50-206
50-361
50-362

80cr81

TO: THE NUCLEAR REGULATORY COMMISSION
Washington, D. C.

SUBJECT: Geologic Conditions in the Vicinity of the San Onofre Nuclear Generating Station, Camp Pendleton, California, and Conduct of the Seismic Safety Hearings at San Diego, California, conducted during June, July, and August, 1981.

PURPOSE: This letter provides the Nuclear Regulatory Commission a summary of observed and inferred geologic conditions near the San Onofre Nuclear Generating Station (SONGS) Units 1,2, and 3, at Camp Pendleton, and a chronological commentary of attempts to bring this data to the NRC Seismic Safety hearings. Its purpose is to clarify and amplify my statement before the NRC of 25 June 81 and provide additional geologic observations. It is not intended to be critical of any person or organization. Rather, it is offered in the interest of public safety and to insure the NRC has a better understanding of the potential seismic risk at SONGS Units 1,2, and 3. Details of field observations are abbreviated and summarized in the interest of brevity. The facts are presented chronologically for clarity.

CHRONOLOGY

On or about 14 June, 1981, I concluded, based upon map analysis and 20 years periodic geologic study of the Camp Pendleton area, that the marine terraces near Horno Canyon, approximately 5 miles from the SONGS site, had been displaced vertically, and that a possible cause could be faulting. Subsequent field work found this conclusion to be supported by physical evidence. On 22 June, 1981, I informed the NRC Hearing Chairman, Mr. Kelly, of the substance of my findings. He then arranged a limited appearance before the Commission at which the data and my interpretation was presented.

On 27 June, 1981, a party of 10 geologists accompanied me to Camp Pendleton to view the reported physical evidence. The names of these men and

Cool 5/1 Drawing To: Reg file Aperture Card Dist Per H. Smith

their affiliations are listed in Enclosure 1. At the conclusion of the field trip (about 6 hours duration), my interpretations had not changed significantly. The presence of the following zones along which significant faulting may be inferred or observed had been established.

Morno Summit Fault, NW-SE - length about 32 miles, apparent vertical displacement greater than 250 feet - East side up.

Morno Canyon Fault, NE-SW - on the axis of Morno Canyon. Length greater than 12 miles. Vertical displacement approximately 100 feet, North side up. Left lateral movement.

San Onofre Mountain Structure, NW-SE - Inferred length about 19 miles. Vertical displacement possibly as much as 500 feet, West side up.

Piedre de Lumbre/Pulgas Canyon Fault, NE-SW - Length greater than 12 miles. Vertical displacement at least 100 feet, North side up.

On 28 June, 1981, I returned to the field and found evidence for two additional faults. The character of these features is listed below.

Mateo Canyon Fault, length greater than 15 miles, vertical displacement approximately 40 feet in the past 125,000 years.

San Onofre Canyon Fault, length greater than 9 miles, vertical displacement greater than 20 feet in the past 125,000 years.

Field studies and map interpretations between 3 and 5 July, 1981, identified the potential for additional faulting between Lake Elsinore and the Pacific Ocean.

On 17 July, 1981, I accompanied NRC and Southern California Edison staff members listed below to examine the Morno Canyon Fault. After visiting 3 sites in 6 hours, it was my opinion that the Morno Canyon Fault is a

major throughgoing fracture which extends from the Oceanside/Carlsbad area to the Northern border of Camp Pendleton. This fault is structurally on line with the Mission Viejo Fault to the North. At the end of the field trip it was my conclusion that the geologists I was accompanying agreed.

Mr. J. S. McNey - Southern California Edison
Mr. P. Ehlig - Consultant, Southern California Edison
Mr. T. Cardon - NRC Staff Geologist

By 27 July, 1981, following additional analysis and field investigations, positive evidence for 2 additional fractures had been found. Their characteristics are listed below.

Mountain Top Fault Zone, NE-SW - length greater than 3 miles, Vertical displacement greater than 600 feet, East side up. Width about 1 1/2 miles. Minimum distance to SONGS site is 2 miles.

Aliso Canyon Fault, NE-SW - length about 8 miles. Vertical displacement unknown. Distance from SONGS site - 11 miles.

On 28 July, 1981, I approached Mr. Kelly of the NRC and offered to present the information gathered to date.

On 31 July, 1981, I again informed Mr. Kelly that I was prepared to testify under oath to the evidence for recent tectonic movement discovered. He indicated that material should be presented in writing to the Commission. At that time, copies of the materials at hand which were reproducible were made and provided. On the same day, Southern California Edison presented a report which largely discounted my earlier information. The NRC staff endorsed the report. It contains significant geologic inconsistencies and interpretations of observed data which are questionable.

On 3 August, 1981, I talked with Mr. Kelly. He indicated that he had referred the material presented to the staff for study and did not wish to call me to present my findings and interpretation to the NRC. I informed Mr. Kelly the information would be made public.

Subsequently, by telephone and letter with accompanying maps and photographs, I attempted to insure that senior mangement of Southern California Edison had been fully apprised of the geologic information and my interpretations. On 21 August, 1981, by letter, Mr. Charles R. Kocher, Southern California Edison Assistant General Counsel, indicated to me that the information reported was of no significance to the seismic design or safety of the SONGS site.

Believing the indications of significant faulting near the SONGS to be unmistakeable, I led a field reconnaissance of the area on 19 September, 1981. The names and affiliation of the men who attended are at Enclosure 2. The visit lasted about 7 hours and covered approximately 60 miles. At the conclusion of the field trip my interpretation of geologic conditions, although modified somewhat, had not changed substantially. The structural map at Enclosure 3 and the descriptions at Enclosure 4 present my current interpretation of the geology of the SONGS site.

CONCLUSIONS

The following conclusions are based upon field observations, geomorphic analysis, and review of geologic work by others. They are restricted to geologic information and interpretations.

* Southern California, in the vicinity of the SONGS site, is a tectonically active zone.

* Faulting is less than 125,000 years old and may be very recent (less than 10,000 years). Deformation may have been continuous since the Miocene.

* Thus far 11 zones of deformation have been observed or inferred. They are:

  - Christianitos
  - Rose Canyon/Newport Inglewood

Subsequently, by telephone and letter with accompanying maps and photographs, I attempted to insure that senior mangement of Southern California Edison had been fully apprised of the geologic information and my interpretations. On 21 August, 1981, by letter, Mr. Charles R. Kocher, Southern California Edison Assistant General Counsel, indicated to me that the information reported was of no significance to the seismic design or safety of the SONGS site.

Believing the indications of significant faulting near the SONGS to be unmistakeable, I led a field reconnaissance of the area on 19 September, 1981. The names and affiliation of the men who attended are at Enclosure 2. The visit lasted about 7 hours and covered approximately 60 miles. At the conclusion of the field trip my interpretation of geologic conditions, although modified somewhat, had not changed substantially. The structural map at Enclosure 3 and the descriptions at Enclosure 4 present my current interpretation of the geology of the SONGS site.

CONCLUSIONS

The following conclusions are based upon field observations, geomorphic analysis, and review of geologic work by others. They are restricted to geologic information and interpretations.

* Southern California, in the vicinity of the SONGS site, is a tectonically active zone.

* Faulting is less than 125,000 years old and may be very recent (less than 10,000 years). Deformation may have been continuous since the Miocene.

* Thus far 11 zones of deformation have been observed or inferred. They are:

  - Christianitos
  - Rose Canyon/Newport Inglewood

- San Onofre Mountain
- Horno Summit
- Mateo Canyon
- San Onofre Canyon
- Horno Canyon
- Pulgas Canyon/Piedre de Lumbre Canyon
- Aliso Canyon
- Mountain Top
- Offshore Zone of Deformation (OZD)

Only three of these, the OZD, Christianitos, and Rose Canyon/Newport Inglewood have been evaluated in detail to my knowledge.

* The geologic structure near the SONGS site is complex and all evidence has probably not been discovered and assessed.

* Observed and inferred faulting and geologic structures are consistent with the overall regional structure of Southern California. Patterns are dominated by major NW-SE fracture zones demonstrating right lateral slippage, and complementary NE-SW fractures. The NW-SE trending block between San Onofre Canyon and Oceanside appears to have been tilted to the SW with the San Onofre Mountain area uplifted.

* Additional independent geologic investigations of the area around SONGS 1,2, and 3 should be conducted before licenses to operate SONGS 2 and 3 are granted. The investigations should center on the potential seismic risk and hazard to public safety posed by the faulting observed near the SONGS site.

* Based upon a limited knowledge of seismicity, I conclude that an earthquake between M7.0 and M8 could occur near the SONGS site. This conclusion is based upon correlations between length of fault and observed earthquake magnitudes. Housner's correla-

tions indicate such a temblor could produce accelerations at the site on the order of 1.0g. My understanding is that the SONGS Units have been engineered to withstand .67g.

Very Truly Yours,

David W. Phifer
944 Stiles Court
Vista, California 92083

Enclosures:

1. Field Trip Participants - 27 June 1981
2. Field Trip Participants - 19 Sept 1981
3. Map, Structural Geology near SONGS site.
4. Summary of Evidence for Tectonism Near the SONGS site.
5. References

cc:

President Ronald Reagan
Mr. Ralph Nader
Department of Energy
Senator S. I. Hayakawa
Senator Alan Cranston
Governor Jerry Brown
Representative R. Badham
Representative C. Burgener
Commanding General, Marine Corps Base Camp Pendleton
Supervisor Paul Eckert
Mr. A. Carstens, Friends Of The Earth
Mr. W. Gould - Southern California Edison
Mr. D. Fife - Converse Ward-Davis-Dixon
Mr. M. Hart - Geocon
Dr. H. Greene - USGS
Mr. K. LaJoie - USGS
Mr. R. Moyle - USGS
Dr. F. Sheppard - Scripps Institute of Oceanography
Dr. M. Kennedy - CDMG
Mr. C. Jennings - CDMG
Editor, Los Angeles Times
Editor, San Diego Union Tribune
Editor, Santa Ana Register
Editor, The Blade Tribune
Faculty, San Diego State University

GEOLOGY FIELD TRIP

27 JUNE 1981

MCB CAMP PENDLETON

PARTICIPANTS	ORGANIZATION
MR PAUL CAMPO	DIRECTOR NATURAL RESOURCES, CAMPEN
MR J.L. McNEY	SOCAL EDISON
DR P.L. ENLIG	SOCAL EDISON, CONSULTANT
MR T. CARDONE	NRC STAFF
MR K. LA JOIE	USGS, MENLO PARK
MR G BARLOW	FRIENDS OF THE EARTH
MR C REINKING	GEOLOGIST, NRO CAMPEN
MR L. CARLSON	
MR D. PAIFER	SDSU
DR H. WALAWENDER	SDSU
DR H. MARSHALL	SOCAL EDISON, CONSULTANT
DR R.J. SHLEMON	PUBLIC AFFAIRS, CAMPEN
1ST LT R.R. THURMAN	

EXHIBIT 1

Camp Pendleton Field Trip
19 Sept 1981

NAME	AFFILIATION	INVITED	ATTENDED
Mr P. Campo	National Resources Com Pen	✓	
Mr L Carlson	" "	✓	✓
Mr M. Hart	GEOCON	✓	✓
Mr G. Farrand	"	✓	✓
Mr A. Fargas	"	✓	✓
Mr J. Kohn	Scripps	✓	
Mr K. LaJoie	USGS	✓	
Dr H. Greene	USGS	✓	
Dr M. Kennedy	CDMG	✓	
San Diego State University Geology Staff		✓	
Mr S. Haley & staff	Woodward Clyde	✓	
Mr T. Cardone	NRC	✓	
Mr R. Scarsella	Geotechnical Exp	✓	
Mr J. McNey	SoCal E	✓	✓
Dr P. Enig	SoCal E, Consultant	✓	✓
Mr C. Lough	SD Cty	✓	
Mr J. Evans	City of Oceanside	✓	
Mr D. Fife	Converse-Ward Davis-Dixon	✓	
Mr M. Bennis	Pfeffer Assoc	✓	
Mr D. Pfeffer		✓	✓

Enclosure 2

SUMMARY OF EVIDENCE FOR TECTONISM NEAR SONGS SITE

FIELD INVESTIGATIONS/RESEARCH

The structural geology interpretations below and accompanying map were compiled between mid-June and October, 1981. They are the result of map analysis, correlation of previously published and unpublished data, and approximately 15 days of reconnaissance field mapping. The descriptions of structures indicate the lines of evidence considered in arriving at conclusions. The interpretations should be considered tentative. Further detailed mapping and analysis are needed to clarify the geologic structure of the area.

TERRACES

At least four main terraces are traceable near the coast line. Shlemon (1978,1979) assigned approximate ages to 9 different terrace bedrock surfaces attributable to shore line erosion. Ehlig has mapped the terrace surfaces near San Onofre Mountain. With the exception of the lowest terrace (Qt1), the terraces are discontinuous toward the northern portion of the area mapped. For the purposes of this report only the 4 terraces have been identified. Their ages are listed below (Shlemon 1978,1979):

TERRACE					AGE (Years Before Present)
Lowest	Emergent	Bedrock	Surface	(Qt1)	120,000-125,000
Second	"	"	"	(Qt2)	250,000
Third	"	"	"	(Qt3)	347,000
Fourth	"	"	"	(Qt4)	440,000

The alluvial and colluvial deposits which now lie on Qt1 have horizons in their higher levels which are from 5000 to 8000 years old, Shlemon (1978, 1979).

Offshore, at least three unconformities have been identified near the SONGS site. These have been interpreted by the USGS, LaJoie/McCrory, (1981), as recent sealevel still stands. Dating indicates sediments lying on the highest terrace are on the order of 8,500 years old at a depth of 27 meters (82 feet). At the point where this age determination was made about 5 meters (16 feet) of younger sediments lie above the dated core sample. Thus the age of the sea floor at the 70 foot depth contour appears to be less than 8500 years.

In this report, an attempt has been made to differentiate between physiographic surfaces and the underlying wave cut bedrock surface. Approximate terrace ages refer to the wave cut surface and not the overlying alluvial, colluvial or near shore deposits which were placed after the surface was abraded.

Field investigations here have found the lowest terrace (Qt1) to be covered by a 50 to 100 foot blanket of alluvial and colluvial materials. Higher terraces (Qt2 thru Qt4) generally retain only a thin veneer of gravels. Lateral correlation of terraces was made by equating surfaces on the basis of the number of intervals above the present shore rather than comparing present surface elevations.

In several instances fluvial bedrock terraces have been used to estimate the age of deformation. Only the lowest bedrock surface has been relied upon and it is assumed to be approximately as old as the lowest marine bedrock surface, ie. about 125,000 years.

FORMATIONAL AGES

Extensive earlier work, Moyle (1973), Larsen (1948), and others has established the age of the formations exposed at Camp Pendleton. No attempt is made here to modify or refine that work.

STRUCTURAL FEATURES

The following summarizes the major structural features observed or

inferred within the map area. After each fault or structure a short description of the geologic and geomorphic evidence is presented. Ages of the latest deformation and the rationale for their assignment are included.

HORNO SUMMIT FAULT

Juxtapositioning of Cretaceous (K) against Eocene (Ts), Eocene (Ts) against Miocene (Tso), and Pliestocene (Qlv) against Miocene (Tso) can be observed as the fault is traced from the northern border of Camp Pendleton to Oceanside. Vertical offset of about 250 feet, west side up, is present at San Mateo Canyon. Shearing and slickensides occur at Range 214 and along Horno Canyon Road. At Vandergrift Boulevard on the south east, Quaternary Linda Vista (Qlv) is faulted against Miocene San Onofre Breccia (Tso). Lowest bedrock fluvial terrace surfaces are offset in San Mateo Canyon about 30 feet, east side up, indicating the latest faulting is less than 125,000 years before present.

SAN ONOFRE MOUNTAIN STRUCTURE

Moyle (1973) inferred a branch of the Christianitos Fault passes across San Onofre Canyon and to the northeast of San Onofre Mountain. Also, he plotted discontinuous faulting on strike with this structure which may be traced NW from the vicinity of Oceanside on a line approximating the landward limit of the lowest marine terrace (Qtl). Discontinuous faulting on this trace at Pulgas Canyon and between Pulgas and Horno Canyons are also shown on Moyle's map. Immediately to the east of the San Onofre Mountain block Moyle (1973) and Ehlig (personal communication-1981) map an angular unconformity between Miocene (Tso) and Eocene (Ts) sediments. This trace is marked by a 200-350 foot high scarp on which there is evidence of several very large landslides. The inference that this structure may be a continuous throughgoing fault or major flexure is supported by the following lines of evidence:

a) The linear continuous trend from Oceanside to San Mateo Canyon.

b) Dips in Eocene Santiago Formation (Ts) to the east of San Onofre Mountain average 10-20 degrees to the west while in the Miocene Onofre Breccia (Tso) dips steepen westward ranging to 30-50 degrees. Stuart (1975) concluded the source of the San Onofre Breccia (Tso) in this area was located offshore to the west.

c) A prominent scarp forms the east side of San Onofre Mountain along the structural trace.

It may be concluded that a major structure (downfold to the west or fault) has formed in post San Onofre Breccia (Tso) time. If is is a fold the San Onofre Mountain region has been tilted westward over 50 degrees without similar tilting of Eocene (Ts) sediments to the east of San Onofre Mountain. Faulting, possibly with NE-SW right lateral movement, offers a less complex interpretation. In any event the structure represents major post San Onofre Breccia (Tso) time deformation.

MATEO CANYON FAULT

In San Mateo Canyon near the eastern border of Camp Pendleton slickensides and gorge zones may be traced about 1/2 mile on the axis of San Mateo Canyon. Cretaceous granite and JuroTriassic metamorphic rocks are involved. To the west near the intersection of the Horno Summit Fault and San Mateo Canyon, the lowest fluvial bedrock terrace is displaced approximately 30 feet vertically, north side down. A fault along the trace of San Mateo Canyon is therefore inferred. This fault appears less than 125,000 years old.

SAN ONOFRE CANYON FAULT

Earlier mapping had located a fault on the upper reaches of the middle fork of San Onofre Creek (CDMG,Santa Ana Sheet). Vertical offset of the lowest fluvial terrace of greater than 20 feet, south side up, has been observed to west of Camp San Onofre. A E-W fault trending down the lower

reaches of San Onofre Canyon is therefore inferred. Additionally, offset of the nearshore bathimetry on this axis (USGS 7.5 minute sheet) reinforces this inference. Faulting is less than 125,000 years old and may be in the order of 5000 to 10,000 years based upon the offset bathimetry.

MOUNTAIN TOP FAULT ZONE

This appears to be a zone up to 1 1/2 miles wide which trends about N20E from the coast across San Onofre Mountain. San Mateo coarse buff pebbly sandstone (Tsm) is sheared against San Onofre Breccia (Tso) west side down on El Camino Real about 2 miles south of the SONGS site. This structure is reported as Fault F by Southern California Edison. To the south, on the axis of Horno Canyon's trace across the lowest marine terrace (Qt1) shears in San Onofre Breccia may be observed from El Camino Real to near the top of San Onofre Mountain. Offshore bathimetry is offset at depths of 30 to 60 feet. Within this zone slickensides in San Onofre Breccia (Tso) parallel geomorphic features. Also, a tuff layer, lithologically similar to a tuff found at an elevation of about 200 feet near Horno Canyon is found at an elevation of about 800 feet. Within the zone the continuous character of Qt2, Qt3, and Qt4, end abruptly near Fault F and Foley Canyon.

At the seacoast, a zone extending about 1200 feet to the north and 2000 feet to the south of the debouchment of Horno Canyon to the Pacific has been mapped by several firms as one of major landsliding. Here the physiographic surface and the 125,000 year old wave cut bench have been broken in many places. This zone is on trace with the trend of the Mountain Top and Horno Canyon Fault Zones. Bed rock dips of San Mateo (Tsm) and Capistrano (Tc) Formations range from 14 degrees east to 6-10 degrees west with on block of Tsm standing vertical. Offshore, bathimetry at depths of 30 and 60 feet appears displaced. Bluff failures to the immediate north and south of this zone are dominated by narrow block falls. Also in this zone, older Capistrano Formation (Tc) is exposed at similar elevations as younger San Mateo Formation (Tsm) units. These observations suggest that a major zone of faulting intersect the coast in this locality. The mapped landsliding appears to be a superficial manifestation of a deeper seated

deformation. Age of this complex structure is younger than 125,000 years and may be as recent as several hundred to 10,000 years based on the offset of todays physiographic surface, offset bathimetry and faulting of the lowest marine terrace.

MORNO CANYON FAULT

Earlier mapping (CDMG, Santa Ana Sheet) traces a fault along the south flank of the Margarita Mountains in the center of Camp Pendleton towards Morno Canyon. Within Morno Canyon several zones of shearing showing left lateral movement were observed. Near the mouth of Morno Canyon Southern California Edison reported 260 feet of stratigraphic displacement along a zone of faulting (SoCalEd 1981). Additionally, near the intersection of El Camino Real and Morno Canyon, marine terraces Qt2, Qt3, and Qt4 are displaced vertically from 20 to 100 feet. The north side of Morno Canyon has been sharply uplifted into a scarp over the south side. Evidence for faulting at the seacoast and offshore parallels that discussed under the Mountain Top Fault Zone. Age of this faulting may be similar to that in the Mountain Top Fault Zone.

PULGAS CANYON AND PIEDRE DE LUMBRE FAULTS

Evidence for the Piedre de Lumbre Fault stems primarily from earlier mapping of a fault in central Camp Pendleton by Moyle (1973) and earlier workers (CDMG, Santa Ana Sheet), and offset of the second marine terrace (Qt2) of about 100 feet (up on the north) near the mouth of Piedre de Lumbre Canyon. In Pulgas Canyon, Miocene Capistrano (Tc), San Mateo (Tsm) and Eocene Santiago (ts) sediments are exposed at elevations of about 200 feet within massive higher outcrops of Miocene San Onofre Breccia (Tso). Faulting along the axis of Pulgas Canyon was mapped by Stuart (1975). Offshore bathimetry is offset on the Pulgas Canyon axis. Faulting appears to have a left lateral sense with south side down an undetermined amount. On the basis of offset terraces and offshore bathimetry the faulting is less than 250,000 year old and may be as recent as several hundreds to 10,000 years before present.

ALISO FAULT

Four lines of evidence argue for faulting on the NE-SW axis along Aliso Canyon. They include:

1) Uplift of the third marine terrace (Qt3) of 20-40 feet across Aliso Canyon, north side up.

2) Shearing and slickensides within Aliso Canyon on a NE-SW trend.

3) Offset bathimetry on Aliso Canyon Axis.

4) Change in rock types within San Mateo Canyon Formation (Tsm) at the coastal bluff.

These together indicate faulting on this axis is between 5000 to 8000 and 342,000 years old. An apparent break in the physiographic surface near the seacoast and on trend with the Canyon could be interpreted as evidence of younger faulting.

CHRISTIANITOS - NEWPORT/INGLEWOOD - ROSE CANYON FAULTS AND OFFSHORE ZONE OF DEFORMATION (OZD)

These structures have been recognized by many geologists and studied in detail. Discussion of the evidence for them is therefore omitted. However, the faults and structures found onshore and discussed above fall into the same general structural pattern as these features. The Horno Canyon and Mountain Top Zones in particular project directly into the OZD.

SUMMARY

It is concluded that the dominate structural trend in the vicinity of the SONGS site reflects NW-SE right lateral faulting with complementary NE-SW shears. From a modeling perspective, this would be consistent with a

NW-SE shear couple between the North American and Pacific plates. Such an interpretation is also consistent with right lateral movement along the Elsinore, San Jacinto & San Andreas Faults. Within the Elsinore Fault to Rose Canyon/Newport Inglewood Fault structural block there are a number of mapped faults and lineaments observable on satelite photos which tend to reinforce this interpretation.

Predominately vertical movement has lifted the San Onofre Mountain area along NE-SW trending faults in post mid-Pleistocene time, This block is tilted downward to the SE from a topographic high in the vicinity of San Onofre Mountain towards Oceanside. This faulting appears primarily compression with left lateral movement observed along the Horno Canyon, Pulgas Canyon, and Aliso Canyon Faults. These fault zones are now occupied by stream courses which have followed zones of weakness through the resistant San Onofre Breccia (Tso) which lies between their sources and the Pacific.

REFERENCES

CDMG, 1965, Geologic Map of California, Santa Ana Sheet. Compiled by Rogers, T. H.

Housner, G. W. Strong Ground Motion in Earthquake Engineering, Prentice Hall, 1970.

LaJoie/McCrory, 1981, Flandrian Transgression, San Onofre Shelf, California Informal Inhouse, USGS Summary.

Larsen, E. S., Batholithic and Associated Rocks of the Elsinore, Corona and San Luis Rey Quadrangles, Geological Society of America - Memoir 29.

Moyle, W. R. Jr., 1973, Geologic Map of Camp Pendleton, California - Northern and Southern Portions, USGS Open File.

Shlemon, R. J., 1978, Late Quaternary Evolution of the Camp Pendleton - San Onofre State Beach, Coastal Area, Northwestern San Diego County, prepared for Southern California Edison, January 1978.

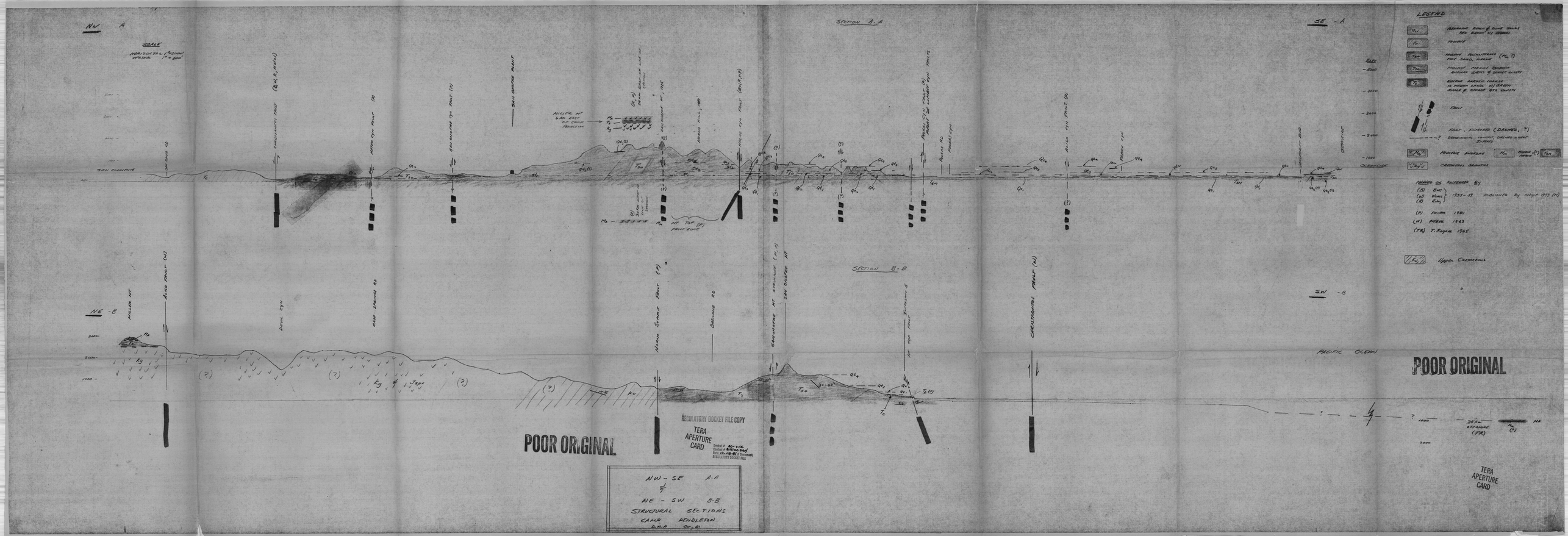
Shlemon, R. J., 1978, Late Quaternary Rates of Deformation, Laguna Beach - San Onofre State Beach, Orange and San Diego Counties, California, prepared for Southern California Edison, October 1978.

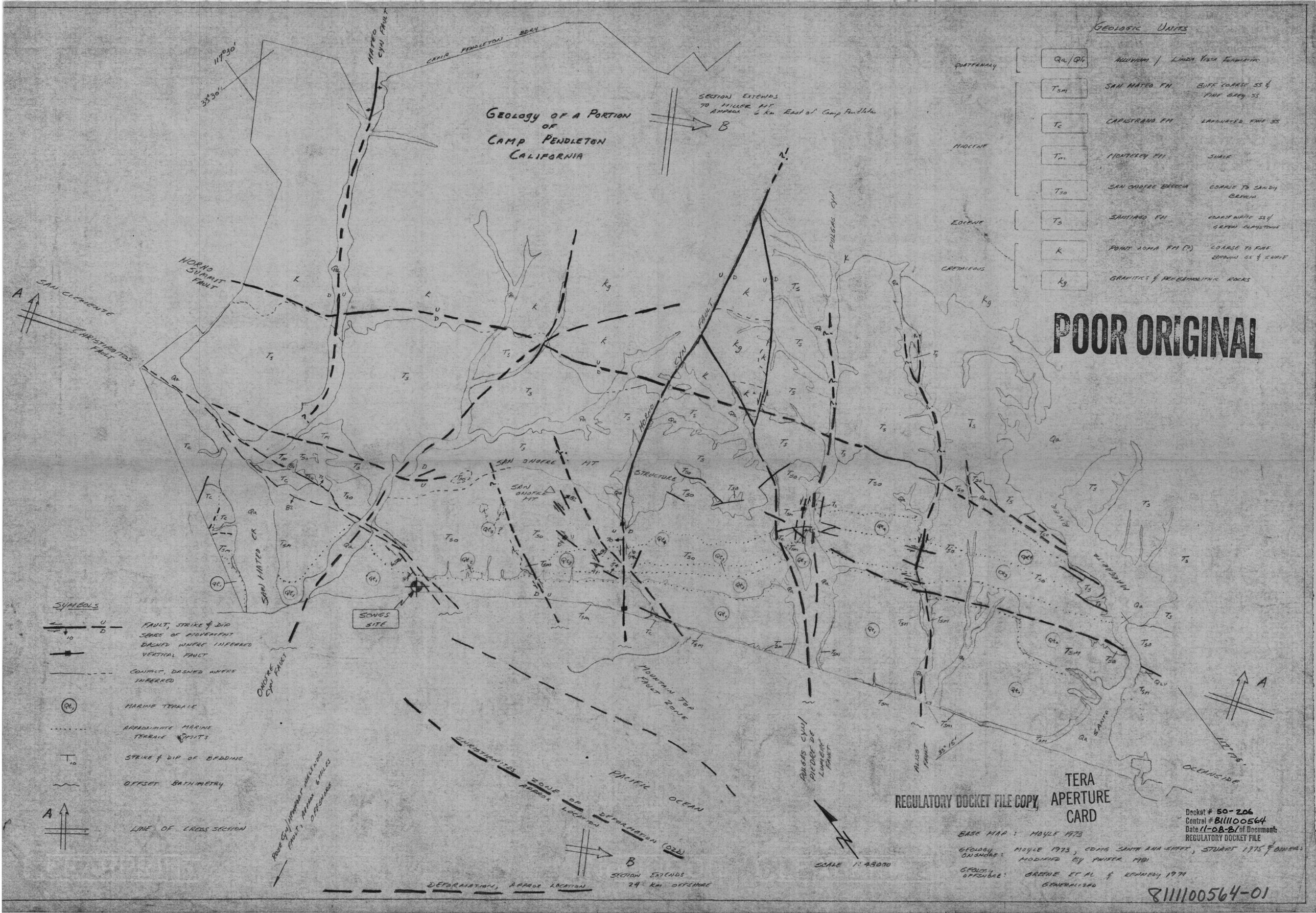
Shlemon, R. J., 1979, Late Cenozoic Stratigraphy Capistrano Embayment Coastal Area, Orange County, California, prepared for Southern California Edison, July 1979.

Southern California Edison, 1981, Report on the Limited Appearance of Mr. D. W. Phifer and Alleged Geologic Features, Camp Pendleton, California, presented to the Nuclear Regulatory Commission on 31 July 1981 at San Diego County.

Stuart, C. J., 1975, The San Onofre Breccia in the Camp Pendleton Area, California in Studies of the Geology of Camp Pendleton and Western San Diego County, California, San Diego Association of Geologists.

USGS, 7.5 Minute Quadrangle Sheets - Oceanside, Pulgas Canyon, San Onofre Bluff and San Clemente 1:24,000.


NW A
SCALE
HORIZONTAL 1" = 2000'
VERTICAL 1" = 500'
SECTION A-A
SE - A
LEGEND
FAULT
FAULT, INFERRED (DASHED, ?)
CRETACEOUS GRANITES
Upper Cretaceous
SAN CLEMENTE
SAN ONOFRE FAULT (?)
SAN ONOFRE MT.
SAN ONOFRE RIDGE
SAN ONOFRE MT. TOP
FAULT ZONE
PACIFIC OCEAN
SECTION B-B
NE - B
SW - B
HILLTOP MT.
ALISO FAULT (N)
DEER CYN.
CAMP SERRANO RD.
MORRO SERRANO FAULT (?)
BALLINGER RD.
SAN ONOFRE MT. STRUCTURE (?)
SAN ONOFRE MT.
MT. TOP FAULT
CHRISTIANITOS FAULT (N)
POOR ORIGINAL
REGULATORY DOCKET FILE COPY
TERA APERTURE CARD
NW - SE A-A
NE - SW B-B
STRUCTURAL SECTIONS
CAMP PENDLETON
POOR ORIGINAL
TERA APERTURE CARD


GEOLOGY OF A PORTION OF CAMP PENDLETON CALIFORNIA
GEOLOGIC UNITS
QUATERNARY
Qa/Qt₁ ALLUVIUM / LINDA VISTA FORMATION
MIOCENE
Tsm SAN MATEO FM BUFF COARSE SS & FINE GREY SS
Tc CAPISTRANO FM LAMINATED FINE SS
Tm MONTEREY FM SHALE
Tso SAN ONOFRE BRECCIA COARSE TO SANDY BRECCIA
EOCENE
Ts SANTIAGO FM COARSE WHITE SS & GREEN CLAYSTONE
CRETACEOUS
K POINT LOMA FM (?) COARSE TO FINE BROWN SS & SHALE
Kg GRANITICS & PREBATHOLITHIC ROCKS
POOR ORIGINAL
SECTION EXTENDS TO HILLER PT. APPROX 6 km East of Camp Pendleton
B
117°30'
33°30'
CAMP PENDLETON BDRY
MATEO CYN FAULT
HORNO SUMMIT FAULT
SAN CLEMENTE
SAN ONOFRE FAULT
A
SAN MATEO CR
SAN ONOFRE MT
HORNO CYN FAULT
STRUCTURE
PULGAS CYN
RIVER
MARGARITA
SONGS SITE
ONOFRE CYN FAULT
MOUNTAIN TOP FAULT ZONE
EVERTON ZONE OF DEFORMATION (OZD) APPROX LOCATION
PACIFIC OCEAN
PULGAS CYN/ PIEDRA DE LUMBRE FAULT
ALISO FAULT
SANTA
OCEANSIDE
SYMBOLS
FAULT, STRIKE & DIP SENSE OF MOVEMENT DASHED WHERE INFERRED VERTICAL FAULT
CONTACT, DASHED WHERE INFERRED
MARINE TERRACE
APPROXIMATE MARINE TERRACE LIMITS
STRIKE & DIP OF BEDDING
OFFSET BATHYMETRY
LINE OF CROSS SECTION
ROCE 5/4/ INFERRED SHELF AND FAULT, APPROX 6 MILES OFFSHORE
DEFORMATION, APPROX LOCATION
SECTION EXTENDS 24 km OFFSHORE
SCALE 1:48000
REGULATORY DOCKET FILE COPY
TERA APERTURE CARD
BASE MAP: MOYLE 1973
GEOLOGY ONSHORE: MOYLE 1973, CDMG SANTA ANA SHEET, STUART 1975 & OTHERS MODIFIED BY PHIFER 1981
GEOLOGY OFFSHORE: GREENE ET AL & KENNEDY 1971 GENERALIZED
Docket # 50-206
Control # 8111100564
Date 11-08-81 of Document
REGULATORY DOCKET FILE
8111100564-01