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DENTON,H.R. Office of Nuclear Reactor Regulation, Director

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SUBJECT: Forwards review of geoligic & seismologic data submitted by Southern CA Edison Co in support of position re San Onofre Units 1 & 2.

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Mr. Harold R. Denton, Director
Office of Nuclear Reactor
Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Denton:

Transmitted herewith, in response to the requests of your staff, is a review of the geologic and seismologic data submitted by the Southern California Edison Company in support of its position concerning the San Onofre Nuclear Generating Station Units 2 and 3 (SONGS 2 and 3).

This review was prepared by Mr. Robert H. Morris and Mr. James F. Devine. Assistance was provided by Dr. H. Gary Greene and Dr. Joseph S. Andrews.

We have no objection to your making this review part of the public record.

Sincerely yours,

for H. William Menard

Enclosure

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A

Review of Geologic and Seismologic Data Relative to the San Onofre Units 2 and 3 Operating License Application

On August 13, 1980, the U.S. Geological Survey (USGS) transmitted to Dr. Robert E. Jackson in response to his request dated July 2, 1980, an Administrative Report entitled "Review of Offshore Seismic Reflections Profiles in the Vicinity of the Cristianitos Fault, San Onofre, California" by H. G. Greene, USGS, and Mr. M. P. Kennedy, California Division of Mines and Geology (CDMG). Since that transmittal, additional reflection profiles have been submitted by the applicant for the San Onofre Nuclear Generating Station Units 2 and 3 (SONGS). On September 23, 1980, a meeting was conducted in Menlo Park, California, during which the applicant, Southern California Edison (SCE), presented their interpretation of the Nekton survey. The USGS, in collaboration with M. P. Kennedy of the CDMG, has completed review of the Nekton data. This review constitutes an addendum to their earlier report and is being made available as an Administrative Report with the title "Addendum to Review of Offshore Seismic Reflections Profiles in the Vicinity of the Cristianitos Fault, San Onofre, California" by H. G. Greene and M. P. Kennedy (attached). In this addendum, Greene and Kennedy conclude that the Cristianitos Zone of Deformation (CZD) merges with or is truncated by the Offshore Zone of Deformation (OZD) and that generally faults within the CZD, with few exceptions, displace shallow stratified sedimentary rock that lies beneath a prominent unconformity and younger, poorly stratified sediments.

The significance of the above described studies on the earthquake potential at the SONGS site has been studied extensively by the applicant. On October 8, 1980, the USGS received edited transcriptions of some of the September 23, 1980, presentations made by SCE and its consultants. Included were the following:

1. Discussion of Geologic Setting, SONGS area, September 23, 1980, Dr. Perry Ehrlig.

2. Discussion of Offshore Recent Seismic Reflection Profiles, September 23, 1980, Dr. David Moore.

3. A description of the A. B, C, and D features at the site.

4. Amended response to NRC question 361.54.

The full set of these presentations represent the most complete summary of the applicant's analysis of this earthquake potential. The transcriptions of September 23, 1980, did not include the discussion by Dr. Roy Shleman, consultant to SCE, whose interpretation of the geomorphology and Holocene history of the area contributed significantly to the interpretation of the ages represented by various marine terrace sequences. The importance of this information is demonstrated by the application of these data to the interpretation of the marine profiles described by Dr. David Moore, and this, in turn, reflects the manner in which projection of the Cristianitos Fault to the south has been made. In assessing the conclusions drawn by the applicant's consultants in contrast with those by Greene and Kennedy, there emerges a difference in the use of

certain named structures. Apparently, the applicant's consultants restrict the use of the term "Cristianitos Fault" to a single fault structure, i.e., a west-dipping normal fault. However, Greene and Kennedy use the terms "Cristianitos Zone of Deformation" (CZD), to refer to a zone of short discontinuous faults and folds. The applicant's consultants conclude that the Cristianitos fault dies out to the south whereas Greene and Kennedy project the Cristianitos Zone of Deformation southward to the OZD. SCE recognizes the southward projection by Greene and Kennedy but state in their conclusion that it does not represent an interconnection between the Cristianitos fault and the OZD. Both parties recognize younger undeformed, probably marine terrace, deposits capping the structures near shore. The range in age of these capping deposits is stated by Dr. Shleman (oral discussion, September 23, 1980, and viewgraph) to be from 80,000 years before present (YBP) to 8,500 YPB. The 8,500 YBP date was obtained by C14 method and the 80,000 YBP was inferred based upon geomorphology and late Pleistocene history. Assuming the inferred age is a reasonable conclusion, then the applicant's contention that the Cristianitos Fault (restricted use) is not capable is permissive. On land, the Cristianitos Fault is capped by the 125,000 year-old marine terrace, and the above conclusion then is consistent with that evidence.

Applicant's consultant, Dr. Perry Ehlig, discussed the origin of the Cristianitos Fault (restricted use) and concluded that the fault originated from 10 to 4 million years ago during a period of crustal extension and that the present stress regime of generally northeast-southwest compression represents a significant change; therefore, movement on the OZD would not trigger movement on the Cristianitos Fault.

The USGS, in general, concurs with the conclusions stated by the applicant and its consultants regarding the history and age of last movement of the Cristianitos Fault, its relation as one of several faults of the CZD of Greene and Kennedy, and its apparent lack of potential for movement in response to movement on the OZD.

The extensive investigations and studies by the applicant and its consultants to develop an estimate of the proper magnitude of the Safe Shutdown Earthquake have been reviewed. The techniques discussed in these studies have value but also limitations and shortcomings. Consequently, uncertainty still remains as to just which magnitude number is the "correct" one. Some of this uncertainty results not from the tools for deriving a specific magnitude number but from the limited relevance of such a number as a primary avenue through which ground motion values are estimated for sites near to the earthquake source structures. It is our judgment that a single magnitude value alone is an insufficient basis for assessing the consequence of the occurrence of an earthquake. Instead, it is necessary to include the entire tectonic package in three dimensions and in time sequence and the engineering considerations in order to develop appropriate seismic design numbers. Continued efforts to define a specific "magnitude" have, in our judgment, rapidly diminishing returns.

One could argue even today that reasoned judgment of the amount of ground shaking from many large earthquakes as indicated by the observed response at or near the fault structure may still be the most useful tool for estimating future ground motions very near to the fault. To the extent that that is the case, the previous estimates of shaking "intensity" and resulting estimated seismic design values, as used in the process leading to the seismic design of the SONGS facilities, still appear to be valid and appropriate to the SONGS 2 and 3 facilities.

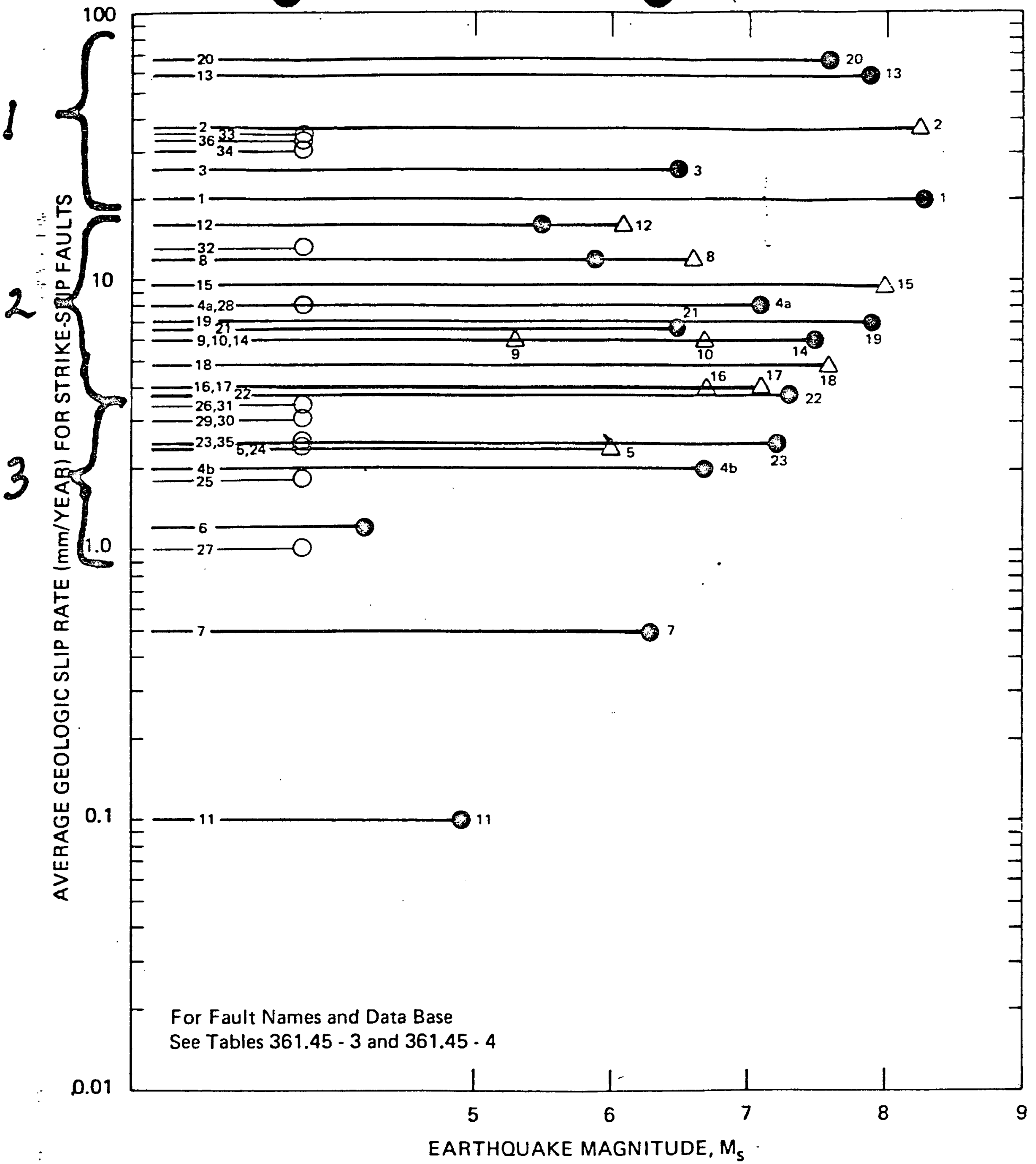
However, in an effort to be responsive to your requests to review the material submitted by the applicant, we offer the following comments concerning the primary technique discussed by the applicant, slip-rate versus magnitude study.

On the question of the statistical significance of the slope of a line bounding points on the log slip-rate versus magnitude plot, the applicant's consultants point out that while a single fault with low slip-rate is unlikely to have a "maximum" earthquake in historic time, a group of low-slip-rate faults has a significance proportional to their moment-rate sum. This same reasoning can be applied quantitatively.

There are 14 faults in Group 2 (see attached figure) with slip-rates ranging from 3.5 to 17.5 mm/yr. Seven of these faults have had historic earthquakes within one magnitude unit of the proposed "maximum earthquake limit" (MEL) line, and two have had earthquakes within 1/2 magnitude unit of the proposed MEL line.

There are 11 faults in Group 3 with slip-rate of 0.7 to 3.5 mm/yr. It is stated on p. 361.51-2 of the SCE report of February 1980 that "The total moment rate for group 3 is roughly equal to the average rate for group 2." Therefore, the faults of group 3 collectively have the statistical weight of a single fault of group 2. The probability that any earthquake in group 3 is within one magnitude unit of a properly-drawn "maximum earthquake limit" line is 7/14 = 0.5, and the probability that any earthquake on any fault in group 3 is within 1/2 magnitude unit of the MEL is 2/14 = 0.14. Therefore, there is a substantial probability that the MEL line should be steeper than shown in Figure 361.45-4, and earthquake magnitudes at smaller geologic slip-rates could be larger. During discussion the applicant made the observation that there are probably many faults with small geologic slip-rates and no historic earthquakes which are not shown on the plot and that these should be included in an estimate of statistical significance. It remains to be shown that the number of such faults increases inversely with decreasing geologic slip-rate. Consequently, an imperical technique based on such limited data cannot be considered definitive in assessing maximum magnitude. However, this technique is helpful, when considered along with other procedures for estimating earthquake size to assess the potential impact of earthquakes on the SONGS site.

A comment is in order relative to other regional and areal studies prepared for a variety of uses that have listed estimates of the magnitude of the maximum earthquake on the various faults in southern California and elsewhere. Such studies are based on a variety of generalized geologic and seismologic assumptions that may be adequate for the purposes for which those reports are intended but quite inappropriate for other purposes such as the development of the seismic design criteria for a specific site. Such specific site design criteria usually require detailed studies with the particular needs and requirements for that site as a basis for the studies. Consequently, the very extensive studies and evaluations accomplished for the particular purpose of assessing the earthquake safety at the SONGS site should provide the bases upon which seismic safety issues relative to that site are resolved.



EXPLANATION

- Maximum instrumental recording
- △ Maximum pre-instrumental estimates
- — Range over which smaller earthquakes occur
- ○ No maximum magnitude from instrumental or pre-instrumental data.

Figure 361.45 - 1 Empirical Plot Geologic Slip Rate VS Historical Magnitude for Strike–Slip Faults

ADDENDUM TO:
REVIEW OF OFFSHORE SEISMIC REFLECTION PROFILES IN THE VICINITY OF THE CRISTIANITOS FAULT, SAN ONOFRE, CALIFORNIA

by

H. Gary Greene[1] and Michael P. Kennedy[2]

INTRODUCTION

On May 8, 1980 the U.S. Nuclear Regulatory Commission (NRC) requested that a comprehensive review by made of all marine geophysical data relevant to the character and recency of faulting along the offshore extension of the Cristianitos fault in the vicinity of the San Onofre Nuclear Generating Station (SONGS) in northwestern San Diego county, California. This request was made to the U.S. Geological Survey (USGS) and was concerned specifically with a proposed structural relationship between the Cristianitos zone of deformation (CZD) and the Newport-Inglewood-Rose Canyon fault zone (Greene et al., 1979) or the Offshore Zone of Deformation (OZD) of Southern California Edison (SCE) Company. H. G. Greene of the U.S.G.S. suggested to the NRC that this review be made jointly by himself and M. P. Kennedy of the California Division of Mines and Geology. This suggestion was made because of the extensive joint research effort then underway between Greene and Kennedy on aspects of the structural geology of the southern California borderland. The NRC agreed to Greene's suggestion and a review and report were completed on July 18, 1980.

[1]U.S. Geological Survey, Menlo Park, California
[2]California Division of Mines and Geology, La Jolla, California

Following the completion of this review and report an additional data set was forwarded for the authors consideration. This data set was collected in June 1980 by NEKTON Inc. for SCE. It consists of about 90 km of high resolution water gun and 3.5 kHz seismic reflection profiles and side-scan sonographs collected within the area of earlier studies (plate 2). The 3.5 kHz data is generally good to moderately good and the penetration is on the order of 10-20 ms. The side-scan data is generally poor and for the most part unuseable for our purpose.

PURPOSE OF NEKTON DATA COLLECTION

The June 1980 NEKTON survey was aimed specifically at collecting data in the vicinity of the proposed intersection of the CZD and the Newport-Inglewood-Rose Canyon fault zone (Greene et al., 1979) or OZD. This relationship was explained in detail by H. G. Greene in a meeting with the NRC and SCE held May 21, 1980. The objectives of the survey as defined by NEKTON, Inc. (1980) were (1) to identify, if possible, the seaward extension of the Cristianitos fault that is mapped onshore 0.8 kilometers southeast of SONGS within our Cristianitos zone of deformation, (2) to determine if the Cristianitos fault connects with the OZD, (3) to identify and map other faults and folds in the area, and (4) to determine whether any faults show evidence of Holocene movement.

DISCUSSION

Although no seismic lines collected by NEKTON in the June 1980 survey actually cross the proposed CZD-OZD intersection of Greene and Kennedy (1980) the CZD can be extended by way of this data (June 1980

NEKTON data) to an area where we interpret it to merge with a synclinal fold and adjoining fault associated with the OZD.

With the exception of minor and consistant navigational errors between the earlier data studied and the June, 1980 NEKTON data nearly all of the geological structures identified correlate with those noted previously (Greene and Kennedy, 1980). Several faults that were inferred and shown in areas labeled "data void" have been confirmed with the June 1980 NEKTON data set. As in the original review no geological features have been shown on plate 1 that cannot be correlated between two or more lines.

The June 1980 NEKTON data suggest that the CZD narrows to the south and merges with a syncline that marks the landward boundary of the OZD. This syncline in turn is truncated by a fault that lies parallel or subparallel to this syncline (plate 1).

In the area of the proposed CZD-OZD intersection the OZD is wide (6.4 km) but appears on the bases of the June 1980 NEKTON data to narrow or trend out onto the continental slope southeast of the intersection (plate 1). Components of the OZD southeast of the proposed CZD-OZD intersection consist primarily of a single continuous fault. At the locality where the OZD is represented by a single fault a scarp on the seafloor suggests recent fault movement. The seafloor scarp is at the intersection of two very continuous faults within the central part of the OZD (plate 1).

Structure noticeably changes southeast of the OZD-CZD intersection. Northwest of this intersection structural components mapped on the shelf are plentiful and relatively complex while southeast of the intersection the structural components are reduced in number and complexity (plate 1).

The geological structure mapped from the total review process, with

only a few exceptions are confined to a section of well stratified sedimentary rock that lies wholly beneath a prominent unconformity and a thin sequence of poorly stratified, locally acoustically transparent (poorly consolidated and possibly water saturated) sediment. The exceptions noted are faults that displace near surface bedrock or sediment in the vicinity of (1) the proposed intersection of the CZD and OZD, (2) along the eastern margin of the CZD at a single locality and (3) centrally in the CZD at four separate localities that lie between approximately 4.5 - 6 km south of SONGS (plate 1).

CONCLUSIONS

The CZD merges with or is truncated by the OZD in the area offshore from SONGS (plate 1). Generally faults within the CZD with few exceptions (plate 1) displace shallow stratified sedimentary rock that lies beneath a prominent unconformity and younger poorly stratified sediments. The June 1980 NEKTON data support the conclusions reported previously by Greene and Kennedy (1980).