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Geology and Geophysics
Subsurface Exploration Non-Destructive Evaluation

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March 26, 2016

Larry D. Gurrola
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Attention: Mr. Larry Gurrola, Ph.D., P.G., C.E.G.

Subject: Report
Seismic Reflection and Refraction Surveys for Investigation of Subsurface Faulting at Sansum Properties
At 215 Pesetas Lane
Santa Barbara, California

INTRODUCTION

This report summarizes the seismic reflection and refraction tomography surveys completed by Advanced Geoscience, Inc. at the referenced site to help investigate subsurface faulting. The purpose of these surveys was to locate the northwest trending San Jose fault patterns mapped near this site and investigate evidence of the possible northeast trending More Ranch fault. The logs from earlier boreholes drilled on site showed there was approximately 20+ feet of artificial fill and Holocene to Late Pleistocene alluvium beneath the site overlying the Santa Barbara Formation. Below this the deeper Miocene-age section is significantly offset by faulting based on results of onsite deep test hole data.

Seismic reflection and refraction tomography data were recorded along three survey lines designated as Lines 1, 2, and 3. The positioning of these survey lines is shown on the site map in Figure 1. Lines 1 and 3 were positioned along northeast transects to cross the expected trend of the San Jose fault. Line 2 was positioned along an intersecting northwest transect to cross the possible trend of the More Ranch fault. The resulting data underwent computer processing to prepare 1) higher-resolution seismic reflection profiles of subsurface geologic layering, and 2) seismic compressional-wave velocity profiles of lithologic conditions. These profiles were evaluated for patterns of sharp vertical separations (apparent offsets) or other changes in geologic layering which could reveal the orientations of subsurface fault planes.

On October 16, 2015, Advanced Geoscience first presented an initial interpretation of subsurface faulting on the profiles for Lines 1 through 3. This interpretation showed the orientations of three fault planes that appeared to project upward toward the ground surface. Based on these results subsurface exploration was conducted across these locations by Larry D. Gurrola Consulting Geologist using a series of closely-spaced boreholes and cone penetrometer tests (CPTs). This report now presents a slightly revised interpretation of subsurface faulting which is consistent with the results of this subsurface investigation.

The following section first provides a description our data collection and computer processing procedures. A concluding section discusses our geologic interpretation of the seismic profiles and our current evaluation of subsurface faulting.

SURVEY PROCEDURES

Data Collection

The field data recording was started on Line 1 on the evening of Monday, September 14, 2015. The plan was to record the seismic data during late evening and early morning hours to minimize interference from traffic vibrations and other sources of noise. However, due to complaints from surrounding residents the data recording was stopped about halfway through Line 1. The recording was resumed again and completed on Lines 1, 2, and 3 during the day-time hours on Saturday and Sunday, September 19 and 20.

Lines 1 through 3 were positioned along the survey lines shown in Figure 1. Lines 1 and 2 were set up across the north parking lot with 606 and 336 feet of geophone coverage (respectively). Line 3 was positioned across the vacant dirt lot with 249 feet of geophone coverage.

The seismic data were recorded using a Seistronix EX-6, 120-channel seismic acquisition system. This system was connected to geophones, spaced 6-feet apart along the survey lines. The geophones consisted of single 40-Hertz vertical geophones commonly used for both high-resolution reflection and refraction surveys. The geophones were firmly coupled to the ground by pressing the metal spikes attached to their base plates into the ground. To place the geophones in the parking lot 3/8-inch diameter holes were drilled in the asphalt.

The seismic waves were generated at “source points” positioned along the survey lines and recorded into all of the geophone channels set up on the survey lines. The source points started off the first geophone position and continued along the line between the geophones at 6-foot intervals to beyond the last geophone position.

The seismic waves were generated using a twenty-five pound sledge hammer impacting a thick steel plate placed on the ground. Multiple impacts were recorded and summed together at each source point to increase the signal-to-noise ratio.

Each seismic field record (from a common source point) was recorded with a 0.8 second record length and 0.25 millisecond sampling rate with 24-bit analog-to-digital resolution.

After the field data recording was completed the geophone positions set up on Lines 1 through 3 were mapped on a topographic site map by Larry D. Gurrola Consulting Geologist.

Computer Data Processing and Modeling

The seismic field records for Lines 1 through 3 first underwent reflection processing using the computer program Visual_SUNT developed by W_GeoSoft (Geneva, Switzerland). These data were input into Visual_SUNT together with the geophone and source point x-coordinates and elevations to perform a specialized sequence of digital filtering, trace sorting, and normal moveout (NMO) velocity corrections to prepare common-midpoint (CMP) summed traces showing the reflection time profiles. The resulting reflection time profiles for Lines 1, 2, and 3 are shown in Figures 2, 3, and 4.

Elevation differences along the survey lines were also accounted for in this processing by applying "surface consistent" static shifts to the field record traces, prior to CMP sorting and NMO correction. The time shifts introduced by this step effectively positioned time=0 on the reflection profiles to datum elevations.

The seismic field records from Lines 1-3 were also used to pick first arrival times ("first breaks") for refracted seismic waves traveling along the surface layer and the deeper higher-velocity layers. The travel time data from these first breaks were input together with geophone and source point x-coordinates and elevations into the computer program RAYFRACT written by Intelligent Resources, Inc. (Vancouver, Canada) to generate a velocity-depth model for Lines 1-3. RAYFRACT used the first break time picks to conduct refraction tomography imaging of the seismic velocity layering. An initial velocity-depth model was first estimated using the Delta-TV CMP velocity profiling procedure. This initial model was then refined to produce a closer fit to the first breaks using the Wavepath Eikonal Traveltime (WET) tomographic inversion method with 60 iterations. This best-fit, velocity-depth model was then gridded and color contoured with SURFER (Golden Software, Inc.) to show estimated vertical and lateral variations. The resulting velocity-depth profiles for Lines 1-3 are shown in Figures 5 and 6.

The refraction velocity profile for Line 1 was also used to make an approximate depth conversion of the Line 1 reflection "time" profile to a reflection "depth" profile. This reflection depth profile shown in Figure 7 was generated at 1:1 horizontal and vertical scale to better correlate the orientation of subsurface faulting on the reflection profile with faulting interpreted in the geologic cross section prepared from the boreholes and CPTs.

DISCUSSION OF RESULTS

Geologic Interpretation and Evaluation of Subsurface Faulting

The seismic reflection profiles for Lines 1-3 show reflection patterns from two subsurface horizons highlighted by yellow and magenta in Figures 2 through 4. The yellow reflection horizon is interpreted to be the upper, dense sand layer within the old alluvium shown on the geologic cross section from the boreholes and CPTs. The stronger-amplitude, magenta reflection horizon appears to be associated with top of the Santa Barbara Formation (Qsb) beneath this area.

The deeper cyan reflection horizon is interpreted as the base of the Santa Barbara Formation and top of the Miocene Monterey or Rincon Formations. Below this the deeper reflection horizons are poorly imaged partly due to extensive faulting and less resolution caused by the diminished reflection amplitude.

A pattern of north-dipping, subsurface faulting is interpreted on the Line 1 seismic reflection profile. This faulting is believed to be associated with the northwest-trending San Jose fault pattern mapped near this site.

The more significant north-dipping faults designated as “Faults A-1, A-2, and B” are shown on the reflection profile for Line 1 between stations 160 and 240 feet (Figure 2). The positions of faults based on this study are approximate and subsurface exploration with borings and CPT’s may refine these fault locations. In the area between stations 160 and 240 feet, the magenta reflection horizon shows an abrupt change in slope and vertical separations. The seismic refraction velocity profile (Figure 5) also shows abrupt changes in slope and vertical separation of velocity layering within the old alluvium and deeper units. This interpretation of more significant faulting across this area is supported by the logs from earlier SBMFC test hole numbers 1 and 2 which showed 190 feet of vertical separation between the deeper shale layers near the top of the Miocene section.

“Fault C” is also interpreted on the Line 1 reflection profile further to the north near station 410 feet. This fault plane is also dipping to the north. The reflection profiles for Lines 2 and 3 (Figures 3 and 4) show reflection patterns associated with this north-dipping fault plane where Fault C is expected to intersect these profiles. The approximate strike orientation of “Fault C” in Figure 1 is estimated by connecting the Line 1 trace with the near-surface projection trace of Line 3.

The fault plane orientations for Faults A-1, A-2, B, and C are shown on the Line 1 reflection depth profile (Figure 7) at an approximate 1:1 horizontal and vertical scale. The final interpretation of these fault plane orientations near the surface is shown to be consistent with the positioning of faulting interpreted on the geologic cross section prepared from the boreholes and CPTs.

Line 2 was positioned along a northwest transect to cross the possible trend of the More

Ranch fault. However, the seismic reflection and refraction profiles did not reveal abrupt changes in slope or vertical separations in layering which indicated this fault is not present at this site. Line 3 was positioned along a northeast transect on the corner lot to intersect a possible trend of the San Jose fault. However, the seismic reflection and refraction profiles did not reveal abrupt changes in slope or vertical separations in layering which indicated this fault is not present at this site.

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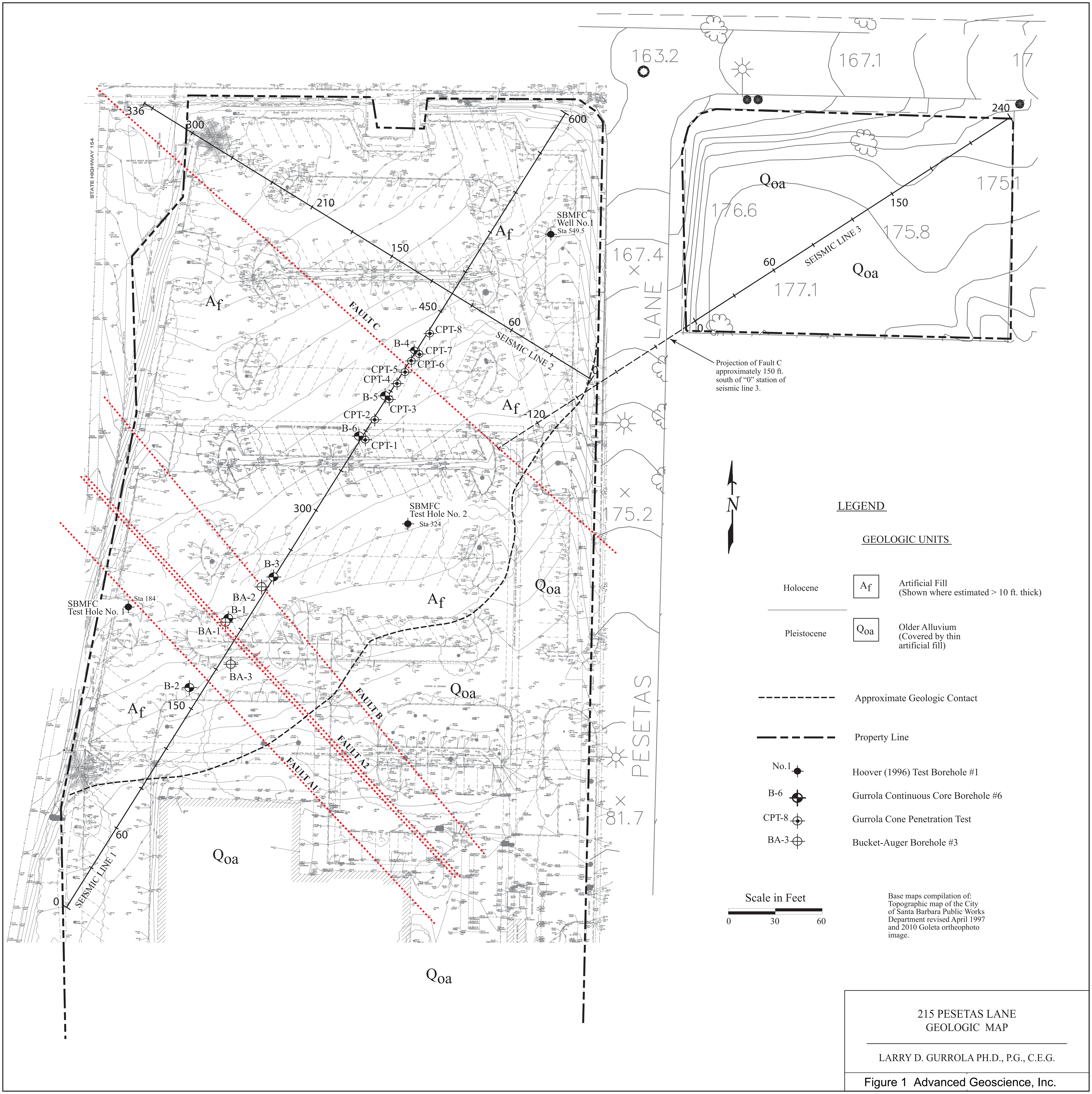
Advanced Geoscience appreciates the opportunity to be of service to Larry G. Gurrola Consulting Geologist and the Sansum Medical Clinic. If you have any questions concerning this report please contact the undersigned. Thank you.

Sincerely,

Advanced Geoscience, Inc.

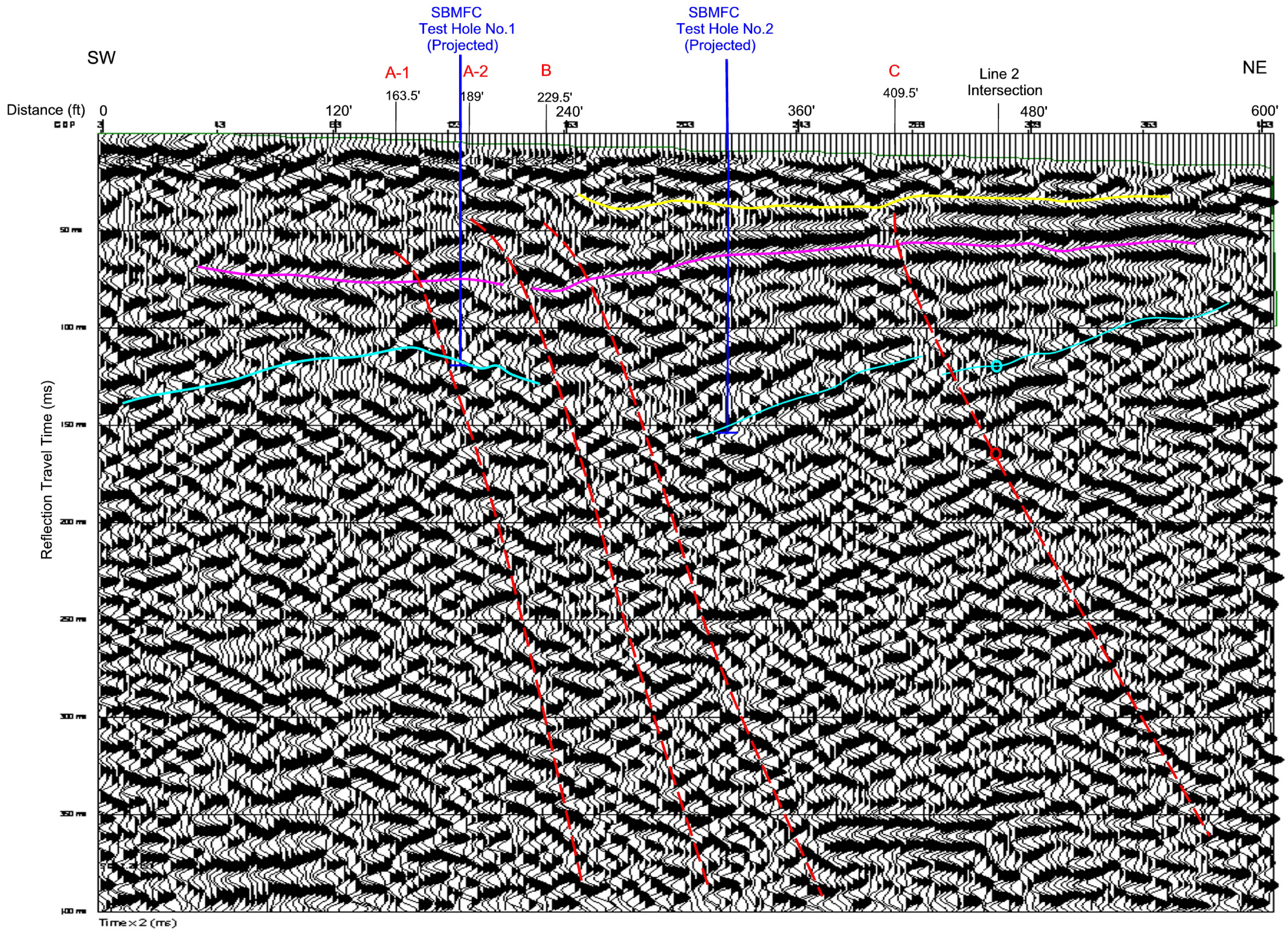
Mark G. Olson, P.Gp., P.G., C.H.G.
Principal Geophysicist and Geologist

Attachments:
Figure 1- Site Map Showing Location of Lines 1-3 and Faults A-1, A-2, B, and C
Figure 2- Line 1 Seismic Reflection Time Profile
Figure 3- Line 2 Seismic Reflection Time Profile
Figure 4- Line 3 Seismic Reflection Time Profile
Figure 5- Line 1 Seismic Refraction Tomography Profile
Figure 6- Lines 2 and 3 Seismic Refraction Tomography Profiles
Figure 7- Line 1 Seismic Reflection Depth Profile



163.2
167.1
17
240
Qoa
175.1
176.6
150
175.8
167.4
SEISMIC LINE 3
60
Qoa
177.1
LANE
0
Projection of Fault C approximately 150 ft. south of "0" station of seismic line 3.
336
300
600
210
150
SBMFC Well No.1 Sta 549.5
Af
Af
FAULT C
450
60
SEISMIC LINE 2
CPT-8
B-4
CPT-7
CPT-6
CPT-5
CPT-4
B-5
CPT-3
Af
120
CPT-2
B-6
CPT-1
N
175.2
300
SBMFC Test Hole No. 2 Sta 324
B-3
BA-2
Af
Qoa
SBMFC Test Hole No. 1 Sta 184
B-1
BA-1
BA-3
B-2
Af
150
Qoa
FAULT B
FAULT A2
FAULT A1
PESETAS
81.7
60
Qoa
0
SEISMIC LINE 1
Qoa
STATE HIGHWAY 154
LEGEND
GEOLOGIC UNITS
Holocene
Af
Artificial Fill (Shown where estimated > 10 ft. thick)
Pleistocene
Qoa
Older Alluvium (Covered by thin artificial fill)
Approximate Geologic Contact
Property Line
No.1
Hoover (1996) Test Borehole #1
B-6
Gurrola Continuous Core Borehole #6
CPT-8
Gurrola Cone Penetration Test
BA-3
Bucket-Auger Borehole #3
Scale in Feet
0
30
60
Base maps compilation of: Topographic map of the City of Santa Barbara Public Works Department revised April 1997 and 2010 Goleta orthophoto image.
215 PESETAS LANE
GEOLOGIC MAP
LARRY D. GURROLA PH.D., P.G., C.E.G.
Figure 1 Advanced Geoscience, Inc.

LINE 1- Seismic Reflection Time Profile



Original Scale:
Horizontal 1 inch= 30 ft
Vertical 1 inch= 30 ms

Reflection from Dense Sand Layer in Old Alluvium Truncating Near Distance 240 feet

Reflection from Top of Santa Barbara Fm (Qsb)

Reflection at Base of Santa Barbara Fm (Qsb)/Top of Monterey Fm (Tm) Unconformity

Interpreted Fault Planes Projecting Near Surface
Older Monterey Fm Fault Planes Not Shown

LINE 1
Seismic Reflection Time Profile
Investigation of Subsurface Faulting
Sansum Medical Facility
Santa Barbara, California

Figure 2
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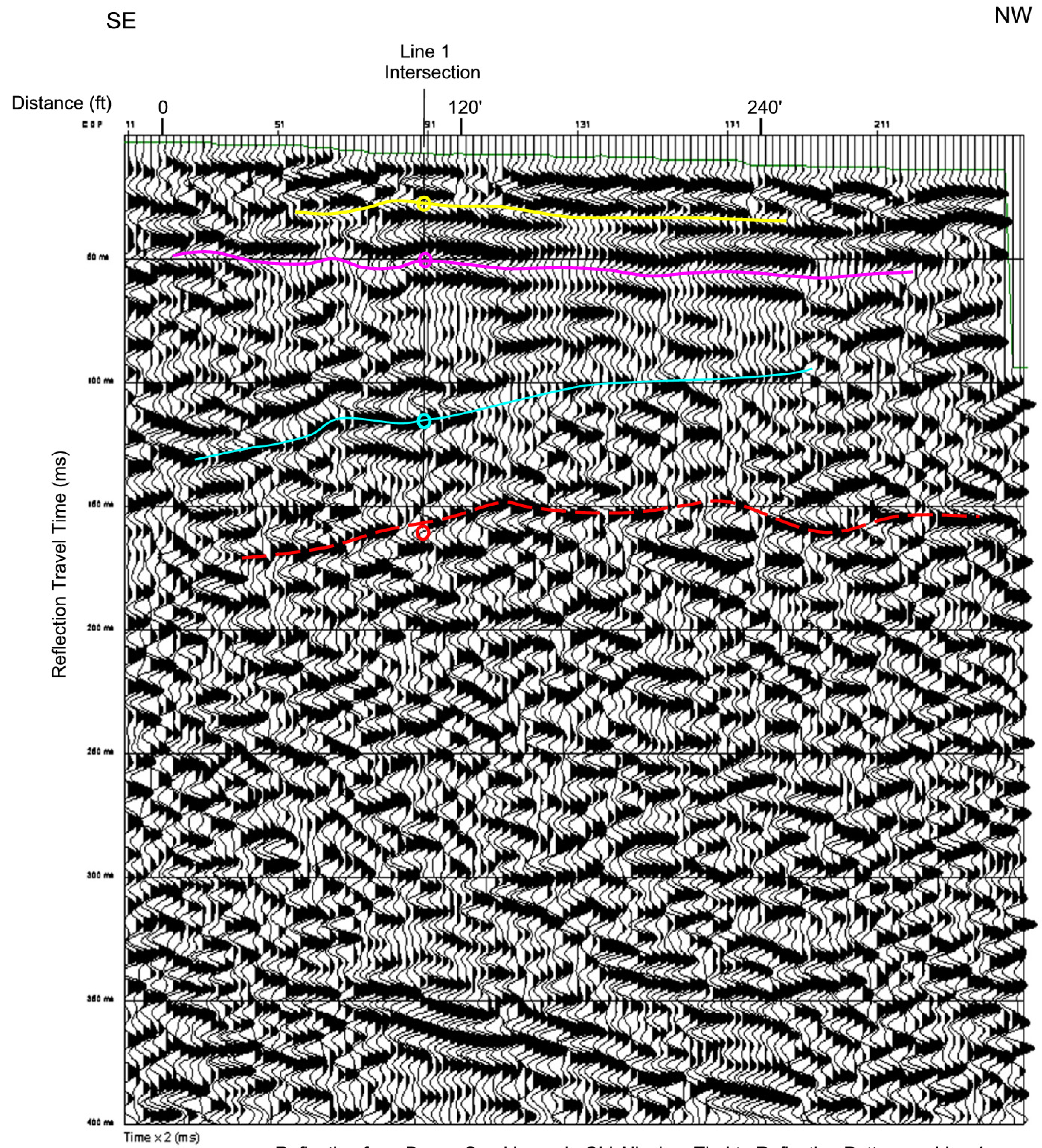
LINE 2- Seismic Reflection Time Profile



Reflection from Dense Sand Layer in Old Alluvium Tied to Reflection Pattern on Line 1

Reflection from Top of Santa Barbara Fm (Qsb) Tied to Reflection Pattern on Line 1

Reflection at Base of Santa Barbara Fm (Qsb)/Top of Monterey Fm (Tm)
Tied to Reflection Pattern on Line 1

Interpreted Paralleling Fault Plane
Tied to Fault Plane C on Line 1

Original Scale:
Horizontal 1 inch= 30 ft
Vertical 1 inch= 30 ms

LINE 2

Seismic Reflection Time Profile
Investigation of Subsurface Faulting
Sansum Medical Facility
Santa Barbara, California

Figure 3
Advanced Geoscience, Inc.
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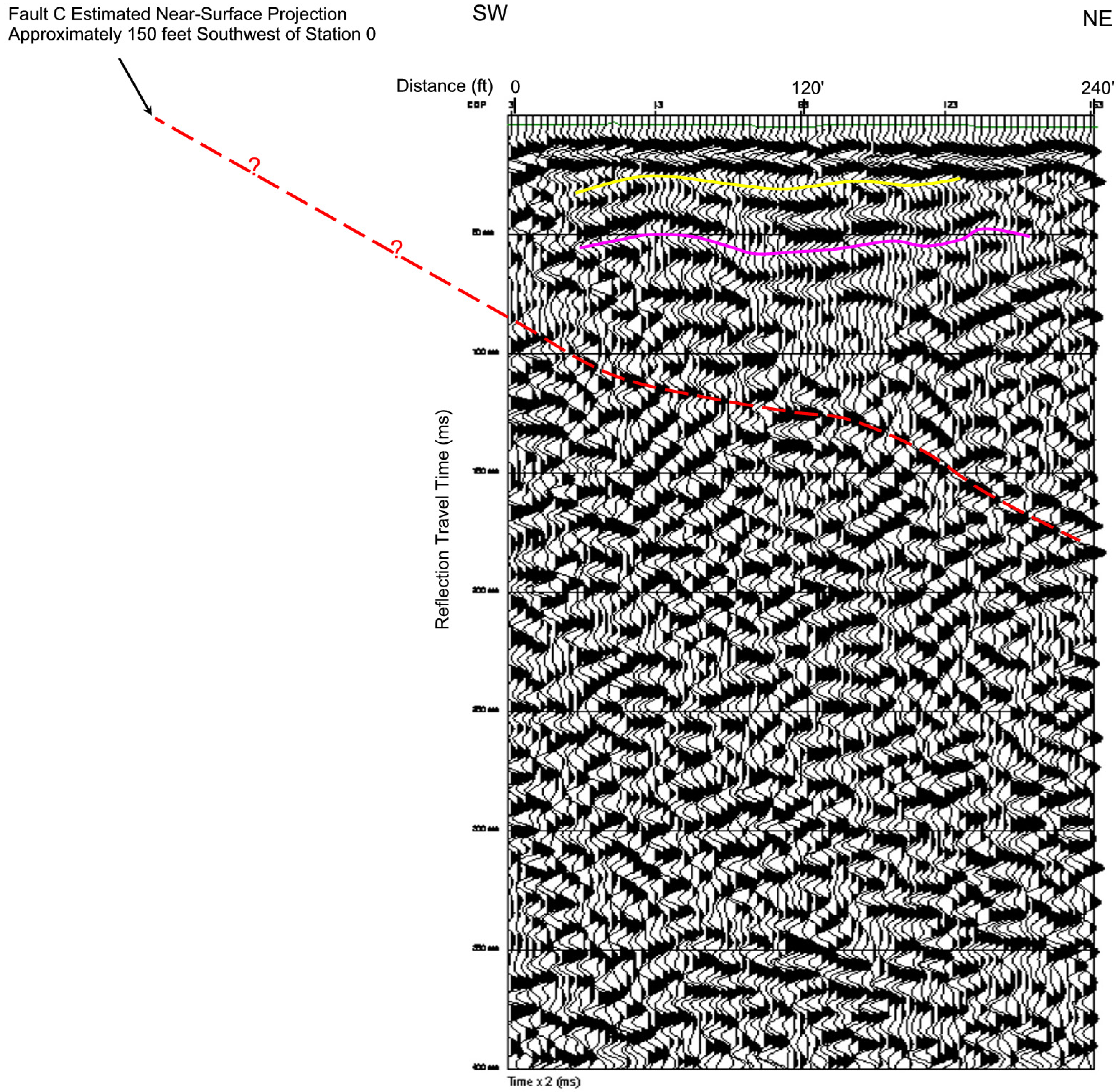
LINE 3- Seismic Reflection Time Profile



Reflection from Dense Sand Layer in Old Alluvium

Reflection from Top of Santa Barbara Fm (Qsb)
Based on Reflections Indicating Seismic Unconformity

Fault C Intepreted Fault Plane Orientation
Based on Pattern of Northeast Dipping Reflections

Original Scale:
Horizontal 1 inch= 30 ft
Vertical 1 inch= 30 ms

LINE 3

Seismic Reflection Time Profile
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Figure 4
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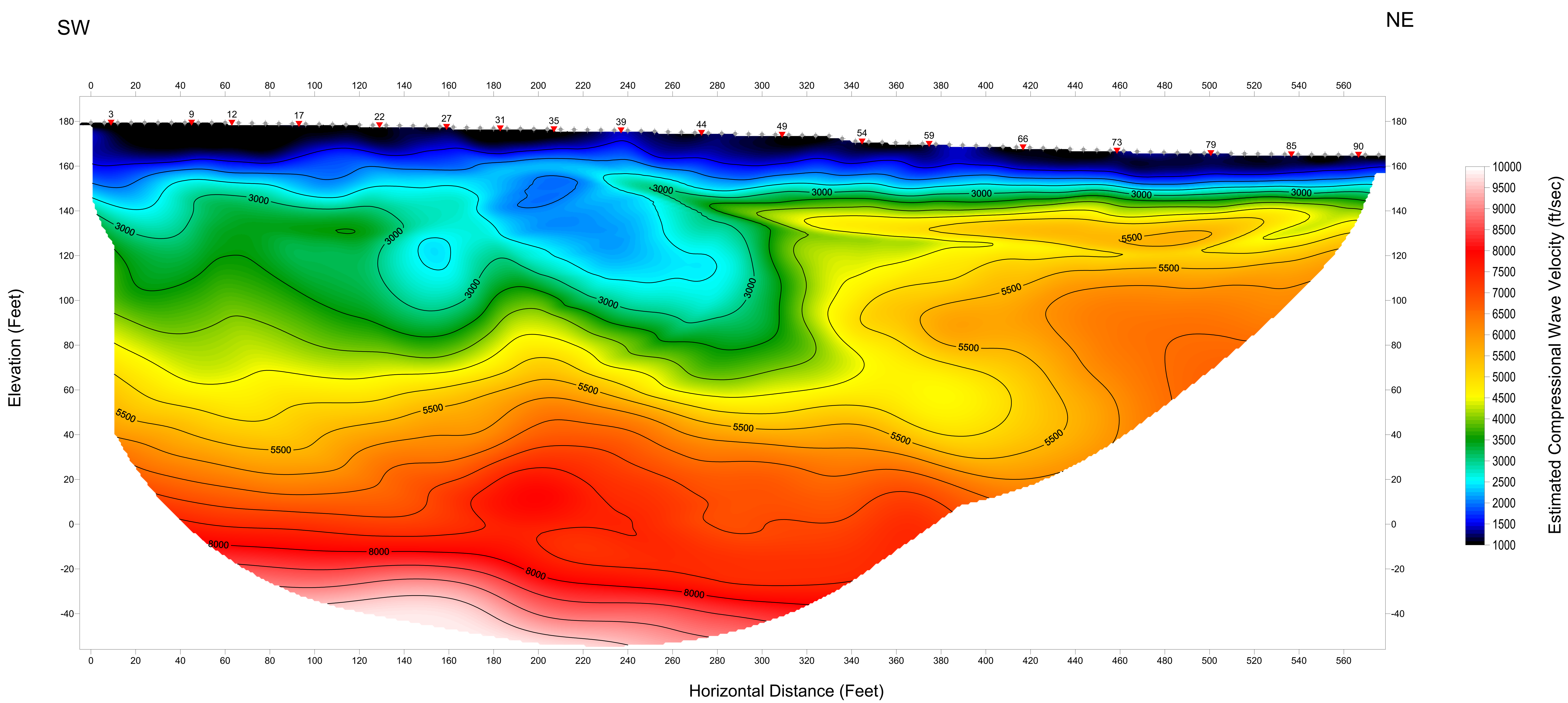
Line 1 Seismic Refraction Velocity Profile



Horizontal and Vertical Scale 1 inch= 30 Feet
Seismic Velocity Contour Interval 500 ft/sec

Based RAYFRACT Refraction Tomography
Initial Delta TV Velocity Model + 60 WET Iterations w/Vmax= 3,000 m/sec

Line 1
Seismic Refraction Velocity Depth Profile
Investigation of Subsurface Faulting
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Santa Barbara, California

Figure 5
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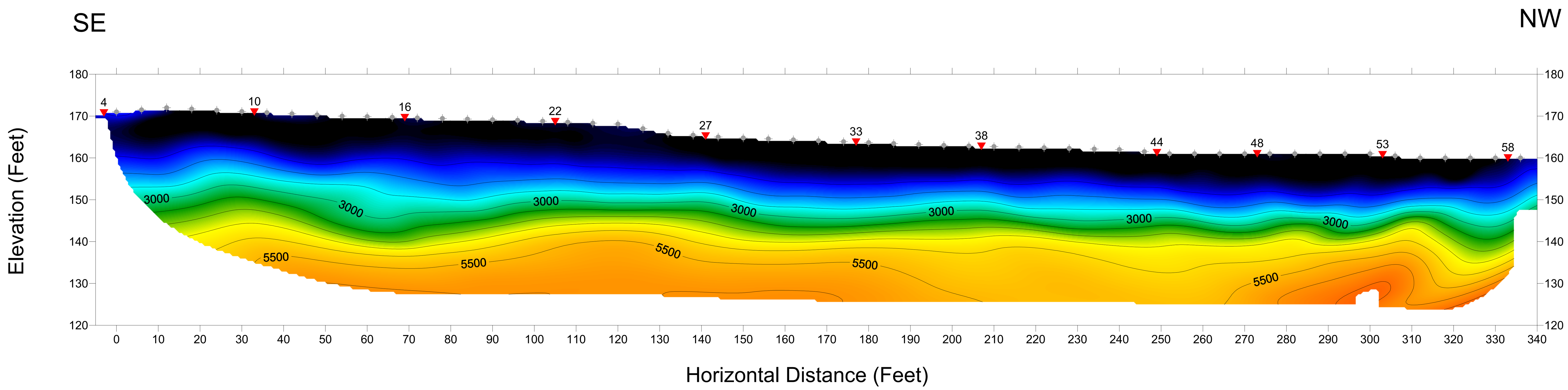
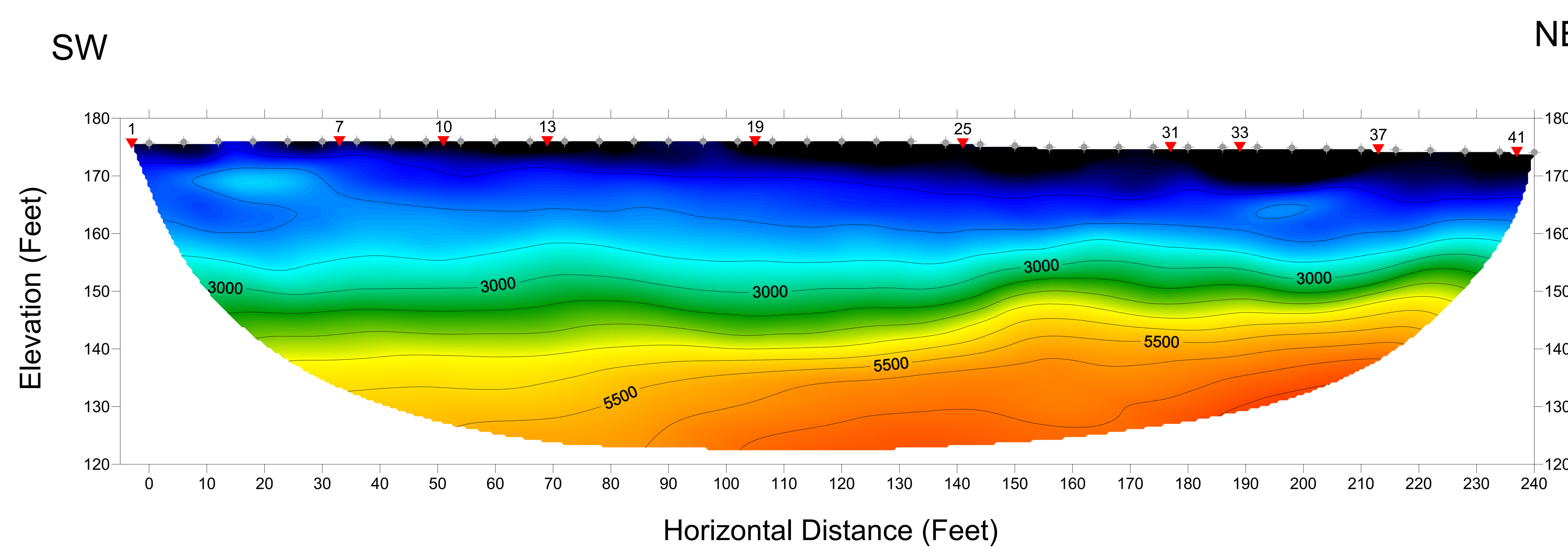
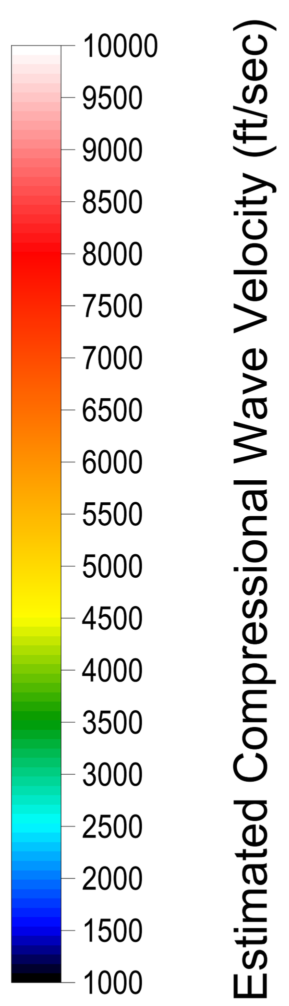
Line 2 Seismic Refraction Velocity Profile



Line 3 Seismic Refraction Velocity Profile





Horizontal and Vertical Scale 1 inch= 20 Feet
Seismic Velocity Contour Interval 500 ft/sec

Based RAYFRACT Refraction Tomography
Initial Delta TV Velocity Model + 60 WET Iterations w/Vmax= 3,000 m/sec

Lines 2 and 3
Seismic Refraction Velocity Depth Profiles
Investigation of Subsurface Faulting
Sansum Medical Facility
Santa Barbara, California

Figure 6
Advanced Geoscience, Inc.
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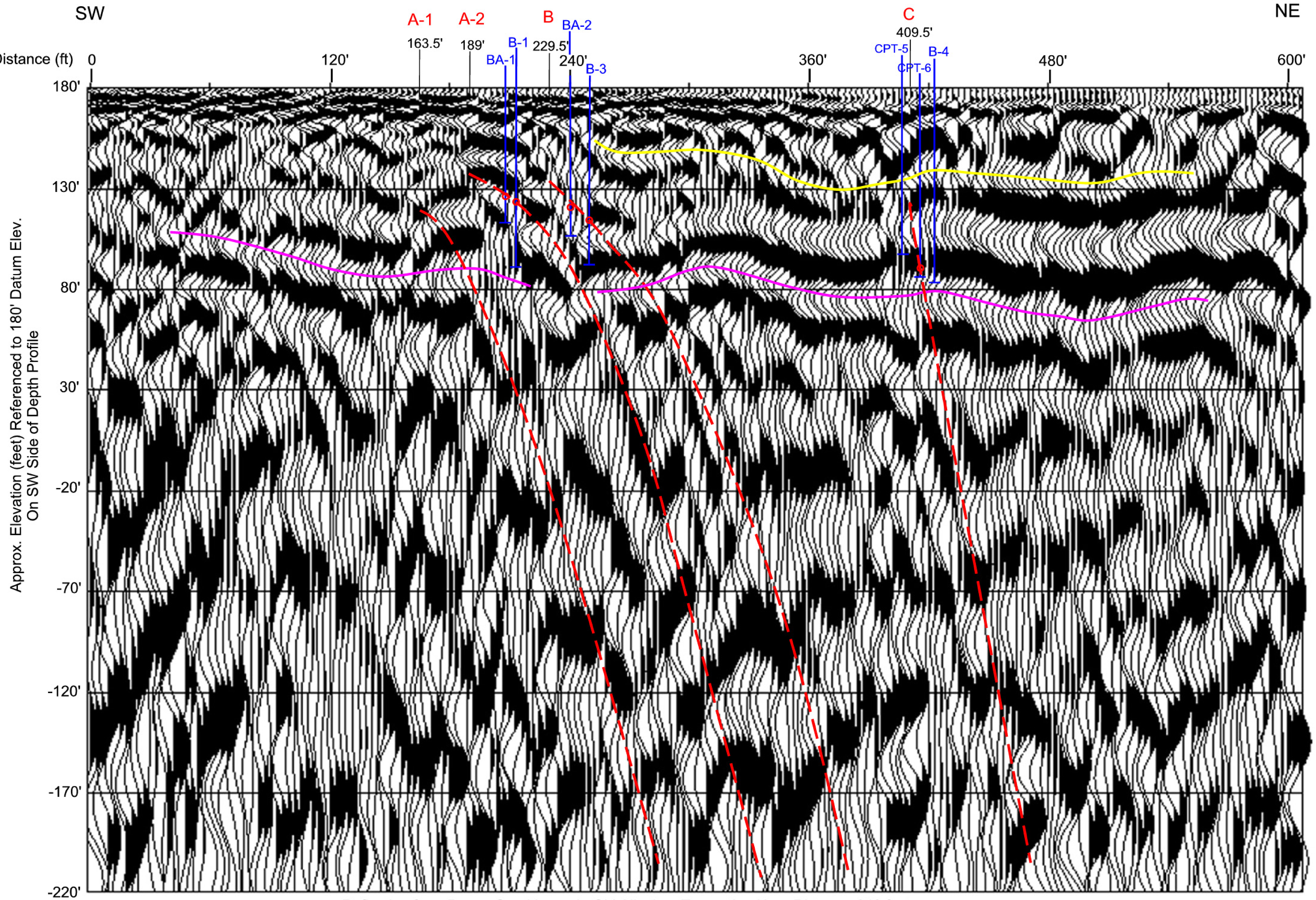
LINE 1- Seismic Reflection Depth Profile



Original Scale:
Horizontal and Vertical 1 inch= 30 ft
Approximately 1:1

Reflection from Dense Sand Layer in Old Alluvium Truncating Near Distance 240 feet

Reflection from Top of Santa Barbara Fm (Qsb)

Interpreted Fault Planes Possibly Projecting Near Surface
Older Monterey Fm Fault Planes Not Shown

Approximate Positions of Faults Discovered in Boreholes and CPTs

LINE 1

Seismic Reflection Approx. Depth Profile
Investigation of Subsurface Faulting
Sansum Medical Facility
Santa Barbara, California

Figure 7
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