United States Department of the Interior

GEOLOGICAL SURVEY

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Hans Schierling, Senior Project Manager
PWR Project Directorate #3
Division of Power Licensing-A
Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Hans:

The San Francisco PG & E-NRC workshop on October 21-22 demonstrated significant progress in geologic, seismologic, and geophysical investigations. Notable examples include: improved assessments of the sense and amount of displacement of geologic markers cut by the San Simeon fault zone; field and laboratory measurements of soil profiles that will help constrain the age of faulting at San Simeon; structure contour maps of late Cenozoic or Quaternary seismic reflection horizons along and southwest of the Hosgri fault; and preliminary 3-dimensional analyses of network seismological data. All of these are high-priority tasks and although they are still incomplete they represent an aggressive, professional effort to resolve questions regarding earthquake hazard at Diablo Canyon.

Progress is also evident in the acquisition of new and existing geophysical data onshore and offshore; however, the considerable task of interpreting these data and translating the results for evaluating earthquake potential is largely incomplete.

Except at San Simeon, mapping of shoreline angles of potentially datable marine terraces has barely begun, but such mapping is clearly recognized as a critical test of both dip- and strike-slip displacement. If individual shoreline angles can be dated and traced along exposed coasts, their distribution can significantly constrain the choice of feasible tectonic models. This is not a simple task, but initial results by both PG & E's consultants and the University of Nevada group justify continued effort.

Clearly, many problems still remain. Most, however, are well-defined and the investigative program is appropriately configured to solve them. Some typical problems that appear most critical for estimates of earthquake size, location, and mechanism are:

- How does the San Simeon fault relate to the offshore Hosgri, both north and south of the Piedras Blancas region? Is the San Simeon an onshore segment of the main fault zone linking offshore faults to the north and south, or is it only a branch of a major offshore Hosgri?

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- How can nearly pure strike slip on the San Simeon fault be reconciled with evidence of reverse or oblique slip from offshore seismic reflection records and from focal mechanisms along the coastal zone of faulting?

- What is the down-dip geometry of late Quaternary faulting along the Hosgri zone, especially at sub-sea-floor depths greater than 2 or 3 km?

- The base of the seismogenic crust, generally near 12 km deep inland, appears to rise to 8 or 9 km offshore and to be better defined there by concentrated seismic activity. Is this an artifact of the velocity model? If it is real, how does it fit with alternative tectonic models?

- What is the relative importance of strike- and dip-slip components (Quaternary) along the Hosgri? (Structure contour maps now in preparation may answer this and may even give some insight into the amount of slip).

- Wave-cut platforms at San Simeon and elsewhere are plausibly but not positively dated by their vertical spacing above sea level and by soils; better age control southwest of the San Simeon fault--and in other areas--would resolve remaining uncertainty regarding sense and rate of slip.

Many and perhaps most of these problems are likely to be solved by planned or current work. Others may remain unsolved, thereby requiring multiple tectonic models to accommodate the uncertainty permitted by ambiguous or conflicting data. Multiple models are desirable in any event because we are unlikely to decipher all the details of faulting and seismicity along the continental border during the life of this study.

Whether more formal technical reports should be sought as individual tasks are completed is a question the NRC staff may wish to discuss with PG & E program management. Clearly, early review of interpretations and conclusions can benefit both parties, but for several reasons it may be more efficient to schedule such reviews closer to the end of the program. The informal workshops provide both adequate reporting and effective communication; they should be continued at least until most tasks are complete and analysis is firm.

Sincerely yours,

Robert D. Brown

cc: Ronald L. Ballard
Gus Giese-Koch
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November 30, 1986

Hans Schierling
Gus Giese-Koch, P-316
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Dear Hans Schierling and Gus Giese-Koch:

This letter summarizes my observations and opinions on the Diablo Canyon Program's NRC/PG&E Geology/Seismology/Geophysics Workshop in San Francisco on October 21-22, 1986. My overall impression followed discussions with Dr. Rich Schweickert and our four geologists that are working on this project.

The studies by PG&E have proper direction, are being actively pursued, are conducted by very capable workers, and show good progress since the last meeting during the August workshop-field trip. The current status of work is still much behind the expected results for the present date, which is past the mid-point of the program that was proposed in the January 1985 Long Term Seismic Program: Program Plan. The program must have vigorous impementation during the next year and a half to meet its goals, and the NRC staff and consultants will need properly and quickly respond if the SER is to prepared at the scheduled time. This will require the PG&E provide a timely and steady flow of documentation ot NRC.

This report is divided into two parts to review the PG&E and UNR results.

PG&E Studies

1. The exploratory trenching studies at San Simeon provided excellent information on the character and rate of faulting along the Hosgri fault trend. The work presented is of high quality, was well concieved, and with continued work after the winter should provide critical information on the character and size of earthquakes along this section of the Hosgri fault system. Our research team reviewed for NRC all trenches at San Simeon and we confirm the results presented by PG&E. The present results strongly indicate moderate fault slip rates (less than about 5 mm/yr) and prove predominant strike-slip late Quaternary (probably Holocene) offsets. The fault is clearly capable by U. S. 10 CFR 100, Appendix A criteria.

2. The seismic reflection program of study showed the start of new results and the additional studies that PG&E is conducting both offshore (between Big Sur and Point Sal) and the onshore studies in the Santa Maria basin are important to the goals for this re-evaluation.

3. Preliminary studies of the San Miguelito fault and the Edna-Los Osos fault system is planned for the winter exploratory program, but some initial studies were presented for the Pismo Beach fault. This initial work is appropriate to the scope of work plan and needs age control for marine terraces, Quaternary soils and stratigraphic units, and exploratory trenching and/or bore hole exploration. The work at Wilmar Avenue in Pismo Beach indicates that the smaller fault at this location is probably capable and appears to have multiple offsets since about 128,000 years bp. The main fault at this locality shows uncertain activity and the relationship of faulting to flexural slip and folding processes is not certain and field, dating and exploratory work is needed for the entire zone, including the San Miguelito fault, the Arroyo Grande area and the zone to the southeast, toward Nipomo, Santa Maria, and the Shuey fault.

4. The seismological program is being implemented and results from the new, local network should be available in the near future. The restudy of the 1927 earthquake by acquiring new data is also underway.

UNR Studies

1. The discovery by Steve Nitchman of a late capable fault with 2 meters of offset of late Quaternary marince terraces at Pismo Beach, along with late Quaternary deformation elsewhere along the San Miguelito trend was the most important UNR finding. Evidence obtained here and elsewhere along this trend indicates late Quaternary deformation, although the style and rate is still uncertain. His analysis showed the possibility of fault propagation folds, and flexural slip faulting. Quaternary activity, although at a low rate, is also present along the Edna-Los Osos fault system. He also reported very low rates of Quaternary deformation of the Paso Robles Formation.

2. Katie Killeen's studies of the Pismo Syncline show slow rates of uplift of the syncline, but no late Quaternary faulting, or very low rates of faulting across the San Luis Obispo Creek, which crosses the syncline, and along the seacoast between Montana de Oro and Mallagh Landing area.

3. Dr. Rich Schweickert's field study of the Little Pine fault area in eastern Santa Maria basin showed that there was no strike-slip fault component on the reverse-slip fault. Paso Robles Formation is highly deformed in this area, which indicates some Quaternary deformation.

4. Eutizio Vittori, a visiting scientist from ENEA, Italy, presented preliminary onshore measurements of late Cenozoic

faults and joints. These showed patterns that were suggestive of compressional deformation, with very sparse data suggesting strike-slip components in the onshore area, including Pismo Syncline.

5. Preliminary remote sensing studies by Barbara Matz, showed no major faults in the Pismo Syncline area. Evidence for Quaternary folding and faulting was observed along the Orcutt-Casmalia trend, south of Santa Maria.

6. Xiaoyi Zhang is continuing his worldwide compilation of surface faulting associated with historic earthquakes. His data base includes many strike-slip and reverse-slip examples that were not used in previous compilations by Bonilla and associates, and by Slemmons.

NRC STAFF COMMENTS ON THE DIABLO-CANYON LTSP
GROUND MOTION WORKSHOP OF OCTOBER 23 AND 24, 1986

- Selection of records based on whether the recording site is a "rock" site or a "soil" site requires close scrutiny and should reflect proper identification with respect to the Diablo Canyon Plant site conditions. In addition, the duration of strong ground motion has a significant influence on structural response. Consequently, this factor requires proper attention.

- The use of empirical Green's functions appears to be promising. However, using the Imperial Valley earthquake records alone may not be sufficient to determine the uncertainties associated with the site conditions.

- The establishment of a seismometer array to estimate earthquake wave coherency/incoherency is a commendable move on the part of the licensee. It can be expected to provide valuable information to verify the use of incoherency in the soil-structure-interaction (SSI) analysis.

- The use of data from small earthquakes to estimate local site conditions by comparing them to the USGS data available for other locations appears to be very useful.

- The estimation and use of angles of incidence of seismic waves should be approached with caution.

- Communication between the earth scientists and the engineers, engaged in the LTSP, should be emphasized to make both parties aware of the manner in which geophysical data are utilized to obtain engineering parameters. For instance, the procedure for evaluating effects of spatial incoherency of ground motion on the SSI analysis was not presented in sufficient detail.

- Based on the questions posed at the meeting, it is imperative that at certain milestones in the LTSP program, the assumptions made to facilitate analysis and the uncertainties associated with the entire process are discussed in detail and properly documented.

- Additional comments received from the staff's consultants since the October meeting identify several issues which, in their opinion, may significantly impact the LTSP results; for example, the use of the Imperial Valley Earthquake records as discussed above, the definition of f_{max} (the maximum frequency in the acceleration spectrum), and departure from the ω^2 scaling model. These concerns need to be addressed by the licensee.