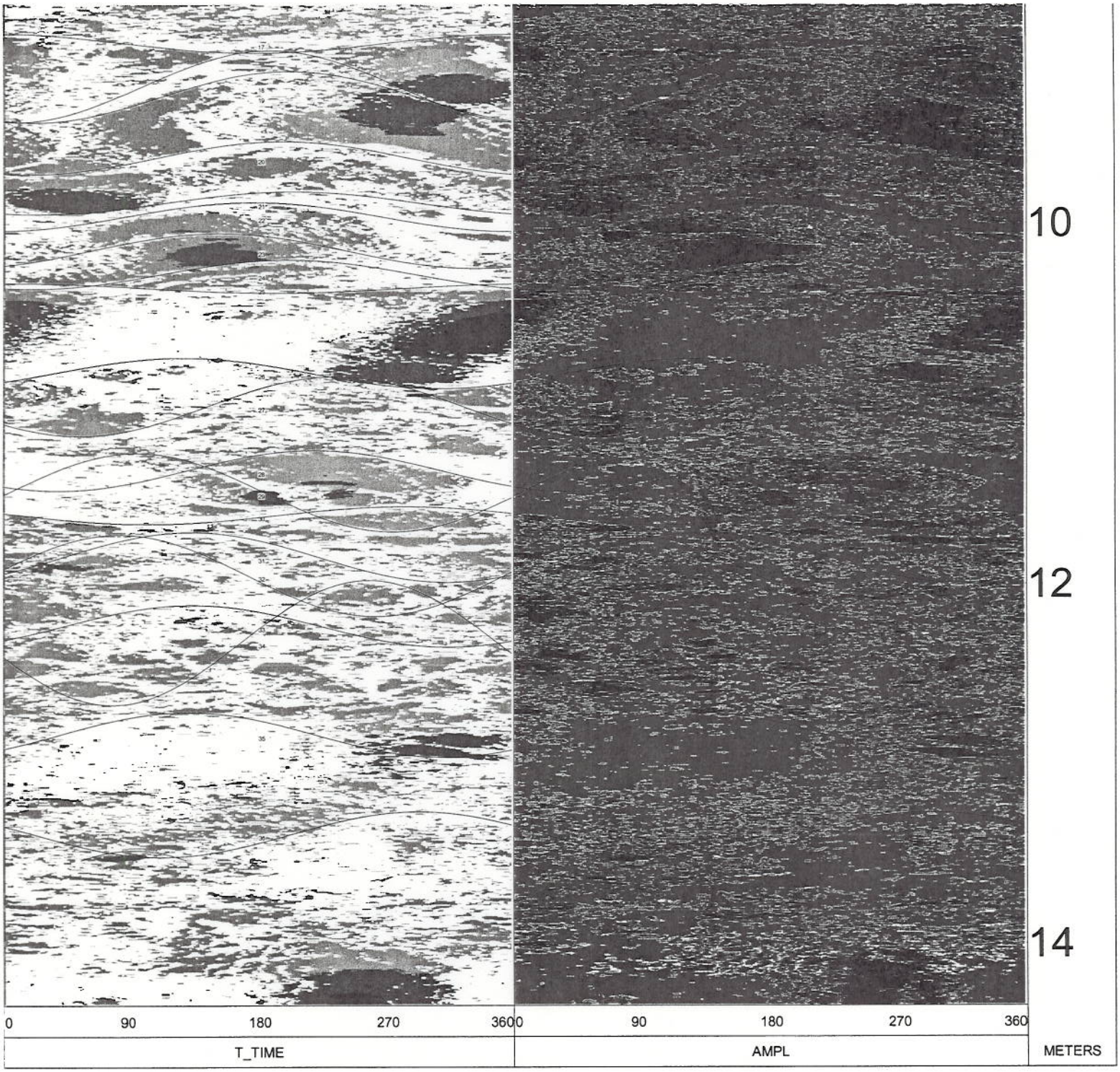
# RTE 58 Realignment 03-B9

| | | | | | |
|---|---|---|---|---|---|
| COMPANY | : Caltrans | | | | |
| WELL | : RTE 58 Realignment 03-B9 | | | | |
| LOCATION/FIELD | : | | | | |
| COUNTY | : SbD | | | | |
| STATE | : CA | | | | |
| SECTION | : | TOWNSHIP | : | RANGE | : |
| DATE | : 09/03/03 | PERMANENT DATUM | : | | |
| DEPTH DRILLER | : 14.6 m. | | | KB | : N/A |
| LOG BOTTOM | : 14.34 | LOG MEASURED FROM: | GL | DF | : N/A |
| LOG TOP | : 1.81 | DRL MEASURED FROM: | GL | GL | : |
| CASING DIAMETER | : N/A | LOGGING UNIT | : 7311 | | |
| CASING TYPE | : N/A | FIELD OFFICE | : Land Hole | | |
| CASING THICKNESS: | | RECORDED BY | : HughesTurn | | |
| BIT SIZE | : 13 | BOREHOLE FLUID | : 0 | FILE | : PROCESSED |
| MAGNETIC DECL. | : 13.5 | RM | : 0 | TYPE | : 9800A |
| MATRIX DENSITY | : 2.71 | RM TEMPERATURE | : 0 | | |
| NEUTRON MATRIX | : Dolomite | MATRIX DELTA T | : 140 | | |
| | | | | THRESH: | 20000 |

OTHER SERVICES:
Caliper
AcousTe

EA: 08-04351

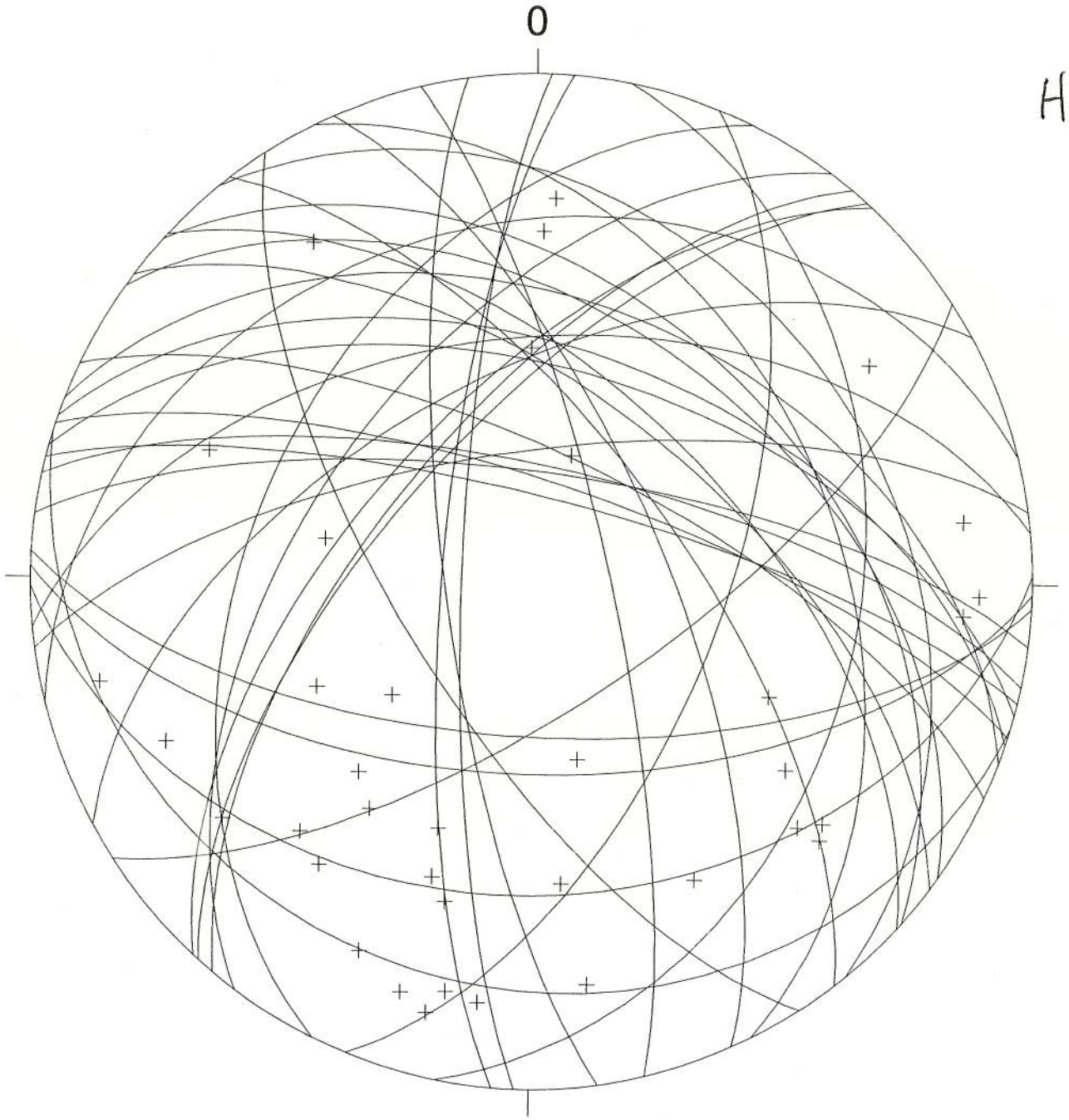

T_TIME
AMPL
METERS
0
90
180
270
360
0
90
180
270
360
2
4
6
8


10
12
14
0
90
180
270
360
0
90
180
270
360
T_TIME
AMPL
METERS

COMPANY : Caltrans
WELL : RTE 58 Realignment 03-B9

| FRACTURE NUMBER | DIP * ( DEG ) | AZIMUTH * ( DEG ) | TO ( M ) | FROM ( M ) | APERTURE ( CM ) | BORE ( CM ) | CATEGORY |
|---|---|---|---|---|---|---|---|
| 1 | 30.04 | 345.61 | 2.20 | 2.27 | 0.00 | 13.00 | Fracture |
| 2 | 64.48 | 182.91 | 2.41 | 2.70 | 0.00 | 13.00 | Fracture |
| 3 | 43.64 | 295.73 | 3.09 | 3.21 | 0.00 | 13.00 | Fracture |
| 4 | 46.35 | 35.42 | 3.26 | 3.39 | 0.00 | 13.00 | Fracture |
| 5 | 39.70 | 63.59 | 3.55 | 3.66 | 0.00 | 13.00 | Fracture |
| 6 | 29.74 | 50.70 | 4.34 | 4.41 | 0.00 | 13.00 | Fracture |
| 7 | 68.21 | 237.16 | 4.22 | 4.53 | 0.00 | 13.00 | Fracture |
| 8 | 74.12 | 17.65 | 4.64 | 5.10 | 0.00 | 13.00 | Fracture |
| 9 | 71.62 | 11.78 | 4.99 | 5.37 | 0.00 | 13.00 | Fracture |
| 10 | 68.73 | 66.01 | 5.81 | 6.19 | 0.00 | 13.99 | Fracture |
| 11 | 69.21 | 351.75 | 6.20 | 6.56 | 0.00 | 14.09 | Fracture |
| 12 | 68.92 | 146.34 | 6.46 | 6.83 | 0.00 | 13.00 | Fracture |
| 13 | 58.35 | 181.21 | 7.53 | 7.76 | 0.00 | 13.83 | Fracture |
| 14 | 76.56 | 13.73 | 7.86 | 8.39 | 0.00 | 13.00 | Fracture |
| 15 | 69.63 | 24.97 | 8.10 | 8.45 | 0.00 | 13.00 | Fracture |
| 16 | 42.62 | 42.11 | 8.41 | 8.53 | 0.00 | 13.00 | Fracture |
| 17 | 37.90 | 179.02 | 8.96 | 9.06 | 0.00 | 13.00 | Fracture |
| 18 | 72.59 | 7.19 | 9.05 | 9.45 | 0.00 | 13.00 | Fracture |
| 19 | 65.85 | 20.07 | 9.16 | 9.45 | 0.00 | 13.00 | Fracture |
| 20 | 55.31 | 15.05 | 9.55 | 9.74 | 0.00 | 13.00 | Fracture |
| 21 | 43.61 | 20.84 | 9.83 | 9.96 | 0.00 | 13.66 | Fracture |
| 22 | 50.25 | 354.16 | 9.89 | 10.05 | 0.00 | 13.93 | Fracture |
| 23 | 56.93 | 330.77 | 10.07 | 10.26 | 0.00 | 13.67 | Fracture |
| 24 | 51.80 | 18.54 | 10.21 | 10.37 | 0.00 | 13.00 | Fracture |
| 25 | 20.91 | 196.66 | 10.34 | 10.40 | 0.00 | 13.00 | Fracture |
| 26 | 52.87 | 306.13 | 10.75 | 10.92 | 0.00 | 13.55 | Fracture |
| 27 | 66.69 | 52.28 | 10.85 | 11.18 | 0.00 | 13.75 | Fracture |
| 28 | 59.57 | 36.92 | 11.26 | 11.49 | 0.00 | 13.00 | Fracture |
| 29 | 75.07 | 274.31 | 11.28 | 11.71 | 0.00 | 13.66 | Fracture |
| 30 | 34.80 | 100.73 | 11.57 | 11.67 | 0.00 | 13.00 | Fracture |
| 31 | 66.00 | 311.42 | 11.72 | 11.99 | 0.00 | 13.85 | Fracture |
| 32 | 75.57 | 262.03 | 11.73 | 12.18 | 0.00 | 13.74 | Fracture |
| 33 | 61.32 | 312.22 | 12.12 | 12.36 | 0.00 | 13.77 | Fracture |
| 34 | 77.69 | 76.50 | 11.98 | 12.68 | 0.00 | 13.00 | Fracture |
| 35 | 64.42 | 309.23 | 12.72 | 12.96 | 0.00 | 13.00 | Fracture |
| 36 | 58.90 | 111.34 | 13.27 | 13.52 | 0.00 | 13.90 | Fracture |
| 37 | 78.31 | 271.72 | 13.48 | 14.02 | 0.00 | 13.00 | Fracture |
| 38 | 57.44 | 42.78 | 13.65 | 13.87 | 0.00 | 13.85 | Fracture |

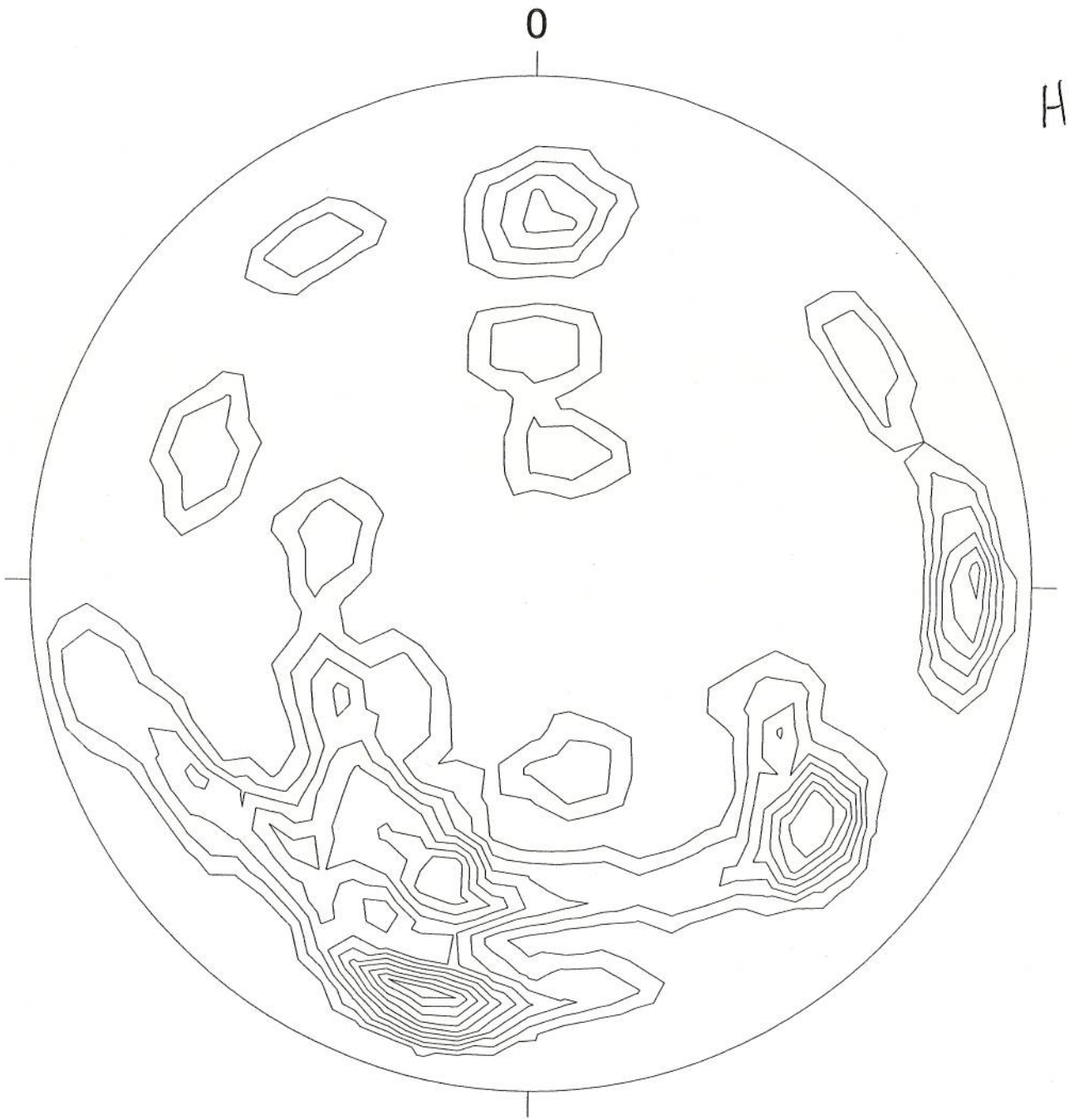
NOTE : THESE MEASUREMENTS ARE DIP & DIP DIRECTION OF THE PLANE




HIGHWAY 58 REALIGN
@ HINKLEY
BORING 03-B9

+ n=38 (P)
Num total: 38

Equal area projection, lower hemisphere




HIGHWAY 58 REALIGN
@ HINKLEY
BORING 03-B9

n=38
max. dens.=10.82 (at 195/ 18)
min. dens.=0.00
Contours at:
0.00,1.00,2.00,3.00,
4.00,5.00,6.00,7.00,
8.00,9.00,10.00,
(Multiples of random distribution)

Equal area projection, lower hemisphere

# APPENDIX 1: GEOPHYSICS AND GEOLOGY BRANCH BOREHOLE GEOPHYSICAL LOGGING PROGRAM

This appendix summarizes the instruments and procedures used in the Borehole Geophysical Logging Program. On this project (RTE 58 Realignment—Hinkley), a Century Geophysical Ultra-Lite system was used. This system consists of downhole probes connected by a winch to a data acquisition system on the surface. Specific attributes of this system are described below.

## I. INSTRUMENTATION

### A. Century Ultra-Lite

The Century Ultra-Lite system is used to obtain caliper measurements. The caliper probe mechanically measures borehole diameter for assessment of hole quality (e.g., the presence of washouts or squeeze-ins, and borehole rugosity).

Additional Century tools include the acoustic televiewer. The acoustic televiewer is an imaging tool that uses sound waves to scan 360 degrees of the borehole wall. Competent rock produces shorter travel time and a stronger reflection of the acoustic waves. Features such as fractures and bedding planes can be identified as an acoustic image. The resulting image is oriented to the magnetic north. The acoustic televiewer also measures borehole deviation relative to magnetic north.